BIOLOGICAL MONITORING (BIOLOGICAL SAMPLES COLLECTION) OF THE LANDED RAPANA CATCH BY THE BULGARIAN FISHING FLEET

SCIENTIFIC REPORT FOR 3rd and 4th QUARTER OF 2019

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This research is carried out by researchers from the Institute of Fish Resources – Varna, Agricultural Academy (AA), within Contract EAFA-Burgas/Д-157/16.05.2018 and is focused on the scientific assessment of the quantity and biological parameters of rapa whelk from the landed catch by the Bulgarian fishing fleet in 2019.

This research was done with the financial support from the European Commission in accordance with Regulation №199/2008 of the Council and Decision 2010/93/EC of the Commission, allocated to support member states in the preparation of technical report for the development of a common framework for collection, management and use of data in the Fisheries' sector and to support the scientific consultations about the overall policy in the fisheries' field.

This research is indicative for the 3rd and 4th quarter of 2019 and reveals the dynamics of the biological parameters of rapa whelk from the landed catch at Kavarna, Balchik, Kavarna, Varna and Sozopol, based on the biometric measurements and analysis of 800 specimens *R. venosa*.

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BIOLOGICAL MONITORING (BIOLOGICAL SAMPLES COLLECTION) OF THE LANDED RAPA WHELK CATCH BY THE BULGARIAN FISHING FLEETSCIENTIFIC REPORT FOR 3RD AND 4TH QUARTER OF 2019

1.INTRODUCTION

The current report is representative for the 3rd and 4th quarter of 2019 and is based on the biometric measurements on 800 specimens *R. venosa.* The analysis reveals biological parameters of the target species – quantity, length, weight, linear-weight ratio and sex structure by landings from the observed ports – Kavarna, Balchik, Varna and Sozopol.

1.1. DATA COLLECTED

The current study allowed the collection of several types of data:

1. Data about the fishing vessels' activity
- Fish expedition data
- Departure port
- Arrival port
- Fishing vessel name
- Vessel type
- Vessel length (m)

2. Fishing gear
- Depth scale of the fishing activities (up to 35 m depth)

3. Basic biological data
- Total weight of the target species, landed at a port
- Number of collected specimens in the biological sample
- Total weight of the sample (Total weight – shell weight (TW, g))
- Shell length (Shell length, SL, mm),
- Shell width (Wd, mm)
- Aperture shell length (Aperture length, AL, mm).

4. Additional biological data
- Ratio between sexes, sex maturity of collected specimens and gonadosomatic index (when applicable);
- Ratio between sex maturity and shell length, sex to shell length ration and sex to total weight ratio;

The final results are presented in the form of tables and maps with data about:
- Landings of the target species at ports
- Biological parameters of rapa whelk – size, weight, linear-weight relationships, sex structure from the samples;

2. MATERIAL AND METHODOLOGY

2.1. SAMPLING SCHEME

The collection of the biological samples (in total 800 individuals rapa whelk) had been performed during landings operations at different ports in the northern and southern part of the Bulgarian territorial waters. The main sampling ports in the 3 rd quarter of 2019 included - Balchik, Varna, Kavarna and Sozopol, while Kavarna and Sozopol were observed during the 4th quarter of 2019. The duration of the research was eight days for the period VII - XII.2019 and the summarized data are presented in Table 1.

Table 1.

Ports and fishing vessels observed during the biological monitoring of the rapa whelk landings

Date	Fishing vessel	Reg No of fishing vessel	Technical specifications	Departure	Arrival	Fishing method
3.07.2019	Elekta	Вн 8042	GT 17,12, KW 110.33, length 16,5 m	Balchik	Balchik	Beam trawl
24.09.2019	PK-5	Вн 8186	GT 91, kW 220, length 14,9 m	Varna	Varna	Beam trawl
25.09.2019	Paldin	Кв 5642	GT 10.04, KW 69,88, length 12.2 m	Kavarna	Kavarna	Beam trawl
29.09.2019	Cr 606	Цр 606	GT 9.79, KW 58.84, length 11.2 m	Sozopol	Sozopol	Scuba diving
01.10.2019	Bc395	Вс 395	GT 1,42, KW 16,18, length 6.95 m	Sozopol	Sozopol	Scuba diving
08.11.2019	Libra	Вн 8311	GT 17.23, kW 126, length 14.95 m	Kavarna	Kavarna	Beam trawl
12.11.2019	Elekta	ВН 8042	17.12 GT; kW 110.33, length 16.5 m	Kavarna	Kavarna	Beam trawl
16.11.2019	Libra	Вн 8311	GT 17.23, kW 126, length 14.95 m	Kavarna	Kavarna	Beam trawl

The standard beam-trawl applied for rapana fisheries has the following parameters – maximum width - 5.3 m, maximum depth – 6m: vertical opening - 280 mm; horizontal opening between the rails - 5 m; effective part of the upper collar - 4.8 m; "eye size" – 40 mm, trawling velocity - 3 - 3.6 Nd; trawling duration 60 - 80 mins.

The samples from the southern region were collected by scuba divers. These data were analyzed separately, because of the selective technique applied for the specimen's collection. The comparison analysis between the two fishing techniques is part of the current report.

2.2. Sample analysis

Random samples of *R. venosa* were taken from the landings by ports with the purpose to monitor the biological parameters of the species during the active fishing season.

The sample collection methodology is based on the following documents:

- " Report of the Workshop on Sampling and Calculation Methodology for Fisheries Data" (WKSCMFD) (ICES 2004);
- Report SGPIDS (ICES, 2011a),
- Report of the Study Group on Practical Implementation of Discard Samples (SGPIDS).

2.3. Laboratory analysis

- For each individual, the following biometric parameters are measured – total weight of the individual (total weight - weight with shell, TW, g), body weight of the individual (body weight – weight w/o shell, BW, g), shell length (shell length, SL, mm), shell width (Wd, mm) and aperture length (aperture length, AL, mm);
- The ratio between the different biometric parameters is calculated;
- The sex maturity is analyzed, as well as the ratio between the sexes and gonadosomatic index (GSI, if applicable);
- The ratio between the sex and the length is calculated and the ratio between the sex to the total weight of the specimens.

2.4. Statistical methods

The morphometric relationships between the biological parameters – total weight (TW), body weight (BW), shell length (SL), shell width (Wd), aperture length (AL) – are analyzed by allometric models. The derived results are processed by using the least squares method and the following equations:

$$Log\ W = Log\ a + b * LogL$$

Where, W – weight; L – size; a, b – constants.

XLSTAT software is used to make the linear and weight histograms of the samples from the landed catch, as well as for the data processing. The statistical data about the different classes, presented in the histograms, include – lower and upper limits of the classes, frequency, relative frequency and density.

3. Results

3.1. Biometric measurements

3.1.1. Linear-weight ratio

3.1.1.1. Port Balchik, 03.07.2019

The sample consists of 100 specimens rapa whelk (collected by beam trawl), with a total weight of 2.412 kg, from a total landing of 3413 kg rapa whelk at Port Balchik.

The average weight of the measured specimens reaches 24.12 g ± 10.22 SD, at an average length - 52.04 mm ± 6.44 SD, shell width – 38.63 mm ± 4.70 SD and aperture length 36.51 ± 4.64 SD. The weight w/o shell (body weight) is 9.65 g ± 4.80 SD and makes 38.64 % ± 5.37 SD from the total weight (TW), varying between 27.03 and 51.61 % TW (Table 2).

Table 2

Summarized statistics of the biological parameters - total weight (TW - shell weight, TW, g), body weight (BW, g), ratio of BW (% TW), shell length (shell length, SL, mm), shell width (Wd, mm) and aperture length (aperture length, AL, mm) at Port Balchik, 3.07.2019

	TW, g	BW, g	% BW from TW	SL, mm	Wd, mm	AL, mm
Mean	24.12	9.65	38.64	52.04	38.63	36.51
Standard Error	1.02	0.68	0.76	0.56	0.47	0.46
Median	21.50	8.50	39.63	51.00	37.00	35.00
Mode	16.00	8.50	34.48	50.00	37.00	35.00
Standard Deviation	10.22	4.80	5.37	5.56	4.70	4.64
Sample Variance	104.36	23.08	28.88	30.95	22.13	21.53
Kurtosis	5.94	5.70	-0.21	0.90	1.20	0.91
Skewness	2.08	2.14	-0.05	0.97	1.05	1.01
Range	62.50	24.50	24.59	27.00	24.00	22.00
Minimum	10.50	4.50	27.03	43.00	29.00	28.00
Maximum	73.00	29.00	51.61	70.00	53.00	50.00
Sum	2412.00	482.50	1932.24	5204.00	3863.00	3651.00
Count	100.00	50.00	50.00	100.00	100.00	100.00
Confidence Level (95.0%)	2.03	1.37	1.53	1.10	0.93	0.92

The most common length classes are - 46 - 56 mm (67 % of the measured specimens), as well as length class 56 -66 mm (20 %). In regard to the weight structure (TW, g), the predominant weight class is <25.6 g (70 % from all measured specimens), while large specimens > 76.8 g have not been observed.

The mean ratio - width (Wd, mm)/length (SL, mm) is 74.17 % ± 2.84 SD, while AL/SL (%) is 70.07 % ± 3.02 SD, the percentage ratio AL/Wd (%), is estimated at – 94.47 % ± 1.92 SD (Table 3).

Table 3

Percentage ratios between shell width and length (Wd/SL, %), aperture length/total shell length (AL/SL, %) and aperture length/total shell width (AL/Wd, %) of the specimens from Balchik, 3.07.2019

	Wd/SL (%)	AL/SL (%)	AL/Wd (%)
Mean	74.17	70.07	94.47
Standard Error	0.28	0.30	0.19
Median	74.17	70.00	94.59
Mode	74.00	70.00	94.59
Standard Deviation	2.84	3.02	1.92
Sample Variance	8.07	9.10	3.71
Kurtosis	0.18	-0.28	0.23
Skewness	-0.04	-0.07	-0.11
Range	14.21	15.10	10.81
Minimum	67.27	61.82	89.19
Maximum	81.48	76.92	100.00
Sum	7417.16	7007.13	9447.31
Count	100.00	100.00	100.00
Confidence Level (95.0%)	0.56	0.60	0.38

Linear-weight ratios:

1) LogTW (g) = 0.2634*log SL (mm) + 1.357, (R^2=0.83, p<0.001, Fig 1.1).
2) LogTW (g) = 0.3094*log Wd (mm) + 1.165, (R^2=0.90, p<0.001, Fig 1.2)
3) Log TW (g) = 0.3218*log Al (mm) + 1.124, (R^2=0.89, p<0.001, Fig 1.3).

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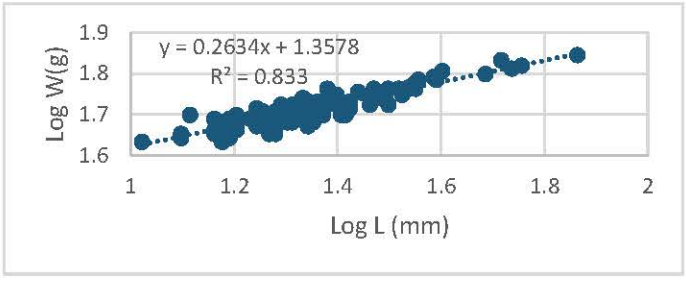

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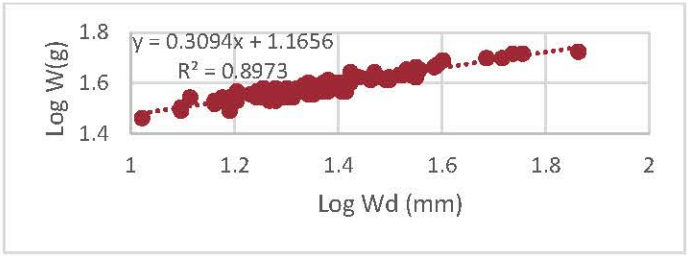


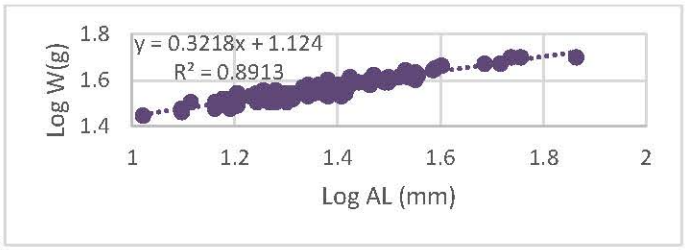
3. 

Figure 1. Linear-weight ratio (Log10) for the measured specimens, Balchik, 3.07.2019

The parameters *a, b* of the linear-weight relationship: $TW(g) = a.SL(mm)^b$ and the correlation coefficient R^2 are presented in Table 4.

Table 4

Parameters *a, b* of L-W relationship: $TW(g) = a.SL(mm)^b$ and R^2

Equation parameters $TW(g) = a.SL(mm)^b$	
a	0.000085596
b	3.16
R^2	0.83

3.1.1.2. Port Varna, 24.09.2019

The sample consists of 100 individuals rapa whelk (beam trawl) with a total weight of 3.938 kg, from a total landing of 8622 kg rapa whelk at Port Varna.

The average weight of the measured specimens reaches 39.38 g ± 10.06 SD, at an average length - 62.43 mm ± 5.42 SD, shell width - 45.72 mm ± 4.43 SD and aperture length 43.84 mm ± 4.83 SD. The weight w/o shell (body weight) is 14.90 g ± 5.01 SD, thus forming 37.48 % ± 4.30 SD from the total weight, varying between 27.19 % и 46.74 % TW (Table 5).

Table 5

Summarized statistics about the measured biological parameters – total weight (TW - weight with shell, TW, g), body weight (BW, g), ratio BW (% TW), shell length (shell length, SL, mm), shell width (Wd, mm) and aperture length (aperture length, AL, mm), Balchik, 24.09.2019

	TW, g	**BW, g**	**% BW from TW**	**SL, mm**	**Wd, mm**	**AL, mm**
Mean	39.38	14.90	37.48	62.43	45.72	43.84
Standard Error	1.01	0.71	0.61	0.54	0.44	0.68
Median	38.50	14.25	38.46	62.50	46.00	43.00
Mode	36.50	11.50	36.51	61.00	42.00	40.00
Standard Deviation	10.06	5.01	4.30	5.42	4.43	4.83

Sample Variance	101.19	25.13	18.52	29.34	19.64	23.32
Kurtosis	0.16	0.72	0.14	-0.28	-0.18	-0.24
Skewness	0.47	0.56	-0.53	0.13	0.17	0.15
Range	56.50	26.50	19.55	27.00	24.00	24.00
Minimum	13.00	4.00	27.19	49.00	34.00	32.00
Maximum	69.50	30.50	46.74	76.00	58.00	56.00
Sum	3938.00	745.00	1874.16	6243.00	4572.00	2192.00
Count	100.00	50.00	50.00	100.00	100.00	50.00
Confidence Level (95.0%)	2.00	1.42	1.22	1.07	0.88	1.37

The most common length class is 56 - 66 mm (65 % from the measured specimens) and 66 - 76 mm (26 %). Concerning the weight structure, the predominant weight class is - 25.6 - 51.2 g (82 % from the measured specimens), followed by weight class 51.2 - 76.8 g, with a share of 15 % from the total number of measured specimens. The structural data is summarized in Table 6.

Table 6

Percentage ratios between shell width and length, aperture length/total shell length and aperture length/total width (Balchik/24.09.2019 г).

	Wd/SL (%)	**AL/ SL (%)**	**AL/Wd (%)**
Mean	73.23	70.30	95.47
Standard Error	0.31	0.44	0.28
Median	72.95	70.46	95.60
Mode	71.43	71.43	93.02
Standard Deviation	3.07	3.09	2.01
Sample Variance	9.42	9.55	4.04
Kurtosis	0.21	0.97	-0.66
Skewness	-0.16	-0.37	-0.07
Range	16.66	16.96	9.09
Minimum	63.93	60.66	90.91
Maximum	80.60	77.61	100.00
Sum	7323.05	3515.20	4773.48
Count	100.00	50.00	50.00
Confidence Level (95.0%)	0.61	0.88	0.57

The following linear-weight relationships have been derived:

4) LogTW (g) = 0.3044*log SL (mm) + 1.3125, (R^2=0.85, p<0.001, Fig 2.1).
5) LogTW (g) = 0.3504*log Wd (mm) + 1.1041, (R^2=0.90, p<0.001, Fig 2.2).
6) LogTW (g) = 0.3218*log Al (mm) + 1.124, (R^2=0.89, p<0.001, Fig 2.3).

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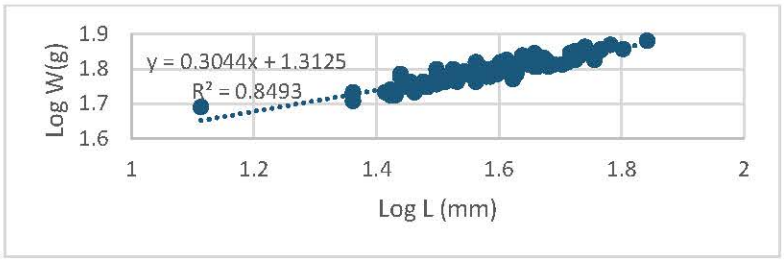

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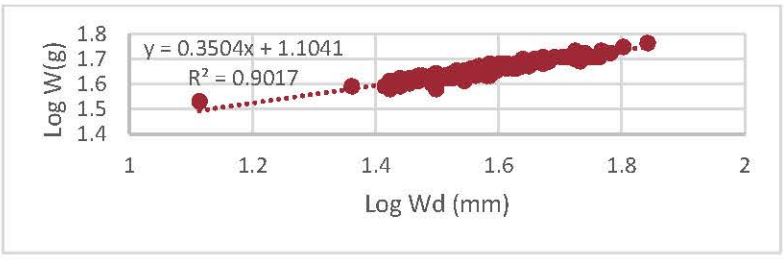

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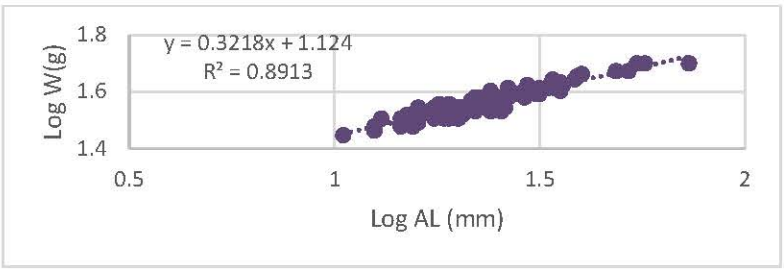

Figure 2. Linear-weight ratio (Log10) for the measured specimens, Balchik, 24.09.2019

The parameters a, b of the linear-weight relationship: TW(g)=a.SL (mm)^b are presented in Table 7.

Table 7

Parameters *a, b* of L-W relationship: $TW(g) = a.SL(mm)^b$ and R^2.

Equation parameters $W(g) = a.L(mm)^b$	
a	0.000387539
b	2.789617
R^2	0.85

3.1.1.3. Port Kavarna, 25.09.2019

The sample consists of 100 specimens rapa whelk (beam trawled), with a total weight of 4.745 kg. The landing at Port Kavarna was 1791 kg.

The average weight of the measured specimens reaches 47.45 g ± 13.83 SD, at an average length - 65.87 mm ± 4.18 SD, shell width - 49.22 mm ± 3.99 SD and aperture length 47.02 ± 3.27 SD. The weight w/o shell (body weight) is 18.60 g ± 4.08 SD or 39.70 % ± 5.33 SD from the total weight, varying between 27.19 % и 51.76 % from the total weight (Table 8).

Table 8

Summarized statistics about the measured biological parameters – total weight (TW - weight with shell, TW, g), body weight (BW, g), ratio BW (% TW), shell length (shell length, SL, mm), shell width (Wd, mm) and aperture length (aperture length, AL, mm), Port Kavarna, 25.09.2019

	TW, g	BW, g	% BW from TW	SL, mm	Wd, mm	AL, mm
Mean	47.45	18.60	39.70	65.87	49.22	47.02
Standard Error	1.38	0.58	0.75	0.42	0.40	0.46
Median	44.00	18.00	40.23	65.00	49.00	46.00
Mode	42.50	19.00	41.76	65.00	49.00	45.00
Standard Deviation	13.83	4.08	5.33	4.18	3.99	3.27
Sample Variance	191.38	16.65	28.44	17.47	15.91	10.71
Kurtosis	16.50	9.44	0.41	3.80	7.22	4.44
Skewness	3.38	2.36	-0.30	1.28	2.05	1.72
Range	102.50	25.50	24.57	26.00	26.00	18.00
Minimum	31.00	12.50	27.19	56.00	42.00	42.00
Maximum	133.50	38.00	51.76	82.00	68.00	60.00
Sum	4744.50	930.00	1985.18	6587.00	4922.00	2351.00
Count	100.00	50.00	50.00	100.00	100.00	50.00
Confidence Level (95.0%)	2.74	1.16	1.52	0.83	0.79	0.93

The most common length classes in the sample are - 56 - 66 SL, mm (52 % from the measured specimens), followed by the length class 66 - 76 mm (45 %). The specimens with length> 76 mm form about 8 % from all specimens. In regards to the weight structure (TW, g), weight class 25.6 - 51.2 g is 74 % from all the measured specimens, followed by a weight class - 51.2 – 76.8 g - 22 %.

The mean ratio - width (Wd, mm)/length (SL, mm) is about 74.73 % ± 3.66 SD, an AL/SL (%) - 71.15 % ± 2.98 SD, while the ratio AL/Wd (%) is - 95.22 % ± 2.40 SD (Table 9).

Table 9

Percentage ratios between the shell width and length (Wd/SL, %), aperture length / total shell length (AL/SL, %) and aperture length/total shell width (AL/Wd, %) of the specimens from Port Kavarna, 25.09.2019

	Wd/SL (%)	AL/ SL (%)	AL/Wd (%)
Mean	74.73	71.15	95.22
Standard Error	0.37	0.42	0.34
Median	74.44	71.11	95.79

Mode	73.44	75.00	93.88
Standard Deviation	3.66	2.98	2.40
Sample Variance	13.43	8.90	5.78
Kurtosis	-0.06	-0.24	0.56
Skewness	0.24	0.04	-0.31
Range	17.28	14.83	11.32
Minimum	66.67	63.64	88.68
Maximum	83.95	78.46	100.00
Sum	7473.14	3557.51	4760.95
Count	100.00	50.00	50.00
Confidence Level (95.0%)	0.73	0.85	0.68

Linear-weight ratios:

1) LogTW (g) = 0.2091*log SL (mm) +1.4701, (R^2=0.60, p<0.001, Fig 3.1).
2) LogTW (g) = 0.279*log Wd (mm) +1.2267, (R^2=0.70, p<0.001, Fig 3.2)
3) Log TW (g) = 0.2778*log Al (mm) +1.2084, (R^2=0.69, p<0.001, Fig 3.3).

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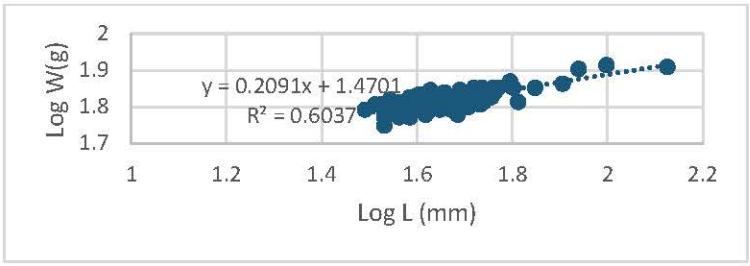

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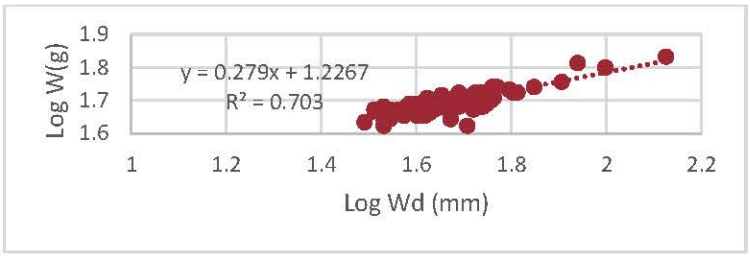

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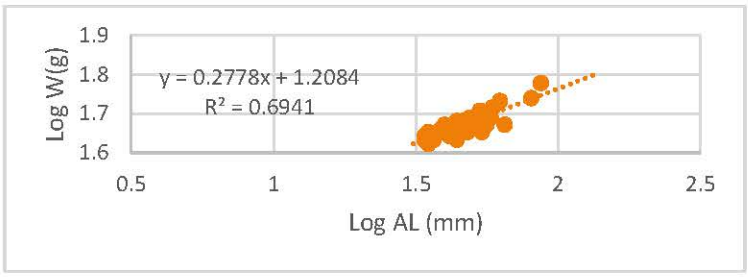


Figure 3. Linear-weight relationship (Log10) for the measured specimens, Kavarna, 25.09.2019

The parameters *a, b* of the linear-weight relationship: $TW(g) = a.SL(mm)^b$ and value of R^2, are presented in Table 10.

Table 10

Parameters *a, b* of the L-W relationship, $TW(g) = a.SL(mm)^b$ and R^2.

Equation parameters $TW(g) = a.SL(mm)^b$	
a	0.000259643
b	2.887
R^2	0.60

3.1.1.4. Port Sozopol, 29.09.2019

The sample consists of 100 specimens rapa whelk (by scuba diving method), with a total weight of 5.972 kg, from a total landing of 2828 kg at Port Sozopol.

The average weight of the measured specimens reaches 59.72 g ± 6.47 SD, at an average length - 69.40 mm ± 2.93 SD, shell width - 52.88 mm ± 2.27 SD and aperture length - 49.90 mm ± 2.26 SD. The weight w/o shell (body weight) is 19.70 g ± 3.65 SD and forms 32.42 % ± 5.28 SD from the total weight, varying between 20.51 % и 42.74 % TW (Table 11).

Table 11

The summarized statistics in regard to the measured biological parameters - total weight of the specimens in the sample (TW – shell weight, TW, g), body weight (BW, g), percentage ratio of the BW (% TW), shell length (shell length, SL, mm), shell width (Wd, mm) and aperture length (aperture length, AL, mm), Port Sozopol, 29.09.2019

	TW, g	**BW, g**	**% BW from TW**	**SL, mm**	**Wd, mm**	**AL, mm**
Mean	59.72	19.70	32.42	69.40	52.88	49.90
Standard Error	0.65	0.52	0.75	0.29	0.23	0.32
Median	60.00	19.50	32.53	69.00	53.00	50.00
Mode	58.50	17.00	35.83	69.00	53.00	51.00
Standard Deviation	6.47	3.65	5.28	2.93	2.27	2.26
Sample Variance	41.89	13.31	27.86	8.59	5.14	08.11
Kurtosis	0.16	0.40	-0.57	1.15	0.44	0.29
Skewness	0.18	0.23	-0.10	0.71	-0.57	-0.38
Range	33.00	18.50	22.22	15.00	12.00	11.00
Minimum	44.50	12.00	20.51	63.00	46.00	44.00
Maximum	77.50	30.50	42.74	78.00	58.00	55.00
Sum	5971.50	985.00	1620.86	6940.00	5288.00	2495.00

Count	100.00	50.00	50.00	100.00	100.00	50.00
Confidence Level (95.0%)	1.28	1.04	1.50	0.58	0.45	0.64

The most common length class is 66 – 76 mm (88 %). In regards to the weight structure (TW, g), the predominant specimens are with weights - 25.6 - 51.2 g (89 % from all measured specimens).

The mean ratio - width (Wd, mm)/length (SL, mm) is about 76.25 % ± 3.02 SD, while AL/SL (%) - 72.02 % ± 2.56 SD, as for the ratio AL/Wd (%), the derived results is 94.34 % ± 2.33 SD (Table 12).

Table 12

Percentage ratios between the shell width and length (Wd/SL, %), aperture length / total shell length (AL/SL, %) and aperture length/total shell width (AL/Wd, %) of the specimens from Port Sozopol, 29.09.2019

	Wd/SL (%)	**AL/ SL (%)**	**AL/Wd (%)**
Mean	76.25	72.02	94.34
Standard Error	0.30	0.36	0.33
Median	76.12	72.26	94.34
Mode	78.57	71.83	94.44
Standard Deviation	3.02	2.56	2.33
Sample Variance	9.13	6.55	5.42
Kurtosis	0.15	-0.15	0.94
Skewness	-0.41	-0.44	0.20
Range	14.71	11.09	12.00
Minimum	67.65	65.38	88.00
Maximum	82.35	76.47	100.00
Sum	7625.15	3600.83	4716.87
Count	100.00	50.00	50.00
Confidence Level (95.0%)	0.60	0.73	0.66

The derived linear-weight ratios are *not statistically representative*:

7) LogTW (g) = 0.1787*log SL (mm) + 1.524, (R^2=0.22, Fig 4.1).
8) LogTW (g) = 0.2363*log Wd (mm) +1.3039, (R^2=0.35, Fig 4.2)
9) Log TW (g) = 0.1953*log Al (mm) +1.3495 (R^2=0.20, Fig 4.3).

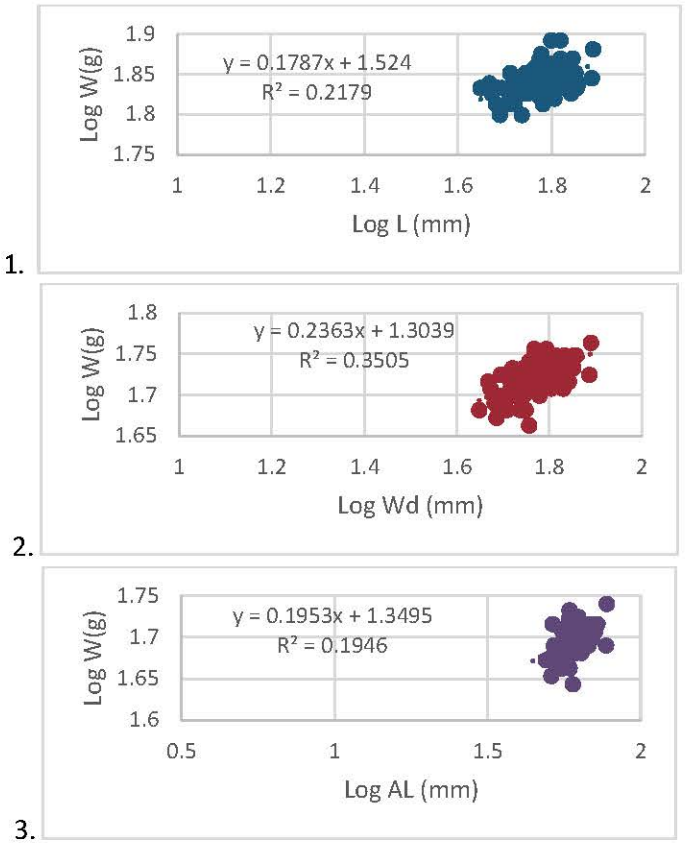


Figure 4. Linear-weight relationship (Log10) for the measured specimens, Sozopol, 29.09.2019

Table 13

Parameters *a, b* of the L-W ratio, $TW(g) = a.SL(mm)^b$ and R^2.

Equation parameters $TW(g) = a.SL(mm)^b$	
a	0.34
b	1.22
R^2	0.22

3.1.1.5. Port Sozopol, 01.10.2019

The sample consists of 100 specimens rapa whelk (collected by scuba divers), with a total weight of 5.622 kg, from a total landing of total 45 kg at Port Sozopol.

The average weight of the measured specimens reaches 56.22 g ± 14.65 SD, at an average length - 67.70 mm ± 6.03 SD, shell width - 51.53 mm ± 4.98 SD and aperture length 49.08 ± 4.80 SD.

The weight w/o shell (body weight) is 18.78 g ± 5.03 SD or 33.82 % ± 3.39 SD from the total weight, varying between 26.24 % и 43.10 % TW (Table 14).

Table 14

The summarized statistics in regard to the measured biological parameters - total weight of the specimens in the sample (TW - shell weight, TW, g), body weight (BW, g), percentage ratio of BW (% TW), shell length (shell length, SL, mm), shell width (Wd, mm) and aperture length (aperture length, AL, mm), Port Sozopol, 1.10.2019.

	TW, g	BW, g	% BW from TW	SL, mm	Wd, mm	AL, mm
Mean	56.22	18.78	33.82	67.70	51.53	49.08
Standard Error	1.46	0.71	0.48	0.60	0.50	0.68
Median	54.50	18.00	33.33	67.00	51.50	48.50
Mode	56.00	17.00	33.33	66.00	52.00	48.00
Standard Deviation	14.65	5.03	3.39	6.03	4.98	4.80
Sample Variance	214.61	25.27	11.52	36.33	24.80	23.05
Kurtosis	-0.50	-0.62	0.46	0.21	-0.36	-0.10
Skewness	0.37	0.35	0.49	0.15	0.13	0.02
Range	64.50	21.00	16.86	33.00	22.00	21.00
Minimum	28.50	10.00	26.24	53.00	41.00	39.00
Maximum	93.00	31.00	43.10	86.00	63.00	60.00
Sum	5622.00	939.00	1691.01	6770.00	5153.00	2454.00
Count	100.00	50.00	50.00	100.00	100.00	50.00
Confidence Level (95.0%)	2.91	1.43	0.96	1.20	0.99	1.36

The most common length class is - 66 - 76 SL mm (60 % from the measured specimens), followed by length class 56 - 66 mm (31 %). The specimens with length> 76 mm are 8 % from all the measured specimens. In regards to the weight structure, the weight class 51.2 – 76.8 g forms 51 % from all measured specimens, followed by weight class - 25.6 - 51.2 g (41 %).

The mean ratio - width (Wd, mm)/length (SL, mm) is 76.13 % ± 3.30 SD; AL/SL (%) - 72.90 % ± 2.55 SD, while the ratio AL/Wd (%) - 96.00 % ± 1.77 SD (Table 15).

Table 15

Percentage ratios between the shell width and length (Wd/SL, %), aperture length / total shell length (AL/SL, %) and aperture length/total shell width (AL/Wd, %) of the specimens from Sozopol, 1.10.2019

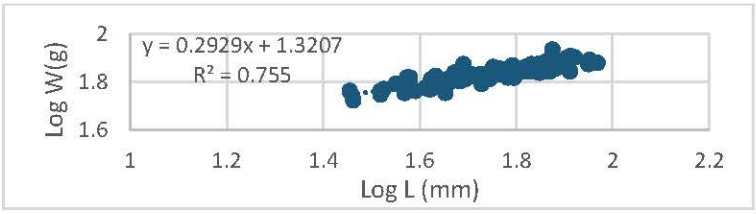
	Wd/SL (%)	AL/ SL (%)	AL/Wd (%)
Mean	76.13	72.90	96.00
Standard Error	0.33	0.36	0.25
Median	76.23	73.59	96.04
Mode	78.79	75.00	96.00
Standard Deviation	3.30	2.55	1.77

Sample Variance	10.87	6.50	3.15
Kurtosis	1.38	-1.15	1.07
Skewness	-0.43	-0.32	0.02
Range	19.70	9.03	9.09
Minimum	63.64	68.12	90.91
Maximum	83.33	77.14	100.00
Sum	7613.34	3645.04	4800.19
Count	100.00	50.00	50.00
Confidence Level (95.0%)	0.65	0.72	0.50

Linear-weight ratios:

1) LogTW (g) = 0.2929*log SL (mm) +1.3207, (R^2=0.76, p<0.001, Fig 5.1).
2) LogTW (g) = 0.344*log Wd (mm) +1.1132, (R^2=0.88, p<0.001, Fig 5.2)
3) Log TW (g) = 0.3338*log Al (mm) +1.111, (R^2=0.89, p<0.001, Fig 5.3).

1.



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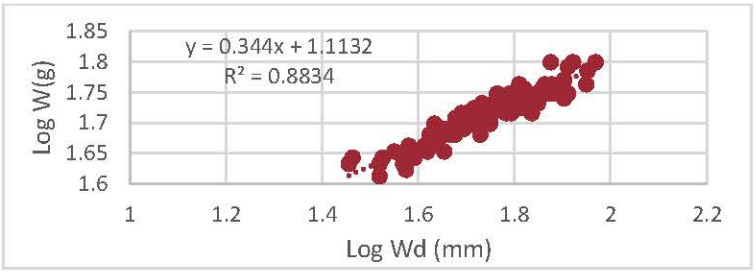

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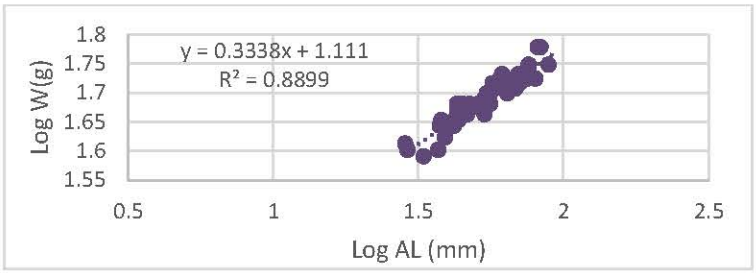


Figure 5. Linear-weight relationships (Log10) for the measured specimens, Sozopol, 1.10.2019

The parameters *a, b* of the linear-weight relationship: $TW(g) = a.SL(mm)^b$ and value of the correlation coefficient R^2 are presented in Table 16.

Table 16

Parameters *a, b* of L-W relationship: $TW(g) = a.SL(mm)^b$ and R^2

Equation parameters $TW(g) = a.SL(mm)^b$	
a	0.001049446
b	2.57759
R^2	0.87

3.1.1.6. Port Kavarna, 08.11.2019

The sample consists of 100 specimens rapa whelk (collected by beam trawl), with a total weight of 3.493 kg, from a landing of total 2100 kg rapa whelk at Port Kavarna.

The average weight of the measured specimens reaches 34.93 g ± 18.51 SD, at an average length - 62.08 mm ± 9.13 SD, shell width - 46.13 mm ± 7.90 SD and aperture length 44.67 ± 7.63 SD. The weight w/o shell (body weight) is 14.95 g ± 7.10 SD and forms 42.05 % ± 4.54 SD from the total weight, varying between 32.14 % and 50 % from the total weight (Table 17).

Table 17

The summarized statistics in regard to the measured biological parameters - total weight of the specimens in the sample (TW - shell weight, TW, g), body weight (BW, g), percentage ratio of BW (% TW), shell length (shell length, SL, mm), shell width (Wd, mm) and aperture length (aperture length, AL, mm), Port Kavarna, 08.11.2019

	TW, g	**BW, g**	**% BW from TW**	**SL, mm**	**Wd, mm**	**AL, mm**
Mean	34.93	14.95	42.05	62.08	46.13	44.67
Standard Error	1.85	1.00	0.64	0.91	0.79	0.76
Median	29.50	13.75	42.32	60.00	44.00	42.50
Mode	20.00	18.50	40.00	57.00	41.00	41.00
Standard Deviation	18.51	7.10	4.54	9.13	7.90	7.63
Sample Variance	342.51	50.41	20.58	83.31	62.40	58.22
Kurtosis	0.40	-0.24	-0.37	-0.36	-0.56	-0.54
Skewness	1.04	0.74	-0.11	0.48	0.47	0.50
Range	82.00	28.00	17.86	41.00	33.00	33.00
Minimum	10.50	5.00	32.14	43.00	32.00	30.00
Maximum	92.50	33.00	50.00	84.00	65.00	63.00
Sum	3492.50	747.60	2102.35	6208.00	4613.00	4467.00
Count	100.00	50.00	50.00	100.00	100.00	100.00
Confidence Level (95.0%)	3.67	2.02	1.29	1.81	1.57	1.51

The most common length class is - 56 - 66 SL, mm (38 % from the measured specimens), followed by the classes 46 - 56 mm (26 %) and 66-76 mm (26 %). In regard to the weight structure (TW, g), the predominant class is - 25.6 - 51.2 g - 44 %, followed by class < 25.6 -39 %.

The mean ratio - width (Wd, mm)/length (SL, mm) or 74.13 % ± 3.82 SD, AL/SL (%) - 71.78 % ± 3.47 SD, AL/Wd (%) - 96.87 % ± 2.04 SD (Table 18).

Table 18

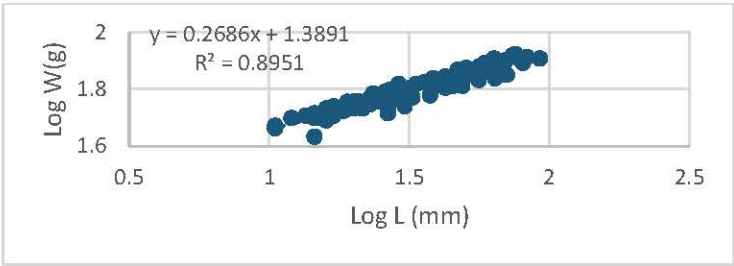
Percentage ratios between the shell width and length (Wd/SL, %), aperture length / total shell length (AL/SL, %) and aperture length/total shell width (AL/Wd, %) of the specimens from Kavarna, 08.11.2019

	Wd/SL (%)	AL/ SL (%)	AL/Wd (%)
Mean	74.13	71.78	96.87
Standard Error	0.38	0.35	0.20
Median	74.11	71.93	96.66
Mode	74.07	75.00	100.00
Standard Deviation	3.82	3.47	2.04
Sample Variance	14.58	12.07	4.14
Kurtosis	-0.53	-0.17	-0.55
Skewness	-0.17	-0.02	-0.05
Range	16.69	17.93	8.33
Minimum	64.71	63.46	91.67
Maximum	81.40	81.40	100.00
Sum	7412.83	7177.99	9686.88
Count	100.00	100.00	100.00
Confidence Level (95.0%)	0.76	0.69	0.40

Linear-weight ratios:

1) LogTW (g) = 0.2686*log SL (mm) +1.3891, (R^2=0.90, p<0.001, Fig. 6.1).
2) LogTW (g) = 0.3222*log Wd (mm) +1.1788, (R^2=0.95, p<0.001, Fig. 6.2)
3) Log TW (g) = 0.3194*log Al (mm) +1.169, (R^2=0.94, p<0.001, Fig. 6.3).

1.



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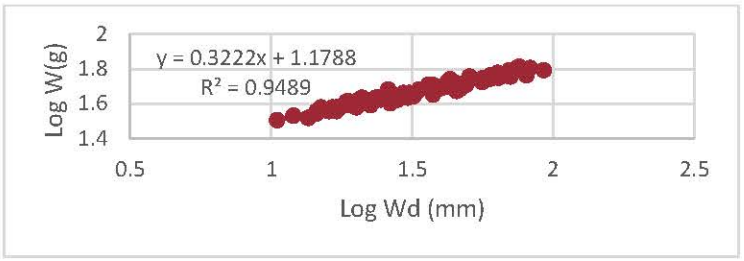

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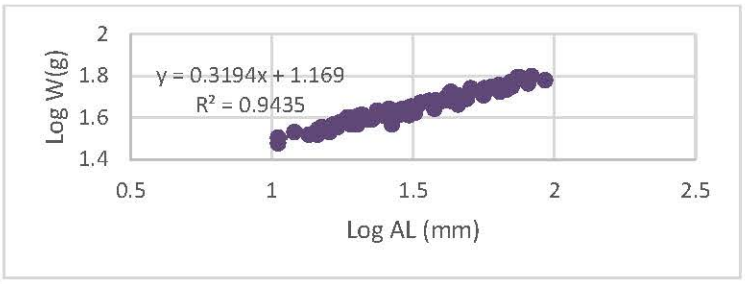


Figure 6. Linear-weight ratio (Log10) for the measured specimens, Kavarna, 08.11.2019

The parameters *a, b* of the linear-weight relationship: $TW(g) = a.SL(mm)^b$ and value of the correlation coefficient R^2 are presented in Table 19.

Table 19

Parameters *a, b* of L-W relationship: $TW(g) = a.SL(mm)^b$ and R^2

Equation parameters $TW(g) = a.SL(mm)^b$	
a	0.000033689
b	3.332
R^2	0.90

3.1.1.7. Port Kavarna, 12.11.2019

The sample consists of 100 specimens rapa whelk (collected by beam trawl), with a total weight of 3.697 kg, from a total landing of total 2507 kg rapa whelk at Port Kavarna.

The average weight of the measured specimens reaches 36.97 g ± 18.33 SD, at an average length - 62.21 mm ± 8.61 SD, shell width - 46.22 mm ± 7.67 SD and aperture length 44.85 mm ± 7.41 SD. The weight w/o shell (body weight) is 15.52 g ± 8.13 SD and forms 44.36 % ± 5.90 SD from the total weight, varying between 26.92 % and 57.50 % from the total weight (Table 20).

Table 20

The summarized statistics in regard to the measured biological parameters - total weight of the specimens in the sample (TW - shell weight, TW, g), body weight (BW, g), percentage ratio of BW (% TW), shell length (shell length, SL, mm), shell width (Wd, mm) and aperture length (aperture length, AL, mm), Port Kavarna, 12.11.2019

	TW, g	BW, g	% BW from TW	SL, mm	Wd, mm	AL, mm
Mean	36.97	15.52	44.36	62.21	46.22	44.85
Standard Error	1.83	1.15	0.83	0.86	0.77	0.74
Median	31.00	13.25	45.16	61.00	44.00	43.00
Mode	57.50	7.00	45.16	54.00	38.00	41.00
Standard Deviation	18.33	8.13	5.90	8.61	7.67	7.41
Sample Variance	335.93	66.15	34.76	74.21	58.76	54.84
Kurtosis	0.13	0.76	1.74	-0.50	-0.50	-0.72
Skewness	0.88	1.18	-0.81	0.37	0.57	0.46
Range	81.50	30.00	30.58	37.00	33.00	31.00
Minimum	12.00	7.00	26.92	46.00	34.00	31.00
Maximum	93.50	37.00	57.50	83.00	67.00	62.00
Sum	3696.50	776.00	2217.84	6221.00	4622.00	4485.00
Count	100.00	50.00	50.00	100.00	100.00	100.00
Confidence Level (95.0%)	3.64	2.31	1.68	1.71	1.52	1.47

The most common length class is - 56 - 66 SL, mm (39 % from the measured specimens), followed by length class 46 - 56 mm (26 %) and 66-76 mm (26 %). In regard to the weight structure (TW, g), the dominant weight class is - 25.6 - 51.2 g – 45 %, followed by weight class < 25.6 - 34 %.

The mean ratio - width (Wd, mm)/length (SL, mm) is 74.14 % ± 4.44 SD, while AL/SL (%) results in 71.93 % ± 4.10 SD, and the ratio AL/Wd (%) - 97.05 % ± 2.01 SD (Table 21).

Table 21

Percentage ratios between the shell width and length (Wd/SL, %), aperture length / total shell length (AL/SL, %) and aperture length/total shell width (AL/Wd, %) of the specimens from Kavarna, 12.11.2019

	Wd/SL (%)	AL/ SL (%)	AL/Wd (%)
Mean	74.14	71.93	97.05
Standard Error	0.44	0.41	0.20
Median	74.00	72.07	97.37
Mode	75.00	75.00	100.00
Standard Deviation	4.44	4.10	2.01
Sample Variance	19.75	16.81	4.05
Kurtosis	4.27	3.27	-0.03
Skewness	0.92	0.77	-0.33
Range	31.98	27.29	8.82

Minimum	63.33	63.33	91.18
Maximum	95.31	90.63	100.00
Sum	7414.40	7193.29	9705.40
Count	100.00	100.00	100.00
Confidence Level (95.0%)	0.88	0.81	0.40

Linear-weight ratios:

1) LogTW (g) = 0.2663*log SL (mm) +1.3859, (R^2=0.89, p<0.001, Fig 7.1).
2) LogTW (g) = 0.3219*log Wd (mm) +1.1708, (R^2=0.94, p<0.001, Fig 7.2)
3) Log TW (g) = 0.3239*log Al (mm) +1.1547, (R^2=0.94, p<0.001, Fig 7.3).

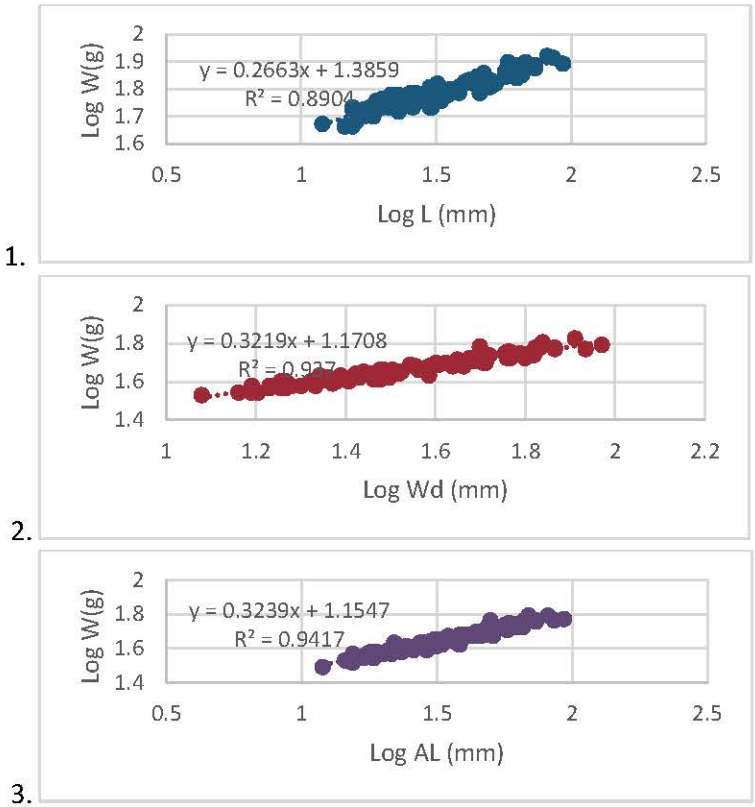


Figure 7. Linear-weight relationships (Log10) for the measured specimens, Kavarna, 12.11.2019

The parameters *a, b* of the linear-weight relationship: $TW(g) = a.SL(mm)^b$ and value of the correlation coefficient R^2 are presented in Table 22.

Table 22

Parameters *a, b* of L-W relationship: $TW(g) = a.SL(mm)^b$ and R^2

Equation parameters $TW(g) = a.SL(mm)^b$	
a	0.00003403
b	3.34
R^2	0.89

3.1.1.8. PORT KAVARNA, 16.11.2019

The sample consists of 100 specimens rapa whelk (beam trawl), with a total weight of 3.859 kg, from a total landing of total 6110 kg rapa whelk at Port Kavarna.

The average weight of the measured specimens reaches 38.59 g ± 21.87 SD, at an average length - 62.54 mm ± 9.14 SD, shell width - 46.42 mm ± 8.09 SD and aperture length 45.03 mm ± 7.90 SD. The weight w/o shell (body weight) is 16.92 g ± 7.67 SD is 43.20 % ± 6.29 SD from the total weight, varying between 31.10 % and 57.58 % from the total weight (Table 23).

Table 23

The summarized statistics in regard to the measured biological parameters - total weight of the specimens in the sample (TW - shell weight, TW, g), body weight (BW, g), percentage ratio of BW (% TW), shell length (shell length, SL, mm), shell width (Wd, mm) and aperture length (aperture length, AL, mm), Port Kavarna, 16.11.2019

	TW, g	**BW, g**	**% BW from TW**	**SL, mm**	**Wd, mm**	**AL, mm**
Mean	38.59	16.92	43.20	62.54	46.42	45.03
Standard Error	2.19	1.09	0.89	0.91	0.81	0.79
Median	31.00	14.25	43.59	62.00	45.00	44.00
Mode	44.50	13.00	50.00	58.00	53.00	40.00
Standard Deviation	21.87	7.67	6.29	9.14	8.09	7.90
Sample Variance	478.15	58.87	39.52	83.56	65.48	62.33
Kurtosis	2.43	-0.65	-0.68	-0.65	-0.62	-0.58
Skewness	1.50	0.59	-0.13	0.27	0.50	0.48
Range	107.00	30.50	26.48	43.00	35.00	35.00
Minimum	13.00	5.00	31.10	43.00	32.00	31.00
Maximum	120.00	35.50	57.58	86.00	67.00	66.00
Sum	3859.00	846.00	2159.78	6254.00	4642.00	4503.00
Count	100.00	50.00	50.00	100.00	100.00	100.00
Confidence Level (95.0%)	4.34	2.18	1.79	1.81	1.61	1.57

The most common length class is - 56 - 66 SL, mm (33 % from the measured specimens), followed by length class 66-76 mm (31 %) and 46 - 56 mm (26 %). In the weight structure (TW, g), the

predominant class is - 25.6 - 51.2 g – 41 %, followed by class < 25.6 - 36 %. The mean ratio - width (Wd, mm)/length (SL, mm) is 74.02 % ± 3.82 SD, AL/SL (%) - 71.78 % ± 3.70 SD, a AL/Wd (%) - 97.00 % ± 1.78 SD (Table 24).

Table 24

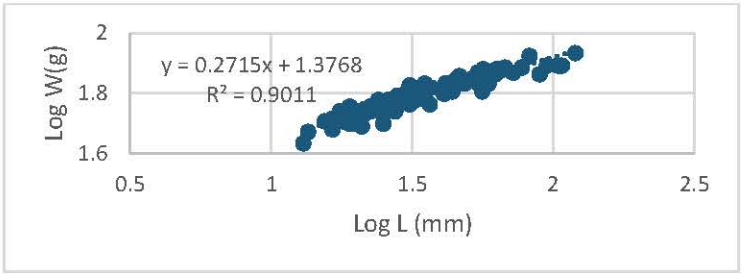
Percentage ratios between the shell width and length (Wd/SL, %), aperture length / total shell length (AL/SL, %) and aperture length/total shell width (AL/Wd, %) of the specimens from Kavarna, 16.11.2019

	Wd/SL (%)	AL/ SL (%)	AL/Wd (%)
Mean	74.02	71.78	97.00
Standard Error	0.38	0.37	0.18
Median	74.07	71.90	97.22
Mode	75.00	66.67	100.00
Standard Deviation	3.82	3.70	1.78
Sample Variance	14.58	13.66	3.17
Kurtosis	1.09	2.04	-0.77
Skewness	0.57	0.74	0.21
Range	22.90	22.33	6.98
Minimum	65.67	64.81	93.02
Maximum	88.57	87.14	100.00
Sum	7401.63	7178.44	9700.18
Count	100.00	100.00	100.00
Confidence Level (95.0%)	0.76	0.73	0.35

Linear-weight ratios:

1) LogTW (g) = 0.2715*log SL (mm) +1.3768, (R^2=0.90, p<0.001, Fig 8.1).
2) LogTW (g) = 0.3243*log Wd (mm) +1.1649, (R^2=0.94, p<0.001, Fig 8.2)
3) Log TW (g) = 0.3255*log Al (mm) +1.1497, (R^2=0.93, p<0.001, Fig 8.3).

1.



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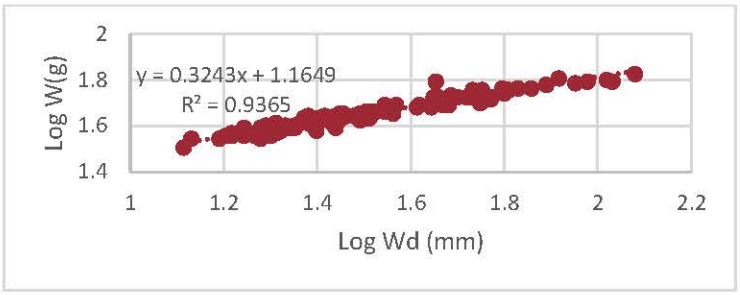

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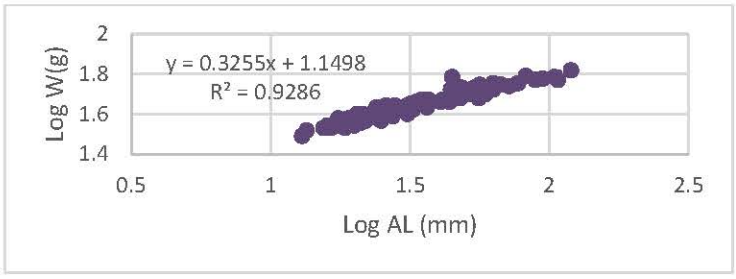


Figure 8. Linear-weight relationship (Log10) for the measured specimens, Kavarna, 16.11.2019

The parameters *a, b* of the linear-weight ratio: $TW(g) = a.SL(mm)^b$ and value of R^2, presented in Table 25.

Table 25

Parameters *a, b* of L-W relationship: $TW(g) = a.SL(mm)^b$ and R^2

Equation parameters $TW(g) = a.SL(mm)^b$	
a	0.00003817
b	3.32
R^2	0.90

3.1.1.9. SUMMARIZED DATA ABOUT THE 3RD AND 4TH QUARTERS OF 2019

The summarized data from the biological monitoring during the period July – November 2019 show that the total landings of rapa whelk by fisheries with beam trawls vary between 1792 - 8622 kg/day; the biggest landing was observed at Port Varna in September 2019. The smallest landings were found in Sozopol by rapana fisheries from scuba divers (Table 26). Fishing vessels with lengths of 14.9 m and power 220 kW, equipped with beam trawl are able to land 3810 kg/day, and fishing vessels form the length class 12.2 -16.5 m and power up to 130 kW land between 900 – 2100 kg/day.

Table 26

Summarized data about the landings by days and ports for the different fishing vessels in July – November 2019

Date	Landing port	Total landing rapa whelk *R.venosa* at port (kg/day)	Fishing vessel length (m)	Landed quantity (kg) from the fishing vessel	Weight (kg) of the sample (100 specimens)	Fishing technique
03.07.2019	Balchik	3413	16.5	1500	2.412	Beam trawl
24.09.2019	Varna	8622	14.9	3810	3.938	Beam trawl
25.09.2019	Kavarna	1791	12.2	1791	4.745	Beam trawl
29.09.2019	Sozopol	2828	11.2	35	5.972	Scuba diving
01.10.2019	Sozopol	45	6.95	45	5.622	Scuba diving
08.11.2019	Kavarna	2100	14.95	2100	3.493	Beam trawl
12.11.2019	Kavarna	2507	16.5	990	3.697	Beam trawl
16.11.2019	Kavrana	6110	14.95	2010	3.859	Beam trawl

During the whole studied period, the average length (SL, mm) of the rapa whelk specimens, collected by beam trawl, is 61.20 mm ± 8.44 SD (Fig. 9.1). The biggest average length is - 65.88 mm SL in the sample from 25.09.2019 (Port Kavarna), the smallest - 52.04 mm SL is observed in Balchik on 03.07.2019 (Port Balchik, Table 27.1). The average weight of the specimens, collected by beam trawl, is 36.90 g ± 17.46 SD for the studied period (Fig. 9.2), and the dynamics by ports is similar to the one of the average lengths (Table 27.2). The average body weight (BW, g) of specimens, collected by beam trawl is 15.09 g ± 6.86 SD (Table 27.3) or 40.91 % of the weight of all the specimens for the observed period. The average percentage share of body weight from the total weight (% BW from TW) by ports varies between 37.5 - 44.4 %, with tendency to increase in November.

The data for rapa whelk, collected by the scuba diving technique shows that the average length of the specimens is 68.55 mm ± 4.80 SD, average weight 57.97 g ± 11.43 SD and body weight - 19.24 g ± 4.39 SD.

The percentage difference between the average weights of the specimens, collected by the two techniques, is 44% in favour of the specimens, collected by scuba diving; the percentage difference for the average length is 11%, while for the body weight - 24.18 %.

Table 27

Statistical data about the distribution of the length (SL, mm, 1) and weight (TW, g, 2) in the samples for the 3rd and 4th quarters of 2019

1. Length (SL, mm)

Date	Port	Observations	Fishing method	Minimum SL, mm	Maximum SL, mm	Mean SL, mm	Std. deviation
03.07.2019	Balchik	100	Beam trawl	43.000	70.000	52.040	5.563

24.09.2019	Varna	100	Beam trawl	49.000	76.000	62.430	5.417
25.09.2019	Kavarna	100	Beam trawl	56.000	82.000	65.870	4.179
29.09.2019	Sozopol	100	Scuba diving	63.000	78.000	69.400	2.930
01.10.2019	Sozopol	100	Scuba diving	53.000	86.000	67.700	6.028
08.11.2019	Kavarna	100	Beam trawl	43.000	84.000	62.080	9.127
12.11.2019	Kavarna	100	Beam trawl	46.000	83.000	62.210	8.614
16.11.2019	Kavarna	100	Beam trawl	43.000	86.000	62.540	9.141

2. Total weight (TW, g)

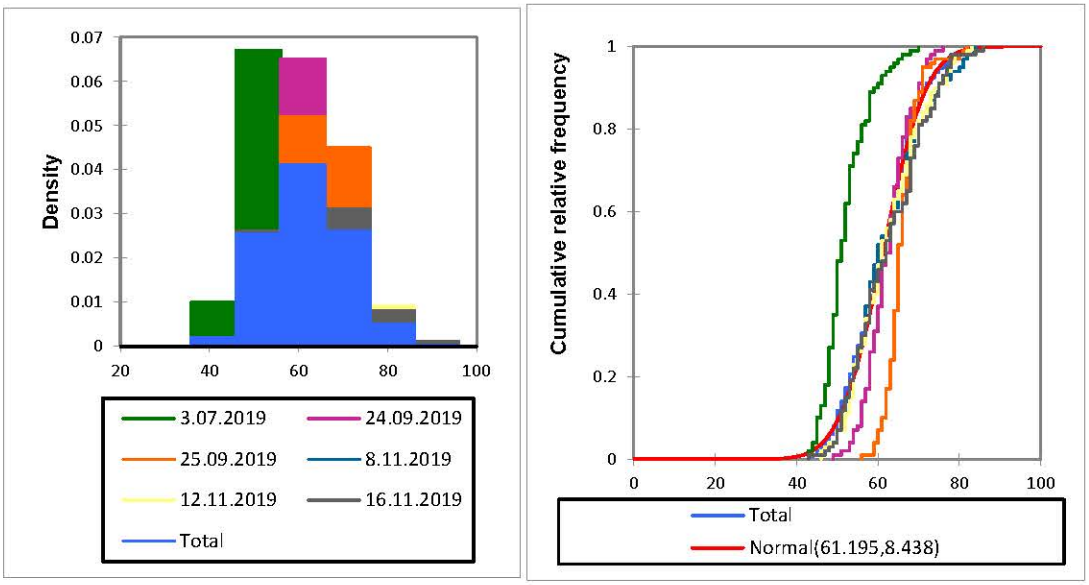
Variable	Port	Observations	Fishing method	Minimum	Maximum	Mean	Std. deviation
03.07.2019	Balchik	100	Beam trawl	10.500	73.000	24.120	10.216
24.092019	Varna	100	Beam trawl	13.000	69.500	39.380	10.059
25.09.2019	Kavarna	100	Beam trawl	31.000	133.500	47.445	13.834
29.09.2019	Sozopol	100	Scuba diving	44.500	77.500	59.715	6.472
01.10.2019	Sozopol	100	Scuba diving	28.500	93.000	56.220	14.649
08.11.2019	Kavarna	100	Beam trawl	10.500	92.500	34.925	18.507
12.11.2019	Kavrana	100	Beam trawl	12.000	93.500	36.965	18.328
16.11.2019	Kavrana	100	Beam trawl	13.000	120.000	38.590	21.867

3. Body weight (BW, g)

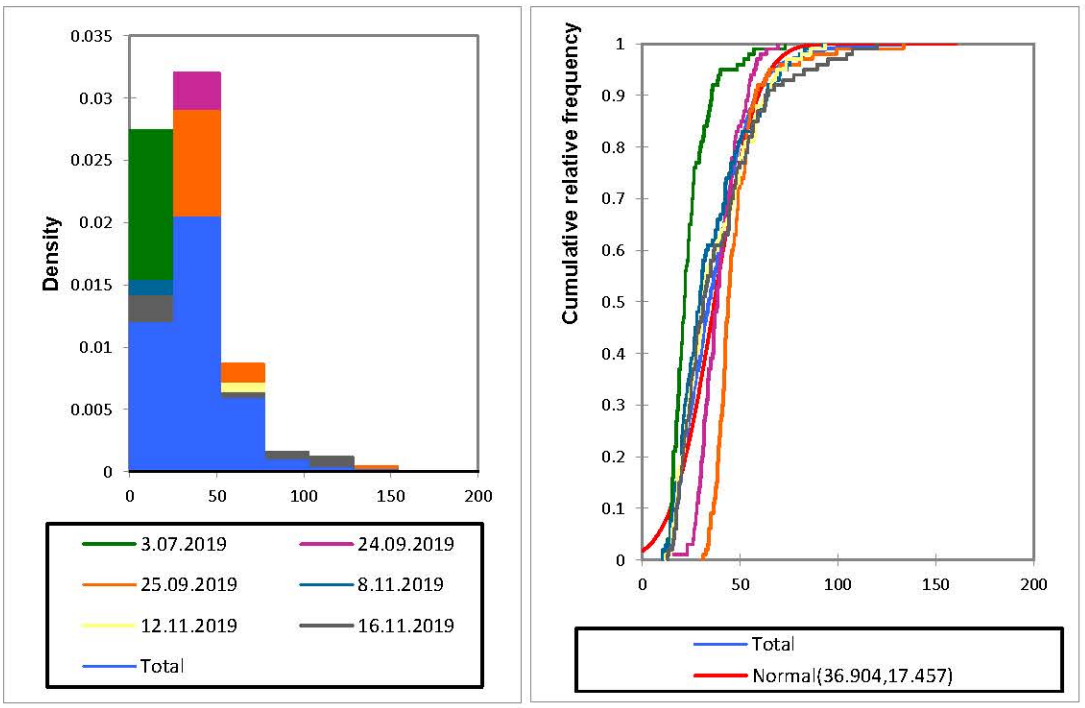
Variable	Port	Observations	Fishing method	Minimum	Maximum	Mean	Std. deviation
03.07.2019	Balchik	50	Beam trawl	4.500	29.000	9.650	4.805
24.092019	Varna	50	Beam trawl	4.000	30.500	14.900	5.013
25.09.2019	Kavarna	50	Beam trawl	12.500	38.000	18.600	4.081
29.09.2019	Sozopol	50	Scuba diving	12.000	30.500	19.700	3.648
01.10.2019	Sozopol	50	Scuba diving	10.000	31.000	18.780	5.027
08.11.2019	Kavarna	50	Beam trawl	5.000	33.000	14.952	7.100
12.11.2019	Kavrana	50	Beam trawl	7.000	37.000	15.520	8.133
16.11.2019	Kavarna	50	Beam trawl	5.000	35.500	16.920	7.673

The most common length class for the samples, collected by the beam trawl technique is - 56 - 66 SL mm (41.2 % from the measured specimens), as well as length classes - 66 - 76 mm (26.2 %) and

46 - 56 mm (25.5 %, Fig. 9.1, Table 28.1). The predominant class for the scuba diving technique is 66 - 76 mm (on average 74 % of the measured specimens during the research period).



1.



2.

Figure 9. Distribution of the shell length (SL, mm, 1) and weight (TW, g, 2) by classes and cumulative distribution by classes for the samples, collected by beam trawls.

In the weight structure (TW, g) of the catches with beam trawl, the following length classes predominate: 26 - 51.2 g (52 % from the measured specimens) and < 26 g (30.3 %) (Fig. 9.2, Table 28.2). The predominant weight class, for the samples collected by scuba diving is 51.2 - 76.8 g (70 % from the measured specimens for the respective period).

Table 28

Statistical data about the distribution of the length (mm, 1) and weight (g, 2) classes; summarized data about the third and fourth quarter 2019.

1

Lower bound	Upper bound	Frequency	Relative frequency	Density
26	36	0	0.000	0.000
36	46	12	0.020	0.002
46	56	153	0.255	0.026
56	66	247	0.412	0.041
66	76	157	0.262	0.026
76	86	30	0.050	0.005
86	96	1	0.002	0.000

2

Lower bound	Upper bound	Frequency	Relative frequency	Density
	<26	182	0.303	0.012
26	51.2	312	0.520	0.020
51.2	76.8	89	0.148	0.006
76.8	102.4	13	0.022	0.001
102.4	128	3	0.005	0.000
128	154	1	0.002	0.000

The data about the percentage distribution by rapana length classes are presented on Fig. 10. At the beginning of the observation period (03.07.2019), Port Balchik, many small specimens < 36-45 mm (10 %) were observed, by relatively high share of the length class 46 - 56 mm (65 %). As for the other observations, the shares of the mid-length classes have increased - 56-66 mm (33 - 65 %) and 66-76 mm (45 -26 %, Fig. 10).

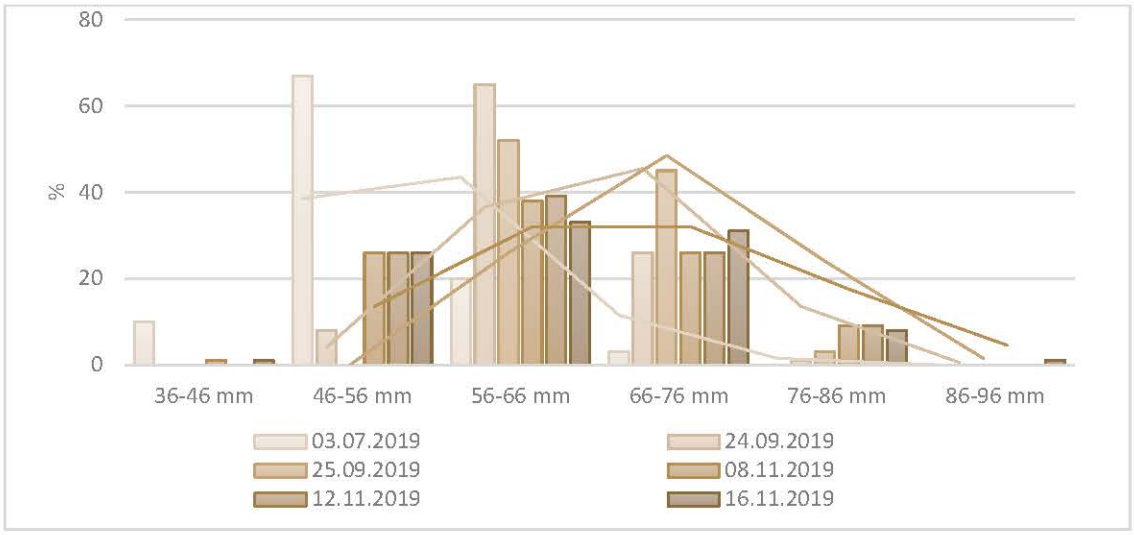


Figure 10. Percentage distribution of the length classes (SL, mm) and moving averaged values for the 3rd and 4th quarters of 2019 (*beam trawl*).

The percentage distribution of the rapa whelk weight classes (collected by beam trawl), for the observed ports are presented on Fig. 11. Specimens with weights < 26 g were observed in almost all landings and reached a maximum of 70 % in the sample from port Balchik, 03.07.2019.

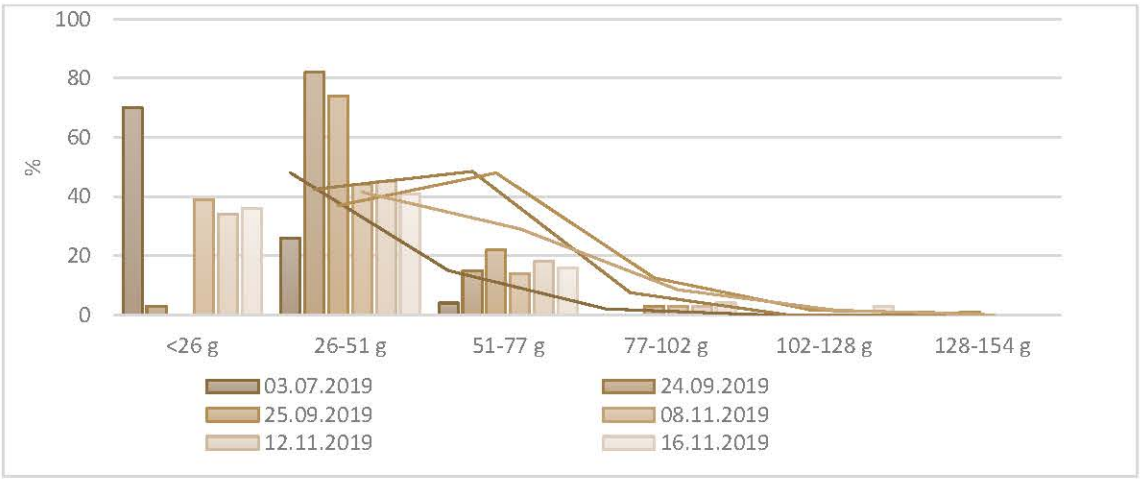


Figure 11. Percentage distribution of the weight classes (TW, g) and moving averaged values for the 3rd and 4th quarters of 2019 (*beam trawl*).

The comparison analysis of the parameters *a* and *b* of the L - W relationship: $W(g) = a.SL(mm)^b$ show allometric growth of *R. venosa* in all samples at a coefficient b ≠ 3 (Fig 12). The parameter b > 3 is an indicator for a positive allometric growth - the big specimens have faster weight

growth than length growth. The coefficient *b* shows relatively high value = 2.8 in the sample from Varna, 24.09.2019, while the maximal value of the parameter *b* = 3.3 was found in the sample from November 2019 (Fig 12).

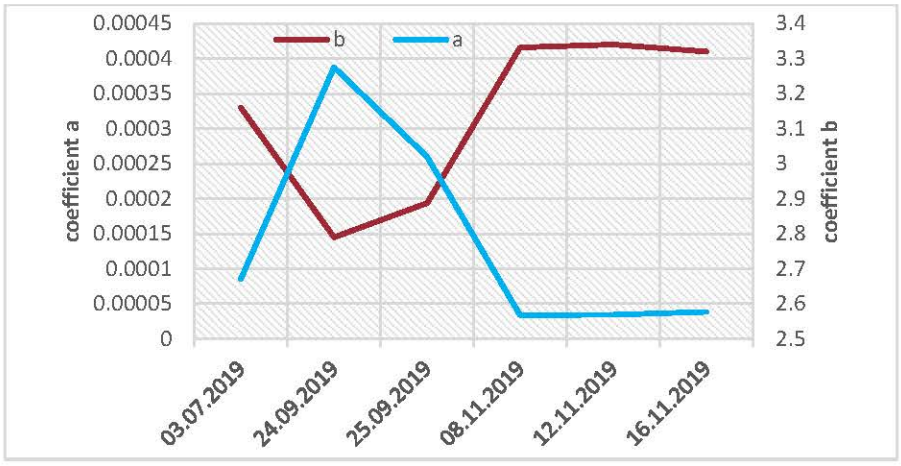


Figure 12. Parameters *a, b* of the linear-weight ratios, given in the equation: $TW(g) = a.SL(mm)^b$, derived for the samples from the different ports for the 3rd and 4th quarter 2019

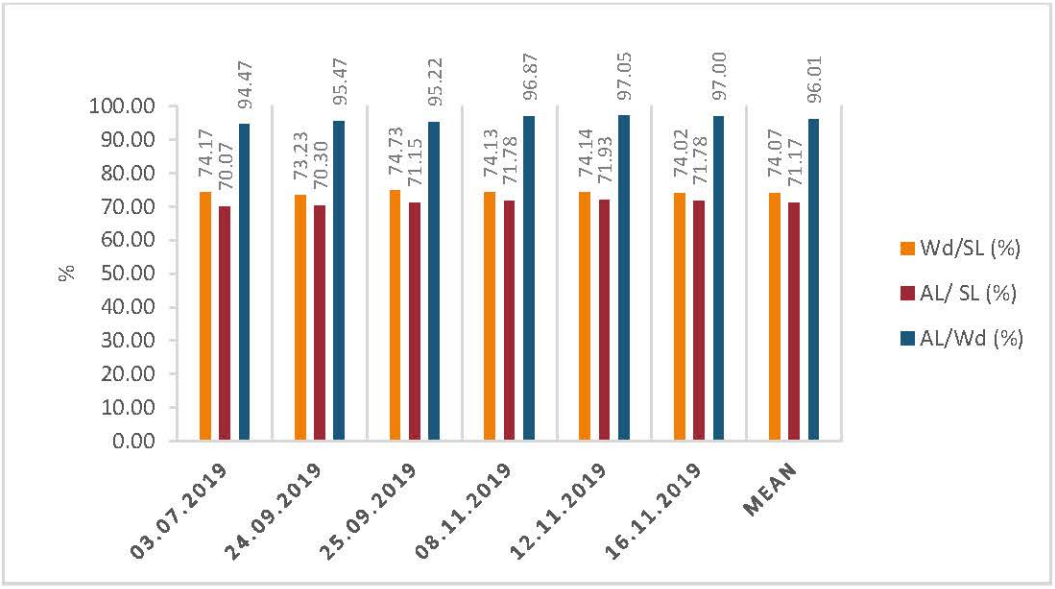


Figure 13. Percentage ratios between the shell width and length (Wd/SL, %) of *R. venosa*, aperture length/total shell length (AL/SL, %) and aperture length/total shell width (AL/Wd, %) by ports, 3rd and 4th quarters 2019.

The mean ratio of the Wd/SL is 74.07 % for the 3rd and 4th quarters of 2019 with slight variations among the samples, approximately 73.23 % - 74.73 % (Fig 13). Similarly, the ratio AL/SL is 71.17 %, varying between 70.07 % and 71.93 %. The average percentage ratio of the AL/Wd (%) is 96.01 %, varying in limits 94.47 % - 97.05 % for the samples from all ports (Fig. 13).

3.1.2. Sex structure

3.1.2.1. Balchik Port, 03.07.2019

The ratio between the sexes in the representative sample is 52 % ♂ : 48 % ♀ or 1.08 : 1. For the female specimens, the average shell length (SL, mm) is 51.46 mm ± 6.63 SD, and the average length is higher for male specimens - 2.4 % percentage difference between sexes. Concerning the average weight, the difference is about 5 %, with the females in favour (Table 29).

Table 29

Summarized statistics of the biological parameters - total weight of the specimens in the sample. shell length (SL, mm) and total weight (TW, g) by sex in the sample from Port Balchik, 3.07.2019

	SL, mm		TW, g	
	Females	Males	Females	Males
Mean	51.46	52.73	25.65	24.40
Standard Error	1.35	1.15	2.78	2.01
Median	50.00	51.50	20.25	21.75
Mode	50.00	53.00	19.00	24.00
Standard Deviation	6.63	5.87	13.62	10.25
Sample Variance	44.00	34.44	185.53	104.98
Kurtosis	1.67	0.36	6.12	1.40
Skewness	1.35	0.96	2.33	1.36
Range	26.00	23.00	60.50	37.50
Minimum	44.00	45.00	12.50	14.50
Maximum	70.00	68.00	73.00	52.00
Sum	1235.00	1371.00	615.50	634.50
Count	24.00	26.00	24.00	26.00
Confidence Level (95.0%)	51.46	52.73	25.65	24.40

Concerning the parameters - shell width (Wd, mm) and aperture length (aperture length, AL, mm), the percentage differences between the male and female specimens is 2 % и 2.2 %, in favour of the male specimens (Table 30).

Table 30

Summarized statistics of the biological parameters - shell width (Wd, mm) and aperture length (aperture length, AL, mm) by sex in the sample from Port Balchik, 3.07.2019

	Wd, mm		AL, mm	
	Females	Males	Females	Males
Mean	38.46	39.19	36.33	37.15
Standard Error	1.14	0.93	1.11	0.89
Median	37.00	38.50	35.00	36.00
Mode	37.00	41.00	35.00	33.00
Standard Deviation	5.58	4.77	5.43	4.52
Sample Variance	31.13	22.72	29.45	20.46
Kurtosis	1.74	0.22	1.67	-0.16
Skewness	1.32	0.91	1.35	0.78
Range	22.00	17.00	21.00	16.00
Minimum	31.00	33.00	29.00	31.00
Maximum	53.00	50.00	50.00	47.00
Sum	923.00	1019.00	872.00	966.00
Count	24.00	26.00	24.00	26.00
Confidence Level (95.0%)	38.46	39.19	36.33	37.15

3.1.2.2. Port Varna, 24.09.2019

The ratio between the sexes in the representative sample is 56 % ♂: 44 % ♀ or 1.3: 1. For the female specimens, the average shell length (SL, mm) is 60.00 mm ± 6.32 SD, while the average length of the male specimens is bigger by 6.7 % (Table 31). As for the male specimens, the average weight is 43.29 g ± 10.04 SD, while for the females it is lower by 23.17 % (Table 31).

Table 31

Summarized statistics of the biological parameters - total weight of the specimens in the sample. shell length (SL, mm) and total weight (TW, g) by sex in the sample from Port Varna, 24.09.2019

	SL, mm		TW, g	
	Females	Males	Females	Males
Mean	60.00	64.14	34.30	43.29
Standard Error	1.35	0.93	2.24	1.90
Median	60.00	63.50	32.50	41.75
Mode	61.00	63.00	31.50	38.50
Standard Deviation	6.32	4.91	10.52	10.04
Sample Variance	40.00	24.13	110.66	100.84
Kurtosis	-0.17	-0.28	-0.05	-0.03
Skewness	0.44	0.33	0.36	0.68
Range	24.00	20.00	42.00	39.50
Minimum	49.00	56.00	13.00	30.00
Maximum	73.00	76.00	55.00	69.50

Sum	1320.00	1796.00	754.50	1212.00
Count	22.00	28.00	22.00	28.00
Confidence Level (95.0%)	2.80	1.90	4.66	3.89

For the parameters shell width (Wd, mm) and aperture length (aperture length, AL, mm), the percentage differences between the male and female specimens are 9.2 % и 9 %, in favour of the male specimens (Table 32).

Table 32

Summarized statistics of the biological parameters - shell width (Wd, mm) and aperture length (aperture length, AL, mm) by sex in the sample from Port Varna, 24.092019

	Wd, mm		**AL, mm**	
	Females	**Males**	**Females**	**Males**
Mean	43.55	47.75	41.64	45.57
Standard Error	1.03	0.72	0.98	0.82
Median	42.50	48.00	41.00	45.00
Mode	42.00	51.00	43.00	50.00
Standard Deviation	4.85	3.83	4.61	4.32
Sample Variance	23.50	14.64	21.29	18.70
Kurtosis	-0.28	0.29	-0.07	-0.50
Skewness	0.38	0.54	0.25	0.35
Range	19.00	16.00	19.00	17.00
Minimum	34.00	42.00	32.00	39.00
Maximum	53.00	58.00	51.00	56.00
Sum	958.00	1337.00	916.00	1276.00
Count	22.00	28.00	22.00	28.00
Confidence Level (95.0%)	2.15	1.48	2.05	1.68

3.1.2.3. Port Kavarna, 25.09.2019

In the representative sample, the ratio between the two sexes is 44 % ♂: 56 % ♀ - 0.79 :1. The average length of the female specimens is 65.00 mm ± 2.94 SD, while the male specimens are bigger by 3.8 % (Table 33). The average weight of the male specimens is 50.14 g ± 12.94 SD, while the average weight for the females is lower by 10.5 % (Table 33).

Table 33

Summarized statistics of the biological parameters - total weight of the specimens in the sample, shell length (SL, mm) and total weight (TW, g) by sex in the sample from Port Kavarna, 25.09.2019

	SL, mm		TW, g	
	Females	Males	Females	Males
Mean	65.00	67.50	45.16	50.14
Standard Error	0.56	0.93	1.47	2.76
Median	65.00	68.00	43.25	45.50
Mode	65.00	68.00	42.50	45.50
Standard Deviation	2.94	4.36	7.77	12.94
Sample Variance	8.67	19.02	60.43	167.48
Kurtosis	2.33	2.60	0.77	2.96
Skewness	0.85	0.64	0.99	1.64
Range	15.00	21.00	31.00	53.00
Minimum	59.00	59.00	34.00	34.00
Maximum	74.00	80.00	65.00	87.00
Sum	1820.00	1485.00	1264.50	1103.00
Confidence Level (95.0%)	28.00	22.00	28.00	22.00

For the parameters - shell width (Wd, mm) and aperture length (aperture length, AL, mm), the percentage differences between the male and female specimens are 3.95 % и 4.24 %, in favour of the male specimens (Table 34).

Table 34

Summarized statistics of the biological parameters - shell width (Wd, mm) and aperture length (aperture length, AL, mm) by sex in the sample from Port Kavarna, 25.09.2019

	Wd, mm		AL, mm	
	Females	Males	Females	Males
Mean	48.54	50.50	46.14	48.14
Standard Error	0.48	0.91	0.48	0.81
Median	48.50	49.00	46.00	47.00
Mode	49.00	48.00	45.00	47.00
Standard Deviation	2.56	4.25	2.55	3.78
Sample Variance	6.55	18.07	6.50	14.31
Kurtosis	0.17	5.81	2.30	3.72
Skewness	0.35	2.11	1.13	1.75
Range	10.00	20.00	12.00	16.00
Minimum	44.00	45.00	42.00	44.00
Maximum	54.00	65.00	54.00	60.00
Sum	1359.00	1111.00	1292.00	1059.00
Count	28.00	22.00	28.00	22.00
Confidence Level (95.0%)	0.99	1.88	0.99	1.68

3.1.2.4. Port Sozopol, 29.09.2019

Using the scuba diving technique, the ratio between the sexes in the representative sample is 52 % ♂ : 48 % ♀, 1.08 : 1. The average shell length (SL, mm) for the female specimens is 68.71 mm ± 6.79 SD, while the average length of the male specimens is 1.7 % bigger (Table 35). The mean weight of males is 61.50 g ± 5.95 SD, while the females the average weight is with 2.2 % lower (Table 35).

Table 35

Summarized statistics of the biological parameters - total weight of the specimens in the sample. shell length (SL, mm) and total weight (TW, g) by sex in the sample from Port Sozopol, 29.09.2019

	SL, mm		TW, g	
	Females	Males	Females	Males
Mean	68.71	69.88	60.19	61.50
Standard Error	0.62	0.52	1.41	1.17
Median	68.00	69.50	60.00	60.50
Mode	68.00	71.00	58.50	57.50
Standard Deviation	3.03	2.66	6.93	5.95
Sample Variance	9.17	7.07	48.02	35.38
Kurtosis	2.86	-0.24	0.27	0.90
Skewness	0.90	0.49	0.60	0.77
Range	15.00	10.00	28.00	25.50
Minimum	63.00	66.00	49.00	52.00
Maximum	78.00	76.00	77.00	77.50
Sum	1649.00	1817.00	1444.50	1599.00
Confidence Level (95.0%)	24.00	26.00	24.00	26.00

For the parameters - shell width (Wd, mm) and aperture length (aperture length, AL, mm), the percentage differences between the male and female specimens are 2.2 % и 3.2 %, in favour of the male specimens (Table 36).

Table 36

Summarized statistics of the biological parameters - shell width (Wd, mm) and aperture length (aperture length, AL, mm) by sex in the sample from Port Sozopol, 29.09.2019

	Wd, mm		AL, mm	
	Females	Males	Females	Males
Mean	52.29	53.46	49.08	50.65
Standard Error	0.46	0.38	0.48	0.37
Median	53.00	53.50	49.00	50.00
Mode	54.00	54.00	49.00	50.00

Standard Deviation	2.26	1.92	2.38	1.90
Sample Variance	5.09	3.70	5.64	3.60
Kurtosis	-0.61	-0.13	-0.70	0.07
Skewness	-0.30	0.56	-0.53	0.39
Range	8.00	7.00	8.00	8.00
Minimum	48.00	51.00	44.00	47.00
Maximum	56.00	58.00	52.00	55.00
Sum	1255.00	1390.00	1178.00	1317.00
Count	24.00	26.00	24.00	26.00
Confidence Level (95.0%)	0.95	0.78	1.00	0.77

3.1.2.5. Port Sozopol, 01.10.2019

By scuba diving fishing, the ratio between the sexes in the representative sample is 78 % ♂: 22 % ♀ or 3.55: 1; this ratio is a result form the selective technique used in this type of fishing by choosing large specimens (males). The average shell length (SL, mm) for the female specimens is 63 mm ± 6.10 SD, while the male specimens have an average size, bigger by 8.42 % (Table 37). The average weight of the male specimens is 59 g ± 14.79 SD, resulting in a percentage difference of 27.3 % in the weights between the two sexes (Table 37).

Table 37

Summarized statistics of the biological parameters - total weight of the specimens in the sample. shell length (SL, mm) and total weight (TW, g) by sex in the sample from Port Sozopol, 01.10.2019

	SL, mm		TW, g	
	Females	**Males**	**Females**	**Males**
Mean	63.00	68.54	44.82	59.00
Standard Error	1.84	0.89	3.26	2.37
Median	65.00	69.00	42.00	56.00
Mode	65.00	69.00	#N/A	70.50
Standard Deviation	6.10	5.57	10.81	14.79
Sample Variance	37.20	30.99	116.76	218.75
Kurtosis	-0.81	-0.30	-1.32	-0.90
Skewness	-0.24	0.07	0.18	0.12
Range	20.00	23.00	32.50	60.50
Minimum	53.00	58.00	29.00	28.50
Maximum	73.00	81.00	61.50	89.00
Sum	693.00	2673.00	493.00	2301.00
Confidence Level (95.0%)	11.00	39.00	11.00	39.00

For the parameters shell width (Wd, mm) and aperture length (aperture length, AL, mm) the percentage differences between the male and female specimens are 8.9 % и 9.7 %, in favour of the male specimens (Table. 38).

Table 38

Summarized statistics of the biological parameters - shell width (Wd, mm) and aperture length (aperture length, AL, mm) by sex in the sample from Port Sozopol, 01.10.2019

	Wd, mm		AL, mm	
	Females	Males	Females	Males
Mean	47.64	52.10	45.45	50.10
Standard Error	1.38	0.73	1.47	0.69
Median	48.00	52.00	45.00	50.00
Mode	48.00	52.00	45.00	48.00
Standard Deviation	4.59	4.58	4.89	4.31
Sample Variance	21.05	20.99	23.87	18.57
Kurtosis	-0.59	-0.10	-0.91	-0.05
Skewness	0.38	0.26	0.24	0.28
Range	15.00	20.00	15.00	19.00
Minimum	41.00	43.00	39.00	41.00
Maximum	56.00	63.00	54.00	60.00
Sum	524.00	2032.00	500.00	1954.00
Count	11.00	39.00	11.00	39.00
Confidence Level (95.0%)	3.08	1.49	3.28	1.40

3.1.2.6. Port Kavarna, 08.11.2019

The ratio between the sexes in the representative sample is 54 % ♂: 46 % ♀ or 1.17: 1. The average shell length of the female specimens is 56.91 mm ± 4.91 SD, for the male individuals - about 17 % bigger (Table 39). The average weight of the male specimens is 45.96 g ± 18.14 SD, which results in a percentage different from the female individuals of 61 % (Table 39).

Table 39

Summarized statistics of the biological parameters - total weight of the specimens in the sample. shell length (SL, mm) and total weight (TW, g) by sex in the sample from Port Kavarna, 08.11.2019

	SL, mm		TW, g	
	Females	Males	Females	Males
Mean	56.91	67.48	24.39	45.96
Standard Error	1.02	1.37	1.96	3.49

Median	57.00	68.00	21.00	42.50
Mode	57.00	65.00	16.00	47.00
Standard Deviation	4.91	7.09	9.42	18.14
Sample Variance	24.08	50.34	88.79	329.06
Kurtosis	-0.18	-0.47	1.35	0.42
Skewness	0.62	-0.12	1.38	0.68
Range	18.00	27.00	34.50	72.50
Minimum	49.00	54.00	14.50	20.00
Maximum	67.00	81.00	49.00	92.50
Sum	1309.00	1822.00	561.00	1241.00
Confidence Level (95.0%)	23.00	27.00	23.00	27.00

For the parameters shell width (Wd, mm) and aperture length (aperture length, AL, mm), the percentage differences between the male and female specimens is 21.1 % and 20.9 %, in favour of the male specimens (Table 40).

Table 40

Summarized statistics of the biological parameters - shell width (Wd, mm) and aperture length (aperture length, AL, mm) by sex in the sample from Port Kavarna, 08.11.2019

	Wd, mm		**AL, mm**	
	Females	**Males**	**Females**	**Males**
Mean	41.17	50.89	40.04	49.37
Standard Error	0.90	1.12	0.89	1.12
Median	41.00	51.00	40.00	50.00
Mode	41.00	42.00	41.00	48.00
Standard Deviation	4.33	5.82	4.28	5.83
Sample Variance	18.79	33.87	18.32	34.01
Kurtosis	0.49	-0.66	1.17	-0.72
Skewness	0.76	-0.30	0.87	-0.22
Range	16.00	22.00	18.00	21.00
Minimum	35.00	40.00	33.00	39.00
Maximum	51.00	62.00	51.00	60.00
Sum	947.00	1374.00	921.00	1333.00
Count	23.00	27.00	23.00	27.00
Confidence Level (95.0%)	1.87	2.30	1.85	2.31

3.1.2.7. PORT KAVARNA, 12.11.2019

The ratio between the sexes in the representative sample is 54 % ♂: 46 % ♀ or 1.17: 1. The average shell length (SL, mm) for the female specimens is 59.52 mm ± 5.75 SD, while the male

specimens have 7 % bigger (Table 41). The average weight of the male specimens is 40.28 g ± 23.69 SD, and the percentage difference compared to the female specimens is 28.5 % (Table 41).

Table 41

Summarized statistics of the biological parameters - total weight of the specimens in the sample, shell length (SL, mm) and total weight (TW, g) by sex in the sample from Port Kavarna, 12.11.2019

	SL, mm		TW, g	
	Females	Males	Females	Males
Mean	59.52	64.04	30.22	40.28
Standard Error	1.20	2.02	2.36	4.56
Median	60.00	61.00	29.00	33.00
Mode	64.00	60.00	18.50	15.50
Standard Deviation	5.75	10.49	11.33	23.69
Sample Variance	33.08	110.11	128.43	561.16
Kurtosis	-0.72	-1.02	0.42	-0.46
Skewness	0.09	0.25	1.06	0.77
Range	20.00	37.00	40.50	78.00
Minimum	50.00	46.00	17.00	15.50
Maximum	70.00	83.00	57.50	93.50
Sum	1369.00	1729.00	695.00	1087.50
Confidence Level (95.0%)	23.00	27.00	23.00	27.00

For the parameters shell width (Wd, mm) and aperture length (aperture length, AL, mm), the percentage differences between the male and female specimens is 7.1 % и 6.8 %, in favour of the male specimens (Table 42).

Table 42

Summarized statistics of the biological parameters - shell width (Wd, mm) and aperture length (aperture length, AL, mm) by sex in the sample from Port Kavarna, 12.11.2019

	Wd, mm		AL, mm	
	Females	Males	Females	Males
Mean	43.83	47.04	42.39	45.37
Standard Error	1.23	1.77	1.15	1.69
Median	43.00	44.00	42.00	42.00
Mode	38.00	38.00	36.00	41.00
Standard Deviation	5.88	9.17	5.51	8.78
Sample Variance	34.60	84.11	30.34	77.09
Kurtosis	1.87	-0.97	1.51	-1.30
Skewness	1.21	0.45	1.09	0.34
Range	24.00	32.00	23.00	29.00

Minimum	37.00	35.00	35.00	33.00
Maximum	61.00	67.00	58.00	62.00
Sum	1008.00	1270.00	975.00	1225.00
Count	23.00	27.00	23.00	27.00
Confidence Level (95.0%)	2.54	3.63	2.38	3.47

3.1.2.8. Port Kavarna, 16.11.2019

The ratio between the sexes in the representative sample is 60 % ♂: 48 % ♀ or 1.5: 1. The average shell length (SL, mm) for the female specimens is 62.90 mm ± 9.45 SD, while the male specimens are with 1.1 % bigger (Table 43). The average weight of the male specimens is 42.15 g ± 24.96 SD, and the average weight of females is 37.20 g (Table 43).

Table 43

Summarized statistics of the biological parameters - total weight of the specimens in the sample. shell length (SL, mm) and total weight (TW, g) by sex in the sample from Port Kavarna, 16.11.2019

	SL, mm		TW, g	
	Females	**Males**	**Females**	**Males**
Mean	62.90	63.57	37.48	42.15
Standard Error	2.11	1.57	3.95	4.56
Median	61.00	63.50	32.50	33.75
Mode	77.00	58.00	25.00	22.50
Standard Deviation	9.45	8.59	18.11	24.96
Sample Variance	89.25	73.84	328.14	622.85
Kurtosis	-1.14	-0.92	-0.45	1.52
Skewness	0.09	0.09	0.70	1.45
Range	30.00	30.00	64.00	91.00
Minimum	47.00	48.00	13.50	16.50
Maximum	77.00	78.00	77.50	107.50
Sum	1258.00	1907.00	787.00	1264.50
Confidence Level (95.0%)	20.00	30.00	21.00	30.00

For the parameters shell width (Wd, mm) and aperture length (aperture length, AL, mm), the percentage differences between the male and female specimens is 0.11 % and 0.04 % (Table 44).

Table 44

Summarized statistics of the biological parameters - shell width (Wd, mm) and aperture length (aperture length, AL, mm) by sex in the sample from Port Kavarna, 16.11.2019

	Wd, mm		AL, mm	
	Females	Males	Females	Males
Mean	47.15	47.20	45.55	45.53
Standard Error	1.80	1.46	1.79	1.41
Median	45.00	45.50	43.50	44.50
Mode	55.00	53.00	40.00	51.00
Standard Deviation	8.07	8.01	8.02	7.74
Sample Variance	65.08	64.23	64.26	59.84
Kurtosis	-1.10	-0.69	-1.06	-0.68
Skewness	0.41	0.44	0.39	0.41
Range	27.00	27.00	28.00	27.00
Minimum	35.00	36.00	33.00	34.00
Maximum	62.00	63.00	61.00	61.00
Sum	943.00	1416.00	911.00	1366.00
Count	20.00	30.00	20.00	30.00
Confidence Level (95.0%)	3.78	2.99	3.75	2.89

3.1.2.5. GONADOSOMATIC INDEX (GSI)

The summarized data about the GSI for the 3rd and 4th quarter of 2019 are presented in Table 45.

Table 45

Summarized statistics of the GSI (% BW) by ports for the 3rd and 4th quarters 2019

	3.07. 2019	24.09. 2019	25.09. 2019	29.09. 2019	1.10. 2019	08.11. 2019	12.11. 2019	16.11. 2019
Mean	15.90	12.22	17.53	16.53	14.37	16.45	15.58	17.20
Standard Error	0.59	0.53	0.34	0.42	0.36	0.55	0.64	0.55
Median	15.38	11.55	17.57	16.53	14.50	16.17	14.56	17.39
Mode	14.29	14.81	17.65	15.91	14.89	16.67	14.29	17.39
Standard Deviation	4.15	3.72	2.40	2.97	2.54	3.90	4.53	3.92
Sample Variance	17.26	13.82	5.76	8.85	6.45	15.18	20.53	15.40
Kurtosis	-0.28	1.50	0.12	5.97	-0.18	0.84	6.40	2.77
Skewness	0.20	0.85	0.24	1.52	0.28	-0.45	1.63	0.78
Range	18.75	19.29	10.63	18.30	11.16	18.40	29.04	23.22
Minimum	6.25	5.71	12.90	11.11	9.68	5.41	6.25	7.55
Maximum	25.00	25.00	23.53	29.41	20.83	23.81	35.29	30.77
Sum	779.05	611.09	876.72	826.44	718.71	822.59	778.82	859.92
Count	49.00	50.00	50.00	50.00	50.00	50.00	50.00	50.00

Confidence Level (95.0%)	15.90	12.22	17.53	16.53	14.37	16.45	15.58	17.20

The average value of the GSI is 15.17 % BW for the whole studied period, with the highest values in the sample from Kavarna (25.09.2019) - 17.53 % BW ± 2.40 SD (Table 45).

3.1.2.6. Summary of the sex structure for 3rd and 4th quarters 2019

Using the beam trawl technique for rapa whelk fishing, the average ratio between the sexes for the 3rd and 4th quarter of 2019 is 46.7 % ♀: 53.3 % ♂ or 1: 1.14 (Fig. 14). The data from Sozopol (29.09.2019 and 01.10.2019) show significant presence of the male specimens (35 % ♀: 65 % ♂), explained by the fact that the fishing was carried out by scuba divers, which use selective approach for the rapa whelk collection (selection of large male specimens). No imposex forms were observed for the whole period.

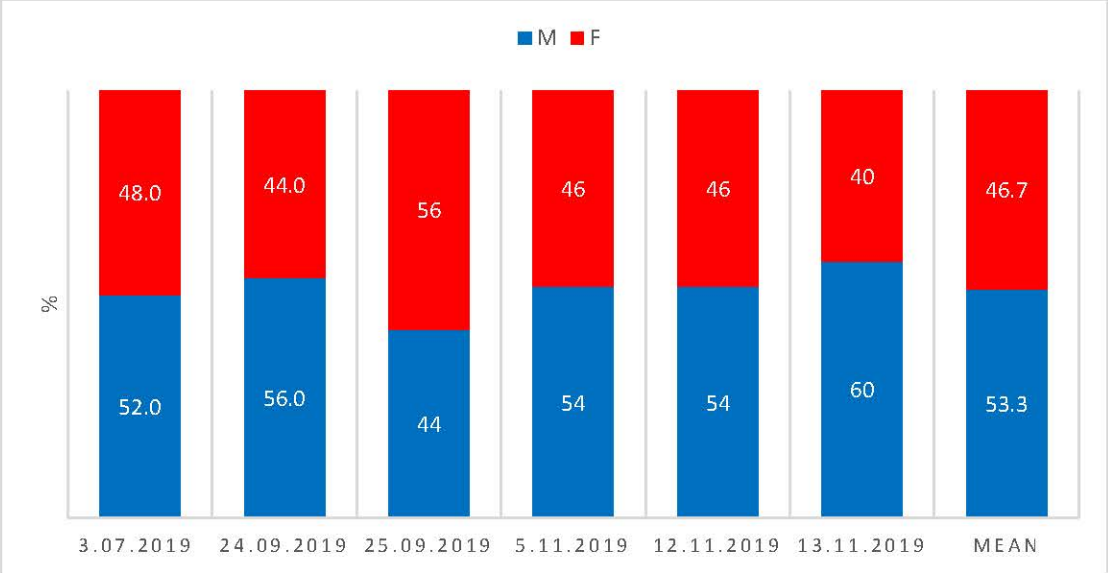


Figure 14. Summarized data about the sex structure of *R. venosa* by ports (*beam trawl fishing*) for the 3rd and 4th quarter 2019

The average length of the male specimens (SL, mm), collected by beam trawl, is 63.19 mm ± 8.70 SD, and the maximal average length - 67.5 mm was observed in the sample from Port Kavarna (25.09.2019). The minimal average length of males - 52.73 mm was found from the Port Balchik sample (03.07.2019) (Table 46.1, Fig 15). The average length (SL, mm) of the female specimens, collected by beam trawl is 59.36 mm ± 7.50 SD which is about 6.3 % smaller compared to males, however the dynamics of mean lengths by ports is similar for both sexes.

Concerning the scuba diving technique, the average length of the male specimens is 69.12 mm ± 4.11 SD, and 65.85 mm ± 4.56 SD - for the females. Comparing the two methods of rapana fisheries, the percentage differences between the mean lengths were - 9% for male specimens and - 10.3% for female specimens, respectively, in favour of the scuba diving data.

Table 46.

Statistical data about the percentage distribution of the length (SL, mm, 1) and weight (TW, g, 2) by sex in the samples from the different ports for the 3rd and 4th quarter of 2019.

1. **Length (SL, mm)**

Date	Port	Observations number	пол	Minimum SL, mm	Maximum SL, mm	Mean SL, mm	Std. deviation
3.07.2019	Balchik	26	M	45.000	68.000	52.731	5.869
		24	F	44.000	70.000	51.458	6.633
24.092019	Varna	28	M	56.000	76.000	64.143	4.912
		22	F	49.000	73.000	60.000	6.325
25.09.2019	Kavarna	22	M	59.000	80.000	67.500	4.362
		28	F	59.000	74.000	65.000	2.944
29.09.2019	Sozopol	26	M	66.000	76.000	69.885	2.658
		24	F	63.000	78.000	68.708	3.029
01.10.2019	Sozopol	39	M	58.000	81.000	68.538	5.567
		11	F	53.000	73.000	63.000	6.099
08.11.2019	Kavarna	27	M	54.000	81.000	67.481	7.095
		23	F	49.000	67.000	56.913	4.907
12.11.2019	Kavarna	27	M	46.000	83.000	64.037	10.494
		23	F	50.000	70.000	59.522	5.751
16.11.2019	Kavarna	30	M	48.000	78.000	63.567	8.593
		20	F	47.000	77.000	62.900	9.447

2. **Total weight (TW, g)**

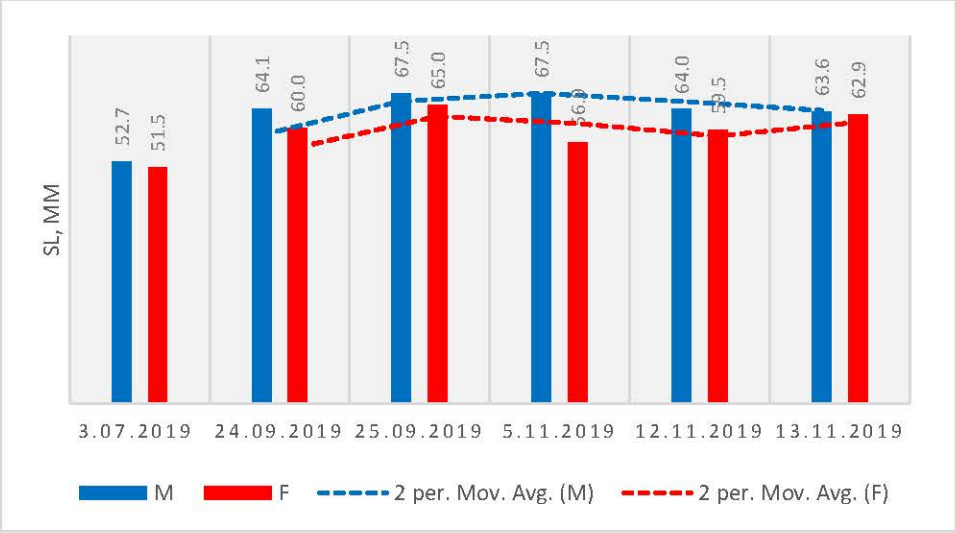
Date	Port	Observations number	пол	Minimum SL, mm	Maximum SL, mm	Mean SL, mm	Std. deviation
3.07.2019	Balchik	26	M	14.500	52.000	24.404	10.246
		24	F	12.500	73.000	25.646	13.621
24.092019	Varna	28	M	30.000	69.500	43.286	10.042
		22	F	13.000	55.000	34.295	10.519
25.09.2019	Kavarna	22	M	34.000	87.000	50.136	12.941
		28	F	34.000	65.000	45.161	7.773

29.09.2019	Sozopol	26	M	52.000	77.500	61.500	5.948
		24	F	49.000	77.000	60.188	6.929
01.10.2019	Sozopol	39	M	28.500	89.000	59.000	14.790
		11	F	29.000	61.500	44.818	10.806
08.11.2019	Kavarna	27	M	20.000	92.500	45.963	18.140
		23	F	14.500	49.000	24.391	9.423
12.11.2019	Kavarna	27	M	15.500	93.500	40.278	23.689
		23	F	17.000	57.500	30.217	11.333
16.11.2019	Kavarna	30	M	16.500	107.500	42.150	24.957
		20	F	13.500	77.500	38.350	18.125

The data about the male specimens shows an average weight of 40.89 g ± 19.42 SD and 33.27 g ± 13.98 SD for the females, resulting in a percentage difference of 21 % between the two sexes.

Concerning the scuba diving technique, males have an average weight - 69.12 g ± 4.11 SD, and the average weight for the female specimens is 65.85 g ± 4.56 SD. The percentage differences in the average weights by different fishing techniques is 51.3 % for the males and 65.7 % for the females, in favour of the scuba diving techniques.

1.



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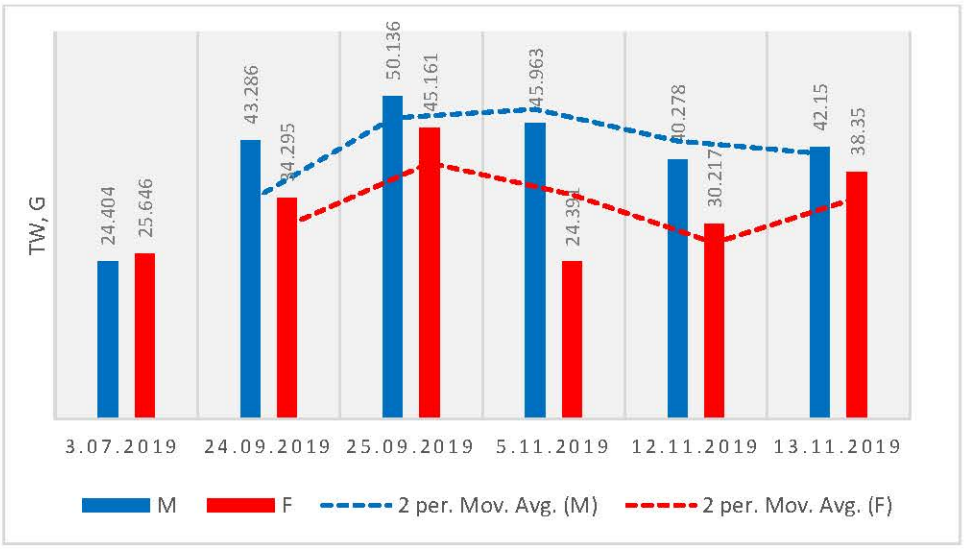

Figure 15. *R. venosa:* summarized data about: (1) average length (SL, mm) by sex and (2) average total weight (TW, g) by sex and ports for the 3rd and 4th quarters 2019 (*beam trawls data*).

The analysis on the dynamics of the length classes by sex for the beam trawl technique (Fig. 16) shows that the predominant length classes are - 66 - 76 mm (35.9 % from the measured male specimens for the period) and 56 - 66 mm (35.7 %). The data for the female specimens show that the predominant length class is 56 - 66 mm (46.5 %), followed by length class 46 - 56 mm (29.30 %) (Fig. 16.2). As for the scuba diving technique, the predominant length class for both sexes is 66 - 76 mm (80.13 % of the male and 57.77 % of the female specimens).

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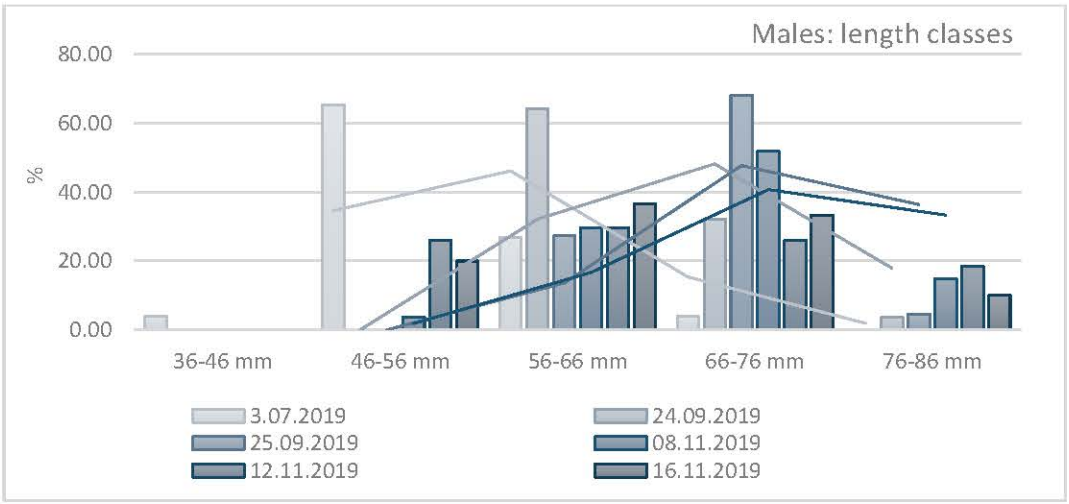

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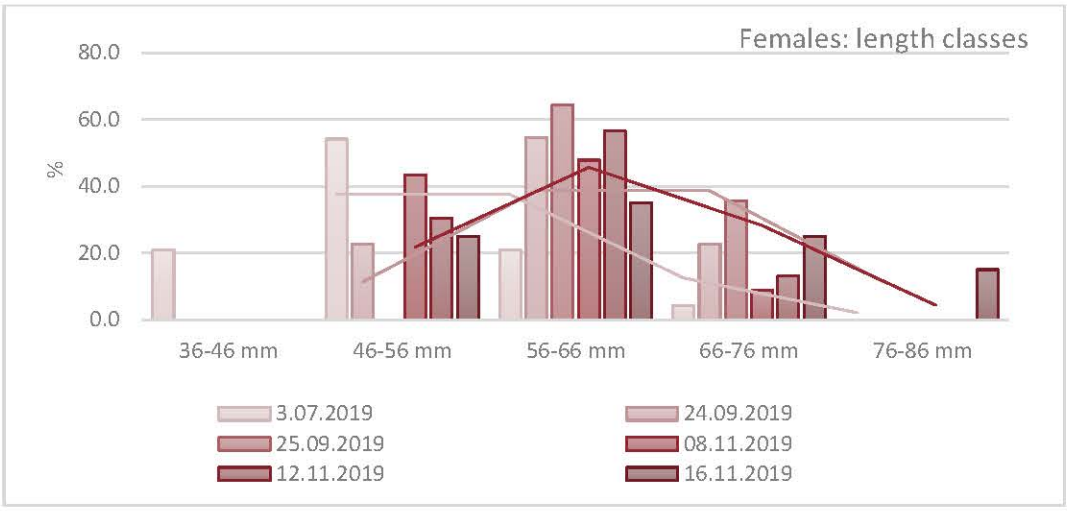
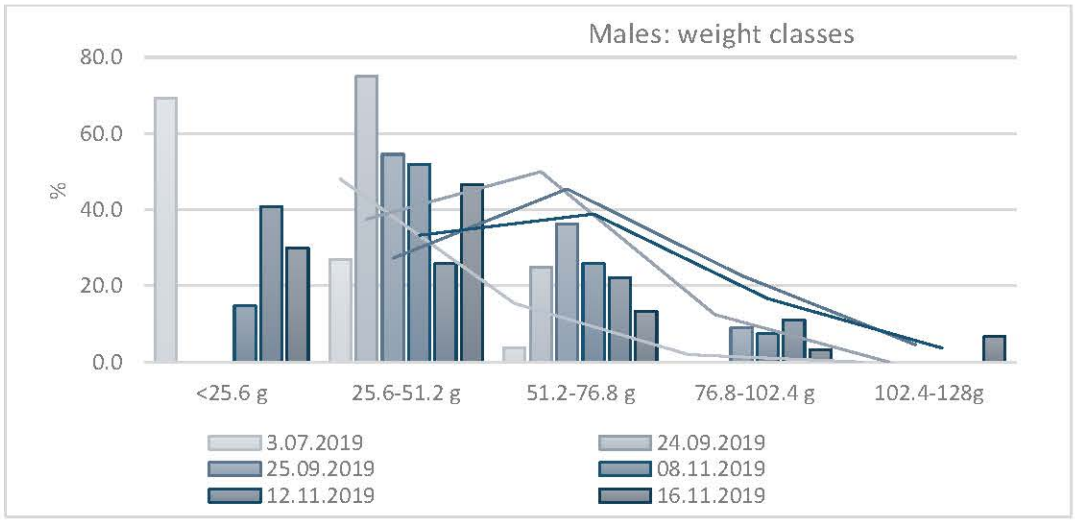


Figure 16. Percentage distribution of the length classes (SL, mm) for the males (1) and female (2) specimens for the 3rd and 4th quarter 2019

In the weight structure of samples collected by beam trawls, the predominant weight class for both sexes is - 25.6 -51.2 g, which was observed in approximately 52.1 % of the male specimens and 54.9 % of the female specimens. As for the male specimens, the second most common length class is 51.2 – 76.8 g (22.8 %), while for the females it is the weight class < 26 g - 35.3 %. No large specimens >102 g were observed.

1.



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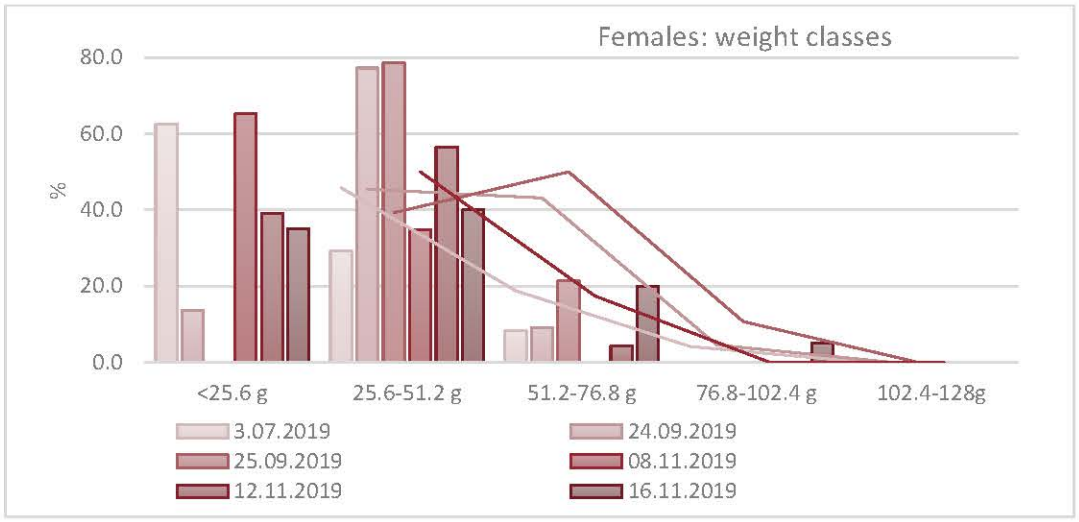

Figure 17. Percentage distribution of the weight classes (TW, g) for male (1) and female (2) specimens for the 3rd and 4th quarter 2019 (*beam trawl fishing*)

For both sexes, the predominant weight class for scuba diving fishing is 51.2 - 76.8 g (75 % of the male and 78 % of the female specimens).

4. CONCLUSIONS

- The analysis on the landings of rapa whelk for the 3rd and 4th quarter of 2019 was made based on 800 specimens *R. venosa*, collected at the ports Kavarna, Balchik, Kavarna, Varna and Sozopol, in order to assess the population parameters dynamics in the main fishing zones.
- In the case of beam trawling, the total landings of the monitored ports vary between 1791 - 8622 kg/day; the most significant quantities were landed at the port of Varna in September 2019. Fishing vessels with length - 14.9 m and power 220 kW, equipped with beam trawl, can land 3810 kg/fishing day and catches from fishing vessels from the length class - 12.2 - 16.5 m and power up to 130 kW vary between 990 - 2100 kg/ fishing day.
- The average length of *R.venosa*, collected by beam trawl, is 61.20 mm ± 8.44 SD. The maximal average length is - 65.88 mm, measured in the sample from Port Varna (25.09.2019), while the minimal average length is 52.04 mm – at Port Balchik on 03.07.2019. The average weight (TW, g) of the specimens, collected by beam trawl, is 36.90 g ± 17.46 SD for the studied period. The dynamics of this parameter by ports is similar to the one for the average length. The average body weight (BW, g) is 15.09 g ± 6.86 SD or 40.91 % of the total weight (TW) of the specimens for the observed period. The average percentage ratio varies between 37.5 - 44.4 % TW by the different ports with tendency to increase in November.
- The data about the landings from scuba diving at Port Sozopol shows that there is an increase in the average length of the rapa whelk - 68.55 mm ± 4.80 SD, the average weight is 57.97 g ± 11.43 SD and the body weight is - 19.24 g ± 4.39 SD. When we compare the biological data, obtained from samples collected by beam trawling and scuba diving method, the percentage difference between the average weights is 44 %, in favour of the specimens, collected by scuba diving, and the percentage difference for the average lengths is 11 %; for the body weight, it is 24.2 %.
- The most common length class of the rapa whelk specimens (collected by beam trawl) is - 56 - 66 SL mm (41.2 %), as well as length classes - 66 - 76 mm (26.2 %) and 46 - 56 mm (25.5 %). In the weight structure, the following classes are predominant: 26 - 51.2 g TW (52 %) and < 26 g TW (30.3 % of all the measured specimens). Concerning the scuba diving data, the predominant rapa whelk length class is 66-76 mm (74 %) and the weight class is - 51.2-76.8 g (70 %).
- The average ratio of Wad/SL is 74.07 %, varying between 73.23 % - 74.73 %. The ratio AL/SL is on average 71.17 %, varying between 70.07 - 71.93 %. The average value for the ratio AL/Wd (%) is 96.01 % with a little variation - 94.47 % - 97.05 % between the different ports.
- The comparison analysis of the parameters a and b of the L-W relationship: W(g)=a.L(mm)^b shows allometric growth of *R. venosa* at a coefficient b ≠ 3.
- For the surveyed ports, the average sex ratio for the specimens, collected by beam trawl, is 46.7 % ♀: 53.3 % ♂ or 1: 1.14. The data from Port Sozopol and specimens collected by scuba diving method show clear predomination of male specimens (35 % ♀: 65 % ♂). This is

explained by the fact, that the scuba diving technique is based on a selective approach for rapana specimen's collection. No imposex forms were observed during the studied period.

- The average length of the male specimens, collected by beam trawl, is 63.19 mm ± 8.70 SD, while for the female specimens it is 59.36 mm ± 7.50 SD, resulting in a percentage difference of 6.3 % between the both sexes. Using the scuba diving technique, the average length of the male specimens is 69.12 mm ± 4.11 SD, while for the females it - 65.85 mm ± 4.56 SD. The percentage differences in the mean weights by sex for these two fishing methods are - 38% for male specimens and 46% - for female specimens, in favour of the scuba diving data.
- Concerning the beam trawl fishing – the average weight of the male specimens is 41.04 g ± 16.67 SD, while for the females - 33.01 g ± 11.78 SD, resulting in a percentage difference of 21.7 % between the sexes. The scuba diving technique shows that the average male length is 60.25 g ± 10.37 SD, while the average female length is - 52.5 g ± 8.69 SD. The percentage differences for the average weights by sexes for these techniques is 38 % for the males and 46 % - for the females, in favour of the scuba diving data.
- In the catches with the beam trawl, the predominant length classes for the male specimens are - 66 - 76 mm (35.9 %) and 56 - 66 mm (35.7 %), while for the female specimens the dominant length class is 46 - 56 mm (29.3 %).
- The gonadosomatic index for the 3rd and 4th quarter of 2019 is on average 15.17 % BW, with the highest values from Port Kavarna (25.09.2019) - 17.53 % BW ± 2.40 SD.

5. REFERENCES

1. ICES, 2004/ACFM:12: Advisory Committee on Fishery Management Report of the Workshop on Sampling and Calculation Methodology for Fisheries Data (WKSCMFD), 26–30 January 2004 Nantes, France, 242 pp

2. ICES, 2011. Report of the Study Group on Practical Implementation of Discard Sampling Plans (SGPIDS), 27 June - 1 July 2011, ICES Headquarters, Denmark. ICES CM 2011/ACOM: 50. 116 pp

3. ICES. 2013. Report of the Study Group on Practical Implementation of Discard Sampling Plans (SGPIDS), 24 June – 28 June 2013, Lysekil, Sweden. ICES CM 2013/ACOM:56. 142pp