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

SCIENTIFIC REPORT FOR 2024

IFR - Varna

3/31/25

Contract with EAFA - 147/10.03.2023

Co-funded by the European Union

MINISTRY OF AGRICULTURE AND FOOD

MARITIME, FISHERIES AND AQUACULTURE PROGRAMME

This study is carried out by researchers from the Institute of Fish Resources – Varna, Agricultural Academy (AA), within Contract EAFA - 147 /10.03.2023 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 2024.

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 2024 and represents the dynamics of the biological parameters of *Rapana venosa* from the landed catch at seven ports "Kavarna", "Rodopa 1", "Nessebar", "Balchik", "Varna", "Pomorie", "Primorsko" based on the biometric measurements and analysis of 1300 specimens of the target species.

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Petrova E., Mihneva V., Tserkova E., F., Stoykov S., Valchev S., Penchev Ph., 2024. BIOLOGICAL MONITORING (BIOLOGICAL SAMPLES COLLECTION) OF THE LANDED RAPANA CATCH BY THE BULGARIAN FISHING FLEET FOR 2024, Report under Contract with the Executive Agency for Fisheries and Aquaculture, National Fisheries Data Collection Program., p.94

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Project № BG14MFPR001-1.002-0001, „Collection, management and use of data for the purposes of scientific analysis and implementation of the Common Fisheries Policy for the period 2023-2024“, funded by the Maritime, Fisheries and Aquaculture Programme, co-financed by the European Union through the European Maritime, Fisheries and Aquaculture Fund.

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1. INTRODUCTION

The current report is representative for 2024 and is based on biometric measurements on 1300 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 – "Kavarna", "Rodopa 1", "Nessebar", "Balchik", "Varna", "Pomorie" and „Primorsko".

1.1. COLLECTED DATA

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

1. Data about the fishing vessels' activity

- Fishery 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* – lengths, 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 1300 specimens of *Rapana venosa*, 800 from beam trawl and 500 from scuba diving) was carried out by landings in ports, as the samples are collected from six ports - in the northern and southern marine waters, with regular fishing of Rapa whelk. The survey covers 12 days in the period March – October 2024, while the surveyed ports are "Kavarna", "Rodopa 1", "Nessebar", "Balchik", "Varna", "Pomorie" and „Primorsko“, 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
31/03/2024	Kavarna	КВ5642	beam trawl	10.04 GT, 12.2 m, 69.88 kW
02/04/2024	Rodopa 1	ВН 7643	beam trawl	26.11 GT, 14.7 m, 147.1 kW
06/04/2024	Nessebar	НС592	scuba diving	3.13 GT, 9 m, 58.84 kW
15/05/2024	Nessebar	НС592	scuba diving	3.13 GT, 9 m, 58.84 kW
16/05/2024	Balchik	ВН 8042	beam trawl	28.94 GT, 17.7 m, 110.33 kW
05/06/2024	Varna	ВН 7979	beam trawl	19.74 GT, 15.97 m, 235 kW
17/06/2024	Pomorie	НС611	scuba diving	1.65 GT, 7.2 m, 22.07 kW
24/07/2024	Kavarna	ВН8311	beam trawl	LOA 17.23, GT 14.95, kW 126
24/07/2024	Rodopa 1	Akula-1	beam trawl	LOA 14.64, GT 26.03, kW 220
24/09/2024	Pomorie	ПМ153	scuba diving	LOA 7.2, GT 1.46, kW 22.07
25/09/2024	Varna	Tais	beam trawl	LOA 19.4, GT 46, kW 378
26/09/2024	Rodopa 1	Akula-1	beam trawl	LOA 14.64, GT 26.03, kW 220
15/10/2024	Primorsko	ПР428	scuba diving	LOA 8, GT 3.35, kW 73.55

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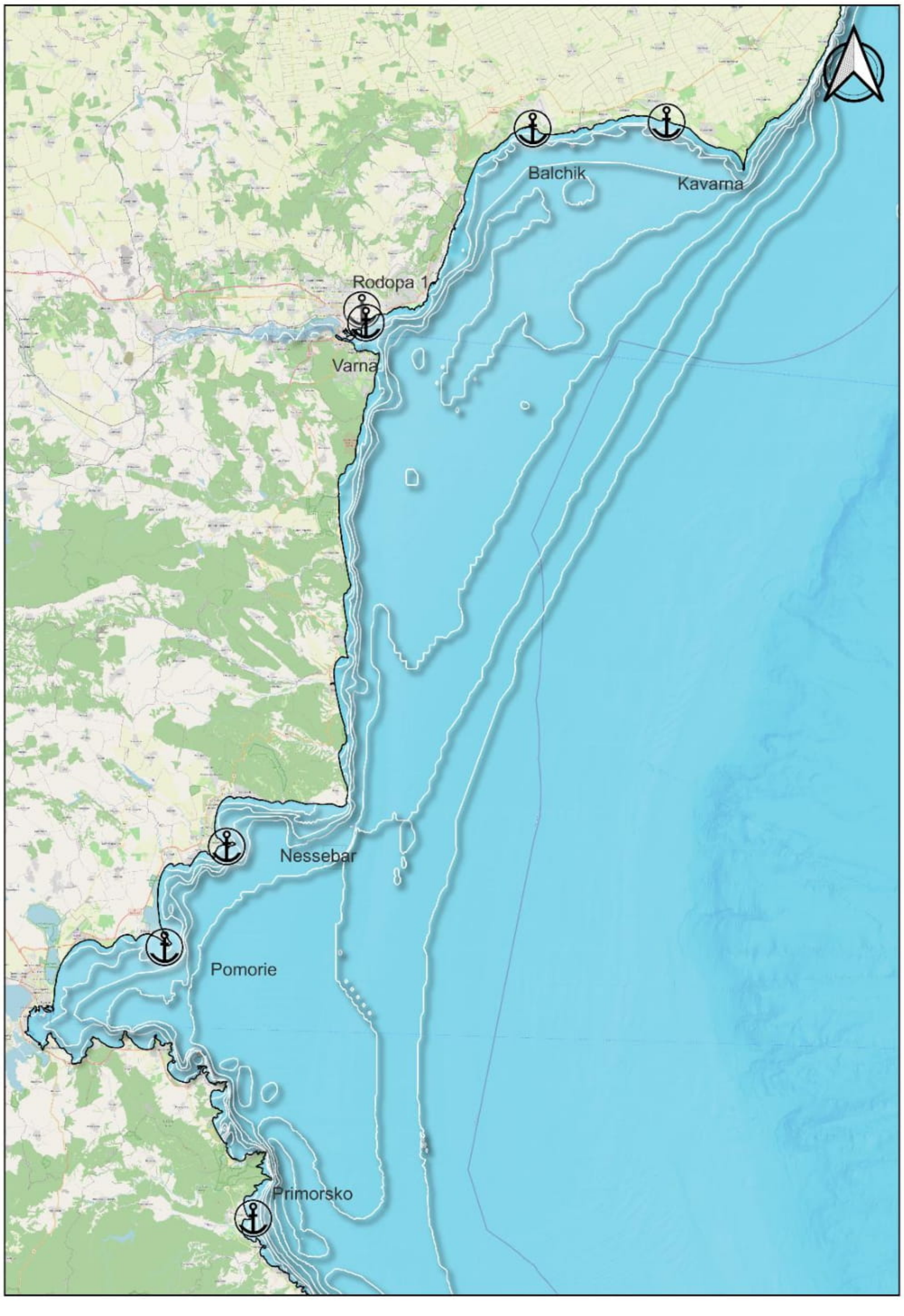

Figure 1 Landing ports for 2024

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The beam-trawl has the following parameters – maximum width - 5.3 m, maximum depth - 6 m: 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 April, May and June, September and October 2024, samples were collected from landings from scuba diving - Nessebar, Pomorie и Primorsko. 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:

$W(g) = a.L(mm)^b$, 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.

3. RESULTS

3.1. BIOMETRIC MEASUREMENTS AND LENGTH-WEIGHT RELATIONSHIPS

3.1.1. PORT KAVARNA, 31.03.2024

The sample consists of 100 individuals rapa whelk, weighing 2.282 kg, from a total landing of 959 kg rapa whelks at port Kavarna (from the fishing vessel).

The mean weight of the measured specimens reaches 22.82 g ± 7.99 SD , at a mean shell length of – 49.33 mm ± 5.31 SD, shell width – 36.84 mm ± 4.43 SD and aperture length 34.29 mm ± 4.23 SD. The mean body weight without shell (BW, g) is 8.54 g ± 2.78 SD forming 35.72 % ± 3.82 SD from the total weight, varying between 23.88 % and 45.85 % 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 Kavarna, 31.03.2024

	TW g	SL mm	Wd mm	Al mm	BW g	BW % TW
Sample size	100	100	100	100	50	50
Mean	22.82	49.33	36.84	34.29	8.54	35.72
Standard deviation	7.99	5.31	4.43	4.23	2.78	3.82
Minimum	9.92	40.00	27.00	25.00	4.56	23.88
50% (median)	22.25	49.00	37.00	34.50	8.18	36.05
Maximum	59.53	67.00	49.00	47.00	20.11	45.85
Sum	2282.40	4933.00	3684.00	3429.00	426.89	1785.91
Mode	23.73	50	39.00	32.00	8.06	38.92
Skewness	1.37	0.50	0.32	0.33	1.63	-0.49
Sample variance	0.35	0.11	0.12	0.12	0.33	0.11
Kurtosis	3.72	0.30	-0.10	0.09	4.50	1.23
Range	49.61	27.00	22.00	22.00	15.55	21.97
Confidence level 95%	1.58	1.05	0.88	0.84	0.79	1.09

The mean ratio between the shell width (Wd, mm)/shell length (SL, mm) is 74.64 % ± 3.27 SD, while AL/SL (%) is 69.45 % ± 3.07 SD, and the ratio between AL/Wd (%) was calculated at – 93.06 % ± 1.73 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 Kavarna, 31.03.2024

	Wd/SL %	Al/SL %	Al/Wd %
Sample size	100	100	100
Mean	74.64	69.45	93.06
Standard deviation	3.27	3.07	1.73
Minimum	65.85	60.98	88.89
50% (median)	74.25	69.31	93.41
Maximum	82.98	76.47	97.06
Sum	7464.11	6945.02	9305.98
Mode	75	66.67	92.31
Skewness	0.18	-0.01	-0.27
Sample variance	0.04	0.04	0.02
Kurtosis	0.33	-0.09	-0.68
Range	17.13	15.49	8.17
Confidence level 95%	0.65	0.61	0.34

The L-W ratios have been calculated, Figure 2. The parameters a, b of the linear-weight relationships and the values of the correlation coefficient R^2 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 Kavarna, 31.03.2024

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	0.00023	0.00147	0.00234
b	2.94	2.67	2.59
R^2	0.95	0.95	0.96

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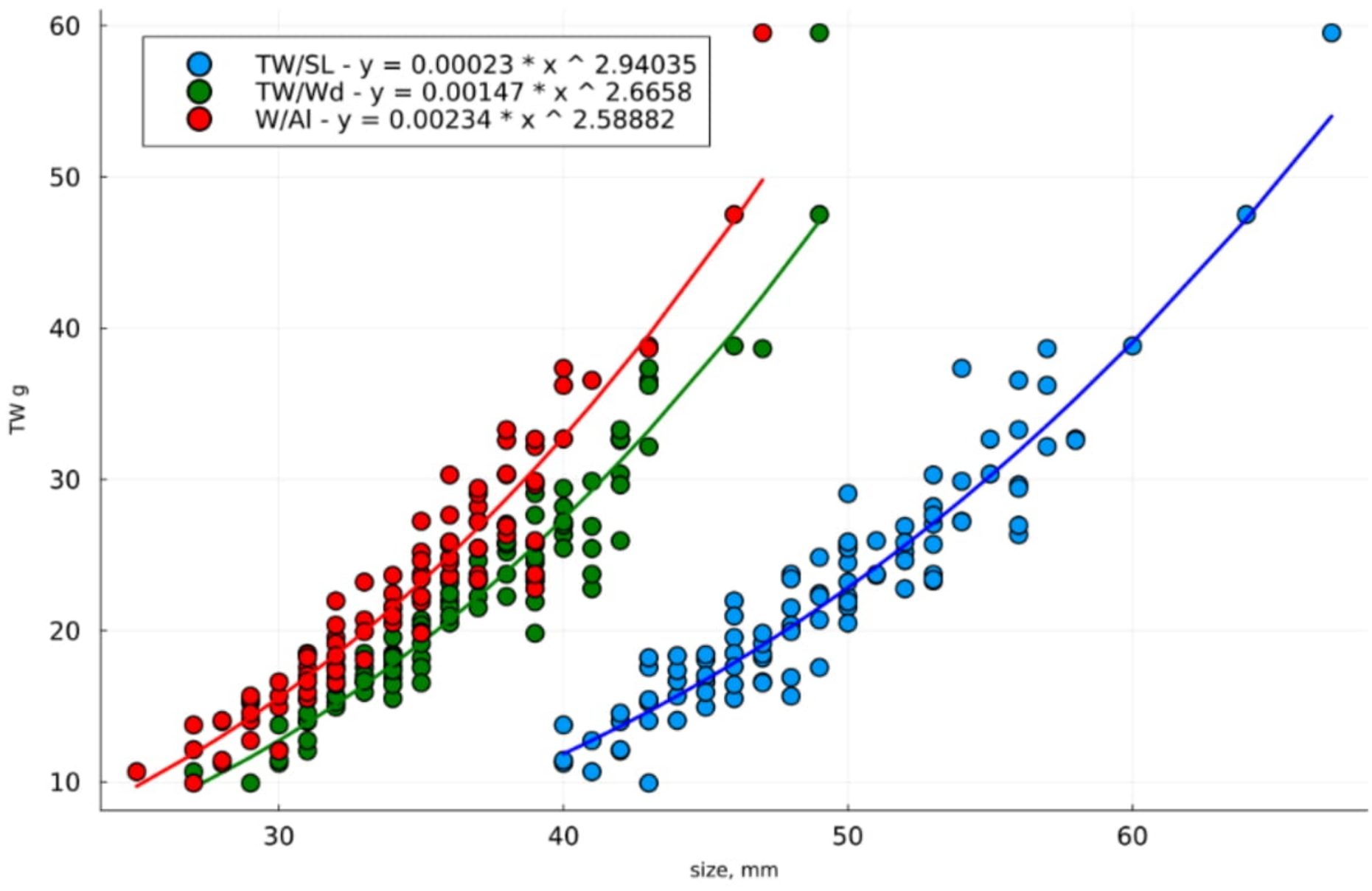

Figure 2 L-W ratios for the sampled individuals, Port Kavarna, 31.03.2024 (1) ratio between total weight (TW, g) and shell length (SL, mm); (2) relationship between total weight (TW, g) and shell width (Wd, mm); (3) relationship between total weight (TW, g) and aperture length (AL, mm)

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3.1.2. PORT RODOPA 1, 02.04.2024

The sample consists of 100 individuals rapa whelk, weighing 2.634 kg, from a total landing of 3219 kg rapa whelks at port Rodopa 1 (from the fishing vessel).

The mean weight of the measured specimens reaches 26.34 g ± 21.31 SD, at a mean shell length of 50.39 mm ± 11.48 SD, shell width 37.55 mm ± 9.12 SD and aperture length 35.35 ± 8.78 SD. The mean body weight without shell (BW, g) is 13.27 g ± 10.62 SD forming 33.79 % ± 6.44 SD from the total weight, varying between 16.87% and 47.05 % 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 Rodopa 1, 02.04.2024

	TW g	SL mm	Wd mm	Al mm	BW g	BW % TW
Sample size	100	100	100	100	50	50
Mean	26.34	50.39	37.55	35.35	13.27	33.79
Standard deviation	21.31	11.48	9.12	8.78	10.62	6.44
Minimum	5.70	35.00	24.00	23.00	2.72	16.87
50% (median)	18.12	47.00	35.00	33.00	8.82	33.55
Maximum	117.19	84.00	65.00	62.00	39.12	47.05
Sum	2634.17	5039.00	3755.00	3535.00	860.87	1693.66
Mode	14.63	47.00	34.00	27.00	15.29	11.29
Skewness	1.93	1.04	0.99	1.01	1.62	2.78
Sample variance	0.81	0.23	0.24	0.25	0.29	0.35
Kurtosis	3.43	0.29	0.17	0.19	4.62	12.09
Range	111.49	49.00	41.00	39.00	27.60	82.51
Confidence level 95%	4.23	2.28	1.81	1.74	1.40	3.34

The mean ratio between the shell width (Wd, mm)/shell length (SL, mm) is 74.37 % ± 3.91 SD, while AL/SL (%) is 69.95 % ± 3.96 SD, and the ratio between AL/Wd (%) was calculated at - 94.06 % ± 1.97 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 Rodopa 1, 02.04.2024

	Wd/SL %	Al/SL %	Al/Wd %
Sample size	100	100	100
Mean	74.37	69.95	94.06
Standard deviation	3.91	3.96	1.97
Minimum	66.67	62.22	88.24
50% (median)	74.39	70	94.37
Maximum	95.12	92.68	97.44
Sum	7437.32	6995.09	9405.69
Mode	72.34	69.05	93.1
Skewness	1.29	1.72	-0.47
Sample variance	0.05	0.06	0.02
Kurtosis	6.38	9.19	-0.14
Range	28.46	30.46	9.2
Confidence level 95%	0.78	0.79	0.39

The L-W ratios are calculated, Figure 3. The parameters a, b of the linear-weight relationships and the values of the correlation coefficient R^2 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 Rodopa 1, 02.04.2024

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	0.00019	0.00096	0.00142
b	2.98	2.77	2.71
R^2	0.98	0.98	0.98

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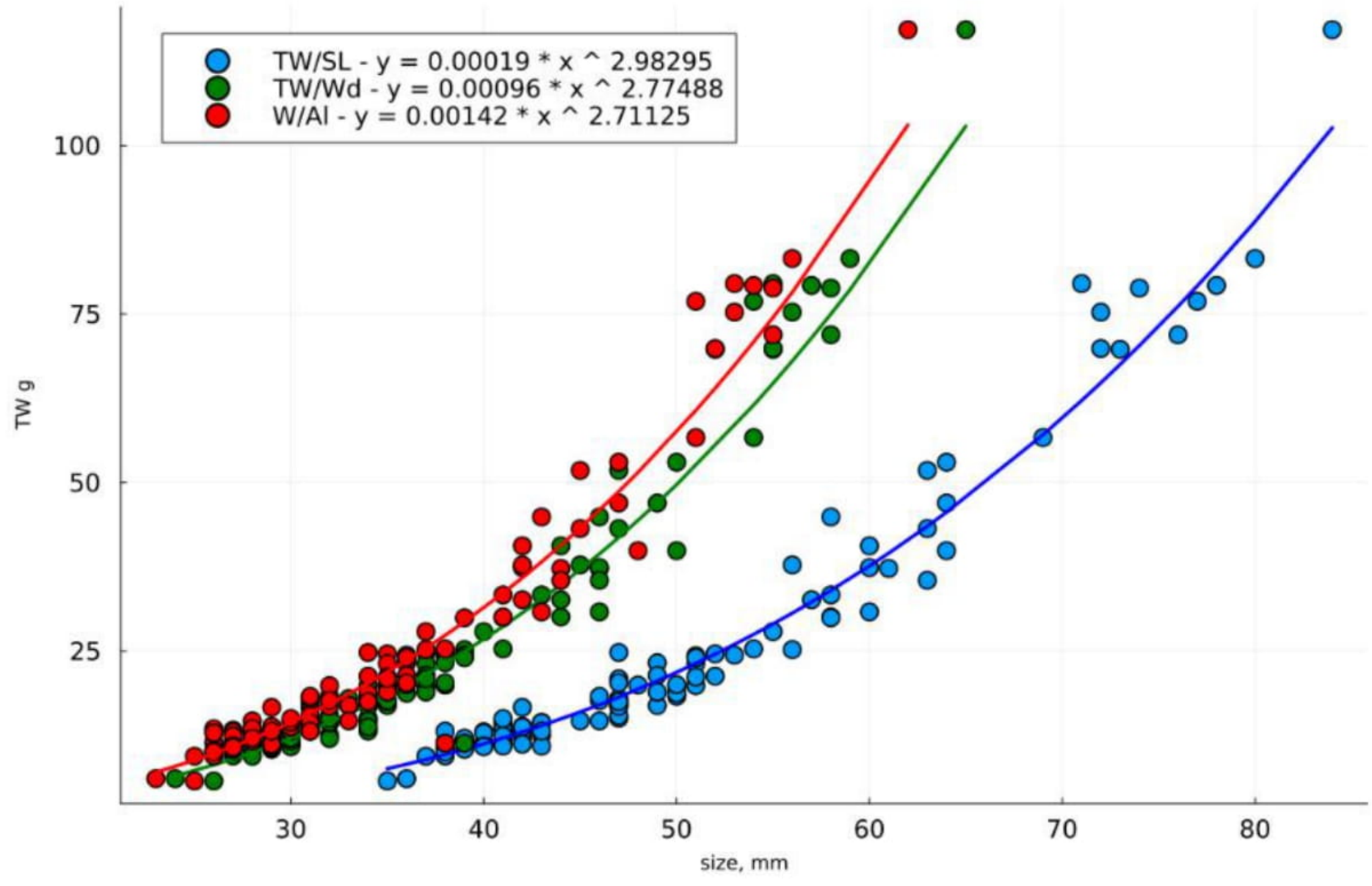

Figure 3 L-W ratios for the sampled individuals, port Rodopa 1, 02.04.2024: (1) Total weight (TW, g) from the shell length (SL, mm); (2) Total weight (TW, g) from the shell width (Wd, mm); (3) total weight (TW, g) and aperture length (AL, mm)

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3.1.3. PORT NESSEBAR (SCUBA DIVING), 06.04.2024

The sample consists of 100 individuals rapa whelk (from scuba diving), with a weight of 4.601 kg, from a total landing of 120 kg rapa whelks at port Nessebar.

The mean weight of the measured specimens reaches 46.01 g ± 28.52 SD, at a mean shell length of 60.91 mm ± 13.03 SD, shell width – 45.80 mm ± 10.39 SD and aperture length 42.83 mm ± 10.1 SD. The mean body weight without shell (BW, g) is 17.39 g ± 10.2 SD forming 30.86 % ± 5.19 SD from the total weight, varying between 18.93 % и 39.04 % from the total weight (Table 8).

Table 8

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 Nessebar, 06.04.2024

	TW g	SL mm	Wd mm	Al mm	BW g	BW % TW
Sample size	100	100	100	100	50	50
Mean	46.01	60.91	45.80	42.83	17.39	30.86
Standard deviation	28.52	13.03	10.39	10.10	10.2	5.19
Minimum	7.52	35.00	25.00	23.00	4.20	18.93
50% (median)	44.14	62.00	46.50	43.00	16.18	39.04
Maximum	148.39	94.00	71.00	68.00	51.18	39.04
Sum	4600.56	6091.00	4580.00	4283.00	578.53	1876.12
Mode	70.94	51.00	52.00	49.00	7.79	41.82
Skewness	1.08	0.14	0.01	0.09	2.33	0.90
Sample variance	0.62	0.21	0.23	0.24	0.57	0.09
Kurtosis	1.46	-0.70	-0.80	-0.75	6.88	0.98
Range	140.87	59.00	46.00	45.00	35.99	16.90
Confidence level 95%	5.66	2.59	2.06	2.00	1.87	0.93

The mean ratio between the shell width (Wd, mm)/shell length (SL, mm) is 75.06 % ± 4.46 SD, while AL/SL (%) is 70.06 % ± 4.31 SD, and the ratio between AL/Wd (%) was calculated at - 93.36 % ± 2.25 SD (Table 9).

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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 Nessebar, 06.04.2024

	Wd/SL %	Al/SL %	Al/Wd %
Sample size	100	100	100
Mean	75.06	70.06	93.36
Standard deviation	4.46	4.31	2.25
Minimum	63.83	59.74	81.36
50% (median)	74.58	70.32	93.68
Maximum	86.76	81.25	98.44
Sum	7505.75	7006.3	9336.16
Mode	75	66.67	92.31
Skewness	0.19	0.14	-1.68
Sample variance	0.06	0.06	0.02
Kurtosis	0.13	-0.26	7.03
Range	22.93	21.51	17.08
Confidence level 95%	0.88	0.85	0.45

The L-W ratios are calculated, Figure 4. 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 Nessebar, 06.04.2024

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	0.00023	0.00123	0.00206
b	2.94	2.72	2.63
R^2	0.97	0.93	0.94

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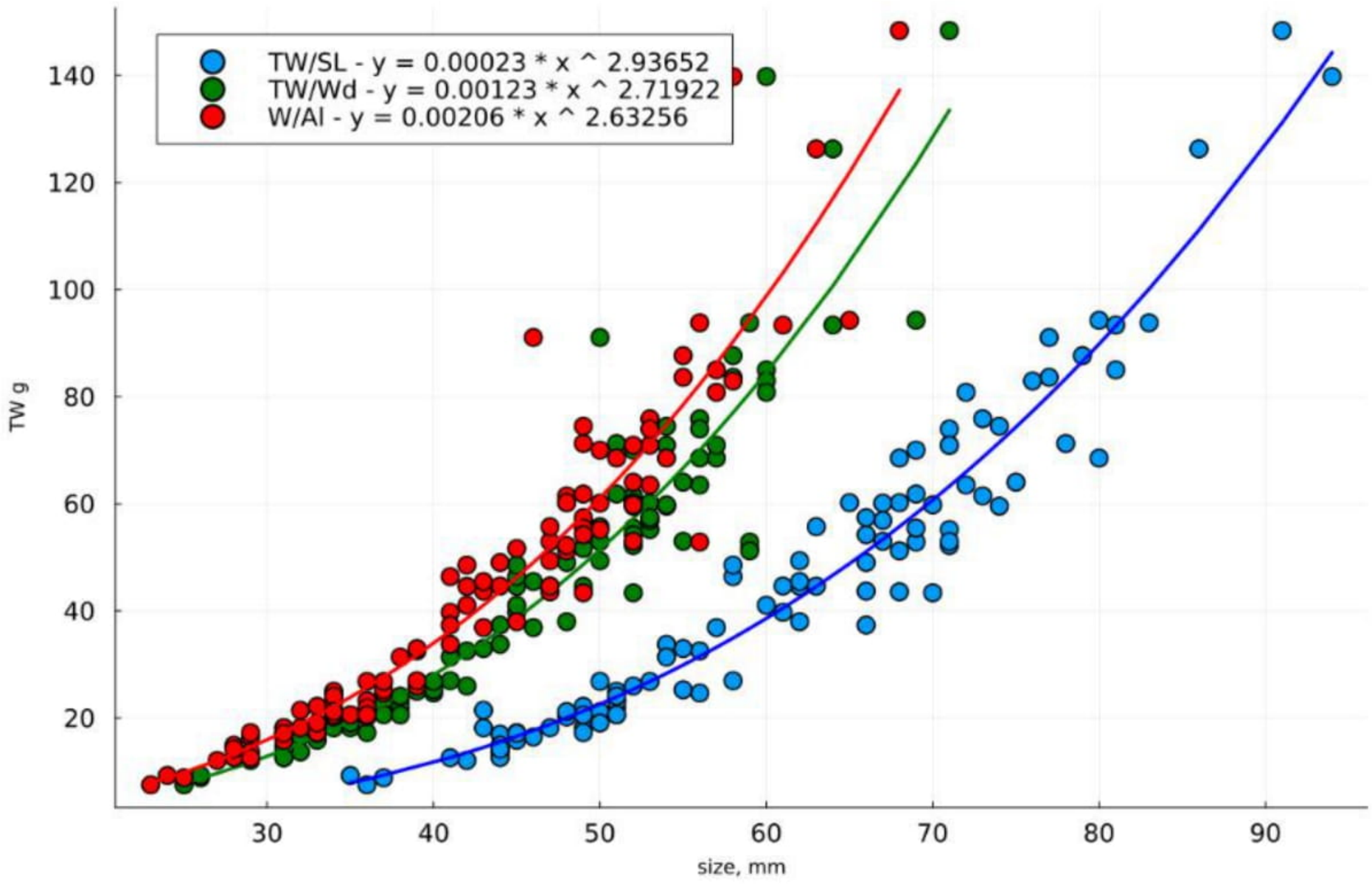

Figure 4 L-W ratios for the sampled individuals, port Nessebar, 06.04.2024: (1) ratio between total weight (TW, g) and shell length (SL, mm); (2) relationship between total weight (TW, g) and shell width (Wd, mm); (3) relationship between total weight (TW, g) and aperture length (AL, mm)

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3.1.4. PORT NESSEBAR (SCUBA DIVING), 15.05.2024

The sample consists of 100 individuals rapa whelk (from scuba diving), weighing 6.149 kg, from a total landing of 600 kg rapa whelks at port Nessebar.

The mean weight of the measured specimens reaches 61.49 g ± 20.00 SD, at a mean shell length of – 68.73 mm ± 6.59 SD, shell width - 53.39 mm ± 5.81 SD and aperture length 50.67 mm ± 5.64 SD. The mean body weight without shell (BW, g) is 21.63 g ± 7.57 SD forming 35.29 % ± 4.49 SD from the total weight, varying between 21.11 % и 44.77 % from the total weight (Table 11).

Table 11

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 Nessebar, 15.05.2024

	TW g	SL mm	Wd mm	Al mm	BW g	BW % TW
Sample size	100	100	100	100	50	50
Mean	61.49	68.73	53.39	50.67	21.63	35.29
Standard deviation	20.00	6.59	5.81	5.64	7.57	4.49
Minimum	22.77	54.00	38.00	36.00	10.55	21.11
50% (median)	58.88	69.00	53.00	50.50	20.94	35.16
Maximum	145.69	87.00	69.00	66.00	47.61	44.77
Sum	6149.21	6873.00	5339.00	5067.00	1081.73	1764.35
Mode	59.99	70.00	53.00	52.00	21.01	32.68
Skewness	1.22	0.47	0.25	0.34	1.17	-0.20
Sample variance	0.33	0.10	0.11	0.11	0.35	0.13
Kurtosis	2.60	0.52	0.27	0.34	1.95	0.96
Range	122.92	33.00	31.00	30.00	37.06	23.66
Confidence level 95%	3.97	1.31	1.15	1.12	2.15	1.28

The mean ratio between the shell width (Wd, mm)/shell length (SL, mm) is 77.63 % ± 3.05 SD, while AL/SL (%) is 73.66 % ± 2.93 SD, and the ratio between AL/Wd (%) was calculated at - 94.89 % ± 1.46 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 Nessebar, 15.05.2024

	Wd/SL %	Al/SL %	Al/Wd %
Sample size	100	100	100
Mean	77.63	73.66	94.89
Standard deviation	3.05	2.93	1.46
Minimum	69.44	66.67	91.38
50% (median)	77.48	73.53	94.87
Maximum	85.71	80.6	98.11
Sum	7763.25	7366.15	9489.45
Mode	75	74.29	94.55
Skewness	0.1	0.06	-0.36
Sample variance	0.04	0.04	0.02
Kurtosis	-0.06	-0.04	-0.25
Range	16.27	13.93	6.73
Confidence level 95%	0.61	0.58	0.29
Sample size	100	100	100
Mean	77.63	73.66	94.89

The L-W ratios are calculated (Figure 5). 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 if the L-W ratio and values of R^2 for the sample from port Nessebar, 15.05.2024

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	0.00012	0.0013	0.00152
b	3.10	2.73	2.96
R^2	0.94	0.95	0.95

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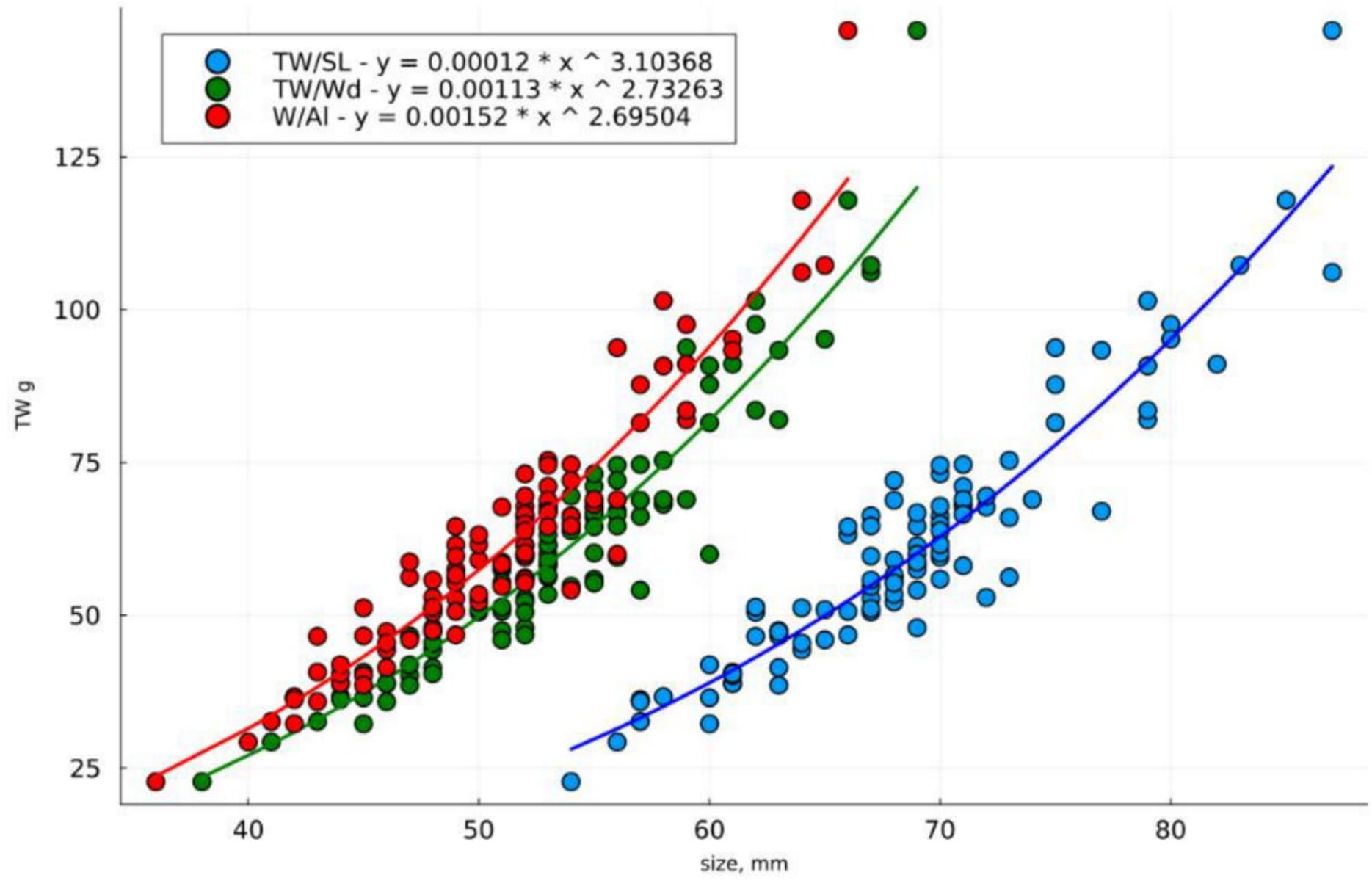

Figure 5 L-W ratios for the sampled individuals, port Nessebar, 15.05.2024: (1) ratio between total weight (TW, g) and shell length (SL, mm); (2) relationship between total weight (TW, g) and shell width (Wd, mm); (3) relationship between total weight (TW, g) and aperture length (AL, mm)

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3.1.5. PORT BALCHIK, 16.05.2024

The sample consists of 100 individuals rapa whelk, weighing 3.64 kg, from a total landing of 2342 kg rapa whelks at port Balchik (from the fishing vessel).

The mean weight of the measured specimens reaches 36.4 g ± 22.40 SD, at a mean shell length of 56.95 mm ± 10.22 SD, shell width - 44.17 mm ± 8.68 SD and aperture length 41.72 ± 8.36 SD. The mean body weight without shell (BW, g) is 11.57 g ± 6.56 SD forming 37.52 % ± 3.29 SD from the total weight, varying between 30.99 % и 47.89 % 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 (AL, mm) at port Balchik, 16.05.2024

	TW g	SL mm	Wd mm	Al mm	BW	BW % TW
Sample size	100	100	100	100	50	50
Mean	36.40	56.95	44.17	41.72	11.57	37.52
Standard deviation	22.40	10.22	8.68	8.36	6.56	3.29
Minimum	12.81	43.00	30.00	29.00	4.71	30.99
50% (median)	28.41	54.00	42.00	39.00	9.33	37.04
Maximum	127.59	89.00	76.00	74.00	40.70	47.89
Sum	3639.97	5695.00	4417.00	4172.00	869.69	1542.77
Mode	49.64	52.00	41.00	38.00	16.18	36.61
Skewness	1.94	1.21	1.20	1.23	1.00	-0.42
Sample variance	0.62	0.18	0.20	0.20	0.59	0.17
Kurtosis	3.71	0.99	1.65	1.83	1.24	-0.70
Range	114.78	46.00	46.00	45.00	46.98	20.11
Confidence level 95%	4.44	2.03	1.72	1.66	2.90	1.47

The mean ratio between the shell width (Wd, mm)/shell length (SL, mm) is 77.44 % ± 4.15 SD, while AL/SL (%) is 73.1 % ± 3.93 SD, and the ratio between AL/Wd (%) was calculated at - 94.41 % ± 1.67 SD (Table 15).

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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 Balchik, 16.05.2024

	Wd/SL %	Al/SL %	Al/Wd %
Sample size	100	100	100
Mean	77.44	73.1	94.41
Standard deviation	4.15	3.93	1.67
Minimum	66.67	63.64	90.7
50% (median)	77.66	73.05	94.49
Maximum	89.47	84.21	98.18
Sum	7744.31	7310.25	9441
Mode	77.78	75	92.68
Skewness	-0.35	-0.05	0.02
Sample variance	0.05	0.05	0.02
Kurtosis	0.69	0.2	-0.38
Range	22.81	20.57	7.48
Confidence level 95%	0.82	0.78	0.33

The L-W ratios are calculated (Figure 6). 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 Balchik, 16.05.2024

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	0.00026	0.0014	0.00195
b	2.91	2.65	2.61
R^2	0.98	0.97	0.97

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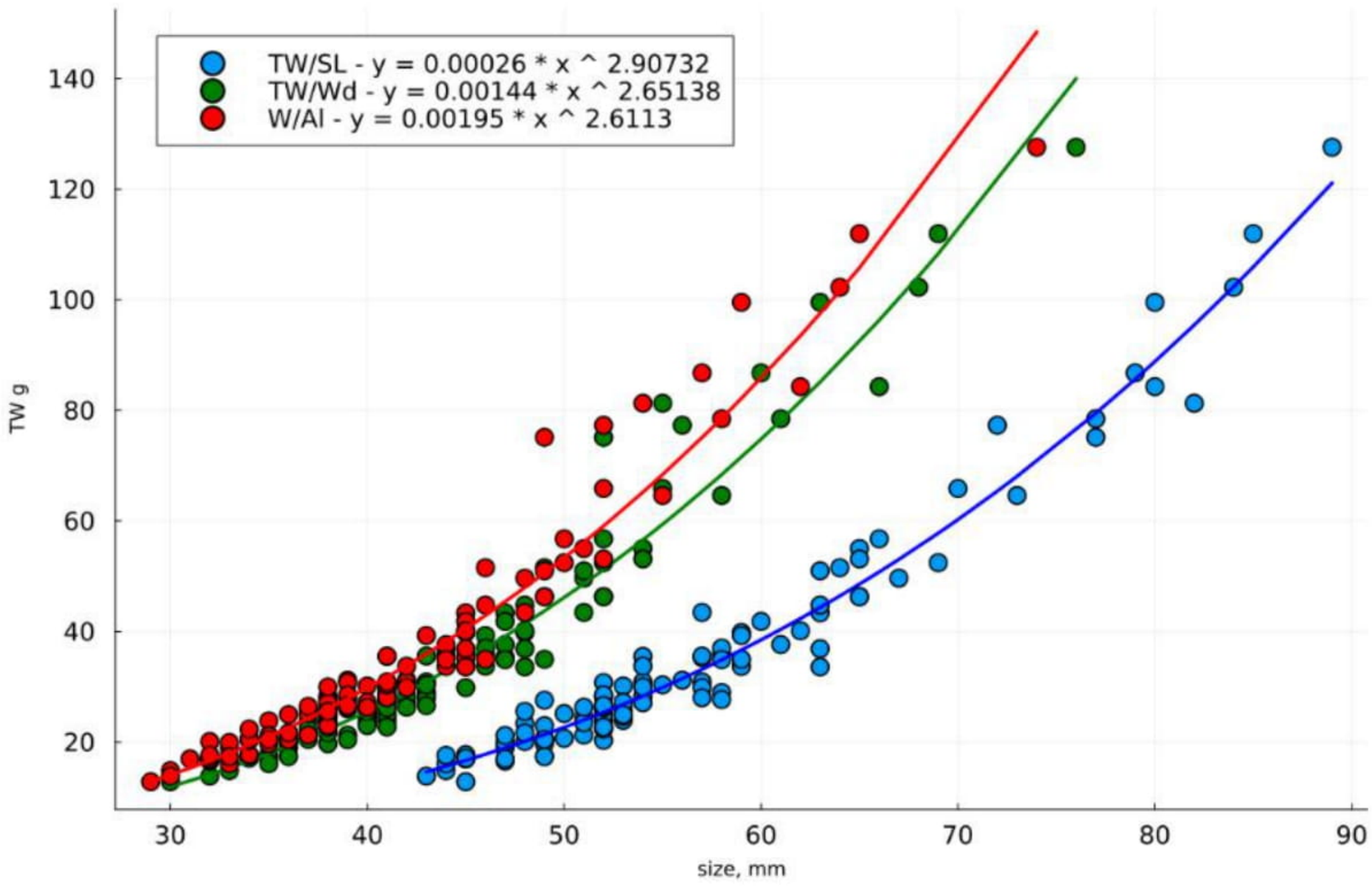

Figure 6 L-W ratios for the sampled individuals, port Balchik, 16.05.2024: (1) ratio between total weight (TW, g) and shell length (SL, mm); (2) relationship between total weight (TW, g) and shell width (Wd, mm); (3) relationship between total weight (TW, g) and aperture length (AL, mm)

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3.1.6. PORT VARNA, 05.06.2024

The sample consists of 100 individuals rapa whelk, weighing 4.646 kg, from a total landing of 2440 kg rapa whelks at port Varna (from the fishing vessel).

The mean weight of the measured specimens reaches 46.46 g ± 21.32 SD, at a mean shell length of 63.57 mm ± 8.05 SD, shell width - 46.7 mm ± 6.15 SD and aperture length 44.38 ± 5.92 SD. The mean body weight without shell (BW, g) is 13.69 g ± 5.28 SD forming 32.57 % ± 3.64 SD from the total weight, varying between 26.44 % и 40.71 % 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 (AL, mm) at port Varna, 05.06.2024

	TW g	SL mm	Wd mm	Al mm	BW g	BW % TW
Sample size	100	100	100	100	50	50
Mean	46.46	63.57	46.70	44.38	13.69	32.57
Standard deviation	21.32	8.05	6.15	5.92	5.28	3.64
Minimum	21.19	49.00	36.00	34.00	6.85	26.44
50% (median)	41.12	62.50	46.00	44.00	12.80	32.24
Maximum	144.17	91.00	71.00	68.00	34.55	40.71
Sum	4646.14	6357.00	4670.00	4438.00	684.67	1628.43
Mode	48.07	62.00	46.00	44.00	22.26	33.19
Skewness	2.64	0.97	1.13	1.15	1.44	0.43
Sample variance	0.46	0.13	0.13	0.13	0.39	0.11
Kurtosis	8.64	1.77	2.76	2.86	3.18	-0.48
Range	122.98	42.00	35.00	34.00	27.70	14.27
Confidence level 95%	4.23	1.60	1.22	1.17	1.50	1.03

The mean value of the ratio width (Wd, mm)/length (SL, mm) of the shell is 73.5 % ± 3.27 SD, while AL/SL (%) is 69.83 % ± 3.08 SD, and the ratio between AL/Wd (%) results 95.03 % ± 1.67 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 Varna, 05.06.2024

	Wd/SL %	Al/SL %	Al/Wd %
Sample size	100	100	100
Mean	73.5	69.83	95.03
Standard deviation	3.27	3.08	1.67
Minimum	65.91	62.5	90.48
50% (median)	73.13	69.53	95.35
Maximum	82.35	79.03	98.08
Sum	7349.55	6982.97	9502.84
Mode	71.21	66.67	95.65
Skewness	0.25	0.24	-0.24
Sample variance	0.04	0.04	0.02
Kurtosis	-0.23	0	-0.15
Range	16.44	16.53	7.6
Confidence level 95%	0.65	0.61	0.33

The L-W ratios are calculated (Figure 7). The parameters *a, b* of the derived L-W ratio and the value of the coefficient of determination 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 Varna, 05.06.2024

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	0.00038	0,00131	0,00164
b	2,81	2,71	2,69
R^2	0.96	0.94	0.94

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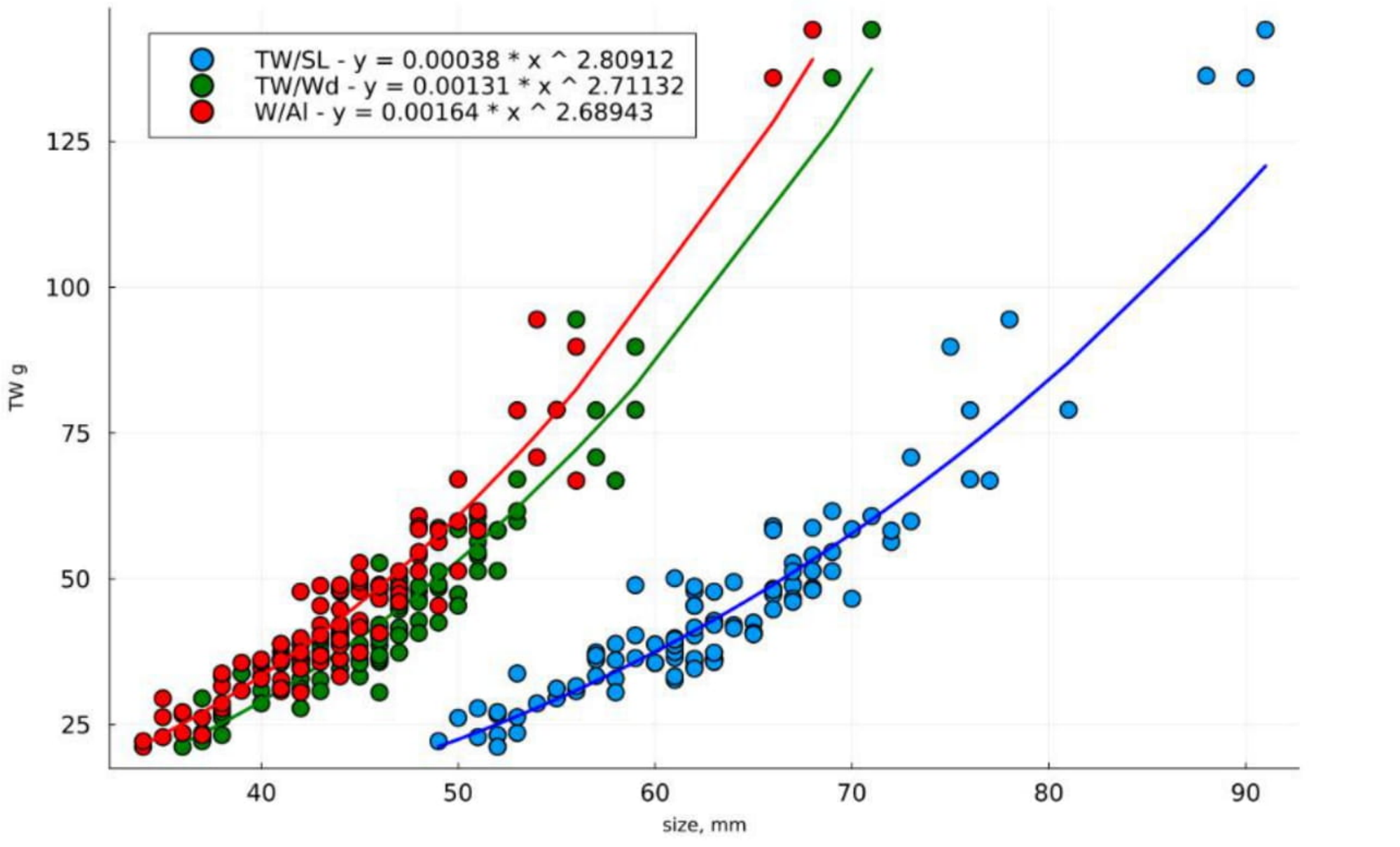

Figure 7 L-W ratios for the sampled individuals, port Varna, 05.06.2024: (1) ratio between total weight (TW, g) and shell length (SL, mm); (2) relationship between total weight (TW, g) and shell width (Wd, mm); (3) relationship between total weight (TW, g) and aperture length (AL, mm)

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3.1.7. PORT POMORIE (SCUBA DIVING), 17.06.2024

The sample consists of 100 individuals (from scuba diving) with a total weight of 5.467 kg, from a total landing of 116 kg rapa whelks at port Pomorie.

The mean weight of the measured specimens reaches 54.67 g ± 17.22 SD at a mean shell length of – 68.35 mm ± 6.48 SD, shell width – 51.19 mm ± 5.19 SD and aperture length 48.39 mm ± 5.01 SD. The mean body weight without shell (BW, g) is 17.22 g ± 4.94 SD, which is 32.54 % ± 8.02 SD from the total weight, varying between 11.29 % and 57.23 % from the total weight (Table 20).

Table 20

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) at port Pomorie, 17.06.2024

	TW g	SL mm	Wd mm	Al mm	BW g	BW % TW
Sample size	100	100	100	100	50	32.54
Mean	54.67	68.35	51.19	48.39	17.22	8.02
Standard deviation	17.22	6.48	5.19	5.01	4.94	11.29
Minimum	24.29	54.00	40.00	38.00	10.53	32.59
50% (median)	52.78	68.50	51.00	48.00	16.90	57.23
Maximum	140.65	95.00	69.00	65.00	38.13	32.54
Sum	5466.64	6835.00	5119.00	4839.00	663.40	1689.66
Mode	46.35	65.00	50	51.00	39.12	33.38
Skewness	2.13	1.16	0.89	0.86	0.91	-0.21
Sample variance	0.31	0.09	0.10	0.10	0.80	0.19
Kurtosis	7.95	3.40	1.85	1.61	-0.51	0.30
Range	116.36	41.00	29.00	27.00	36.40	30.19
Confidence level 95%	3.42	1.29	1.03	0.99	3.02	1.83

The mean ratio between the shell width (Wd, mm)/shell length (SL, mm) is 74.91 % ± 3.08 SD, while AL/SL (%) is 70.8 % ± 2.98 SD, and the ratio between AL/Wd (%) results in - 94.52 % ± 1.49 SD (Table 21).

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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 Pomorie, 17.06.2024.

	Wd/SL %	Al/SL %	Al/Wd %
Sample size	100	100	100
Mean	74.91	70.8	94.52
Standard deviation	3.08	2.98	1.49
Minimum	66.67	61.9	91.3
50% (median)	74.67	70.83	94.34
Maximum	81.16	77.14	98.15
Sum	7490.74	7079.78	9452.14
Mode	74.29	73.85	94
Skewness	-0.24	-0.18	0.02
Sample variance	0.04	0.04	0.02
Kurtosis	-0.2	-0.19	-0.56
Range	14.49	15.24	6.84
Confidence level 95%	0.61	0.59	0.3

The L-W ratios are calculated (Figure 8). The parameters a, b of the linear-weight relationships and the values of the correlation coefficient R^2 are presented in Table 22.

Table 22

Parameters a,b of the L-W ratios and values of R^2 for the sample from port Pomorie, 17.06.2024.

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	0.0017	0.00629	0.00931
b	2.45	2.30	2.23
R^2	0.84	0.84	0.83

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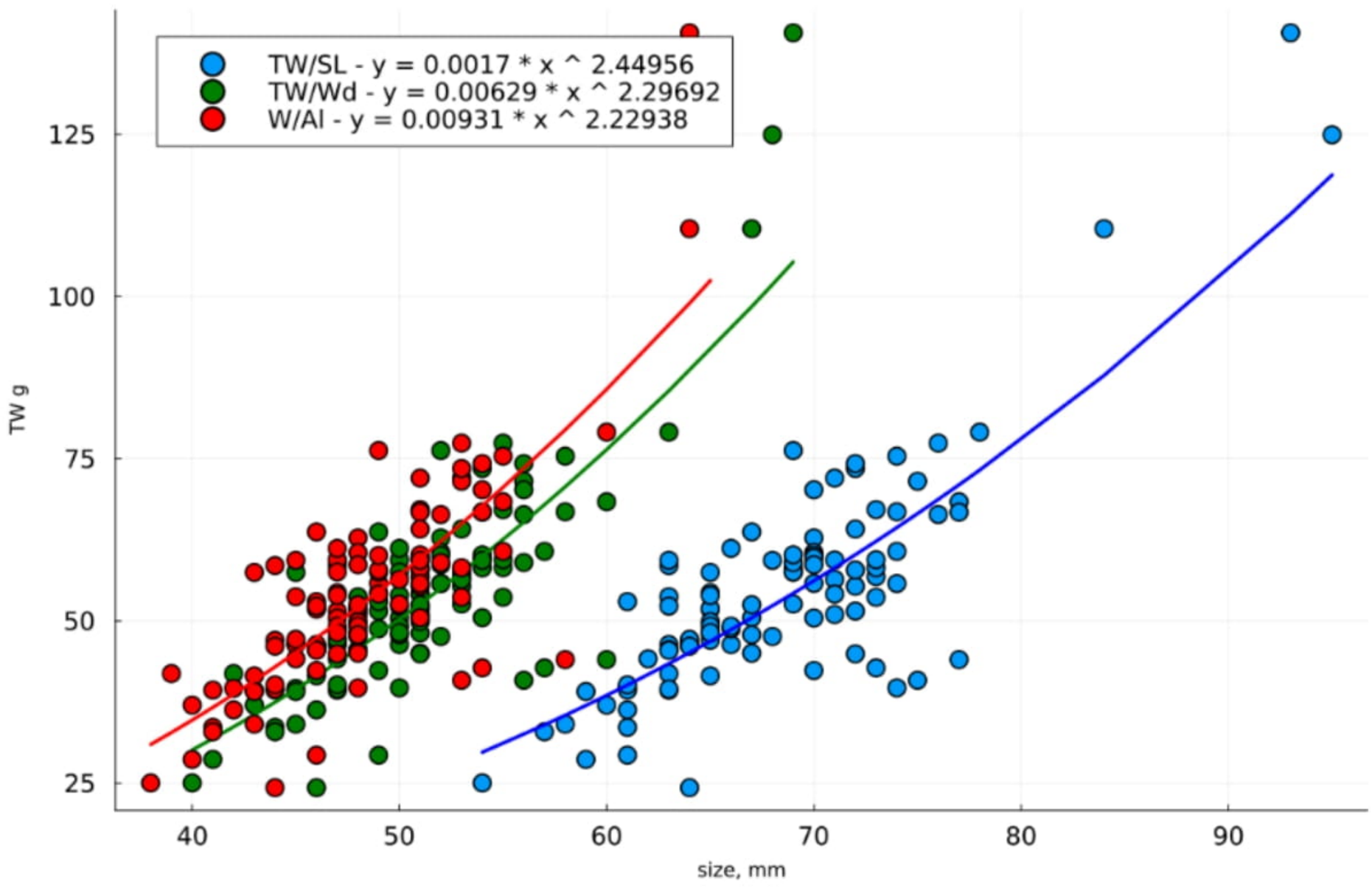

Figure 8 L-W ratios for the sampled individuals, port Pomorie, 17.06.2024: (1) ratio between total weight (TW, g) and shell length (SL, mm); (2) relationship between total weight (TW, g) and shell width (Wd, mm); (3) relationship between total weight (TW, g) and aperture length (AL, mm).

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3.1.8. PORT KAVARNA, 24.07.2024

The sample consists of 100 individuals rapa whelk, weighing 3.145 kg, from a total landing of 1018 kg rapa whelks at port Kavarna (from the fishing vessel).

The mean weight of the measured specimens reaches 31.45 g ± 19.88 SD , at a mean shell length of – 54.87 mm ± 9.28 SD, shell width – 42.15 mm ± 7.44 SD and aperture length 39.52 mm ± 7.29 SD.

The mean body weight without shell (BW, g) is 7.94 g ± 3.78 SD forming 30.77 % ± 5.2 SD from the total weight, varying between 17.0 % и 41.0 % from the total weight. (Table 23)

Table23

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 Kavarna, 24.07.2024

	TW g	SL mm	Wd mm	Al mm	BW g	BW % TW
Sample size	100	100	100	100	50	50
Mean	31.45	54.87	42.15	39.52	7.94	30.77
Standard deviation	19.88	9.28	7.44	7.29	3.78	5.20
Minimum	14.22	43.00	33.00	30.00	3.14	17.41
50% (median)	23.64	51.00	39.00	37.00	6.74	30.22
Maximum	103.31	82.00	65.00	63.00	19.73	40.54
Sum	3144.73	5487.00	4215.00	3952.00	397.16	1538.34
Mode	20.71	50.00	38.00	36.00	4.55	39.63
Skewness	2.11	1.34	1.48	1.51	1.67	-0.01
Sample variance	0.63	0.17	0.18	0.18	0.48	0.17
Kurtosis	4.11	1.09	1.64	1.77	2.34	-0.18
Range	89.09	39.00	32.00	33.00	16.59	23.13
Confidence level 95%	3.95	1.84	1.48	1.45	1.07	1.48

The mean ratio between the shell width (Wd, mm)/shell length (SL, mm) is 76.82 % ± 3.36 SD, while AL/SL (%) is 71.94 % ± 3.11 SD, and the ratio between AL/Wd (%) was calculated at – 93.67 % ± 1.9 SD (Table 24).

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Table 24

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, 24.07.2024

	Wd/SL %	Al/SL %	Al/Wd %
Sample size	100	100	100
Mean	76.82	71.94	93.67
Standard deviation	3.36	3.11	1.9
Minimum	66	64	88.89
50% (median)	76.63	71.74	94.12
Maximum	86.67	80	98.04
Sum	7682	7194.26	9367.22
Mode	76	73.33	94.74
Skewness	-0.01	0.03	-0.22
Sample variance	0.04	0.04	0.02
Kurtosis	0.53	-0.28	0.02
Range	20.67	16	9.15
Confidence level 95%	0.67	0.62	0.38

The L-W ratios have been calculated, Figure 9. The parameters a, b of the linear-weight relationships and the values of the correlation coefficient R^2 are presented in Table 25.

Table 25

Parameters a, b of the L-W ratios and values of R^2 for the sample from port Kavarna, 24.07.2024

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	0.00017	0.00051	0.00096
b	3.00	2.92	2.80
R^2	0.97	0.98	0.98

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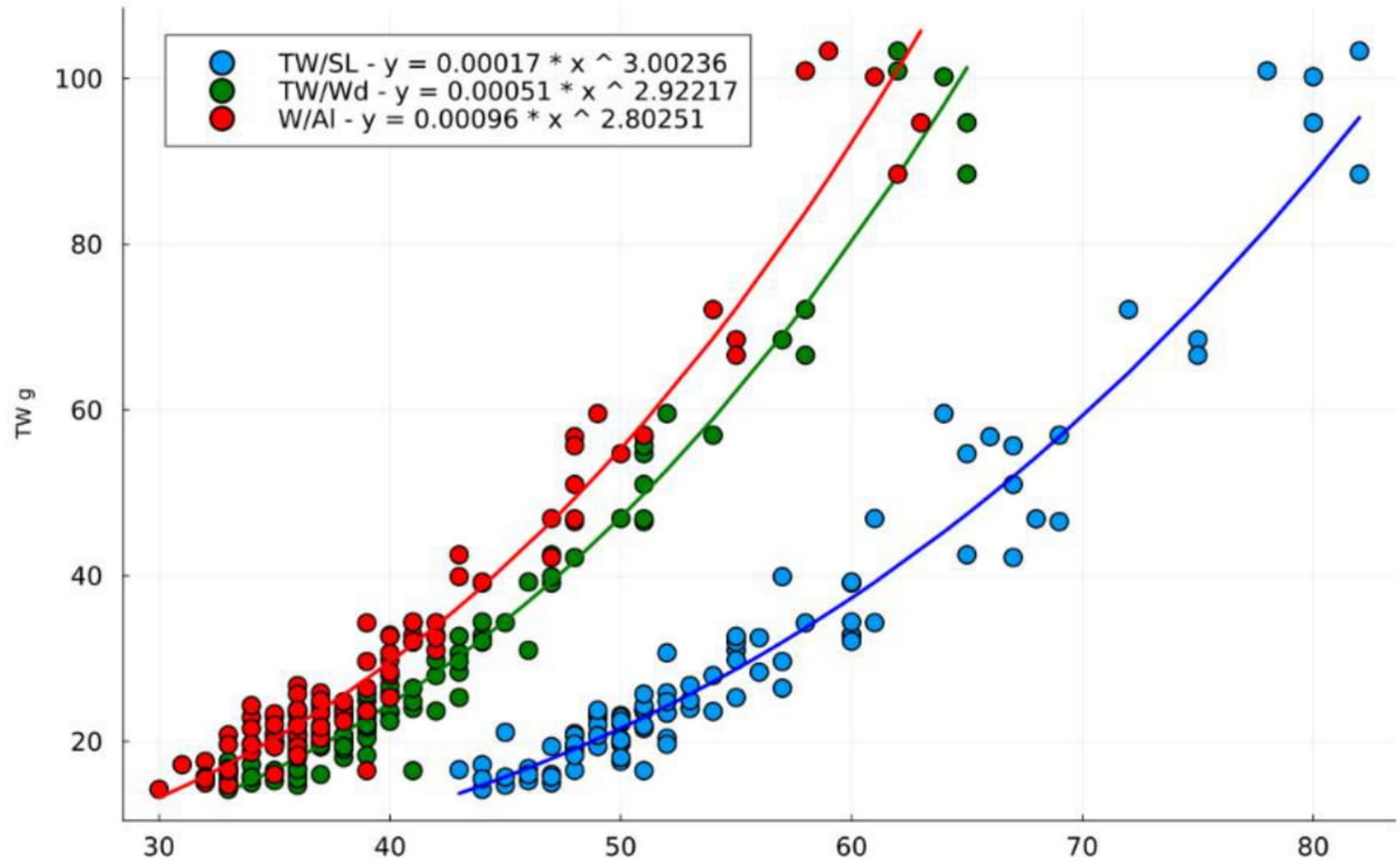

Figure 9 L-W ratios for the sampled individuals, Port Kavarna, 24.07.2024 (1) ratio between total weight (TW, g) and shell length (SL, mm); (2) relationship between total weight (TW, g) and shell width (Wd, mm); (3) relationship between total weight (TW, g) and aperture length (AL, mm)

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3.1.9. PORT RODOPA 1, 24.07.2024

The sample consists of 100 individuals rapa whelk, weighing 5.417 kg, from a total landing of 1900 kg rapa whelks at port Rodopa 1 (from the fishing vessel).

The mean weight of the measured specimens reaches 54.17 g ± 19.88 SD, at a mean shell length of 64.38 mm ± 7.19 SD, shell width 50.21 mm ± 6.17 SD and aperture length 47.4 mm ± 6.01 SD. The mean body weight without shell (BW, g) is 20.91 g ± 7.83 SD forming 38.78 % ± 4.48 SD from the total weight, varying between 30.0 % и 52.0 % from the total weight (Table 26).

Table 26

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 Rodopa 1, 24.07.2024

	TW g	SL mm	Wd mm	Al mm	BW g	BW % TW
Sample size	100	100	100	100	50	50
Mean	54.17	64.38	50.21	47.40	20.91	38.78
Standard deviation	18.21	7.19	6.17	6.01	7.83	4.48
Minimum	29.44	53.00	38.00	36.00	10.31	29.72
50% (median)	50.32	63.00	49.00	46.00	18.45	38.21
Maximum	110.90	84.00	69.00	66.00	40.14	52.28
Sum	5416.65	6438.00	5021.00	4740.00	1045.70	1938.77
Mode	42.24	68.00	47.00	46.00	15.57	38.34
Skewness	1.01	0.67	0.67	0.64	0.67	0.75
Sample variance	0.34	0.11	0.12	0.13	0.37	0.12
Kurtosis	0.58	-0.22	0.05	0.01	-0.70	1.29
Range	81.46	31.00	31.00	30.00	29.83	22.55
Confidence level 95%	3.61	1.43	1.22	1.19	2.23	1.27

The mean ratio between the shell width (Wd, mm)/shell length (SL, mm) is 77.97 % ± 3.58 SD, while AL/SL (%) is 73.58 % ± 3.56 SD, and the ratio between AL/Wd (%) was calculated at - 94.37 % ± 1.43 SD (Table 27).

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Table 27

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 Rodopa 1, 24.07.2024

	Wd/SL %	Al/SL %	Al/Wd %
Sample size	100	100	100
Mean	77.97	73.58	94.37
Standard deviation	3.58	3.56	1.43
Minimum	66.13	62.9	90.48
50% (median)	77.97	73.96	94.34
Maximum	92.45	86.79	96.61
Sum	7797.39	7358.4	9437
Mode	77.94	75	93.88
Skewness	0.04	-0.06	-0.44
Sample variance	0.05	0.05	0.02
Kurtosis	2.7	1.92	-0.6
Range	26.32	23.89	6.13
Confidence level 95%	0.71	0.71	0.28

The L-W ratios are calculated, Figure10. The parameters a, b of the linear-weight relationships and the values of the correlation coefficient R^2 are presented in Table 28.

Table 28

Parameters a, b of the L-W ratios and values of R^2 for the sample from port Rodopa 1, 24.07.2024

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	0.00063	0.00246	0.00407
b	2.72	2.54	2.45
R^2	0.95	0.97	0.97

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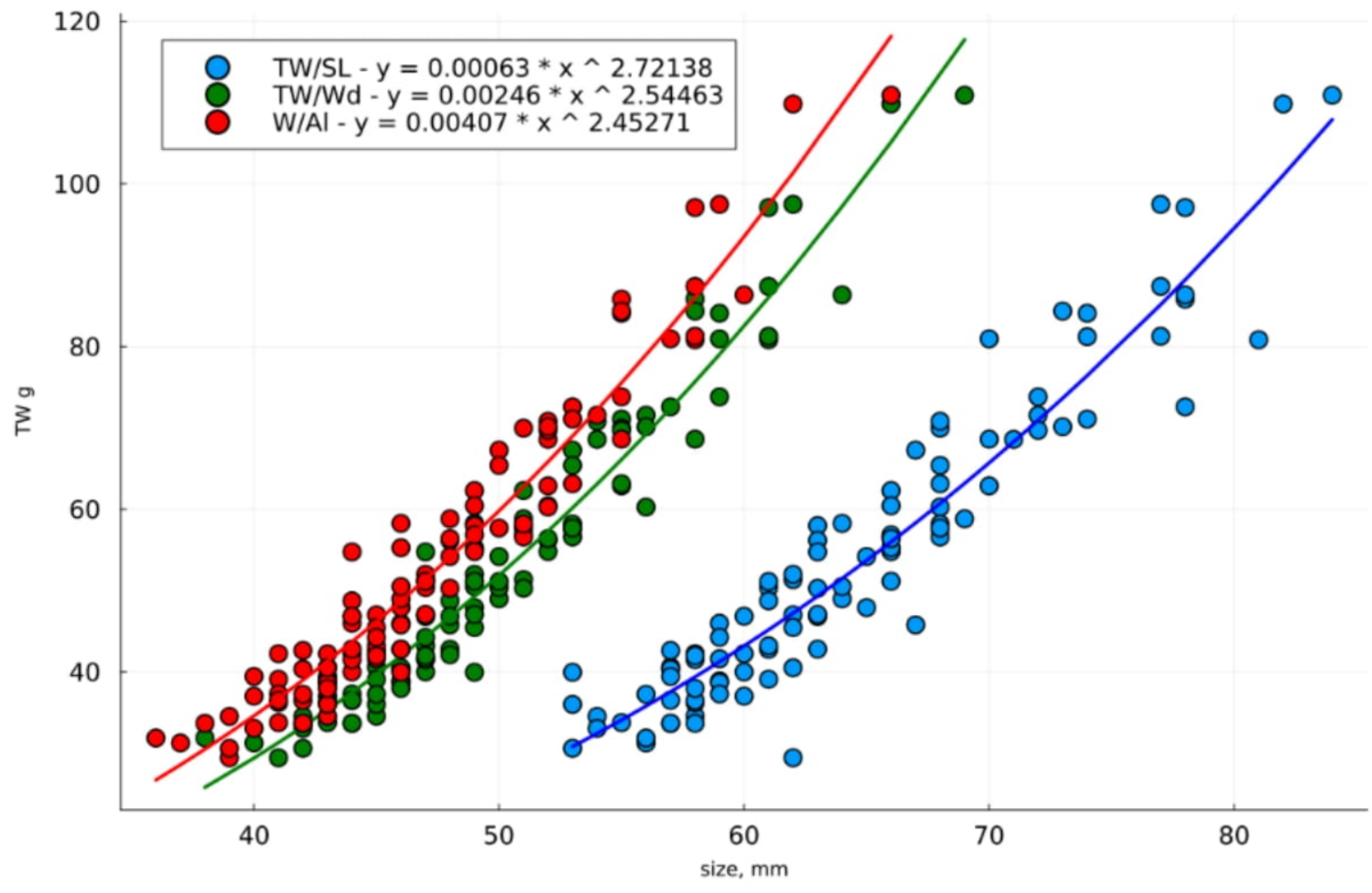

Figure 10 L-W ratios for the sampled individuals, port Rodopa 1, 24.07.2024: (1) Total weight (TW, g) from the shell length (SL, mm); (2) Total weight (TW, g) from the shell width (Wd, mm); (3) total weight (TW, g) and aperture length (AL, mm)

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3.1.10. PORT POMORIE (SCUBA DIVING), 24.09.2024

The sample consists of 100 individuals rapa whelk (from scuba diving), with a weight of 6.435 kg, from a total landing of 815 kg rapa whelks at port Pomorie.

The mean weight of the measured specimens reaches 64.35 g ± 19.88 SD, at a mean shell length of 69.41 mm ± 8.4 SD, shell width – 53.58 mm ± 6.56 SD and aperture length 50.91 mm ± 6.42 SD. The mean body weight without shell (BW, g) is 22.74 g ± 9.01 SD forming 37.97 % ± 5.13 SD from the total weight, varying between 28.0 % и 55.0 % from the total weight. (Table 29)

Table 29

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 Pomorie, 24.09.2024

	TW g	SL mm	Wd mm	Al mm	BW g	BW % TW
Sample size	100	100	100	100	50	50
Mean	64.35	69.41	53.58	50.91	22.74	37.97
Standard deviation	22.04	8.40	6.56	6.42	9.01	5.13
Minimum	20.99	50.00	41.00	40.00	7.75	27.75
50% (median)	60.14	68.00	53.00	51.00	20.20	37.60
Maximum	132.26	89.00	70.00	67.00	44.60	54.58
Sum	6435.28	6940.66	5357.62	5090.76	1136.92	1898.34
Mode	59.94	65.00	48.00	42.00	18.10	30.20
Skewness	0.57	0.32	0.12	0.15	1.11	0.43
Sample variance	0.34	0.12	0.12	0.13	0.40	0.14
Kurtosis	-0.17	-0.44	-0.78	-0.81	0.66	0.79
Range	111.27	39.00	29.00	27.00	36.85	26.83
Confidence level 95%	4.37	1.67	1.30	1.27	2.56	1.46

The mean ratio between the shell width (Wd, mm)/shell length (SL, mm) is 77.23 % ± 3.14 SD, while AL/SL (%) is 73.36 % ± 3.19 SD, and the ratio between AL/Wd (%) was calculated at - 94.99 % ± 1.45 SD. (Table 30)

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Table 30

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 Pomorie, 24.09.2024

	Wd/SL %	Al/SL %	Al/Wd %
Sample size	100	100	100
Mean	77.23	73.36	94.99
Standard deviation	3.14	3.19	1.45
Minimum	68.75	65.62	91.67
50% (median)	77.23	73.43	95.08
Maximum	86.15	81.54	98.15
Sum	7723.25	7336.41	9499.07
Mode	77.23	73.43	95.45
Skewness	0.17	0.22	-0.18
Sample variance	0.04	0.04	0.02
Kurtosis	0.11	-0.29	-0.1
Range	17.4	15.91	6.48
Confidence level 95%	0.62	0.63	0.29

The L-W ratios are calculated, Figure 11. The parameters a, b of the linear-weight relationships and the values of the correlation coefficient R^2 are presented in Table 31.

Table 31

Parameters *a,b* of the L-W ratios and values of R^2 for the sample from Pomorie, 24.09.2024

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	0.00062	0.0011	0.00178
b	2.71	2.75	2.66
R^2	0.93	0.97	0.97

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Figure 11 L-W ratios for the sampled individuals, port Pomorie, 24.09.2024: (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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3.1.11. PORT VARNA, 25.09.2024

The sample consists of 100 individuals rapa whelk, weighing 4.616 kg, from a total landing of 5665 kg rapa whelks at port Varna (from the fishing vessel).

The mean weight of the measured specimens reaches 46.16 g ± 19.88 SD, at a mean shell length of 64.24 mm ± 6.18 SD, shell width - 47.96 mm ± 4.51 SD and aperture length 45.17 mm ± 4.61 SD. The mean body weight without shell (BW, g) is 14.63 g ± 3.93 SD forming 34.51 % ± 3.73 SD from the total weight, varying between 27.0 % и 44.0 % from the total weight. (Table 32)

Table 32

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) at port Varna, 25.09.2024

	TW g	SL mm	Wd mm	Al mm	BW g	BW % TW
Sample size	100.00	100.00	100.00	100.00	50	50
Mean	46.16	64.24	47.96	45.17	14.63	34.51
Standard deviation	12.41	6.18	4.51	4.61	3.93	3.73
Minimum	27.05	53.00	40.00	38.00	8.61	27.49
50% (median)	45.20	64.00	48.00	45.00	14.41	34.21
Maximum	95.43	84.00	61.00	59.00	27.43	43.76
Sum	4615.62	6424.00	4796.00	4517.00	731.46	1725.68
Mode	40.96	58.00	46.00	43.00	15.85	36.91
Skewness	1.33	0.54	0.58	0.65	0.94	0.35
Sample variance	0.27	0.10	0.09	0.10	0.27	0.11
Kurtosis	2.93	0.21	0.36	0.24	1.11	-0.52
Range	68.38	31.00	21.00	21.00	18.82	16.27
Confidence level 95%	2.46	1.23	0.89	0.92	1.12	1.06

The mean ratio between the shell width (Wd, mm)/shell length (SL, mm) is 74.72 % ± 2.75 SD, while AL/SL (%) is 70.32 % ± 2.57 SD, and the ratio between AL/Wd (%) was calculated at - 94.13 % ± 1.71 SD. (Table 33)

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Table 33

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, 25.09.2024

	Wd/SL %	Al/SL %	Al/Wd %
Sample size	100	100	100
Mean	74.72	70.32	94.13
Standard deviation	2.75	2.57	1.71
Minimum	67.61	64.29	89.13
50% (median)	74.29	70.21	94.12
Maximum	81.67	77.27	98
Sum	7472.33	7032.33	9412.85
Mode	75	71.67	93.48
Skewness	0.18	0.27	-0.36
Sample variance	0.04	0.04	0.02
Kurtosis	0.16	0.22	0.03
Range	14.06	12.99	8.87
Confidence level 95%	0.55	0.51	0.34
Sample size	100	100	100
Mean	74.72	70.32	94.13

The L-W ratios are calculated (Figure 12). The parameters *a, b* of the derived L-W ratio and the value of the coefficient of determination R^2 are presented in Table 34.

Table 34

Parameters a, b of the L-W ratios and values of R2 for the sample from port Varna, 25.09.2024

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	0.00157	0.00236	0.00542
b	2.47	2.54	2.40
R^2	0.94	0.94	0.95

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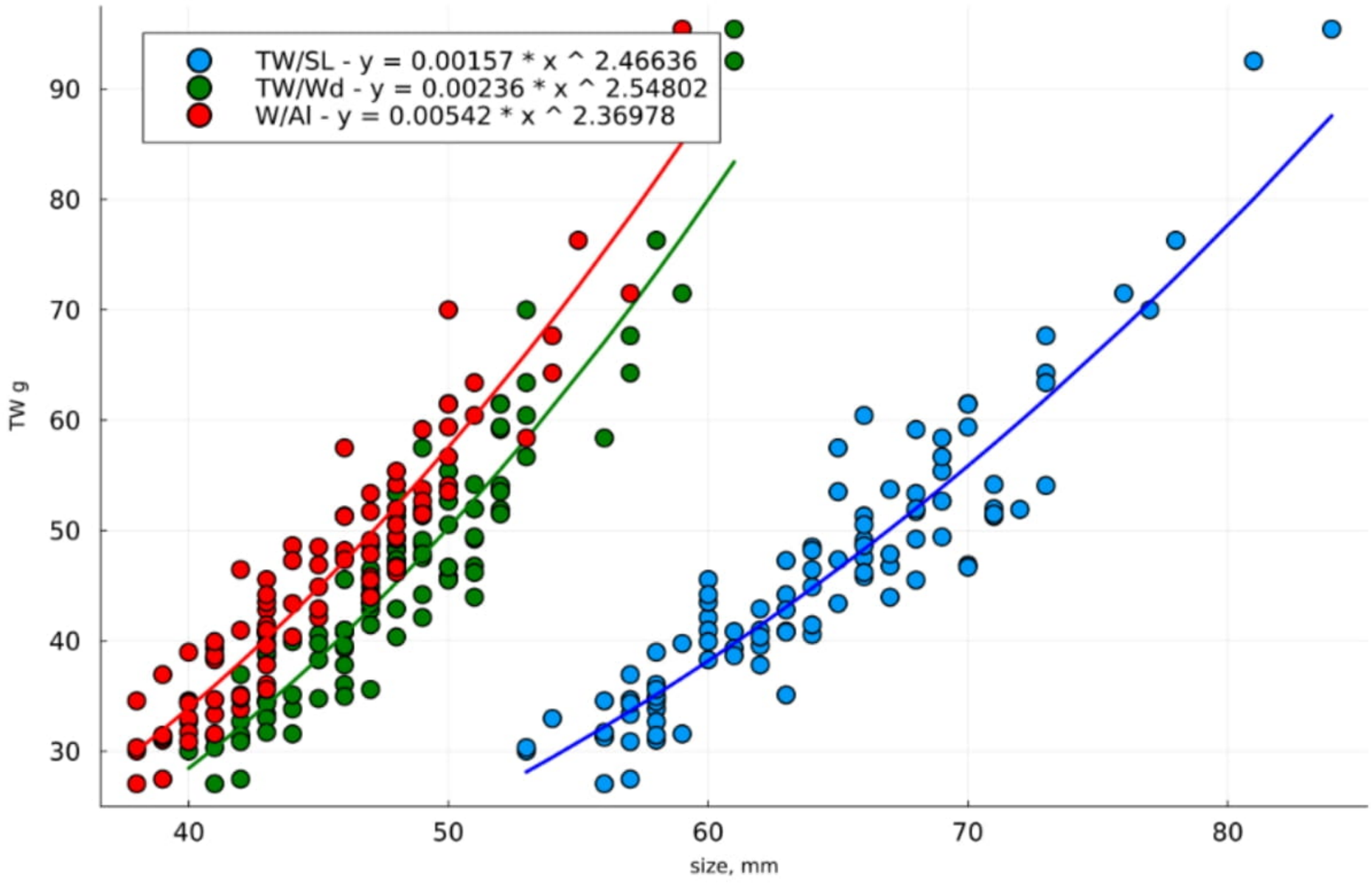

Figure 4 L-W ratios for the sampled individuals, port Varna, 25.09.2024: (1) ratio between total weight (TW, g) and shell length (SL, mm); (2) relationship between total weight (TW, g) and shell width (Wd, mm); (3) relationship between total weight (TW, g) and aperture length (AL, mm)

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3.1.12. PORT RODOPA 1, 26.09.2024

The sample consists of 100 individuals rapa whelk, weighing 4.179 kg, from a total landing of 1950 kg rapa whelks at port Rodopa 1 (from the fishing vessel).

The mean weight of the measured specimens reaches 41.79 g ± 19.88 SD, at a mean shell length of 62.12 mm ± 6.06 SD, shell width 46.35 mm ± 4.68 SD and aperture length 43.69 mm ± 4.62 SD. The mean body weight without shell (BW, g) is 14.52 g ± 5.42 SD forming 34.82 % ± 4.24 SD from the total weight, varying between 27.0 % и 44.0 % % from the total weight (Table 35).

Table 35

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 Rodopa 1, 26.09.2024

	TW g	SL mm	Wd mm	Al mm	BW	BW % TW
Sample size	100.00	100.00	100.00	100.00	50	50
Mean	41.79	62.12	46.35	43.69	14.52	34.82
Standard deviation	12.23	6.06	4.68	4.62	5.42	4.24
Minimum	26.17	53.00	39.00	36.00	8.74	26.86
50% (median)	39.44	61.00	45.00	43.00	12.95	34.87
Maximum	103.61	86.00	65.00	62.00	39.45	43.85
Sum	4178.52	6211.90	4634.70	4368.70	725.81	1740.96
Mode	39.34	63.00	44.00	44.00	14.45	40.28
Skewness	2.28	1.34	1.28	1.30	2.36	0.17
Sample variance	0.29	0.10	0.10	0.11	0.37	0.12
Kurtosis	7.51	2.78	2.13	2.08	7.45	-0.73
Range	77.44	33.00	26.00	26.00	30.71	16.99
Confidence level 95%	2.43	1.20	0.93	0.92	1.54	1.20

The mean ratio between the shell width (Wd, mm)/shell length (SL, mm) is 74.65 % ± 3.15 SD, while AL/SL (%) is 70.34 % ± 3.16 SD, and the ratio between AL/Wd (%) was calculated at - 94.23 % ± 1.48 SD (Table 36).

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Table 36

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 Rodopa 1, 26.09.2024

	Wd/SL %	Al/SL %	Al/Wd %
Sample size	100	100	100
Mean	100	70.34	94.23
Standard deviation	74.65	3.16	1.48
Minimum	3.15	62.07	89.8
50% (median)	67.24	70.4	93.94
Maximum	74.65	78.33	97.96
Sum	83.33	7034.47	9422.93
Mode	7465.31	66.67	93.18
Skewness	75.41	0.08	-0.03
Sample variance	0.09	0.04	0.02
Kurtosis	0.04	-0.09	0.07
Range	0.23	16.26	8.16
Confidence level 95%	16.09	0.63	0.29

The L-W ratios are calculated, Figure 13. The parameters *a, b* of the linear-weight relationships and the values of the correlation coefficient R^2 are presented in Table 37.

Table 37

Parameters *a, b* of the L-W ratios and values of R^2 for the sample from Rodopa 1, 26.09.2024

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	0.00172	0.00425	0.00754
b	2.44	2.39	2.27
R^2	0.93	0.94	0.93

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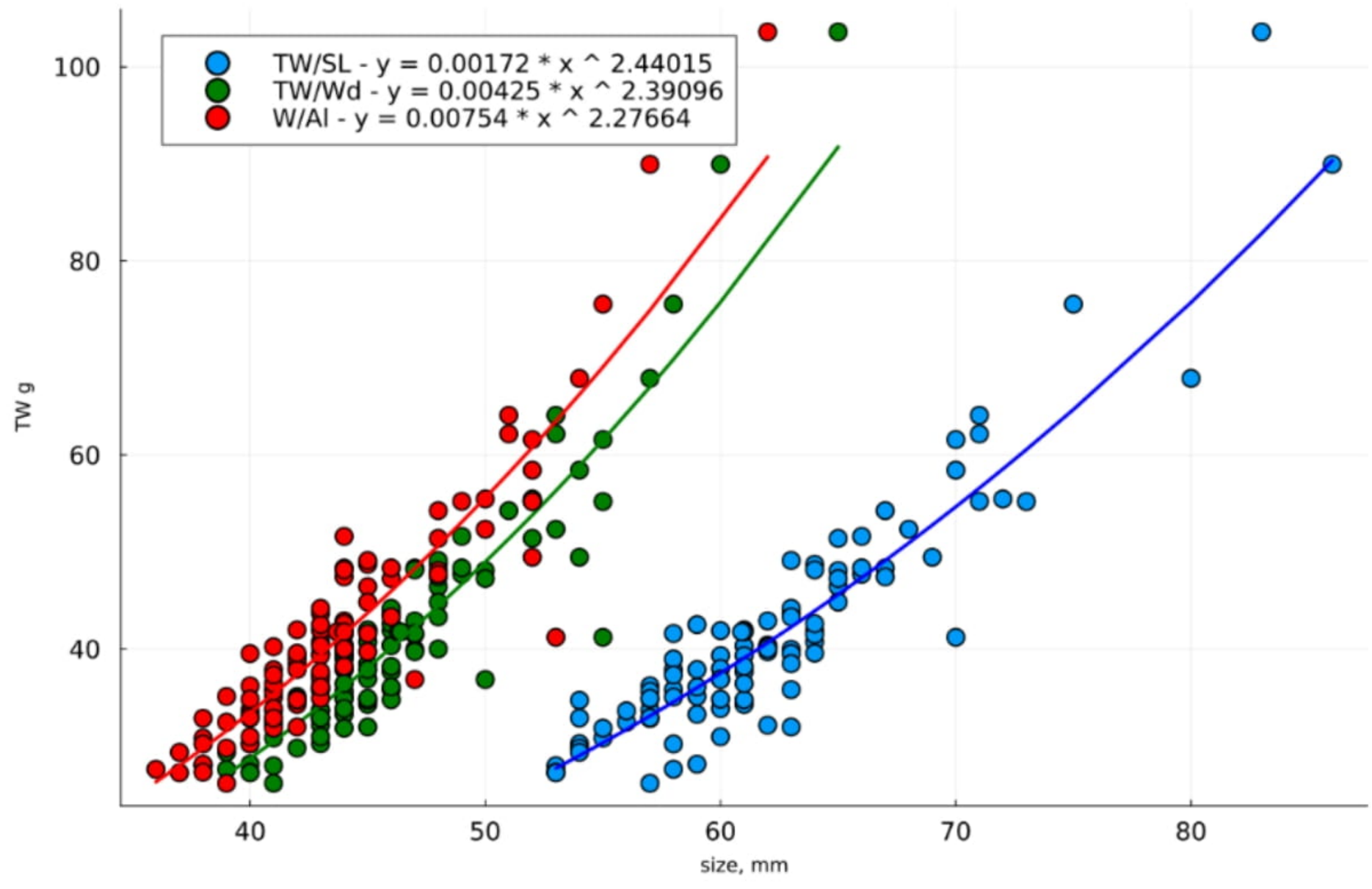

Figure 13 L-W ratios for the sampled individuals, port Rodopa 1, 26.09.2024: (1) Total weight (TW, g) from the shell length (SL, mm); (2) Total weight (TW, g) from the shell width (Wd, mm); (3) total weight (TW, g) and aperture length (AL, mm)

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3.1.13 PORT PRIMORSKO, 15.10.2024 (SCUBA DIVING)

The sample consists of 100 individuals rapa whelk (from scuba diving), with a weight of 10.79 kg, from a total landing of 20 kg rapa whelks at port Primorsko.

The mean weight of the measured specimens reaches 107.9 g ± 25.62 SD, at a mean shell length of 85.09 mm ± 6.72 SD, shell width – 65.45 mm ± 5.86 SD and aperture length 62.37 mm ± 5.78 SD. The mean body weight without shell (BW, g) is 41.88 g ± 11.39 SD forming 41.59 % ± 3.53 SD from the total weight, varying between 33.0 % и 49.0 % from the total weight (Table 38).

Table 38

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 Primorsko, 15.10.2024

	TW g	SL mm	Wd mm	Al mm	BW g	BW % TW
Sample size	100.00	100.00	100.00	100.00	50	50
Mean	107.90	85.09	65.45	62.37	41.88	41.59
Standard deviation	25.62	6.72	5.86	5.78	11.39	3.53
Minimum	49.97	67.00	49.00	46.00	16.30	32.62
50% (median)	106.58	85.00	65.00	62.00	41.26	42.05
Maximum	171.96	102.00	84.00	82.00	72.34	49.28
Sum	10789.72	8509.00	6545.00	6237.00	2093.76	2079.47
Mode	135.02	83.00	63.00	61.00	42.15	42.77
Skewness	0.42	0.06	0.11	0.18	0.67	-0.34
Sample variance	0.24	0.08	0.09	0.09	0.27	0.08
Kurtosis	-0.16	-0.28	0.51	0.77	0.47	-0.06
Range	121.99	35.00	35.00	36.00	56.04	16.66
Confidence level 95%	5.08	1.33	1.16	1.15	3.24	1.00

The mean ratio between the shell width (Wd, mm)/shell length (SL, mm) is 76.91 % ± 2.93 SD, while AL/SL (%) is 73.27 % ± 2.86 SD, and the ratio between AL/Wd (%) was calculated at - 95.27 % ± 1.12 SD (Table 39).

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Table 39

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 Primorsko, 15.10.2024

	Wd/SL %	Al/SL %	Al/Wd %
Sample size	100	100	100
Mean	76.91	73.27	95.27
Standard deviation	2.93	2.86	1.12
Minimum	70	65.71	92.98
50% (median)	76.79	73.06	95.28
Maximum	85.71	83.67	98.44
Sum	7690.55	7326.82	9527.36
Mode	75	73.49	95.16
Skewness	0.32	0.4	0.24
Sample variance	0.04	0.04	0.01
Kurtosis	0.1	1.18	-0.32
Range	15.71	17.96	5.46
Confidence level 95%	0.58	0.57	0.22

The L-W ratios are calculated, Figure 14. The parameters *a, b* of the linear-weight relationships and the values of the correlation coefficient R^2 are presented in Table 40.

Table 40

Parameters *a,b* of the L-W ratios and values of R^2 for the sample from port Primorsko, 15.10.2024

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	0,00312	0,00465
b	2.77	2.49	2.43
R^2	0.91	0.92	0.92

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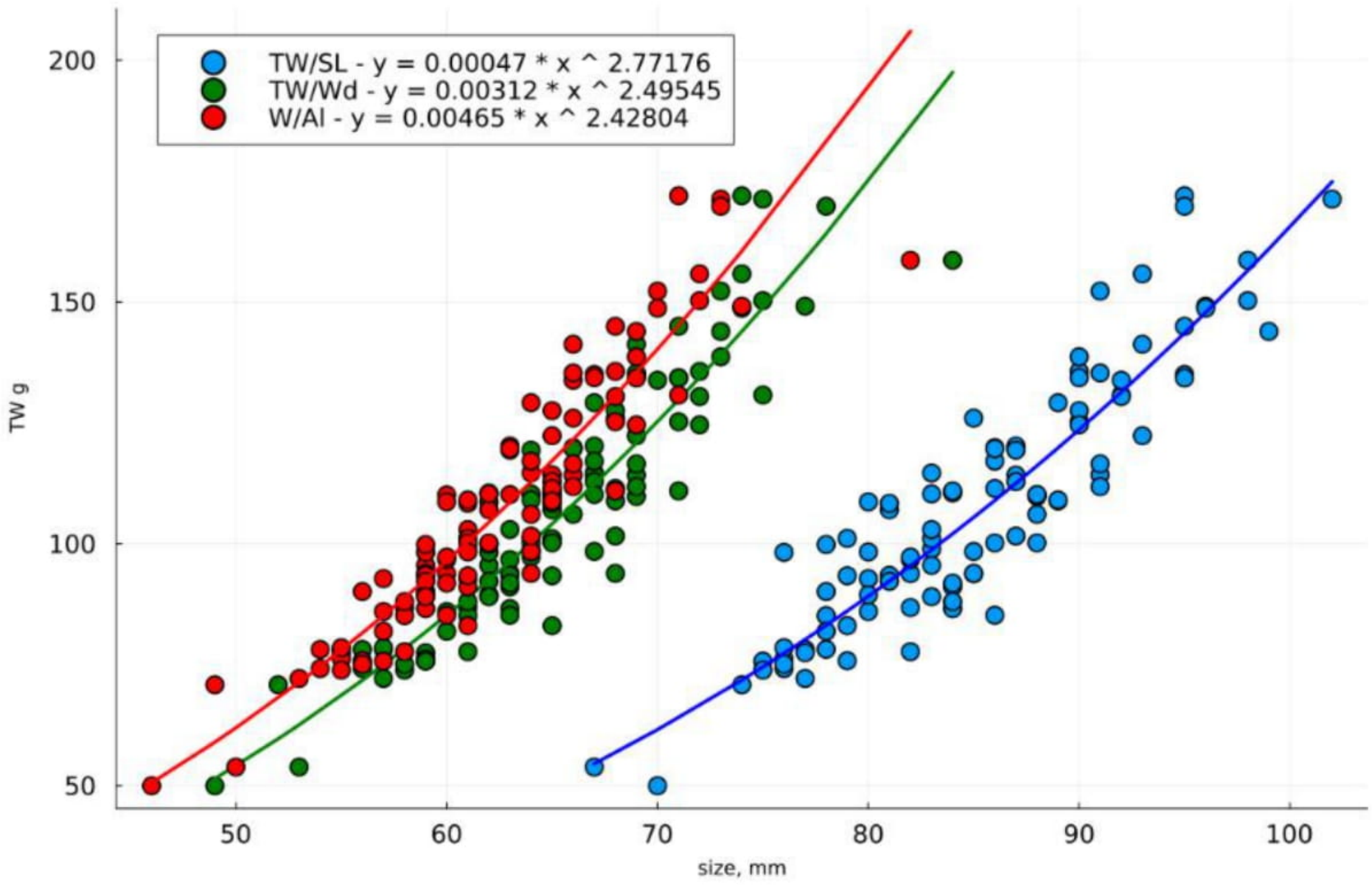

Figure 14 L-W ratios for the sampled individuals, port Primorsko, 15.10.2024: (1) ratio between total weight (TW, g) and shell length (SL, mm); (2) relationship between total weight (TW, g) and shell width (Wd, mm); (3) relationship between total weight (TW, g) and aperture length (AL, mm)

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3.1.14. SUMMARIZED RESULTS FOR 2024

The landings for the period March – October 2024 vary between 20 and 5665 kg/day for all observed ports. The biggest landing from beam trawl fishing was registered at port Varna in September 2024.(Table 41)

Table 41
Summarized data about the landings by days and ports from different fishing vessels and fishing methods for 2024

Date	Landing port	Fishing vessel	Fishing method	Catch (kg)	Sample weight (per 100 ind) (kg)
31/03/2024	Kavarna	KB5642	beam trawl	959	2.28
02/04/2024	Rodopa 1	BH 7643	beam trawl	321	2.63
06/04/2024	Nessebar	HC592	scuba diving	120	4.60
15/05/2024	Nessebar	HC592	scuba diving	600	6.16
16/05/2024	Balchik	BH 8042	beam trawl	234	3.64
05/06/2024	Varna	BH 7979	beam trawl	2440	4.64
17/06/2024	Pomorie	HC611	scuba diving	116	5.47
24/07/2024	Kavarna	BH 8311	beam trawl	1018	3.15
24/07/2024	Rodopa 1	Akula - 1	beam trawl	1900	5.42
24/09/2024	Pomorie	ПМ153	scuba diving	815	6.44
25/09/2024	Varna	Tais	beam trawl	5665	4.62
26/09/2024	Rodopa 1	Akula - 1	beam trawl	1950	4.18
15/10/2024	Primorsko	ПР428	scuba diving	20	10.79

The mean size (SL, mm) of the specimens, caught by beam trawl, for the first half of 2024 is 55.06 mm ± 10.70 SD. In general, the size varies by ports and is dependent on the fishing method. In the beam trawl samples the variations are between 49 – 60 mm, while the mean size of individuals from scuba diving is in the range 61 – 69 mm. (Table 42.1)Table . Accordingly, for beam trawl catches, the mean weight (TW, g) is 33.00 g ± 21.24 SD (Table 42.2), and for scuba diving catches, the mean weight of the measured specimens is 54.05 g ± 23.24 SD. The mean body weight without shell (BW, g) for beam trawl catches is 11.77 g ± 7.16 SD (Table 42.3), forming 34.90% from the total body weight during the observed period, with the average percentage distribution by ports varying between 32.5% and 37.30%. For scuba diving catches, the mean body weight without shell is 18.75 g ± 8.08 SD, or 33.33% of the total body weight. (Table 42.2)

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The mean size (SL, mm) of the specimens, caught by beam trawl, for the second half of 2024 reaches 61.40 mm ± 8.23 SD. In general, the size varies by ports and is dependent on the fishing method. In the beam trawl samples the variations are between 55 – 65 mm, while the mean size of individuals from scuba diving is in the range 64 – 85 mm. (Table 42.1). Accordingly, for beam trawl catches, the mean weight (TW, g) is 43.38 g ± 17.97 SD (Table 42.2), and for scuba diving catches, the mean weight of the measured specimens is 86.13 g ± 32.32 SD. The mean body weight without shell (BW, g) for beam trawl catches is 13.18 g ± 7.43 SD (Table 42.3), forming 32.43% from the total body weight during the observed period, with the average percentage share across ports varying between 30.67 % and 34%. For scuba diving catches, the mean body weight without shell is 26.31 g ± 16.08 SD, or 34.80% of the total body weight. (Table 42.2).

An analysis of the results for the entire year was also conducted, revealing that the mean shell length (SL,mm) of the observed specimens from the ports reaches 62.92 mm ± 10.05 SD. In general the size varies by ports and is dependent on the fishing method. In the beam trawl samples the variations are between 53 – 66 mm, while the mean size of individuals from scuba diving is in the range 63 – 80 mm. Accordingly, for beam trawl catches, the mean weight (TW, g) is 38.19 g ± 20.33 SD, and for scuba diving catches, the mean weight of the measured specimens is 65.88 g ± 31.20 SD. (Table 42.1)The mean body weight without shell (BW, g) for beam trawl catches is 12.47 g ± 7.32 SD (Table 42.3), forming 33.51% from the total body weight during the observed period. For scuba diving catches, the mean body weight without shell is 21.77 g ± 12.47 SD, or 33.46 % of the total body weight.

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Table 42

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 2024. (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
Kavarna	100	49.33	5.31	40.00	67.00
Rodopa 1	100	50.39	11.48	35.00	84.00
Nessebar	100	60.91	13.03	35.00	94.00
Nessebar	100	68.73	6.59	54.00	87.00
Balchik	100	56.95	10.22	43.00	89.00
Varna	100	63.57	8.05	49.00	91.00
Pomorie	100	68.35	6.48	54.00	95.00
Kavarna	54.87	9.28	43.00	82.00	54.87
Rodopa 1	64.38	7.19	53.00	84.00	64.38
Pomorie	67.36	7.22	50.00	88.00	67.36
Varna	64.24	6.18	53.00	84.00	64.24
Rodopa 1	62.12	6.06	53.00	86.00	62.12
Primorsko	85.09	6.72	67.00	102.00	85.09

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

Port	Sample size	Mean TW, g	Standard deviation	Minimum TW, g	Maximum TW, g
Kavarna	100	22.82	7.99	9.92	59.53
Rodopa 1	100	26.34	21.31	5.70	117.19
Nessebar	100	46.01	28.52	7.52	148.39
Nessebar	100	61.49	20.00	22.77	145.69
Balchik	100	36.40	22.40	12.81	127.59
Varna	100	46.46	21.32	21.19	144.17
Pomorie	100	54.67	17.22	24.29	140.65
Kavarna	31.45	19.88	14.22	103.31	31.45
Rodopa 1	54.17	18.21	29.44	110.90	54.17
Pomorie	59.94	20.30	20.99	132.26	59.94
Varna	46.16	12.41	27.05	95.43	46.16
Rodopa 1	41.79	12.23	26.17	103.61	41.79
Primorsko	107.90	25.62	49.97	171.96	107.90

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

Port	Sample size	Mean BW, g	Standard deviation	Minimum BW, g	Maximum BW, g
Kavarna	50	24.13	8.13	12.05	59.53
Rodopa 1	50	36.46	25.60	11.17	117.19
Nessebar	50	54.54	27.41	16.97	139.81
Nessebar	50	61.64	21.81	29.27	145.69
Balchik	50	30.52	16.12	12.81	99.54
Varna	50	41.66	13.53	21.19	89.81
Pomorie	50	55.13	19.48	29.31	140.65
Kavarna	50	7.81	3.86	1.89	19.73
Rodopa 1	50	18.23	8.94	1.31	36.32
Pomorie	50	16.11	6.30	1.23	31.75
Varna	50	13.04	5.44	1.33	27.43
Rodopa 1	50	13.65	6.63	1.27	39.45
Primorsko	50	36.51	16.44	3.22	72.34

The weight and size classes distributions from beam trawl fishing and by ports are presented on Figure 15. According to the size structure, most individuals fall into the size class - 40 - 60 SL mm, while in terms of weight composition (TW, g), the predominant weight class is < 60 g (93% of the total number of measured specimens).

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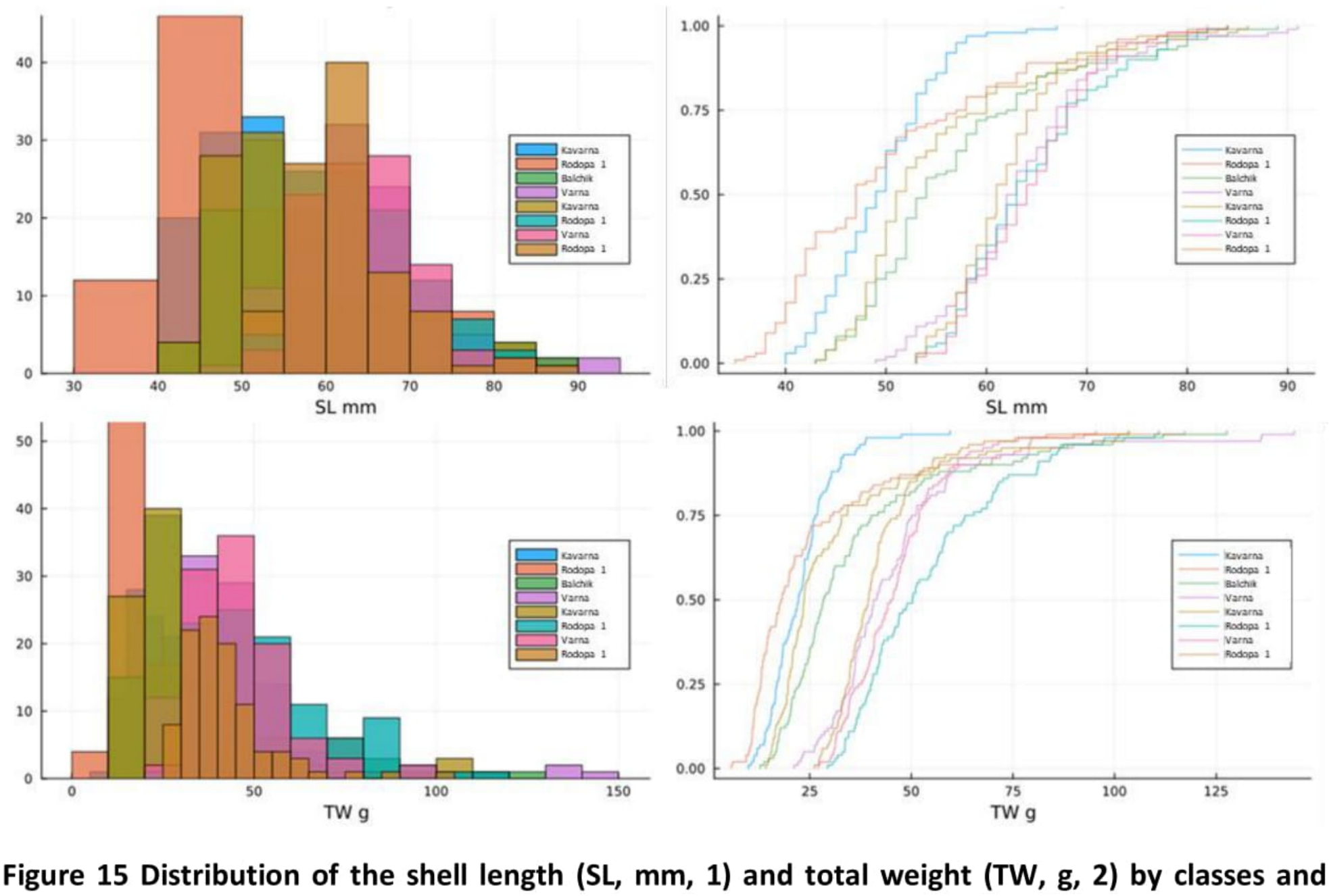

Figure 15 Distribution of the shell length (SL, mm, 1) and total weight (TW, g, 2) by classes and cumulative distribution by classes for the samples from beam trawl for 2024

Detailed data about the percentage distribution of the size and weight classes for the observed individuals in the first half of 2024 is presented on Figure 16 and Figure 17 .

The dominant size classes in the beam trawl samples are 50 - 60 mm SL and 60 – 70 mm SL (64 %), while for the scuba diving method, dominant are 60 - 70 mm SL (38 %) and 70 – 80 mm SL (28%) (Figure 16). As for the weight structure, the dominant weight class for the beam trawl samples is < 50 g TW (78 % from the measured individuals), while the scuba diving method results in the weight class > 50 g TW (67 % from the measured individuals) (Figure 17).

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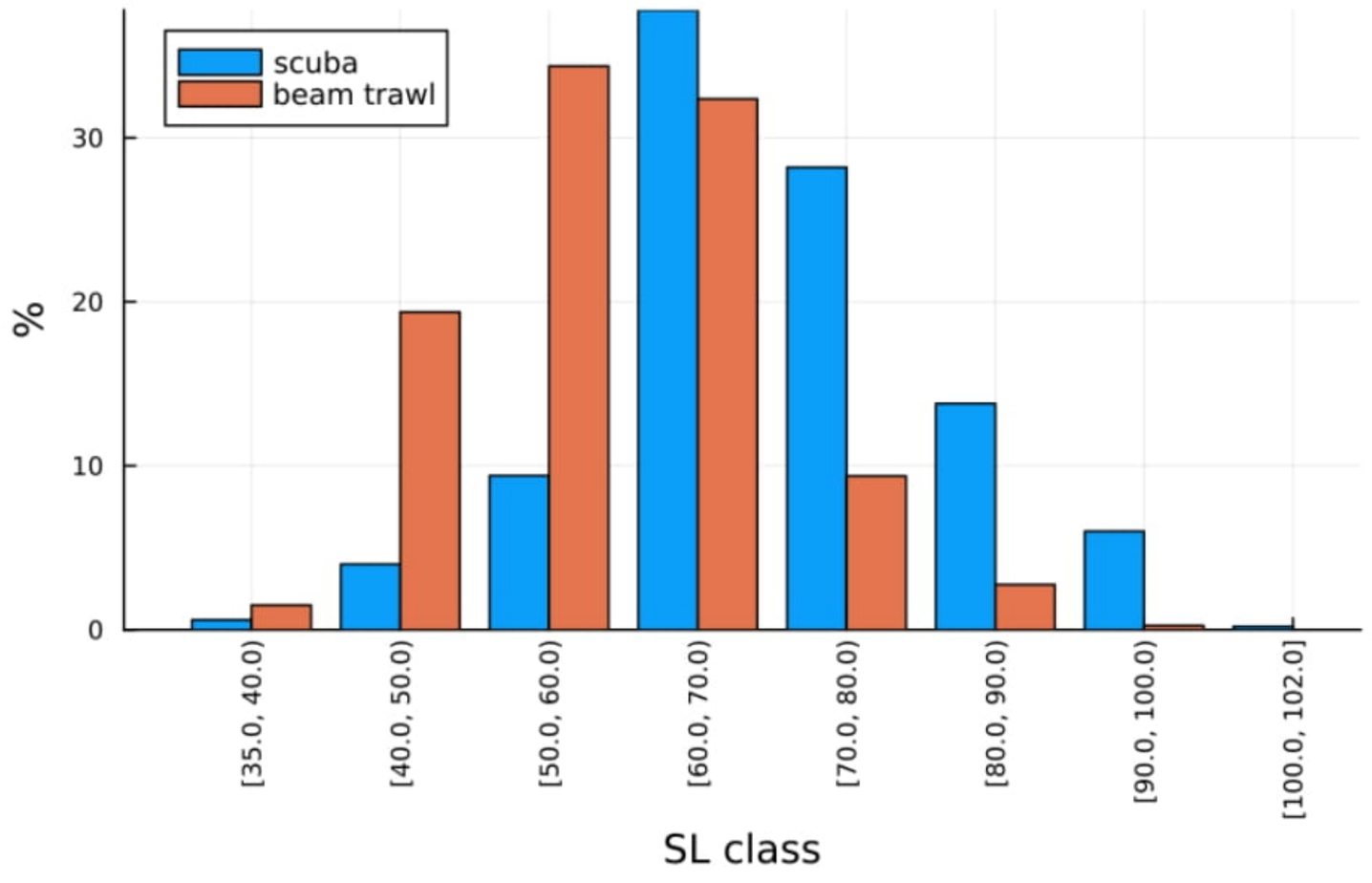

Figure 16 Distribution in % by size class (SL, mm), based on the summarized data from both fishing methods (beam trawl and scuba diving) for 2024

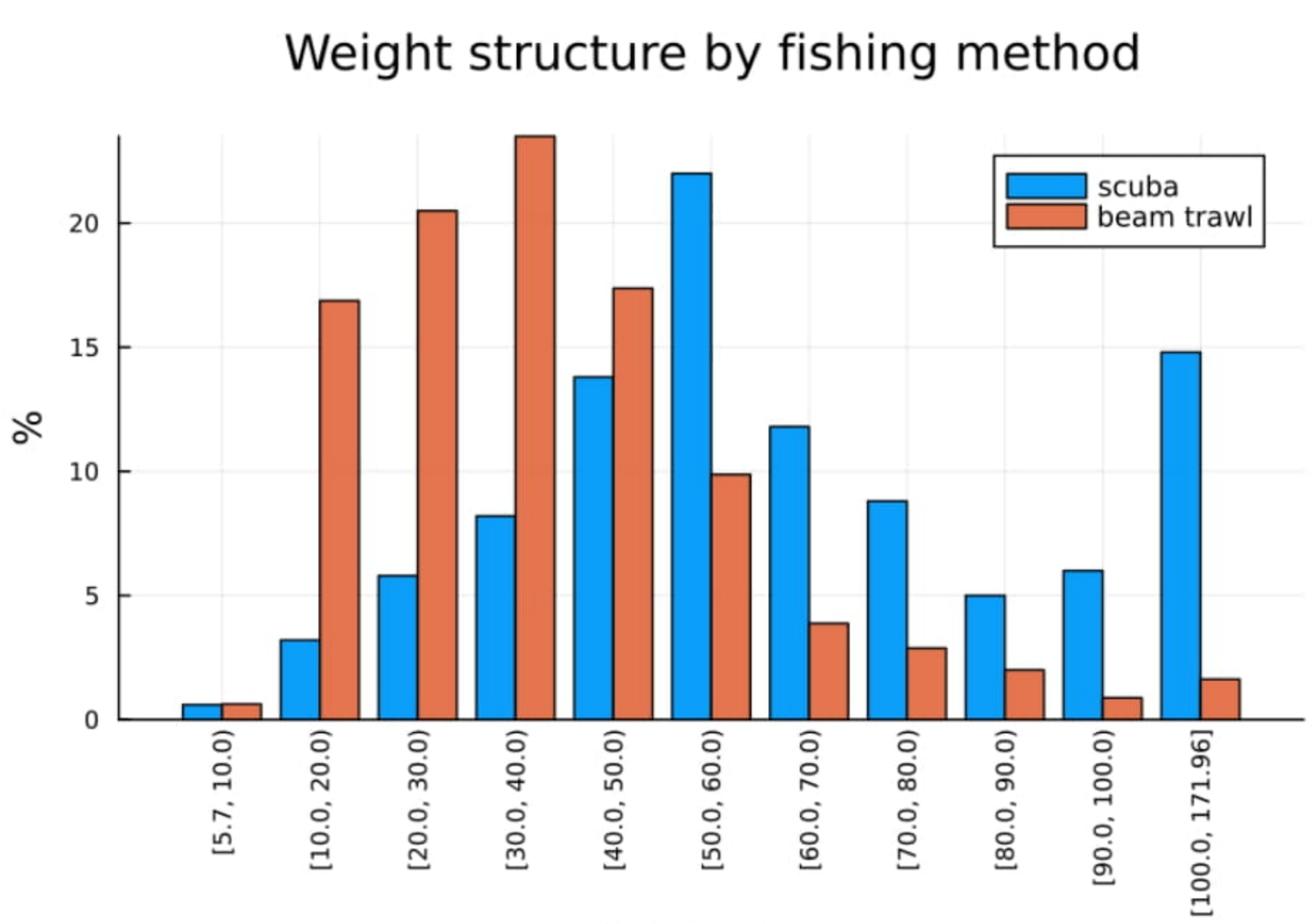

Figure 17 Distribution in % by weight class (TW, g) based on the summarized data from both fishing methods (beam trawl and scuba diving) for 2024

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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 (Figure 18). The coefficient b < 3 is an indicator for a negative allometric growth, which means that the bigger individuals grow faster in length (size) than in weight. The minimum value of the coefficient b was registered in the sample from Rodopa 1, 26.08.2024 - b = 2.57.

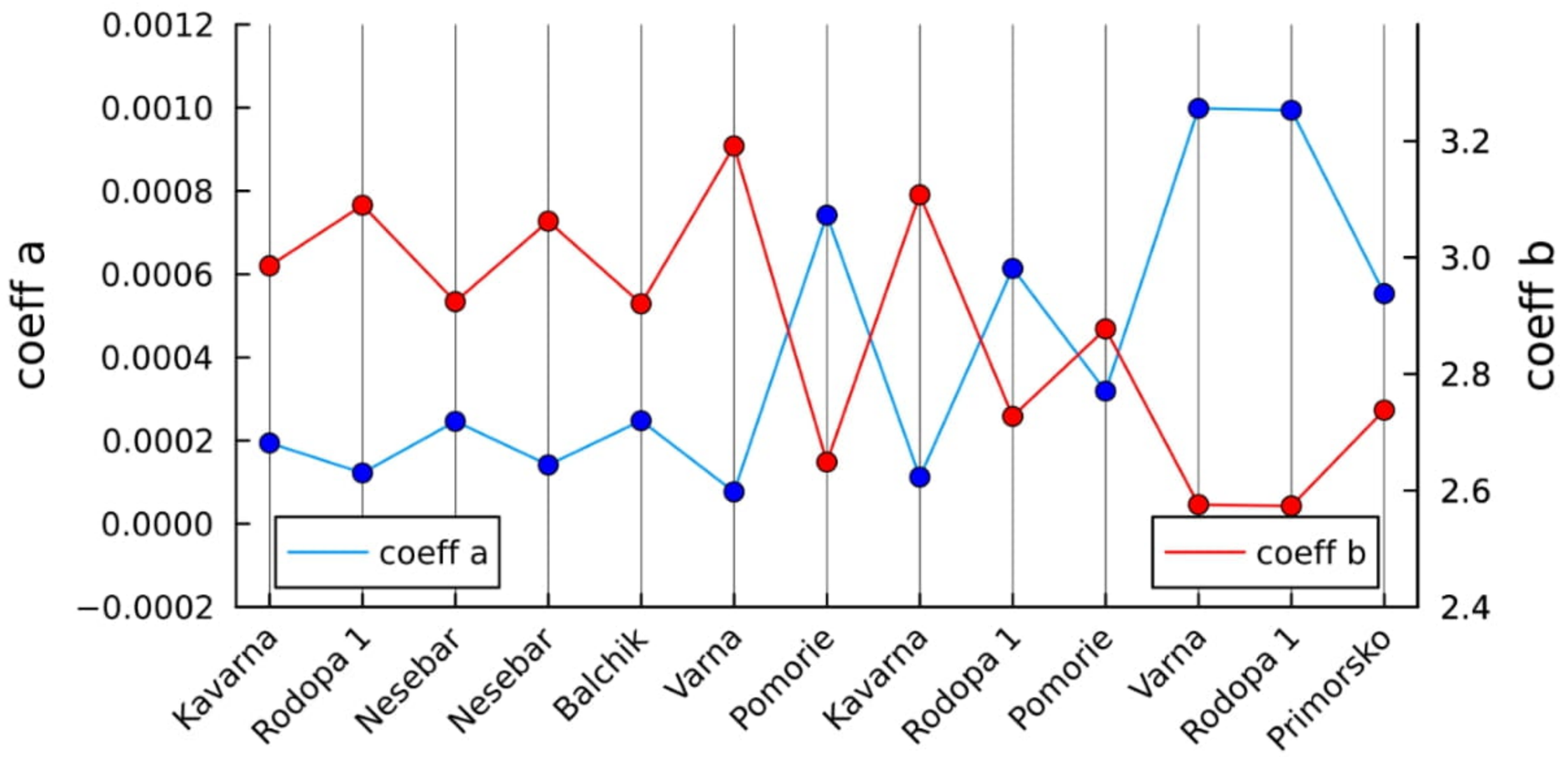

Figure 18 Parameters *a, b* of the L-W ratios for the equation $TW(g) = a.SL(mm)^b$ for all landing ports of 2024.

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3.2. Sex structure

3.2.1. Port Kavarna (scuba diving), 31.03.2024

The sex ratio in the sample is 34 % ♂ : 66 % ♀ or 1 : 1.94.
The mean size of the females' shell length in the sample is 49.88 mm ± 5.22 SD, while for the males the mean size is with 3 % bigger - 51.18 mm ± 5.16 SD. In regard to the parameter total weight (TW, g), the mean weight of the male individuals is 24.96 g ± 7.42 SD, while for the females it is slightly lower ↓ 5 % (Table 43).

Table 43

Summarized statistics of the biological parameters - shell length (SL, mm) and total weight (TW, g) by sex in the sample from port Kavarna, 31.03.2024

	SL mm		TW g	
Sex	M	F	M	F
Number	17	33	17	33
Mean	51.18	49.88	24.96	23.71
Standard deviation	5.16	5.22	7.42	8.55
Minimum	43.00	41.00	14.94	12.05
50% (median)	53.00	50	23.57	23.38
Maximum	60.00	67.00	38.82	59.53
Sum	870.00	1646.00	424.27	782.33
Mode	53.00	50	38.82	59.53
Skewness	0.10	0.10	0.30	0.36
Sample variance	0.01	0.87	0.29	2.22
Kurtosis	-1.20	1.97	-0.95	7.50
Range	17.00	26.00	23.88	47.48
Confidence level 95%	2.65	1.85	3.81	3.03

Looking at the parameters shell width (Wd, mm) and aperture length (aperture length, AL, mm), the percentage differences are similarly disproportionate, 3 % in favor of the male individuals (Table 44).

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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, 31.03.2024

	Wd mm		Al mm	
Sex	M	F	M	F
Number	17	33	17	33
Mean	38.53	37.21	35.76	34.79
Standard deviation	4.17	4.07	4.04	3.89
Minimum	32.00	31.00	29.00	28.00
50% (median)	39.00	38.00	37.00	35.00
Maximum	46.00	49.00	43.00	47.00
Sum	655.00	1228.00	608.00	1148.00
Mode	43.00	39.00	37.00	36.00
Skewness	0.11	0.11	0.11	0.11
Sample variance	-0.09	0.48	-0.08	0.67
Kurtosis	-1.04	0.46	-0.97	1.23
Range	14.00	18.00	14.00	19.00
Confidence level 95%	2.14	1.44	2.08	1.38

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3.2.2. PORT RODOPA 1, 02.04.2024

The sex ratio in the sample is 74 % ♂ to 26 % ♀ or 1 : 0.35.

The mean shell length of the female individuals is 50.85 mm ± 10.22 SD, while for the males the mean shell length is considerably longer - 58.03 ± 12.90 SD (Table 45).

Table 45

Summarized statistics of the biological parameters - shell length (SL, mm) and total weight. (TW, g) by sex in the sample from port Port Rodopa 1, 02.04.2024

	SL mm		TW g	
Sex	M	F	M	F
Number	37	13	37	13
Mean	58.03	50.85	38.99	29.27
Standard deviation	12.90	10.22	26.91	20.70
Minimum	40.00	38.00	11.17	11.32
50% (median)	57.00	49.00	29.93	17.96
Maximum	84.00	71.00	117.19	79.51
Sum	2147.00	661.00	1442.63	380.57
Mode	42.00	49.00	117.19	79.51
Skewness	0.22	0.20	0.69	0.71
Sample variance	0.31	0.51	1.01	1.18
Kurtosis	-1.03	-0.80	0.17	0.52
Range	44.00	33.00	106.02	68.19
Confidence level 95%	4.30	6.18	8.97	12.51

For the parameters shell width (Wd, mm) and aperture length (aperture length, AL, mm), the percentage differences between the male and female individuals are 10-11% in favor of the male individuals (Table 46).

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Table 46

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, 02.04.2024

	Wd mm		Al mm	
Sex	M	F	M	F
Number	37	13	37	13
Mean	43.30	39.00	40.73	36.77
Standard deviation	10.31	8.42	10.04	8.23
Minimum	28.00	28.00	26.00	27.00
50% (median)	41.00	38.00	39.00	36.00
Maximum	65.00	55.00	62.00	53.00
Sum	1602.00	507.00	1507.00	478.00
Mode	46.00	55.00	29.00	42.00
Skewness	0.24	0.22	0.25	0.22
Sample variance	0.26	0.42	0.27	0.45
Kurtosis	-1.05	-0.92	-1.06	-0.83
Range	37.00	27.00	36.00	26.00
Confidence level 95%	3.44	5.09	3.35	4.97

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3.2.3. PORT NESSEBAR (SCUBA DIVING), 06.04.2024

The sex ratio in the sample is 80 % ♂ to 20 % ♀ or 1 : 0.25.

The mean shell length of the female individuals is 54.60 mm ± 9.07 SD. The mean shell length of the males is considerably bigger - 67.62 mm ± 10.90 SD (Table 47). It has to be noted that the number of female individuals in the representative sample is small.

Table 47

Summarized statistics of the biological parameters - shell length (SL, mm) and total weight. (TW, g) by sex in the sample from port Nessebar, 06.04.2024

	SL mm		TW g	
Sex	M	F	M	F
Number	40	10	40	10
Mean	67.62	54.60	60.77	29.62
Standard deviation	10.90	9.07	26.42	14.25
Minimum	43.00	44.00	18.15	16.97
50% (median)	68.00	50.50	58.78	23.94
Maximum	94.00	69.00	139.81	55.46
Sum	2705.00	546.00	2430.67	296.16
Mode	68.00	50	139.81	55.46
Skewness	0.16	0.17	0.43	0.48
Sample variance	-0.07	0.70	0.79	1.00
Kurtosis	-0.08	-1.17	1.07	-0.56
Range	51.00	25.00	121.66	38.49
Confidence level 95%	3.49	6.49	8.45	10.19

As for the parameters shell width (Wd, mm) and aperture length (aperture length, AL, mm), the percentage differences between the males and the females are respectively 27 % and 25 % in favor of the male individuals. (Table 48).

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Table 48

Summarized statistics of the biological parameters - shell width (Wd, mm) and aperture length (aperture length, AL, mm) by sex in the sample from port Nessebar, 06.04.2024

	Wd mm		Al mm	
Sex	M	F	M	F
Number	40	10	40	10
Mean	51.42	40.90	47.90	38.30
Standard deviation	7.97	7.56	8.08	7.24
Minimum	34.00	31.00	31.00	29.00
50% (median)	52.00	38.50	48.50	36.00
Maximum	69.00	55.00	65.00	52.00
Sum	2057.00	409.00	1916.00	383.00
Mode	60.00	36.00	49.00	36.00
Skewness	0.16	0.18	0.17	0.19
Sample variance	-0.33	0.77	-0.20	0.83
Kurtosis	-0.20	-0.50	-0.25	-0.42
Range	35.00	24.00	34.00	23.00
Confidence level 95%	2.55	5.41	2.58	5.18

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3.2.4. PORT NESSEBAR (SCUBA DIVING), 15.05.2024

The sex ratio in the sample is 50 % ♂ to 50 % ♀ or 1 : 1. The mean shell length of the female individuals is 66.56 mm ± 5.81 SD, while it was observed that the length of the males is with 7 % longer – 71.36 mm ± 7.31 SD (Table 49)

Table 49

Summarized statistics of the biological parameters - shell length (SL, mm) and total weight. (TW, g) by sex in the sample from port Nessebar, 15.05.2024

	SL mm		TW g	
Sex	M	F	M	F
Number	25	25	25	25
Mean	71.36	66.56	67.63	55.64
Standard deviation	7.31	5.81	23.88	18.05
Minimum	56.00	57.00	29.27	32.26
50% (median)	70.00	67.00	59.99	51.11
Maximum	87.00	85.00	145.69	117.91
Sum	1784.00	1664.00	1690.75	1391.02
Mode	69.00	61.00	59.99	117.91
Skewness	0.10	0.09	0.35	0.32
Sample variance	0.55	1.08	1.53	1.59
Kurtosis	0.25	2.13	2.82	3.66
Range	31.00	28.00	116.42	85.65
Confidence level 95%	3.02	2.40	9.86	7.45

For the parameters shell width (Wd, mm) and aperture length (aperture length, AL, mm), the percentage differences between male and female individuals are in favor of males – 9.5 % (Table 50).

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Table 50

Summarized statistics of the biological parameters - shell width (Wd, mm) and aperture length (aperture length, AL, mm) by sex in the sample from port Nessebar, 15.05.2024

	Wd mm		Al mm	
Sex	M	F	M	F
Number	25	25	25	25
Mean	54.88	51.20	52.28	48.68
Standard deviation	6.41	4.95	6.13	4.73
Minimum	41.00	43.00	40.00	41.00
50% (median)	53.00	51.00	52.00	48.00
Maximum	69.00	66.00	66.00	64.00
Sum	1372.00	1280.00	1307.00	1217.00
Mode	53.00	51.00	52.00	48.00
Skewness	0.12	0.10	0.12	0.10
Sample variance	0.31	0.86	0.35	1.09
Kurtosis	0.04	1.43	-0.04	2.56
Range	28.00	23.00	26.00	23.00
Confidence level 95%	2.64	2.04	2.53	1.95

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3.2.5.PORT BALCHIK, 16.05.2024

The sex ratio in the sample is 60 % ♂: 40 % ♀ or 1: 0.67.

The mean shell length of the female individuals is 53.60 mm ± 9.02 SD, while it was observed that the length of the males is similar – 54.15 mm ± 6.93 SD (Table 51).

In regard to the parameter total weight (TW, g), the mean weight of the male individuals is 30.47 g ± 12.32 SD, while for the females is 30.60 ± 20.93 (Table 51).

Table 51

Summarized statistics of the biological parameters - shell length (SL, mm) and total weight. (TW, g) by sex in the sample from port Balchik, 16.05.2024

	SL mm		TW g	
Sex	M	F	M	F
Number	30	20	30	20
Mean	54.13	53.60	30.47	30.60
Standard deviation	6.93	9.02	12.32	20.93
Minimum	44.00	47.00	12.81	16.95
50% (median)	53.00	51.00	27.16	24.02
Maximum	67.00	80.00	56.75	99.54
Sum	1624.00	1072.00	914.22	611.93
Mode	59.00	49.00	49.64	99.54
Skewness	0.13	0.17	0.40	0.68
Sample variance	0.17	2.20	0.50	2.50
Kurtosis	-1.03	3.65	-0.76	5.08
Range	23.00	33.00	43.94	82.59
Confidence level 95%	2.59	4.22	4.60	9.79

For the parameters shell width (Wd, mm) and aperture length (aperture length, AL, mm), the percentage differences between male and female individuals are insignificantly small (Table 52Table).

Table 52

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, 16.05.2024

	Wd mm		Al mm	
Sex	M	F	M	F
Number	30	20	30	20
Mean	41.90	41.25	39.63	39.00
Standard deviation	6.34	8.07	6.21	7.53
Minimum	30.00	32.00	29.00	31.00
50% (median)	41.00	39.50	38.00	37.00
Maximum	54.00	63.00	51.00	59.00
Sum	1257.00	825.00	1189.00	780.00
Mode	46.00	42.00	38.00	35.00
Skewness	0.15	0.20	0.16	0.19
Sample variance	0.08	1.66	0.08	1.71
Kurtosis	-0.94	2.12	-1.10	2.19
Range	24.00	31.00	22.00	28.00
Confidence level 95%	2.37	3.78	2.32	3.53

3.2.6. PORT VARNA, 05.06.2024

The sex ratio in the sample is 72 % ♂: 28 % ♀ or 1: 0.39.

The mean size of the females' shell length in the sample is 56.00 mm ± 5.22 SD, while for the males the mean size is with 14 % bigger (Table 53). In regard to the total weight (TW, g), the mean weight of the male individuals is 45.35 g ± 13.32 SD, while for the females is 32.16 ± 8.79 SD (Table 53).

Table 53

Summarized statistics of the biological parameters - shell length (SL, mm) and total weight (TW, g) by sex in the sample port Varna, 05.06.2024

	SL mm		TW g	
Sex	M	F	M	F
Number	36	14	36	14
Mean	64.11	56.00	45.35	32.16
Standard deviation	5.54	5.22	13.32	8.79
Minimum	51.00	49.00	22.84	21.19
50% (median)	64.00	55.00	45.98	31.83
Maximum	76.00	64.00	89.81	48.91
Sum	2308.00	784.00	1632.76	450.31
Mode	66.00	52.00	48.07	42.07
Skewness	0.09	0.09	0.29	0.27
Sample variance	-0.06	0.14	1.11	0.31
Kurtosis	-0.04	-1.57	1.88	-1.13
Range	25.00	15.00	66.97	27.72
Confidence level 95%	1.87	3.01	4.51	5.08

As for the parameters shell width (Wd, mm) and aperture length (aperture length, AL, mm), the percentage differences between the males and the females are with 13 % in favor of the male individuals. (Table 54).

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Table 54

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, 05.06.2024

	Wd mm		Al mm	
Sex	M	F	M	F
Number	36.00	14.00	36.00	14.00
Mean	46.58	41.00	44.11	38.93
Standard deviation	4.69	3.55	4.41	3.43
Minimum	37.00	36.00	35.00	34.00
50% (median)	47.00	42.00	44.00	39.00
Maximum	59.00	46.00	56.00	44.00
Sum	1677.00	574.00	1588.00	545.00
Mode	45.00	43.00	45.00	41.00
Skewness	0.10	0.09	0.10	0.09
Sample variance	0.28	0.01	0.34	0.09
Kurtosis	0.67	-1.47	0.79	-1.21
Range	22.00	10.00	21.00	10.00
Confidence level 95%	1.59	2.05	1.49	1.98

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3.2.7. PORT POMORIE (SCUBA DIVING), 17.06.2024

The sex ratio in the sample is 68 % ♂ : 32 % ♀ or 1 : 0.47.

The mean size of the females' shell length (SL, mm) in the sample 65.31 mm ± 4.21 SD, which is 7% smaller than the male individuals. (Table 55). The mean weight of the males is 57.39 g ± 22.34 SD, while the mean weight of the females is 14% lower. ↓(Table 55)

Table 55

Summarized statistics of the biological parameters - shell length (SL, mm) and total weight. (TW, g) by sex in the sample from port Pomorie, 17.06.2024

	SL mm		TW g	
Sex	M	F	M	F
Number	34	16	34	16
Mean	69.97	65.31	57.39	50.33
Standard deviation	7.82	4.21	22.34	10.25
Minimum	61.00	60.00	29.31	36.29
50% (median)	69.50	65.00	52.77	49.53
Maximum	95.00	75.00	140.65	72.01
Sum	2379.00	1045.00	1951.31	805.21
Mode	63.00	65.00	46.35	40.85
Skewness	0.11	0.06	0.39	0.20
Sample variance	1.58	0.75	2.31	0.38
Kurtosis	2.99	-0.16	5.87	-0.64
Range	34.00	15.00	111.34	35.72
Confidence level 95%	2.73	2.24	7.79	5.46

As for the parameters shell width (Wd, mm) and aperture length (aperture length, AL, mm), the percentage differences between the male and female individuals are respectively 6% and 5% in favor of the males (Table 56).

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Table 56

Summarized statistics of the biological parameters - shell width (Wd, mm) and aperture length (aperture length, AL, mm) by sex in the sample from port Pomorie, 17.06.2024

	Wd mm		Al mm	
Sex	M	F	M	F
Number	34	16	34	16
Mean	51.74	48.88	48.82	46.06
Standard deviation	5.89	3.67	5.71	3.66
Minimum	42.00	43.00	39.00	40.00
50% (median)	50.50	49.00	48.00	46.00
Maximum	69.00	56.00	65.00	53.00
Sum	1759.00	782.00	1660.00	737.00
Mode	47.00	53.00	48.00	48.00
Skewness	0.11	0.08	0.12	0.08
Sample variance	1.26	0.16	1.09	0.07
Kurtosis	1.85	-0.86	1.39	-0.80
Range	27.00	13.00	26.00	13.00
Confidence level 95%	2.05	1.95	1.99	1.95

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3.2.8. PORT KAVARNA, 24.07.2024

The sex ratio in the sample is 74 % ♂: 26 % ♀ or 1: 0.35.

The mean size of the females' shell length in the sample is 52.23 mm ± 6.33 SD, while for the males the mean size is with 52.08 (Table 57). In regard to the total weight (TW, g), the mean weight of the male individuals is 26.08 g ± 10.54 SD, while for the females is 23.75 g ± 8.37 SD (Table 57).

Table 57

Summarized statistics of the biological parameters - shell length (SL, mm) and total weight. (TW, g) by sex in the sample from port Kavarna, 24.07.2024

	SL mm		TW g	
Sex	M	F	M	F
Number	37.00	13.00	37.00	13.00
Mean	52.08	52.23	26.08	23.75
Standard deviation	6.02	6.33	10.54	8.37
Minimum	67.00	68.00	59.56	46.86
50% (median)	51.00	51.00	23.38	21.72
Maximum	43.00	45.00	14.22	14.71
Sum	1927.00	679.00	964.81	308.81
Mode	48.00	52.00	20.71	21.72
Skewness	0.77	1.22	1.67	1.71
Sample variance	36.24	40.03	111.12	70.09
Kurtosis	-0.03	1.06	2.51	2.58
Range	24.00	23.00	45.34	32.15
Confidence level 95%	3.99	3.64	4.30	3.84

As for the parameters shell width (Wd, mm) and aperture length (aperture length, AL, mm), the percentage differences between the male and female individuals are insignificant , less than 1%.

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Table 58

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, 24.07.2024

	Wd mm		Al mm	
Sex	M	F	M	F
Number	37.00	13.00	37.00	13.00
Mean	40.16	39.38	37.41	36.92
Standard deviation	4.54	4.39	4.39	4.23
Minimum	52.00	51.00	49.00	48.00
50% (median)	39.00	39.00	36.00	37.00
Maximum	33.00	34.00	30.00	32.00
Sum	1486.00	512.00	1384.00	480.00
Mode	38.00	37.00	36.00	34.00
Skewness	1.01	1.44	0.96	1.35
Sample variance	20.64	19.26	19.30	17.91
Kurtosis	0.50	1.84	0.69	1.62
Range	19.00	17.00	19.00	16.00
Confidence level 95%	4.18	3.87	4.32	3.78

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3.2.9. PORT RODOPA 1, 24.07.2024

The sex ratio in the sample is 54 % ♂: 46 % ♀ or 1: 0.85.

The mean size of the females' shell length in the sample is 60.65 mm ± 4.31 SD, while for the males the mean size is 66.96 mm ±8.15, which is in the favor of the males (Table 59). In regard to the total weight (TW, g), the mean weight of the male individuals is 61.15 g ± 20.01 SD, while for the females is 44.93 g ± 11.04 SD. (Table 59)

Table 59

Summarized statistics of the biological parameters - shell length (SL, mm) and total weight (TW, g) by sex in the sample port Rodopa 1, 24.07.2024

	SL mm		TW g	
Sex	M	F	M	F
Number	27.00	23.00	27.00	23.00
Mean	66.96	60.65	61.15	44.93
Standard deviation	8.15	4.31	20.01	11.04
Minimum	81.00	68.00	97.10	70.81
50% (median)	68.00	60.00	60.43	41.98
Maximum	54.00	53.00	31.26	29.44
Sum	1808.00	1395.00	1651.17	1033.50
Mode	66.00	57.00	81.21	42.24
Skewness	-0.14	0.31	-0.02	0.74
Sample variance	66.50	18.60	400.55	121.94
Kurtosis	-1.24	-0.84	-1.31	-0.28
Range	27.00	15.00	65.84	41.37
Confidence level 95%	3.31	3.48	3.29	3.75

As for the parameters shell width (Wd, mm) and aperture length (aperture length, AL, mm), the percentage differences between the males and the females are 13 % and 11 % in favor of the male individuals. (Table 60)

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Table 60

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, 24.07.2024

	Wd mm		Al mm	
Sex	M	F	M	F
Number	27.00	23.00	27.00	23.00
Mean	52.19	46.83	49.22	44.13
Standard deviation	7.15	3.74	6.97	3.66
Minimum	61.00	54.00	58.00	52.00
50% (median)	52.00	46.00	49.00	44.00
Maximum	38.00	41.00	36.00	39.00
Sum	1409.00	1077.00	1329.00	1015.00
Mode	61.00	44.00	58.00	41.00
Skewness	-0.32	0.47	-0.28	0.53
Sample variance	51.08	13.97	48.64	13.39
Kurtosis	-1.05	-0.83	-1.08	-0.66
Range	23.00	13.00	22.00	13.00
Confidence level 95%	3.22	3.48	3.15	3.55

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3.2.10. Port Pomorie (scuba diving), 24.09.2024

The sex ratio in the sample is 58 % ♂: 42 % ♀ or 1: 0.72.

The mean size of the females' shell length in the sample is 64.72 mm ± 6.37 SD, while for the males the mean size is 64.48, which is in the favor of the males (Table 59). In regard to the total weight (TW, g), the mean weight of the male individuals is 51.38 g ± 12.13 SD, while for the females is 50.36 g ± 13.71 SD. (Table 61)

Table 61

Summarized statistics of the biological parameters - shell length (SL, mm) and total weight. (TW, g) by sex in the sample from port Pomorie, 24.09.2024

	SL mm		TW g	
Sex	M	F	M	F
Number	29	21	29	21
Mean	64.48	64.72	51.38	50.36
Standard deviation	4.96	6.37	12.13	13.71
Minimum	74.00	78.00	75.93	77.17
50% (median)	67.36	67.00	59.39	55.50
Maximum	54.00	50.00	26.83	20.99
Sum	1869.96	1359.16	1489.89	1057.49
Mode	67.36	67.36	59.94	59.94
Skewness	-0.66	-0.42	-0.39	-0.37
Sample variance	24.59	40.59	147.22	188.06
Kurtosis	-0.14	0.19	-0.66	-0.43
Range	20.00	28.00	49.10	56.18
Confidence level 95%	4.03	4.39	4.05	4.10

For the parameters shell width (Wd, mm) and aperture length (aperture length, AL, mm), the percentage differences between male and female individuals are insignificantly small (Table 62).

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Table 62

Summarized statistics of the biological parameters - shell width (Wd, mm) and aperture length (aperture length, AL, mm) by sex in the sample from port Pomorie, 24.09.2024

	Wd mm		Al mm	
Sex	M	F	M	F
Number	29	21	29	21
Mean	49.77	49.48	47.21	46.99
Standard deviation	4.12	4.59	4.14	4.26
Minimum	59.00	58.00	56.00	54.00
50% (median)	52.02	51.00	49.46	49.00
Maximum	40.00	41.00	38.00	40.00
Sum	1443.22	1039.12	1369.06	986.76
Mode	52.02	52.02	49.46	49.46
Skewness	-0.47	-0.40	-0.48	-0.49
Sample variance	17.01	21.09	17.15	18.17
Kurtosis	0.02	-0.68	-0.29	-0.97
Range	19.00	17.00	18.00	14.00
Confidence level 95%	4.61	3.70	4.35	3.28

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3.2.11. PORT VARNA, 25.09.2024

The sex ratio in the sample is 50 % ♂ to 50 % ♀ or 1 : 1.

The mean shell length of the female individuals is 59.16 mm ± 4.42 SD, while it was observed that the length of the males is 65.2 mm, which is in the favor of the males (Table 63). In regard to the total weight (TW, g), the mean weight of the male individuals is 47.03 g ± 9.0 SD, while for the females is 37.4 g ± 7.02 SD. (Table 63)

Table 63

Summarized statistics of the biological parameters - shell length (SL, mm) and total weight (TW, g) by sex in the sample port Varna, 25.09.2024 r.

	SL mm		TW g	
Sex	M	F	M	F
Number	25	25	25	25
Mean	65.20	59.16	47.03	37.40
Standard deviation	4.68	4.42	9.00	7.02
Minimum	77.00	70.00	70.00	51.96
50% (median)	65.00	58.00	46.46	34.57
Maximum	58.00	53.00	31.45	27.05
Sum	1630.00	1479.00	1175.76	934.89
Mode	65.00	56.00	46.46	34.51
Skewness	0.48	0.87	0.44	0.58
Sample variance	21.92	19.56	81.01	49.28
Kurtosis	0.10	0.14	0.10	-0.83
Range	19.00	17.00	38.55	24.91
Confidence level 95%	4.06	3.84	4.28	3.55

As for the parameters shell width (Wd, mm) and aperture length (aperture length, AL, mm), the percentage differences between the males and the females are with 10 % in favor of the male individuals (Table 64).

Table 64

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, 25.09.2024

	Wd mm		Al mm	
Sex	M	F	M	F
Number	25	25	25	25
Mean	48.52	44.36	45.60	41.52
Standard deviation	2.84	3.20	3.08	3.07
Minimum	53.00	51.00	50.00	48.00
50% (median)	48.00	43.00	46.00	40.00
Maximum	42.00	40.00	39.00	38.00
Sum	1213.00	1109.00	1140.00	1038.00
Mode	52.00	43.00	50.00	40.00
Skewness	-0.21	0.56	-0.09	0.92
Sample variance	8.09	10.24	9.50	9.43
Kurtosis	-0.60	-0.72	-0.88	-0.01
Range	11.00	11.00	11.00	10.00
Confidence level 95%	3.87	3.44	3.57	3.26

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3.2.12. PORT RODOPA 1, 26.09.2024

The sex ratio in the sample is 62 % ♂ to 38 % ♀ or 1 : 0.61.

The mean shell length of the female individuals is 59.15 mm ± 3.48 SD, while it was observed that the length of the males is 62.9 mm, which is in the favor of the males (Table 65). In regard to the total weight (TW, g), the mean weight of the male individuals is 44.15 g ± 13.64 SD, while for the females is 36.31 g ± 4.99 SD. (Table 65)

Table 65

Summarized statistics of the biological parameters - shell length (SL, mm) and total weight. (TW, g) by sex in the sample from port Rodopa 1, 26.09.2024

	SL mm		TW g	
Sex	M	F	M	F
Number	31	19	31	19
Mean	62.90	59.15	44.15	36.31
Standard deviation	6.64	3.48	13.64	4.99
Minimum	86.00	66.00	89.96	47.72
50% (median)	62.00	60.00	40.02	34.92
Maximum	53.00	53.00	27.31	27.25
Sum	1950.00	1123.90	1368.74	689.95
Mode	64.00	61.00	40.02	32.47
Skewness	1.41	-0.11	1.65	0.31
Sample variance	44.02	12.12	186.02	24.89
Kurtosis	3.06	-0.70	2.86	-0.20
Range	33.00	13.00	62.65	20.47
Confidence level 95%	4.97	3.73	4.59	4.10

As for the parameters shell width (Wd, mm) and aperture length (aperture length, AL, mm), the percentage differences between the males and the females are with 8 % in favor of the male individuals (Table 66).

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Table 66

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, 26.09.2024 г.

	Wd mm		Al mm	
Sex	M	F	M	F
Number	31	19	31	19
Mean	47.27	43.81	44.44	41.21
Standard deviation	4.49	2.39	4.29	2.57
Minimum	60.00	49.00	57.00	48.00
50% (median)	46.30	44.00	44.00	42.00
Maximum	40.00	39.00	38.00	37.00
Sum	1465.30	832.40	1377.70	783.00
Mode	46.00	44.00	44.00	42.00
Skewness	1.00	-0.17	1.28	0.50
Sample variance	20.18	5.73	18.40	6.62
Kurtosis	1.18	0.01	1.63	0.98
Range	20.00	10.00	19.00	11.00
Confidence level 95%	4.45	4.18	4.43	4.28

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3.2.13 PORT PRIMORSKO, 15.10.2024 (SCUBA DIVING)

The sex ratio in the sample is 82 % ♂ to 18 % ♀ or 1 : 0.22.

The mean shell length of the female individuals is 81.11 mm ± 6.37 SD, while it was observed that the length of the males is 83.8 mm, which is in the favor of the males (Table 67). In regard to the total weight (TW, g), the mean weight of the male individuals is 101.73 g ± 23.69 SD, while for the females is 93.53 g ± 26.39 SD. (Table 67)

Table 67

Summarized statistics of the biological parameters - shell length (SL, mm) and total weight (TW, g) by sex in the sample port Primorsko, 15.10.2024

	SL mm		TW g	
Sex	M	F	M	F
Number	41	9	41	9
Mean	83.80	81.11	101.73	93.53
Standard deviation	6.47	6.37	23.69	26.39
Minimum	98.00	90.00	158.64	124.60
50% (median)	83.00	82.00	97.26	93.40
Maximum	75.00	70.00	72.16	49.97
Sum	3436.00	730.00	4171.10	841.73
Mode	76.00	79.00	81.91	119.68
Skewness	0.47	-0.37	0.72	-0.24
Sample variance	41.81	40.61	560.98	696.68
Kurtosis	-0.77	-0.79	-0.44	-1.28
Range	23.00	20.00	86.48	74.63
Confidence level 95%	3.56	3.14	3.65	2.83

As for the parameters shell width (Wd, mm) and aperture length (aperture length, AL, mm), the percentage differences between the males and the females are 9 % and 7 % in favor of the male individuals. (Table 68)

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Table 68

Summarized statistics of the biological parameters - shell width (Wd, mm) and aperture length (aperture length, AL, mm) by sex in the sample from port Primorsko, 15.10.2024

	Wd mm		Al mm	
Sex	M	F	M	F
Number	41	9	41	9
Mean	64.37	61.33	61.32	58.56
Standard deviation	5.94	7.14	5.89	7.26
Minimum	84.00	72.00	82.00	69.00
50% (median)	64.00	64.00	60.00	61.00
Maximum	56.00	49.00	53.00	46.00
Sum	2639.00	552.00	2514.00	527.00
Mode	64.00	64.00	61.00	63.00
Skewness	1.02	-0.47	1.23	-0.52
Sample variance	35.34	51.00	34.72	52.78
Kurtosis	1.47	-0.60	2.18	-0.67
Range	28.00	23.00	29.00	23.00
Confidence level 95%	4.71	3.22	4.92	3.17

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3.2.14. GONADOSOMATIC INDEX (GSI)

The summarized statistics of the dynamics of the gonadosomatic index (GSI) by ports for the whole 2024 is presented in Table 69. The mean ratio of the index reaches 15.60 % BW. The gonadosomatic index for all samples by quarters is presented in Figure 19:

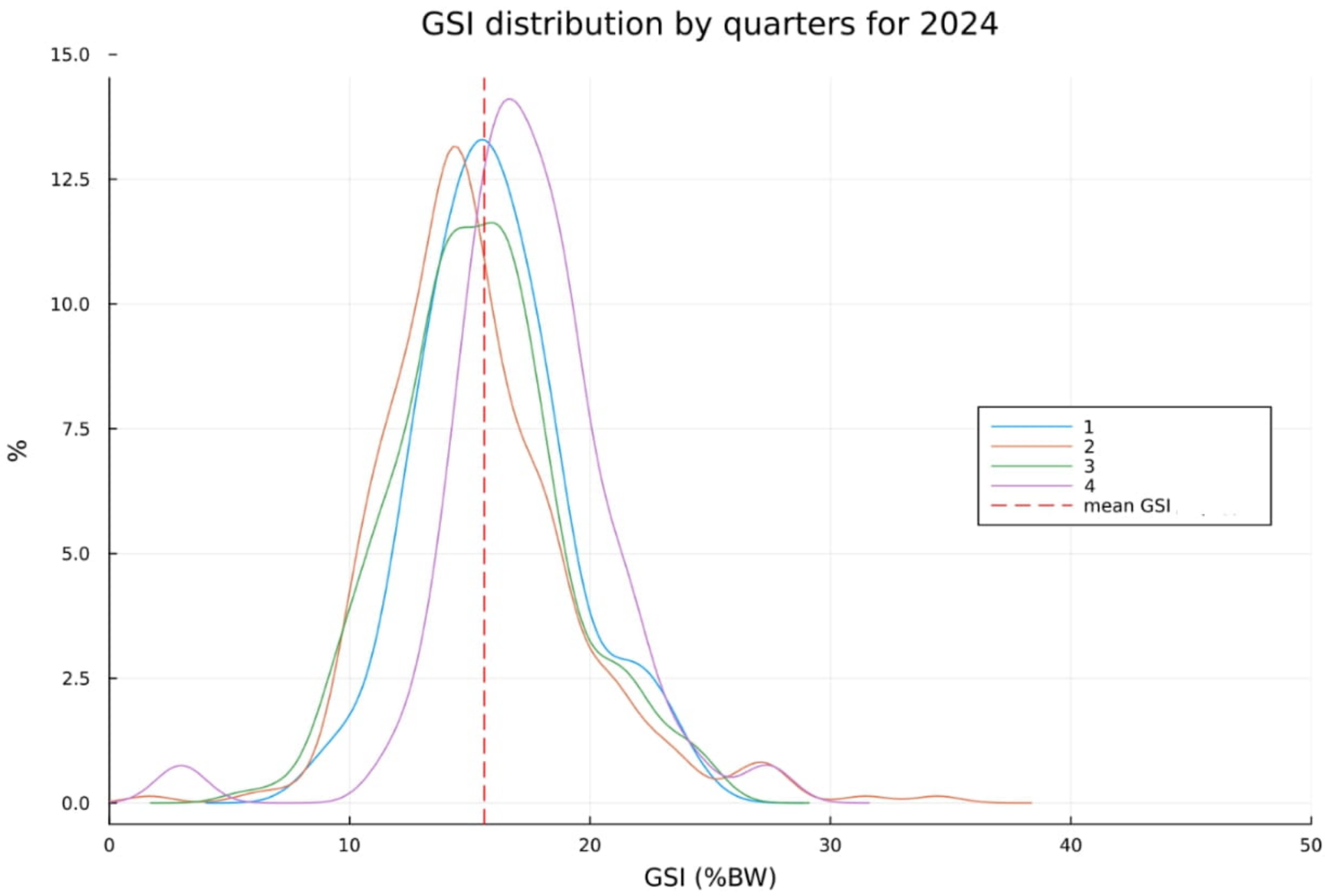

Figure 19 Gonadosomatic index by quarters for 2024

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Table 69

Summarized statistics of GSI (% BW) by ports for 2024. (data from scuba diving is in grey)

Date	Port	Sample size	Mean	Standart deviation	Maximum	Median	Minimum
31/03/2024	Kavarna	50	16.03	3.07	23.81	15.59	9.09
02/04/2024	Rodopa 1	50	18.36	5.87	34.47	17.33	1.68
06/04/2024	Nessebar	50	13.80	2.98	23.41	12.59	9.98
15/05/2024	Nessebar	50	16.33	3.45	27.05	15.79	11.13
16/05/2024	Balchik	50	14.81	2.45	21.34	14.42	10.29
05/06/2024	Varna	50	14.77	3.77	26.33	14.31	6.00
17/06/2024	Pomorie	50	14.15	3.01	20.53	13.73	9.19
24/07/2024	Kavarna	50	14.31	4.06	25.37	13.89	5.47
24/07/2024	Rodopa 1	50	14.26	3.14	23.56	14.24	6.97
24/09/2024	Pomorie	50	16.43	2.48	22.23	16.41	9.57
25/09/2024	Varna	50	16.99	3.22	23.53	16.99	10.73
26/09/2024	Rodopa 1	50	15.14	3.75	24.58	14.69	9.19
15/10/2024	Primorsko	50	17.41	3.57	27.37	17.39	2.99

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3.2.15. SUMMARIZED RESULTS ABOUT SEX STRUCTURE

The sex ratio for all observed ports is 63 % ♂: 37 % ♀ (Figure 20). No imposex forms were identified in 2024.

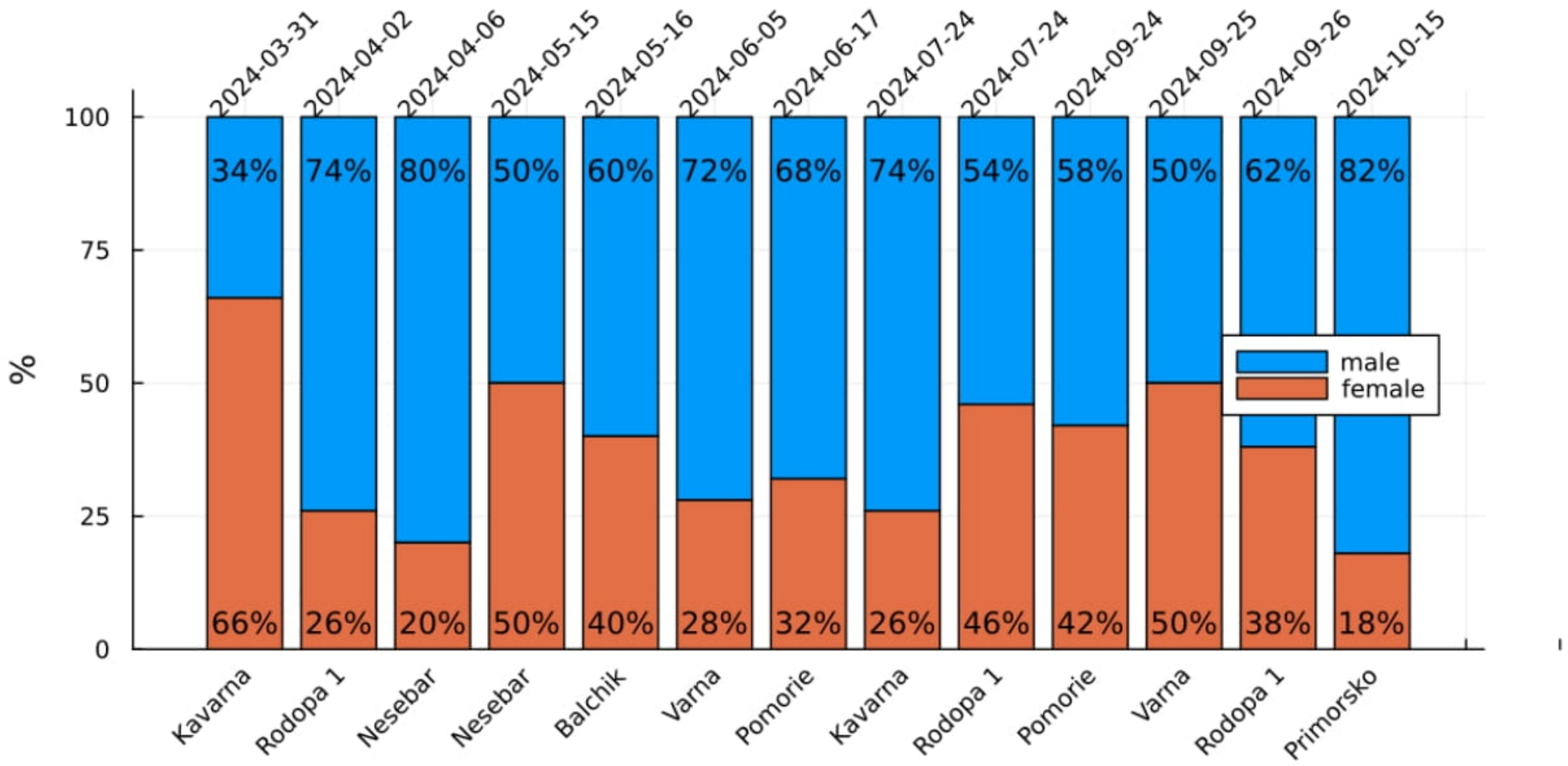

Figure 20 Summarized data about the sex structure of *R. venosa* by ports for 2024

The mean shell length (SL, mm) of the male individuals, caught by beam trawl, is 59.43 mm ± 9.45 SD, with the longest mean size of 66.96 mm – in the sample from July at port Rodopa 1 (24.07.2024, Table 70, Figure 21.1). The mean length of the female individuals reached 55.29 mm ± 7.23 SD for the period, with a percentage difference of 7 % ↓ compared to the mean length of the male specimens. Accordingly, the mean weight of the males for the period is 39.89 g ± 19.21 SD, and for females – 32.45 g ± 13.77 SD, with a percentage difference of 22.9 % between the two sexes (Table 70, Figure 21.2).

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Table 70

Statistical data about the distribution of the size (SL, mm, 1) and weight (TW, g, 2) by sex and ports for 2024 (data from scuba diving is in grey).

	Port	Sex	Mean	Standart deviation	Minimum	Maximum
1. Size (SL, mm)	Kavarna	M	51.00	5.00	43.00	60.00
		F	50	5.00	41.00	67.00
	Rodopa 1	M	58.00	13.00	40.00	84.00
		F	51.00	10.00	38.00	71.00
	Nessebar scuba diving	M	68.00	11.00	43.00	94.00
		F	55.00	9.00	44.00	69.00
	Nessebar scuba diving	M	71.00	7.00	56.00	87.00
		F	67.00	6.00	57.00	85.00
	Balchik	M	54.00	7.00	44.00	67.00
		F	54.00	9.00	47.00	80.00
	Varna	M	64.00	6.00	51.00	76.00
		F	56.00	5.00	49.00	64.00
	Pomorie scuba diving	M	70.00	8.00	61.00	95.00
		F	65.00	4.00	60.00	75.00
	Kavarna	M	52.08	6.02	67.00	43.00
		F	52.23	6.33	68.00	45.00
	Rodopa 1	M	66.96	8.15	81.00	54.00
		F	60.65	4.31	68.00	53.00
	Pomorie	M	64.48	4.96	74.00	54.00
		F	64.72	6.37	78.00	50.00
	Varna	M	65.20	4.68	77.00	58.00
		F	59.16	4.42	70.00	53.00
	Rodopa 1	M	62.90	6.64	86.00	53.00
		F	59.15	3.48	66.00	53.00
	Primorsko	M	83.80	6.47	98.00	75.00
		F	81.11	6.37	90.00	70.00
	Port	**Sex**	**Mean**	**Standart deviation**	**Minimum**	**Maximum**
2. Total weight (TW, g)	Kavarna	M	25.00	7.00	15.00	39.00
		F	24.00	9.00	12.00	60.00
	Rodopa 1	M	39.00	27.00	11.00	117.00
		F	29.00	21.00	11.00	80.00
	Nessebar scuba diving	M	61.00	26.00	18.00	140.00
		F	30.00	14.00	17.00	55.00

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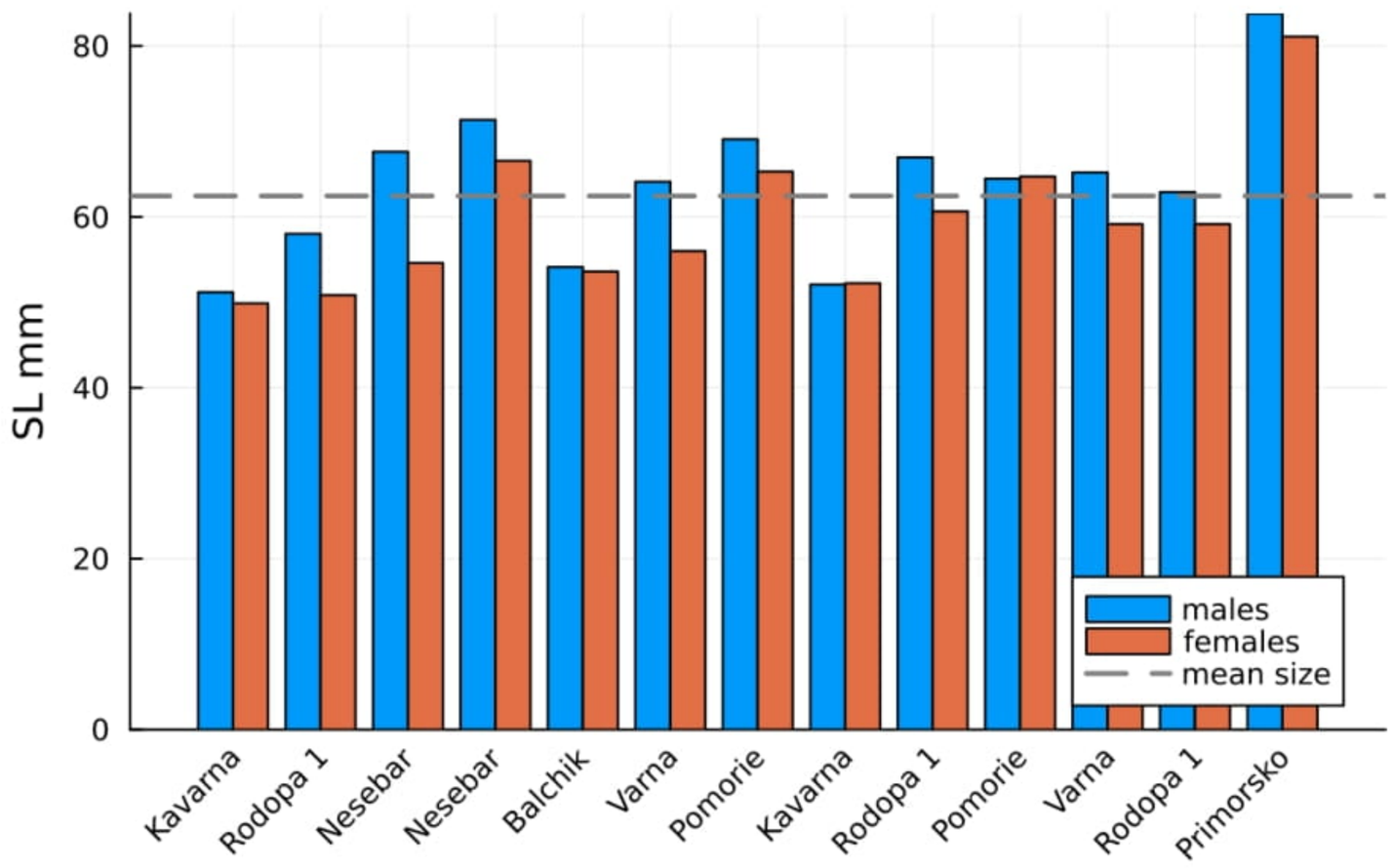
	Nessebar scuba diving	M	68.00	24.00	29.00	146.00
		F	56.00	18.00	32.00	118.00
	Balchik	M	30.00	12.00	13.00	57.00
		F	31.00	21.00	17.00	100
	Varna	M	45.00	13.00	23.00	90.00
		F	32.00	9.00	21.00	49.00
	Pomorie scuba diving	M	57.00	22.00	29.00	141.00
		F	50	10.00	36.00	72.00
	Kavarna	M	26.08	10.54	59.56	14.22
		F	23.75	8.37	46.86	14.71
	Rodopa 1	M	61.15	20.01	97.10	31.26
		F	44.93	11.04	70.81	29.44
	Pomorie	M	51.38	12.13	75.93	26.83
		F	50.36	13.71	77.17	20.99
	Varna	M	47.03	9.00	70.00	31.45
		F	37.40	7.02	51.96	27.05
	Rodopa 1	M	44.15	13.64	89.96	27.31
		F	36.31	4.99	47.72	27.25
	Primorsko	M	101.73	23.69	158.64	72.16
		F	93.53	26.39	124.60	49.97



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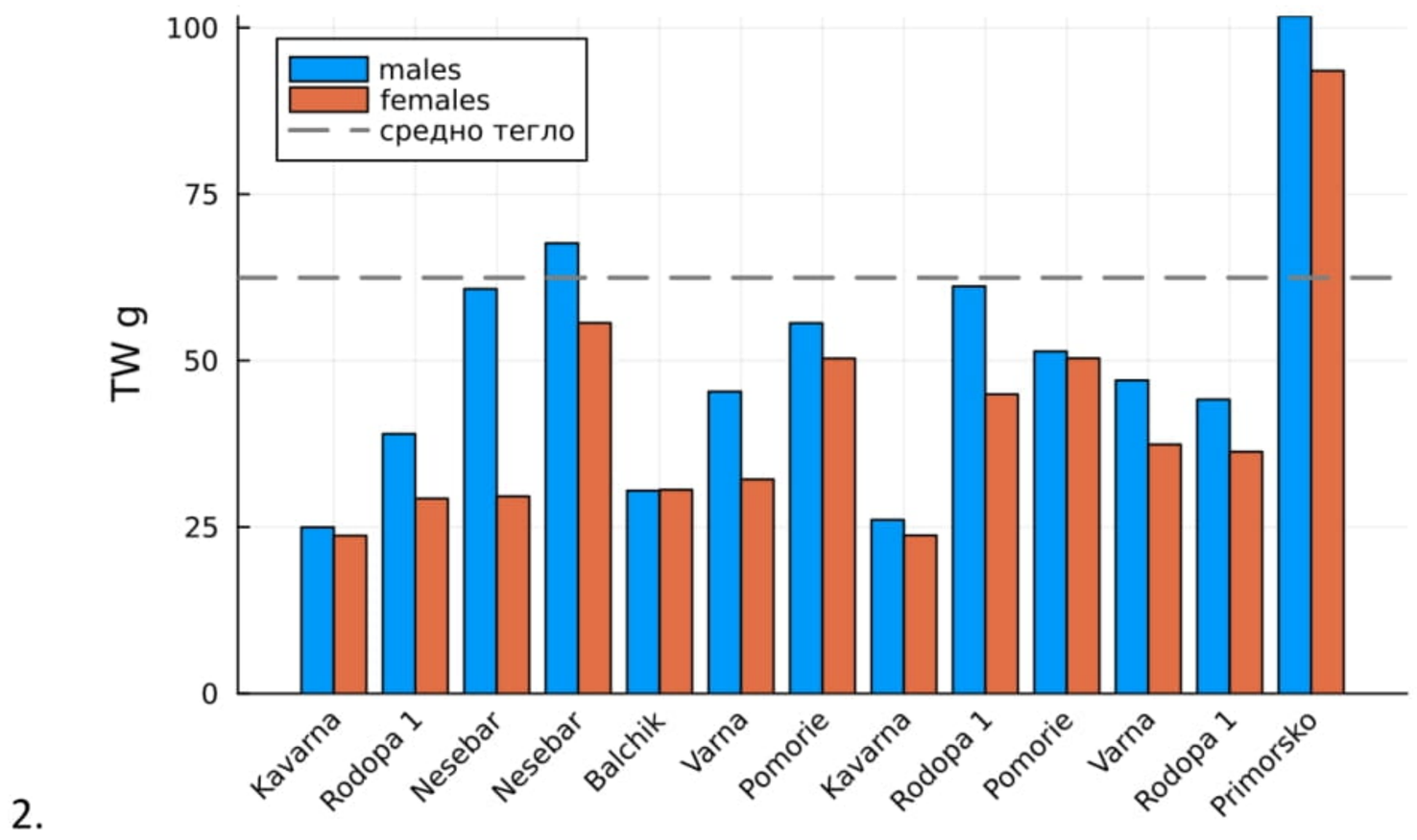
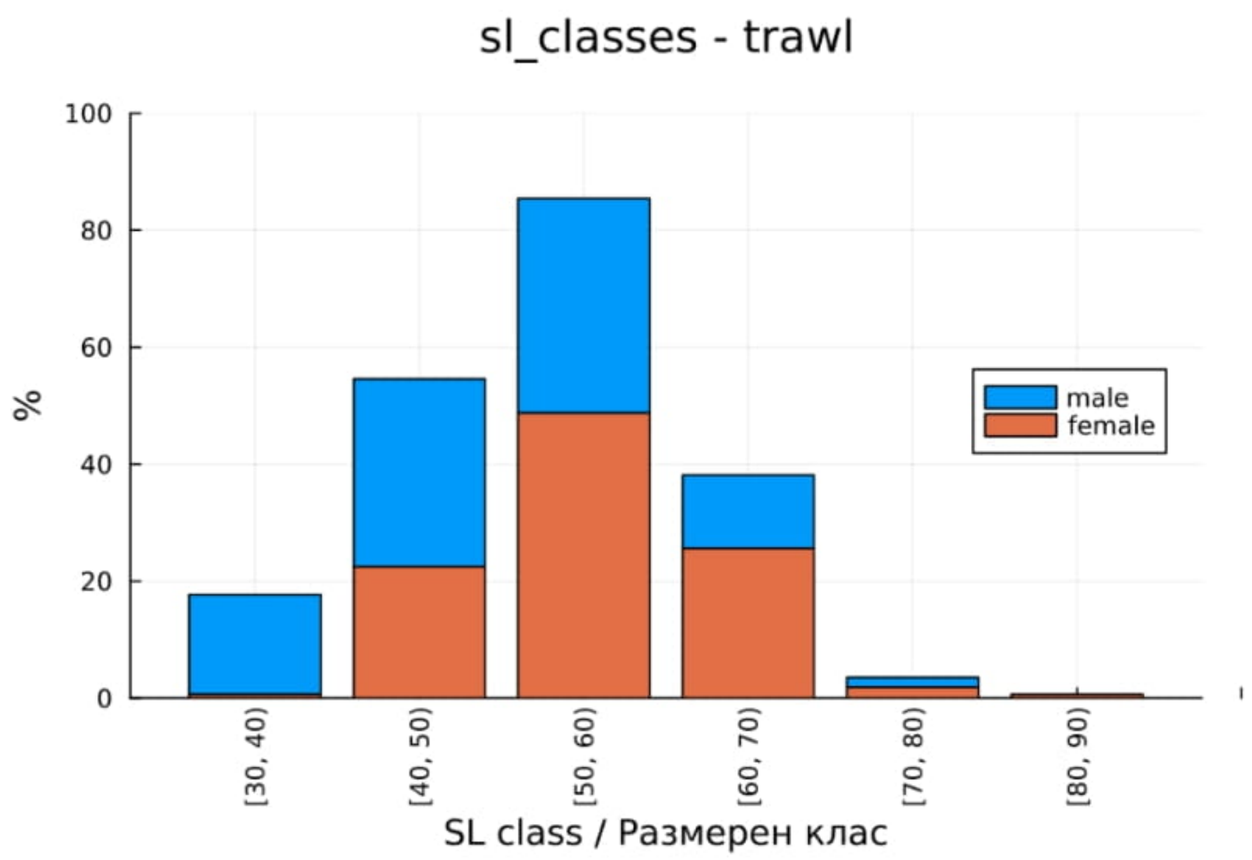


2.

Figure 21 Summarized data for the (1) mean size (SL, mm) of *R. venosa* by sex and (2) mean weight (TW, g) by sex for 2024

The analysis of the size class dynamics by sex shows that in beam trawl catches, the size class 50 - 70 mm is the dominant one or 48 % from all the male individuals. The female individuals that fall into this size class are 73 % from the observed individuals (Figure 22.1). The bigger size classes > 80 mm in the beam trawl catches form only 1% of the female individuals and are not observed in the males. In the scuba diving method (Figure 21.2), the predominant size classes are 60 – 70 mm and 70 – 80 mm, which are present in about 72 % of the males and 78 % of the females.



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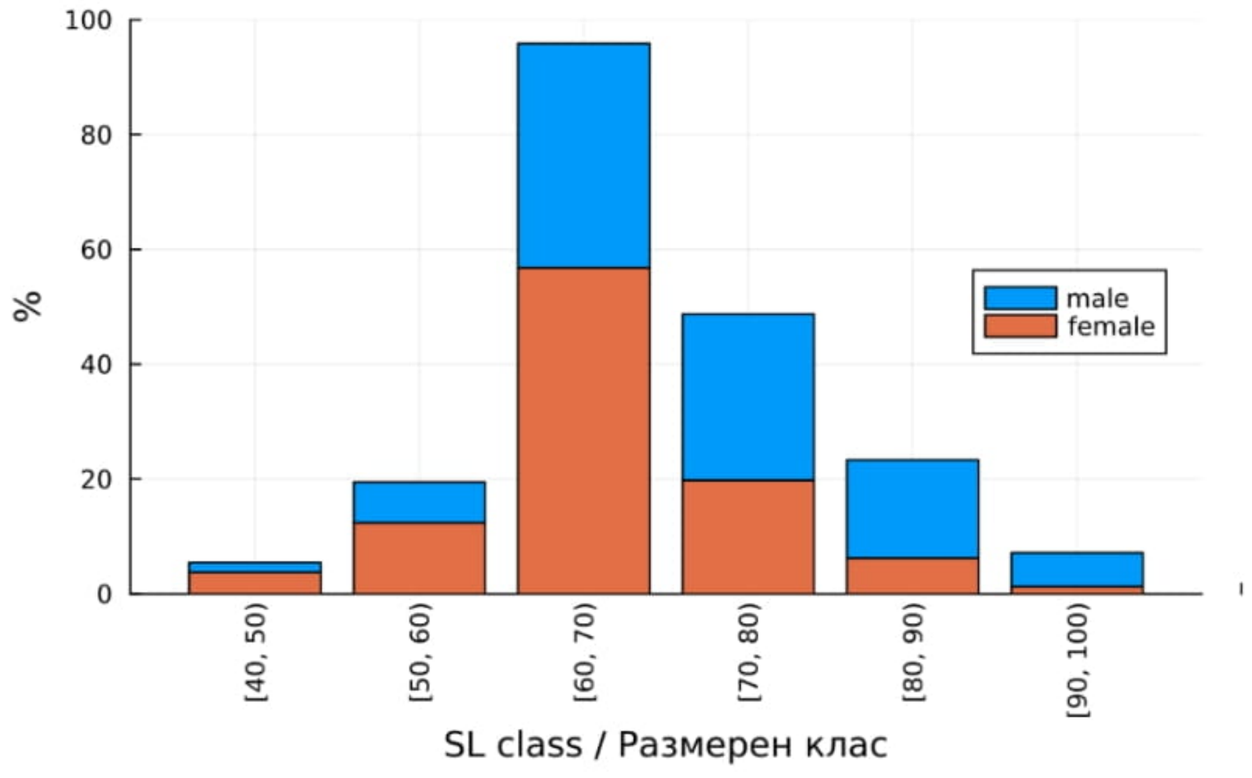
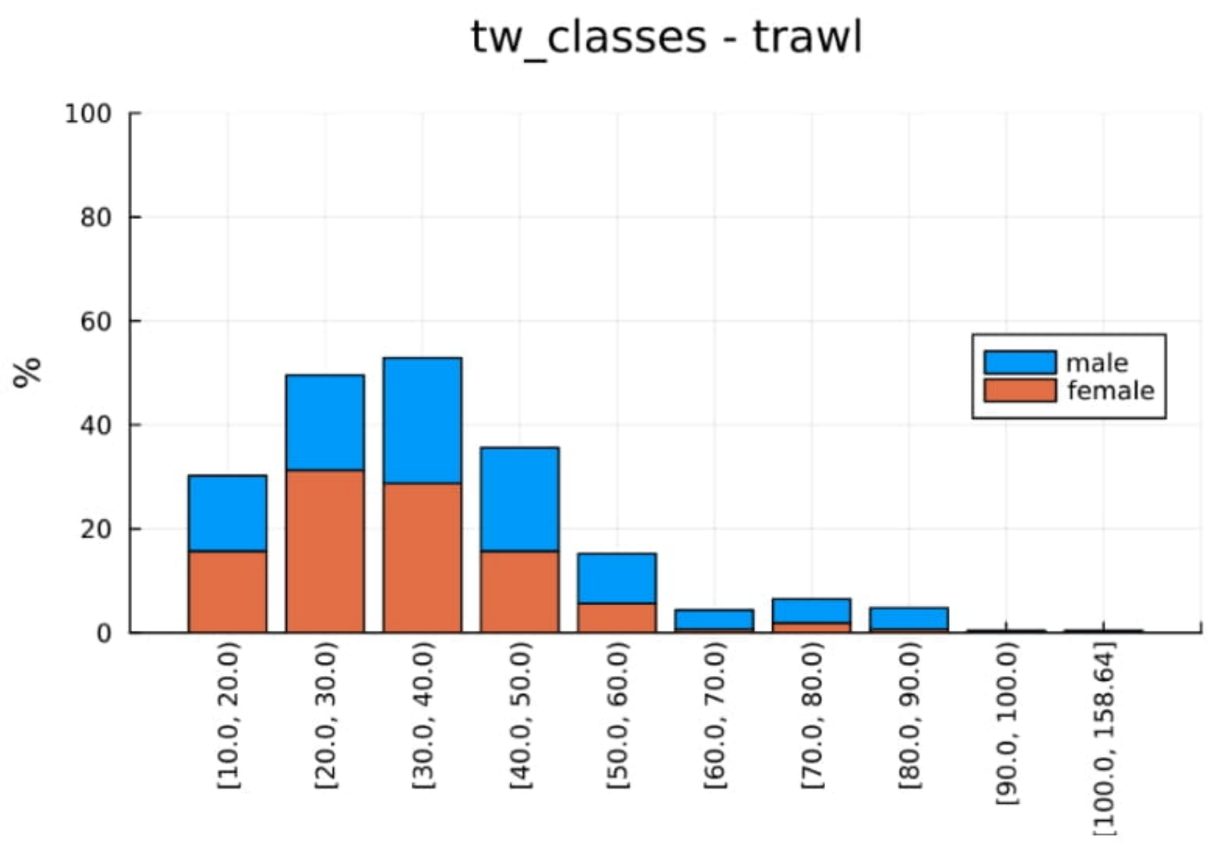


Figure 22 Percentage distribution by size class (SL, mm) of males (M) and females (F) for 2024: (1) beam trawl and (2) scuba diving

The most common weight in the samples for both the male and female individuals from beam trawl is 30 – 40 g, which was observed in 26% of the males and 30% of the females. (Figure 23). Respectively, in the samples from scuba diving, the most common weight class is 50-60 g for the female individuals (around 30% of them), while for the males 25 %.



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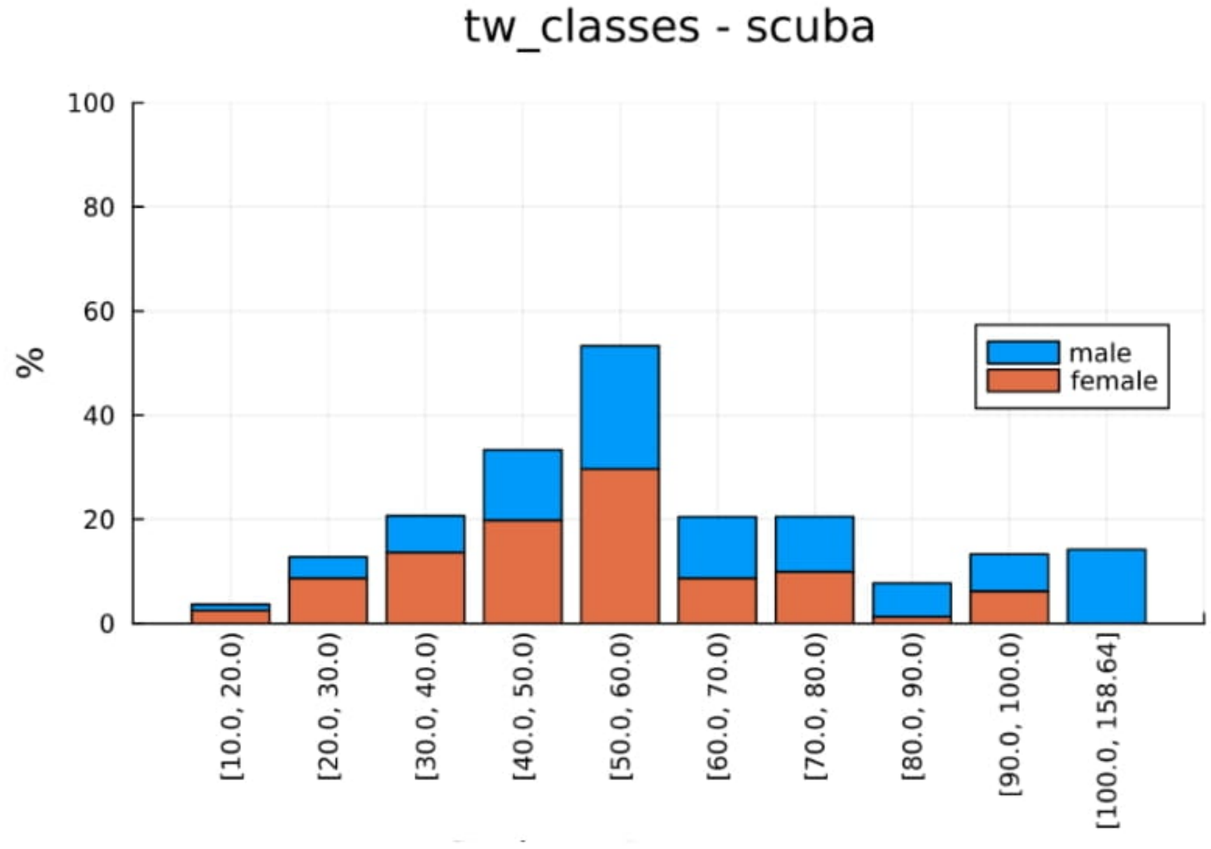

Figure 23 Percentage distribution by weight class (TW, g) of males (M) and females (F) for 2024: (1) beam trawl and (2) scuba diving

Based on summarized data from all beam trawl catches in 2024, it can be concluded that the growth for both males and females is negative allometric with a coefficient b < 3. (The parameters of the equation ration L-W for both sexes are presented on Figure 24 and in Table 71).

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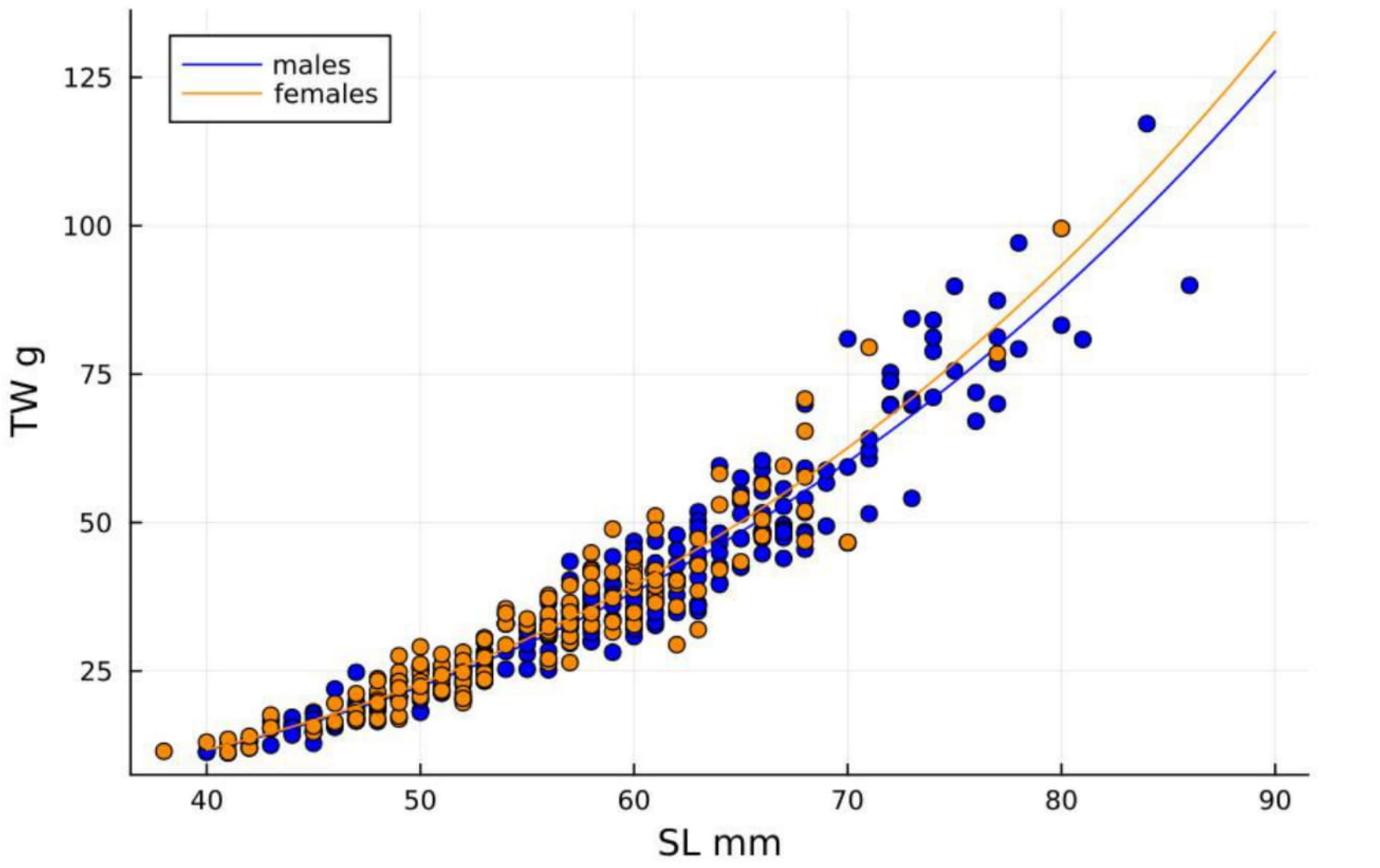

Figure 24 Total weight (TW, g) from the shell length (SL, mm) for all individuals based on the summarized data for the beam trawl fishing for 2024 (M - males, F - females)

Table 71

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 2024

Parameters $TW(g) = a.SL(mm)^b$	♀	♂
a	0.00014	0.00022
b	2.99	2.94
R^2	0.92	0.94

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4. CONCLUSIONS

- The analyzes in this report are based on biometric measurements of 1300 individuals *R. venosa*, including 800 specimens, collected from beam trawl catches and 500 specimens from scuba diving catches. The landings' samples were collected at 7 ports – "Kavarna", "Rodopa 1", "Nessebar", "Balchik", "Varna", "Pomorie" and "Primorsko" . For beam trawling, the total daily landings at the observed ports varied between 234 - 5665 kg/day, with the most significant catch landed at port Varna on 25.09.2024. The landings from scuba diving for the observed period vary between 29 – 815 kg/day with the highest observed at port Pomorie (24.09.2024).
- The mean size (SL, mm) of the specimens from the landing ports is 62.92 mm ± 10.05 SD. The variations of the mean sizes by ports mainly depend on the fishing method – for the beam trawl fishing they are between 53 – 66mm, while for the scuba diving 63 – 80 mm. Concerning the weight structure, the beam trawl catches result in a mean weight (TW, g) of 38.19 g ± 20.33 SD, while the scuba diving method resulted in a mean weight of 65.88 g ± 31.20 SD. The mean body weight (BW, g) for the beam trawl catches is 12.47 g ± 7.32 SD, forming 33.51 % of the total weight of all the individuals for the whole observed period. The mean body weight of the individuals caught by scuba diving is 21.77 g ± 12.47 SD or 33.46 % from the body weight.
- The predominant size class in the beam trawl catches is - 50 - 60 mm and 60-70 mm SL (64 % from the observed individuals), while in the scuba diving catches are 60-70 mm SL (38%) and 70-80 mm SL (28 %). Most of the individuals from the beam trawl catches are in the weight class < 50 g TW (50 % from all the rapa whelks), while in the landing from scuba diving, the weight class > 50 g TW (67 % from the observed individuals).
- The comparison analysis of the parameters *a* and *b* of the L-W ratio: W(g) = $TW(g) = a.SL(mm)^b$ shows an allometric growth of *R. venosa* at a coefficient $b \neq 3$. When b < 3 is an indicator for negative allometric growth, or the growth in length outpaces the growth in weight. The coefficient b has its lowest value $b = 2.57$ for the sample from port Rodopa 1 (26.09.2024).
- The mean ratio of the index GSI reaches 15.60 % BW. The highest index value was observed in the port sample from Rodopa 1 on 02.04.2024 (18.53 % BW). The lowest index value was recorded in the port sample from Nessebar on 06.04.2024.
- The mean length (SL, mm) of the male specimens from the beam trawl catches 59.43 mm ± 9.45 SD, with the largest mean size - 66.96 mm - in the July sample from the port Rodopa 1 (24.07.2024). The mean length of female specimens is 55.29 mm ± 7.23 SD for the period, with a percentage decrease of 7 % ↓ compared to the male individuals. Accordingly, the average weight of the male individuals is 39.89 g ± 19.21 SD, and of the females – 32.45 g ± 13.77 SD, with a percentage difference of 32 % between the males and the females.
- The analysis of the dynamics of size classes by sex shows that in the beam trawl catches, the size class - 50 - 60 mm and 60-70 mm are dominant, with a share of 64 % of the total measured male specimens and 90% female individuals from the observed individuals. In the beam trawl catches, size classes > 80 mm form only 2% of males, and females are completely absent from

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this class. In the catches by selective scuba diving method, size classes - 60 - 70 mm and 70 - 80 mm dominate, which form about 55 % of the measured male individuals and 65 % of the female individuals.

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