

**BIOLOGICAL MONITORING (BIOLOGICAL SAMPLES
COLLECTION) OF THE LANDED RAPANA CATCH BY THE
BULGARIAN FISHING FLEET
SCIENTIFIC REPORT
2025**



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This study is carried out by researchers from the Institute of Fish Resources – Varna, Agricultural Academy (AA), within Contract EAFA - 155 /27.03.2025 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 2025.

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 2025 and represents the dynamics of the biological parameters of *Rapana venosa* from the landed catch at eight ports - Ada Bahcha, Balchik, Bolata, Byala, Varna, Kavarna, Rodopa 1 and Tsarevo, based on the biometric measurements and analysis of 1300 specimens of the target species.

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1. INTRODUCTION

The current report is representative for 2025 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 – Ada Bahcha, Balchik, Bolata, Byala, Varna, Kavarna, Rodopa 1 and Tsarevo.

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* from beam trawl and scuba diving) was carried out by landings in ports, as the samples are collected from eight ports in the northern and southern marine waters. The survey covers 11 days in the period March –December 2025, while the surveyed ports are Ada Bahcha, Balchik, Bolata, Byala, Varna, Kavarna, Rodopa 1 and Tsarevo, while 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	Fishing vessel	Fishing method	Catch/day in kg	Technical specifications
25.03.2025	Rodopa 1	Корсар 2	beam trawl	503	26.11 GT, 14.7 m, 147.1 kW
05.04.2025	Kavarna	Викинг	beam trawl	2720	30.6 GT, 14.52 m, 132.39 kW
30.04.2025	Rodopa 1	Корсар 2	beam trawl	1950	26.11 GT, 14.7 m, 147.1 kW
02.05.2025	Балчик	Хермес-4	beam trawl	2600	24.62 GT, 14.95 m, 280 kW
01.06.2025	Ada bahcha	ТЕСИ	beam trawl	2278	15.51 GT, 15.73 m, 133.86 kW
01.06.2025	Kavarna	НЕПТУН-70	beam trawl	500	31.35 GT, 17.18 m, 103 kW
19.07.2025	Rodopa 1	Вн 3453	scuba diving	80	4.71 GT, 8.4 m, 33.1 kW
09.08.2025	Byala	БЛ2957	scuba diving	5	0.47 GT, 4.5 m, 5.88 kW
23.08.2025	Tsarevo	ГОЛЯМОТО СИНЬО	scuba diving	4	3.35 GT, 8 m, 73.55 kW
28.08.2025	Tsarevo	ПР 560	scuba diving	10	0.75 GT, 4.7 m, 4.41 kW
31.08.2025	Byala	БЛ2957	scuba diving	5	0.47 GT, 4.5 m, 5.88 kW



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03.09.2025	Kavarna	КОРСАР	beam trawl	2750	38.26 GT, 17.3 m, 283.17 kW
10.09.2025	Byala	КАПТАН 1	beam trawl	250	12.91 GT, 11.9 m, 119.15 kW
22.09.2025	Rodopa 1	Вн 7486	scuba diving	66	5 GT, 8 m, 22 kW
01.10.2025	Bolata	Кв 6353	scuba diving	990	2.29 GT, 6.1 m, 58.83 kW
16.10.2025	Rodopa 1	ВН 8793	scuba diving	360	2.61 GT, 9 m, 51.49 kW
26.10.2025	Varna	ВН 8710	scuba diving	5	0.58 GT, 4.8 m, 4.41 kW
31.10.2025	Varna	Хоризонт	beam trawl	2810	9.95 GT, 11.8 m, 156 kW
12.11.2025	Tsarevo	ГОЛЯМОТО СИНЬО	scuba diving	10	3.35 GT, 8 m, 73.55 kW
12.11.2025	Varna	Borei	бийм трал	1500	15.77 GT, 14.95 m, 132.39 kW



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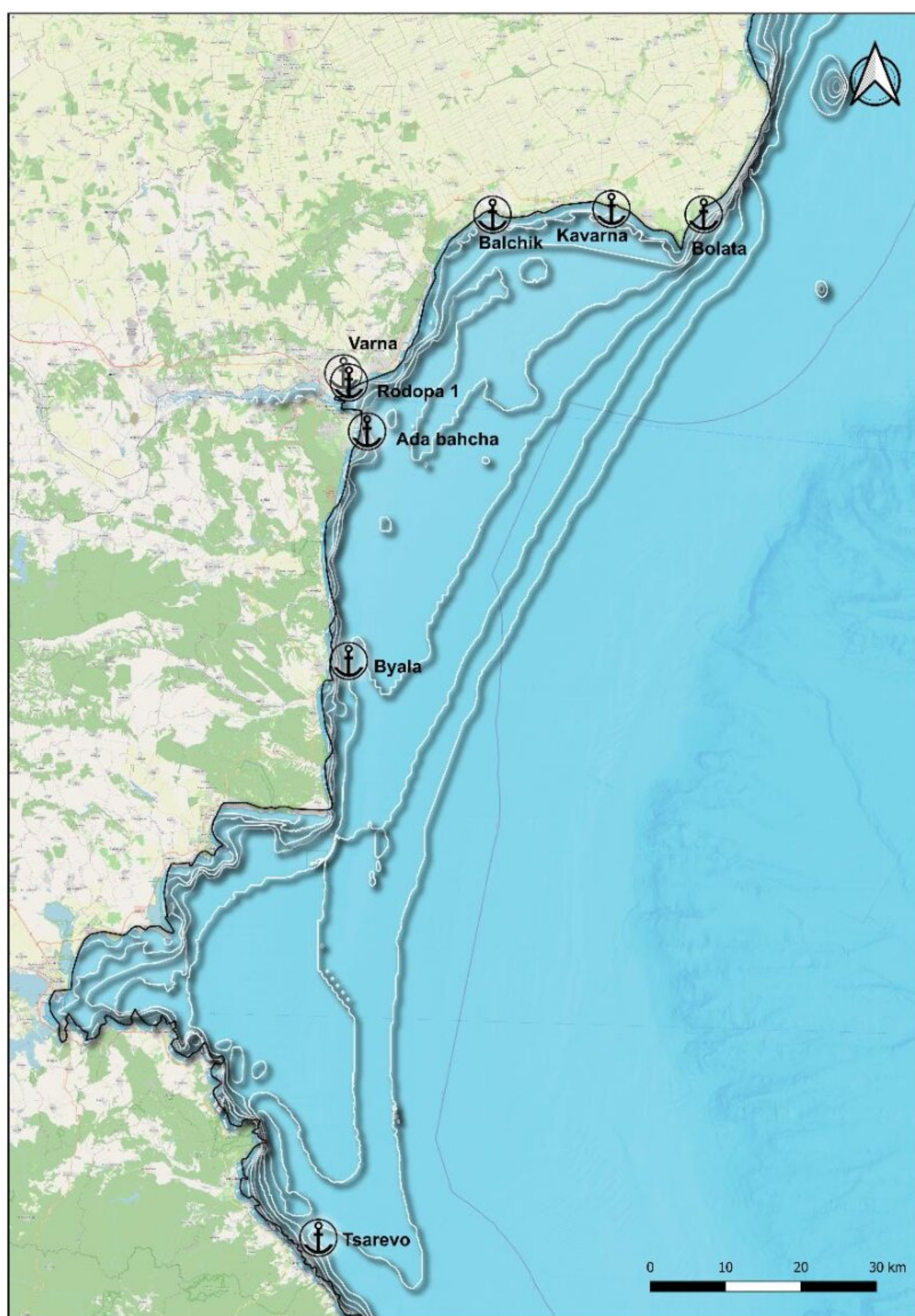


Figure 1 Landing ports for 2025

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.

During the study period, a total of 10 samples collected by scuba-diving were collected.



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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%20Documents/2004/ACFM/ACFM1204.pdf>
- Report SGPIIDS (ICES, 2011a):
<https://www.ices.dk/community/Documents/PGCCDBS/SGPIIDS%202011.pdf>
- Report of the Study Group on Practical Implementation of Discard Samples (SGPIIDS)

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:

$W(g) = a \cdot L(mm)^b$, 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:

$$GSI = [\text{gonad weight} / \text{body weight}] \times 100.$$

When estimating the percentage difference between two values, a and b, the used formula was = $|\text{Absolute difference between the two values} / \text{Average of both the values}| \times 100 \%$



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The XLSTAT software product, together with the statistical libraries of JULIA 1.11.7, were used to display the linear-weight histograms of the samples from the Rapana landings. The statistical data about the different length and weight classes, presented in the histograms, include lower and upper limits, frequency, relative frequency, and density.



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3. RESULTS

3.1. BIOMETRIC MEASUREMENTS AND LENGTH-WEIGHT RELATIONSHIPS

3.1.1. Port Rodopa 1, 25.03.2025

The sample consists of 100 individuals rapa whelk, weighing 2.51 kg, from a total landing of 503 kg rapa whelks at port Rodopa 1 (from the fishing vessel).

The mean weight of the measured specimens reaches $25.13 \text{ g} \pm 7.94 \text{ SD}$ at a mean shell length of $51.32 \text{ mm} \pm 5.55 \text{ SD}$, shell width $38.9 \text{ mm} \pm 4.17 \text{ SD}$ and aperture length $36.71 \text{ mm} \pm 4.05 \text{ SD}$. The mean body weight without shell (BW, g) is $8.03 \text{ g} \pm 2.69 \text{ SD}$, forming $29.83 \% \pm 3.59 \text{ SD}$ from the total weight, varying between 21.24 % and 37.72 % from the total weight (Table 2).

Table 2

Summarized statistics of the biological parameters - total weight (TW, g), body weight (BW, g), percentage ratio of BW (% TW), shell length (SL, mm), shell width (Wd, mm) and aperture length (aperture length, AL, mm) at port Rodopa 1, 25.03.2025

	TW g	SL mm	Wd mm	Al mm	BW g	BW % TW
Sample size	100	100	100	100	50	50
Mean	25.13	51.32	38.9	36.71	8.03	29.83
Standard deviation	7.94	5.55	4.17	4.05	2.69	3.59
Minimum	12.11	39	28	26	4.4	21.24
50% (median)	23.68	51	38	36	7.15	29.67
Maximum	52.36	68	50	48	17.26	37.72
Sum	2513.33	5132	3890	3671	401.56	1491.67
Mode	25.01	48	38	36	7.13	30.11
Skewness	63.01	30.79	17.36	16.39	7.26	12.89
Sample variance	2.2	0.08	0.25	0.37	2.78	-0.04
Kurtosis	1.29	0.42	0.34	0.4	1.64	0.03
Range	40.25	29	22	22	12.86	16.49
Confidence level 95%	(23.58, 26.69)	(50.23, 52.41)	(38.08, 39.72)	(35.92, 37.5)	(7.28, 8.78)	(28.84, 30.83)

The dominant size classes from the sample are 50- 60 mm (51% of the measured individuals). As for the weight structure, the dominant weight class (TW, g) is 20-30 g (58% of the measured individuals).



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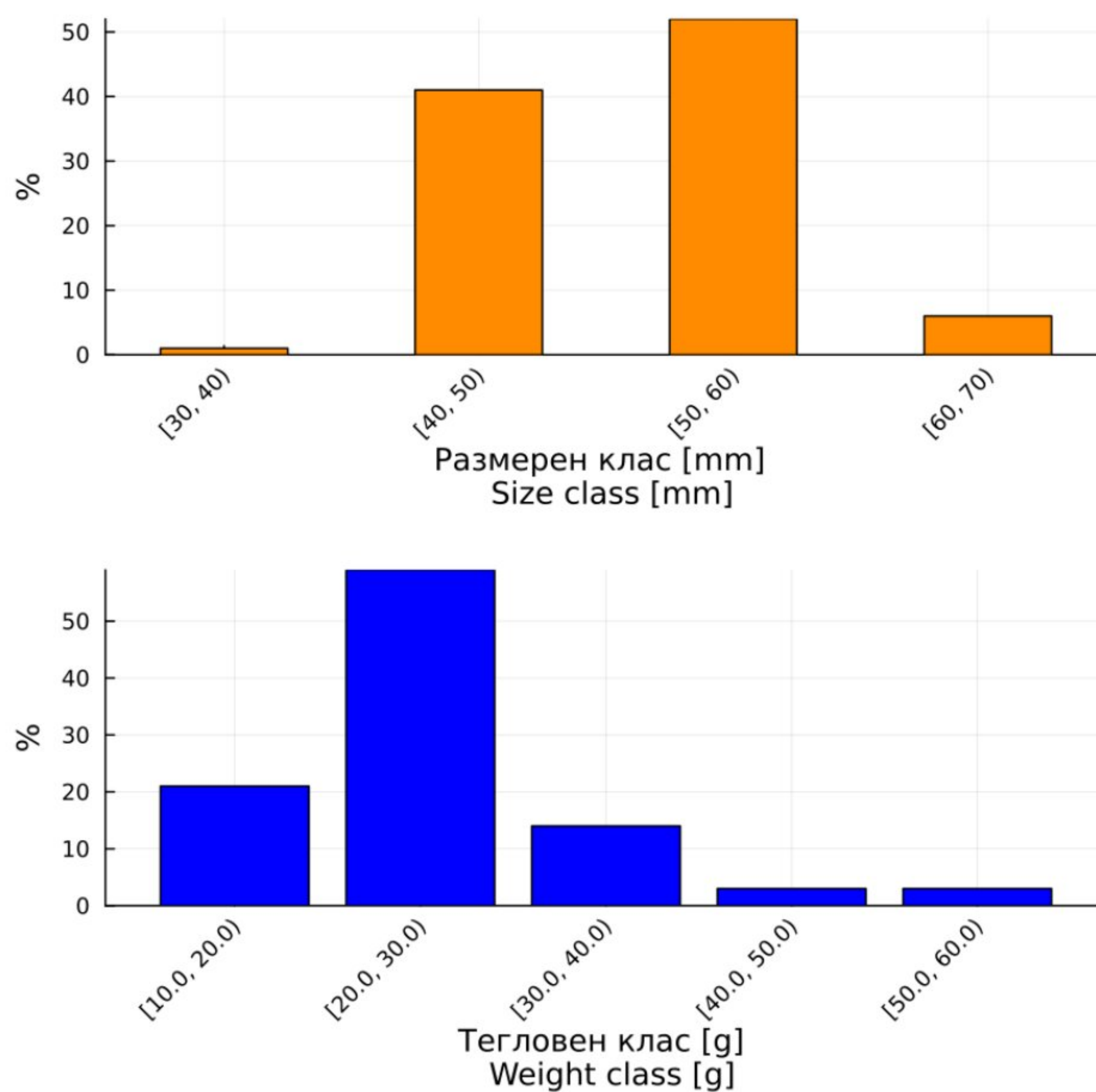


Figure 2 Size structure [mm] and weight structure [g] of the sample from port Rodopa 1, 25.03.2025

The mean ratio between the shell width (Wd, mm)/shell length (SL, mm) is $75.86\% \pm 3.01$ SD, while AL/SL (%) is $71.57\% \pm 2.87$ SD, and the ratio between AL/Wd (%) was calculated at $-94.35\% \pm 1.61$ SD (Table 3).



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Table 3

Percentage ratios between shell width and length (Wd/SL,%), aperture length/total shell length (AL/SL,%) and aperture length/total shell width (AL/Wd,%) of the individuals from the sample from port Rodopa 1, 25.03.2025

	Wd/SL%	Al/SL%	Al/Wd%
Sample size	100	100	100
Mean	75.86	71.57	94.35
Standard deviation	3.01	2.87	1.61
Minimum	69.49	65.38	90.62
50% (median)	76.04	71.87	94.59
Maximum	84.44	80.00	97.73
Sum	7586.27	7157.07	9435.41
Mode	75.00	75.00	94.74
Skewness	0.09	0.08	0.03
Sample variance	-0.22	-0.06	-0.45
Kurtosis	0.24	0.10	-0.02
Range	0.15	0.15	0.07
Confidence level 95%	(0.75, 0.76)	(0.71, 0.72)	(0.94, 0.95)

The L-W ratios have been calculated in Figure 3. 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 Rodopa 1, 25.03.2025

Parameters	$TW(g) = a \cdot SL(mm)^b$	$TW(g) = a \cdot Wd(mm)^b$	$W(g) = a \cdot AL(mm)^b$
a	0.0005	0.0011	0.0016
b	2.7488	2.7442	2.6726
R²	0.93	0.91	0.92



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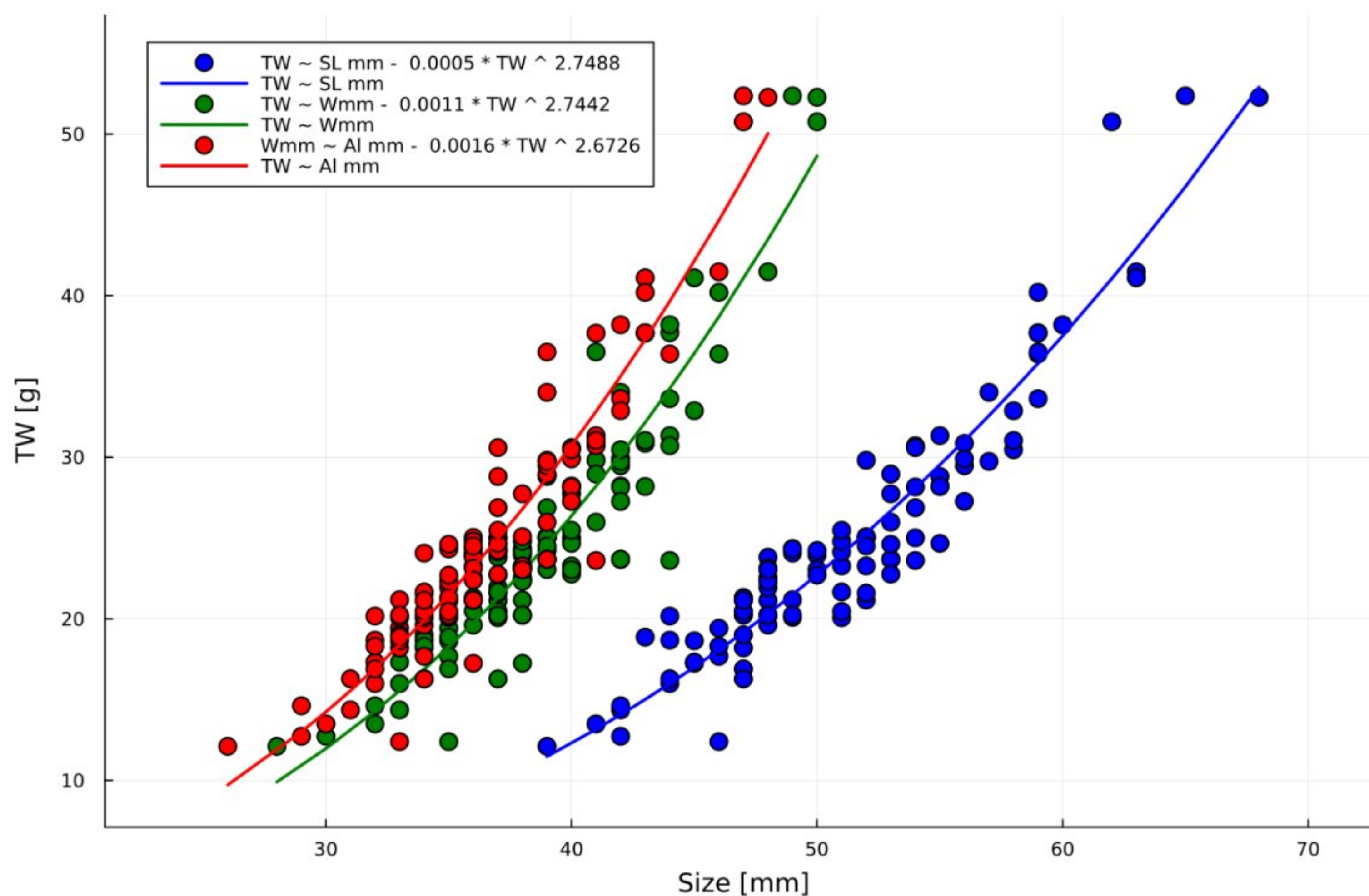


Figure 3 L-W ratios for the sampled individuals, port Rodopa 1, 25.03.2025(1) ratio between total weight (TW, g) and shell length (SL, mm); (2) relationship between total weight (TW, g) and shell width (Wd, mm); (3) relationship between total weight (TW, g) and aperture length (AL, mm)



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3.1.2. Port Kavarna, 05.04.2025

The sample consists of 100 individuals, weighing 3.3 kg, from a total landing of 2720 kg rapa whelks at port Kavarna (from the fishing vessel)

The mean weight of the measured specimens reaches $32.97 \text{ g} \pm 15.69 \text{ SD}$, at a mean shell length of $56.56 \text{ mm} \pm 8.03 \text{ SD}$, shell width $42.58 \text{ mm} \pm 6.1 \text{ SD}$ and aperture length $40.02 \text{ mm} \pm 5.94 \text{ SD}$. The mean body weight without shell (BW, g) is $11.82 \text{ g} \pm 7.91 \text{ SD}$ forming $35.22\% \pm 4.72 \text{ SD}$ from the total weight, varying between 22.13% and 48.38% from the total weight (Table 5).

Table 5

Summary statistics of the biological parameters – total weight (TW, g), body weight (BW, g), percentage ratio BW (% TW), shell length (SL, mm), shell width (Wd, mm) and aperture length (aperture length, AL, mm) from port Kavarna, 05.04.2025

	TW g	SL mm	Wd mm	Al mm	BW g	BW % TW
Sample size	100	100	100	100	50	50
Mean	32.97	56.56	42.58	40.02	11.82	35.22
Standard deviation	15.69	8.03	6.1	5.94	7.91	4.72
Minimum	11.55	40	30	28	3.93	22.13
50% (median)	27.8	55	42	39.5	9.93	35.66
Maximum	107.86	88	65	62	52.18	48.38
Sum	3297.36	5656	4258	4002	590.96	1761.1
Mode	17.13	52	40	38	7.31	48.38
Skewness	246.32	64.49	37.2	35.31	62.52	22.32
Sample variance	4.9	2.02	1.49	1.5	12.33	1.5
Kurtosis	1.9	1.14	0.95	0.93	3.13	-0.47
Range	96.31	48	35	34	48.25	26.24
Confidence level 95%	(29.9, 36.05)	(54.99, 58.13)	(41.38, 43.78)	(38.86, 41.18)	(9.63, 14.01)	(33.91, 36.53)

The dominant size classes from the sample are 50 - 60 mm (51% of the measured individuals). As for the weight structure, the dominant weight class (TW, g) is 20-30 g (41% of the measured individuals).



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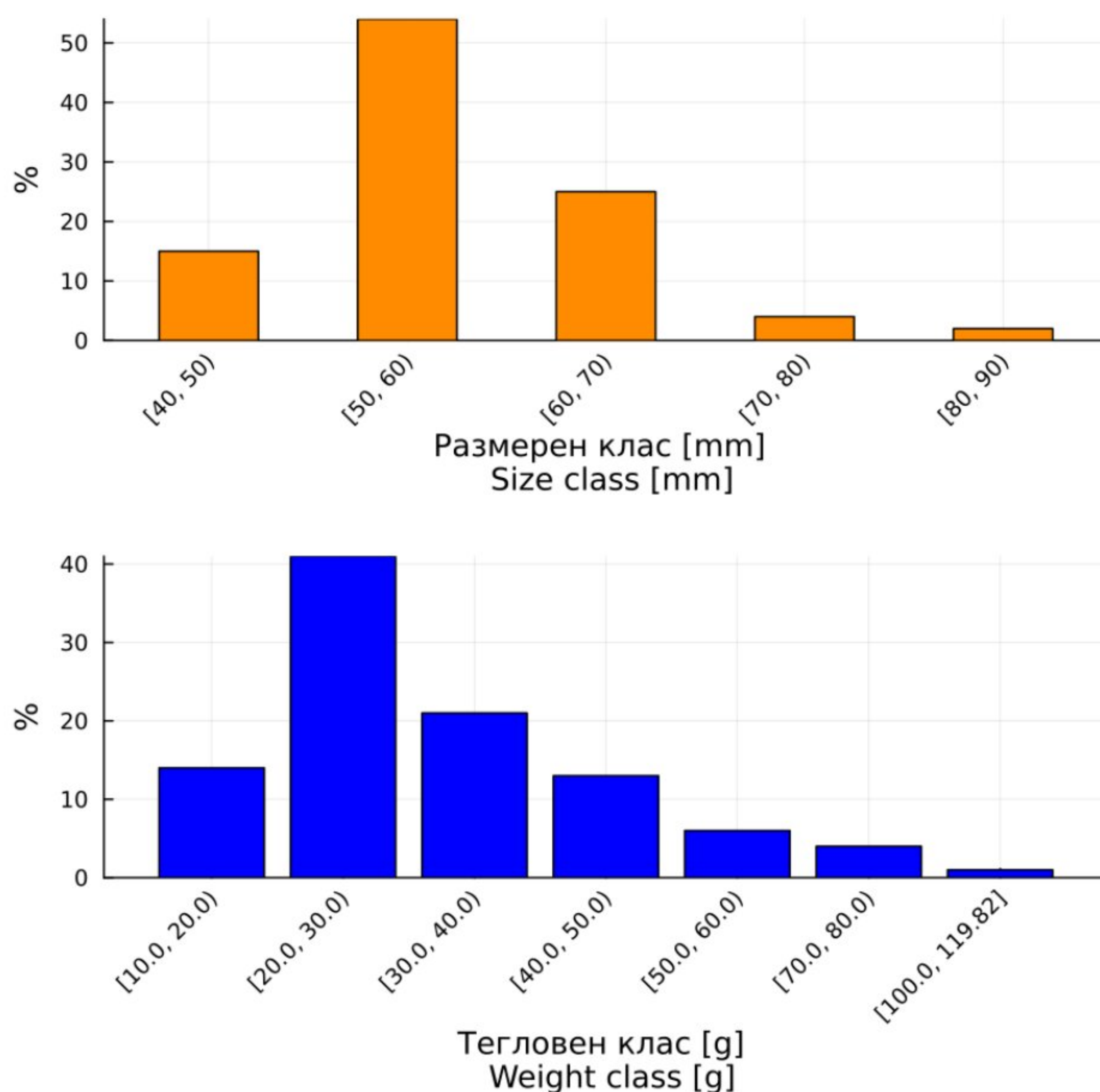


Figure 4 Size structure [mm] and weight structure [g] of the sample from port Kavarna, 05.04.2025

The mean ratio between the shell width (Wd, mm)/shell length (SL, mm) is $75.32\% \pm 3.09$ SD, while AL/SL (%) is $70.74\% \pm 2.87$ SD, and the ratio between AL/Wd (%) was calculated at $-93.94\% \pm 2.02$ SD (Table 6).



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Table 6

Percentage ratios between shell width and length (Wd/SL,%), aperture length/total shell length (AL/SL,%) and aperture length/total shell width (AL/Wd,%) of the individuals from the sample from port Kavarna, 05.04.2025

	Wd/SL%	Al/SL%	Al/Wd%
Sample size	100	100	100
Mean	75.32	70.74	93.94
Standard deviation	3.09	2.87	2.02
Minimum	67.86	64.29	80.00
50% (median)	75.00	70.97	94.06
Maximum	85.11	80.00	97.96
Sum	7532.17	7074.06	9394.24
Mode	75.00	68.75	95.00
Skewness	0.10	0.08	0.04
Sample variance	0.47	0.57	20.81
Kurtosis	0.23	0.18	-3.07
Range	0.17	0.16	0.18
Confidence level 95%	(0.75, 0.76)	(0.7, 0.71)	(0.94, 0.94)

The L-W ratios are calculated in 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 Kavarna, 05.04.2025

Parameters	$TW(g) = a \cdot SL(mm)^b$	$TW(g) = a \cdot Wd(mm)^b$	$W(g) = a \cdot AL(mm)^b$
a	0.0003	0.0006	0.001
b	2.8395	2.901	2.8088
R²	0.96	0.95	0.95



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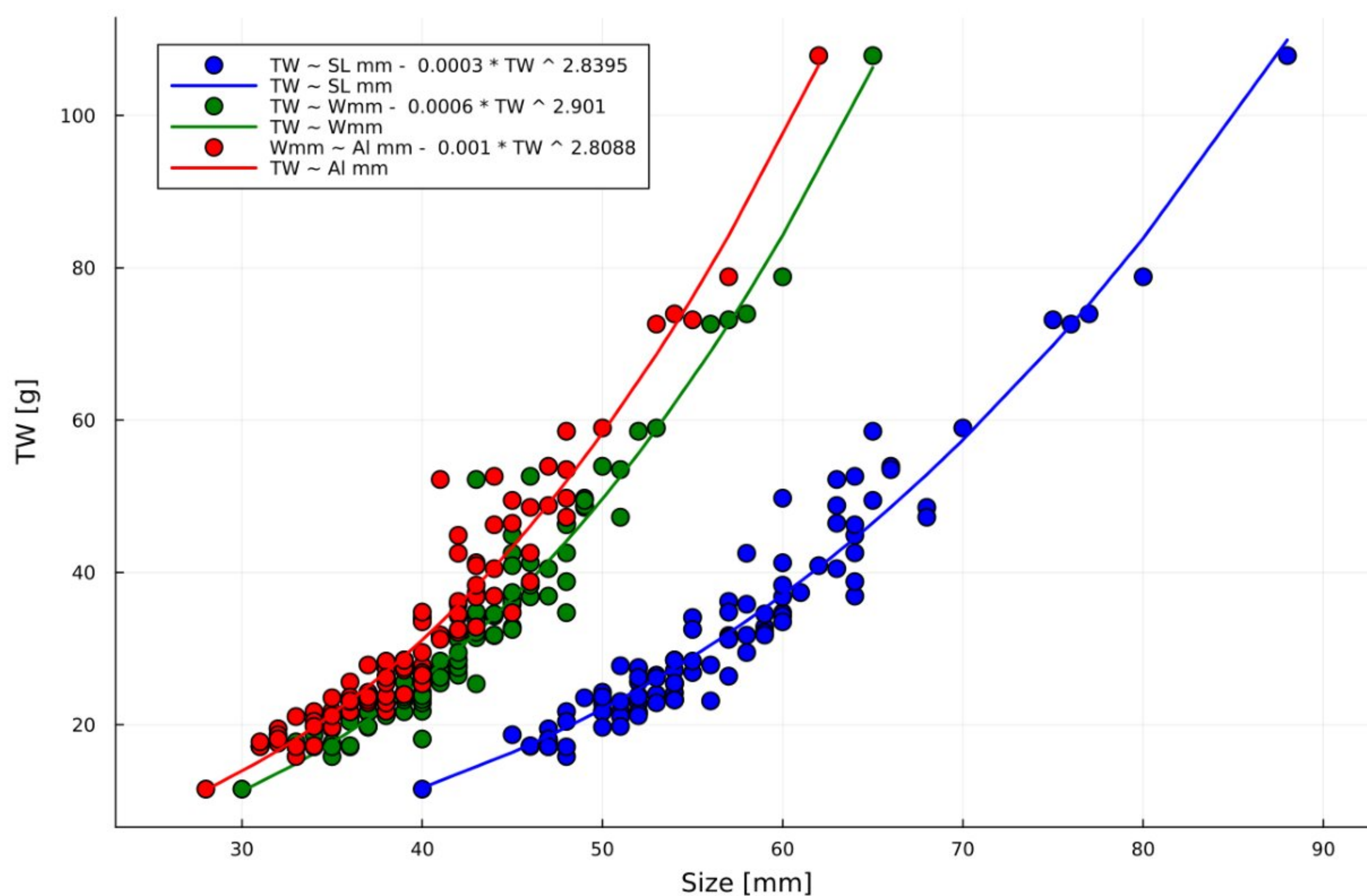


Figure 5 L-W ratios for the sampled individuals, port Kavarna, 05.04.2025: (1) Total weight (TW, g) from the shell length (SL, mm); (2) Total weight (TW, g) from the shell width (Wd, mm); (3) total weight (TW, g) and aperture length (AL, mm)



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3.1.3. Port Rodopa 1, 30.04.2025

The sample consists of 100 individuals rapa whelk, weighing 3.46 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 $34.61 \text{ g} \pm 7.76 \text{ SD}$, at a mean shell length of $58.55 \text{ mm} \pm 4.67 \text{ SD}$, shell width – $43.07 \text{ mm} \pm 4.02 \text{ SD}$ and aperture length $40.57 \text{ mm} \pm 3.72 \text{ SD}$. The mean body weight without shell (BW, g) is $12.02 \text{ g} \pm 3.1 \text{ SD}$ forming $34.33\% \pm 3.86 \text{ SD}$ from the total weight, varying between 23.51% and 43.86% 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 Rodopa 1, 30.04.2025

	TW g	SL mm	Wd mm	Al mm	BW g	BW% TW
Sample size	100	100	100	100	50	50
Mean	34.61	58.55	43.07	40.57	12.02	34.33
Standard deviation	7.76	4.67	4.02	3.72	3.1	3.86
Minimum	18	48	34	32	5.97	23.51
50% (median)	34.26	58	43	41	11.48	33.98
Maximum	65.39	73	53	50	18.87	43.86
Sum	3460.59	5855	4307	4057	600.88	1716.34
Mode	34.26	63	43	40	8.11	35.54
Skewness	60.18	21.81	16.19	13.84	9.6	14.89
Sample variance	1.37	-0.06	-0.48	-0.48	-0.76	0.69
Kurtosis	0.66	0.16	-0.01	-0.08	0.24	0.21
Range	47.39	25	19	18	12.9	20.34
Confidence level 95%	(33.09, 36.13)	(57.63, 59.47)	(42.28, 43.86)	(39.84, 41.3)	(11.16, 12.88)	(33.26, 35.4)

The dominant size classes from the sample are 50 - 60 mm (58% of the measured individuals). As for the weight structure, the dominant weight class (TW, g) is 30-40 g (51% of the measured individuals).



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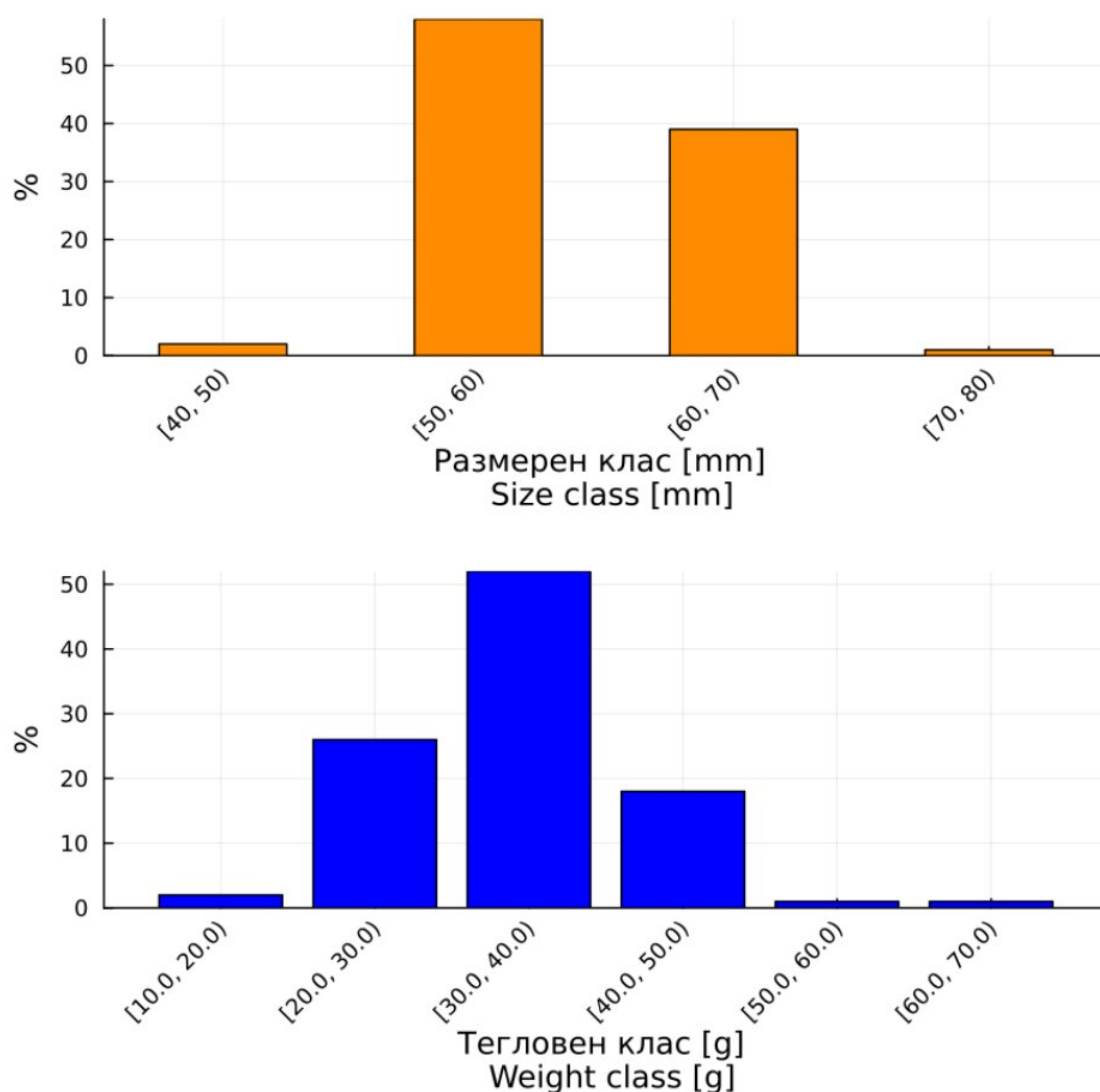


Figure 6 Size structure [mm] and weight structure [g] of the sample from port Rodopa 1, 30.04.2025

The mean ratio between the shell width (Wd, mm)/shell length (SL, mm) is $73.63\% \pm 3.31$ SD, while AL/SL (%) is $68.19\% \pm 3.42$ SD, and the ratio between AL/Wd (%) was calculated at $92.61\% \pm 1.78$ 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 Rodopa 1, 30.04.2025

	Wd/SL%	Al/SL%	Al/Wd%
Sample size	100	100	100
Mean	73.55	69.29	94.22
Standard deviation	3.37	3.15	1.52
Minimum	66.67	62.96	89.80
50% (median)	73.15	68.63	94.31
Maximum	86.27	80.39	97.73
Sum	7354.65	6928.62	9422.08
Mode	70.00	66.67	93.48
Skewness	0.11	0.10	0.02
Sample variance	1.44	0.93	-0.07
Kurtosis	0.84	0.75	0.02
Range	0.20	0.17	0.08
Confidence level 95%	(0.73, 0.74)	(0.69, 0.7)	(0.94, 0.95)

The L-W ratios are calculated, Figure 7. 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 Rodopa 1, 30.04.2025

Parameters	$TW(g)$ $= a \cdot SL(mm)^b$	$TW(g)$ $= a \cdot Wd(mm)^b$	$W(g) = a \cdot AL(mm)^b$
a	0.0011	0.0068	0.0006
b	2.534	2.266	2.3341
R²	0.88	0.92	0.93



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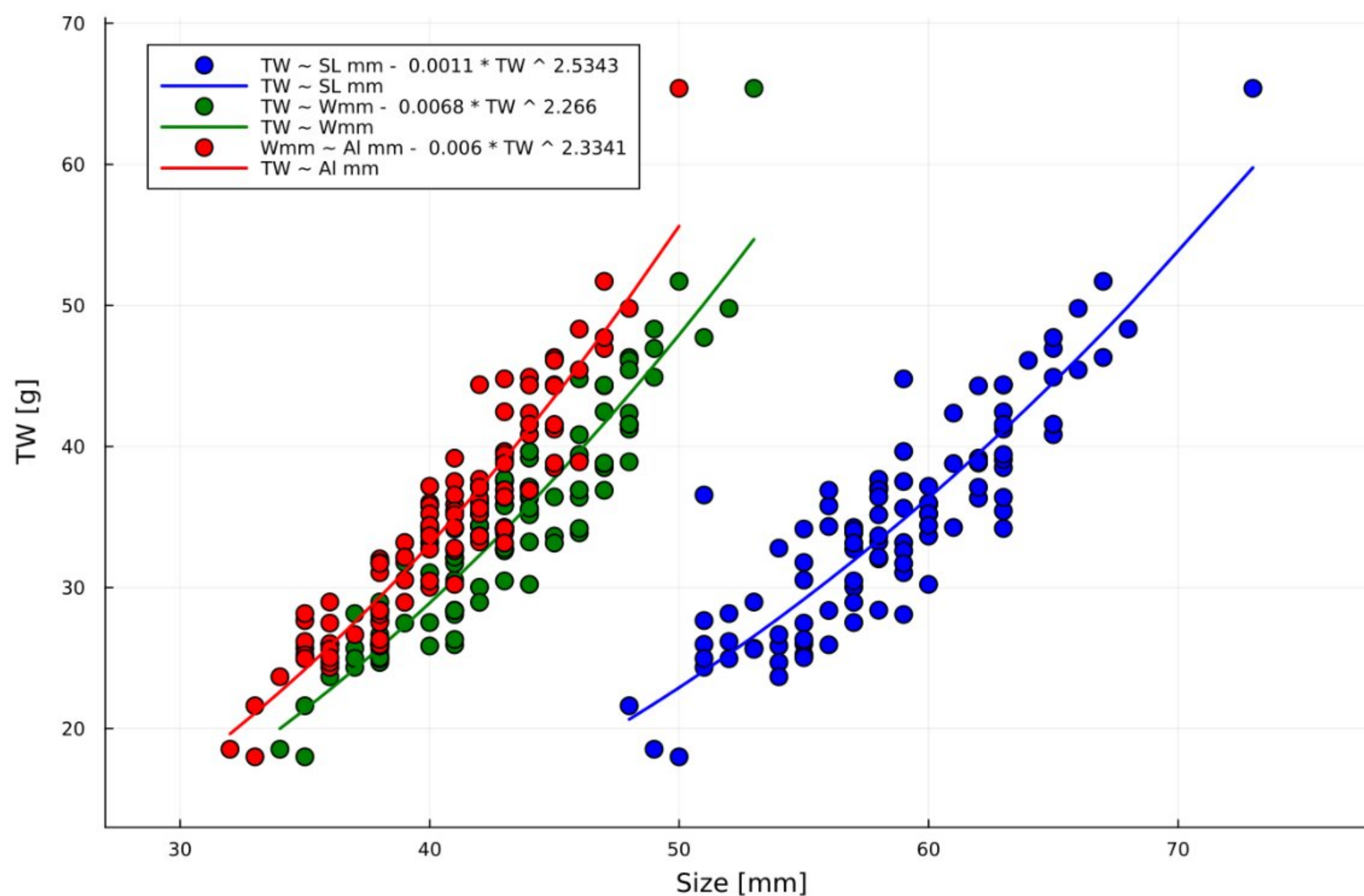


Figure 7 L-W ratios for the sampled individuals, port Rodopa 1, 30.04.2025: (1) ratio between total weight (TW, g) and shell length (SL, mm); (2) relationship between total weight (TW, g) and shell width (Wd, mm); (3) relationship between total weight (TW, g) and aperture length (AL, mm)



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3.1.4. PORT BALCHIK, 02.05.2025

The sample consists of 100 individuals rapa whelk, weighing 5.16 kg, from a total landing of 2600 kg rapa whelks at port Balchik (from the fishing vessel).

The mean weight of the measured specimens reaches $51.61 \text{ g} \pm 15.82 \text{ SD}$, at a mean shell length of $66.48 \text{ mm} \pm 6.02 \text{ SD}$, shell width - $49.91 \text{ mm} \pm 4.92 \text{ SD}$ and aperture length $47.46 \text{ mm} \pm 4.83 \text{ SD}$. The mean body weight without shell (BW, g) is $19.95 \text{ g} \pm 5.99 \text{ SD}$ forming $39.18\% \pm 15.96 \text{ SD}$ from the total weight, varying between 17.34% and 115.39% from the total weight (Table 11).

Table 11

Summarized statistics of the biological parameters - total weight (TW, g), body weight (BW, g), percentage ratio of BW (% TW), shell length (SL, mm), shell width (Wd, mm) and aperture length (AL, mm) at port Balchik, 02.05.2025

	TW g	SL mm	Wd mm	Al mm	BW g	BW% TW
Sample size	100	100	100	100	48	48
Mean	55.82	67.57	53.59	51.25	23.15	39.23
Standard deviation	18.94	7.56	6.62	6.47	8.5	5.88
Minimum	9.88	39	29	28	1.57	15.89
50% (median)	53.34	68	54	52	22.5	40.57
Maximum	112.64	83	69	66	40.22	47.63
Sum	5582.26	6757	5359	5125	1111.37	1882.85
Mode	63.75	62	53	52	28.19	31.51
Skewness	358.57	57.22	43.8	41.91	72.29	34.58
Sample variance	0.35	0.99	0.84	0.65	-0.33	3.56
Kurtosis	0.57	-0.35	-0.36	-0.27	0.01	-1.47
Range	102.76	44	40	38	38.65	31.74
Confidence level 95%	(52.11, 59.53)	(66.09, 69.05)	(52.29, 54.89)	(49.98, 52.52)	(20.75, 25.56)	(37.56, 40.89)

The dominant size classes from the sample are 60 - 70 mm (60% of the measured individuals). As for the weight structure, the dominant weight class (TW, g) is 40-50 g (31% of the measured individuals).



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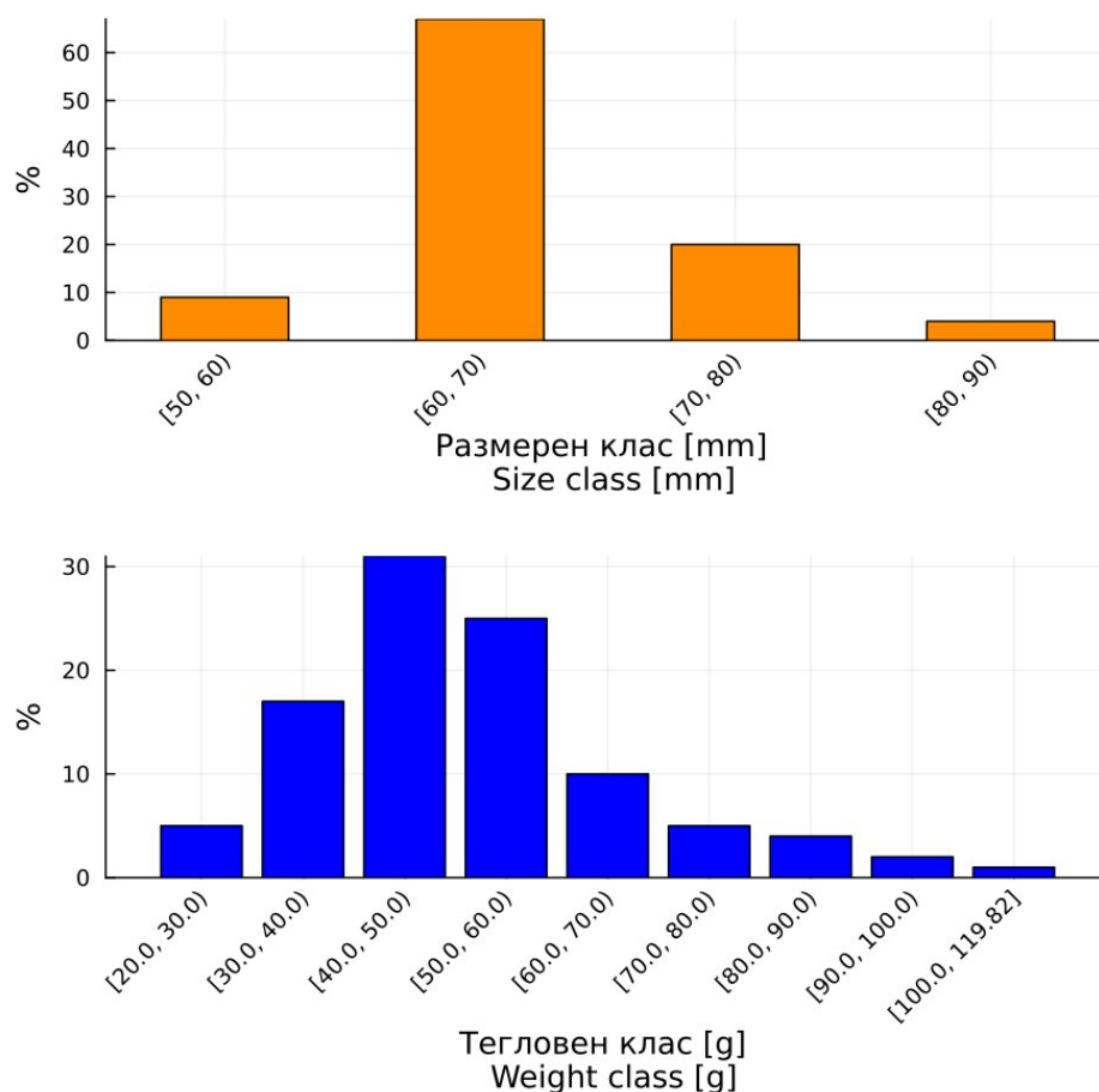


Figure 8 Size structure [mm] and weight structure [g] of the sample from port Balchik, 02.05.2025

The mean ratio between the shell width (Wd, mm)/shell length (SL, mm) is $75.09\% \pm 3.37$ SD, while AL/SL (%) is $71.38\% \pm 3.24$ SD, and the ratio between AL/Wd (%) was calculated at $-95.07\% \pm 1.54$ 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 Balchik, 02.05.2025

	Wd/SL%	Al/SL%	Al/Wd%
Sample size	100	100	100
Mean	75.09	71.38	95.07
Standard deviation	3.37	3.24	1.54
Minimum	64.86	62.16	91.49
50% (median)	74.65	71.43	95.29
Maximum	84.48	81.03	98.08
Sum	7509.20	7138.50	9507.38
Mode	78.46	71.43	95.83
Skewness	0.11	0.10	0.02
Sample variance	0.42	0.53	-0.50
Kurtosis	0.14	0.17	-0.10
Range	0.20	0.19	0.07
Confidence level 95%	(0.74, 0.76)	(0.71, 0.72)	(0.95, 0.95)

The L-W ratios are calculated (Figure 9). The parameters a , b of the derived L-W ratio and the value of the coefficient of determination R^2 are presented in Table 13.

Table 13

Parameters a , b of the L-W ratios and values of R^2 for the sample from port Balchik, 02.05.2025

Parameters	$TW(g) = a \cdot SL(mm)^b$	$TW(g) = a \cdot Wd(mm)^b$	$W(g) = a \cdot AL(mm)^b$
a	0.0043	0.00275	0.0318
b	2.33	1.925	1.913
R²	0.74	0.76	0.77



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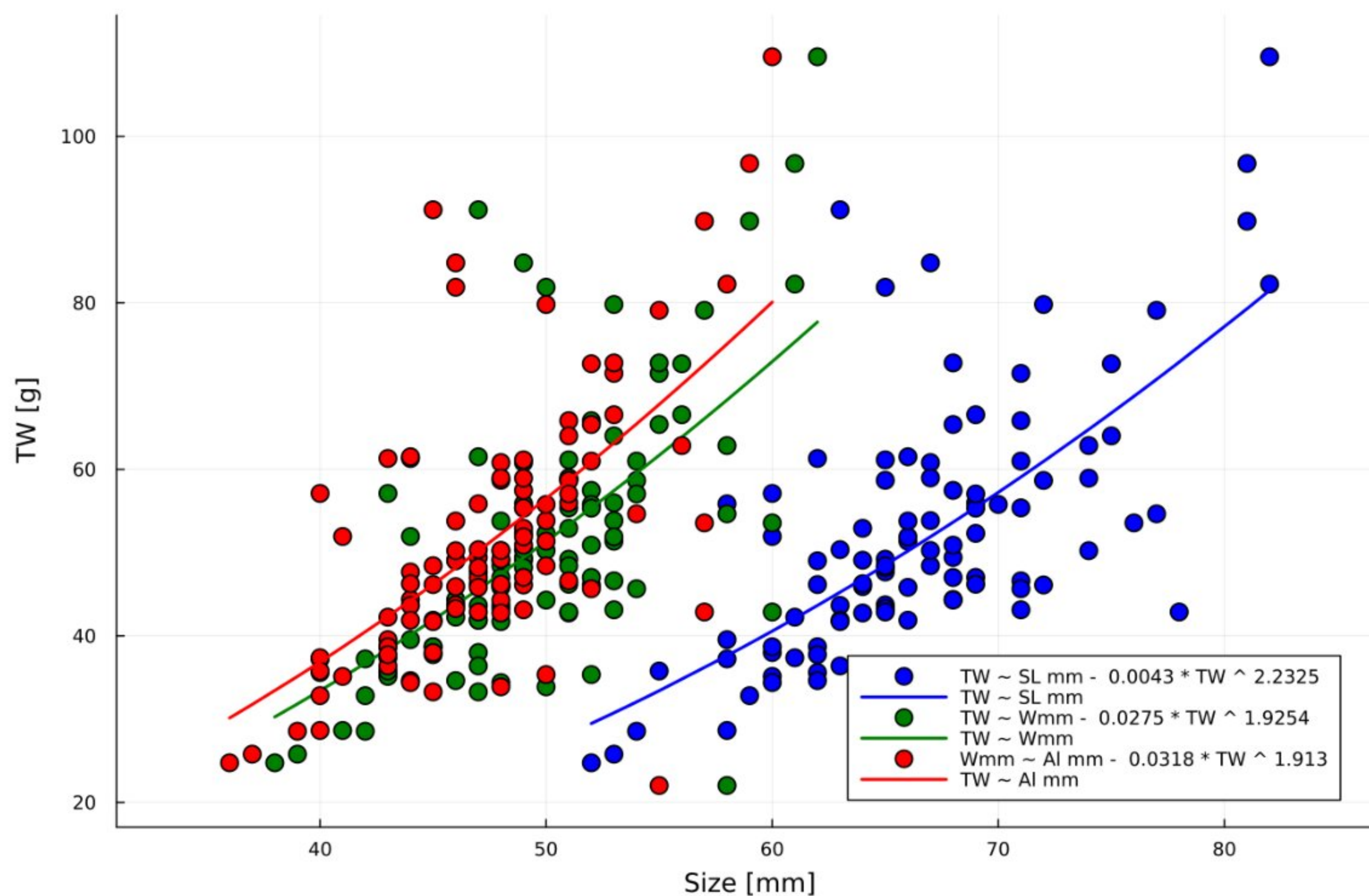


Figure 9 L-W ratios for the sampled individuals, port Balchik, 02.05.2025: (1) ratio between total weight (TW, g) and shell length (SL, mm); (2) relationship between total weight (TW, g) and shell width (Wd, mm); (3) relationship between total weight (TW, g) and aperture length (AL, mm)



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3.1.5. PORT ADA BAHCHA, 01.06.2025

The sample consists of 100 individuals (from scuba diving) with a total weight of 4.65 kg, from a total landing of 2278 kg rapa whelks at port Ada bahcha (from the fishing vessel).

The mean weight of the measured specimens reaches $46.48 \text{ g} \pm 25.26 \text{ SD}$ at a mean shell length of $62.54 \text{ mm} \pm 12.41 \text{ SD}$, shell width $48.49 \text{ mm} \pm 10.28 \text{ SD}$ and aperture length $46.08 \text{ mm} \pm 9.9 \text{ SD}$. The mean body weight without shell (BW, g) is $19.89 \text{ g} \pm 8.82 \text{ SD}$, which is $34.34\% \pm 3.07 \text{ SD}$ from the total weight, varying between 24.75% and 39.21% 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 Ada bahcha, 01.06.2025

	TW g	SL mm	Wd mm	Al mm	BW	BW% TW
Sample size	100	100	100	100	50	50
Mean	46.48	62.54	48.49	46.08	19.89	34.34
Standard deviation	25.26	12.41	10.28	9.9	8.82	3.07
Minimum	10.46	37	28	26	4.14	24.75
50% (median)	43.76	63	48	45	19.75	35.01
Maximum	119.82	94	73	69	45.83	39.21
Sum	4648.44	6254	4849	4608	994.3	1717.11
Mode	39.58	58	48	53	15.43	38.25
Skewness	638.18	154.09	105.69	98.05	77.81	9.44
Sample variance	0.16	-0.8	-0.74	-0.82	0.33	1.02
Kurtosis	0.75	0.04	0.18	0.14	0.58	-1.04
Range	109.36	57	45	43	41.69	14.45
Confidence level 95%	(41.53, 51.44)	(60.11, 64.97)	(46.48, 50.5)	(44.14, 48.02)	(17.44, 22.33)	(33.49, 35.19)

The dominant size classes from the sample are 50 -70 mm (48% of the measured individuals). As for the weight structure, there is no dominant weight class.



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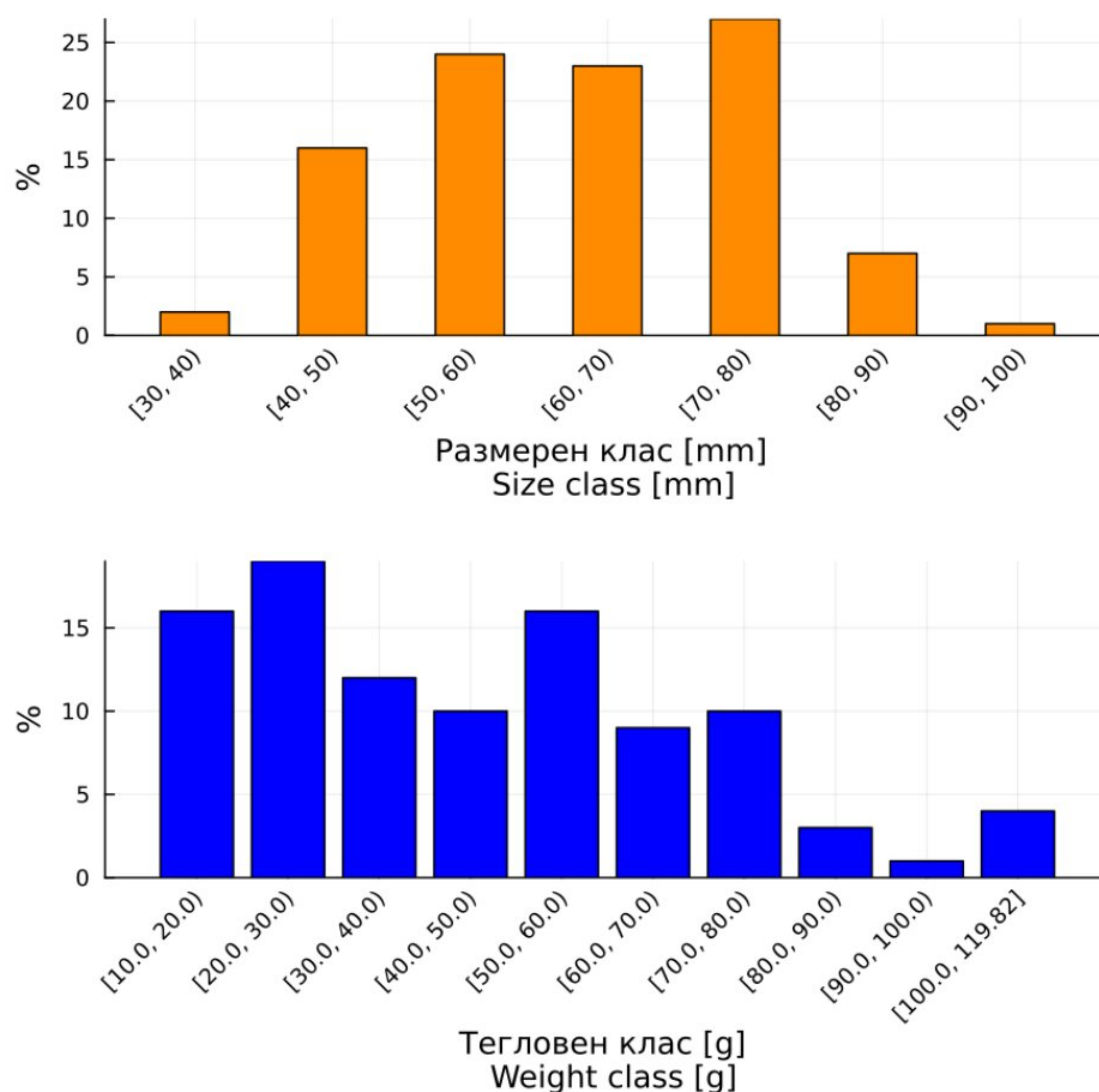


Figure 10 Size structure [mm] and weight structure [g] of the sample from port Ada bahcha, 01.06.2025

Percentage ratios between shell width and length (Wd/SL,%), aperture length/total shell length (AL/SL,%) and aperture length/total shell width are presented in Table 15. (AL/Wd,%)

The mean ratio between the shell width (Wd, mm)/shell length (SL, mm) is $77.41\% \pm 3.29$ SD, while AL/SL (%) is $73.51\% \pm 3.22$ SD, and the ratio between AL/Wd (%) was calculated at $-94.97\% \pm 1.50$ SD.



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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 port Ada bahcha, 01.06.2025

	Wd/SL %	Al/SL %	Al/Wd %
Sample size	100	100	100
Mean	77.41	73.51	94.97
Standard deviation	3.29	3.22	1.50
Minimum	61.73	59.26	91.67
50% (median)	77.27	73.37	94.94
Maximum	85.25	80.72	98.15
Sum	7741.18	7351.24	9496.98
Mode	76.19	75.00	93.75
Skewness	0.11	0.10	0.02
Sample variance	4.53	2.94	-0.40
Kurtosis	-0.94	-0.80	-0.05
Range	0.24	0.21	0.06
Confidence level 95%	(0.77, 0.78)	(0.73, 0.74)	(0.95, 0.95)

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 16.

Table 16

Parameters a , b of the L-W ratios and values of R^2 for the sample from port Ada bahcha, 01.06.2025

Parameters	$TW(g) = a.SL(mm)^b$	$TW(g) = a.Wd(mm)^b$	$W(g) = a.AL(mm)^b$
a	0.0004	0.0022	0.0026
b	2.7887	2.5478	2.5331
R²	0.96	0.97	0.96



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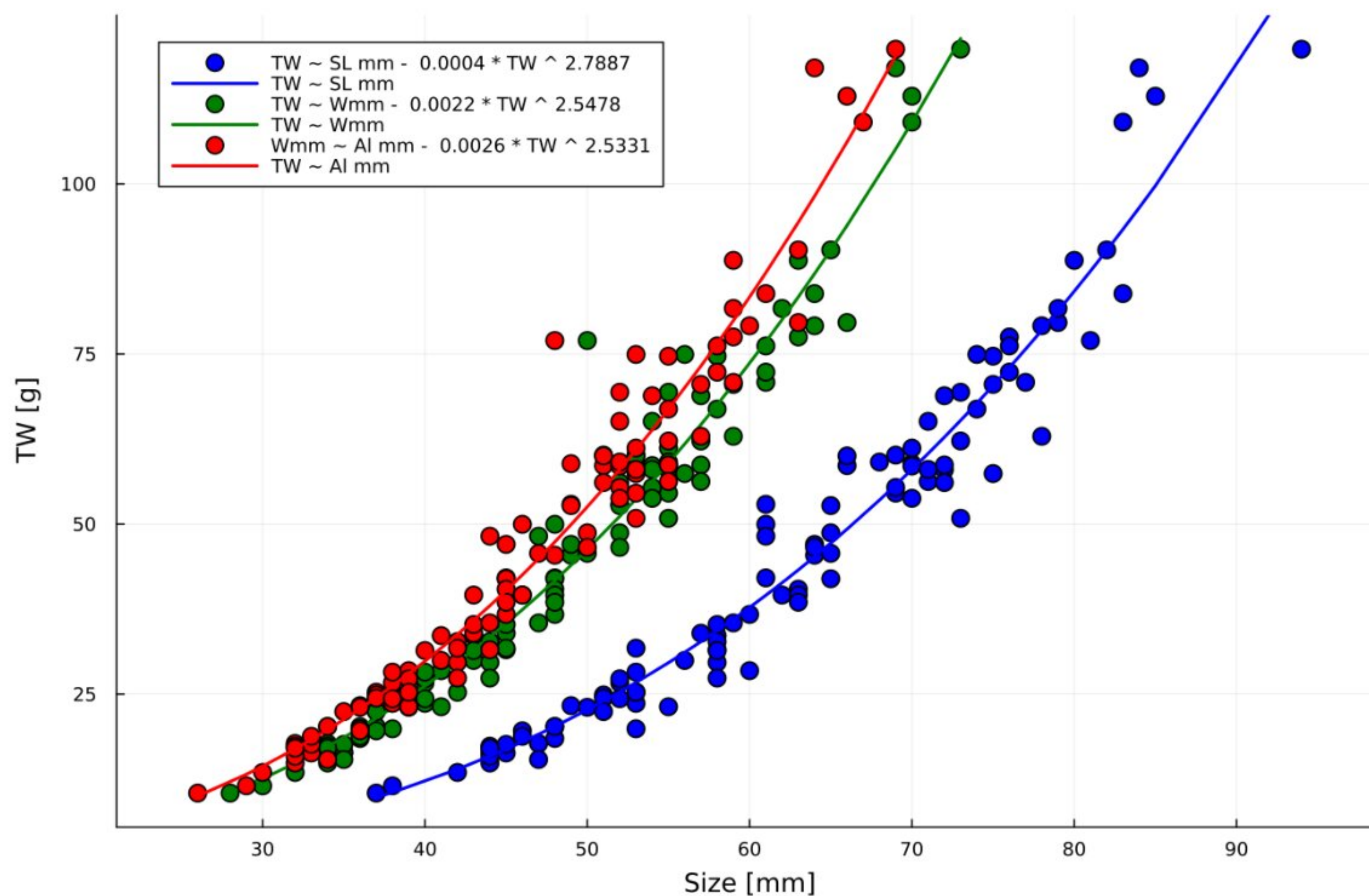


Figure 11 L-W ratios for the sampled individuals, port Ada Bahcha, 01.06.2025: (1) ratio between total weight (TW, g) and shell length (SL, mm); (2) relationship between total weight (TW, g) and shell width (Wd, mm); (3) relationship between total weight (TW, g) and aperture length (AL, mm).



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3.1.6. PORT KAVARNA, 01.06.2025

The sample consists of 100 individuals (from scuba diving) with a total weight of 3.05 kg, from a total landing of 500 kg rapa whelks at port Kavarna (from the fishing vessel)

The mean weight of the measured specimens reaches $30.5 \text{ g} \pm 11.31 \text{ SD}$ at a mean shell length of $53.24 \text{ mm} \pm 6.35 \text{ SD}$, shell width $41.27 \text{ mm} \pm 5.06 \text{ SD}$ and aperture length $38.84 \text{ mm} \pm 4.87 \text{ SD}$. The mean body weight without shell (BW, g) is $11.24 \text{ g} \pm 2.98 \text{ SD}$, which is $32.57\% \pm 3.94 \text{ SD}$ from the total weight, varying between 23.06% and 39.77% 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 Kavarna, 01.06.2025

	TW g	SL mm	Wd mm	Al mm	BW g	BW% TW
Sample size	100	100	100	100	50	50
Mean	30.5	53.24	41.27	38.84	11.24	32.57
Standard deviation	11.31	6.35	5.06	4.87	2.98	3.94
Minimum	15.37	42	33	30	6.45	23.06
50% (median)	27.88	53	40.5	38	10.58	32.97
Maximum	77.44	74	58	56	19.15	39.77
Sum	3050.48	5324	4127	3884	561.9	1628.46
Mode	28.54	53	39	36	8.44	32.44
Skewness	127.81	40.37	25.57	23.67	8.88	15.52
Sample variance	3.02	0.87	0.91	1.25	0.28	-0.14
Kurtosis	1.56	0.77	0.89	0.96	0.85	-0.47
Range	62.07	32	25	26	12.7	16.71
Confidence level 95%	(28.29, 32.72)	(51.99, 54.49)	(40.28, 42.26)	(37.89, 39.79)	(10.41, 12.06)	(31.48, 33.66)

The dominant size classes from the sample are 50 - 60 mm (58% of the measured individuals). As for the weight structure, the dominant weight class (TW, g) is 30 - 40 g (43% of the measured individuals).



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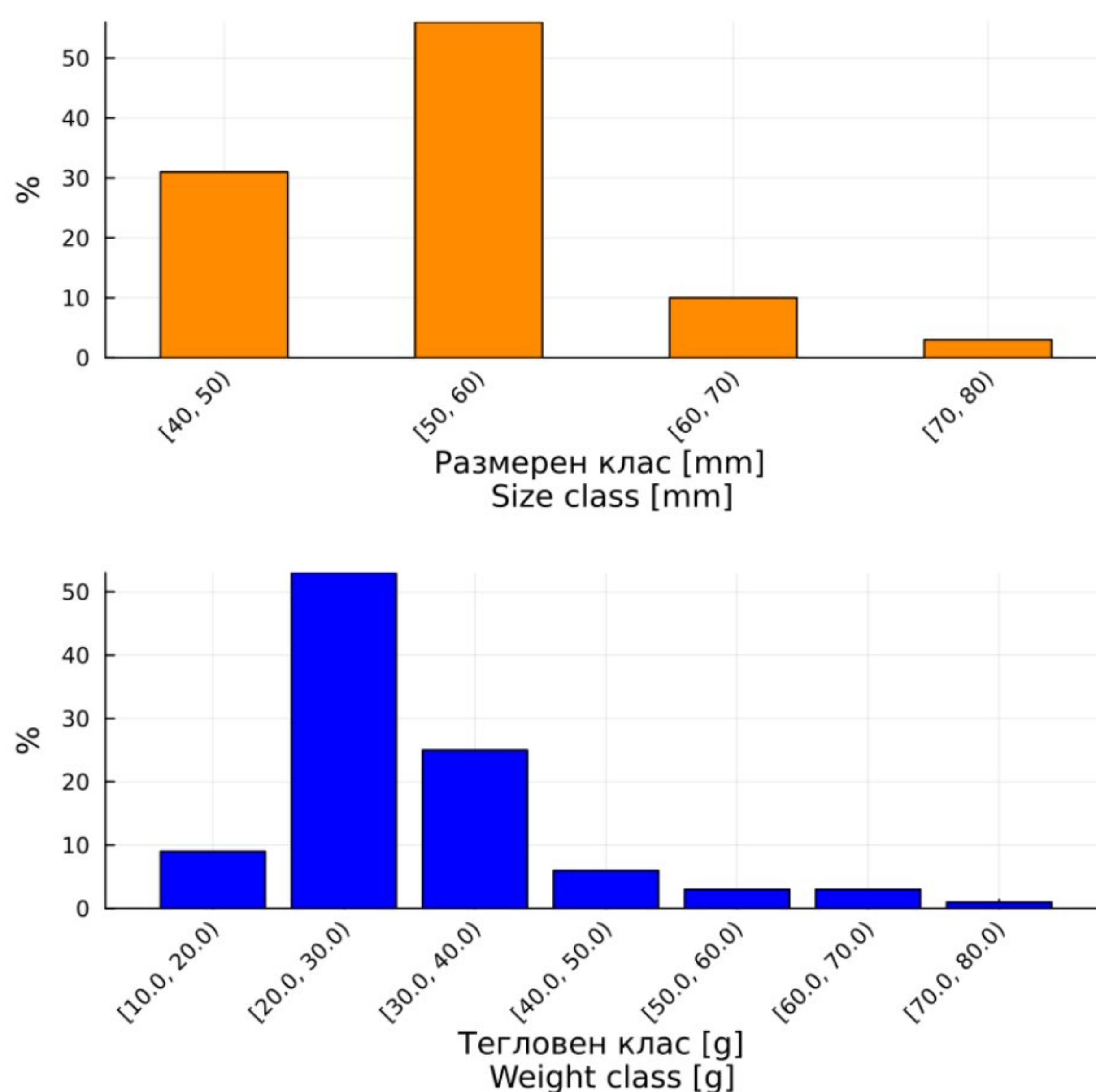


Figure 12 Size structure [mm] and weight structure [g] of the sample from port Kavarna, 01.06.2025

The mean ratio between the shell width (Wd, mm)/shell length (SL, mm) is $77.55\% \pm 3.09SD$, while AL/SL (%) is $72.97\% \pm 3.2.98SD$, and the ratio between AL/Wd (%) was calculated at $-94.10\% \pm 1.61 SD$ (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 Kavarna, 01.06.2025

	Wd/SL %	Al/SL %	Al/Wd %
Sample size	100	100	100
Mean	77.55	72.97	94.10
Standard deviation	3.09	2.98	1.61
Minimum	70.18	66.67	90.00
50% (median)	77.36	72.97	94.44
Maximum	85.71	80.33	97.62
Sum	7755.49	7297.05	9409.87
Mode	77.78	75.00	94.74
Skewness	0.10	0.09	0.03
Sample variance	-0.26	-0.27	-0.15
Kurtosis	0.34	0.17	-0.21
Range	0.16	0.14	0.08
Confidence level 95%	(0.77, 0.78)	(0.72, 0.74)	(0.94, 0.94)

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 19.

Table 19

Parameters a , b of the L-W ratios and values of R^2 for the sample from port Port Kavarna, 01.06.2025

Parameters	$TW(g) = a.SL(mm)^b$	$TW(g) = a.Wd(mm)^b$	$W(g) = a.AL(mm)^b$
a	0.00043	0.0012	0.0021
b	2.8043	2.7078	2.607
R²	0.82	0.83	0.82



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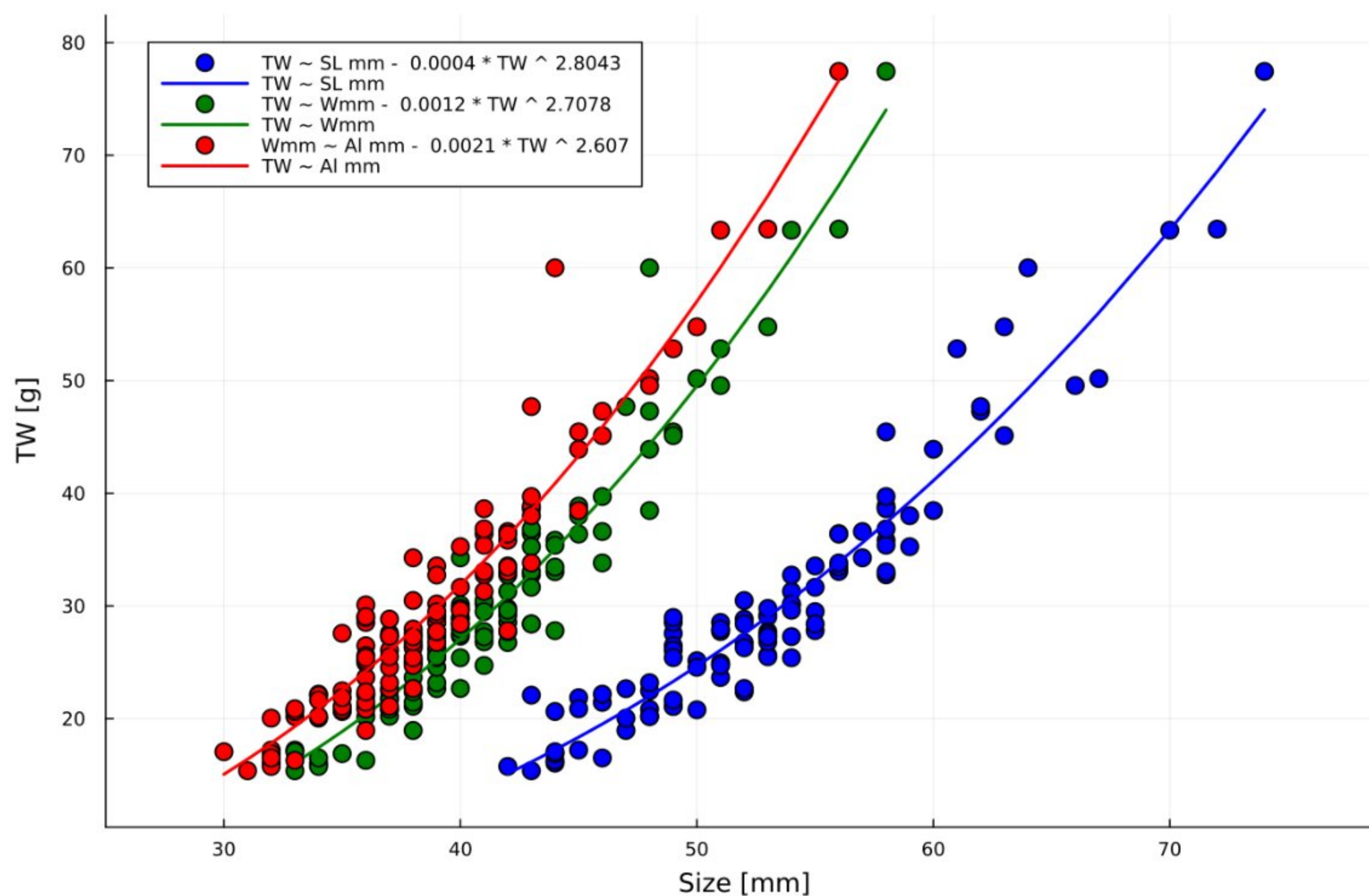


Figure 13 L-W ratios for the sampled individuals, port Kavarna, 01.06.2025: (1) ratio between total weight (TW, g) and shell length (SL, mm); (2) relationship between total weight (TW, g) and shell width (Wd, mm); (3) relationship between total weight (TW, g) and aperture length (AL, mm).



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3.1.7. PORT RODOPA 1, 19.07.2025 (SCUBA DIVING)

The sample consists of 100 individuals, with a total weight 5.6 kg, from a total landing of 80 kg rapa whelks at port Rodopa 1 (from the fishing vessel).

The mean weight of the measured specimens reaches $56.02 \text{ g} \pm 19.63 \text{ SD}$ at a mean shell length of $67.39 \text{ mm} \pm 8.58 \text{ SD}$, shell width – $51.19 \text{ mm} \pm 6.59 \text{ SD}$ and aperture length $48.55 \text{ mm} \pm 6.35 \text{ SD}$. The mean body weight without shell (BW, g) is $23.8 \text{ g} \pm 8.5 \text{ SD}$ and forms $35.48 \% \pm 4.78 \text{ SD}$ from the total weight, varying between 23.03 % and 44.15 % 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 Rodopa 1, 19.07.2025

	TW g	SL mm	Wd mm	Al mm	BW g	BW % TW
Sample size	100	100	100	100	50	50
Mean	56.02	67.39	51.19	48.55	23.8	35.48
Standard deviation	19.63	8.58	6.59	6.35	8.5	4.78
Minimum	22.11	50	38	36	12.28	23.03
50% (median)	52.26	66	50	48	22.3	35.8
Maximum	133.94	98	73	70	49.8	44.15
Sum	5601.72	6739	5119	4855	1189.92	1774.08
Mode	64.68	61	54	46	12.48	30.55
Skewness	385.37	73.61	43.39	40.33	72.17	22.85
Sample variance	3.29	0.82	0.76	0.78	1.58	-0.01
Kurtosis	1.48	0.64	0.68	0.7	1.23	-0.38
Range	111.83	48	35	34	37.52	21.12
Confidence level 95%	(52.17, 59.86)	(65.71, 69.07)	(49.9, 52.48)	(47.31, 49.79)	(21.44, 26.15)	(34.16, 36.81)

The dominant size classes from the sample are 60—70 mm (46 % of the measured individuals). As for the weight structure, the dominant weight class (TW, g) is 40-50 g (25 %).



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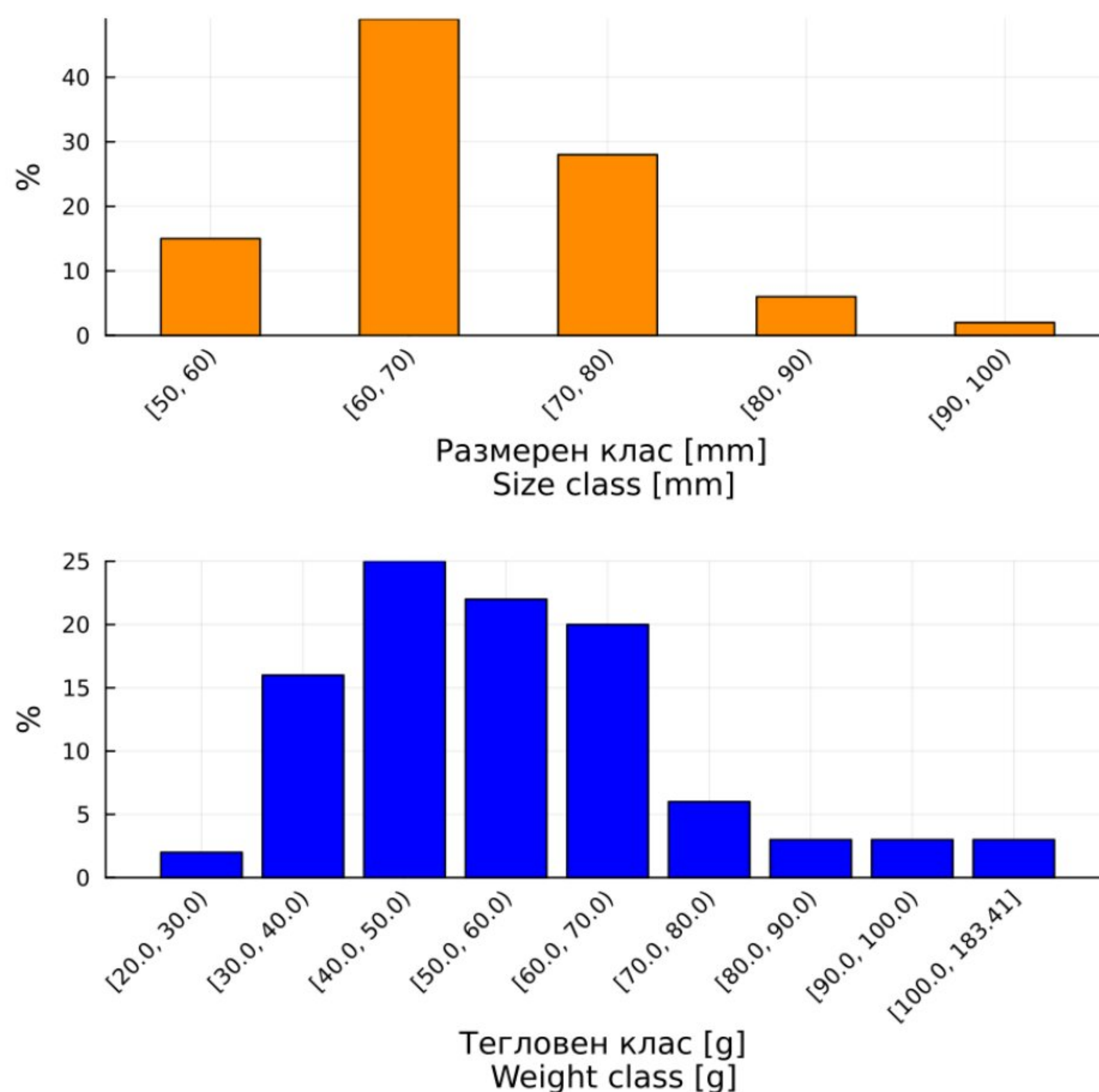


Figure 14 Size structure [mm] and weight structure [g] of the sample from port Rodopa 1, 19.07.2025

The mean ratio between the shell width (Wd, mm)/shell length (SL, mm) is $76.05\% \pm 3.82$ SD, while AL/SL (%) is $72.10\% \pm 3.56$ SD, and the ratio between AL/Wd (%) was calculated at $94.83\% \pm 1.31$ 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 Rodopa 1, 19.07.2025

	Wd/SL %	Al/SL %	Al/Wd %
Sample size	100.00	100.00	100.00
Mean	76.05	72.10	94.83
Standard deviation	3.82	3.56	1.31
Minimum	64.94	62.34	91.30
50% (median)	75.83	72.07	95.00
Maximum	88.89	83.95	98.00
Sum	7604.55	7210.25	9482.80
Mode	75.00	70.77	95.83
Skewness	0.15	0.13	0.02
Sample variance	1.03	0.73	0.31
Kurtosis	0.11	0.13	-0.50
Range	0.24	0.22	0.07
Confidence level 95%	(0.75, 0.77)	(0.71, 0.73)	(0.95, 0.95)

The L-W ratios are calculated (Figure 15). 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 Rodopa 1, 19.07.2025

Parameters	$TW(g) = a.SL(mm)^b$	$TW(g) = a.Wd(mm)^b$	$W(g) = a.AL(mm)^b$
a	0.0007	0.0019	0.0027
b	2.667	2.597	2.545
R²	0.89	0.93	0.93



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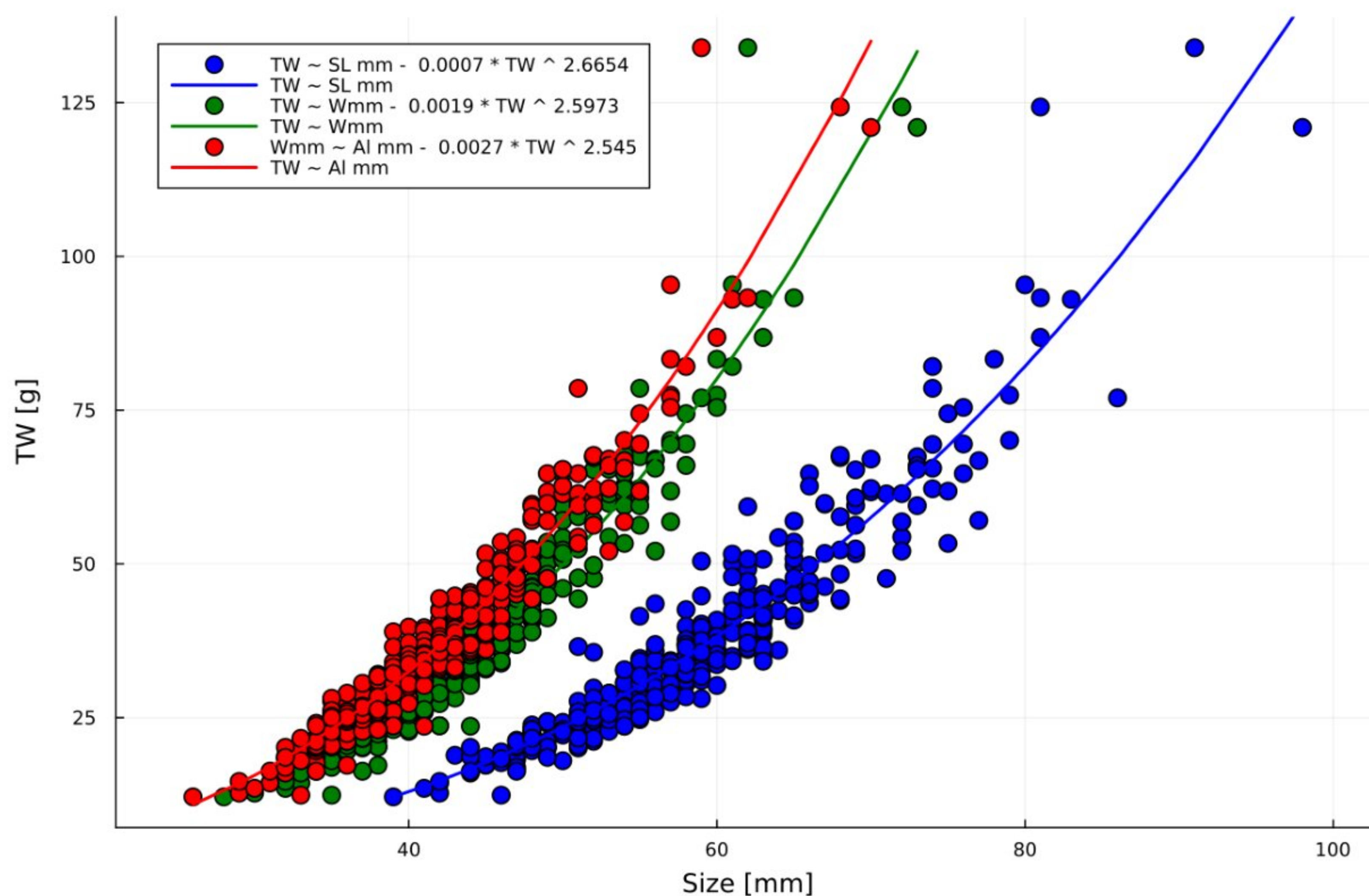


Figure 15 L-W ratios for the sampled individuals, port Rodopa 1, 19.07.2025: (1) ratio between total weight (TW, g) and shell length (SL, mm); (2) relationship between total weight (TW, g) and shell width (Wd, mm); (3) relationship between total weight (TW, g) and aperture length (AL, mm).



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3.1.8. PORT KAVARNA, 03.09.2025

The sample consists of 100 individuals, with a total weight of 5.06 kg, from a total landing of 2750 kg rapa whelks at port Kavarna (from the fishing vessel).

The mean weight of the measured specimens reaches $50.64 \text{ g} \pm 27.82 \text{ SD}$ at a mean shell length of $65.15 \text{ mm} \pm 11.66 \text{ SD}$, shell width $50.9 \text{ mm} \pm 9.57 \text{ SD}$ and aperture length $48.59 \text{ mm} \pm 9.3 \text{ SD}$. The mean body weight without shell (BW, g) is $17.15 \text{ g} \pm 9.97 \text{ SD}$ and forms $34.69 \% \pm 7.22 \text{ SD}$ from the total weight, varying between 23.86 % and 55.78 % from the total weight (Table 23).

Table 23

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 Port Kavarna, 03.09.2025

	TW g	SL mm	Wd mm	Al mm	BW g	BW % TW
Sample size	100	100	100	100	50	50
Mean	50.64	65.15	50.9	48.59	17.15	34.69
Standard deviation	27.82	11.66	9.57	9.3	9.97	7.22
Minimum	11.43	39	30	29	5.6	23.86
50% (median)	42.88	64	49	47	16.61	33.88
Maximum	154.23	95	74	72	52.55	55.78
Sum	5064.41	6515	5090	4859	857.27	1734.52
Mode	25.18	57	43	58	24.66	28.8
Skewness	773.86	136.03	91.59	86.41	99.43	52.15
Sample variance	1.73	-0.53	-0.7	-0.66	2.1	0.2
Kurtosis	1.32	0.3	0.33	0.32	1.36	0.78
Range	142.8	56	44	43	46.95	31.92
Confidence level 95%	(45.19, 56.1)	(62.86, 67.44)	(49.02, 52.78)	(46.77, 50.41)	(14.38, 19.91)	(32.69, 36.69)

The dominant size classes from the sample are 50—60 mm (28% of the measured individuals). As for the weight structure, the dominant weight class (TW, g) is 30-40 g (23%).



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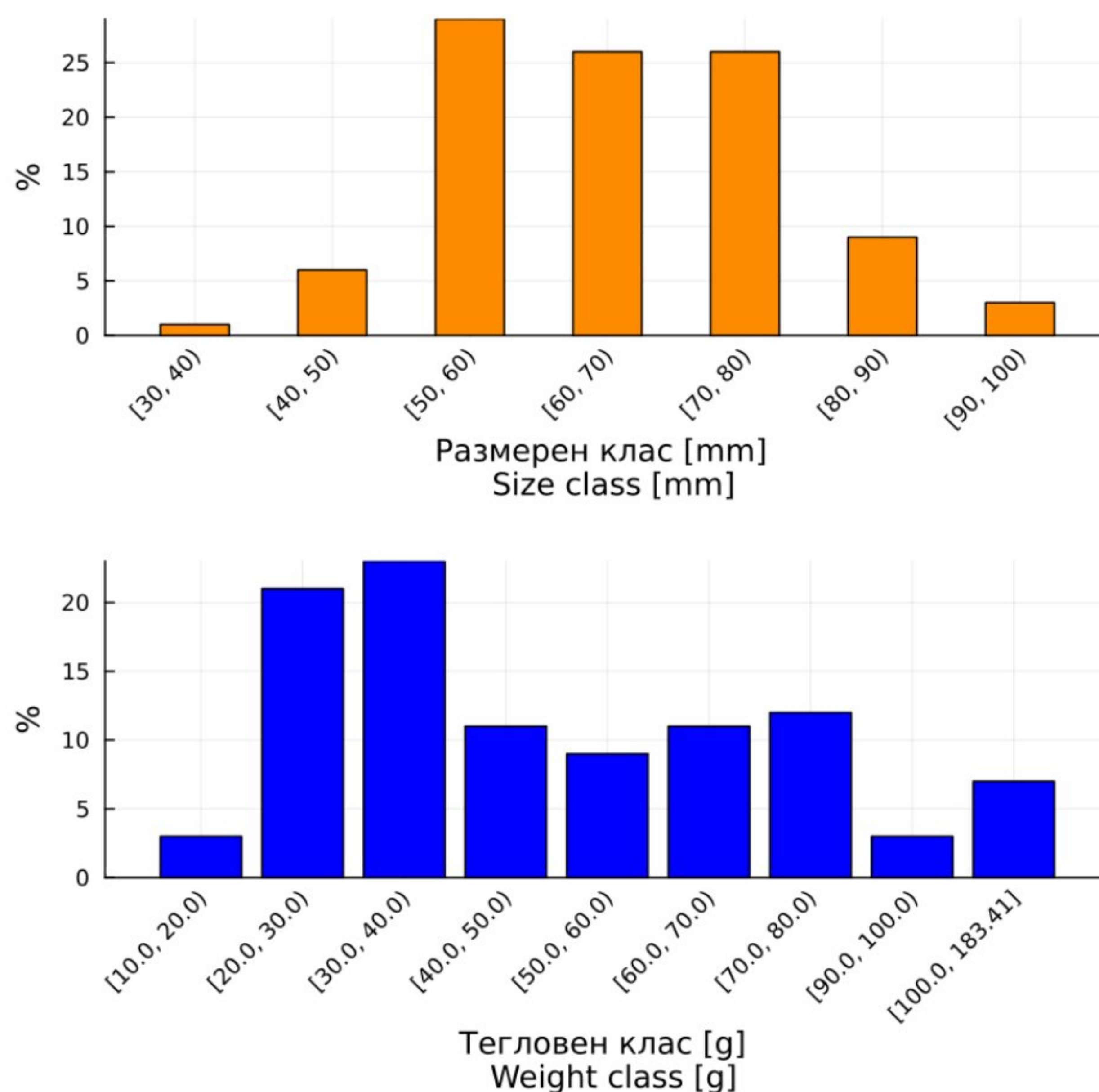


Figure 16 Size structure [mm] and weight structure [g] of the sample from port Kavarna, 03.09.2025

The mean ratio between the shell width (Wd, mm)/shell length (SL, mm) is $78.09\% \pm 3.71$ SD, while AL/SL (%) is $74.51\% \pm 3.64$ SD, and the ratio between AL/Wd (%) was calculated at $-95.41\% \pm 1.46$ 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, 03.09.2025

	Wd/SL %	Al/SL %	Al/Wd %
Sample size	100.00	100.00	100.00
Mean	78.09	74.51	95.41
Standard deviation	3.71	3.64	1.46
Minimum	67.19	62.50	89.74
50% (median)	78.15	74.41	95.56
Maximum	89.86	84.06	98.18
Sum	7809.24	7450.57	9541.12
Mode	75.00	75.00	96.67
Skewness	0.14	0.13	0.02
Sample variance	0.50	0.37	1.76
Kurtosis	-0.02	-0.25	-0.94
Range	0.23	0.22	0.08
Confidence level 95%	(0.77, 0.79)	(0.74, 0.75)	(0.95, 0.96)

The L-W ratios are calculated (Figure 17). 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, 03.09.2025

Parameters	$TW(g) = a \cdot SL(mm)^b$	$TW(g) = a \cdot Wd(mm)^b$	$W(g) = a \cdot AL(mm)^b$
a	0.0001	0.0005	0.0006
b	3.034	2.92	2.876
R²	0.93	0.95	0.95



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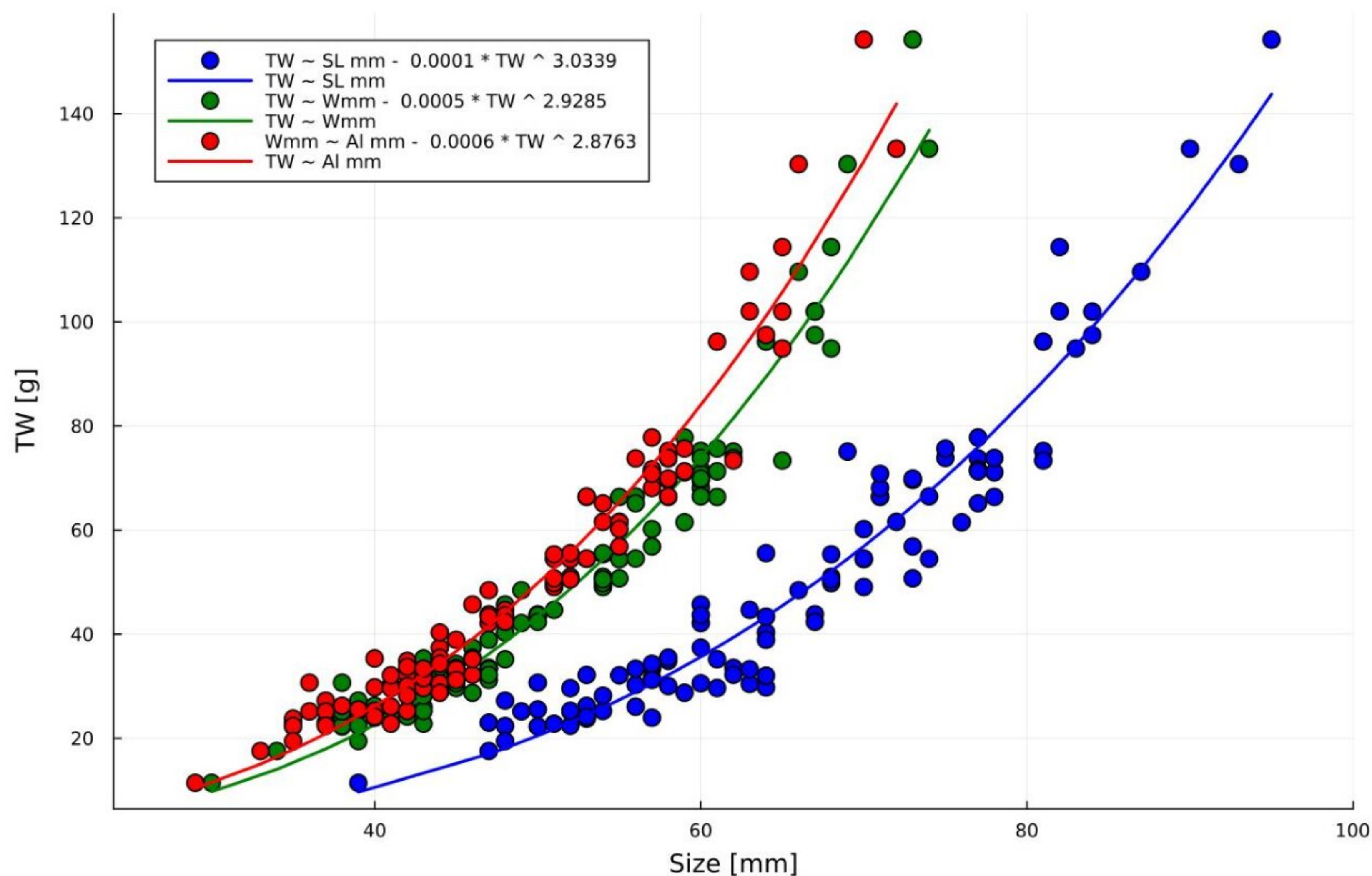


Figure 17 L-W ratios for the sampled individuals, port Kavarna, 03.09.2025: (1) ratio between total weight (TW, g) and shell length (SL, mm); (2) relationship between total weight (TW, g) and shell width (Wd, mm); (3) relationship between total weight (TW, g) and aperture length (AL, mm).



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3.1.9. PORT BYALA, 10.09.2025

The sample consists of 100 individuals, with a total weight of 5.52 kg, from a total landing of 250 kg rapa whelks at port Byala (from the fishing vessel).

The mean weight of the measured specimens reaches $55.16 \text{ g} \pm 20.9 \text{ SD}$ at a mean shell length of $65.5 \text{ mm} \pm 7.71 \text{ SD}$, shell width $51.24 \text{ mm} \pm 6.1 \text{ SD}$ and aperture length $48.4 \text{ mm} \pm 6.17 \text{ SD}$. The mean body weight without shell (BW, g) is $18.43 \text{ g} \pm 9.44 \text{ SD}$ and forms $33.57 \% \pm 5.98$ from the total weight, varying between 23.27 % and 44.58 % from the total weight (Table 26).

Table 26

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 Port Byala, 10.09.2025

	TW g	SL mm	Wd mm	Al mm	BW g	BW % TW
Sample size	100	100	100	100	50	50
Mean	55.16	65.5	51.24	48.4	18.43	33.57
Standard deviation	20.9	7.71	6.1	6.17	9.44	5.98
Minimum	21.34	48	37	35	6.22	23.27
50% (median)	51.01	64	50	48	16.85	34.02
Maximum	128.56	90	70	68	47.19	44.58
Sum	5516.47	6550	5124	4840	921.42	1678.36
Mode	21.34	61	51	48	7.19	26.18
Skewness	436.76	59.51	37.25	38.08	89.05	35.73
Sample variance	1.21	0.47	0.59	0.66	0.8	-1.2
Kurtosis	1.15	0.63	0.63	0.73	1.06	-0.05
Range	107.22	42	33	33	40.97	21.31
Confidence level 95%	(51.07, 59.26)	(63.99, 67.01)	(50.04, 52.44)	(47.19, 49.61)	(15.81, 21.04)	(31.91, 35.22)

The dominant size classes from the sample are 60-70 mm (51% of the measured individuals). As for the weight structure, the dominant weight class (TW, g) is 50-60 g (23 %).



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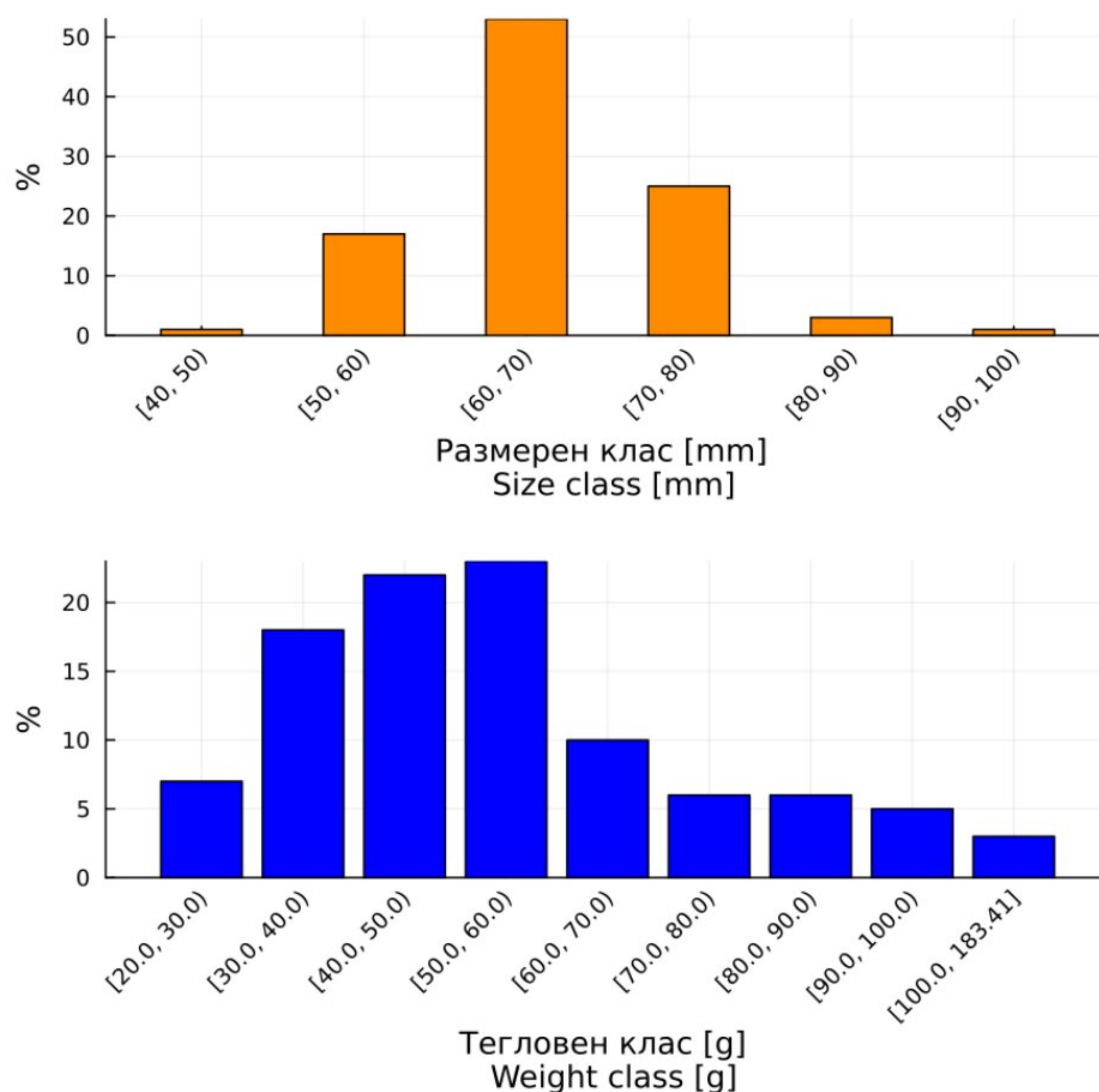


Figure 18 Size structure [mm] and weight structure [g] of the sample from port Port Byala, 10.09.2025

The mean ratio between the shell width (Wd, mm)/shell length (SL, mm) is $78.30\% \pm 3.64$ SD, while AL/SL (%) is $73.89\% \pm 3.31$ SD, and the ratio between AL/Wd (%) was calculated at $94.39\% \pm 1.78$ 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 port Byala, 10.09.2025

	Wd/SL %	Al/SL %	Al/Wd %
Sample size	100	100	100
Mean	78.30	73.89	94.39
Standard deviation	3.64	3.31	1.78
Minimum	67.19	65.62	89.80
50% (median)	78.46	74.07	94.17
Maximum	87.88	81.48	98.11
Sum	7830.08	7388.67	9438.69
Mode	80.00	75.00	94.12
Skewness	0.13	0.11	0.03
Sample variance	0.65	0.18	-0.44
Kurtosis	-0.12	-0.09	-0.15
Range	0.21	0.16	0.08
Confidence level 95%	(0.78, 0.79)	(0.73, 0.75)	(0.94, 0.95)

The L-W ratios are calculated (Figure19). 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 L-W of the L-W ratios and values of R^2 for the sample from port Byala, 10.09.2025

Parameters	$TW(g) = a.SL(mm)^b$	$TW(g) = a.Wd(mm)^b$	$W(g) = a.AL(mm)^b$
a	0.0003	0.0007	0.0017
b	2,858	2.85	2.66
R²	0.93	0.95	0.95



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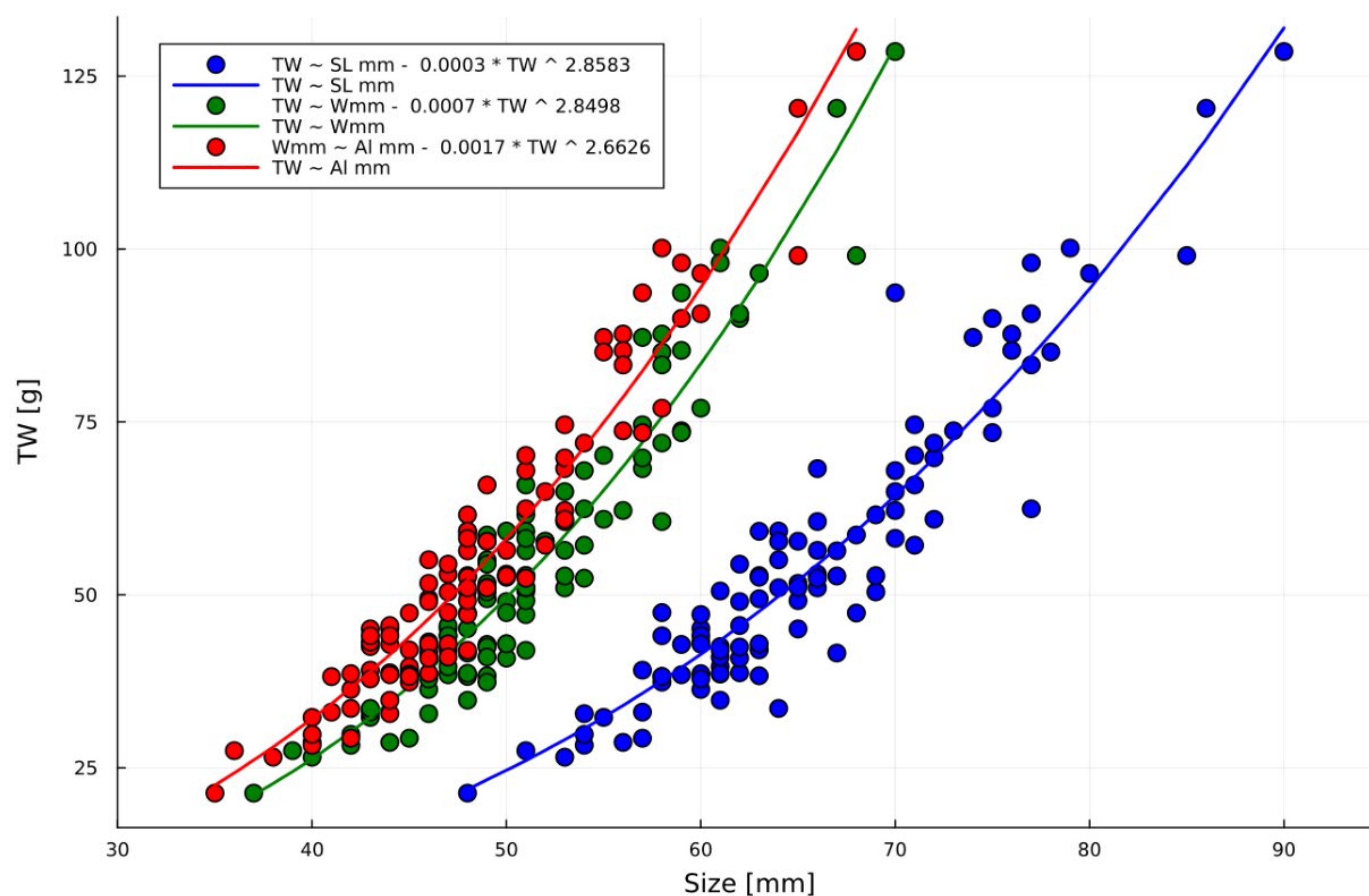


Figure 19 L-W ratios for the sampled individuals, port Byala, 10.09.2025: (1) ratio between total weight (TW, g) and shell length (SL, mm); (2) relationship between total weight (TW, g) and shell width (Wd, mm); (3) relationship between total weight (TW, g) and aperture length (AL, mm).



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3.1.10. PORT BOLATA, 01.10.2025 (SCUBA DIVING)

The sample consists of 100 individuals, with a total weight of 5.58 kg, from a total landing of 900 kg rapa whelks at port Bolata (from the fishing vessels).

The mean weight of the measured specimens reaches $55.82 \text{ g} \pm 18.94 \text{ SD}$ at a mean shell length of $67.57 \text{ mm} \pm 7.56 \text{ SD}$, shell width $53.59 \text{ mm} \pm 6.62 \text{ SD}$ and aperture length $51.25 \text{ mm} \pm 6.47 \text{ SD}$. The mean body weight without shell (BW, g) is $23.15 \text{ g} \pm 8.5 \text{ SD}$, which is $39.23 \% \pm 5.88 \text{ SD}$ from the total weight, varying between 15.89 % and 47.63 % from the total weight (Table 29).

Table 29

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 Bolata, 01.10.2025

	TW g	SL mm	Wd mm	Al mm	BW g	BW % TW
Sample size	100	100	100	100	48	48
Mean	55.82	67.57	53.59	51.25	23.15	39.23
Standard deviation	18.94	7.56	6.62	6.47	8.5	5.88
Minimum	9.88	39	29	28	1.57	15.89
50% (median)	53.34	68	54	52	22.5	40.57
Maximum	112.64	83	69	66	40.22	47.63
Sum	5582.26	6757	5359	5125	1111.37	1882.85
Mode	63.75	62	53	52	28.19	31.51
Skewness	358.57	57.22	43.8	41.91	72.29	34.58
Sample variance	0.35	0.99	0.84	0.65	-0.33	3.56
Kurtosis	0.57	-0.35	-0.36	-0.27	0.01	-1.47
Range	102.76	44	40	38	38.65	31.74
Confidence level 95%	(52.11, 59.53)	(66.09, 69.05)	(52.29, 54.89)	(49.98, 52.52)	(20.75, 25.56)	(37.56, 40.89)

The dominant size classes from the sample are 60—70 mm (50% of the measured individuals). As for the weight structure, the dominant weight class (TW, g) is 50-60 g (25 %)



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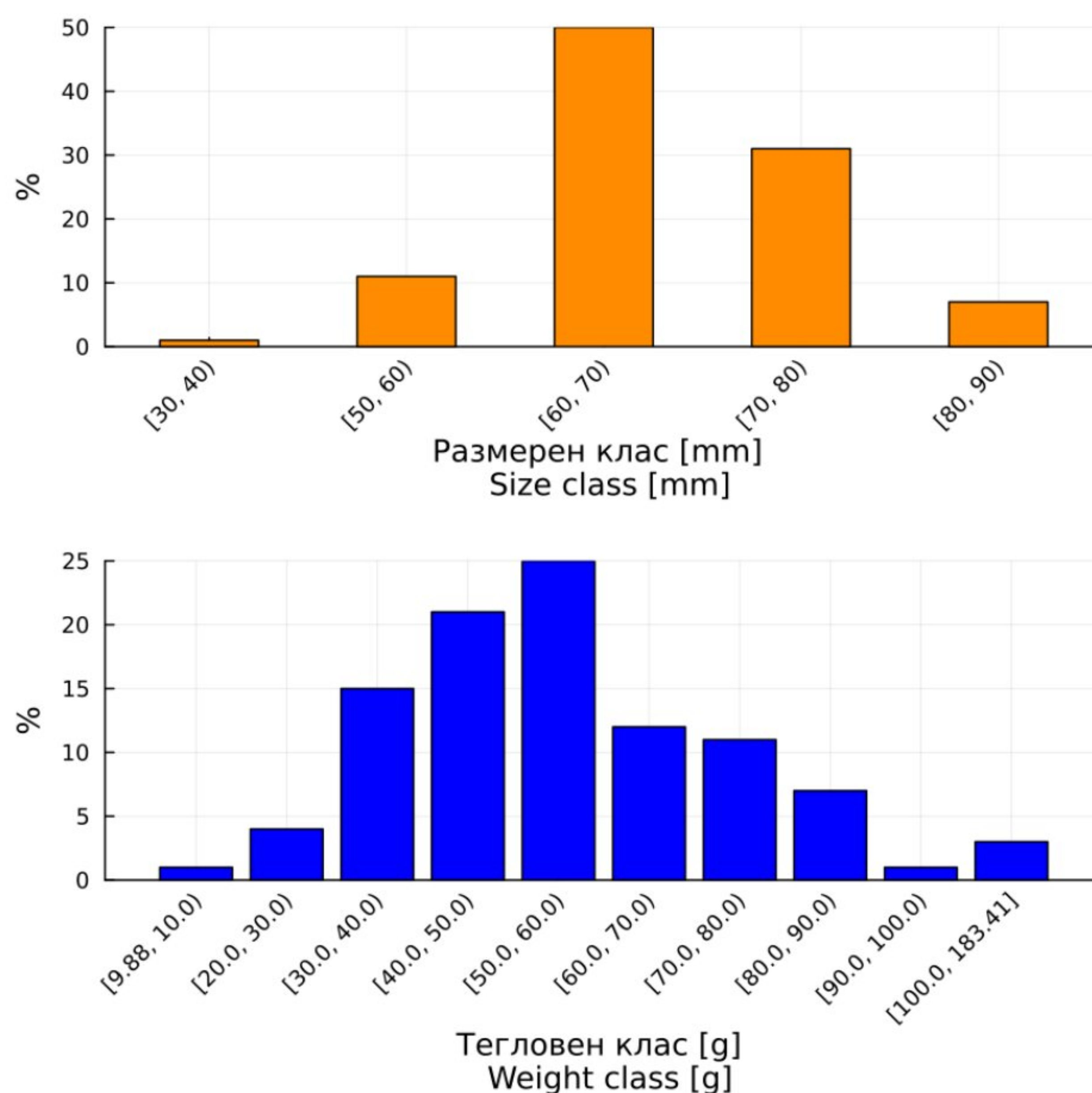


Figure 20 Size structure [mm] and weight structure [g] of the sample from port Bolata,01.10.2025

The mean ratio between the shell width (Wd, mm)/shell length (SL, mm) is $79.26\% \pm 3.29$ SD, while AL/SL (%) is $79.26\% \pm 3.29$ SD, and the ratio between AL/Wd (%) was calculated at $-95.61\% \pm 1.45$ 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 Bolata, 01.10.2025

	Wd/SL %	Al/SL %	Al/Wd %
Sample size	100	100	100
Mean	79.26	75.78	95.61
Standard deviation	3.29	3.33	1.45
Minimum	71.64	65.67	89.80
50% (median)	79.69	75.83	95.79
Maximum	87.32	83.10	98.21
Sum	7926.02	7578.42	9561.45
Mode	80.00	75.00	94.74
Skewness	0.11	0.11	0.02
Sample variance	-0.21	0.10	1.62
Kurtosis	-0.41	-0.55	-0.67
Range	0.16	0.17	0.08
Confidence level 95%	(0.79, 0.8)	(0.75, 0.76)	(0.95, 0.96)

The L-W ratios are calculated (Figure21). 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 port Bolata, 01.10.2025

Parameters	$TW(g) = a.SL(mm)^b$	$TW(g) = a.Wd(mm)^b$	$W(g) = a.AL(mm)^b$
a	0.0003	0.001	0.0016
b	2.902	2.73	2.65
R²	0.91	0.93	0.94



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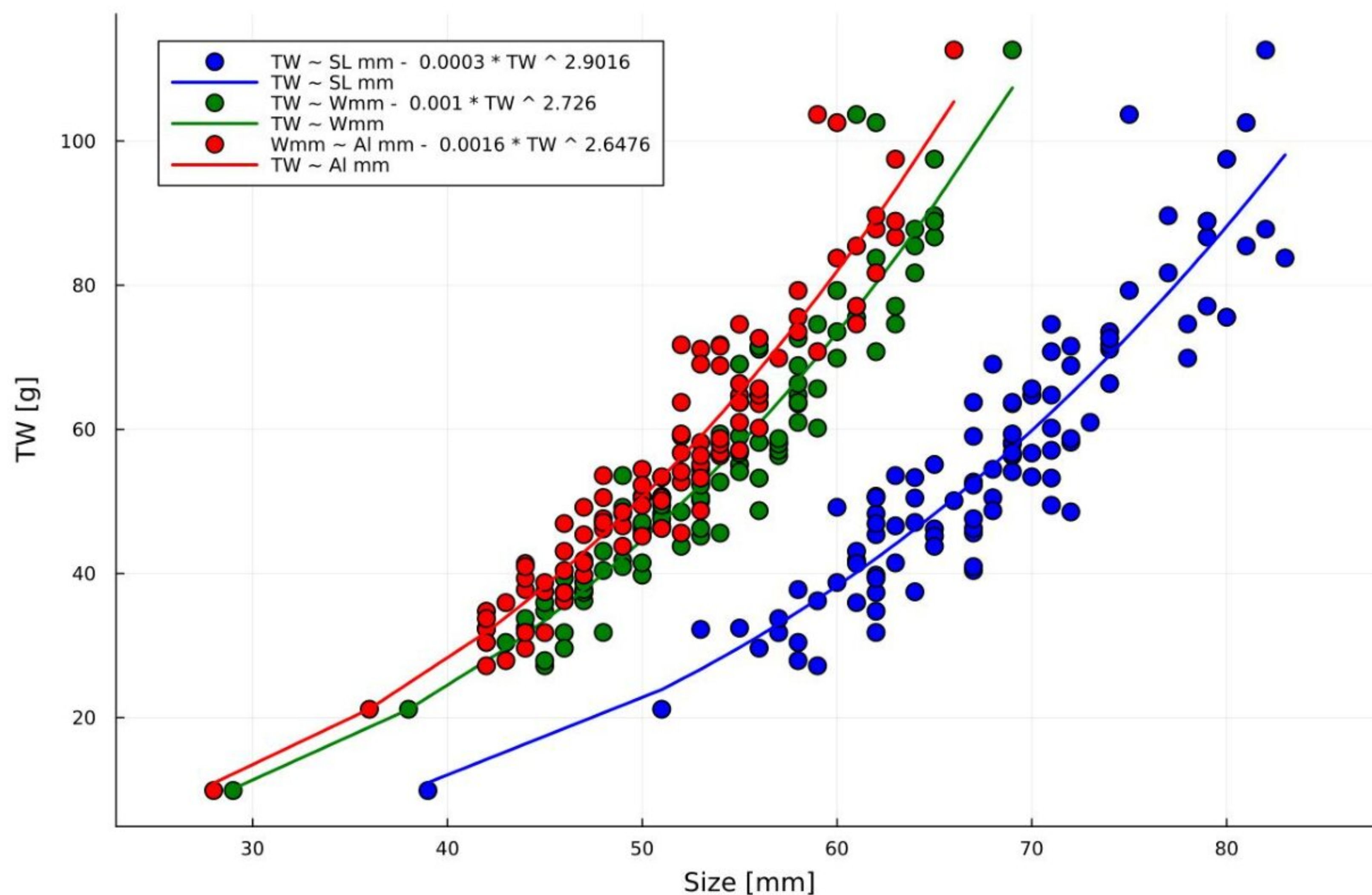


Figure 21 L-W ratios for the sampled individuals, port Bolata, 01.10.2025: (1) ratio between total weight (TW, g) and shell length (SL, mm); (2) relationship between total weight (TW, g) and shell width (Wd, mm); (3) relationship between total weight (TW, g) and aperture length (AL, mm).



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3.1.11. PORT VARNA, 31.10.2025

The sample consists of 100 individuals, with a total weight of 5.13 kg, from a total landing of 2810 kg rapa whelks at port Varna (from the fishing vessel).

The mean weight of the measured specimens reaches $51.26 \text{ g} \pm 15.49 \text{ SD}$ at a mean shell length of $65.48 \text{ mm} \pm 6.21 \text{ SD}$, shell width $51.99 \text{ mm} \pm 5.24 \text{ SD}$ and aperture length $49.82 \text{ mm} \pm 5.16 \text{ SD}$. The mean body weight without shell (BW, g) is $19.19 \text{ g} \pm 6.33 \text{ SD}$, which is $38.1 \% \pm 4.73 \text{ SD}$ from the total weight, varying between 21.29 % and 47.84 % 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, 31.10.2025

	TW g	SL mm	Wd mm	Al mm	BW g	BW % TW
Sample size	100	100	100	100	50	50
Mean	51.26	65.48	51.99	49.82	19.19	38.1
Standard deviation	15.49	6.21	5.24	5.16	6.33	4.73
Minimum	21.58	53	41	39	8.23	21.29
50% (median)	48.06	64	51	49.5	17.56	38.31
Maximum	90.47	84	65	62	32.27	47.84
Sum	5126.33	6548	5199	4982	959.45	1905.05
Mode	73.27	70	49	44	16.93	40.18
Skewness	240.04	38.62	27.42	26.59	40.01	22.36
Sample variance	-0.49	-0.17	-0.76	-0.73	-0.57	2.13
Kurtosis	0.49	0.4	0.34	0.33	0.51	-0.77
Range	68.89	31	24	23	24.04	26.55
Confidence level 95%	(48.23, 54.3)	(64.26, 66.7)	(50.96, 53.02)	(48.81, 50.83)	(17.44, 20.94)	(36.79, 39.41)

The dominant size classes from the sample are 60—70 mm (50% of the measured individuals). As for the weight structure, the dominant weight class (TW, g) is 40-50 g (25 %).



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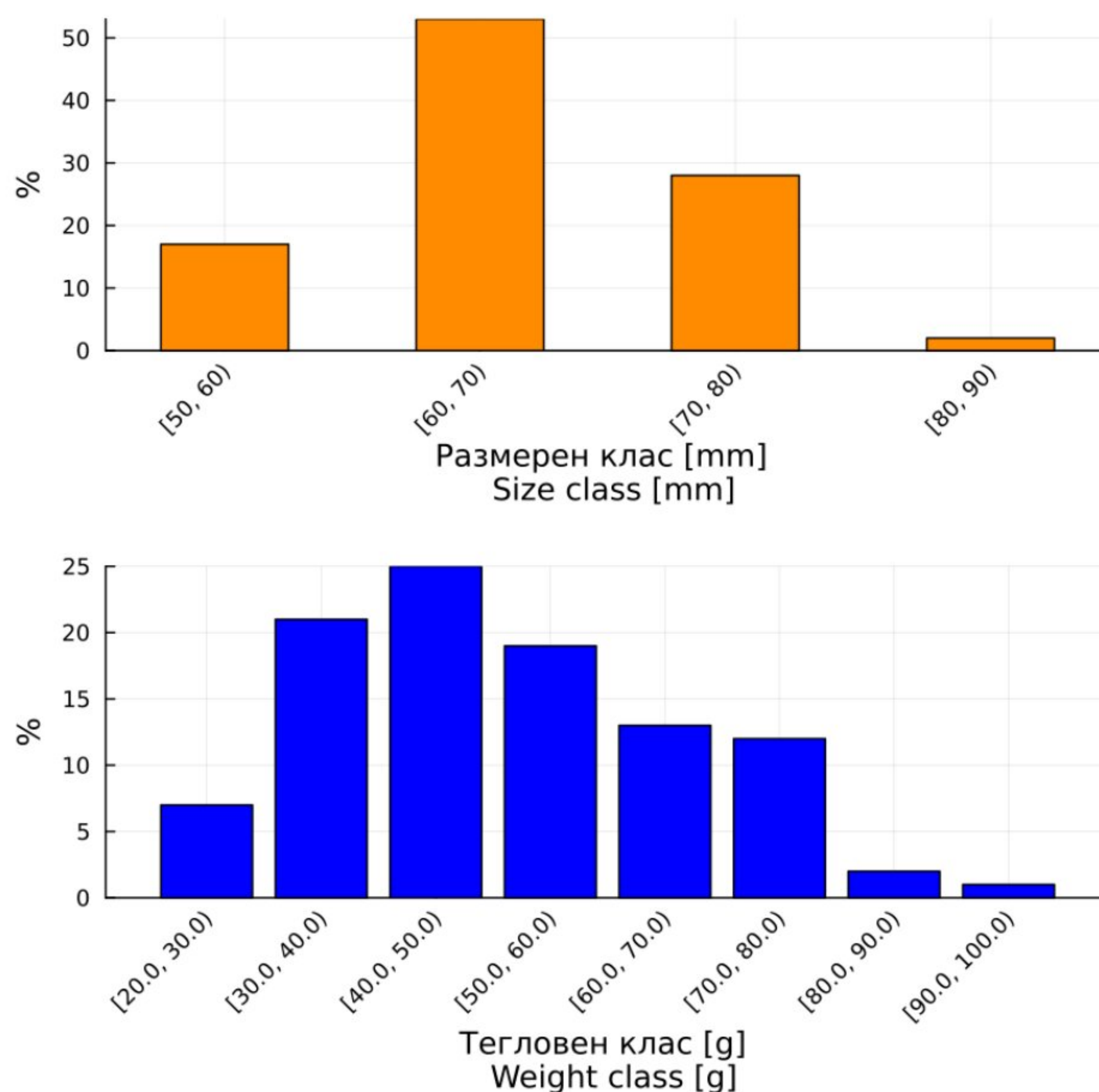


Figure 22 Size structure [mm] and weight structure [g] of the sample from port Varna, 31.10.2025

The mean ratio between the shell width (Wd, mm)/shell length (SL, mm) is $79.46 \% \pm 4.18 \text{ SD}$, while AL/SL (%) is $76.12 \% \pm 3.87 \text{ SD}$, and the ratio between AL/Wd (%) was calculated at $-95.81\% \pm 1.27 \text{ SD}$ (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, 31.10.2025

	Wd/SL %	Al/SL %	Al/Wd %
Sample size	100	100	100
Mean	79.46	76.12	95.81
Standard deviation	4.18	3.87	1.27
Minimum	70.97	68.25	89.80
50% (median)	80.00	77.04	95.92
Maximum	88.41	84.06	98.39
Sum	7946.40	7611.83	9580.75
Mode	80.00	78.57	95.65
Skewness	0.18	0.15	0.02
Sample variance	-0.79	-0.80	3.94
Kurtosis	-0.24	-0.23	-0.98
Range	0.17	0.16	0.09
Confidence level 95%	(0.79, 0.8)	(0.75, 0.77)	(0.96, 0.96)

The L-W ratios are calculated (Figure23). The parameters a , b of the linear-weight relationships and the values of the correlation coefficient R^2 are presented in Table 34.

Table 34

Parameters a , b of the L-W ratios and values of R^2 for the sample from port Varna, 31.10.2025

Parameters	$TW(g) = a \cdot SL(mm)^b$	$TW(g) = a \cdot Wd(mm)^b$	$W(g) = a \cdot AL(mm)^b$
a	0.0003	0.001	0.0016
b	2.902	2.73	2.65
R²	0.91	0.93	0.94



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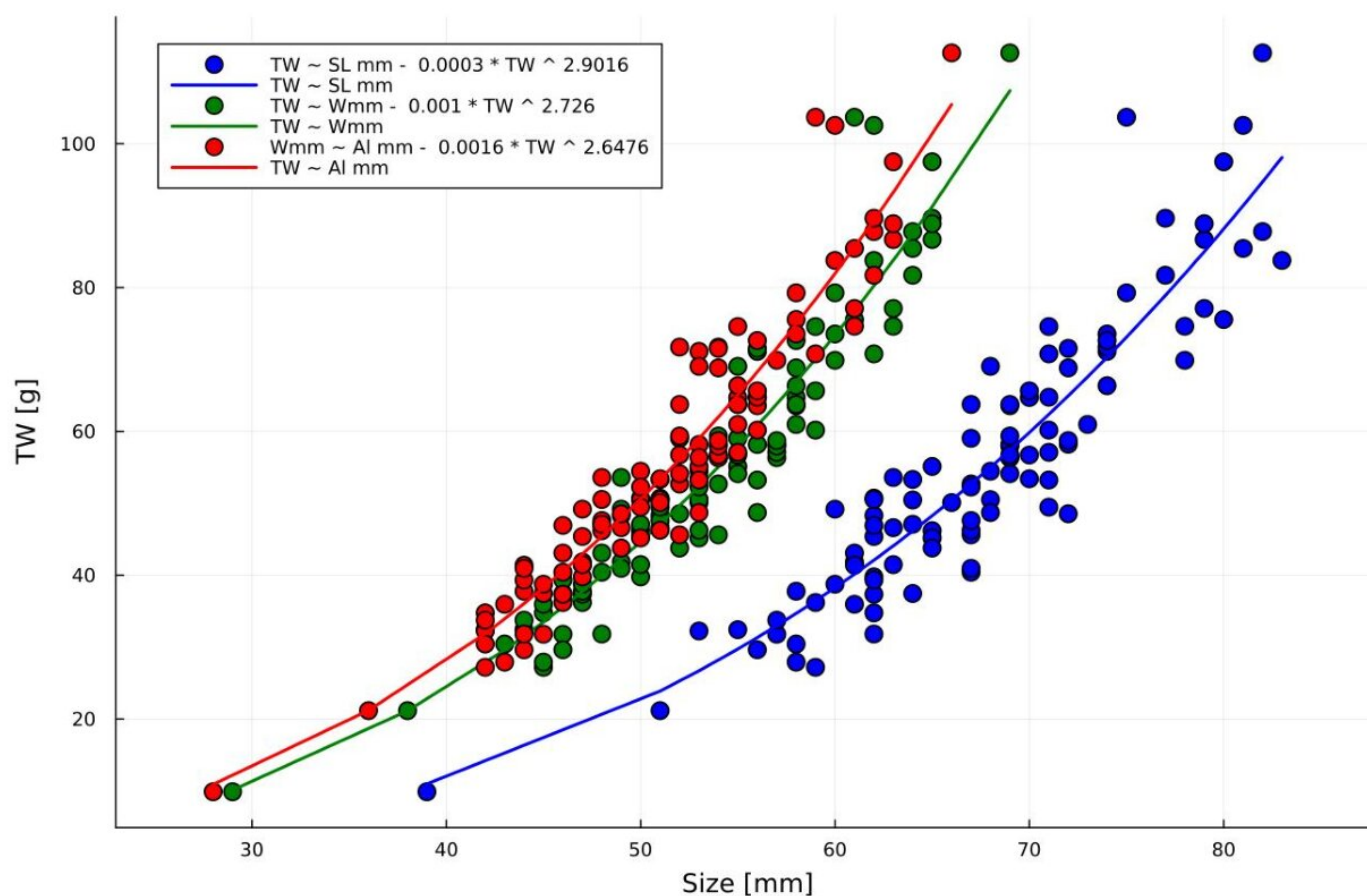


Figure 23 L-W ratios for the sampled individuals, port Varna, 31.10.2025: (1) ratio between total weight (TW, g) and shell length (SL, mm); (2) relationship between total weight (TW, g) and shell width (Wd, mm); (3) relationship between total weight (TW, g) and aperture length (AL, mm).



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3.1.12. PORT TSAREVO, 12.11.2025 (SCUBA DIVING)

The sample consists of 100 individuals, with a total weight of 9.2 kg, from a total landing of 10 kg rapa whelks at port Tsarevo (from the fishing vessel).

The mean weight of the measured specimens reaches $92.04 \text{ g} \pm 30.32$ at a mean shell length of $78.31 \text{ mm} \pm 9.4 \text{ SD}$, shell width $60.72 \text{ mm} \pm 7.77 \text{ SD}$ and aperture length $58.05 \text{ mm} \pm 7.71 \text{ SD}$. The mean body weight without shell (BW, g) is $35.12 \text{ g} \pm 15.12 \text{ SD}$, which is $40.05 \% \pm 6.05 \text{ SD}$ from the total weight, varying between 25.04 % and 55.83 % from the total weight (Table 35).

Table 35

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 Tsarevo, 12.11.2025

	TW g	SL mm	Wd mm	Al mm	BW g	BW % TW
Sample size	100	100	100	100	50	50
Mean	92.04	78.31	60.72	58.05	35.12	40.05
Standard deviation	30.32	9.4	7.77	7.71	15.12	6.05
Minimum	28.72	53	42	40	9.97	25.04
50% (median)	89.76	79	61	58	33.95	39.91
Maximum	183.41	102	82	80	73.03	55.83
Sum	9204.02	7831	6072	5805	1756.1	2002.41
Mode	97.23	80	64	61	36.33	29.58
Skewness	919.24	88.44	60.37	59.44	228.55	36.55
Sample variance	0.22	0.26	0.17	0.12	0.56	0.09
Kurtosis	0.36	-0.03	-0.14	-0.09	0.82	-0.07
Range	154.69	49	40	40	63.06	30.79
Confidence level 95%	(86.1, 97.98)	(76.47, 80.15)	(59.2, 62.24)	(56.54, 59.56)	(30.93, 39.31)	(38.37, 41.72)

The dominant size classes from the sample are 70—80 mm (36% of the measured individuals). As for the weight structure, the dominant weight class (TW, g) > 100 g (32 %).



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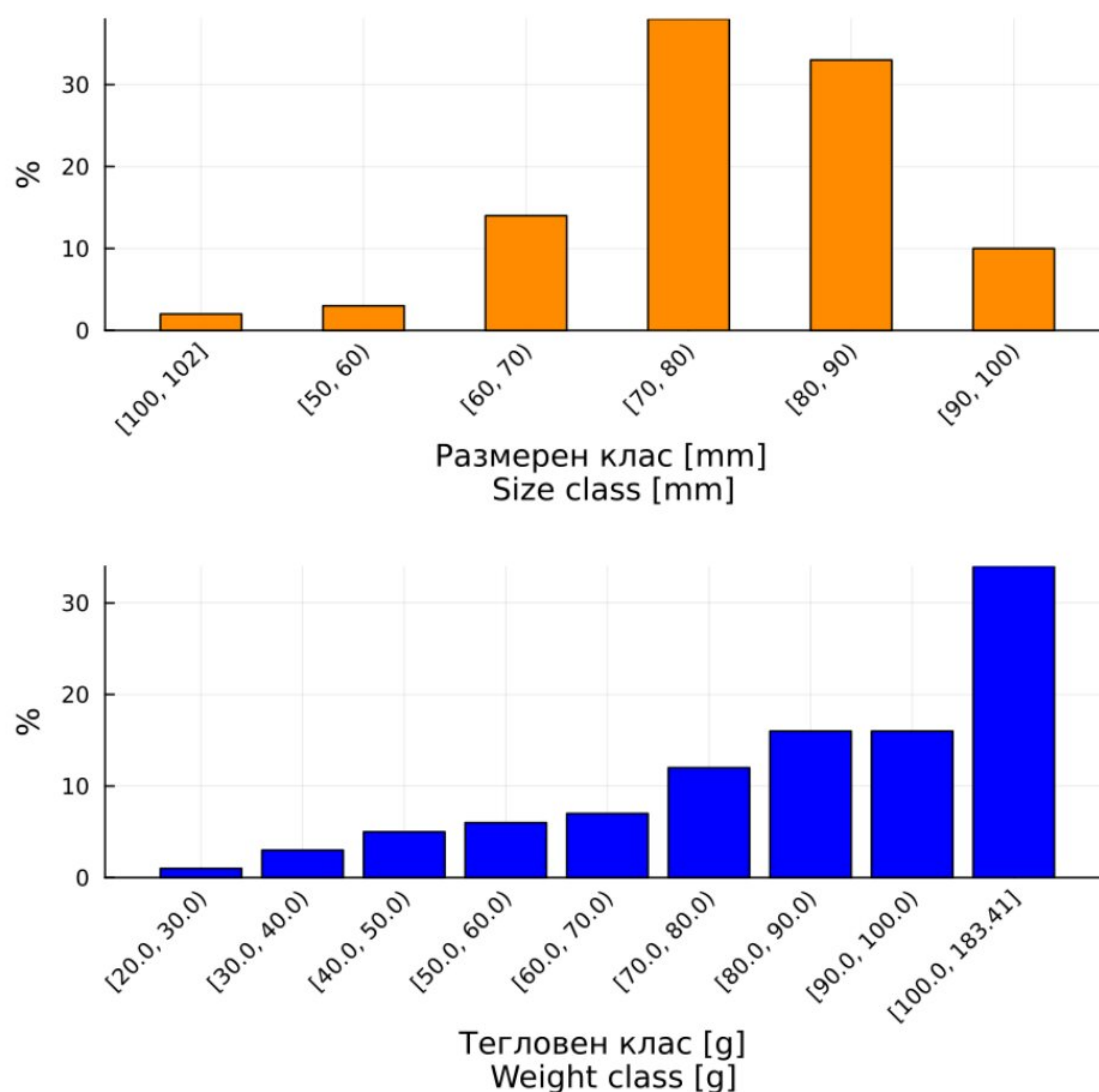


Figure 24 Size structure [mm] and weight structure [g] of the sample from port Tsarevo, 12.11.2025

The mean ratio between the shell width (Wd, mm)/shell length (SL, mm) is $77.53\% \pm 3.58$ SD, while AL/SL (%) is $74.08\% \pm 3.58$ SD, and the ratio between AL/Wd (%) was calculated at $-95.55\% \pm 1.30$ 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 port Tsarevo, 12.11.2025

	Wd/SL %	Al/SL %	Al/Wd %
Sample size	100	100	100
Mean	77.53	74.08	95.55
Standard deviation	3.58	3.55	1.30
Minimum	68.66	65.67	91.67
50% (median)	77.14	74.02	95.35
Maximum	87.32	84.51	98.63
Sum	7753.44	7408.49	9555.15
Mode	75.00	71.43	95.31
Skewness	0.13	0.13	0.02
Sample variance	0.04	-0.05	0.29
Kurtosis	0.28	0.09	-0.17
Range	0.19	0.19	0.07
Confidence level 95%	(0.77, 0.78)	(0.73, 0.75)	(0.95, 0.96)

The L-W ratios are calculated (Figure25). 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 port Tsarevo, 12.11.2025

Parameters	$TW(g) = a \cdot SL(mm)^b$	$TW(g) = a \cdot Wd(mm)^b$	$W(g) = a \cdot AL(mm)^b$
a	0.00011	0.0031	0.0053
b	2.589	2.503	2.39
R²	0.93	0.95	0.95



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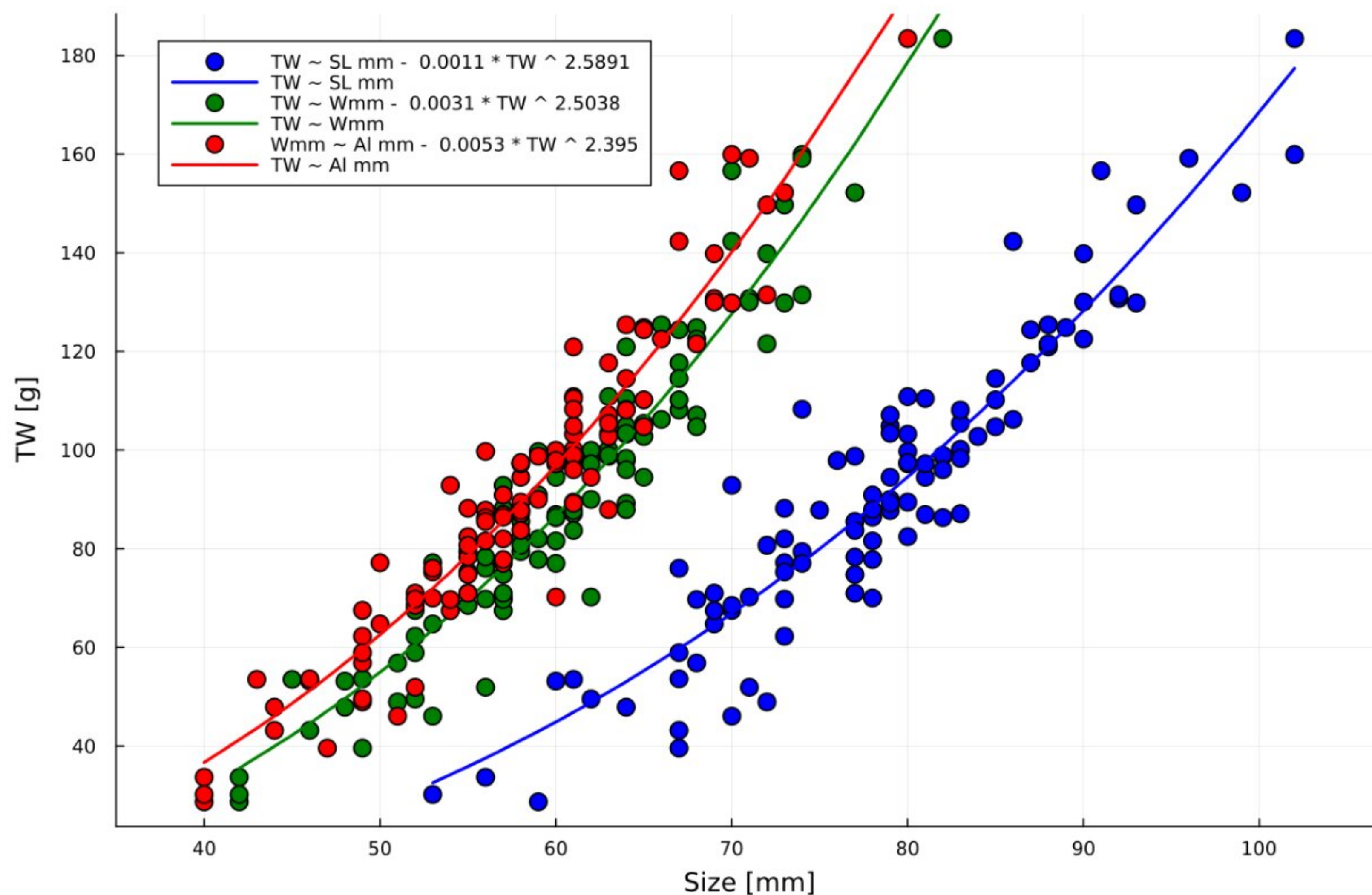


Figure 25 L-W ratios for the sampled individuals, port Tsarevo, 12.11.2025: (1) ratio between total weight (TW, g) and shell length (SL, mm); (2) relationship between total weight (TW, g) and shell width (Wd, mm); (3) relationship between total weight (TW, g) and aperture length (AL, mm)



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3.1.13. PORT VARNA, 12.11.2025

The sample consists of 100 individuals, with a total weight of 5.01 kg, from a total landing of 1500 kg rapa whelks at port Varna (from the fishing vessel).

The mean weight of the measured specimens reaches $51.27 \text{ g} \pm 15.37 \text{ SD}$ at a mean shell length of $65.46 \text{ mm} \pm 6.18 \text{ SD}$, shell width $52.0 \text{ mm} \pm 5.23 \text{ SD}$ and aperture length $49.82 \text{ mm} \pm 5.16 \text{ SD}$. The mean body weight without shell (BW, g) is $19.19 \text{ g} \pm 6.29 \text{ SD}$, which is $38.05 \% \pm 4.77 \text{ SD}$ from the total weight, varying between 21.29 % and 47.84 % from the total weight (Table 32).

Table 38

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, 12.11.2025

	TW g	SL mm	Wd mm	Al mm	BW g	BW % TW
Sample size	100	100	100	100	50	50
Mean	51.27	65.44	52.02	49.77	19.19	38
Standard deviation	15.31	6.18	5.24	5.17	6.31	4.87
Minimum	26.54	54	43	41	8.23	21.29
50% (median)	48.56	64	51	49.5	17.57	38.21
Maximum	90.47	84	65	62	32.27	47.61
Sum	5127.45	6544	5202	4977	959.67	1899.78
Mode	73.27	70	49	44	16.93	40.35
Skewness	234.52	38.15	27.47	26.76	39.82	23.67
Sample variance	-0.49	-0.16	-0.74	-0.73	-0.57	1.73
Kurtosis	0.53	0.46	0.37	0.35	0.52	-0.6
Range	63.93	30	22	21	24.04	26.31
Confidence level 95%	(48.27, 54.28)	(64.23, 66.65)	(50.99, 53.05)	(48.76, 50.78)	(17.44, 20.94)	(36.65, 39.34)

The dominant size classes from the sample are 60 - 70 mm (51% of the measured individuals). As for the weight structure, the dominant weight class (TW, g) is 40-50 g (25 %).



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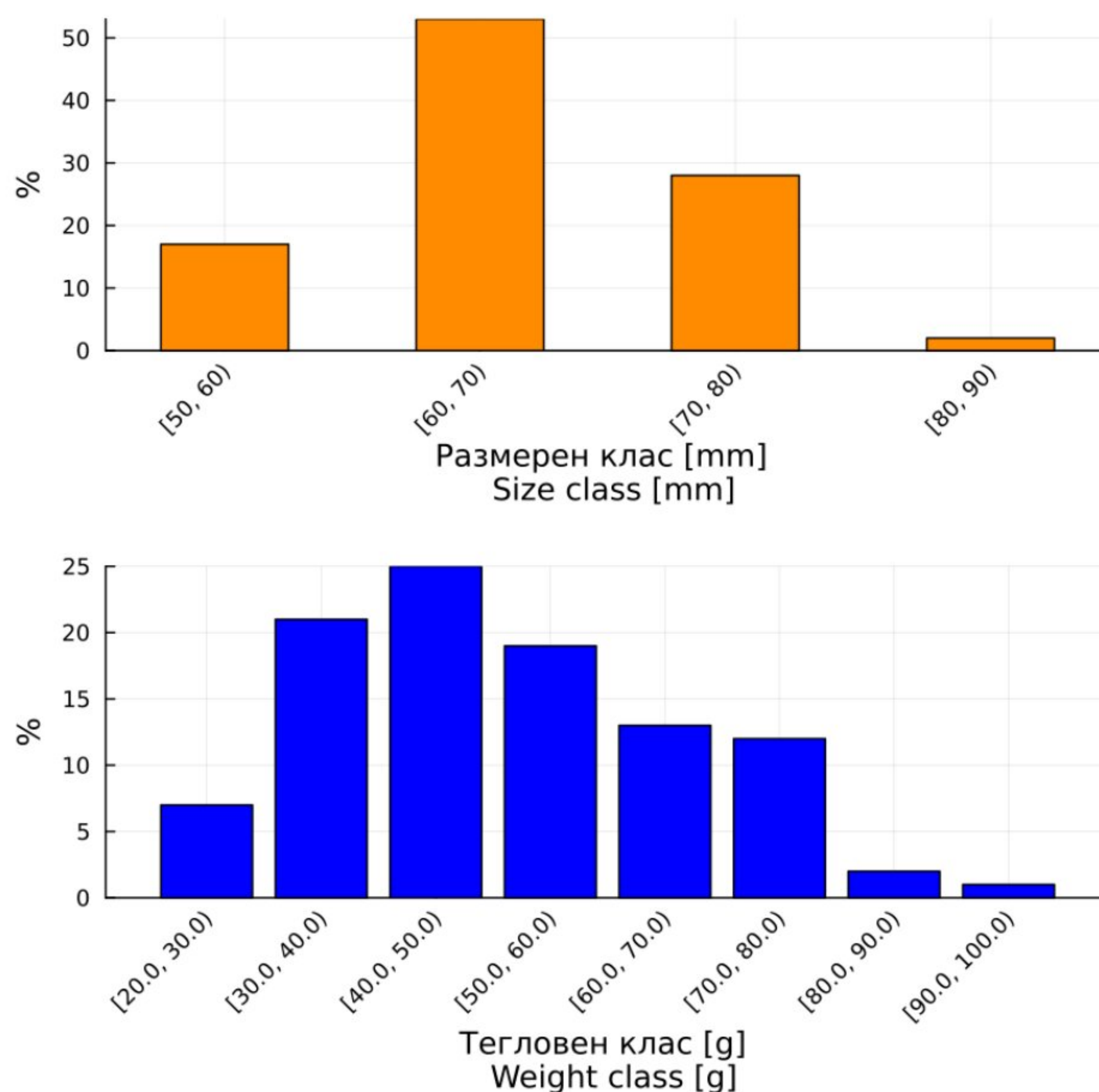


Figure 26 Size structure [mm] and weight structure [g] of the sample from port Varna, 12.11.2025

The mean ratio between the shell width (Wd, mm)/shell length (SL, mm) is $79.36 \% \pm 5.18 \text{ SD}$, while AL/SL (%) is $76.67 \% \pm 3.97 \text{ SD}$, and the ratio between AL/Wd (%) was calculated at $-95.80\% \pm 1.29 \text{ SD}$ (Table 33).



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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 Varna, 12.11.2025

	Wd/SL %	Al/SL %	Al/Wd %
Sample size	100	100	100
Mean	79.36	76.67	95.80
Standard deviation	5.18	3.97	1.29
Minimum	70.97	68.25	89.80
50% (median)	80.00	77.04	95.92
Maximum	88.41	84.06	98.39
Sum	7946.40	7611.83	9580.75
Mode	80.00	78.57	95.65
Skewness	0.18	0.15	0.02
Sample variance	-0.79	-0.80	3.94
Kurtosis	-0.24	-0.23	-0.98
Range	0.17	0.16	0.09
Confidence level 95%	(0.79, 0.8)	(0.75, 0.77)	(0.96, 0.96)

The L-W ratios are calculated (Figure23). The parameters a , b of the linear-weight relationships and the values of the correlation coefficient R^2 are presented in Table 34.

Table 40

Parameters a , b of the L-W ratios and values of R^2 for the sample from port Varna, 12.11.2025

Parameters	$TW(g) = a \cdot SL(mm)^b$	$TW(g) = a \cdot Wd(mm)^b$	$W(g) = a \cdot AL(mm)^b$
a	0.0013	0.001	0.0015
b	2.527	2.741	2.69
R²	0.92	0.93	0.94



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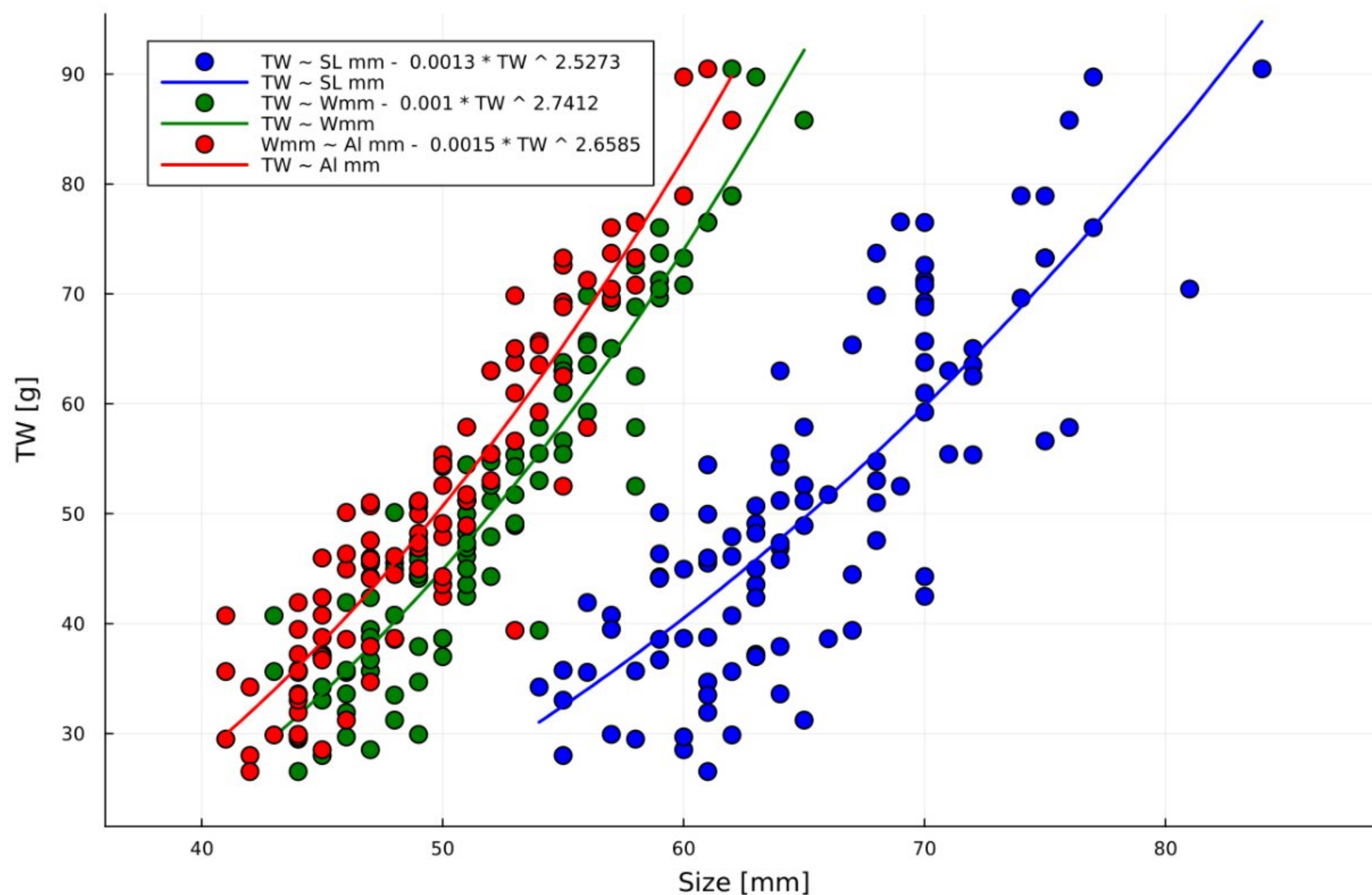


Figure 27 L-W ratios for the sampled individuals, port Varna, 12.11.2025: (1) ratio between total weight (TW, g) and shell length (SL, mm); (2) relationship between total weight (TW, g) and shell width (Wd, mm); (3) relationship between total weight (TW, g) and aperture length (AL, mm).



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3.1.14. SUMMARIZED RESULTS FOR 2025

The rapa whelk landings for the period March – December 2025 vary between 10 and 2810 kg/day for all observed ports; the biggest landing from beam trawl fishing was registered at port Varna in October 2025 (Table 41).

Table 41

Summarized data about the landings by days and ports from different fishing vessels and fishing methods for 2025

Date	Port of Landing	Fishing Vessel	Fishing Gear	Catch (kg)
25.03.2025	Rodopa 1	Korsar 2	beam trawl	503
05.04.2025	Kavarna	Viking	beam trawl	2720
30.04.2025	Rodopa 1	Korsar 2	beam trawl	1950
02.05.2025	Balchik	Hermes-4	beam trawl	2600
01.06.2025	Ada bahcha	Tesi	beam trawl	2278
01.06.2025	Kavarna	Neptun-70	beam trawl	500
19.07.2025	Rodopa 1	Vn 3453	scuba	80
09.08.2025	Byala	BL2957	scuba	5
23.08.2025	Tsarevo	GOLYAMOTO SINYO	scuba	4
28.08.2025	Tsarevo	PR 560	scuba	10
31.08.2025	Byala	BL2957	scuba	5
03.09.2025	Kavarna	KORSAR	beam trawl	2750
10.09.2025	Byala	KAPTAN 1	beam trawl	250



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22.09.2025	Rodopa 1	Vn 7486	scuba	66
01.10.2025	Bolata	Kv 6353	scuba	990
16.10.2025	Rodopa 1	VN 8793	scuba	360
26.10.2025	Varna	VN 8710	scuba	5
31.10.2025	Varna	Horizont	beam trawl	2810
12.11.2025	Tsarevo	GOLYAMOTO SINYO	scuba	10
12.11.2025	Varna	Borey	beam trawl	1500

The mean size (SL, mm) of the specimens, caught by beam trawl, for the first half of 2025 is 58.20 mm $\pm$ 9.19 SD. In general, the size varies by ports and is dependent on the fishing method - in the beam trawl samples the variations are between 57 – 68 mm. (Table 39.1) Respectively, the mean weight (TW, g) from beam trawl is 36.88 g $\pm$ 17.71 SD, (Table 39.2), with a variation between 36-60g.

In the first half of 2025, the mean body weight (BW, g) from beam trawl samples is 13.82 g $\pm$ 7.31 SD (Table 39.3), forming 34.34% of the individuals' weight in the observed period, as the mean percentage by ports varies from 33.9 to 38.86%.

The mean size (SL, mm) of the specimens, caught by beam trawl, for the second half of 2025 is 65.37 mm $\pm$ 8.80 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 – 69 mm. Respectively, the mean weight (TW, g) from beam trawl is 52.36 g $\pm$ 22.00 SD, with a variation between 39-60g.

In the second half of 2025, the mean body weight (BW, g) from beam trawl samples is 18.25 g $\pm$ 8.71 SD (Table 39), forming 34.86% of the individuals' weight in the observed period, as the mean percentage by ports varies from 33.7 to 38.9%. For scuba diving catches, the mean shell length (SL, mm) is 71.09 mm $\pm$ 9.93 SD, while the mean body weight is 67.96 g $\pm$ 20.01 SD.

An analysis of the results for the entire year indicated that the mean shell length (SL, mm) of the observed specimens from the ports reaches 60.53 mm $\pm$ 9.68 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 – 69 mm. Accordingly, for beam trawl catches, the mean weight (TW, g) is 42.04 g $\pm$ 20.58 SD, with a variation between 36-60 g. In the first half of 2025, the mean body weight without shell (BW, g) for beam trawl catches is 13.82 g $\pm$ 7.31 SD (Table 39), forming 36.40 % from the total body weight during



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the observed period, as the mean percentage by ports varies from 33.7 – 38.9 %. For scuba diving catches, the mean body weight without shell (BW, g) reaches 40.33 % 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 2025

1. Size (SL, mm)

Port	Sample size	Mean SL, mm	Standard deviation	Minimum SL, mm	Maximum SL, mm
Rodopa 1	100	60.71	6.62	47	80
Kavarna	100	59.29	11.85	41	95
Rodopa 1	100	65.663	8.58	48	96
Balchik	100	68.05	10.55	50	104
Ada Bahcha	100	64.41	9.49	46	84
Kavarna	100	57.95	5.01	45	72
Rodopa 1	100	67.39	8.58	50	98
Kavarna	100	65.15	11.66	39	95
Byala	100	65.5	7.71	48	90
Bolata	100	67.57	7.56	39	83
Varna	100	65.48	6.21	53	84
Tsarevo	100	78.31	9.4	53	102
Varna	100	65.48	6.21	53	84

2. Total weight (TW, g)

Port	Sample size	Mean TW, g	Standard deviation	Minimum TW, g	Maximum TW, g
Rodopa 1	100	36.58	11.56	16.5	76.21
Kavarna	100	38.21	28.03	10.5	156.0
Rodopa 1	100	50.72	22.89	20.46	163.34
Balchik	100	59.53	30.78	20.41	197.94
Ada Bahcha	100	49.02	19.33	16.24	102.87
Kavarna	100	35.73	8.93	14.28	63.08
Rodopa 1	100	56.02	19.63	22.11	133.94
Kavarna	100	50.64	27.82	11.43	154.23
Byala	100	55.16	20.9	21.34	128.56
Bolata	100	55.82	18.94	9.88	112.64
Varna	100	51.26	15.49	21.58	90.47
Tsarevo	100	92.04	30.32	28.72	183.41
Varna	100	51.26	15.49	21.58	90.47



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3. Body weight (BW, g)

Port	Sample size	Mean BW, g	Standard deviation	Minimum BW, g	Maximum BW, g
Rodopa 1	50	12.28	3.27	6.79	19.74
Kavarna	50	13.52	11.79	5.3	66.98
Rodopa 1	50	19.18	7.29	8.41	36.85
Balchik	50	24.31	14.55	7.82	80.4
Ada Bahcha	50	17.46	7.69	4.08	37.71
Kavarna	50	13.74	4.08	2.9	24.91
Rodopa 1	50	23.8	8.5	12.28	49.8
Kavarna	50	17.15	9.97	5.6	52.55
Byala	50	18.43	9.44	6.22	47.19
Bolata	50	23.15	8.5	1.57	40.22
Varna	50	19.19	6.33	8.23	32.27
Tsarevo	50	35.12	15.12	9.97	73.03
Varna	100	19.19	6.33	8.23	32.27

The weight and size classes distributions from beam trawl fishing and by ports are presented on Figure 26. According to the size structure, most individuals fall into the size class - 50 - 60 SL mm, while in terms of weight composition (TW, g), the predominant weight class is < 60 g (90% of the total number of measured specimens).



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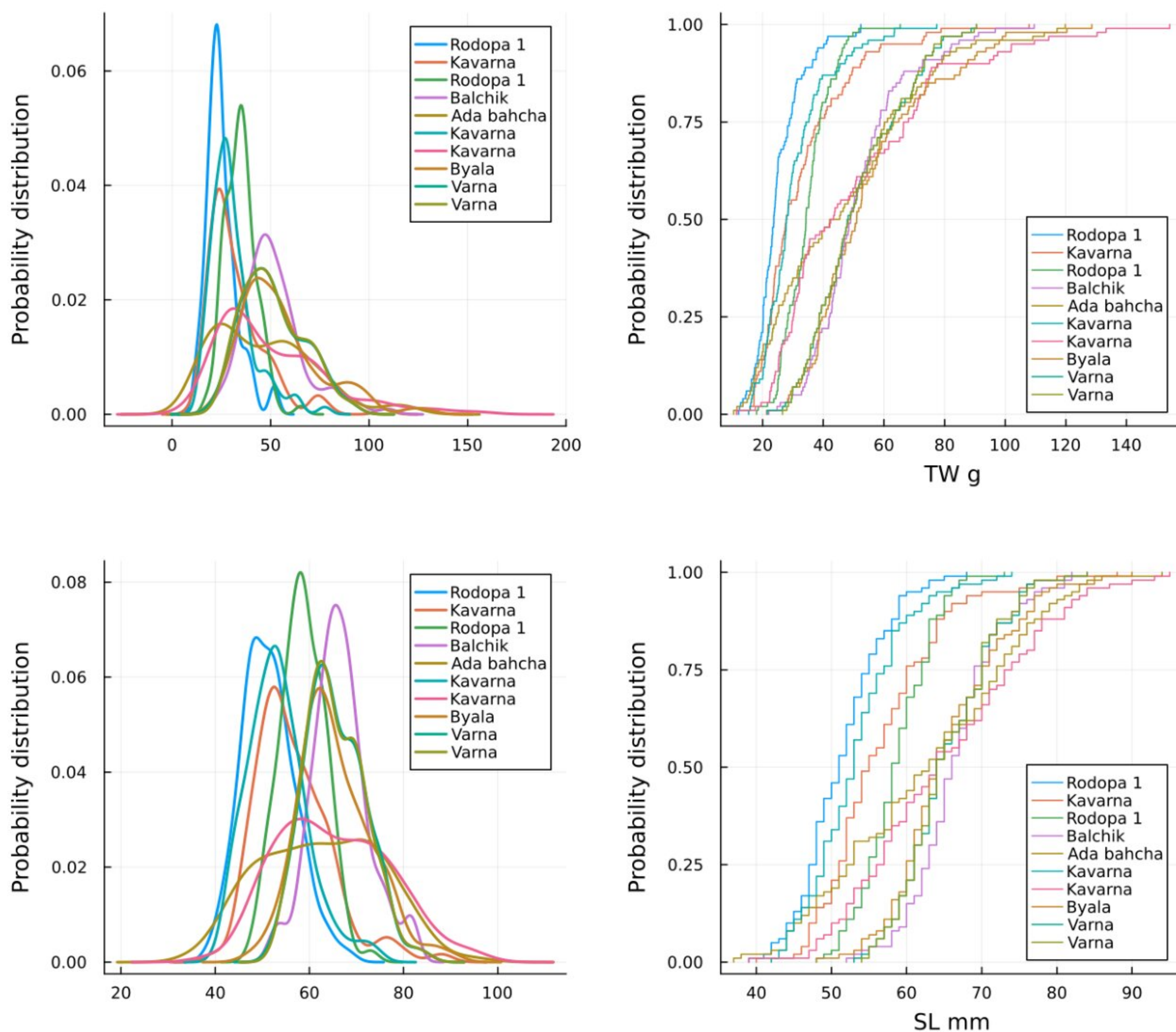


Figure 28 Distribution of the shell length (SL, mm, 1) and total weight (TW, g, 2) by classes and cumulative distribution by classes for the samples from beam trawl for 2025

Detailed data about the percentage distribution of the size and weight classes for the observed individuals in 2025 is presented on Figure 27 and Figure 28.



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In the beam trawl samples, the most common size class is 50–60 mm SL (34%), followed by 60–70 mm (32%). Individuals in the 40–50 mm range make up 13%, while those larger than 70 mm represent about 20% of all measured specimens (Figure 27). In the scuba diving samples, the 60–70 mm size class is the most frequent, followed by the 70–80 mm class, each accounting for roughly 33% of the individuals collected through this method.

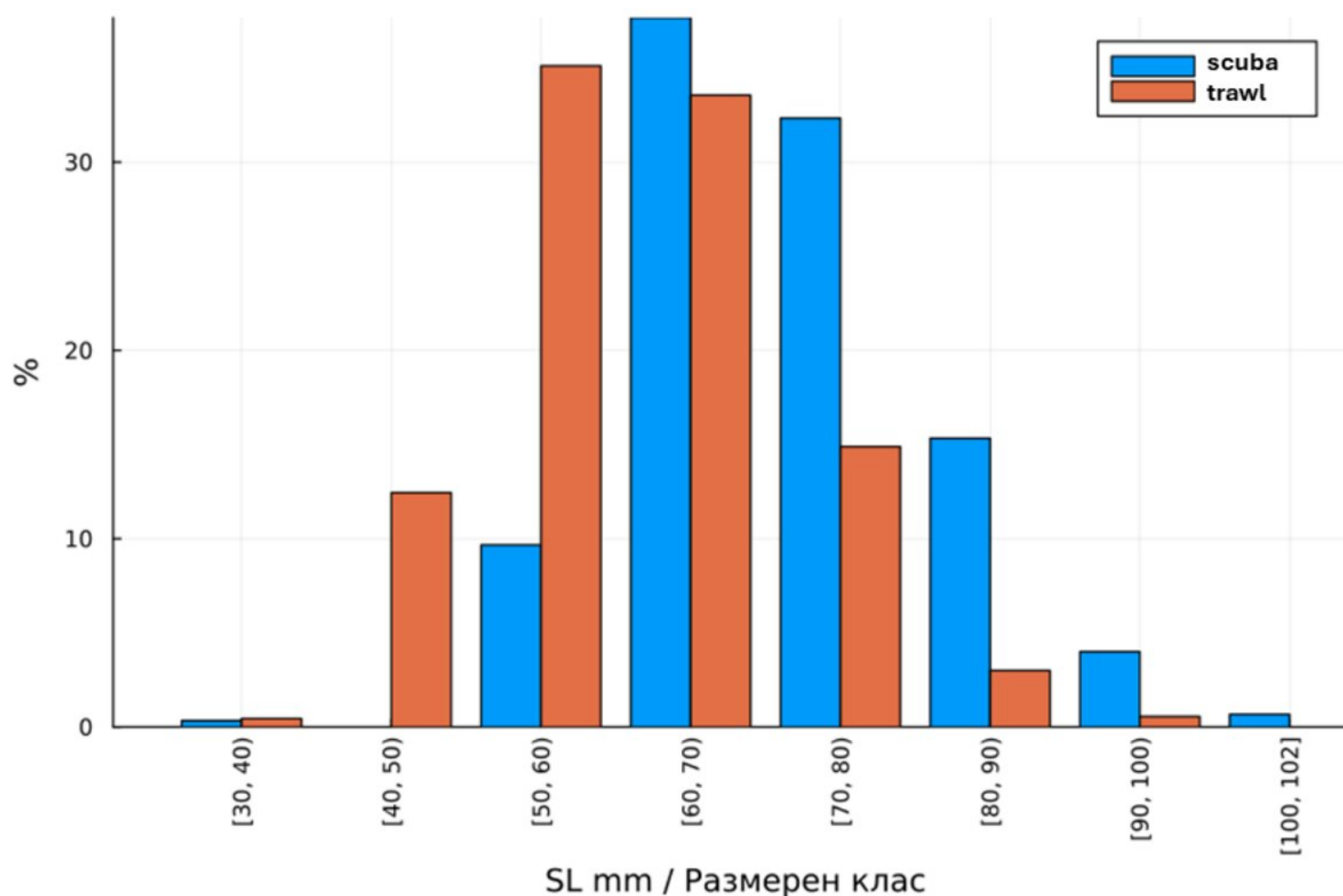


Figure 29 Distribution in % by size class (SL, mm), based on the summarized data from both fishing methods for 2025

Respectively, the dominant weight class for the beam trawl samples is < 50 g TW (70 % from the measured individuals). The largest relative share are the groups 20-30 g (27 %) and 30-40 g (23 %). The specimen over 70 g are less than 10% from all the individuals. (Figure 28) As for the scuba diving method, the big specimen with weight more than 90 g, are 20 %.



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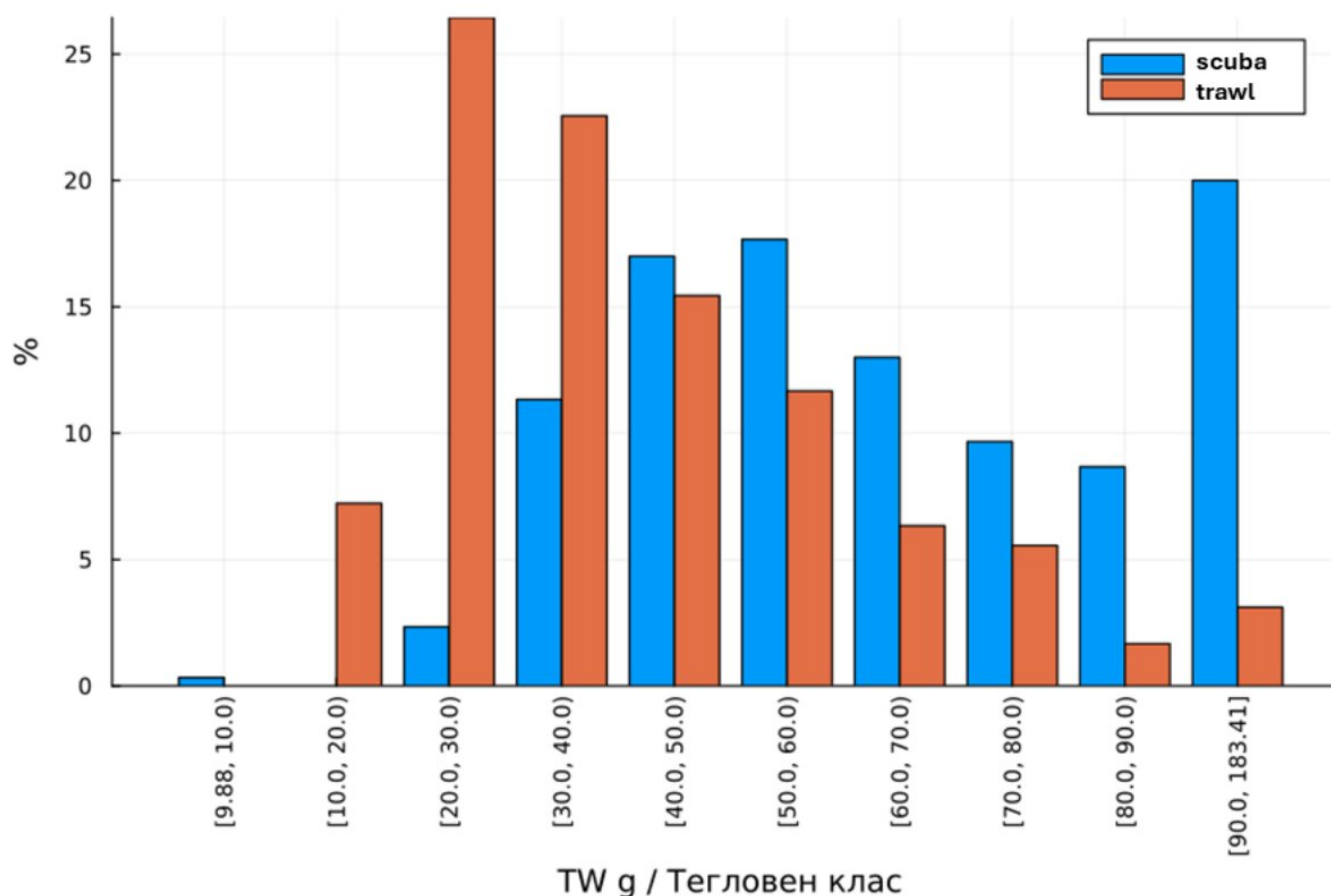


Figure 30 Distribution in % by weight class (TW, g) based on the summarized data from both fishing methods for 2025

The comparison analysis of the parameters a and b of the L-W ratio: $TW(g) = a \cdot SL(mm)^b$ shows there is mostly allometric growth of *R. venosa* in all samples with a coefficient $b \neq 3$ (Figure 29).

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 $b=2.24$ was registered in the sample from Balchik, 02.05.2025



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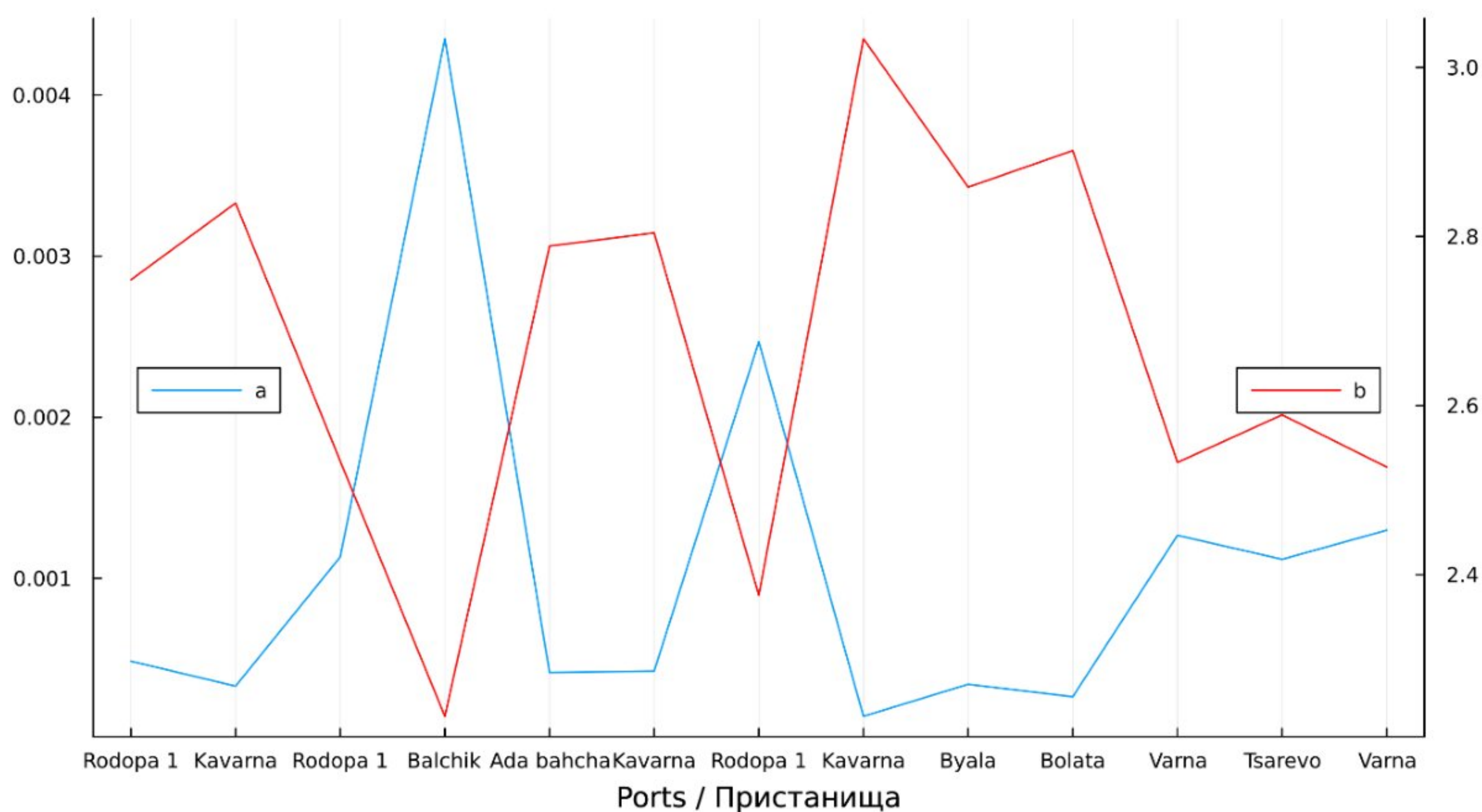


Figure 31 Parameters a , b of the L-W ratios for the equation $TW(g) = a.SL(mm)^b$ for all landing ports of 2025

The mean ratios of the width/length of the shells (Wd/SL,%) of *R. venosa*, the aperture length to the shell length (AL/SL,%) and aperture length/total shell width (AL/Wd,%) by ports for the entire year of 2025 are presented on Figure 32.



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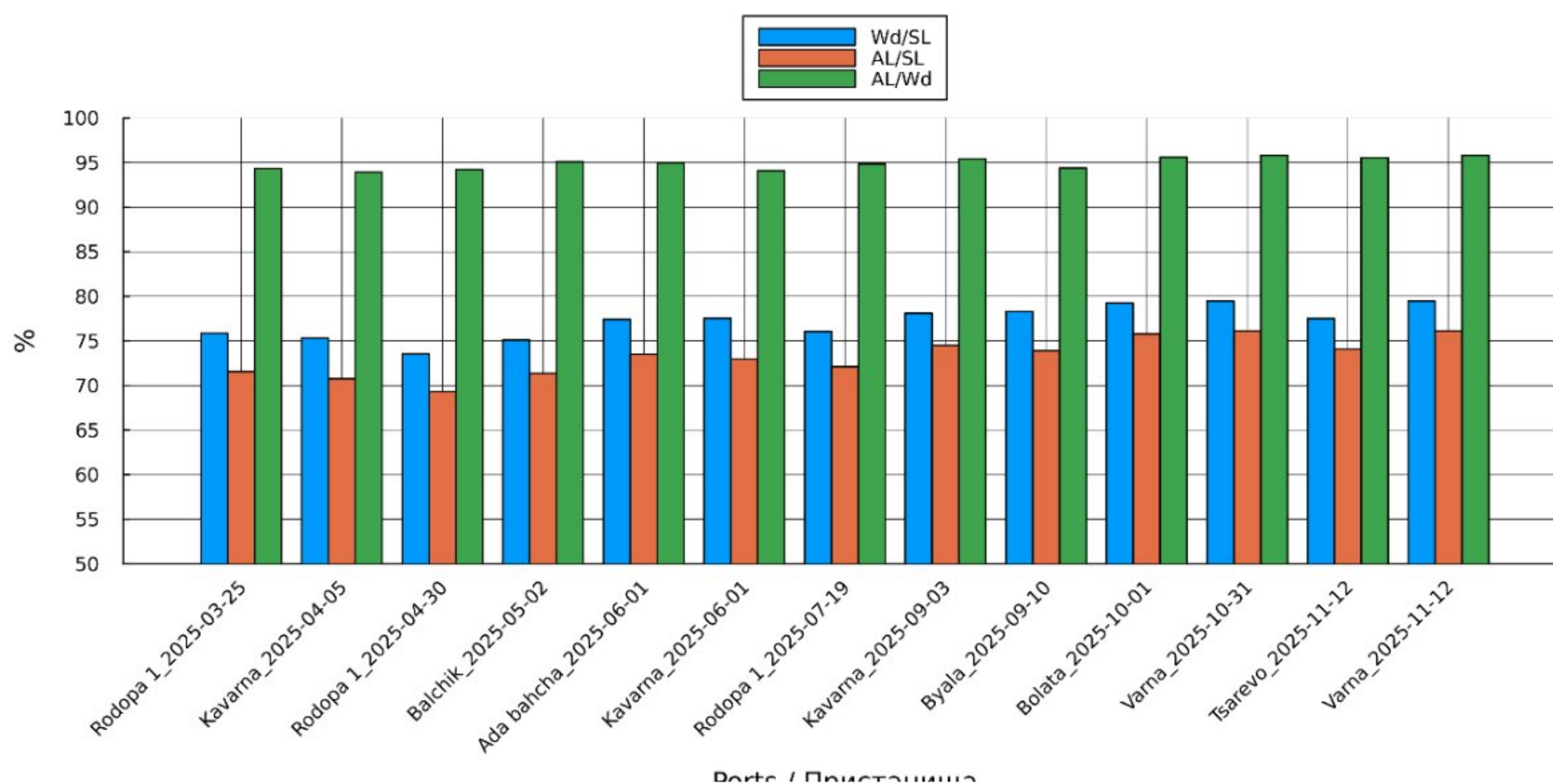


Figure 32 The mean ratios of the width/length of the shells (Wd/SL,%) of *R. venosa*, aperture length/shell length (AL/SL,%) and aperture length/total shell width (AL/Wd,%) by ports for 2025

The mean ratio Wd/SL reaches 75% in the first half of 2025, with very little variations between the different samples. Respectively, the ratio AL/SL is 71%, on average, varying between 59% and 81%. The mean value of the ratio AL/Wd (%) for the first half of 2025 is 94%. The results in the second half of 2025 are similar, and it can be noted that the Wd/SL ratio reaches 76.4 % while the other two ratios have less than 1% difference.



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3.2. SEX STRUCTURE

3.2.1. Port Rodopa 1, 25.03.2025

The sex ratio in the sample is 78% ♂ : 22% ♀ or 1 : 0.28.

The mean size of the females' shell length in the sample is 50.36 mm $\pm$ 3.53 SD, while for the males the mean size is slightly bigger – 53.77 mm $\pm$ 4.77 SD. In regard to the parameter total weight (TW, g), the mean weight of the male individuals 27.96 g $\pm$ 8.11 SD, while for the females it is 22.76 g $\pm$ 3.58 SD. (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 Rodopa 1, 25.03.2025

	TW g		SL mm	
Sex	M	F	M	F
Number	39	11	39	11
Mean	27.96	22.76	53.77	50.36
Standard deviation	8.11	3.58	4.77	3.53
Minimum	16.28	16.29	44	44
50% (median)	26.88	22.76	54	51
Maximum	52.36	30.59	65	55
Sum	1090.62	250.38	2097	554
Mode	29.9	23.68	59	53
Skewness	65.81	12.83	22.76	12.45
Sample variance	1.53	0.76	-0.54	-1.13
Kurtosis	1.2	0.43	0.11	-0.32
Range	36.08	14.3	21	11
Confidence level 95%	(25.42, 30.51)	(20.64, 24.88)	(52.27, 55.27)	(48.28, 52.45)

Looking at the parameters shell width (Wd, mm) and aperture length (aperture length, AL, mm), the percentage differences are insignificantly small, around 5-6% 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 Rodopa 1, 25.03.2025

	Wd mm		Al mm	
Sex	M	F	M	F
Number	39	11	39	11
Mean	40.64	38.64	38.31	35.82
Standard deviation	3.62	2.46	3.73	2.36
Minimum	35	34	32	31
50% (median)	40	38	38	36
Maximum	50	42	47	39
Sum	1585	425	1494	394
Mode	37	38	40	37
Skewness	13.13	6.05	13.9	5.56
Sample variance	-0.12	-0.65	-0.31	-0.25
Kurtosis	0.57	-0.28	0.39	-0.44
Range	15	8	15	8
Confidence level 95%	(39.5, 41.78)	(37.18, 40.09)	(37.14, 39.48)	(34.42, 37.21)



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3.2.2. Port Kavarna, 05.04.2025

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 50.57 mm $\pm$ 6.15 SD, while for the males the mean size is 58.81 mm $\pm$ 8.98 SD. In regard to the parameter total weight (TW, g), the mean weight of the male individuals is 36.73 g $\pm$ 19.03 SD, while for the females it is 23.63 g $\pm$ 10.25 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 Kavarna, 05.04.2025

	TW g		SL mm	
Sex	M	F	M	F
Number	36	14	36	14
Mean	36.73	23.63	58.81	50.57
Standard deviation	19.03	10.25	8.98	6.15
Minimum	17.25	11.55	46	40
50% (median)	31.96	19.27	57.5	48
Maximum	107.86	48.79	88	63
Sum	1322.25	330.82	2117	708
Mode	107.86	17.13	59	47
Skewness	362.03	104.97	80.68	37.8
Sample variance	4.05	0.61	2.03	-0.27
Kurtosis	1.89	1.2	1.31	0.58
Range	90.61	37.24	42	23
Confidence level 95%	(30.51, 42.94)	(18.26, 29.0)	(55.87, 61.74)	(47.35, 53.79)

For the parameters shell width (Wd, mm) and aperture length (aperture length, AL, mm), the percentage differences between the male and female individuals varies around 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 Kavarna, 05.04.2025

	Wd mm		Al mm	
Sex	M	F	M	F
Number	36	14	36	14
Mean	43.67	38.29	41.08	35.5
Standard deviation	6.82	5.17	6.58	5.08
Minimum	33	30	31	28
50% (median)	43	37	40.5	34
Maximum	65	49	62	47
Sum	1572	536	1479	497
Mode	43	35	37	34
Skewness	46.57	26.68	43.28	25.81
Sample variance	1.61	-0.3	1.84	0.12
Kurtosis	1.19	0.56	1.24	0.86
Range	32	19	31	19
Confidence level 95%	(41.44, 45.9)	(35.58, 40.99)	(38.93, 43.23)	(32.84, 38.16)



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3.2.3. Port Rodopa 1, 30.04.2025

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 57.43 mm $\pm$ 3.8 SD, while for the males the mean size is 60.48 mm $\pm$ 4.69 SD. In regard to the parameter total weight (TW, g), the mean weight of the male individuals is 36.72 g $\pm$ 8.64 SD, while for the females it is 32.83 g $\pm$ 6.28 SD (Table 47).

Table 47

Summarized statistics of the biological parameters - shell length (SL, mm) and total weight (TW, g) by sex in the sample from port Rodopa 1, 30.04.2025

	TW g		SL mm	
Sex	M	F	M	F
Number	27	23	27	23
Mean	36.72	32.83	60.48	57.43
Standard deviation	8.64	6.28	4.69	3.8
Minimum	18.54	23.67	49	51
50% (median)	36.92	32.79	62	58
Maximum	51.71	45.43	68	66
Sum	991.42	754.98	1633	1321
Mode	30.47	32.72	63	59
Skewness	74.64	39.44	22.03	14.44
Sample variance	-0.8	-0.38	-0.27	-0.33
Kurtosis	-0.11	0.53	-0.56	0.24
Range	33.17	21.76	19	15
Confidence level 95%	(33.46, 39.98)	(30.26, 35.39)	(58.71, 62.25)	(55.88, 58.99)

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 4% and 6% 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 Rodopa 1, 30.04.2025

	Wd mm		Al mm	
Sex	M	F	M	F
Number	27	23	27	23
Mean	44.74	42.3	41.89	39.74
Standard deviation	4.47	3.59	4.13	3.39
Minimum	34	36	32	34
50% (median)	45	43	43	40
Maximum	52	48	48	46
Sum	1208	973	1131	914
Mode	48	43	45	43
Skewness	19.97	12.86	17.03	11.47
Sample variance	-0.36	-1.07	-0.32	-1.05
Kurtosis	-0.53	-0.25	-0.65	-0.17
Range	18	12	16	12
Confidence level 95%	(43.06, 46.43)	(40.84, 43.77)	(40.33, 43.45)	(38.35, 41.12)



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3.2.4. PORT BALCHIK, 02.05.2025

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 65.15 mm $\pm$ 4.1 SD, while for the males the mean size is 68.3 mm $\pm$ 5.49 SD. In regard to the parameter total weight (TW, g), the mean weight of the male individuals is 53.1 g $\pm$ 16.27 SD, while for the females it is 58.1 g $\pm$ 17.92 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 Balchik, 02.05.2025

	TW g		SL mm	
Sex	M	F	M	F
Number	37	13	37	13
Mean	53.1	58.1	68.3	65.15
Standard deviation	16.27	17.92	5.49	4.1
Minimum	22.03	34.39	58	60
50% (median)	51.94	55.37	67	65
Maximum	109.55	91.17	82	71
Sum	1964.79	755.32	2527	847
Mode	42.87	51.9	69	60
Skewness	264.59	321	30.1	16.81
Sample variance	2.8	-0.75	0.25	-1.16
Kurtosis	1.29	0.63	0.75	0.19
Range	87.52	56.78	24	11
Confidence level 95%	(47.86, 58.34)	(48.36, 67.84)	(66.53, 70.07)	(62.93, 67.38)

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 6% in favor of the male individuals (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 Balchik, 02.05.2025

	Wd mm		Al mm	
Sex	M	F	M	F
Number	37	13	37	13
Mean	51.92	48.85	49.38	46.15
Standard deviation	4.52	3.56	4.47	3.44
Minimum	44	43	41	40
50% (median)	51	49	49	46
Maximum	62	54	60	52
Sum	1921	635	1827	600
Mode	51	53	49	49
Skewness	20.41	12.64	20.02	11.81
Sample variance	-0.56	-1.13	-0.32	-0.89
Kurtosis	0.5	-0.16	0.47	0.02
Range	18	11	19	12
Confidence level 95%	(50.46, 53.37)	(46.91, 50.78)	(47.94, 50.82)	(44.29, 48.02)



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3.2.5. PORT ADA BAHCHA, 01.06.2025

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

The mean size of the females' shell length in the sample is 61.22 mm $\pm$ 10.93 SD, while for the males the mean size is with 10% bigger - 69.93 mm $\pm$ 9.93 SD. In regard to the parameter total weight (TW, g), the mean weight of the male individuals is 60.55 g $\pm$ 23.95 SD, while for the females it is 42.95 g $\pm$ 18.93 SD (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 Ada Bahcha, 01.06.2025

	TW g		SL mm	
Sex	M	F	M	F
Number	41	9	41	9
Mean	60.55	42.95	69.93	61.22
Standard deviation	23.95	18.93	9.93	10.93
Minimum	18.8	15.4	46	44
50% (median)	57.43	48.23	71	61
Maximum	119.82	62.91	94	78
Sum	2482.6	386.56	2867	551
Mode	119.82	40.44	65	61
Skewness	573.72	358.32	98.52	119.44
Sample variance	0.08	-1.38	0.02	-0.75
Kurtosis	0.58	-0.41	-0.22	-0.16
Range	101.02	47.51	48	34
Confidence level 95%	(53.22, 67.88)	(30.58, 55.32)	(66.89, 72.97)	(54.08, 68.36)

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 12% in favor of the male individuals. (Table 49)



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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 Ada Bahcha, 01.06.2025

	Wd mm		Al mm	
Sex	M	F	M	F
Number	41	9	41	9
Mean	54.85	47.67	52.1	45.44
Standard deviation	8.28	8.83	8.05	8.62
Minimum	36	34	33	32
50% (median)	55	48	52	45
Maximum	73	59	69	57
Sum	2249	429	2136	409
Mode	52	48	59	45
Skewness	68.63	78	64.74	74.28
Sample variance	-0.31	-1.01	-0.3	-1.03
Kurtosis	-0.02	-0.41	-0.16	-0.28
Range	37	25	36	25
Confidence level 95%	(52.32, 57.39)	(41.9, 53.44)	(49.63, 54.56)	(39.81, 51.08)



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3.2.6. PORT KAVARNA, 01.06.2025

The sex ratio in the sample is 84% ♂ : 16% ♀ or 1 : 0.19.

The mean size of the females' shell length in the sample is 53.62 mm $\pm$ 2.83 SD, while for the males the mean size is 57.12 mm $\pm$ 5.39 SD. In regard to the parameter total weight (TW, g), the mean weight of the male individuals is 35.78 g $\pm$ 10.86 SD, while for the females it is 30.53 g $\pm$ 5.55 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 from port Kavarna, 01.06.2025

	TW g		SL mm	
Sex	M	F	M	F
Number	42	8	42	8
Mean	35.78	30.53	57.12	53.62
Standard deviation	10.86	5.55	5.39	2.83
Minimum	22.68	21.65	49	49
50% (median)	33.05	29.7	56	53.5
Maximum	63.45	39.71	72	58
Sum	1502.69	244.24	2399	429
Mode	35.26	27.71	53	53
Skewness	117.96	30.83	29.03	7.98
Sample variance	0.43	-0.49	0.34	-0.68
Kurtosis	1.14	0.2	0.9	-0.12
Range	40.77	18.06	23	9
Confidence level 95%	(32.49, 39.06)	(26.68, 34.38)	(55.49, 58.75)	(51.67, 55.58)

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 5% 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 Kavarna, 01.06.2025

	Wd mm		Al mm	
Sex	M	F	M	F
Number	42	8	42	8
Mean	44	42.25	41.4	39.62
Standard deviation	4.4	2.71	4.2	2.67
Minimum	39	37	36	34
50% (median)	43	42	41	40
Maximum	56	46	53	43
Sum	1848	338	1739	317
Mode	43	42	38	40
Skewness	19.37	7.36	17.61	7.12
Sample variance	0.19	0.07	0.33	0.74
Kurtosis	0.95	-0.56	0.99	-1.02
Range	17	9	17	9
Confidence level 95%	(42.67, 45.33)	(40.37, 44.13)	(40.14, 42.67)	(37.78, 41.47)



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3.2.7. PORT RODOPA 1, 19.07.2025 (SCUBA DIVING)

The sex ratio in the sample is 18% ♂ : 84% ♀ or 1 : 4.56.

The mean size of the females' shell length in the sample is 68.89 mm $\pm$ 5.51 SD, while for the males the mean size is 73.56 mm, which is in favour of the males. In regard to the parameter total weight (TW, g), the mean weight of the male individuals is 69.29 g $\pm$ 21.77 SD, while for the females it is 54.97 g $\pm$ 8.21 SD (Table 52).

Table 55

Summarized statistics of the biological parameters - shell length (SL, mm) and total weight (TW, g) by sex in the sample from port Rodopa 1, 19.07.2025

	TW g		SL mm	
Sex	M	F	M	F
Number	41	9	41	9
Mean	69.29	54.97	73.56	68.89
Standard deviation	21.77	8.21	7.86	5.51
Minimum	133.94	64.68	98.00	76.00
50% (median)	66.01	54.38	73.00	69.00
Maximum	36.09	40.85	59.00	60.00
Sum	2840.95	494.77	3016.00	620.00
Mode	36.09	64.68	74.00	72.00
Skewness	1.19	-0.39	0.76	-0.32
Sample variance	473.92	67.38	61.70	30.36
Kurtosis	1.41	-0.89	1.10	-1.06
Range	97.85	23.83	39.00	16.00
Confidence level 95%	(62.63, 75.96)	(49.61, 60.34)	(71.16, 75.97)	(65.29, 72.49)

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 5% in favor of the male individuals (Table 53).



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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 Rodopa 1, 19.07.2025

	Wd mm		Al mm	
Sex	M	F	M	F
Number	41	9	41	9
Mean	56.22	50.89	53.34	48.44
Standard deviation	5.93	3.41	5.73	3.09
Minimum	73.00	54.00	70.00	51.00
50% (median)	55.00	51.00	53.00	49.00
Maximum	46.00	45.00	45.00	43.00
Sum	2305.00	458.00	2187.00	436.00
Mode	55.00	54.00	52.00	51.00
Skewness	0.78	-0.74	0.86	-0.82
Sample variance	35.18	11.61	32.83	9.53
Kurtosis	0.87	-0.84	0.79	-0.77
Range	27.00	9.00	25.00	8.00
Confidence level 95%	(54.4, 58.03)	(48.66, 53.12)	(51.59, 55.1)	(46.43, 50.46)



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3.2.8. PORT KAVARNA, 03.09.2025

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

The mean size of the females' shell length in the sample is 61.03 mm $\pm$ 9.52 SD, while for the males the mean size is 69.0 mm, which is in favour of the males. In regard to the parameter total weight (TW, g), the mean weight of the male individuals is 59.7 g $\pm$ 26.63 SD, while for the females it is 40.53 g $\pm$ 17.35 SD (Table 54).

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, 03.09.2025

	TW g		SL mm	
Sex	M	F	M	F
Number	20	30	20	30
Mean	59.70	40.53	69.00	61.03
Standard deviation	26.63	17.35	10.06	9.52
Minimum	133.27	73.88	90.00	81.00
50% (median)	57.89	32.79	70.00	57.00
Maximum	22.43	19.48	52.00	48.00
Sum	1194.04	1215.95	1380.00	1831.00
Mode	22.43	19.48	77.00	57.00
Skewness	0.96	0.71	0.13	0.39
Sample variance	708.90	301.17	101.16	90.72
Kurtosis	1.13	-0.93	-0.66	-1.17
Range	110.84	54.40	38.00	33.00
Confidence level 95%	(48.03, 71.37)	(34.32, 46.74)	(64.59, 73.41)	(57.62, 64.44)

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 9% in favor of the male individuals (Table 55).



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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, 03.09.2025

	Wd mm		Al mm	
Sex	M	F	M	F
Number	20	30	20	30
Mean	54.55	48.33	52.40	46.10
Standard deviation	8.61	7.67	8.57	7.34
Minimum	74.00	65.00	72.00	62.00
50% (median)	55.50	46.00	53.00	44.50
Maximum	39.00	38.00	37.00	35.00
Sum	1091.00	1450.00	1048.00	1383.00
Mode	60.00	43.00	53.00	41.00
Skewness	0.17	0.56	0.21	0.48
Sample variance	74.05	58.78	73.52	53.89
Kurtosis	-0.21	-0.85	-0.16	-0.81
Range	35.00	27.00	35.00	27.00
Confidence level 95%	(50.78, 58.32)	(45.59, 51.08)	(48.64, 56.16)	(43.47, 48.73)



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3.2.9. PORT BYALA, 10.09.2025

The sex ratio in the sample is 32 % ♂ : 68 % ♀ or 1 : 2.12.

The mean size of the females' shell length in the sample is 62.44 mm $\pm$ 5.93 SD, while for the males, the mean size is 65.38 mm which is in favour of the males. In regard to the parameter total weight (TW, g), the mean weight of the male individuals is 54.83 g $\pm$ 22.4 SD, while for the females it is 48.18 g $\pm$ 14.14 SD (Table 56).

Table 59

Summarized statistics of the biological parameters - shell length (SL, mm) and total weight (TW, g) by sex in the sample from port Byala, 10.09.2025

Sex	TW g		SL mm	
	M	F	M	F
Number	34	16	34	16
Mean	54.83	48.18	65.38	62.44
Standard deviation	22.40	14.14	8.38	5.93
Minimum	120.34	85.33	86.00	76.00
50% (median)	46.47	50.03	63.00	62.50
Maximum	26.53	27.46	53.00	51.00
Sum	1864.20	770.93	2223.00	999.00
Mode	26.53	27.46	60.00	60.00
Skewness	1.03	0.89	0.77	0.29
Sample variance	501.64	200.08	70.24	35.20
Kurtosis	0.61	0.99	0.01	0.40
Range	93.81	57.87	33.00	25.00
Confidence level 95%	(47.3, 62.36)	(41.25, 55.11)	(62.57, 68.2)	(59.53, 65.34)

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 5% in favor of the male individuals (Table 57).



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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 Byala, 10.09.2025

	Wd mm		Al mm	
Sex	M	F	M	F
Number	34	16	34	16
Mean	50.97	48.81	48.00	45.63
Standard deviation	6.56	4.48	6.55	4.53
Minimum	68.00	59.00	65.00	56.00
50% (median)	49.00	49.00	46.00	46.00
Maximum	40.00	39.00	38.00	36.00
Sum	1733.00	781.00	1632.00	730.00
Mode	47.00	49.00	44.00	48.00
Skewness	0.77	-0.07	0.94	0.04
Sample variance	43.00	20.03	42.85	20.52
Kurtosis	0.36	0.86	0.54	0.70
Range	28.00	20.00	27.00	20.00
Confidence level 95%	(48.77, 53.17)	(46.62, 51.01)	(45.8, 50.2)	(43.41, 47.84)



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3.2.10. PORT BOLATA, 01.10.2025 (SCUBA DIVING)

The sex ratio in the sample is 40 % ♂ : 60 % ♀ or 1 : 1.67.

The mean size of the females' shell length in the sample is 68.56 mm $\pm$ 9.62 SD, while for the males the mean size is 68.17 mm, which is in favour of the males. In regard to the parameter total weight (TW, g), the mean weight of the male individuals is 56.82 g $\pm$ 18.17 SD, while for the females it is 59.68 g $\pm$ 19.57 SD (Table 58).

Table 61

Summarized statistics of the biological parameters - shell length (SL, mm) and total weight. (TW, g) by sex in the sample from port Bolata, 01.10.2025

	TW g		SL mm	
Sex	M	F	M	F
Number	30	20	30	20
Mean	56.82	59.68	68.17	68.56
Standard deviation	18.17	19.57	6.31	9.62
Minimum	103.69	97.50	81.00	83.00
50% (median)	53.35	61.56	69.00	69.00
Maximum	21.16	9.88	51.00	39.00
Sum	1704.69	1074.18	2045.00	1234.00
Mode	71.11	63.75	69.00	74.00
Skewness	0.69	-0.55	-0.32	-1.43
Sample variance	330.24	383.15	39.80	92.61
Kurtosis	0.34	0.86	0.44	3.11
Range	82.53	87.62	30.00	44.00
Confidence level 95%	(50.32, 63.33)	(50.63, 68.72)	(65.91, 70.42)	(64.11, 73.0)

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 5% in favor of the male individuals (Table 59).



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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 Bolata, 01.10.2025

	Wd mm		Al mm	
Sex	M	F	M	F
Number	30	18	30	18
Mean	54.13	53.72	51.40	51.50
Standard deviation	5.98	8.09	5.97	7.89
Minimum	65.00	65.00	63.00	63.00
50% (median)	53.50	54.50	51.50	52.50
Maximum	38.00	29.00	36.00	28.00
Sum	1624.00	967.00	1542.00	927.00
Mode	51.00	54.00	54.00	52.00
Skewness	-0.19	-1.48	-0.13	-1.32
Sample variance	35.71	65.51	35.63	62.26
Kurtosis	0.39	2.96	0.23	2.52
Range	27.00	36.00	27.00	35.00
Confidence level 95%	(52.0, 56.27)	(49.98, 57.46)	(49.26, 53.54)	(47.85, 55.15)



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3.2.11. PORT VARNA, 31.10.2025

The sex ratio in the sample is 40 % ♂ : 60 % ♀ or 1 : 1.5.

The mean size of the females' shell length in the sample is 64.95 mm $\pm$ 6.64 SD, while for the males the mean size is 65.53 mm, which is in favour of the males. In regard to the parameter total weight (TW, g), the mean weight of the male individuals is 51.11 g $\pm$ 13.06 SD, while for the females it is 49.43 g $\pm$ 19.11 SD (Table 60).

Table 63

Summarized statistics of the biological parameters - shell length (SL, mm) and total weight (TW, g) by sex in the sample from port Varna, 31.10.2025

	TW g		SL mm	
Sex	M	F	M	F
Number	30	20	30	20
Mean	51.11	49.43	65.53	64.95
Standard deviation	13.06	19.11	6.50	6.64
Minimum	78.91	85.79	81.00	76.00
50% (median)	47.89	42.54	63.50	64.00
Maximum	26.54	21.58	54.00	53.00
Sum	1533.38	988.51	1966.00	1299.00
Mode	34.22	21.58	63.00	64.00
Skewness	0.56	0.51	0.55	0.09
Sample variance	170.51	365.00	42.19	44.05
Kurtosis	-0.34	-1.05	-0.27	-1.05
Range	52.37	64.21	27.00	23.00
Confidence level 95%	(46.44, 55.79)	(41.05, 57.8)	(63.21, 67.86)	(62.04, 67.86)

Looking at the parameters shell width (Wd, mm) and aperture length (aperture length, AL, mm), the percentage differences between males and females are insignificantly small (<1%)(Table 61).



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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, 31.10.2025

	Wd mm		Al mm	
Sex	M	F	M	F
Number	30	20	30	20
Mean	51.50	51.50	49.30	48.95
Standard deviation	4.83	6.61	4.81	6.56
Minimum	62.00	65.00	60.00	62.00
50% (median)	51.00	49.00	49.00	46.50
Maximum	44.00	41.00	42.00	39.00
Sum	1545.00	1030.00	1479.00	979.00
Mode	51.00	49.00	49.00	44.00
Skewness	0.44	0.56	0.45	0.55
Sample variance	23.29	43.63	23.11	43.00
Kurtosis	-0.73	-0.77	-0.58	-0.85
Range	18.00	24.00	18.00	23.00
Confidence level 95%	(49.77, 53.23)	(48.61, 54.39)	(47.58, 51.02)	(46.08, 51.82)



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3.2.12. PORT TSAREVO, 12.11.2025 (SCUBA DIVING)

The sex ratio in the sample is 56 % ♂ : 44 % ♀ or 1 : 0.79.

The mean size of the females' shell length in the sample is 73.36 mm $\pm$ 9.23 SD, while for the males the mean size is 80.36 mm, which is in favour of the males. In regard to the parameter total weight (TW, g), the mean weight of the male individuals is 95.26 g $\pm$ 30.36 SD, while for the females it is 78.88 g $\pm$ 28.57 SD (Table 62).

Table 65

Summarized statistics of the biological parameters - shell length (SL, mm) and total weight (TW, g) by sex in the sample from port Tsarevo, 12.11.2025

	TW g		SL mm	
Sex	M	F	M	F
Number	22	28	22	28
Mean	95.26	78.88	80.36	73.36
Standard deviation	30.36	28.57	9.01	9.23
Minimum	159.91	156.64	102.00	91.00
50% (median)	88.48	79.27	79.00	73.00
Maximum	46.08	30.21	68.00	53.00
Sum	2095.67	2208.57	1768.00	2054.00
Mode	46.08	33.71	79.00	67.00
Skewness	0.65	0.48	0.87	-0.29
Sample variance	921.92	816.35	81.10	85.20
Kurtosis	-0.15	0.30	0.30	-0.39
Range	113.83	126.43	34.00	38.00
Confidence level 95%	(82.57, 107.95)	(68.29, 89.46)	(76.6, 84.13)	(69.94, 76.78)

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 9% in favor of the male individuals (Table 63).



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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 Tsarevo, 12.11.2025

	Wd mm		Al mm	
Sex	M	F	M	F
Number	22	28	22	28
Mean	62.86	56.86	59.95	54.14
Standard deviation	6.85	7.48	6.66	7.30
Minimum	77.00	70.00	73.00	67.00
50% (median)	62.00	58.00	59.50	55.50
Maximum	53.00	42.00	51.00	40.00
Sum	1383.00	1592.00	1319.00	1516.00
Mode	56.00	52.00	61.00	49.00
Skewness	0.51	-0.30	0.49	-0.20
Sample variance	46.89	55.90	44.33	53.31
Kurtosis	-0.80	-0.63	-0.82	-0.69
Range	24.00	28.00	22.00	27.00
Confidence level 95%	(60.0, 65.72)	(54.09, 59.63)	(57.17, 62.74)	(51.44, 56.85)



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3.2.13. PORT VARNA, 31.10.2025

The sex ratio in the sample is 36 % ♂ : 64 % ♀ or 1 : 1.78.

The mean size of the females' shell length in the sample is 65.67 mm $\pm$ 6.34 SD, while for the males the mean size is 64.94 mm, which is in favour of the males. In regard to the parameter total weight (TW, g), the mean weight of the male individuals is 49.83 g $\pm$ 13.46 SD, while for the females it is 51.69 g $\pm$ 18.63 SD (Table 60).

Table 67

Summarized statistics of the biological parameters - shell length (SL, mm) and total weight (TW, g) by sex in the sample from port Varna, 12.11.2025

Sex	TW g		SL mm	
	M	F	M	F
Number	32	18	32	18
Mean	49.83	51.69	64.94	65.67
Standard deviation	13.46	18.63	6.46	6.34
Minimum	78.91	85.79	81.00	76.00
50% (median)	47.45	46.62	63.00	64.00
Maximum	26.54	29.49	54.00	57.00
Sum	1594.67	930.50	2078.00	1182.00
Mode	50.70	33.61	63.00	70.00
Skewness	0.53	0.47	0.59	0.17
Sample variance	181.28	346.96	41.74	40.24
Kurtosis	-0.32	-1.23	-0.11	-1.32
Range	52.37	56.30	27.00	19.00
Confidence level 95%	(45.17, 54.5)	(43.09, 60.3)	(62.7, 67.18)	(62.74, 68.6)

Looking at the parameters shell width (Wd, mm) and aperture length (aperture length, AL, mm), the percentage differences between males and females are insignificantly small (<1%) (Table 61).



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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 Varna, 12.11.2025

	Wd mm		Al mm	
Sex	M	F	M	F
Number	32	18	32	18
Mean	51.03	52.44	48.69	49.72
Standard deviation	5.06	6.27	5.05	6.37
Minimum	62.00	65.00	60.00	62.00
50% (median)	51.00	49.50	48.50	47.00
Maximum	43.00	44.00	41.00	41.00
Sum	1633.00	944.00	1558.00	895.00
Mode	51.00	49.00	49.00	44.00
Skewness	0.36	0.59	0.37	0.55
Sample variance	25.64	39.32	25.51	40.57
Kurtosis	-0.68	-0.95	-0.55	-1.04
Range	19.00	21.00	19.00	21.00
Confidence level 95%	(49.28, 52.79)	(49.55, 55.34)	(46.94, 50.44)	(46.78, 52.66)



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3.2.14. GONADOSOMATIC INDEX (GSI)

The summarized statistics of the dynamics of the gonadosomatic index (GSI) for 2025 is presented in Table 64. The mean ratio of the index reaches 16.69% BW. Highest mean value for the index is observed in the sample from Port Byala (10.09.2025).

Table 69

Summarized statistics of GSI (% BW) by ports for 2025

	Port	Number	Mean	Std.	Min	Median	Max
1	Rodopa 1	50	17.08	3.55	10.86	17.24	25.07
2	Kavarna	50	15.45	3.71	9.02	14.88	32.42
3	Rodopa 1	50	15.28	2.63	7.78	15.37	20.92
4	Balchik	50	15.44	2.21	9.98	15.10	20.57
5	Ada Bahcha	50	13.96	4.36	9.01	12.59	31.50
6	Kavarna	50	15.61	2.61	9.73	15.26	22.99
7	Rodopa 1	50	16.14	4.02	11.70	15.51	33.48
8	Kavarna	50	18.41	10.53	8.21	16.15	84.11
9	Byala	50	18.89	2.89	13.02	19.55	25.49
10	Bolata	50	14.56	2.85	10.18	14.51	21.35
11	Varna	50	18.82	5.04	10.74	17.02	36.04
12	Tsarevo	50	18.44	2.94	9.12	18.69	23.96
13	Varna	50	18.72	5.03	10.23	17.05	35.83



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GSI distribution by quarters for 2025

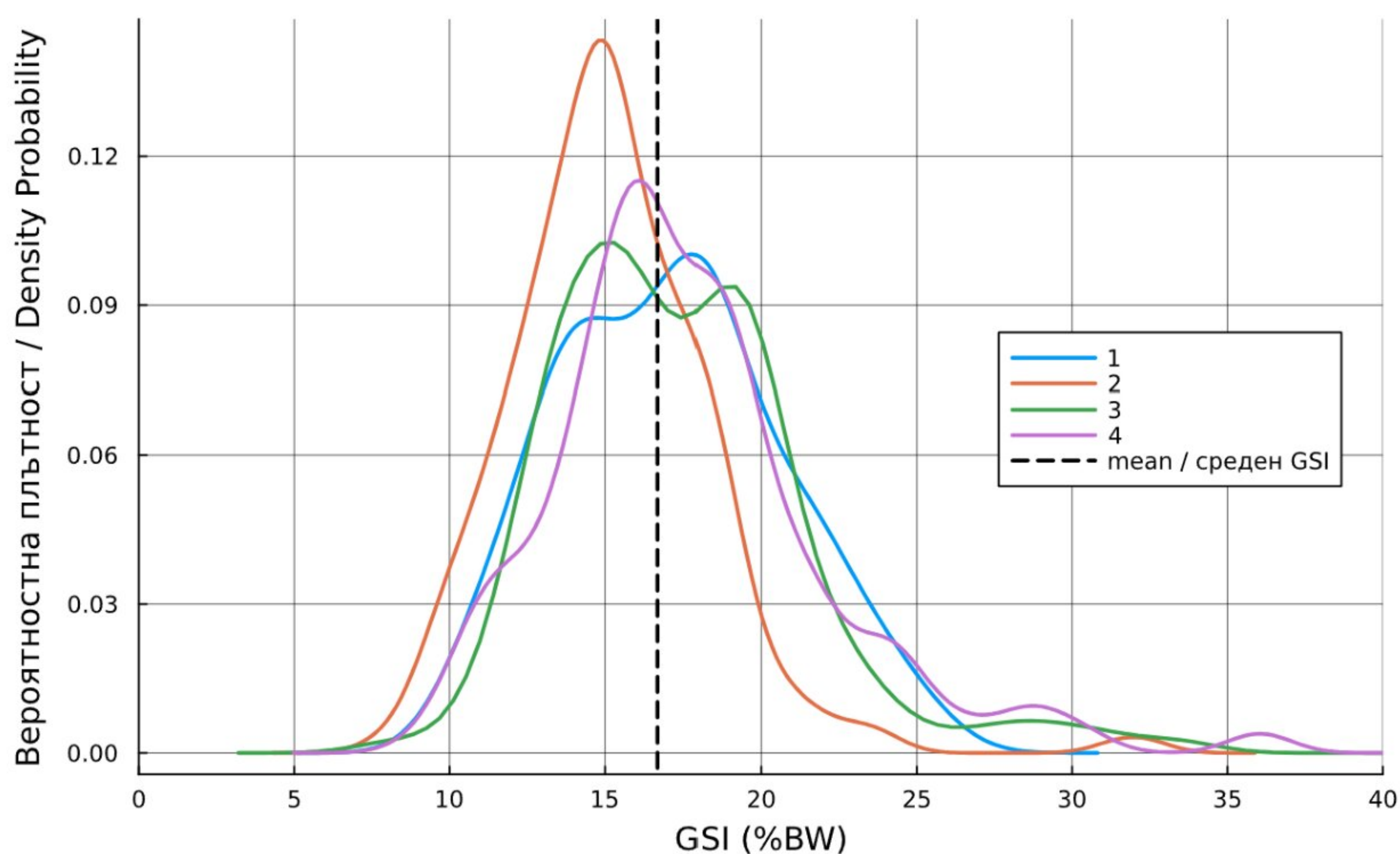


Figure 33 Gonadosomatic index (GSI) by trimesters for 2025



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3.2.15. SUMMARIZED RESULTS OF SEX STRUCTURE

The mean ratio between sexes for the observed period is 66 % ♂: 34 % ♀ (Figure 32). No imposex forms were identified in the first and second halves of 2025.

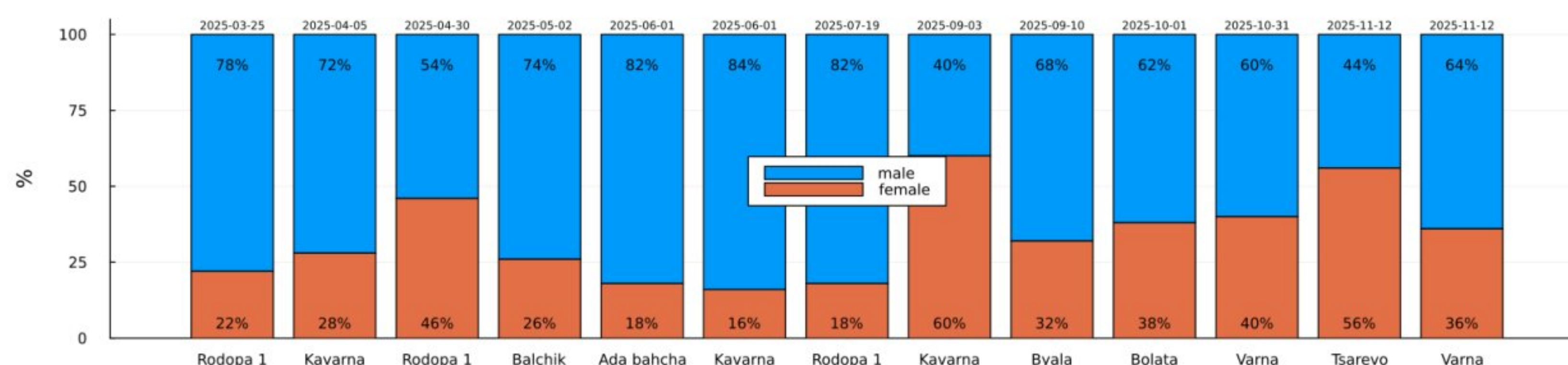


Figure 34 Summarized data about the sex structure of *R. venosa* by ports for 2025

The mean shell length (SL, mm) of the male individuals, caught by beam trawl, is 64.36 mm $\pm$ 10.16 SD, with the longest mean size of 76.44 mm – in the sample from June at port Varna (01.06.2025). The mean length of the female individuals reached 62.54 mm $\pm$ 9.97 SD for the period, with a percentage difference of 4 $\downarrow$ compared to the mean length of the male specimens. Accordingly, the mean weight of the males for the period is 51.59 g $\pm$ 24.76 SD, and for females – 47.61 g $\pm$ 23.88 SD, with a percentage difference of 7.71% between the two sexes (Table 70, Figure 35.2).



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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 2025

	Port	Sex	Mean	Std	Min	Median	Max
1. Size (SL, mm)	Rodopa 1	M	53.77	4.77	44.00	54.00	65.00
		F	50.36	3.53	44.00	51.00	55.00
	Kavarna	M	58.81	8.98	46.00	57.50	88.00
		F	50.57	6.15	40.00	48.00	63.00
	Rodopa 1	M	60.48	4.69	49.00	62.00	68.00
		F	57.43	3.80	51.00	58.00	66.00
	Balchik	M	68.30	5.49	58.00	67.00	82.00
		F	65.15	4.10	60.00	65.00	71.00
	Ada Bahcha	M	69.93	9.93	46.00	71.00	94.00
		F	61.22	10.93	44.00	61.00	78.00
	Kavarna	M	57.12	5.39	49.00	56.00	72.00
		F	53.62	2.83	49.00	53.50	58.00
	Rodopa 1	M	69.29	21.77	36.09	133.94	69.29
		F	54.97	8.21	40.85	64.68	54.97
	Kavarna	M	59.70	26.63	22.43	133.27	59.70
		F	40.53	17.35	19.48	73.88	40.53
	Byala	M	54.83	22.40	26.53	120.34	54.83
		F	48.18	14.14	27.46	85.33	48.18
	Bolata	M	56.82	18.17	21.16	103.69	56.82
		F	59.68	19.57	9.88	97.50	59.68
2. Total weight (TW, g)	Varna	M	51.11	13.06	26.54	78.91	51.11
		F	49.43	19.11	21.58	85.79	49.43
	Tsarevo	M	95.26	30.36	46.08	159.91	95.26
		F	78.88	28.57	30.21	156.64	78.88
	Varna	M	50.24	12.87	26.95	80.09	50.1
		F	50.21	18.84	21.93	87.02	48.59
	Rodopa 1	M	27.96	8.11	16.28	26.88	52.36
		F	22.76	3.58	16.29	22.76	30.59
	Kavarna	M	36.73	19.03	17.25	31.96	107.86
		F	23.63	10.25	11.55	19.27	48.79
	Rodopa 1	M	36.72	8.64	18.54	36.92	51.71
		F	32.83	6.28	23.67	32.79	45.43
		M	53.10	16.27	22.03	51.94	109.55



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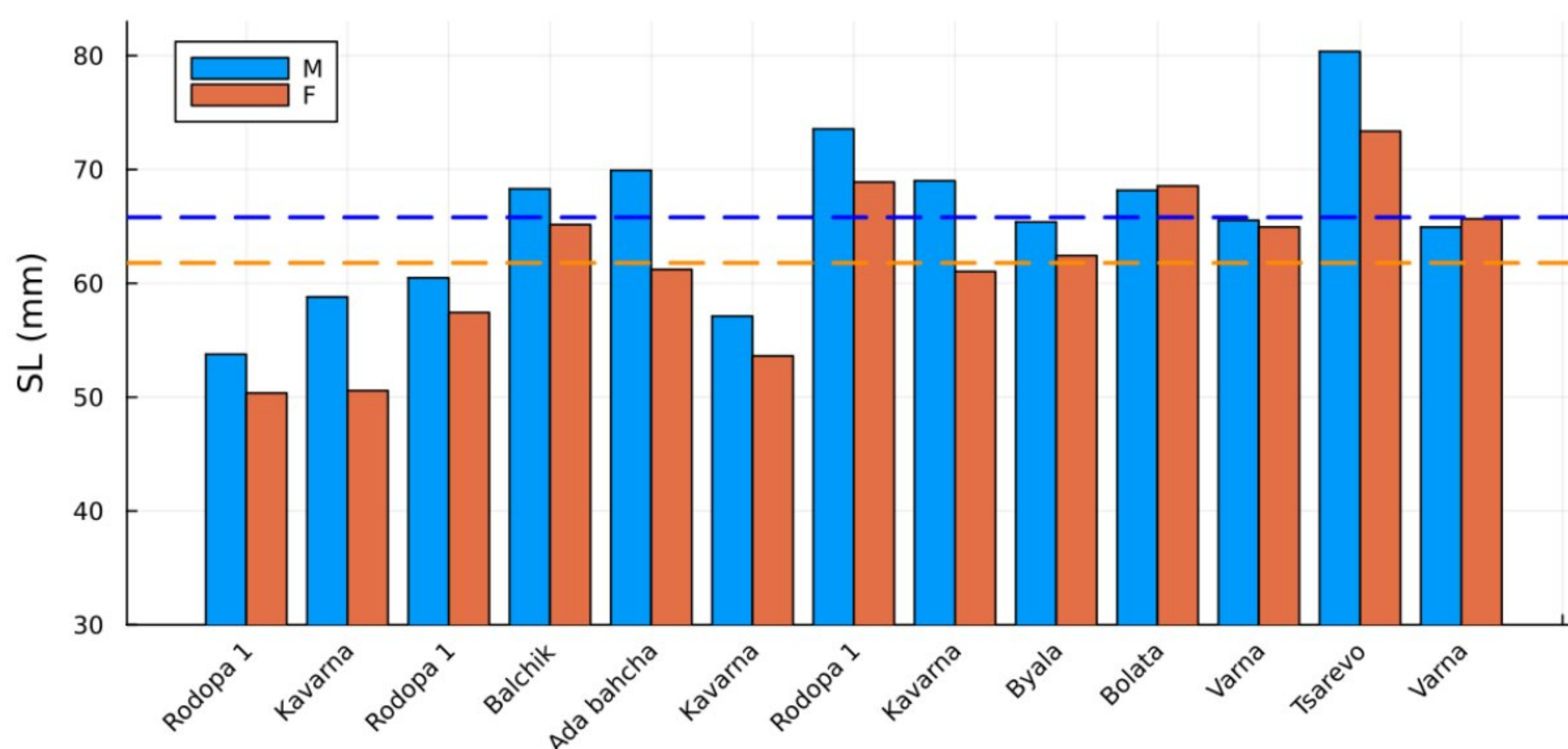


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	Balchik	F	58.10	17.92	34.39	55.37	91.17
	Ada Bahcha	M	60.55	23.95	18.80	57.43	119.82
		F	42.95	18.93	15.40	48.23	62.91
	Kavarna	M	35.78	10.86	22.68	33.05	63.45
		F	30.53	5.55	21.65	29.70	39.71
	Rodopa 1	M	69.29	21.77	36.09	133.94	69.29
		F	54.97	8.21	40.85	64.68	54.97
	Kavarna	M	59.70	26.63	22.43	133.27	59.70
		F	40.53	17.35	19.48	73.88	40.53
	Byala	M	54.83	22.40	26.53	120.34	54.83
		F	48.18	14.14	27.46	85.33	48.18
	Bolata	M	56.82	18.17	21.16	103.69	56.82
		F	59.68	19.57	9.88	97.50	59.68
	Varna	M	51.11	13.06	26.54	78.91	51.11
		F	49.43	19.11	21.58	85.79	49.43
	Tsarevo	M	95.26	30.36	46.08	159.91	95.26
		F	78.88	28.57	30.21	156.64	78.88
	Varna	M	49.9	13.35	25.85	76.98	52.16
		F	50.58	19.63	22.02	88.22	50.42

1.

Mean SL by Sex





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2. Mean TW by Sex

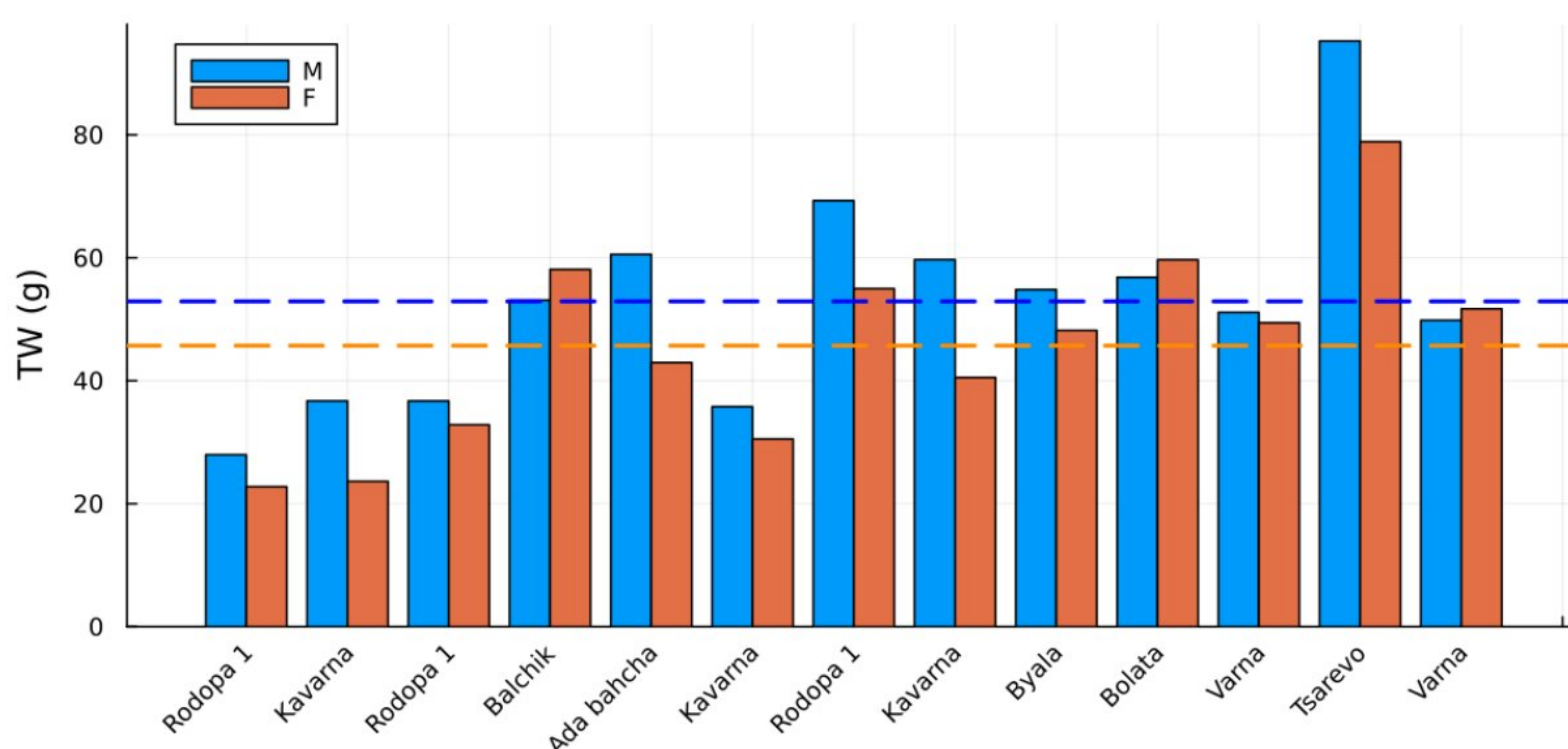


Figure 35 Summarized data for the (1) mean size (SL, mm) of *R. venosa* by sex and (2) mean weight (TW, g) by sex for 2025

The analysis of the size class dynamics by sex shows that in beam trawl catches, the size class 60 - 70 mm is the dominant one or 42 % from all the male individuals. The female individuals that fall into this size class are 33 % from the observed individuals (Figure 34). The bigger size classes > 80 mm in the beam trawl catches form only 7% of the male individuals and around 2% of the females. In the samples collected through scuba diving, a shift in the size distribution is observed, with the highest proportion of individuals falling within the 70–80 mm size class, accounting for 40% of both males and females.



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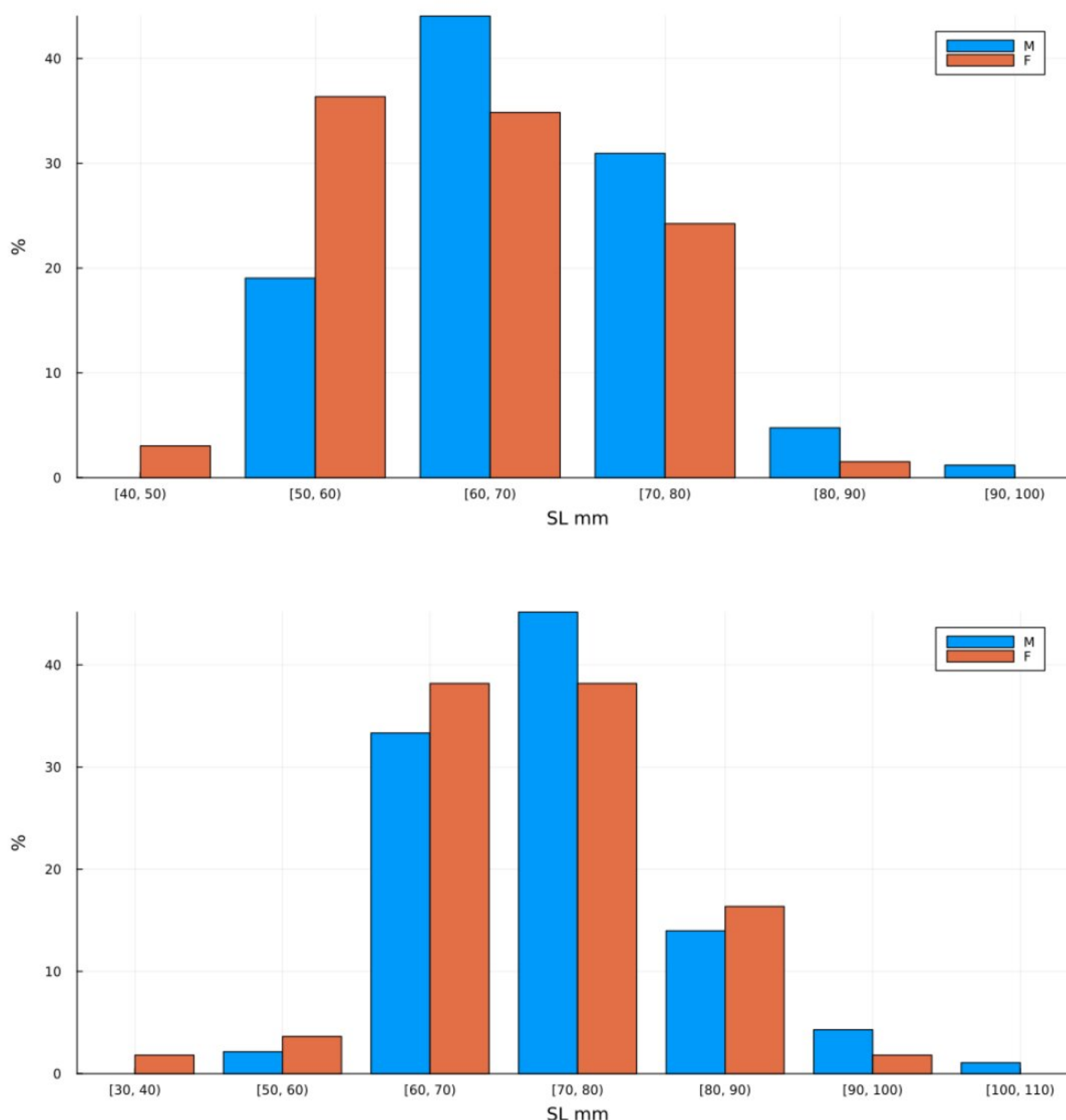


Figure 36 Summarized data for the (1) mean size (SL, mm) of *R. venosa* by sex and (2) mean weight (TW, g) for 2025. (1 – beam trawl, 2 – scuba diving)

As for the weight structure of the beam trawl samples (Figure 35), both sexes show a clear dominance of the 20–40 g weight classes, observed in 53% of the measured female individuals and in 27% of the males. Among the male specimens, a significant proportion also falls within the 40–50 g weight class (30%). In contrast, the samples obtained through scuba diving do not exhibit a clearly dominant weight class, which can be explained with the selective nature of this harvesting method. It is important to note that both male and female individuals include representatives of the larger weight classes (>100 g), accounting for roughly 10% of each sex.



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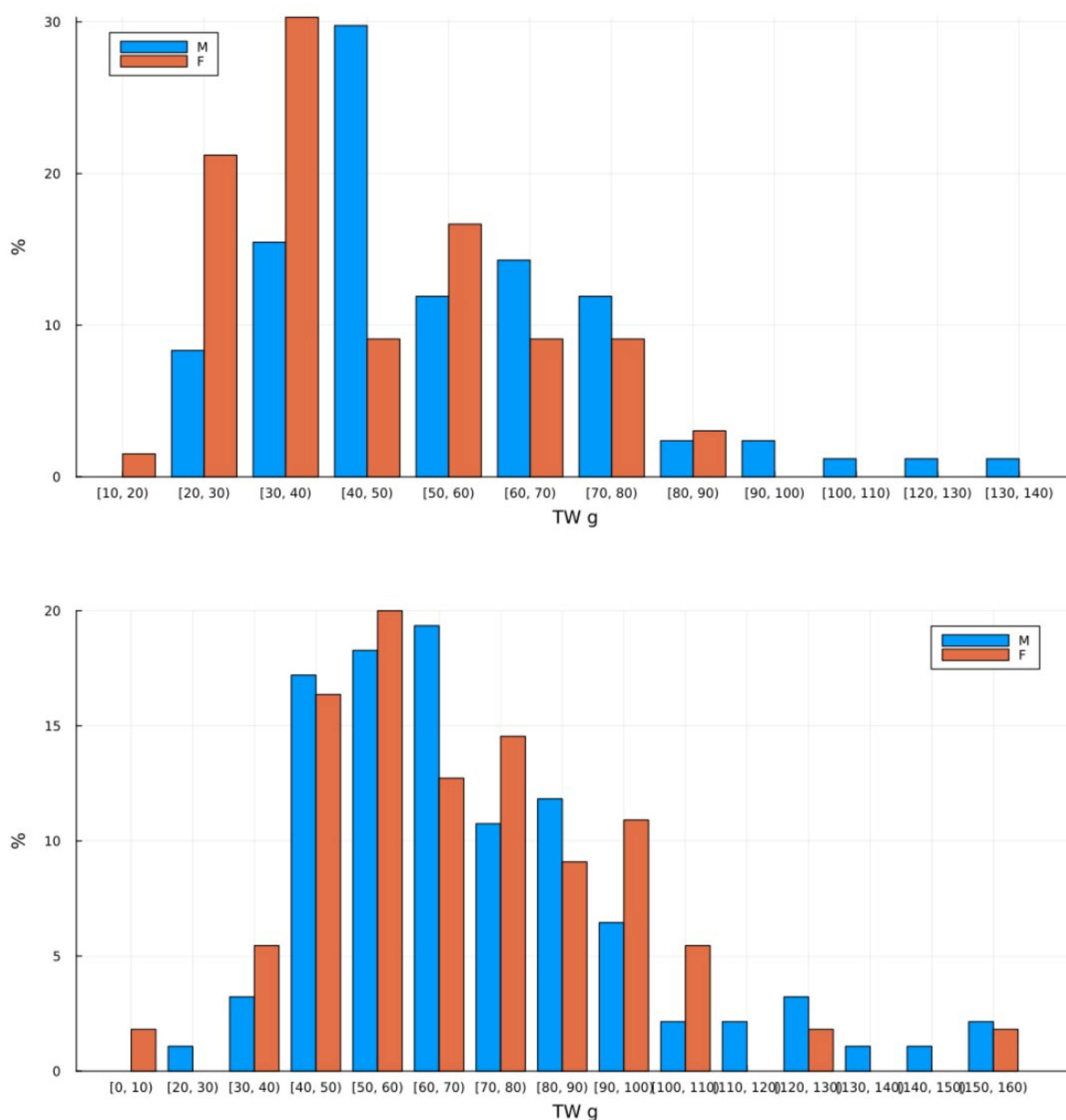


Figure 37 Percentage distribution by weight class (TW, g) of males (M) and females (F) for 2025 (1 – beam trawl, 2 – scuba diving)

Based on summarized data from all beam trawl catches in the first and second half of 2025, it can be concluded that the growth for males is negative allometric with a coefficient $b < 3$. The same trend is observed for the females - negative allometric as well with a coefficient $b < 3$. (The parameters of the equation ration L-W for both sexes are presented in Figure 36 and in Table 66.



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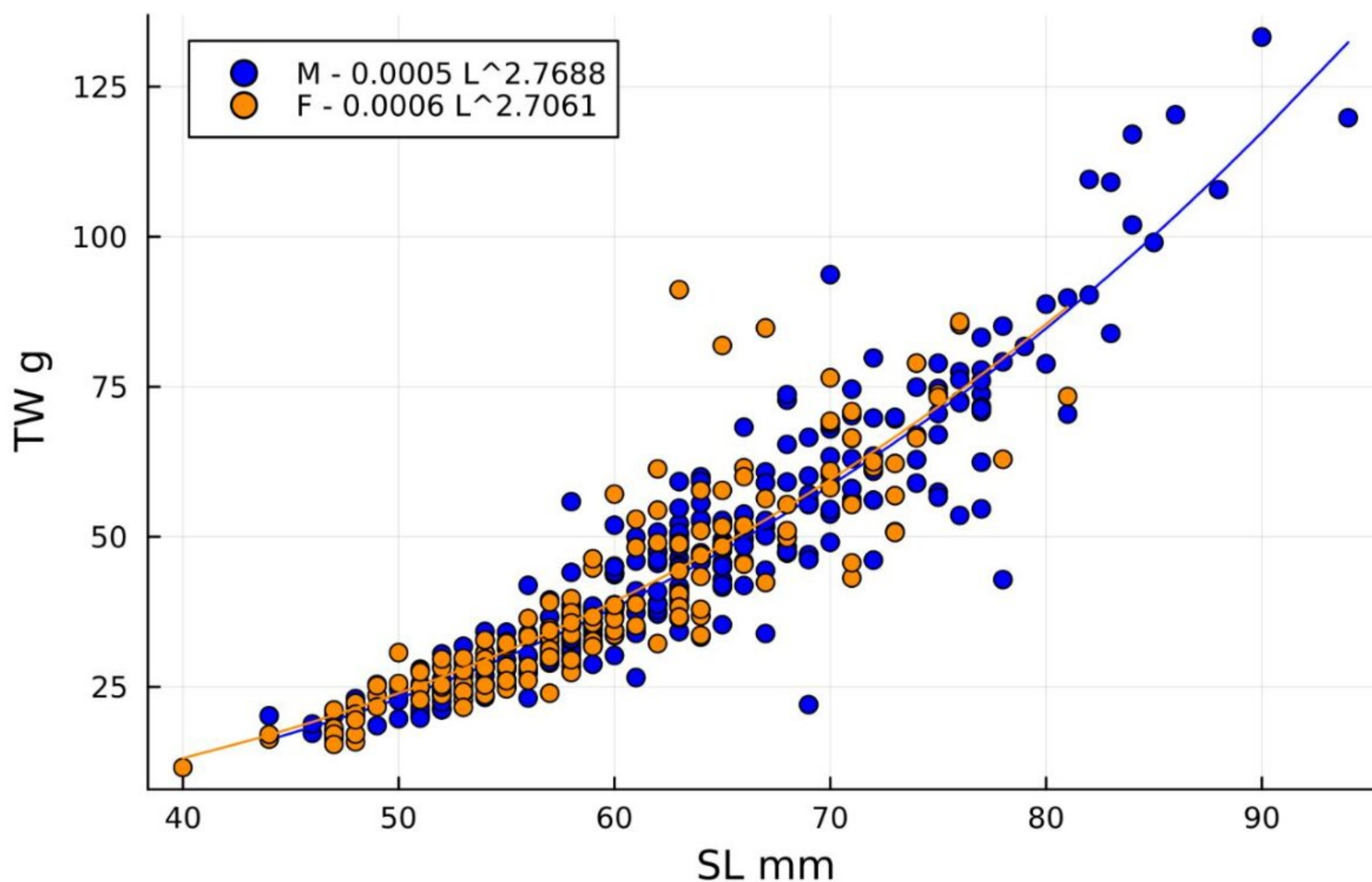


Figure 38 Total weight (TW, g) from the shell length (SL, mm) for all individuals based on the summarized data for the beam trawl fishing for the first half of 2025 (M - males, F - females)

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 2025

Parameters	♀	♂
$TW(g) = a.SL(mm)^b$		
a	0.0006	0.0007
b	2.70	2.77
R²	0.88	0.92



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4. CONCLUSIONS

- In 2025, a total of 1300 biological samples of *Rapana venosa* were collected and analyzed, from landings of the fishing fleet at the main ports along the Bulgarian Black Sea coast. The samples were obtained through two harvesting methods—beam trawl and scuba diving, which enabled a comparative assessment of the species' biological characteristics under different exploitation conditions.
- The mean size (SL) of all observed individuals is 61 mm, as it varies between 39 and 94 mm. The total weight (TW) reaches around 45 g, while the body weight (BW) is around 17 g or approximately 37% of the total weight.
- The analysis of the size structure, revealed a clear dominance of medium size classes, with the highest relative proportion represented by individuals in the 50–60 mm range. Larger specimens exceeding 70–80 mm were considerably less common in the catches. This indicates that the landings are composed predominantly of medium-sized individuals, which may reflect both the selectivity of the fishing gears and the intensity of exploitation of the population.
- The analysis of the length-weight relationships (**LWR**) showed predominantly negative allometric growth ($b < 3$). This indicates that increases in shell length outpace increases in body weight as individuals grow. Such patterns are characteristic of many *Rapana venosa* populations under conditions of active fishing pressure.
- The sex ratio in the samples shows a predominance of male individuals (66% ♂ : 34% ♀). Male individuals are, on average, slightly larger and heavier than females, with mean shell length and mean weight being about 4–8% higher in males.
- The comparative analysis between the first and second half of 2025 showed relatively stable biological parameters of the *Rapana venosa* population, with only moderate variations in size and weight structure.
- During the first half of the year (March–June), the catches were dominated by medium-sized individuals, with the 50–60 mm size classes being most abundant. This corresponds to the active fishing season, during which beam trawls are mainly used, and the selectivity of this gear favors the capture of medium-sized specimens.
- In the second half of the year (July–December), a shift in size structure was observed, with an increased relative share of larger individuals in some samples. This reflects both seasonal growth and the use of different harvesting methods, including scuba diving, which allows for



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selective collection of larger *Rapana* specimens. As a result, some samples from the second part of the year exhibited higher mean shell lengths and weights.

- Despite these seasonal variations, the key morphometric relationships between shell dimensions and body weight remained relatively stable throughout the year. The parameters of the length–weight relationships showed similar trends in both halves of the year, consistently indicating negative allometric growth ($b < 3$). This suggests stability in the biological structure of the *Rapana venosa* population in the Bulgarian Black Sea waters during the observed period.
- The obtained results provide up-to-date information on the biological parameters of *Rapana venosa* in the Bulgarian Black Sea area and can be used as a basis for future assessments of stock status and for supporting the management of the rapa whelk fishery.



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