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

SCIENTIFIC REPORT FOR 1ST AND 2ND QUARTERS OF 2022

IFR - Varna

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This study is carried out by researchers from the Institute of Fish Resources – Varna, Agricultural Academy (AA), within Contract EAFA /78/17.03.2022 and is focused on the assessment of the quantity and biological parameters of *Rapana venosa* from the landed catch by the Bulgarian fishing fleet in 2022.

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

The current research is indicative for the first half of 2022 and shows the dynamics of the biological parameters of *Rapana venosa* from the landed catch at five ports – Rodopa 1, Kavarna, Varna, Nesebar and Sozopol, based on the biometric measurements and analysis of 700 specimens of the target species.

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1. INTRODUCTION

The current report is representative for the first half of 2022 and is based on biometric measurements on 700 specimens of *R. venosa*. The report presents data and analyzes on the biological characteristics of the target species - quantities, size-weight composition, linear-weight relationships and sex structure according to data from landings at ports – Rodopa 1, Kavarna, Varna, Sozopol and Nesebar.

1.1. COLLECTED DATA

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 length (m)

2. Fishing gear
- Depth scale of the fishing activities

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

4. Additional biological data
- Sex ratio, sex maturity of collected individuals and gonadosomatic index (when applicable);
- Size and weight structure by sex, sex ratio to shell length and sex ratio to total weight;

The final results are presented in the form of tables and figures with data about:
- Landings of the target species at ports
- Biological parameters of *Rapana venosa* – lenghts, weight, length-weight relationships, sex structure from the samples of the observed ports.

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2. Material and Methodology

2.1. Sampling scheme

The collection of biological samples (based on 700 specimens of *Rapana venosa*) was carried out by landings in ports, as the samples are collected from four ports - in the northern and southern marine waters, with intensive catching of Rapa whelk. The main ports for sampling include Rodopa 1, Kavarna, Varna, Sozopol and Nesebar. The collected samples were taken in 7 days between February and June 2022. The summary of the collected data is presented in Table 1.

Table 1 Vessels and ports, where biological samples were taken from *Rapana venosa* landings

Date	Landing port	Reg No Fishing vessel	Fishing method	Technical specifications
2022-02-10	Rodopa 1	ВН 8396	Beam trawl	VL 11.8,kW 33.1,GT 9.7
2022-05-17	Kavarna	ВН 7643	Beam trawl	VL 14.7,kW 147.1,GT 26.11
2022-05-01	Kavarna	КВ5642	Beam trawl	VL 12.2,kW 69.88,GT 10.04
2022-05-27	Varna	ВН 8012	Beam trawl	VL 12.02,kW 180.2,GT 9.83
2022-05-25	Rodopa 1	ВН 8793	Scuba diving	VL 9,kW 51.49,GT 2.61
2022-06-17	Nesebar	НС592	Beam trawl	VL 9,kW 58.84,GT 3.13
2022-06-21	Sozopol	БС1098	Scuba diving	VL 6.3, kW 21.33, GT 1.46

The beam-trawl has the following parameters – maximum width - 5.3 m, maximum depth - 6 м: vertical opening - 280 mm; horizontal opening between the rails - 5 m; effective part of the upper collar - 4.8 m; trawling velocity - 3 - 3.6 Nd; trawling duration 60 - 80 mins. This particular beam trawl was used for rapa fishing in all observed landing ports.

In May and June 2022, the samples were collected by a scuba diving method, this method is selective and includes the collection of large specimens, therefore in the summaries, there is a distinction between the data collected by the two methods.

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2.2. Sample analysis

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

The accuracy of the program for sample collection is based on the following documents:

- "Report of the Workshop on Sampling and Calculation Methodology for Fisheries Data" (WKSCMFD) (ICES 2004):
  https://www.ices.dk/sites/pub/CM%20Doccuments/2004/ACFM/ACFM1204.pdf
- Report SGPIDS (ICES, 2011a):
  https://www.ices.dk/community/Documents/PGCCDBS/SGPIDS%202011.pdf
- Report of the Study Group on Practical Implementation of Discard Samples (SGPIDS)

2.3. Laboratory analysis

- For each individual, the following biometric parameters were measured – total weight of the individual (total weight, weight with shell, TW, g), body weight (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 relationships for the individual biometric parameters to each of the other biometric parameters were calculated.;
- The sex ratio and the gonadosomatic index were determined, as well as the sexual maturity of the collected individuals (if applicable);
- The length - weight structure by sex, the ratio of the sexes to the shell length and to the weight of the specimens were determined.

2.4. Analytical methods

The morphometric relationships between the biological parameters - total weight (TW), shell length (SL), shell width (Wd), aperture length (AL) was analyzed on the basis of classical allometric models. The least squares method was used to estimate the linear - weight relationships (**LWR**), based on the following equation:

$W = a \times L^b$, where, W – weight; L – length; a, b – constants.

The gonadosomatic index (**GSI**) is determined by the mass of the gonads as a proportion of total body weight. It is presented with the formula:

GSI = [gonad weight / body weight] × 100.

When estimating the percentage difference between two values, a and b, the used formula was = |Absolute difference between the two values/Average of both the values| × 100 %

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The XLSTAT software product, together with the statistical libraries of PYTHON, were used to display the linear-weight histograms of the samples from the *Rapana* landings. The statistical data about the different length and weight classes, presented in the histograms, include lower and upper limits, frequency, relative frequency, and density.

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3. Results

3.1. Biometric measurements and length-weight relationships

3.1.1. Port Rodopa 1, 10.02.2022

The sample includes 100 individuals rapa whelk, weighing 3.29 kg, from a total landing of 14 kg at Port Rodopa 1 (from the fishing vessel).

The mean weight of the measured specimens reached 32.97 g ± 8.17 SD, at a mean length of 56.03 mm ± 4.68 SD, shell width 41.33 mm ± 3.56 SD and aperture length 38.48 ± 3.39 SD. The mean body weight without shell (BW, g) is 12.62 g ± 3.00 SD forming 39.43 % ± 3.52 SD from the total weight, varying between 30 and 47 % from the total weight (Table 2).

Table 2

Summarized statistics of the biological parameters - total weight (TW, g), body weight (BW, g), percentage ratio of BW (% TW), shell length (SL, mm), shell width (Wd, mm) and aperture length (aperture length, AL, mm) at Port Rodopa 1, 10.02.2022

	TW g	SL mm	W mm	Al mm	BW g	BW % TW
Sum	100	100	100	100	50	50
Mean	32.97	56.03	41.33	38.48	12.62	39.43
Standard deviation	8.17	4.68	3.56	3.39	3.00	3.52
Minimum	18.63	47	36	33	7.98	30.61
25%	27.33	53	39	36	10	36.80
50% (median)	31.81	56	41	38	12.37	39.68
75%	36.75	59	44	41	14.41	41.73
Maximum	68.13	70	56	52	20	46.49
Sum	3296.94	5603	4133	3848	631.07	1971.54
Mode	26.19	56	41	38	10	30.61
Skewness	1.38	0.73	0.98	0.87	0.61	-0.30
Sample variance	66.78	21.95	12.69	11.52	9.03	12.39
Kurtosis	3.37	0.66	2.05	1.62	-0.33	-0.14
Range	49.5	23	20	19	12.02	15.88
Confidence level 95%	1.60	0.92	0.70	0.67	0.83	0.98

The most common size class is - 50 - 60 mm (77 % from the observed individuals). In regard to the weight structure (TW, g), the predominant weight class is: 20 - 40 g (82 % from all individuals).

The mean ratio between the shell width (Wd, mm)/shell length (SL, mm) is 73.82 % ± 3.13 SD, while the AL/SL (%) is 68.71 % ± 2.89 SD, and the ratio between AL/Wd (%) was calculated at - 93.10 % ± 1.55 SD (Table 3).

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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 individuals from the sample from Port Rodopa 1, 10.02.2022

	Wd/SL %	Al/SL %	Al/Wd %
Sum	100	100	100
Mean	73.82	68.71	93.10
Standard deviation	3.13	2.89	1.55
Minimum	66.07	60.71	88.37
25%	71.69	66.67	92.31
50% (median)	74.04	68.64	92.86
75%	75.93	70.61	94.48
Maximum	81.13	75.00	95.65
Sum	7381.77	6871.36	9309.96
Mode	75.00	66.67	92.68
Skewness	-0.06	-0.14	-0.43
Sample variance	9.81	8.35	2.39
Kurtosis	-0.27	-0.21	0.24
Range	15.06	14.29	7.28
Confidence level 95%	0.61	0.57	0.30

The L-W ratios are calculated, Fig.1. The parameters a, b of the linear-weight relationships and the values of the correlation coefficient R2 are presented in Table 4.

TABLE 4

Parameters a,b of the L-W ratios and values of R^2 for the sample from Port Rodopa 1, 10.02.2022

Parameters	$\mathbf{T}W(g) = a.SL(mm)^b$	$\mathbf{T}W(g) = a.Wd(mm)^b$	$W(g) = a.AL(mm)^b$
a	0.00087	0.00267	0.0039
b	2.61465	2.52735	2.47361
R^2	0.81	0.85	0.82

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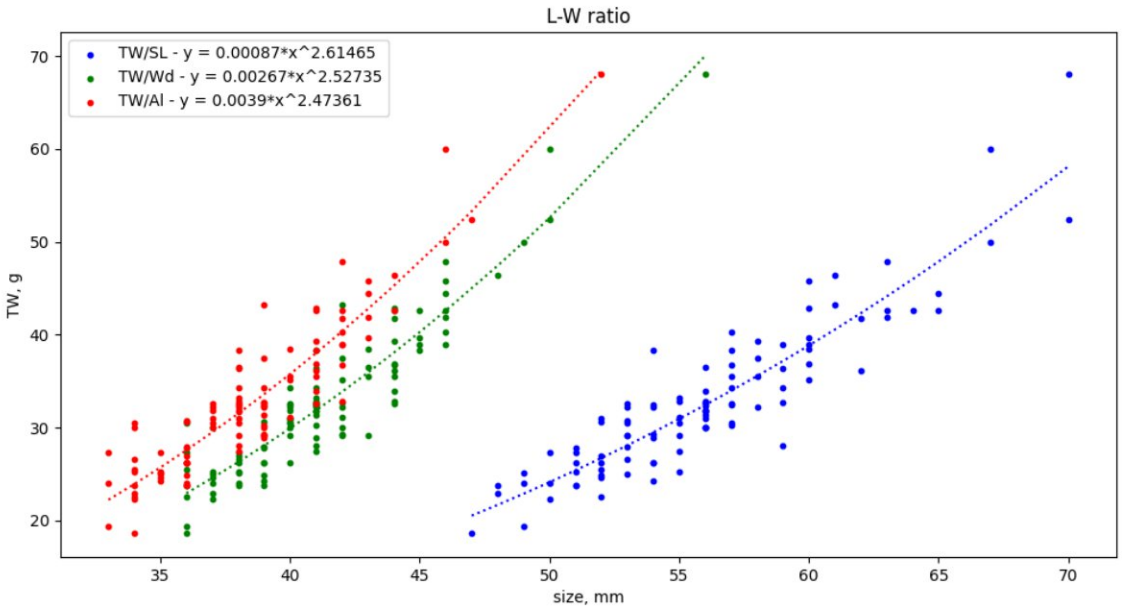

Figure 1. L-W ratios for the sampled individuals, Port Rodopa 1, 10.02.2022: (1) ratio between total weight (TW, g) and shell length (SL, mm); (2) relationship between total weight (TW, g) and shell width (Wd, mm); (3) relationship between total weight (TW, g) and aperture length (AL, mm)

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3.1.2. Port Kavarna, 17.05.2022

The sample includes 100 individuals rapa whelk, weighing 3.54 kg, from a total landing of 3684 kg at Port Kavarna (from the fishing vessel).

The mean weight of the measured specimens reached 34.57 g ± 11.17 SD, at a mean length of 56.28 mm ± 5.58 SD, shell width 41.76 mm ± 4.46 SD and aperture length 38.85 ± 2.90 SD. The mean body weight without shell (BW, g) is 13.10 g ± 4.11 SD forming 38.24 % ± 2.90 SD from the total weight, varying between 31 и 45 % from the total weight (Table 5).

TABLE 5

Summary statistics of the biological parameters – total weight (TW, g), body weight (BW, g), percentage ratio BW (% TW), shell length (SL, mm), shell width (Wd, mm) and aperture length (aperture length, AL, mm) from Port Kavarna, 17.05.2022

	TW g	SL mm	W mm	Al mm	BW g	BW % TW
Sum	100	100	100	100	50	50
Mean	34.57	56.28	41.76	38.85	13.10	38.24
Standard deviation	11.17	5.58	4.46	4.34	4.11	2.90
Minimum	17.03	45.00	31.00	29.00	6.51	31.13
25%	28.76	53.00	39.00	36.00	10.50	37.47
50% (median)	32.85	56.00	41.00	38.00	12.68	38.25
75%	38.36	59.00	43.25	41.00	13.99	39.83
Maximum	103.89	80.00	60.00	57.00	32.39	44.98
Sum	3456.92	5628.00	4176.00	3885.00	654.92	1912.01
Mode	30.00	54.00	42.00	38.00	10.00	31.13
Skewness	2.80	0.96	1.06	1.15	2.44	-0.52
Sample variance	124.69	31.15	19.88	18.86	16.88	8.44
Kurtosis	14.38	2.52	2.47	2.65	9.64	0.81
Range	86.86	35.00	29.00	28.00	25.88	13.85
Confidence level 95%	2.19	1.09	0.87	0.85	1.14	0.81

The most common size class is - 50 - 60 mm (67 % from the observed individuals). In regard to the weight structure (TW, g), the predominant weight class is: 20 – 40 g (79 % from all individuals).

The mean ration between the shell width (Wd, mm)/shell length (SL, mm) is 74.24 % ± 3.83 SD, while AL/SL (%) is 69.04 % ± 3.69 SD, and the ratio between AL/Wd (%), is estimated at 93.00 % ± 1.51 SD (Table 6).

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TABLE 6

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 individuals from the sample from Port Kavarna, 17.05.2022

	Wd/SL %	Al/SL %	Al/Wd %
Sum	100	100	100
Mean	74.24	69.04	93.00
Standard deviation	3.83	3.69	1.51
Minimum	65.52	60.34	89.74
25%	71.86	66.67	92.11
50% (median)	74.04	68.97	92.68
75%	76.36	70.85	94.29
Maximum	90.38	84.62	95.92
Sum	7424.40	6904.41	9300.01
Mode	75.00	66.67	92.68
Skewness	0.85	1.06	-0.04
Sample variance	14.64	13.63	2.27
Kurtosis	2.92	3.57	-0.69
Range	24.87	24.27	6.17
Confidence level 95%	0.75	0.72	0.30

The L-W ratios are calculated, Fig.2. The parameters a, b of the linear-weight relationships and the values of the correlation coefficient R2 are presented in Table 7.

TABLE 7

Parameters a,b of the L-W ratios and values of R^2 for the sample from Port Kavarna, 17.05.2022

Parameters	$\mathrm{T}\boldsymbol{W(g) = a.SL(mm)^b}$	$\mathrm{T}\boldsymbol{W(g) = a.Wd(mm)^b}$	$\boldsymbol{W(g) = a.AL(mm)^b}$
a	0.00031	0.00212	0.00382
b	2.874	2.59186	2.4828
R^2	0.78	0.779	0.795

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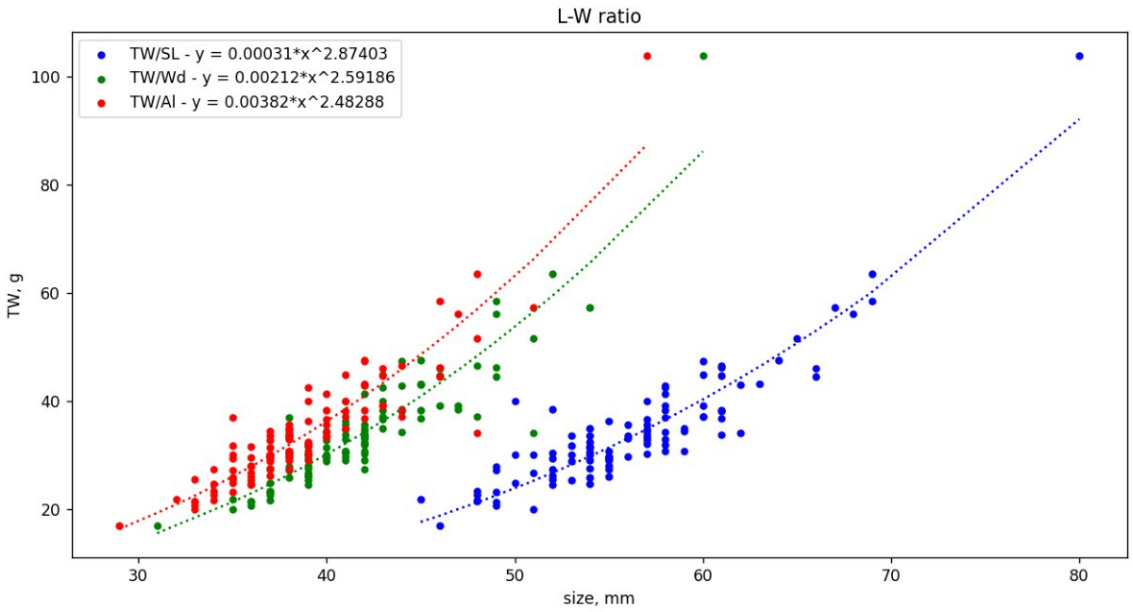

Figure 1. L-W ratios for the sampled individuals, Port Kavarna, 17.05.2022: (1) Total weight (TW, g) from the shell length (SL, mm); (2) Total weight (TW, g) from the shell width (Wd, mm); (3) total weight (TW, g) and aperture length (AL, mm)

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3.1.3. Port Kavarna, 01.05.2022

The sample includes 100 individuals rapa whelk, weighing 3.330 kg, from a total landing of 3211 kg at Port Kavarna (from the fishing vessel).

The mean weight of the measured specimens reached 33.30 g ± 11.22 SD, at a mean length of – 57.10 mm ± 6.92 SD, shell width - 40.63 mm ± 5.06 SD and aperture length 37.86 ± 4.87 SD. The mean body weight without shell (BW, g) is 10.82 g ± 5.14 SD forming 31.47 % ± 6.54 SD from the total weight, varying between 15.30 и 43.52 % from the total weight (Table 8).

TABLE 8

Summarized statistics of the biological parameters - total weight (TW, g), body weight (BW, g), percentage ratio of BW (% TW), shell length (SL, mm), shell width (Wd, mm) and aperture length (AL, mm) from Port Kavarna, 01.05.2022

	TW g	SL mm	W mm	Al mm	BW g	BW % TW
Sum	100.00	100.00	100.00	100.00	50.00	50.00
Mean	33.30	57.10	40.63	37.86	10.82	31.47
Standard deviation	11.22	6.92	5.06	4.87	5.14	6.54
Minimum	12.51	43.00	28.00	27.00	4.07	15.30
25%	24.89	52.00	37.00	34.00	6.63	27.30
50% (median)	33.61	57.50	40.00	38.00	10.47	32.05
75%	39.69	62.00	44.00	41.00	13.59	37.10
Maximum	76.19	77.00	57.00	53.00	33.16	43.52
Sum	3330.24	5710.00	4063.00	3786.00	541.19	1573.26
Mode	36.09	58.00	44.00	36.00	17.28	15.30
Skewness	0.79	0.12	0.27	0.29	1.66	-0.46
Sample variance	125.88	47.83	25.61	23.70	26.42	42.72
Kurtosis	1.72	-0.01	0.42	0.28	5.78	-0.11
Range	63.68	34.00	29.00	26.00	29.09	28.23
Confidence level 95%	2.20	1.36	0.99	0.95	1.42	1.81

The most common size class is - 50 - 60 mm (50 % from the observed individuals). In regard to the weight structure (TW, g), the predominant weight class is: 20 - 40 g (65 % from all individuals).

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The mean ratio between shell width (Wd, mm)/ shell length (SL, mm) is 69.35 % ± 4.83 SD, while for the AL/SL (%) it is 62.18 % ± 3.99 SD, and the ratio between AL/Wd (%) is estimated at - 89.72 % ± 2.29 SD (Table 9).

TABLE 9

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 individuals from the sample from Port Kavarna, 01.05.2022

	Wd/SL %	Al/SL %	Al/Wd %
Sum	100	100	100
Mean	71.22	66.32	93.15
Standard deviation	3.63	3.19	1.80
Minimum	63.64	59.02	88.24
25%	69.23	64.62	92.26
50% (median)	71.06	66.00	93.18
75%	72.46	67.80	94.44
Maximum	90.20	82.35	97.50
Sum	7121.83	6632.18	9315.39
Mode	71.15	66.67	93.18
Skewness	1.56	1.30	-0.30
Sample variance	13.19	10.15	3.24
Kurtosis	6.89	5.72	0.60
Range	26.56	23.34	9.26
Confidence level 95%	0.71	0.62	0.35

The L-W ratios are calculated (Fig.2). The parameters a, b of the linear-weight relationships and the values of the correlation coefficient R^2 are presented in Table 10.

TABLE 10

Parameters a,b of the L-W ratios and values of R^2 for the sample from Port Kavarna, 01.05.2022

Parameters	$\mathrm{T}W(g) = a.SL(mm)^b$	$\mathrm{T}W(g) = a.Wd(mm)^b$	$W(g) = a.AL(mm)^b$
a	0.00106	0.00302	0.00482
b	2.552	2.505	2.425
R^2	0.788	0.879	0.879

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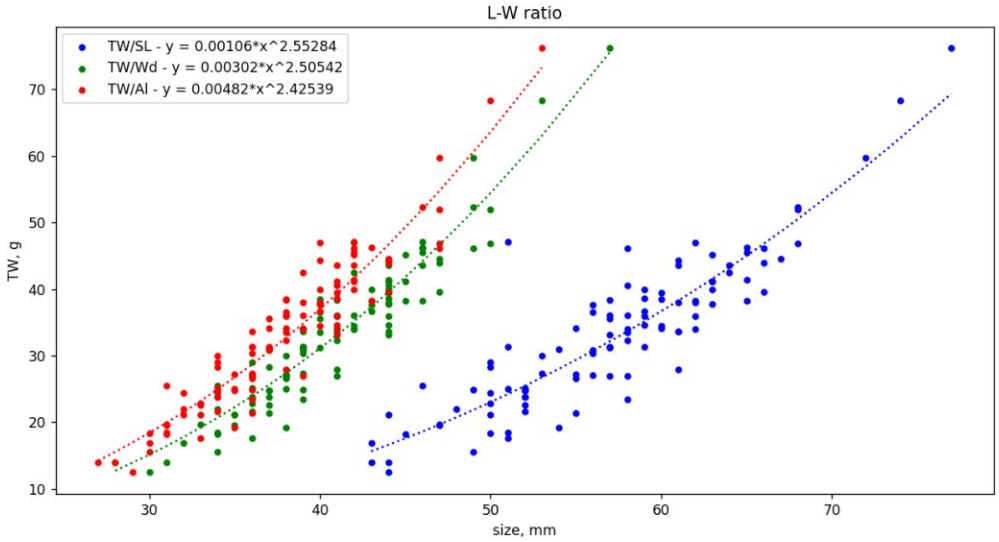

Figure 2. L-W ratios for the sampled individuals, Port Kavarna, 01.05.2022: (1) Total weight (TW, g) from the shell length (SL, mm); (2) Total weight (TW, g) from the shell width (Wd, mm); (3) Total weight (TW, g) and aperture length (AL, mm)

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3.1.4. Port Varna, 27.05.2022

The sample includes 100 individuals rapa whelk, weighing 3.55 kg, from a total landing of 1600 kg at Port Varna (from the fishing vessel).

The mean weight of the measured specimens reached 35.50 g ± 13.47 SD, at a mean length of - 57.64 mm ± 7.43 SD, shell width – 41.97 mm ± 5.97 SD and aperture length 38.81 mm ± 5.71 SD SD. The mean body weight without shell (BW, g) is 11.75 g ± 5.67 SD forming 32.49 % ± 5.25 SD from the total weight, varying between 18 % и 43 % from the total weight (Table 11).

Table 11

Summarized statistics of the biological parameters - total weight (TW, g), body weight (BW, g), percentage ratio of BW (% TW), shell length (SL, mm), shell width (Wd, mm) and aperture length (AL, mm) на Port Varna, 27.05.2022

	TW g	SL mm	W mm	Al mm	BW g	BW % TW
Sum	100.00	100.00	100.00	100.00	50.00	50.00
Mean	35.50	57.64	41.97	38.81	11.75	32.49
Standard deviation	13.47	7.43	5.97	5.71	5.67	5.25
Minimum	14.45	40.00	28.00	27.00	2.65	18.34
25%	25.00	52.00	37.00	34.75	7.26	30.09
50% (median)	32.78	58.00	42.00	38.50	10.60	33.06
75%	44.53	63.00	46.00	42.25	15.37	35.98
Maximum	78.03	79.00	57.00	54.00	24.13	42.65
Sum	3550.41	5764.00	4197.00	3881.00	587.65	1624.29
Mode	24.81	61.00	44.00	33.00	2.65	18.34
Skewness	0.72	0.14	0.18	0.25	0.52	-0.66
Sample variance	181.54	55.16	35.69	32.56	32.14	27.57
Kurtosis	0.06	-0.35	-0.58	-0.62	-0.76	0.18
Range	63.58	39.00	29.00	27.00	21.48	24.31
Confidence level 95%	2.64	1.46	1.17	1.12	1.57	1.46

The most common size class is 45 - 70 mm (92 % from the observed individuals). In regard to the weight structure (TW, g), the predominant weight class is 20 - 40 g (60 % from all individuals).

The mean ratio between the shell width and the shell length (Wd, mm)/ (SL, mm) is 72.76 % ± 3.43 SD, while the ratio AL/SL (%) is 67.26 % ± 3.43 SD, and the ratio between the AL/Wd (%) was calculated at 92.43 % ± 1.62 SD (Table 12).

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TABLE 12

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 individuals from the sample from Port Varna, 27.05.2022

	Wd/SL %	Al/SL %	Al/Wd %
Sum	100	100	100
Mean	72.76	67.26	92.43
Standard deviation	3.43	3.43	1.62
Minimum	65.52	60.34	87.88
25%	70	64.68	91.4
50% (median)	73.01	67.21	92.31
75%	75	69.64	93.37
Maximum	83.02	76.36	96.43
Sum	7276.19	6725.57	9242.94
Mode	70	66.67	92.31
Skewness	0.43	0.27	-0.09
Sample variance	11.8	11.75	2.63
Kurtosis	0.12	-0.15	0.22
Range	17.5	16.02	8.55
Confidence level 95%	0.67	0.67	0.32

The L-W ratios are calculated, Fig.3. The parameters a, b of the linear-weight relationships and the values of the correlation coefficient R^2 are presented in Table 13.

TABLE 13

Parameters a,b of the L-W ratios and values of R^2 for the sample from Port Varna, 27.05.2022

Parameters	$\mathrm{T}\boldsymbol{W(g) = a.SL(mm)^b}$	$\mathrm{T}\boldsymbol{W(g) = a.Wd(mm)^b}$	$\boldsymbol{W(g) = a.AL(mm)^b}$
a	0.00047	0.00239	0.00453
b	2.758	2.559	2.440
R^2	0.844	0.894	0.887

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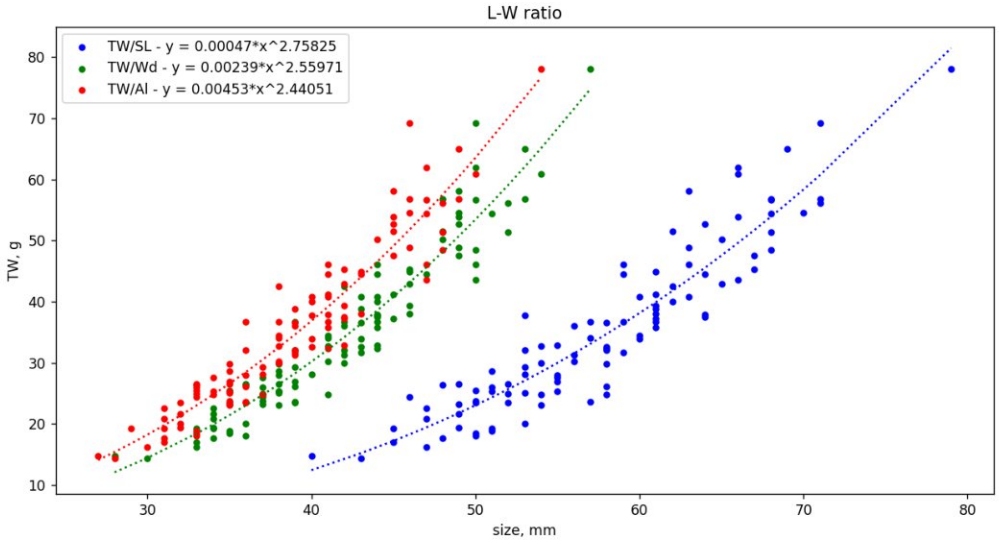

Figure 3. L-W ratios for the sampled individuals, Port Varna, 27.05.2022: (1) Total weight (TW, g) from the shell length (SL, mm); (2) Total weight (TW, g) from the shell width (Wd, mm); (3) Total weight (TW, g) and aperture length (AL, mm)

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3.1.5. Port Rodopa 1, 25.05.2022

The sample consists of 100 rapa whelk individuals (collected by scuba diving), with a weight of 4.903 kg, from a total landing of 87 kg at Port Rodopa 1.

The mean weight of the measured specimens reached 49.04 g ± 19.36 SD, at a mean length of 64.90 mm ± 9.07 SD, shell width - 46.09 mm ± 6.70 SD and aperture length 64.41 ± 9.51 SD. The mean body weight without shell (BW, g) is 17.47 g ± 7.70 SD forming 36.73 % ± 5.08 SD from the total weight, varying between 14 % и 45 % from the total weight (Table 14).

Table 14

Summarized statistics of the biological parameters – total weight (TW, g), body weight (BW, g), percentage ratio of BW (% TW), shell length (SL, mm), shell width (Wd, mm) and aperture length (aperture length, AL, mm), at Port Rodopa 1, 25.05.2022

	TW g	SL mm	W mm	Al mm	BW	BW % TW
Sum	100	100	100	100	50	50
Mean	49.04	64.41	48.42	44.98	17.62	37.24
Standard deviation	19.36	9.51	7.48	7.2	7.51	3.94
Minimum	16.24	46	31	29	6.13	28.6
25%	31.97	56.75	42	38	11.52	35.08
50% (median)	48.28	66.5	49	45	16.51	37.56
75%	61.44	71	54	50.25	22.76	39.99
Maximum	102.87	84	66	62	37.71	45.29
Sum	4903.59	6441	4842	4498	880.86	1862.24
Mode	31.18	69	49	45	10	28.6
Skewness	0.52	-0.02	-0.09	-0.08	0.7	-0.43
Sample variance	374.64	90.43	56	51.8	56.33	15.49
Kurtosis	-0.26	-0.87	-0.66	-0.7	-0.02	-0.28
Range	86.63	38	35	33	31.58	16.69
Confidence level 95%	3.79	1.86	1.47	1.41	2.08	1.09

The most common size class is - 50 - 70 mm, which is 67 % from the observed individuals. There is no clear dominant class in regard to the weight structure.

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The following percentage ratios have been calculated – shell width (Wd, mm)/shell length (SL, mm), aperture length (Al, mm)/shell width (Wd, mm) and aperture length (AL, mm)/shell width (Wd, mm) (Table 15).

TABLE 15

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 individuals from the sample from Port Rodopa 1, 25.05.2022

	Wd/SL %	Al/SL %	Al/Wd %
Sum	100	100	100
Mean	75.16	69.77	92.83
Standard deviation	3.47	3.39	1.93
Minimum	67.39	63.04	81.36
25%	72.92	67.29	91.84
50% (median)	75.4	69.81	92.86
75%	77.59	71.63	93.95
Maximum	84.31	78.43	96.23
Sum	7516.28	6976.84	9283.33
Mode	75	66.67	91.84
Skewness	0.12	0.16	-2.1
Sample variance	12.06	11.5	3.73
Kurtosis	-0.1	-0.39	11.5
Range	16.92	15.39	14.87
Confidence level 95%	0.68	0.66	0.38

The L-W ratios are calculated, Fig.4. The parameters a, b of the linear-weight relationships and the values of the correlation coefficient R^2 are presented in Table 16.

TABLE 16

Parameters a,b of the L-W ratios and values of R^2 for the sample from Port Rodopa 1, 25.05.2022

Parameters	$\mathrm{T}\boldsymbol{W(g) = a.SL(mm)^b}$	$\mathrm{T}\boldsymbol{W(g) = a.Wd(mm)^b}$	$\boldsymbol{W(g) = a.AL(mm)^b}$
a	0.00089	0.00228	0.00404
b	2.609	2.559	2.4914
R^2	0.89	0.94	0.89

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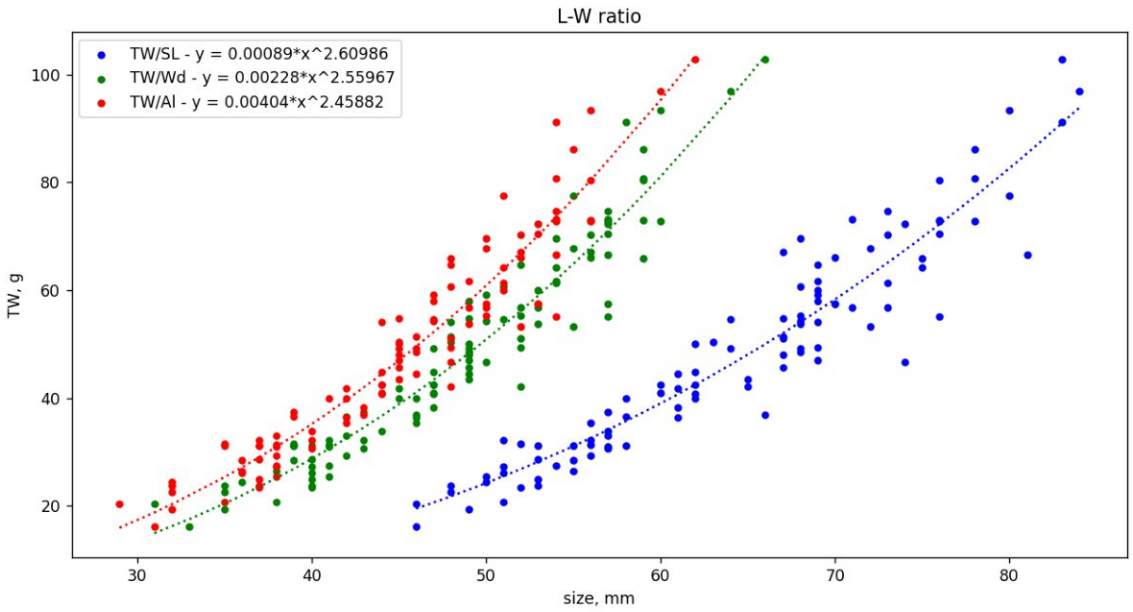

Figure 4. L-W ratios for the sampled individuals, Port Rodopa 1, 25.05.2022: (1) Total weight (TW, g) from the shell length (SL, mm); (2) Total weight (TW, g) from the shell width (Wd, mm); and (3) Total weight (TW, g) and aperture length (AL, mm)

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3.1.6. Port Nesebar, 17.06.2022

The sample consists of 100 rapa whelk individuals (beam trawl), with a weight of 3.138 kg, from a total landing of 1450 kg at Port Nesebar (from the fishing vessel).

The mean weight of the collected individuals is 31.39 g ± 13.15 SD, at a mean length of - 54.06 mm ± 7.62 SD, shell width - 40.08 mm ± 6.10 SD and aperture length 36.73 ± 5.84 SD. The mean body weight without shell (BW, g) is 12.10 g ± 5.63 SD forming 38.93 % ± 3.70 SD from the total weight, varying between 26 % и 45 % from the total weight (Table.17).

Table 17

Summarized statistics of the biological parameters – total weight (TW, g), body weight (BW, g), percentage ratio of BW (% TW), shell length (SL, mm), shell width (Wd, mm) and aperture length (aperture length, AL, mm), at Port Nesebar, 17.06.2022

	TW g	SL mm	W mm	Al mm	BW g	BW % TW
Sum	100.00	100.00	100.00	100.00	50.00	50.00
Mean	31.39	54.06	40.08	36.73	12.10	38.93
Standard deviation	13.15	7.62	6.10	5.84	5.63	3.70
Minimum	7.35	37.00	25.00	23.00	2.61	26.10
25%	21.58	48.00	36.00	32.00	8.12	36.90
50% (median)	28.67	53.00	40.00	36.50	10.99	39.36
75%	38.10	58.00	44.00	41.00	15.05	41.27
Maximum	75.19	74.00	56.00	52.00	27.46	44.70
Sum	3138.78	5406.00	4008.00	3673.00	604.84	1946.36
Mode	20.00	58.00	42.00	38.00	2.61	26.10
Skewness	0.88	0.31	0.18	0.25	0.91	-0.95
Sample variance	173.01	58.04	37.25	34.12	31.72	13.72
Kurtosis	0.98	0.00	-0.14	-0.19	0.59	2.23
Range	67.84	37.00	31.00	29.00	24.85	18.60
Confidence level 95%	2.58	1.49	1.20	1.14	1.56	1.03

The most common size class is - 40 - 60 SL, mm (83 % from the observed individuals). In regard to the weight structure, the dominant weight class is 20 - 40 TW g (61 %).

The mean ratio between the shell width (Wd, mm)/shell length (SL, mm) is 74.1 % ± 3.69 SD, while the ratio AL/SL (%) is 67.85 % ± 3.65 SD, and the ratio between the AL/Wd (%) was calculated at 91.57 % ± 1.76 SD (Table 18).

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TABLE 18

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 individuals from the sample from Port Nesebar, 17.06.2022

	Wd/SL %	Al/SL %	Al/Wd %
Sum	100	100	100
Mean	74.1	67.85	91.57
Standard deviation	3.69	3.65	1.76
Minimum	62.5	58.33	87.18
25%	71.74	65.52	90.48
50% (median)	74.11	67.8	91.58
75%	75.92	69.41	92.86
Maximum	85.37	80.49	95.35
Sum	7409.73	6785.04	9156.94
Mode	73.68	66.67	90.48
Skewness	-0.15	0.36	-0.07
Sample variance	13.65	13.33	3.08
Kurtosis	1.01	0.76	-0.33
Range	22.87	22.15	8.17
Confidence level 95%	0.72	0.72	0.34

The L-W ratios are calculated (Fig.5). The parameters *a, b* of the calculated L-W ratios and the correlation coefficient R^2 are presented in Table 19.

TABLE 19

Parameters a,b of the L-W ratios and values of R^2 for the sample from Port Nesebar, 17.06.2022

Parameters	$\mathrm{T}\boldsymbol{W(g) = a.SL(mm)^b}$	$\mathrm{T}\boldsymbol{W(g) = a.Wd(mm)^b}$	$\boldsymbol{W(g) = a.AL(mm)^b}$
a	0.00044	0.00165	0.0035
b	2.791	2.655	2.512
R^2	0.89	0.89	0.87

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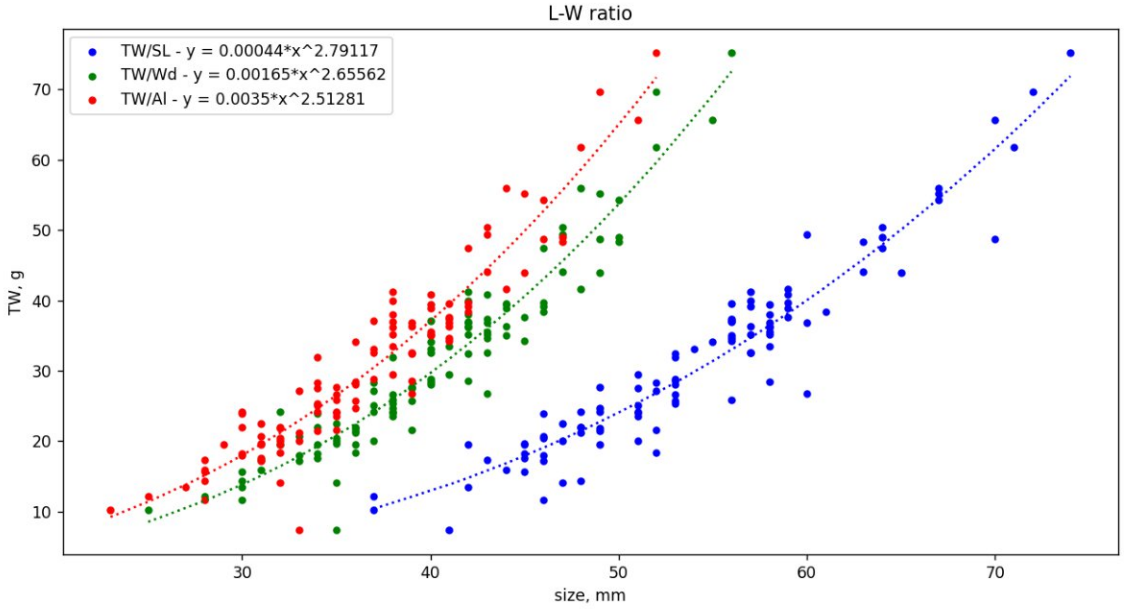

Figure 5. L-W ratios for the sampled individuals, Port Nesebar, 17.06.2022: (1) Total weight (TW, g) from the shell length (SL, mm); (2) Total weight (TW, g) from the shell width (Wd, mm); (3) total weight (TW, g) and aperture length (AL, mm)

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3.1.7. Port Sozopol, 21.06.2022

The sample consists of 100 individuals (collected by scuba diving) with a weight of 7.78 kg, from a total landing of 21 kg at Port Sozopol.

The mean weight of the individuals is 77.81 g ± 31.76 SD, at a mean length of – 74.56 mm ± 9.63 SD, shell width – 54.97 mm ± 8.25 SD and aperture length 51.67 ± 8.02 SD. The mean body weight without shell (BW, g) is 29.9 g ± 15.38 SD forming 37.89 % ± 6.31 SD from the total weight, varying between 5 % и 49 % from the total weight (Table 20).

Table 20

Summarized statistics of the biological parameters – total weight of the individuals in the sample (TW, g), body weight (BW, g), percentage ratio of BW (% TW), shell length (SL, mm), shell width (Wd, mm) and aperture length (aperture length, AL, mm), at Port Sozopol, 21.06.2022

	TW g	SL mm	W mm	Al mm	BW g	BW % TW
Sum	100.00	100.00	100.00	100.00	50	50
Mean	77.81	74.56	54.97	51.67	30.83	37.89
Standard deviation	31.76	9.63	8.25	8.02	15.24	6.31
Minimum	36.75	56.00	41.00	38.00	10.31	4.92
25%	55.62	68.00	48.00	45.00	20.93	35.88
50% (median)	71.16	73.00	54.00	51.00	26.15	38.59
75%	83.87	79.00	59.00	56.00	33.82	41.19
Maximum	209.99	107.00	83.00	79.00	87.6	49.23
Sum	7781.42	7456.00	5497.00	5167.00	1541.48	1894.67
Mode	58.43	69.00	48.00	45.00	10.31	4.92
Skewness	1.60	0.71	0.92	0.96	1.54	-2.89
Sample variance	1008.68	92.79	68.03	64.34	232.3	39.84
Kurtosis	3.34	0.74	0.85	1.01	2.77	14.74
Range	173.24	51.00	42.00	41.00	77.29	44.32
Confidence level 95%	6.22	1.89	1.62	1.57	4.22	1.75

The predominant size class is 60 - 80 SL, mm, which results in 71 % from the observed individuals. In regard to the weight structure (TW, g), the dominant class is > 70 g (52 % from all individuals).

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The mean ratio between the shell width and the shell length (WD, mm / SL, mm) is 73.05 % ± 3.47 SD, while the ratio AL/SL (%) is 69.65 % ± 3.32 SD, and the ratio of AL/Wd (%) was calculated at - 95.38 % ± 2.23 SD (Table 21).

TABLE 21

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 individuals from the sample from Port Sozopol, 21.06.2022

	Wd/SL %	Al/SL %	Al/Wd %
Sum	100	100	100
Mean	73.63	69.16	93.94
Standard deviation	3.66	3.48	1.34
Minimum	61.64	57.53	90.57
25%	71.54	67.13	92.98
50% (median)	73.48	69.23	93.91
75%	75.88	71.14	94.92
Maximum	81.93	77.17	96.88
Sum	7363.03	6916.37	9394.03
Mode	66.67	66.67	93.75
Skewness	-0.15	-0.16	-0.16
Sample variance	13.38	12.09	1.79
Kurtosis	0.33	0.57	-0.36
Range	20.28	19.64	6.31
Confidence level 95%	0.72	0.68	0.26

The L-W ratios are calculated (Fig.6). The parameters a, b of the linear-weight relationships and the values of the correlation coefficient R^2 are presented in Table 22.

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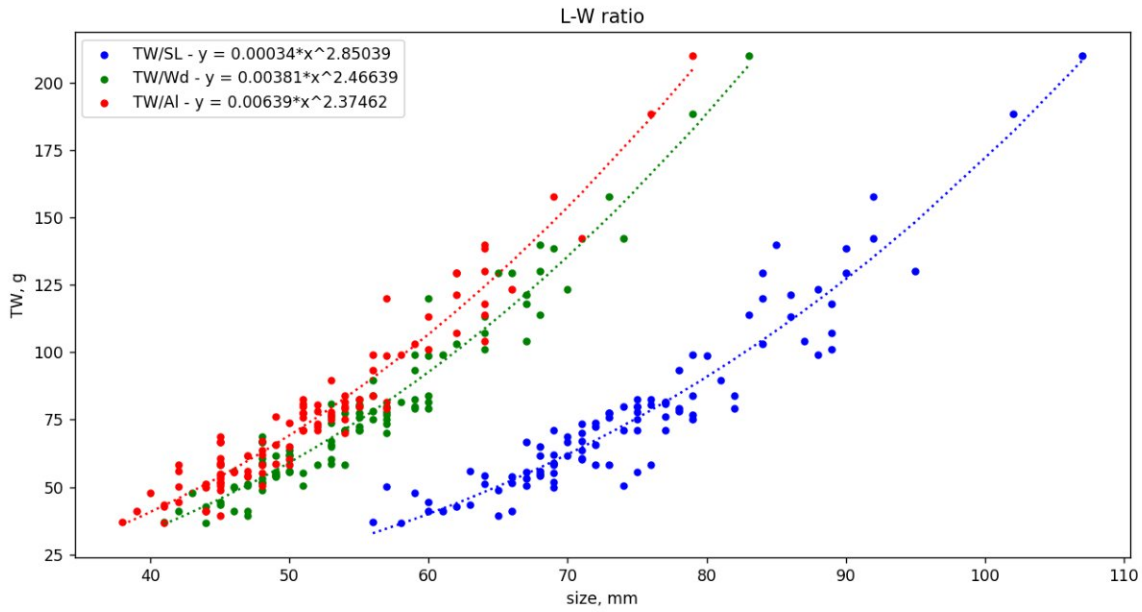

Figure 6. L-W ratios for the sampled individuals, Port Sozopol, 21.06.2022: (1) Total weight (TW, g) from the shell length (SL, mm); (2) Total weight (TW, g) from the shell width (Wd, mm); и (3) total weight (TW, g) and aperture length (AL, mm).

TABLE 22

Parameters a,b of the L-W ratios and values of R^2 for the sample from Port Sozopol, 21.06.2022

Parameters	$\mathbf{TW(g) = a.SL(mm)^b}$	$\mathbf{TW(g) = a.Wd(mm)^b}$	$\mathbf{W(g) = a.AL(mm)^b}$
a	0.00034	0.00381	0.00639
b	2.85	2.466	2.37
R^2	0.87	0.913	0.913

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3.1.8. SUMMARIZED RESULTS FOR THE FIRST HALF OF 2022

The total rapa whelk landings for the period February – June 2022 vary in the range 14 - 3211 kg/day, with the most abundant catch registered in May 2022 at Kavarna with the beam trawl fishing method (Table 23).

TABLE 23

Summarized data about the landings by days and ports from different fishing vessels for the first half of 2022

Date	Landing Port	Fishing Vessel	Fishing Method	Catch (9kg)	Sample weight (per 100 ind) (kg)
10-02-22	Rodopa 1	ВН 8396	Beam trawl	14	3.29
17-05-22	Kavarna	ВН 7643	Beam trawl	3684	3.54
01-05-22	Kavarna	КВ5642	Beam trawl	3211	3.33
27-05-22	Varna	ВН 8012	Beam trawl	1600	3.55
25-05-22	Rodopa 1	ВН 8793	Scuba diving	87	4.90
17-06-22	Nesebar	НС592	Beam trawl	1450	3.14
21-06-22	Sozopol	БС1098	Scuba diving	21	7.17

For the first half of 2022, the mean shell length size (SL, mm) in the catches from beam trawl is 56.22 mm ± 6.46 SD (Fig 10.1). In general, the size varies by ports and is dependent on the fishing method. The size varies between 54 – 57 mm for the beam trawl, while for the scuba diving it is 64 – 74 mm. (Table 24.1). The results for the weight structure (TW, g) show that the beam trawl fishing varies between 33.54 g ± 11.44 SD, (Table 24.2), while the scuba diving 63.43 g ± 25.56 SD. The mean body weight (BW, g, without shell) for the beam trawl method is 12.08 g ± 4.71 SD (Table 24.3) forming 36.10 % from the total number of the measured individuals. The average percentage ratio is in the range 31.46 % - 39.43 % from the total weight. The scuba diving shows that the body weight is 24.23 g ± 11.38 SD or 38.08% from the total weight.

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TABLE 24

Statistical data about the distribution of the shell length (SL, mm, 1), total weight (TW, g, 2) and body weight (BW, g, 3) in the samples from all ports for the first half of 2022 (The samples, collected by scuba diving, are shown in grey.)

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

Port	Sample size	Mean SL, mm	Standard deviation	Minimum SL, mm	Maximum SL, mm
Rodopa 1	100	56.03	4.68	47	70
Kavarna - 17.05.2022	100	56.28	5.58	45	80
Kavarna - 01.05.2022	100	57.1	6.92	43	77
Varna	100	57.64	7.43	40	79
Rodopa 1 scuba diving	100	64.41	9.51	46	84
Nesebar	100	54.06	7.62	37	74
Sozopol scuba diving	100	74.56	9.63	56	107

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

Port	Sample size	Mean TW, g	Standard deviation	Minimum TW, g	Maximum TW, g
Rodopa 1	100	32.97	8.17	18.63	68.13
Kavarna - 17.05.2022	100	34.57	11.17	17.03	103.89
Kavarna - 01.05.2022	100	33.3	11.22	12.51	76.19
Varna	100	35.5	13.47	14.45	78.03
Rodopa 1 scuba diving	100	49.04	19.36	16.24	102.87
Nesebar	100	31.39	13.15	7.35	75.19
Sozopol scuba diving	100	77.81	31.76	36.75	209.99

3. **Body weight (BW, g)**

Port	Sample size	Mean BW, g	Standard deviation	Minimum BW, g	Maximum BW, g
Rodopa 1	50	12.62	3	7.98	20
Kavarna - 17.05.2022	50	13.1	4.11	6.51	32.39
Kavarna - 01.05.2022	50	10.82	5.14	4.07	33.16
Kavarna 01.05.2022	50	11.75	5.67	2.65	24.13
Kavarna 01.05.2022	50	17.62	7.51	6.13	37.71
Nesebar	50	12.1	5.63	2.61	27.46

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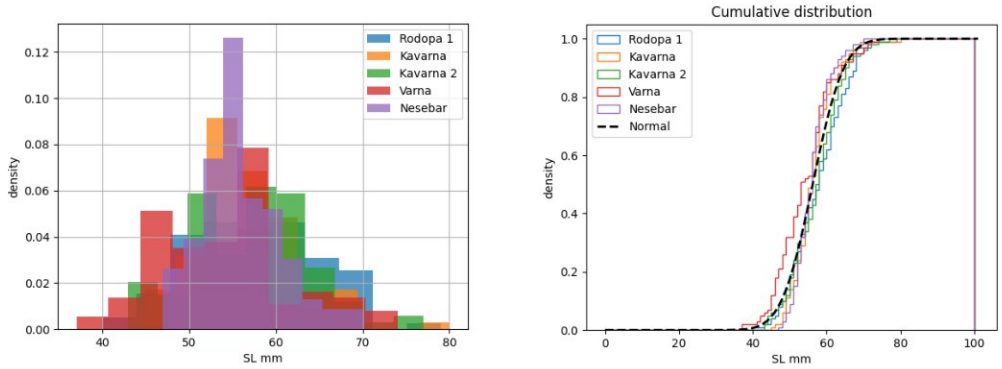
Sozopol scuba diving	50	30.83	15.24	10.31	87.6

Based on the summarized data, the most common size class is - 46 - 66 SL mm, which was observed 81 % from the observed individuals (Fig 7.1).

In regard to the weight structure (TW, g), the predominat class is < 51.2 g (96 % from the total number of observed individuals) (Fig 7.2).

1 SL mm



2 TW g

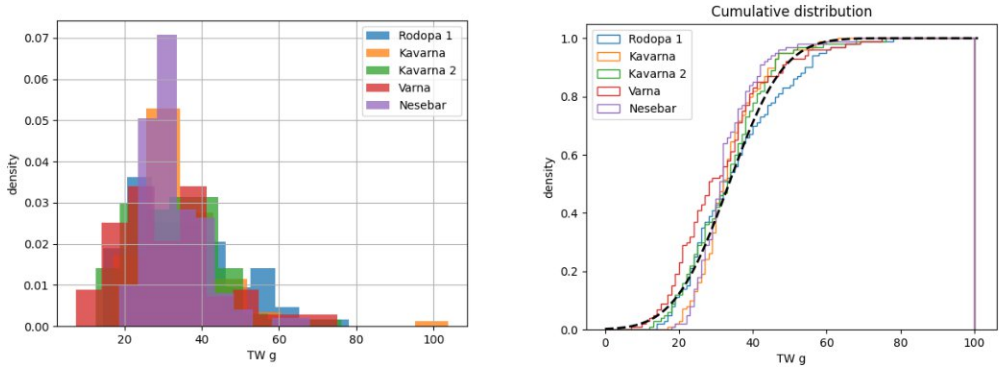


Figure 7. Distribution of the shell length (SL, mm, 1) and total weight (TW, g, 2) by classes and cumulative distribution by classes for the samples from beam trawl for the first half of 2022

Detailed data about the percentage distribution of the size and weight classes for the observed individuals in the first half of 2022 is presented on Fig. 8 и Fig. 9.

The dominant size classes in the beam trawl samples are 50 - 60 mm SL (56 %), while for the scuba diving method - 55 - 65 mm SL (37 %) (Figure 8). As for the weight structure, the dominant

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weight class for the beam trawl samples is < 50 g TW (92 % from all observed individuals), while the scuba diving method results in the weight > 80 g TW (20 % from the observed individuals) (Fig. 9).

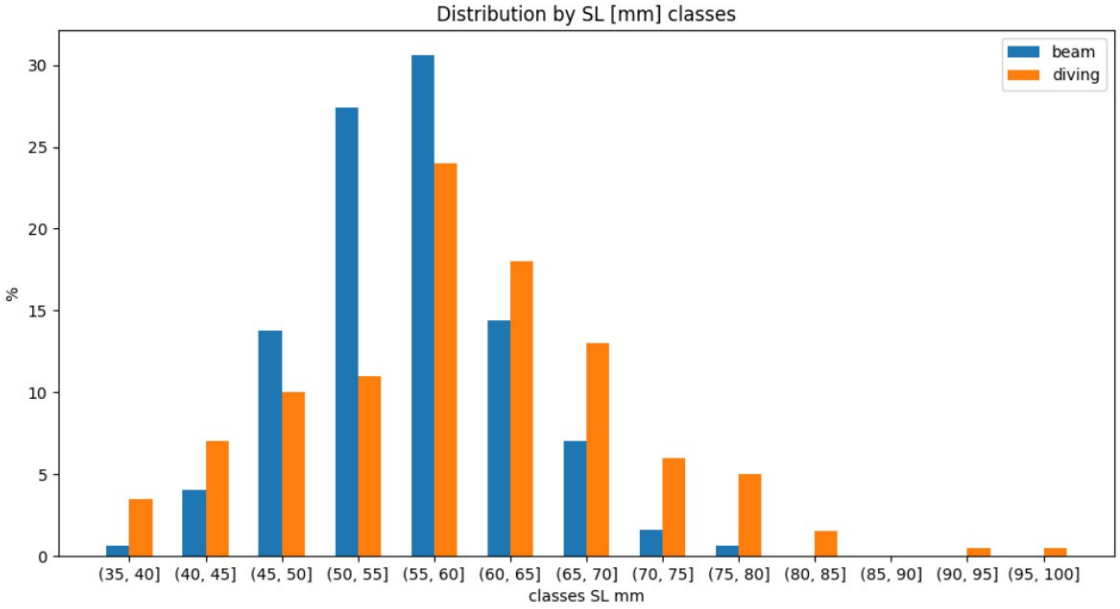

Figure 8. Distribution in % by **size class** (SL, mm), based on the summarized data from both fishing (Beam trawl and Scuba diving) for the first half of 2022

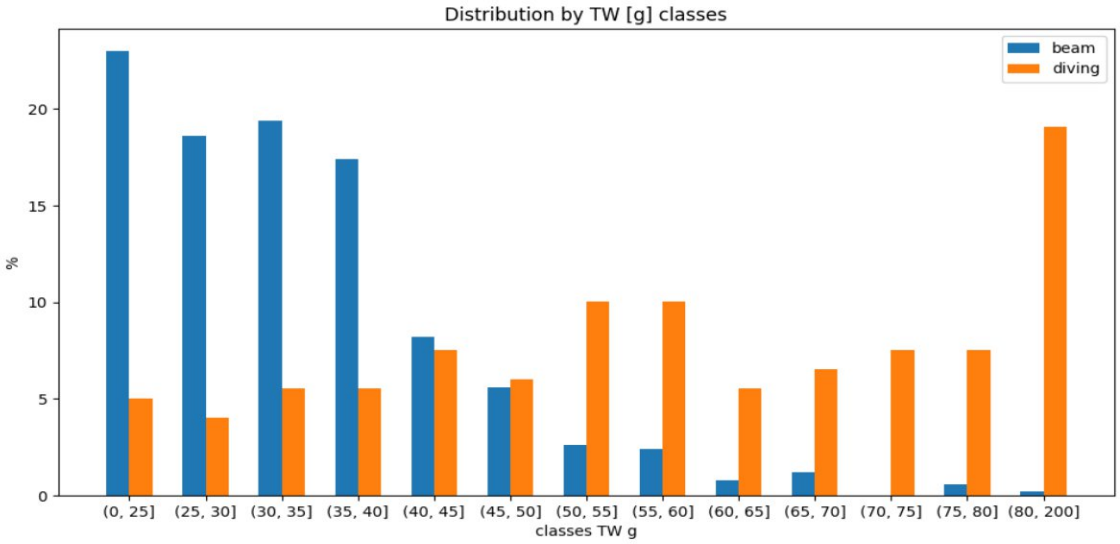

Figure 9. Distribution in % by **weight class** (TW, g) based on the summarized data from both fishing (Beam trawl and Scuba diving) for the first half of 2022

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The comparison analysis of the parameters *a* and *b* of the L-W ratio: $TW(g) = a.SL(mm)^b$ shows there is mostly allometric growth of *R. venosa* in all samples with a coefficient b ≠ 3 (Fig.10). The coefficient b < 3 is an indicator for a negative allometric growth, which means that the bigger indivuals grow faster in size than in weight. The minimum value of the coefficient *b* was registered in the sample from Kavarna, 27.05.2022, *b* = 2.55.

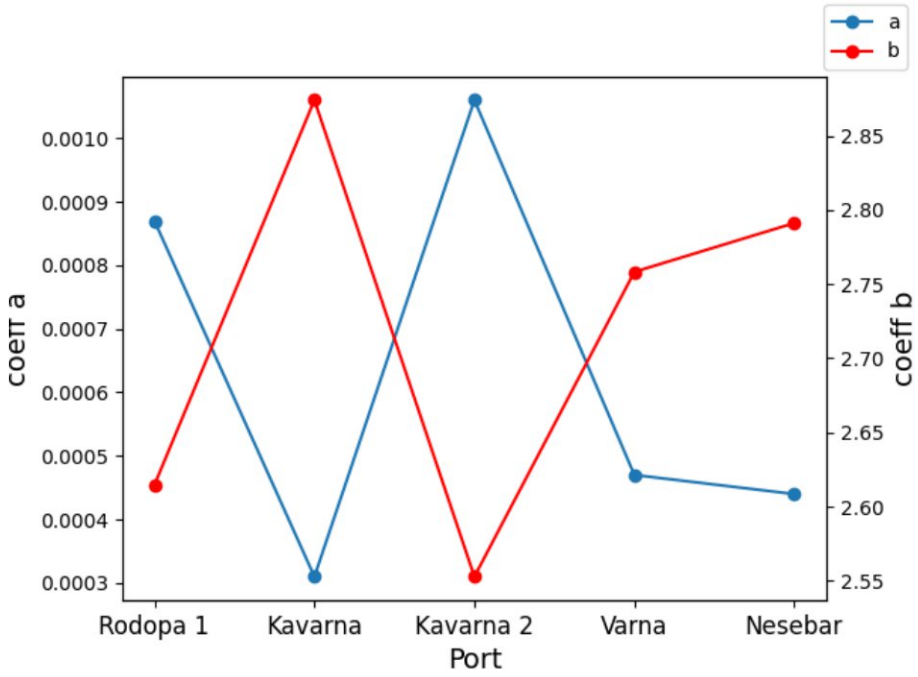

Figure 10. Parameters *a, b* of the L-W ratios for the equation $TW(g) = a.SL(mm)^b$ for all ports (beam trawl) for the first half of 2022

The mean ratios of the width/length of the shells (Wd/SL, %) of *R. venosa*, the aperture length to the shell length (AL/SL, %) and aperture length/total shell width (AL/Wd, %) by ports for the first half of 2022 are presented on Fig 11.

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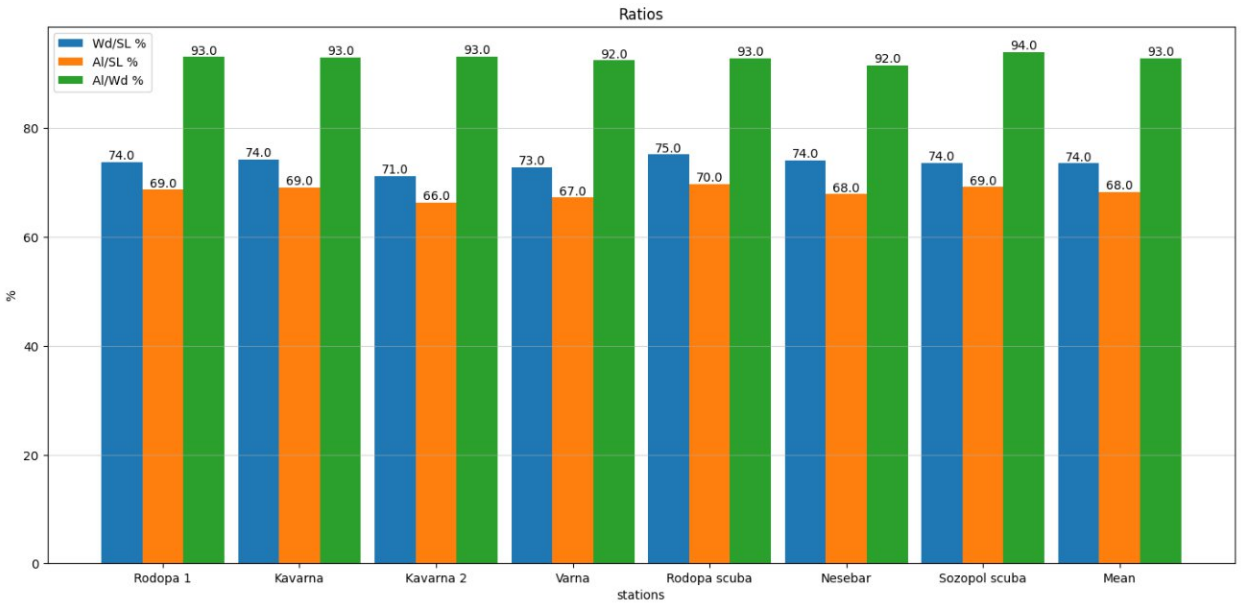

Figure 11. The mean ratios of the width/length of the shells (Wd/SL, %) of *R. venosa*, aperture length/ shell length (AL/SL, %) and aperture length/total shell width (AL/Wd, %) by ports for the first half of 2022

The mean ratio Wd/SL reaches 74 % in the first half of 2022 with very little variations between the different samples. The ratio AL/SL is 68 % on average, varying between 66 % and 70 %. The mean value of the ratio AL/Wd (%) is 93%.

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3.2. Sex structure

3.2.1. Port Rodopa 1, 10.02.2022

The sex ratio in the sample is 76 % ♂ to 24 % ♀ or 1 : 0.32.

The mean shell length for the female individuals is (SL, mm) is 56.08 mm ± 5.95 SD with similar values for the male individuals (Table 25).

Table 25

Summarized statistics of the biological parameters - shell length (SL, mm) and total weight (TW, g) by sex in the sample from Port Rodopa 1, 10.02.2022

	SL mm		TW g	
Sex	M	F	M	F
Sample size	38	12	38	12
Mean	55.61	56.08	31.92	32.55
Standard deviation	4.18	5.95	7.09	8.39
Minimum	47	48	18.63	22.93
25%	52.25	52.25	27.055	25.915
50% (median)	56	56	31.815	30.86
75%	57.75	59.25	34.2875	36.065
Maximum	65	67	47.93	49.99
Sum	2113	673	1212.81	390.64
Skewness	0.21	0.49	0.56	0.94
Sample variance	17.49	35.36	50.24	70.41
Kurtosis	-0.18	-0.37	-0.11	0.15
Range	18	19	29.3	27.06
Mode	56	56	32.19	N/A

For the parameters shell width (Wd, mm) and aperture length (aperture length, AL, mm), the percentage difference is negligible (< 1%) (Table 26).

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TABLE 26

Summarized statistics of the biological parameters - shell width (Wd, mm) and aperture length (AL, mm) by sex in the sample from Port Rodopa 1, 10.02.2022

	Wd mm		Al mm	
Sex	M	F	M	F
Sample size	38	12	38	12
Mean	41.00	41.42	38.21	38.50
Standard deviation	3.09	4.01	2.87	3.85
Minimum	36	37	33	34
25%	38.25	38	36	35
50% (median)	41	40.5	38	37.5
75%	42.75	44.5	39.75	41.25
Maximum	48	49	44	46
Sum	1558	497	1452	462
Skewness	0.36	0.64	0.17	0.64
Sample variance	9.57	16.08	8.22	14.82
Kurtosis	-0.59	-0.80	-0.73	-0.68
Range	12	12	11	12
Mode	41	N/A	39	35

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3.2.2. Port Kavarna, 17.05.2022

The sex ratio in the sample is 82 % ♂ to 18 % ♀ or 4.5 : 1.

The mean shell length for the female individuals is (SL, mm) e 52.44 mm ± 3.28 SD, while the mean shell length for the males is longer by 9 % (Table 27).

TABLE 27

Summarized statistics of the biological parameters - shell length (SL, mm) and total weight (TW, g) by sex in the sample from Port Kavarna, 17.05.2022

	SL mm		TW g	
Sex	M	F	M	F
Sample size	41	9	41	9
Mean	57.66	52.44	35.64	30.56
Standard deviation	6.11	3.28	14.11	5.80
Minimum	46	48	17.03	22.68
25%	54	49	29.1	27.59
50% (median)	57	53	33.33	29.44
75%	60	54	38.37	31.43
Maximum	80	58	103.89	42.56
Sum	2364	472	1461.04	275.02
Skewness	1.23	0.12	3.03	1.11
Sample variance	37.38	10.78	199.18	33.63
Kurtosis	3.41	-0.70	13.23	1.58
Range	34	10	86.86	19.88
Mode	N/A	N/A	N/A	N/A

For the parameters shell width (Wd, mm) and aperture length (aperture length, AL, mm), the percentage differences between the male and female individuals are 7.28 % and 7.23 %, in favor of the males (Table 28).

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TABLE 28

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, 17.05.2022

	Wd mm		Al mm	
Sex	M	F	M	F
Sample size	41	9	41	9
Mean	42.44	39.56	39.44	36.78
Standard deviation	5.20	1.81	5.11	1.64
Minimum	31	37	29	34
25%	40	38	37	36
50% (median)	42	40	38	37
75%	44	40	40	37
Maximum	60	43	57	39
Sum	1740	356	1617	331
Skewness	1.08	0.53	1.27	-0.20
Sample variance	27.05	3.28	26.15	2.69
Kurtosis	2.70	0.41	2.85	-0.19
Range	29	6	28	5
Mode	42	40	38	37

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3.2.3. Port Kavarna, 01.05.2022

The sex ratio in the sample is 60 % ♂ to 40 % ♀ or 1.5: 1. The mean shell length for the female individuals is (SL, mm) 58.05 mm ± 6.44 SD, while the shell length of the male individuals is 1% shorter (Table 29).

Table 29

Summarized statistics of the biological parameters - shell length (SL, mm) and total weight (TW, g) by sex in the sample from Port Kavarna, 01.05.2022

	SL mm		TW g	
Sex	M	F	M	F
Sample size	30	20	30	20
Mean	57.67	58.05	34.50	31.94
Standard deviation	6.75	6.44	11.94	8.99
Minimum	46	44	17.68	13.97
25%	52	54.75	25.215	24.795
50% (median)	57	59	31.34	33.865
75%	61.75	63	42.03	38.5475
Maximum	77	66	76.19	45.57
Sum	1730	1161	1034.91	638.87
Skewness	0.78	-0.77	1.52	-0.36
Sample variance	45.54	41.42	142.60	80.78
Kurtosis	0.78	-0.21	3.73	-0.85
Range	31	22	58.51	31.6
Mode	52	58	N/A	N/A

For the parameters shell width (Wd, mm) and aperture length (aperture length, AL, mm), the percentage differences between the two sexes are negligible < 1% (Table 30).

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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 Kavarna, 01.05.2022

	Wd mm		Al mm	
Sex	M	F	M	F
Sample size	30	20	30	20
Mean	41.27	40.95	38.43	38.00
Standard deviation	5.06	4.88	4.88	4.54
Minimum	34	28	31	27
25%	37.25	38.75	35	35.75
50% (median)	39.5	41	37.5	38.5
75%	44	44.25	41	41.25
Maximum	57	47	53	44
Sum	1238	819	1153	760
Skewness	1.11	-0.97	1.03	-0.76
Sample variance	25.65	23.84	23.77	20.63
Kurtosis	1.69	1.09	1.36	0.27
Range	23	19	22	17
Mode	N/A	N/A	36	36

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3.2.4. Port Varna, 27.05.2022

The sex ratio in the sample is 72 % ♂ : 28 % ♀ or 2.57 : 1. The mean female shell length (SL, mm) is 56.29 mm ± 8.66 SD, while the males are with 1% longer (Table 28). Looking at the body weight (TW, g), the mean weight for the males is 36.34 g ± 13.17 SD, while the females are lighter by 13.21 % (Table 31).

Table 31

Summarized statistics of the biological parameters - shell length (SL, mm) and total weight (TW, g) by sex in the sample from Port Varna, 27.05.2022

	SL mm		TW g	
Sex	M	F	M	F
Sample size	36	14	36	14
Mean	57.53	56.29	36.34	31.54
Standard deviation	7.57	8.66	13.17	14.02
Minimum	43	40	14.45	14.74
25%	52	50	25.415	19.9775
50% (median)	57	54	36.33	25.7
75%	63.25	63.75	46.455	42.0575
Maximum	71	68	60.91	56.74
Sum	2071	788	1308.11	441.51
Skewness	-0.06	-0.10	0.33	0.58
Sample variance	57.28	74.99	173.49	196.44
Kurtosis	-0.87	-0.97	-1.05	-1.14
Range	28	28	46.46	42
Mode	55	N/A	N/A	N/A

For the parameters shell width (Wd, mm) and aperture length (aperture length, AL, mm), the percentage differences between the male and female individuals are 5 % и 3.96 %, in favor of the males (Table 32).

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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, 27.05.2022

	Wd mm		Al mm	
Sex	M	F	M	F
Sample size	36	14	36	14
Mean	42.25	40.21	39.06	37.57
Standard deviation	6.19	7.31	5.82	6.88
Minimum	30	28	28	27
25%	38	35.25	35	33
50% (median)	42	37.5	39	34.5
75%	48.25	47	44.25	45
Maximum	54	52	50	48
Sum	1521	563	1406	526
Skewness	0.08	0.26	0.07	0.38
Sample variance	38.31	53.41	33.83	47.34
Kurtosis	-0.87	-1.05	-0.85	-1.32
Range	24	24	22	21
Mode	N/A	N/A	N/A	33

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3.2.5. Port Rodopa 1 (Scuba diving), 25.05.2022

The sex ratio in the sample is 62 % ♂: 38 % ♀ or 1.63: 1. The mean female shell length (SL, mm) is 61.32 mm ± 9.17 SD, while the mean size of the males is c 4.75 % longer (Table 30). In regard to the (TW, g) the mean body weight of the males is 49.51 g ± 18.99 SD, while the females are lighter by 12.7 % (Table 33).

Table 33

Summarized statistics of the biological parameters - shell length (SL, mm) and total weight (TW, g) by sex in the sample from Port Rodopa 1, 25.05.2022

	SL mm		TW g	
Sex	M	F	M	F
Sample size	31	19	31	19
Mean	64.23	61.32	49.51	43.20
Standard deviation	9.30	9.17	18.99	17.99
Minimum	50	46	20.8	16.24
25%	57.5	54.5	36.015	29.98
50% (median)	64	61	44.79	40.75
75%	71.5	69.5	61.66	57.58
Maximum	83	76	93.3	73.21
Sum	1991	1165	1534.66	820.73
Skewness	0.14	0.17	0.56	0.46
Sample variance	86.45	84.12	360.64	323.73
Kurtosis	-0.92	-1.02	-0.17	-1.06
Range	33	30	72.5	56.97
Mode	N/A	53	N/A	N/A

For the parameters shell width (Wd, mm) and aperture length (aperture length, AL, mm), the percentage differences between the male and female individuals are 10.23 % и 12.27 %, in favor of the males (Table 34).

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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 Rodopa 1, 25.05.2022

	Wd mm		Al mm	
Sex	M	F	M	F
Sample size	31	19	31	19
Mean	49.26	46.32	45.58	43.16
Standard deviation	6.65	7.67	6.11	7.36
Minimum	38	33	35	31
25%	44	40.5	40.5	37.5
50% (median)	49	46	45	42
75%	55.5	53.5	50	50
Maximum	60	60	56	56
Sum	1527	880	1413	820
Skewness	0.03	0.13	0.03	0.17
Sample variance	44.26	58.89	37.32	54.14
Kurtosis	-1.21	-0.87	-1.07	-0.95
Range	22	27	21	25
Mode	47	N/A	N/A	37

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3.2.6. Port Nesebar, 17.06.2022

The sex ratio in the sample is 50 % ♂ : 50 % ♀ or 1 : 1. The mean shell size (SL, mm) for the female individuals is 50.88 mm ± 3.58 SD, which is about 2.08 % shorter than the size of the males (Table 35). The mean weight of the male individuals 21.02 g ± 5.59 SD, while the female mean weight is with 4.85% lower (Table 35).

Table 35

Summarized statistics of the biological parameters - shell length (SL, mm) and total weight.(TW, g) by sex in the sample from Port Nesebar, 17.06.2022

	SL mm		TW g	
Sex	M	F	M	F
Sample size	25	25	25	25
Mean	55.92	52.40	34.10	27.88
Standard deviation	8.55	6.55	17.48	9.26
Minimum	41	43	7.35	14.13
25%	51	47	21.6	20.68
50% (median)	56	52	34.29	26.58
75%	60	56	39.73	34.61
Maximum	74	70	75.19	48.75
Sum	1398	1310	852.47	697.09
Skewness	0.42	0.95	0.82	0.59
Sample variance	73.16	42.92	305.62	85.72
Kurtosis	-0.24	0.83	0.42	-0.51
Range	33	27	67.84	34.62
Mode	51	N/A	N/A	N/A

For the parameters shell width (Wd, mm) and aperture length (aperture length, AL, mm), the percentage differences between the male and female individuals are 7.07 % и 7.36 % in favor of the male individuals (Table 36).

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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 Nesebar, 17.06.2022

	Wd mm		Al mm	
Sex	M	F	M	F
Sample size	25	25	25	25
Mean	41.80	39.04	38.48	35.84
Standard deviation	7.07	4.95	6.79	4.76
Minimum	30	31	28	28
25%	37	36	34	32
50% (median)	42	38	38	35
75%	46	43	42	39
Maximum	56	49	52	46
Sum	1045	976	962	896
Skewness	0.29	0.49	0.36	0.52
Sample variance	50.00	24.46	46.09	22.64
Kurtosis	-0.43	-0.48	-0.56	-0.47
Range	26	18	24	18
Mode	46	N/A	N/A	N/A

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3.2.7. Port Sozopol (Scuba diving), 21.06.2022

The sex ratio in the sample is 48 % ♂ : 52 % ♀ or 1 : 1.08.

The mean shell size (SL, mm) for the female individuals is 70.08 mm ± 7.17 SD, which is about 13.91 % shorter than the size of the males (Table 37). The mean weight of the male individuals 90.35 g ± 36.38 SD, while the female mean weight is with 35.23% lower.

Table 37

Summarized statistics of the biological parameters - shell length (SL, mm) and total weight. (TW, g) by sex in the sample from Port Sozopol, 21.06.2022

	SL mm		TW g	
Sex	M	F	M	F
Sample size	24	26	24	26
Mean	79.83	70.08	90.35	66.81
Standard deviation	9.60	7.17	36.68	24.83
Minimum	66	56	41.05	37.14
25%	71.75	66	64.3075	53.5475
50% (median)	77.5	69	79.135	61.525
75%	87.25	73	118.485	75.345
Maximum	102	92	188.51	157.69
Sum	1916	1822	2168.40	1737.07
Skewness	0.54	1.05	0.92	2.20
Sample variance	92.14	51.43	1345.40	616.40
Kurtosis	-0.47	2.66	0.51	6.71
Range	36	36	147.46	120.55
Mode	71	68	N/A	N/A

For the parameters shell width (Wd, mm) and aperture length (aperture length, AL, mm), the percentage differences between the male and female individuals are 13.68 % и 13.93 % in favor of the male individuals (Table 39).

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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, 21.06.2022

	Wd mm		Al mm	
Sex	M	F	M	F
Sample size	24	26	24	26
Mean	59.38	52.23	55.92	49.08
Standard deviation	8.62	7.15	8.50	6.85
Minimum	47	41	44	38
25%	53	48	49.75	45
50% (median)	58	50	54	47.5
75%	67	55	64	52
Maximum	79	73	76	69
Sum	1425	1358	1342	1276
Skewness	0.59	1.26	0.71	1.19
Sample variance	74.33	51.14	72.17	46.95
Kurtosis	-0.43	2.09	-0.24	2.15
Range	32	32	32	31
Mode	53	55	64	N/A

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3.2.8. Gonadosomatic Index (GSI)

The summarized statistics of the dynamics of the gonadosomatic index (GSI) for the first half of 2022 is presented in Table 39. The mean ratio of the index is 15.30 % BW.

Table 39

Summarized statistics of GSI (% BW) by ports for the first half of 2022

	Rodopa 1	Kavarna 17.05.2022	Kavarna 2 01.05.2022	Varna	Rodopa 1 scuba	Nesebar	Sozopol scuba
Mean	14.23	15.53	14.11	14.14	14.84	17.27	17.03
Standard deviation	3.67	2.55	2.96	4.22	3.41	3.44	3
Minimum	4.74	3.76	8.06	7.43	9.75	10.88	12.44
25%	12.34	14.26	12.33	11.11	12.59	15.1	14.59
50% (median)	14.88	15.55	14.28	13.6	14.14	17.04	17.2
75%	16.81	16.59	15.66	16.49	16.98	19.22	18.68
Maximum	20.8	20.02	19.71	27.12	23.16	27.79	26.1
Sample variance	-0.7	-1.7	-0.02	0.89	0.62	0.56	0.75
Skewness	13.46	6.5	8.77	17.78	11.6	11.81	8.99
Kurtosis	0.01	8.34	-0.53	0.72	-0.22	0.63	0.28
Range	16.06	16.26	11.65	19.69	13.41	16.91	13.67
Mode	4.74	3.76	8.06	7.43	9.75	10.88	12.44
Confidence level (95.0%)	0.51	0.35	0.41	0.58	0.48	0.48	0.42

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3.2.9. SUMMARIZED RESULTS ABOUT SEX STRUCTURE

The ratio between the two sexes is 64 % ♂: 36 % ♀ for all observed individuals (Fig 12). No imposex forms were identified in the first half of 2022.

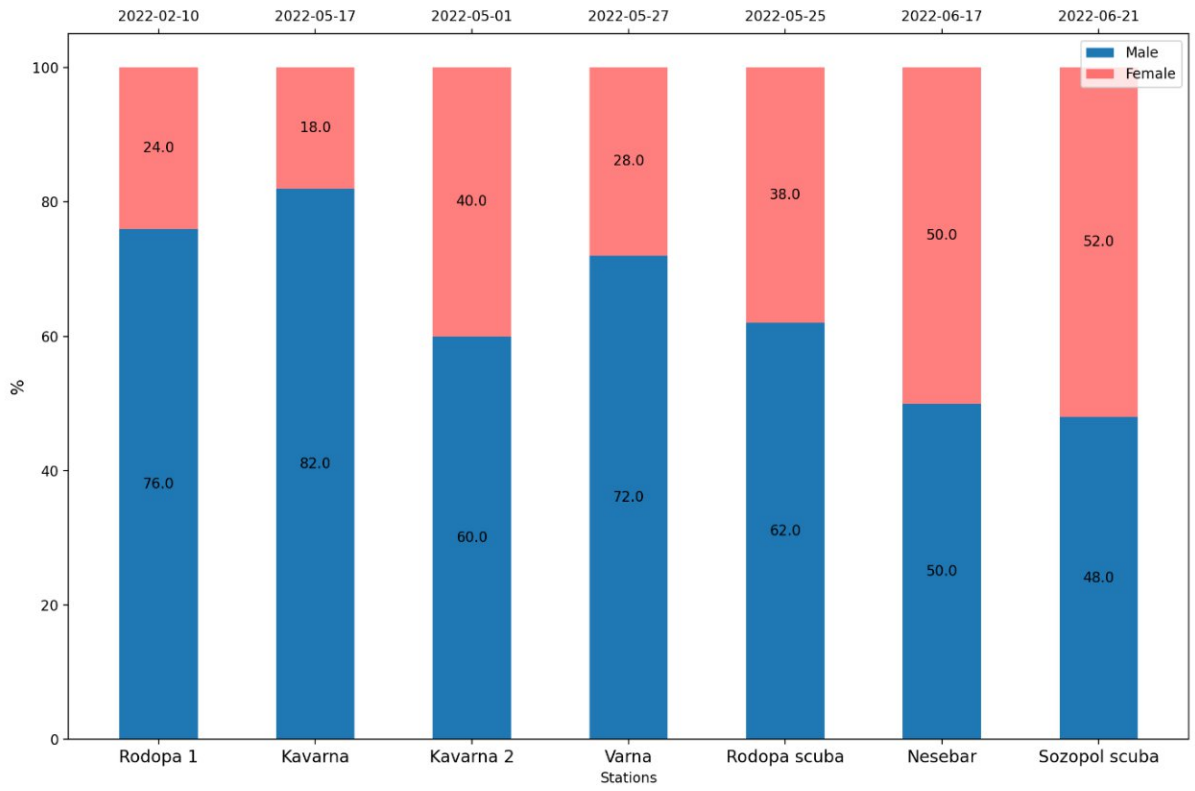

Figure 12. Summarized data about the sex structure of *R. venosa* by ports for the first half of 2022

The mean shell length (SL, mm) of the male individuals from beam trawl 56.87 mm ± 6.63 SD, with the highest value in the sample from Kavarna (17.05.2021, Table 36.1, Fig.13.1) - 57.65 mm. The mean shell length of the female individuals is 55.05 mm ± 6.17 SD, which is about 4.7% smaller than the males. Looking at the weight structure, the males have a mean weight of 34.50 g ± 12.76 SD, while the females – 33.96 g ± 9.29 SD, which is 1.5% in favor of the male individuals (Table 40, Fig.13.2).

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TABLE 40

Statistical data about the distribution of the size (SL, mm, 1) and weight (TW, g, 2) by sex and ports for the first half 2022(data from scuba diving is in grey).

1. Size (SL, mm)

Port	Sex	Mean	Standard deviation	min	max
Rodopa 1	M	55.61	4.18	47.00	65.00
	F	56.08	5.95	48.00	67.00
Kavarna 17.05.2022	M	57.66	6.11	46.00	80.00
	F	52.44	3.28	48.00	58.00
Kavarna 01.05.2022	M	57.67	6.75	46.00	77.00
	F	58.05	6.44	44.00	66.00
Varna	M	57.53	7.57	43.00	71.00
	F	56.29	8.66	40.00	68.00
Rodopa 1 scuba diving	M	64.23	9.30	50.00	83.00
	F	61.32	9.17	46.00	76.00
Nesebar	M	55.92	8.55	41.00	74.00
	F	52.40	6.55	43.00	70.00
Sozopol scuba diving	M	79.83	9.60	66.00	102.00
	F	70.08	7.17	56.00	92.00

2. Total weight (TW, g)

Port	Sex	Mean	Standard deviation	min	max
Rodopa 1	M	31.92	7.09	18.63	47.93
	F	32.55	8.39	22.93	49.99
Kavarna 17.05.2022	M	35.64	14.11	17.03	103.89
	F	30.56	5.80	22.68	42.56
Kavarna 01.05.2022	M	34.50	11.94	17.68	76.19
	F	31.94	8.99	13.97	45.57
Varna	M	36.34	13.17	14.45	60.91
	F	31.54	14.02	14.74	56.74
Rodopa 1 scuba diving	M	49.51	18.99	20.80	93.30
	F	43.20	17.99	16.24	73.21
Nesebar	M	34.10	17.48	7.35	75.19
	F	27.88	9.26	14.13	48.75
Sozopol scuba	M	90.35	36.68	41.05	188.51

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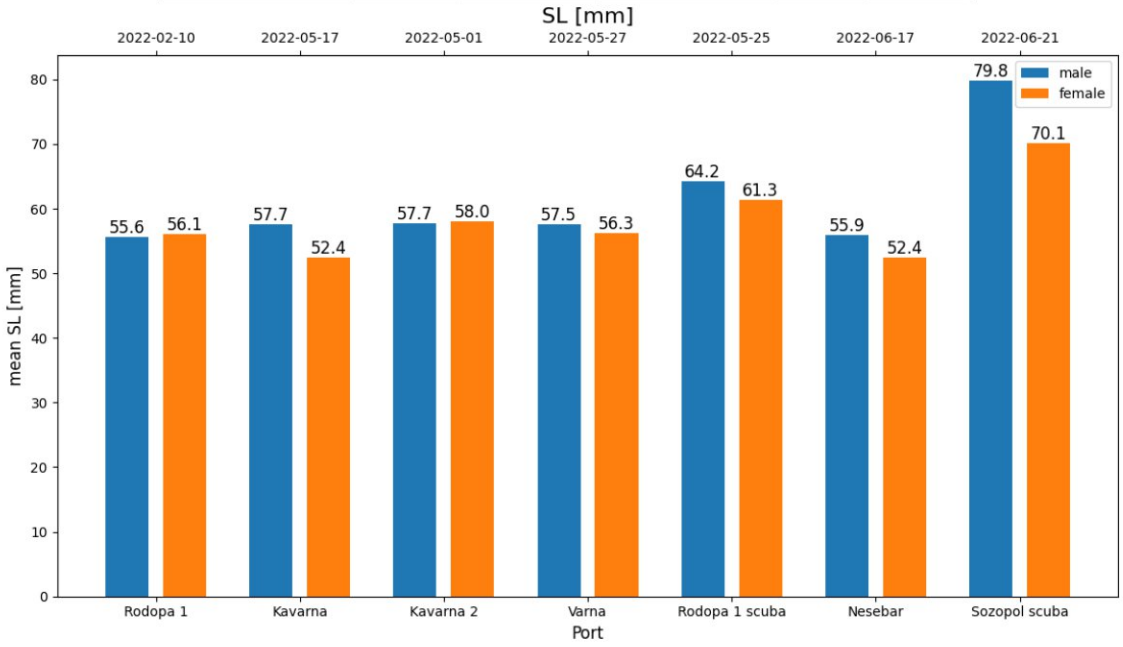
diving	F	66.81	24.83	37.14	157.69



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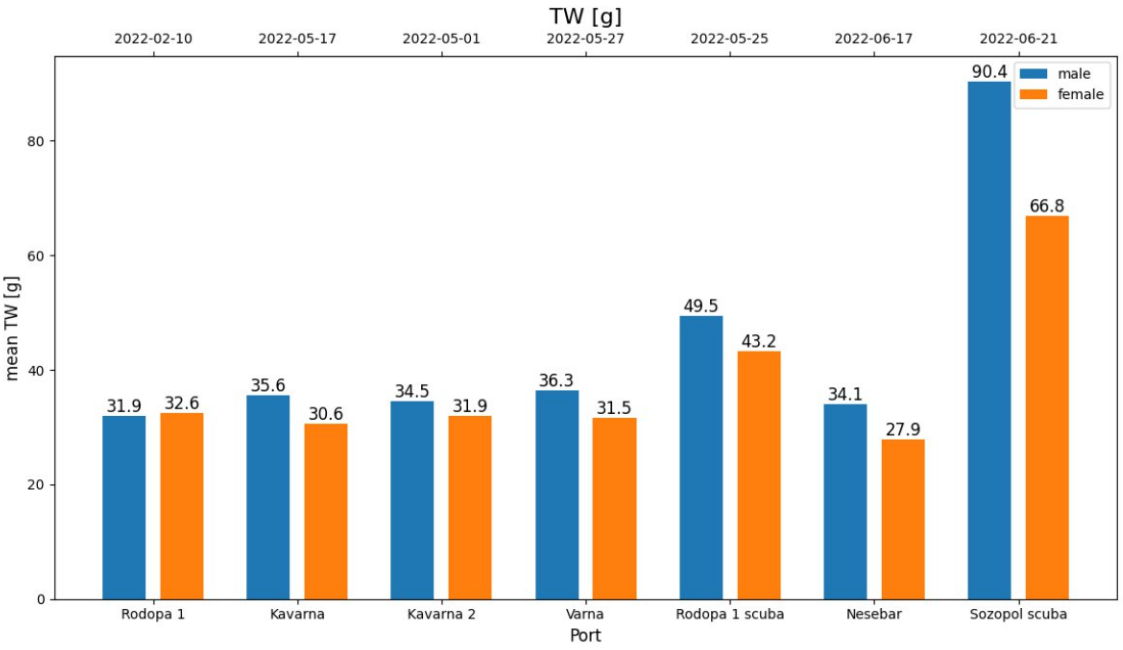

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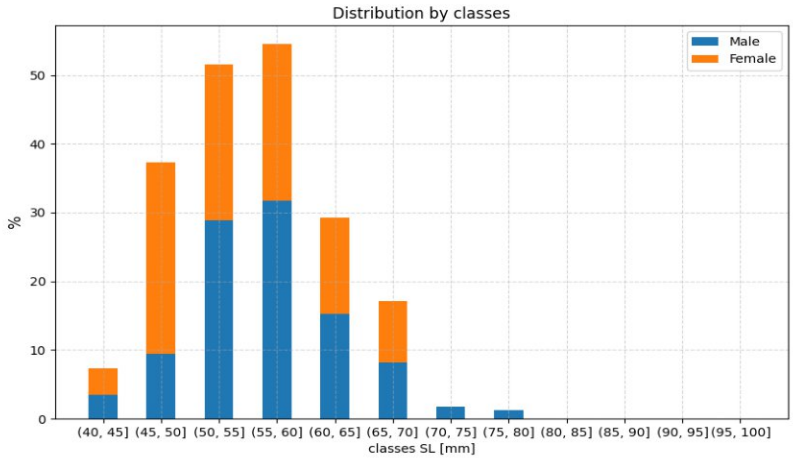
Figure 13. Summarized data for the (1) mean size (SL, mm) of *R. venosa* by sex and (2) mean weight (TW, g) by sex for the first half of 2022

The analysis of the size class dynamics by sex shows that in beam trawl catches, the size class 51 - 60 mm is the dominant one or 60 % from the total number of the male individuals. The female individuals that fall into this size class 35 % from the observed individuals (Fig.14.1). The situation in the beam trawl catches shows that the bigger size classes are almost missing for the male individuals with just 3.5% in the class > 71 mm, while no female individual was observed in this size class. On the contrary, the weight classes 65 – 70 and 70 – 75 mm are predominant in the scuba diving catches for both sexes (40% from both the male and female individuals).



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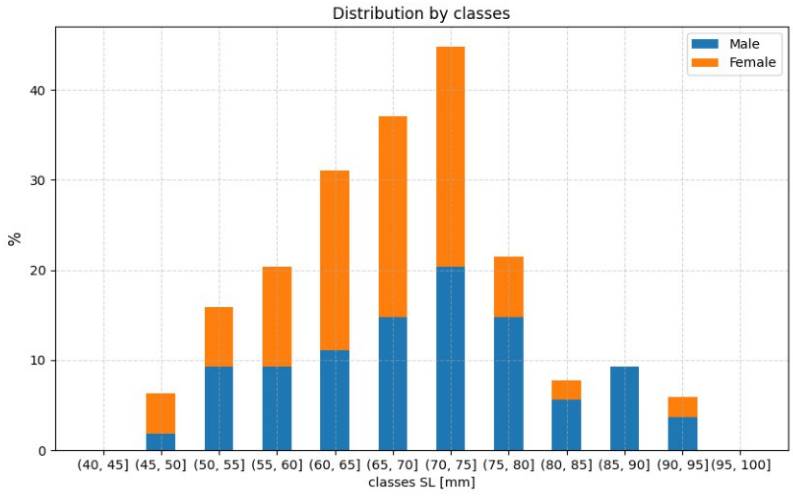

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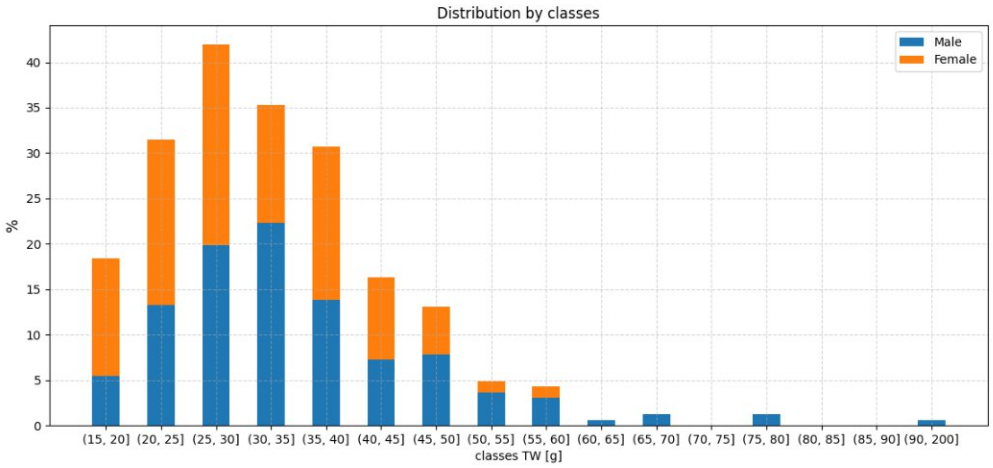
Figure 14. Percentage distribution by size class (SL, mm) of males (M) and females (F) for the first half of 2022: (1) beam trawl and (2) scuba diving

The weight structure of the beam trawl catches reveals that the dominant weight class from both sexes is 25 – 30 g (Fig. 15.1), which can be observed in 20 % of the male individuals and 25% of the females. The scuba diving catches show that most males fall into the weight class > 90 g (20%), while the females are in the class 50 – 55g (30%).

1.



2.

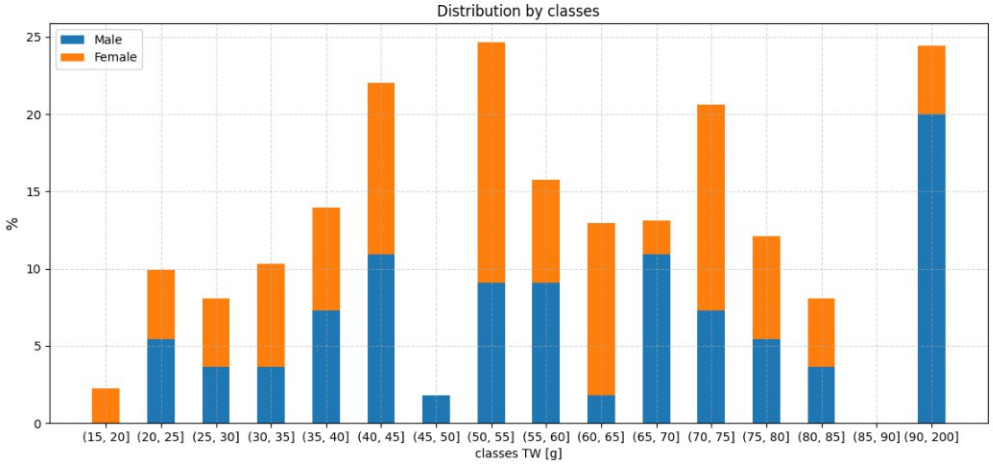


Figure 15. Percentage distribution by weight class (TW, g) of males (M) and females (F) for the first half of 2022: (1) beam trawl and (2) scuba diving

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Based on all the data it can be concluded that for the first half of 2022 the growth of the male individuals is negative allometric ($b < 3$), while the growth of the female individuals is positive allometric ($b > 3$). The parameters of the equation L-W for both sexes are presented on Fig. 16 and in Table 41).

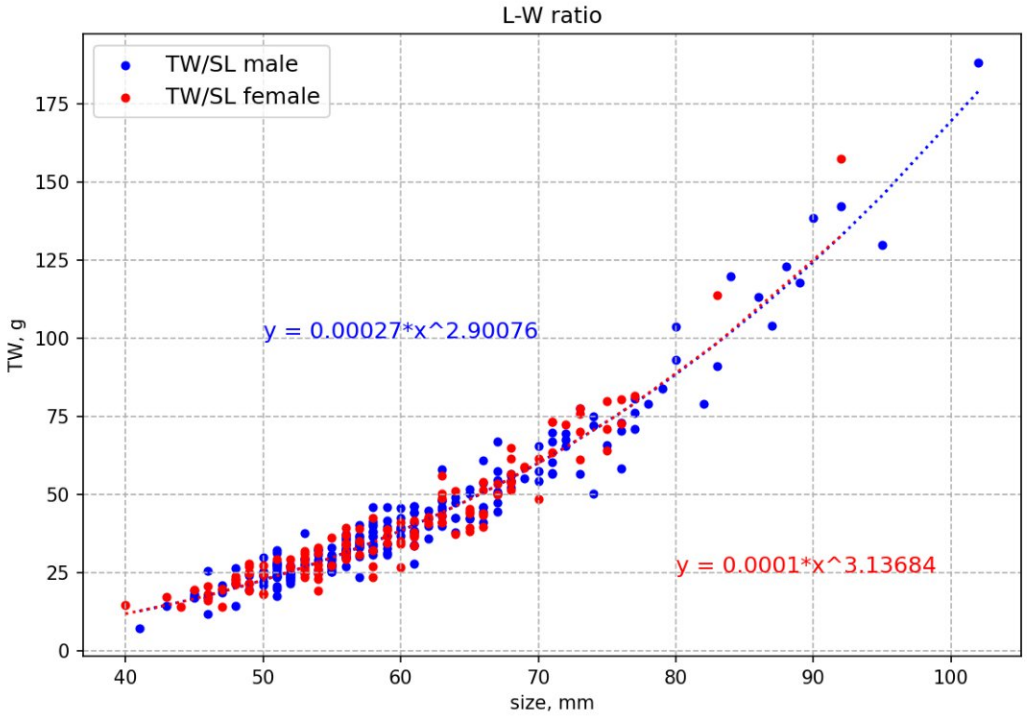

Figure 16. Total weight (TW, g) from the shell length (SL, mm) for all individuals based on the summarized data for the beam trawl fishing for the first half of 2022 (M - males, F - females).

TABLE 41

Parameters a, b of the L-W ratios and values of R^2 by sex based on the summarized data from the beam trawl samples for the first half of 2022

Parameters $TW(g) = a.SL(mm)^b$	♀	♂
a	0.0001	0.00027
b	3.1368	2.9007
R^2	0.855	0.897

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4. CONCLUSIONS

- The analyzes in this report are based on biometric measurements of 700 individuals *R. venosa*, including 500 specimens, collected from beam trawl catches and 200 specimens from scuba diving catches. The landings samples were collected at the ports – Rodopa 1, Kavarna, Varna, Nesebar and Sozopol. In the case of the beam-trawls fishery, the total daily quantities of landings at the observed ports vary between 14 - 3684 kg/day, as the most significant quantities were landed in May at Port Kavarna. When fishing by scuba diving, landings in May – June vary between 21 - 87 kg/day, with the highest value at port Rodopa 1 (25.05.2022).
- The variations of the average sizes of *Rapana venosa* by ports depend mostly on the fishing method - for beam trawl fishery, the average lengths of the specimens are between 54 - 57 mm, and for scuba diving samples between 64 – 74 mm. The mean length of specimens, collected by beam trawl in this period, is 56.22 mm ± 6.45 SD, with an average weight of 33.55 g ± 11.43 SD. By the scuba diving fishery, the average weight of the Rapa whelk is 63.43 g ± 25.56 SD, with an average length of 69.49 mm ± 9.57 SD. The average body weight (BW) in the beam trawl samples is 12.08 g ± 4.71 SD, forming 36.10 % of the weight of individuals, and by ports, thee average percentage varies slightly between 31.46 % - 39.43 %. %. In the case of scuba diving fishery, the mean body weight of Rapa whelk is 24.23 g ± 11.38 SD or 38.08% from the total weight.
- The beam trawls catches are dominated by the specimens from the size class - 46 - 60 mm SL (72 % from the observed individuals), while the predominant class in the catches by scuba diving method was with larger sizes - 55 - 70 mm SL (60 %). The same can be observed for the weight structure of the rapa whelks, with the beam trawl fishing resulting in classes < 50 g TW (92 % from the samples), while the scuba diving method has classes above > 80 g TW (20 % from the observed individuals).
- The mean Wd/SL (%) percentage ratio of the beam trawl specimens for the first half of 2022 is 73.2 % with no clear variations in the samples. The mean ratio of AL/SL (%) is 67.8 %, varying in the 66 % - 69 % for the different samples. The mean ratio AL/Wd (%) is 92.5 %, varying between 92 % до 93 %. The scuba diving method results in 74.5 % Wd/SL, 69.5 % AL/SL and 93.5 % AL/Wd accordingly.
- The comparison analysis of the *a* and *b* of the L-W ratio: $W(g) = a \times L(mm)^b$, shows allometric growth of *R. venosa* at a coefficient $b \neq 3$. The smallest value of the coefficient $b = 2.55$ was observed at Port Kavarna (27.05.2022), while $b < 3$ is an indicator for the negative allometric growth, meaning that the bigger in weight individuals do not grow in size with the same rate.
- The averaged sex ratio for all the samples from all ports results in 64 ♂: 36 % ♀. The mean value of the gonadosomatic index (GSI) is 15.30 % BW, with the highest observed in the sample from Sozopol in June 2022 (17.06.2022) – 17.27 % BW ± 3.44 SD.

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- The average length of the males in the samples from beam trawl fishing 56.87 mm ± 6.63 SD, while the highest length (57.65 mm) was observed for the individuals at Port Kavarna in May 2022 (17.05.2022). The mean length of the female individuals is 55.05 mm ± 6.17 SD, which is about 4.70% lower than the males. The mean weight of the male individuals e 34.50 g ± 12.76 SD, the females being smaller by 1.5% at 33.96 g ± 9.29 SD. The scuba diving method results in the males having a mean length in the range 72.03 mm ± 9.45 SD with a weight of 69.93 g ± 27.83 SD, while the females are 65.70 mm ± 8.17 SD with a weight of 55.00 g ± 21.41 SD.
- In the beam trawl catches, the size class 51 - 60 mm is dominant with 60 % share from the total male individuals and 31% from the females. The selective scuba diving method results in 65 – 70 mm and 70 -75 mm accordingly, which is 40 % from the observed both male and female individuals. The weight structure of the individuals, caught by beam trawl, is dominated by the class - 25 - 30 g, which was registered in 20 % of the male individuals and 22.5 % of the females. In regard to the scuba diving, the following classes are predominant – males > 90 g (20 %), females - 50 - 55 g (30 %).

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