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**BIOLOGICAL MONITORING (BIOLOGICAL
SAMPLES COLLECTION) OF THE LANDED RAPANA
CATCH BY THE BULGARIAN FISHERY FLEET
Summary for 2018 - 2019**

SUMMARY

Analyses of data from the biometric measurements of 2400 specimens *Rapana venosa*, collected during 2018 – 2019 from landings of Bulgarian fishing fleet in nine ports – Krapets, Durankulak, Kavarna, Balchik, Varna, Byala, Sozopol, Tsarevo and Rezovo are included in this study. The *Rapana* fishing techniques involve beam trawling and scuba diving.

For comparative analysis, we added additional data for lengths and weights of 1800 specimens *R. venosa*, gathered in 2017 through a pilot project for assessment of turbot (*Scophthalmus maximus*) bycatch by *Rapana* fishery with beam trawls.

Institute of Fish Resources (IFR) -
Varna
04/2020



МИНИСТЕРСТВО НА ЗЕМЕДЕЛИЕТО, ХРАНИТЕ И
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This study is performed by researchers from the Institute of Fish Resources – Varna, Agricultural Academy (AA), within Contract EAFA-Burgas/D-157/16.05.2018, focused on the scientific assessment of the quantity and biological parameters of Rapa whelk from the landed catch by the Bulgarian fishery fleet in 2018-2019.

The research was carried out with the financial support of the European Commission in accordance with Regulation №199/2008 of the Council and Decision 2010/93/EC of the Commission, developed to support member states in the preparation of technical reports for the elaboration of a common framework for collection, management and use of data in the Fishery' sector, and to support the scientific consultations related to the Common Fishery Policy.

Scientific team

Leader - Assoc. Prof. Elitsa Petrova

Members

Assoc. Prof. Vesselina Mihneva

Assoc. Prof. Stoyko Stoykov

Chief Ass. Prof Feriha Tserkova

Stanimir Valchev

Chief Ass. Prof. Philip Penchev

Rositsa Kuneva

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1. Introduction

This report is representative for 2018 - 2019 and is based on the biometric measurements on 2400 specimens *R. venosa*. The analysis reveals the main biological parameters of the target species – quantity, length, weight, linear-weight relationships and sex structure by samples from landings from the observed ports – **Krapets, Durankulak, Kavarna, Balchik, Varna, Byala, Sozopol, Tsarevo and Rezovo**.

1.1. Data collected

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

1. Data about the fishery vessels' activity

- Fish expedition data
- Departure port
- Arrival port
- Fishery vessel name
- Vessel type
- Vessel length (m)

2. Fishery gear

- Depth scale of the fishery activities (up to 35 m depth)

3. Basic biological data

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

4. Additional biological data

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

The final results are presented in the form of tables and figures for:

- Landings of the target species at ports;
- Biological parameters of Rapa whelk – length, weight, linear-weight relationships, sex structure.

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2. Materials and methodology

2.1. Sampling scheme

The research took 24 days, split into quarters, during the active fishery seasons in 2018 - 2019 (Table 1)

Table 1.
Ports and fishing vessels observed during the biological monitoring of the Rapa whelk landings

Date	Fishing vessel	Reg No of fishery vessel	Technical specifications	Departure	Arrival	Fishery method
18.06.2018	БС 1280	БС 1280	length - 9 m; Weight - 4.66 GT; power - 58.84 kW	Rezovo	Rezovo	Scuba diving
18.06.2018	Tais	BH 393	Length - 19.4 m; Weight - 46 GT; Power 378 kW	Varna	Varna	Beam trawl
21.06.2018	ШБ 5939	ШБ 5939	Length - 3.95 m.; Weight - 0.48 GT	Durankulak	Durankulak	Scuba diving
22.06.2018	БЛ 2947	БЛ 2947	Length - 7.5 m.; Weight - 3.68 GT; Power 40.45 kW	Chaika, Biala	Chaika, Biala	Scuba diving
12.07.2018	Viking	BH 8406	Length - 14.52 m; Weight - 30.06 GT; Power 132.39 kW	Kavarna	Kavarna	Beam trawl
27.07.2018	Elekta	BH 8042	Length - 16.5 m; Weight - 17.12 GT; Power 110.33 kW	Balchik	Balchik	Beam trawl
28.07.2018	Elekta	BH 8042	Length - 16.5 m; Weight - 17.12 GT; Power 110.33 kW	Balchik	Balchik	Beam trawl
01.09.2018	Elekta	BH 8042	Length - 16.5 m; Weight - 17.12 GT; Power 110.33 kW	Balchik	Balchik	Beam trawl
03.10.2018	ШБ 6026	ШБ 6026	Length - 6.5 m; Weight - 1.82	Krapets	Krapets	Scuba diving

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			GT; Power 58.84 kW			
04.10.2018	ЦР 591	ЦР 591	Length - 8.9 m; Weight - 3.56 GT; Power 55.16 kW	Tsarevo	Tsarevo	Scuba diving
19.10.2018	ЦР 591	ЦР 591	Length - 8.9 m; Weight - 3.56 GT; Power 55.16 kW	Tsarevo	Цатево	Scuba diving
07.11.2018	PK №4	PK №4	Length - 12.58 m; Weight - 24.46 GT; Power 220.59 kW	Varna	Varna	Beam trawl
25.05.2019	PK 4	Вн 7599	Length -12.58 m; Weight - 24.46 GT; Power 220.59 kW	Varna	Varna	Beam trawl
31.05.2019	PK 5	Вн 8186	Length – 14.9 m; Weight - 24.91 GT; Power 220 kW	Varna	Varna	Beam trawl
13.06.2019	Tais	Вн 393	Length - 19.4 m.; Weight - 46 GT; Power 378 kW	Varna	Varna	Beam trawl
22.06.2019	Viking	ВН 8406	Length – 14.52 m.; Weight - 30.06 GT; Power 132.39 kW	Kavarna	Kavarna	Beam trawl
03.07.2019	Elekta	Вн 8042	Length 16,5 m; Weight GT 17,12, Power kW 110.33,	Balchik	Balchik	Beam trawl
24.09.2019	PK-5	Вн 8186	Length 14,9 m, Weight GT 91, Power kW 220,	Varna	Varna	Beam trawl
25.09.2019	Пълдин	Кв 5642	Length 12.2 m, Weight GT 10.04, Power 69,88 kW,	Kavarna	Kavarna	Beam trawl
29.09.2019	Цр 606	Цр 606	Length 11.2 m, Weight GT 9.79, Power kW 58.84,	Sozopol	Sozopol	Scuba diving
01.10.2019	Вс395 Синюга	Вс 395	Length 6.95 m, Weight GT 1,42, Power 16,18 kW	Sozopol	Sozopol	Scuba diving

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08.11.2019	Libra	BH 8311	Length 14.95 m, Weight GT 17.23, Power 126 kW	Kavarna	Kavarna	Beam trawl
12.11.2019	Електа	BH 8042	Length 16.5 m, Weight 17.12 GT; Power 110.33 kW	Kavarna	Kavarna	Beam trawl
16.11.2019	Libra	BH 8311	Length 14.95 m, Weight GT 17.23, Power 126 kW	Kavarna	Kavarna	Beam trawl

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

In the summer to early autumn, some part of the Rapa whelk fishery is performed by scuba diving. The samples from this catch are analysed separately because of the size selective approach used. In addition, we present a comparison between the data obtained from both fishing methods - beam trawling vs scuba diving.

To enrich the comparative analysis, an additional set of data (on 1800 *R. venosa* specimens) from 2017 is used. This data covers the period June – October 2017, based on a Contract with EAFA /D-/46/14.05.2017 (part of the National Programme for the fishery data collection), to estimate the by-catch of bottom fish species aboard of fishing vessels, equipped with beam trawls.

2.2. Sample processing

Random samples of *R. venosa* were taken from the landings of Bulgarian fishing fleet to monitor the biological parameters of the target species during the active fishing season.

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

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

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2.3. Laboratory analysis

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

2.4. Analytical methods

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

$$\text{Log } W = \text{Log } a + b * \text{Log } L$$

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

XLSTAT software is used to plot histograms of the lengths and weights distribution of Rapana samples from the landed catch. The statistical data about the different classes, presented in the histograms, include - lower and upper limits of the classes, frequency, relative frequency and density.

3. Results

3.1. Biometric measurements

The average length of the *R. venosa* specimens, collected by beam trawling in 2018 – 2019, is $62.31 \text{ mm} \pm 8.29 \text{ SD}$ ($62.66 \text{ mm} \pm 8.25 \text{ SD}$ for 2018 and $61.97 \text{ mm} \pm 8.33 \text{ SD}$ for 2019). The maximal average length was observed in Port Balchik (29.07.2018) - 67.30 mm, while the minimal average length - 52.04 mm was found also in Balchik but in 2019 (03.07.2019) (Table 2.1).

The average total weight TW (g) of the *R. venosa* is $41.13 \text{ g} \pm 18.46 \text{ SD}$ for 2018 – 2019 ($42.79 \text{ g} \pm 18.88 \text{ SD}$ for 2018 and $39.47 \pm 18.04 \text{ SD g}$ for 2019) and reveals similar dynamics of the minimal and maximal values with the ones of the average size. The data

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by ports showed relatively high weight of the sample from the port of Balchik – 54.56 g in July 2018 (Table 2.2).

The body weight (BW, g) is $15.80 \text{ g} \pm 3.10 \text{ SD}$ (Table 2.3), with a trend for bimodal distribution and growth in the spring and early autumn (September). The *Rapana* body weight is approximately 40% of the total weigh, varying between 34.10 - 44.4% by the different ports (Table 2.4).

Table 2

Statistical data about the distribution of the shell lengths (SL, mm, 1), the total weight (TW, g, 2), body weight (BW, g, 3) and ratio BW (%TW) in the samples by ports for 2018 – 2019, (**beam trawl data**).

1. Shell length (SL, mm)

Date	Port	Observations	Minimum SL, mm	Maximum SL, mm	Mean SL, mm	Std. deviation
18.06.2018	Varna	100	52.00	84.00	64.64	7.715
12.07.2018	Kavarna	100	45.00	82.00	61.02	7.051
27.07.2018	Balchik	100	48.00	87.00	61.62	6.324
28.07.2018	Balchik	100	52.00	90.00	67.14	7.733
29.07.2018	Balchik	100	50.00	93.00	67.30	10.04
01.09.2018	Balchik	100	45.00	90.00	63.35	9.107
07.11.2018	Varna	100	48.00	73.00	59.66	5.723
23.05.2019	Varna	100	53.00	88.00	65.85	6.436
31.05.2019	Varna	100	49.00	84.00	62.73	8.645
14.06.2019	Varna	100	53.00	87.00	65.44	6.923
22.06.2019	Kavarna	100	44.00	78.00	58.51	7.867
03.07.2019	Balchik	100	43.00	70.00	52.04	5.563
24.09.2019	Varna	100	49.00	76.00	62.43	5.417
25.09.2019	Kavarna	100	56.00	82.00	65.87	4.179
08.11.2019	Kavarna	100	43.00	84.00	62.08	9.127
12.11.2019	Kavarna	100	46.00	83.00	62.21	8.614
16.11.2019	Kavarna	100	43.00	86.00	62.54	9.141

2. Total weight (TW, g)

Variable	Port	Observations	Minimum	Maximum	Mean	Std. Deviation
18.06.2018	Varna	100	17.500	88.500	47.190	16.068

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12.07.2018	Kavarna	100	13.000	99.000	40.340	14.944
27.07.2018	Balchik	100	22.500	101.000	41.815	13.572
28.07.2018	Balchik	100	22.000	123.000	52.625	18.818
29.07.2018	Balchik	100	20.000	124.500	54.555	25.466
01.09.2018	Balchik	100	14.500	98.000	43.450	18.719
07.11.2018	Varna	100	15.000	82.500	41.030	14.865
23.05.2019	Varna	100	23.50	101.50	48.295	13.616
31.05.2019	Varna	100	18.00	105.50	41.875	20.779
14.06.2019	Varna	100	25.00	97.00	48.160	15.358
22.06.2019	Kavarna	100	10.50	100.00	34.980	19.216
03.07.2019	Balchik	100	10.500	73.000	24.120	10.216
24.09.2019	Varna	100	13.000	69.500	39.380	10.059
25.09.2019	Kavarna	100	31.000	133.500	47.445	13.834
05.11.2019	Kavarna	100	10.500	92.500	34.925	18.507
12.11.2019	Kavarna	100	12.000	93.500	36.965	18.328
16.11.2019	Kavarna	100	13.000	120.000	38.590	21.867

3. Body weight (BW, g)

Variable	Port	Observations	Minimum	Maximum	Mean	Std. Deviation
07.11.2018	Varna	50	6.500	23.000	13.98	4.77
23.05.2019	Varna	50	10.5	45.5	21.27	7.64
31.05.2019	Varna	50	6.5	27.5	13.42	5.49
14.06.2019	Varna	50	10	40.5	18.73	6.77
22.06.2019	Kavarna	50	7	33	15.93	7.06
03.07.2019	Balchik	50	4.500	29.000	9.65	4.81
24.09.2019	Varna	50	4.000	30.500	14.90	5.01
25.09.2019	Kavarna	50	12.500	38.000	18.60	4.08
08.11.2019	Kavarna	50	5.000	33.000	14.95	7.10
12.11.2019	Kavarna	50	7.000	37.000	15.52	8.13
16.11.2019	Kavarna	50	5.000	35.500	16.92	7.67

4. Ratio of BW (% TW)

Variable	Port	Observations	Minimum	Maximum	Mean	Std. Deviation
07.11.2018	Varna	50	23.33	51.22	39.08	5.88

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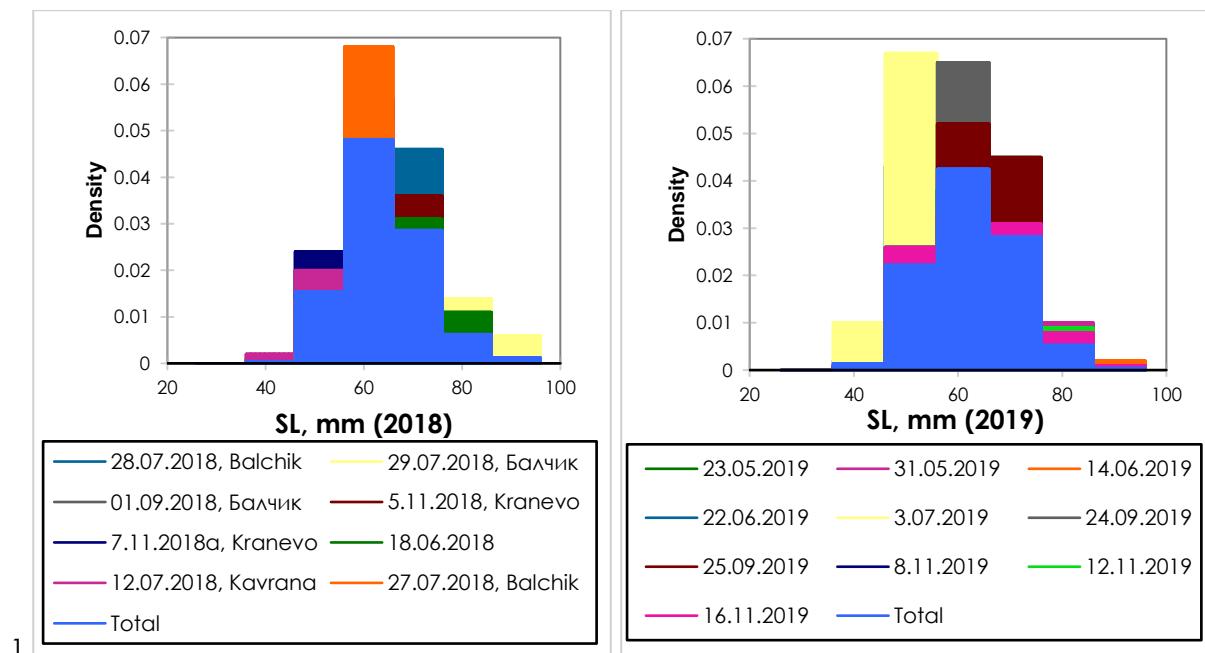
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23.05.2019	Varna	50	27.84	72.97	43.06	7.13
31.05.2019	Varna	50	22.27	42.15	34.10	4.66
14.06.2019	Varna	50	31.90	44.59	39.79	3.47
22.06.2019	Kavarna	50	33.00	53.85	44.39	4.41
03.07.2019	Balchik	50	27.03	51.61	38.64	5.37
24.09.2019	Varna	50	27.19	46.74	37.48	4.30
25.09.2019	Kavarna	50	27.19	51.76	39.70	5.33
08.11.2019	Kavarna	50	31.10	57.58	43.20	6.29
12.11.2019	Kavarna	50	23.33	51.22	39.08	5.88
16.11.2019	Kavarna	50	27.84	72.97	43.06	7.13

Based on the summarized data for 2018-2019 from the beam trawl fishery, the length structure of Rapa whelk catch is dominated by the class – 56 – 66 SL mm (50.7 % in 2018 and 42.5 % in 2019), followed by classes – 66 – 76 mm (24.1% in 2018 and 28.2 % in 2019) and 46 – 56 mm (17.9 % in 2018 and 22.2 % in 2019, Fig. 1.1, Table 3.1).

Concerning the weight structure, the predominant weight class is 25.6 – 51.2 g (61.1 % in 2018 and 53.0 % in 2019), followed by weight classes <25.6 g – (14.4 % in 2018 and 24.6 % in 2019), and 51.2 - 76.8 g – (18.7% in 2018 and 18.3% in 2019) (Fig. 1.2, Table 3.2). There is an increasing trend in 2019 in the share of the smallest weight class < 25.6 g up to 24.6 %, compared to 14.4 % in 2018.



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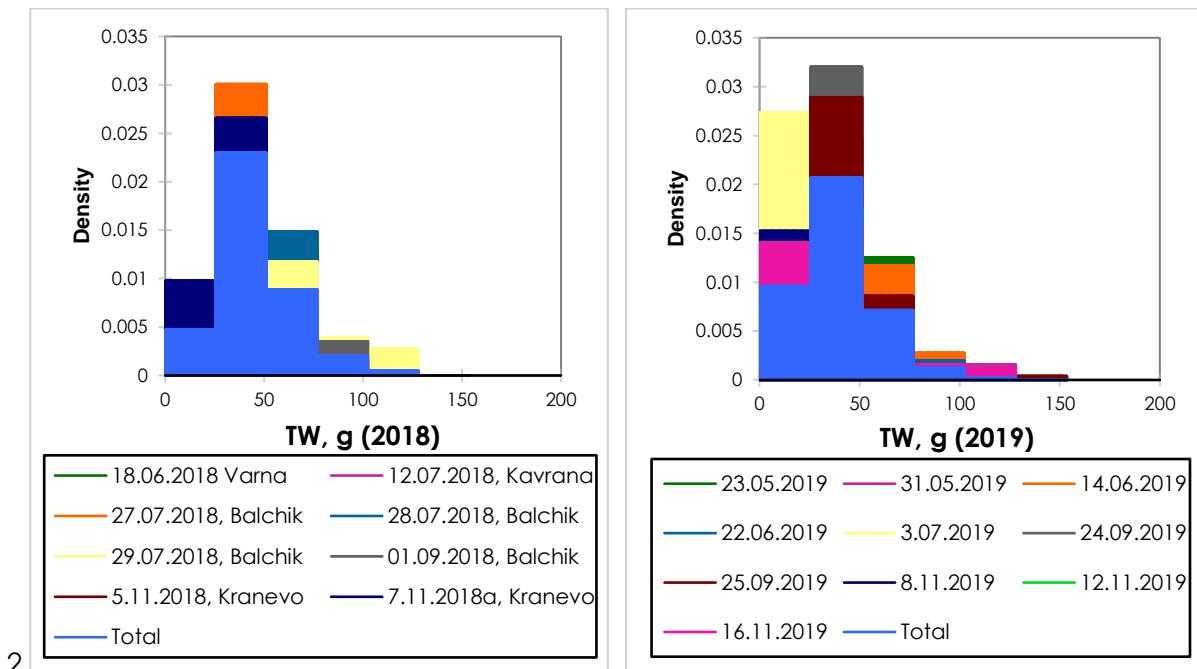


Fig. 1. Length (1) and weight classes (2) of rapana samples by ports in 2018 - 2019

Table 3

Statistical data about the distribution of the length (mm, 1) and weight (g, 2) classes of Rapa whelk (for beam trawl fishery) in 2018 (A) and 2019 г (B).

A. 2018

1	Lower bound	Upper bound	Frequency	Relative frequency	Density
	26	36	0	0.000	0.000
	36	46	6	0.005	0.001
	46	56	197	0.179	0.018
	56	66	558	0.507	0.051
	66	76	265	0.241	0.024
	76	86	56	0.051	0.005
	86	96	16	0.015	0.001

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2

Lower bound	Upper bound	Frequency	Relative frequency	Density
	<25.6	158	0.144	0.006
25.6	51.2	672	0.611	0.024
51.2	76.8	206	0.187	0.007
76.8	102.4	47	0.043	0.002
102.4	128	15	0.014	0.001
128	153.6	1	0.001	0.000
153.6	179.2	1	0.001	0.000

B. 2019

1

Lower bound	Upper bound	Frequency	Relative frequency	Density
26	36	0	0.000	0.000
36	46	14	0.014	0.001
46	56	222	0.222	0.022
56	66	425	0.425	0.043
66	76	282	0.282	0.028
76	86	53	0.053	0.005
86	96	4	0.004	0.000

2

Lower bound	Upper bound	Frequency	Relative frequency	Density
	<26	246	0.246	0.010
26	51.2	530	0.530	0.021
51.2	76.8	183	0.183	0.007
76.8	102.4	33	0.033	0.001
102.4	128	7	0.007	0.000
128	154	1	0.001	0.000

3.1.2. Linear-weight relationships

A. 2018

1) I-II quarter:

$$\text{Log TW (g)} = 2.6998 * \log \text{SL (mm)} - 3.2312, (R^2=0.85, p<0.001, \text{Fig.2.1}).$$

$$\text{Log TW (g)} = 2.6659 * \log \text{Wd (mm)} - 2.8425, (R^2=0.83, p<0.001, \text{Fig.2.2})$$

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Log TW (g) = 2.2597*log AL (mm) - 1.7179, ($R^2=0.72$, $p<0.001$, Fig.2.3).

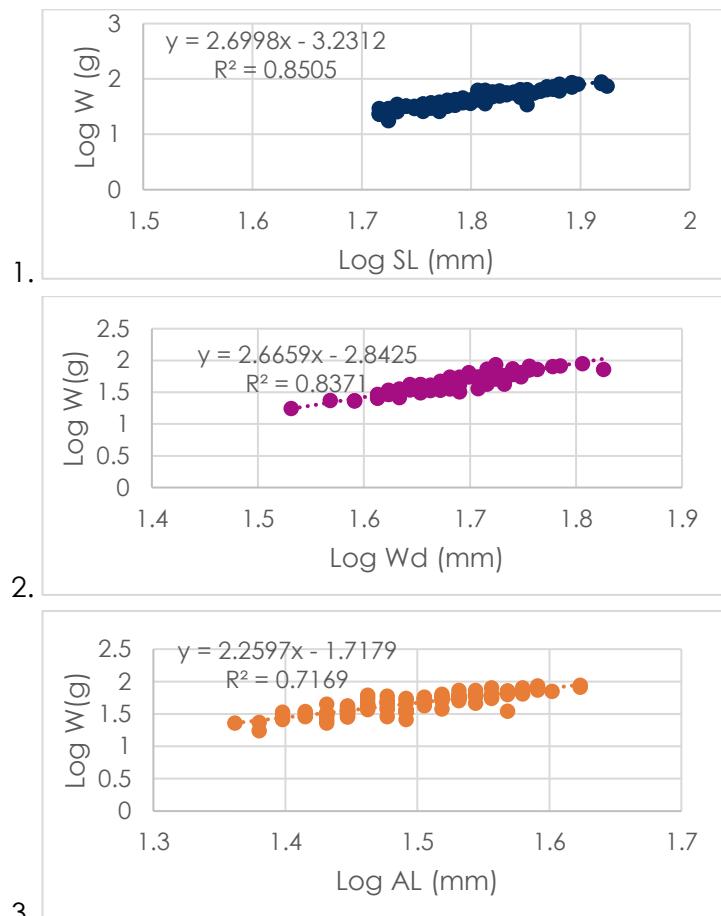


Figure 2. Linear-weight relationships (Log 10) for the 1-2nd quarter 2018

2) III-IV quarter:

Log TW (g) = 2.8346*log SL (mm) - 3.4906, ($R^2=0.77$, $p<0.001$, Fig.3.1).

Log TW (g) = 2.0032*log Wd (mm) - 1.754, ($R^2=0.54$, $p<0.05$, Fig.3.2)

Log TW (g) = 2.296*log AL (mm) - 2.1619, ($R^2=0.70$, $p<0.001$, Fig.3.3).



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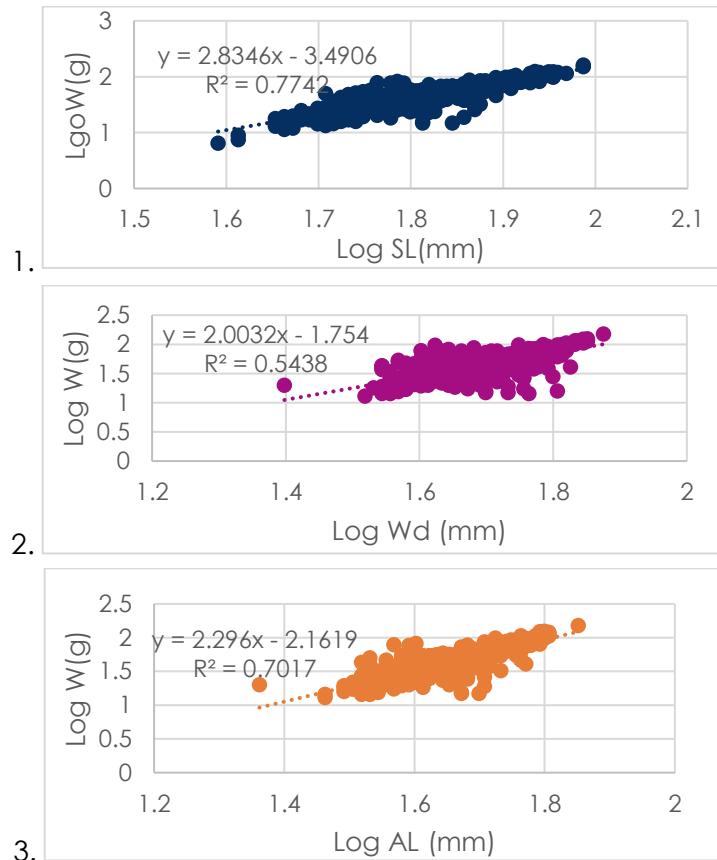


Figure 3. Linear-weight relationships (Log 10) for the 3-4th quarter 2018

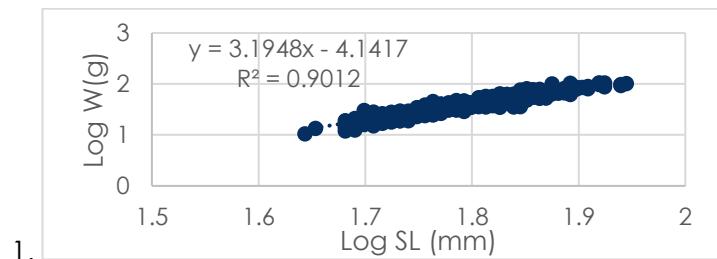
B. 2019

1) I-II quarter:

$\text{Log TW (g)} = 3.1948 \cdot \text{log SL (mm)} - 4.1417$, ($R^2=0.90$, $p<0.001$, Fig.4.1).

$\text{Log TW (g)} = 2.3655 \cdot \text{log Wd (mm)} - 2.3612$, ($R^2=0.56$, $p<0.05$, Fig.4.2)

$\text{Log TW (g)} = 2.4143 \cdot \text{log AL (mm)} - 2.3965$, ($R^2=0.54$, $p<0.001$, Fig.4.3).



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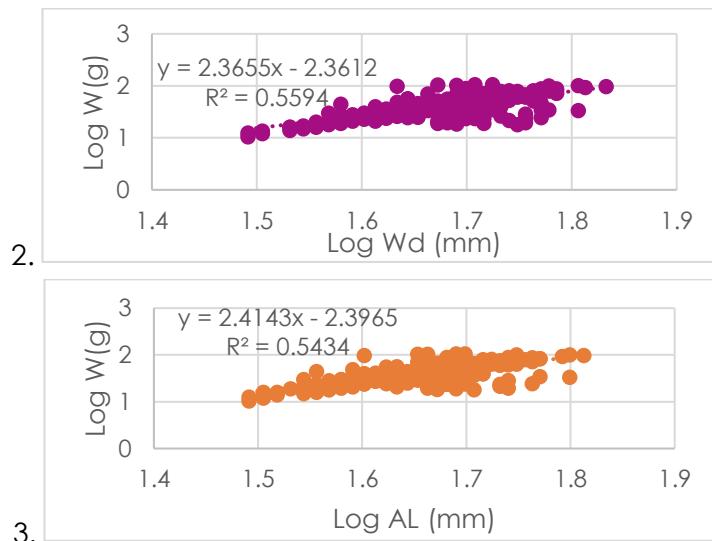


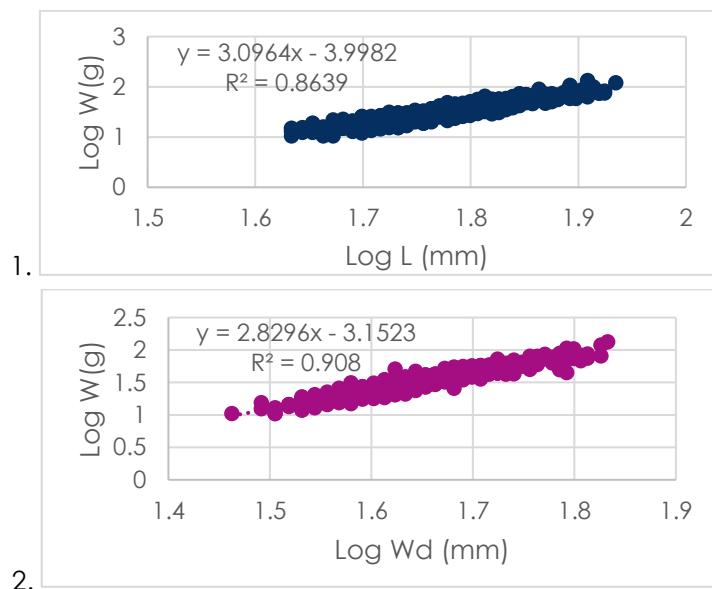
Figure 4. Linear-weight relationships (Log 10) for the 1-2nd quarter 2019

2) III-IV quarter:

$$\text{Log TW (g)} = 3.0964 * \text{log SL (mm)} - 3.9982, (R^2=0.86, p<0.001, \text{Fig.5.1}).$$

$$\text{Log TW (g)} = 2.829 * \text{log Wd (mm)} - 3.1523, (R^2=0.91, p<0.001, \text{Fig.5.2})$$

$$\text{Log TW (g)} = 2.5408 * \text{log AL (mm)} - 2.6409, (R^2=0.80, p<0.001, \text{Fig.5.3}).$$



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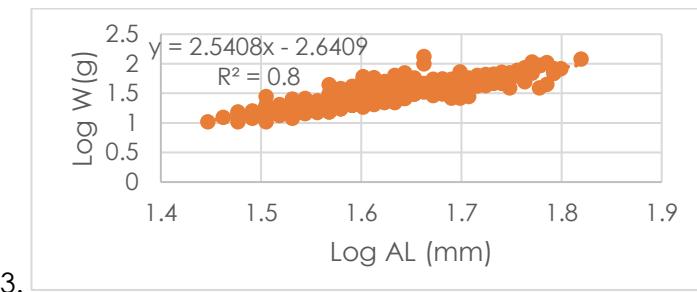


Figure 5. Linear-weight ratios (Log 10) for the 3-4th quarter 2019

3.1.3. Summarized data

The total daily landings in the observed ports vary between 1500 – 10165 kg/day and the biggest landings were observed in Varna in May 2019 (Table 4). Fishing vessels with power 220 kW, equipped with beam trawls, can land up to 3810 kg/day, while fishing vessels with power 58 kW and scuba divers can land up to 985 kg/day.

Table 4

Summarized data about the landings by days and ports from different fishery vessels and fishing technique for 2018 – 2019.

Date	Landing port	Total daily landings <i>R.venosa</i> at port (kg/day)	Fishing vessel length (m) and power (kW)	Landed quantity (kg) from the studied fishing vessel	Weight (kg) of the sample (100 specimens)	Fishing technique
18.06.2018	Rezovo	345	9 m, 58.84 kW	345	14.069	Scuba diving
18.06.2018	Varna	1500	19.4 m, 378 kW	1500	4.719	Beam trawl
21.06.2018	Durankulak	430	3.95 m	430	10.036	Scuba diving
22.06.2018	Byala	300	7.5 m, 40.45 kW	300	11.583	Scuba diving
12.07.2018	Kavarna	1628	14.52 m, 132.39 kW	1628	4.058	Beam trawl
27.07.2018	Balchik	1820	16.5 m, 110.33 kW	1820	4.182	Beam trawl
28.07.2018	Balchik	2070	16.5 m, 110.33 kW	2070	5.263	Beam trawl
01.09.2018	Balchik	2060	16.5 m, 110.33 kW	2060	4.353	Beam trawl
03.10.2018	Krapets	985	6.5 m, 58.84 kW	985	9.545	Scuba diving

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04.10.2018	Tsarevo	600	8.9 m, 55.16 kW	600	8.356	Scuba diving
19.10.2018	Tsarevo	280	8.9 m, 55.16 kW	280	5.401	Scuba diving
07.11.2018	Varna	2690	12.58 m, 220.59 kW	2690	4.107	Beam trawl
23.05.2019	Varna	10165	12.58 m, 220.59 kW	3020	4.829	Beam trawl
31.05.2019	Varna	6135	14.9 m, 220 kW	3015	4.188	Beam trawl
14.06.2019	Varna	3420	19.4 m, 378 kW	3420	4.816	Beam trawl
22.06.2019	Kavarna	1792	14.52 m, 132.39 kW	1792	3.498	Beam trawl
03.07.2019	Balchik	3413	16.5 m, 110.33 kW	1500	2.412	Beam trawl
24.09.2019	Varna	8622	14.9 m, 220 kW	3810	3.938	Beam trawl
25.09.2019	Kavarna	1791	12.2 m, 69.88 kW	1791	4.745	Beam trawl
29.09.2019	Sozopol	2828	11.2 m, 58.84 kW	35	5.972	Scuba diving
01.10.2019	Sozopol	45	6.95 m, 16,18 kW	45	5.622	Scuba diving
08.11.2019	Kavarna	2100	14.95 m, 126 kW	2100	3.493	Beam trawl
12.11.2019	Kavarna	2507	16.5 m, 110.33 kW	990	3.697	Beam trawl
16.11.2019	Kavarna	6110	14.95 m, 126 kW	2010	3.859	Beam trawl

For 2018-2019, the average weight of a sample of 100 specimens *R. venosa* (by beam trawling) is $4.3 \text{ kg} \pm 0.2 \text{ SE}$; the maximal average of 4.72 kg is observed in 1st half of 2018 and the minimum - 3.69 kg - in 2nd half of 2019 (Fig. 6). The weight of the sample of 100 specimens, collected by scuba diving, is $8.80 \text{ kg} \pm 1.76 \text{ SE}$ on average, with minimal levels in the 2nd half of 2019. For both fishing methods, the weights of the samples decreased towards the end of the observed period. The decreasing tendency is well-pronounced for the samples, gathered by scuba diving technique, estimated at 69 % difference between the maximal and minimal weights for the period (Fig. 6).

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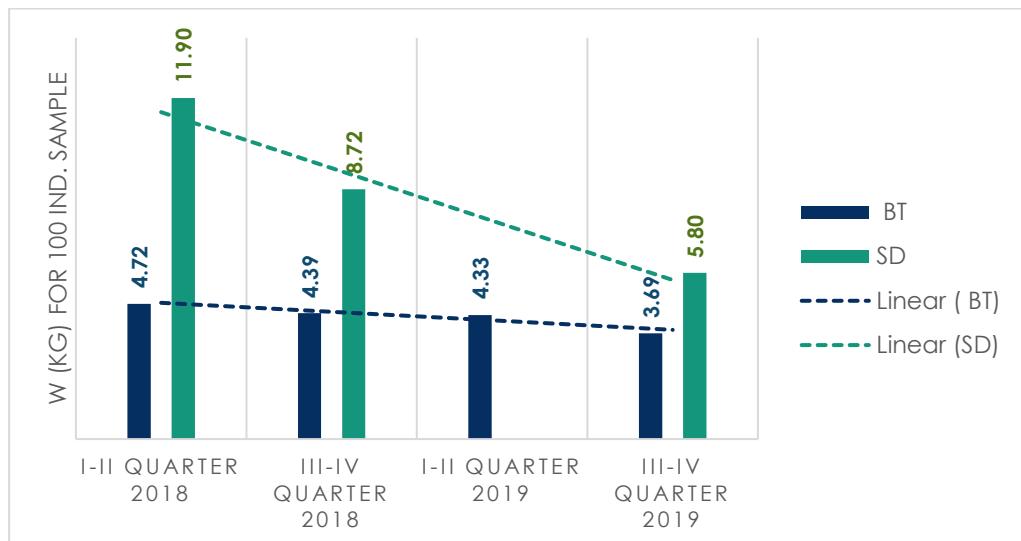


Figure 6. Weight (kg) of the sample 100 ind. *R. venosa*, for fishery with beam trawl (BT) and scuba diving (SD) for 2018-2019

The summarised data by quarters for the beam trawl catches in 2017 - 2019 (Fig. 7 and Table 5) show the average length of the Rapana shell (SL) varies between 65.82 - 61.20 mm, with a percentage difference of 3 - 4% between the quarterly values and decreasing trend by 2019 (Figure 7.1). The maximal individual length of 110 mm was registered in the second half of 2017 (Table 5.1). Concerning the scuba diving technique, for the period 2017 – 2019 (Table 6.1), the average length of the Rapa whelk varies between 84.98 – 68.55 mm, with minimum in 2019 and a percentage difference of 21.4% between the threshold values. The comparison between the average Rapana lengths by beam trawling and scuba diving shows percentage differences of 11.3 - 25.4% and larger average lengths for size selective fishing by diving.



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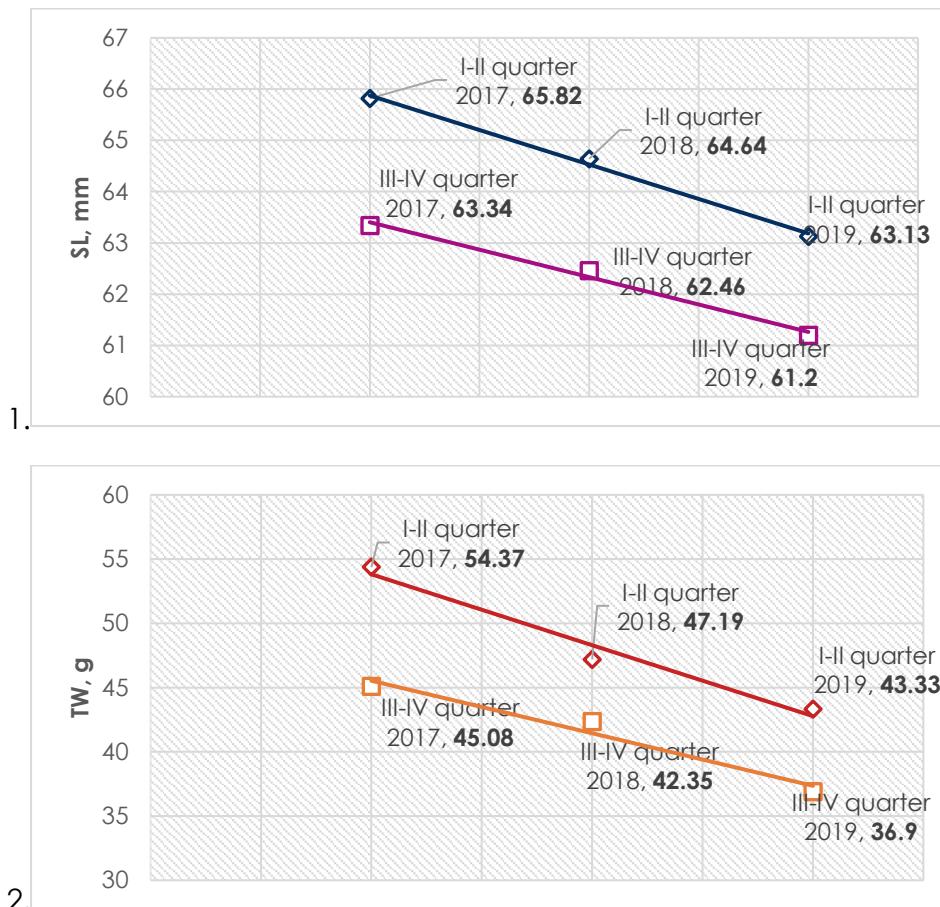


Fig. 7. Average shell length (1, SL, mm) dynamics and total weight (2, TW, g) by quarters for the period 2017-2019, for beam trawl fishery

The average weights of the Rapa whelk (TW, g), from the beam trawl fishery, are 54.37 – 36.90 g for 2017 – 2019, with a decreasing trend in 2018 – 2019 and a drop of 20 – 23 % of the values by quarters (Table 5.2, Figure 7.2). The maximal individual weight is 226.50 g, measured in the 2nd half of 2017 (Table 5.2). For the scuba diving technique, the average weight is 118.97 – 57.97 g (Table 6.2), showing a significant drop of 40.4 % in the 2nd half of 2019. The percentage ratios between the average weights of the Rapa whelk for both fishery methods is 44 – 75 %, in favour of the scuba diving.

The average values of the Rapa whelk width (Wd, mm) vary between 48.72 – 45.39 mm for the beam trawl fishing (Table 5.3) and between 65.89 – 52.21 mm for scuba diving (Table 6.3). The minimal widths were observed in 2019. The sole parameter with an increased value for 2019 was the aperture length (AL mm). The average values for the AL for 2018 – 2019 vary between 45.54 – 31.15 mm, with the maximal levels in the 1st half of

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2019 (Table 5.4). The Rapa whelk catch with scuba diving show high values for the aperture lengths - 57.16 – 49.49 mm and maximum in 2018 (Table 6.4).

Table 5.

Dynamics of the observed parameters by quarters for **Rapa whelk catch by beam trawl** – length (SL, mm) (1), total weight (TW, g) (2), shell width (Wd, mm) (3) and aperture length (AL, mm) (4).

1. SL (mm)

	2017		2018		2019	
	I-II quarter	III-IV quarter	I-II quarter	III-IV quarter	I-II quarter	III-IV quarter
Mean	65.82	63.34	64.64	62.46	63.13	61.20
Standard Error	0.59	0.25	0.77	0.26	0.40	0.34
Median	64.00	62.00	64.00	61.00	63.00	61.00
Mode	62.00	65.00	62.00	58.00	58.00	58.00
Standard Deviation	10.33	9.54	7.72	8.28	8.04	8.44
Sample Variance	106.81	91.01	59.53	68.60	64.65	71.20
Kurtosis	-0.12	1.54	-0.41	1.20	-0.07	-0.32
Skewness	0.61	0.40	0.42	0.81	0.35	0.19
Range	49.00	84.00	32.00	58.00	44.00	43.00
Minimum	47.00	26.00	52.00	39.00	44.00	43.00
Maximum	96.00	110.00	84.00	97.00	88.00	86.00
Sum	20338.00	95067.32	6464.00	62459.00	25253.00	36717.00
Count	309.00	1501.00	100.00	1000.00	400.00	600.00
Confidence level (95.0%)	1.16	0.48	1.53	0.51	0.79	0.68

2. (TW, g)

	2017		2018		2019	
	I-II quarter	III-IV quarter	I-II quarter	III-IV quarter	I-II quarter	III-IV quarter
Mean	54.37	45.08	47.19	42.35	43.33	36.90
Standard Error	1.69	0.57	1.61	0.60	0.91	0.71
Median	46.00	41.00	43.75	38.00	40.50	34.00
Mode	33.00	45.00	29.00	32.00	40.00	20.00
Standard Deviation	29.70	21.94	16.07	19.09	18.26	17.46
Sample Variance	882.14	481.57	258.18	364.61	333.30	304.74
Kurtosis	1.87	14.03	-0.45	4.94	1.04	2.96
Skewness	1.41	2.59	0.53	1.74	0.93	1.28
Range	168.00	224.50	71.00	156.50	95.00	123.00
Minimum	14.00	2.00	17.50	6.50	10.50	10.50
Maximum	182.00	226.50	88.50	163.00	105.50	133.50
Sum	16801.00	67665.90	4719.00	42350.00	17331.00	22142.50
Count	309.00	1501.00	100.00	1000.00	400.00	600.00

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Confidence level (95.0%)	3.32	1.11	3.19	1.18	1.79	1.40
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3. (Wd, mm)

	2018		2019	
	I-II quarter	III-IV quarter	I-II quarter	III-IV quarter
Mean	48.72	47.97	47.63	45.39
Standard Error	0.58	0.28	0.32	0.29
Median	48.00	47.00	48.00	45.00
Mode	45.00	45.00	50.00	49.00
Standard Deviation	5.80	7.31	6.30	7.13
Sample Variance	33.60	53.40	39.70	50.86
Kurtosis	0.40	0.52	0.04	-0.08
Skewness	0.37	0.70	0.03	0.44
Range	33.00	50.00	37.00	39.00
Minimum	34.00	25.00	31.00	29.00
Maximum	67.00	75.00	68.00	68.00
Sum	4872.00	33579.00	19051.00	27234.00
Count	100.00	700.00	400.00	600.00
Confidence Level (95.0%)	1.15	0.54	0.62	0.57

4. AL (mm)

	2018		2019	
	I-II quarter	III-IV quarter	I-II quarter	III-IV quarter
Mean	31.15	44.14	45.54	42.88
Standard Error	0.41	0.25	0.29	0.36
Median	31.00	43.00	46.00	41.00
Mode	28.00	41.00	50.00	41.00
Standard Deviation	4.09	6.62	5.86	7.60
Sample Variance	16.71	43.79	34.39	57.71
Kurtosis	-0.17	0.58	0.12	-0.33
Skewness	0.49	0.66	0.14	0.59
Range	19.00	48.00	34.00	38.00
Minimum	23.00	23.00	31.00	28.00
Maximum	42.00	71.00	65.00	66.00
Sum	3115.00	30897.00	18216.00	19298.00
Count	100.00	700.00	400.00	450.00
Confidence Level (95.0%)	0.81	0.49	0.58	0.70

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Table 6.

Dynamics of the observed parameters by quarters for **Rapa whelk catch by scuba diving** – length (SL, mm) (1), total weight (TW, g) (2), shell width (Wd, mm) (3) and aperture length (AL, mm) (4).

1. SL (mm)

	2018		2019	
	I-II quarter	III-IV quarter	I-II quarter	III-IV quarter
Mean	84.98	73.47	NA	68.55
Standard Error	0.44	0.49		0.34
Median	85.00	74.00		69.00
Mode	81.00	77.00		69.00
Standard Deviation	7.54	8.53		4.80
Sample Variance	56.88	72.68		23.07
Kurtosis	-0.54	-0.07		1.33
Skewness	0.03	-0.10		-0.09
Range	36.00	56.00		33.00
Minimum	68.00	42.00		53.00
Maximum	104.00	98.00		86.00
Sum	25494.00	22040.47		13710.00
Count	300.00	300.00		200.00
Confidence level(95.0%)	0.86	0.97		0.67

2. (TW, g)

	2018		2019	
	I-II quarter	III-IV quarter	I-II quarter	III-IV quarter
Mean	118.96	87.38	NA	57.97
Standard Error	1.91	0.99		0.81
Median	115.00	84.50		58.00
Mode	114.50	75.00		56.00
Standard Deviation	33.00	17.18		11.43
Sample Variance	1089.11	295.05		130.67
Kurtosis	-0.24	2.78		0.40
Skewness	0.47	1.23		0.10
Range	159.00	130.50		64.50
Minimum	56.50	37.50		28.50
Maximum	215.50	168.00		93.00
Sum	35688.90	26213.88		11593.50
Count	300.00	300.00		200.00
Confidence level (95.0%)	3.75	1.95		1.59

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3. (Wd, mm)

	2018		2019	
	I-II quarter	III-IV quarter	I-II quarter	III-IV quarter
Mean	65.89	58.39	NA	52.21
Standard Error	0.37	0.40		0.28
Median	66.00	60.00		53.00
Mode	68.00	60.00		52.00
Standard Deviation	6.41	6.88		3.92
Sample Variance	41.09	47.37		15.35
Kurtosis	-0.37	0.04		0.64
Skewness	0.25	-0.15		-0.26
Range	32.00	47.00		22.00
Minimum	52.00	33.00		41.00
Maximum	84.00	80.00		63.00
Sum	19768.00	17516.39		10441.00
Count	300.00	300.00		200.00
Confidence Level(95.0%)	0.73	0.78		0.55

4. AL (mm)

	2018		2019	
	I-II quarter	III-IV quarter	I-II quarter	III-IV quarter
Mean	57.16	53.08		49.49
Standard Error	0.49	0.39		0.38
Median	57.00	54.00		50.00
Mode	62.00	58.00		51.00
Standard Deviation	8.40	6.70		3.76
Sample Variance	70.59	44.95		14.11
Kurtosis	-0.45	0.08		1.01
Skewness	0.22	-0.09		-0.23
Range	40.00	45.00		21.00
Minimum	39.00	29.00		39.00
Maximum	79.00	74.00		60.00
Sum	17149.00	15924.08		4949.00
Count	300.00	300.00		100.00
Confidence Level (95.0%)	0.95	0.76		0.75

The structure of the dominant length and weight classes is stable for the whole reviewed period 2017 – 2019. The predominant length class for the period (beam trawl fishery) is - 56 - 66 mm (46.4 % of the measured specimens), followed by the classes - 66 - 76 mm (26.3 %) and 46 - 56 mm (20.0 %) (Fig.8.1, Table 7.1)

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The dominant weight class is – 25.6 - 51.2 g (average 57.2 % from the measured specimens), followed by the classes - 51.2 - 76.8 g (18.5 %) and < 25.6 g (19 %). The specimens from weight classes >154 g are registered only in 2017, with almost no specimens observed in 2018 – 2019 (Fig. 8.2, Table 7.2).

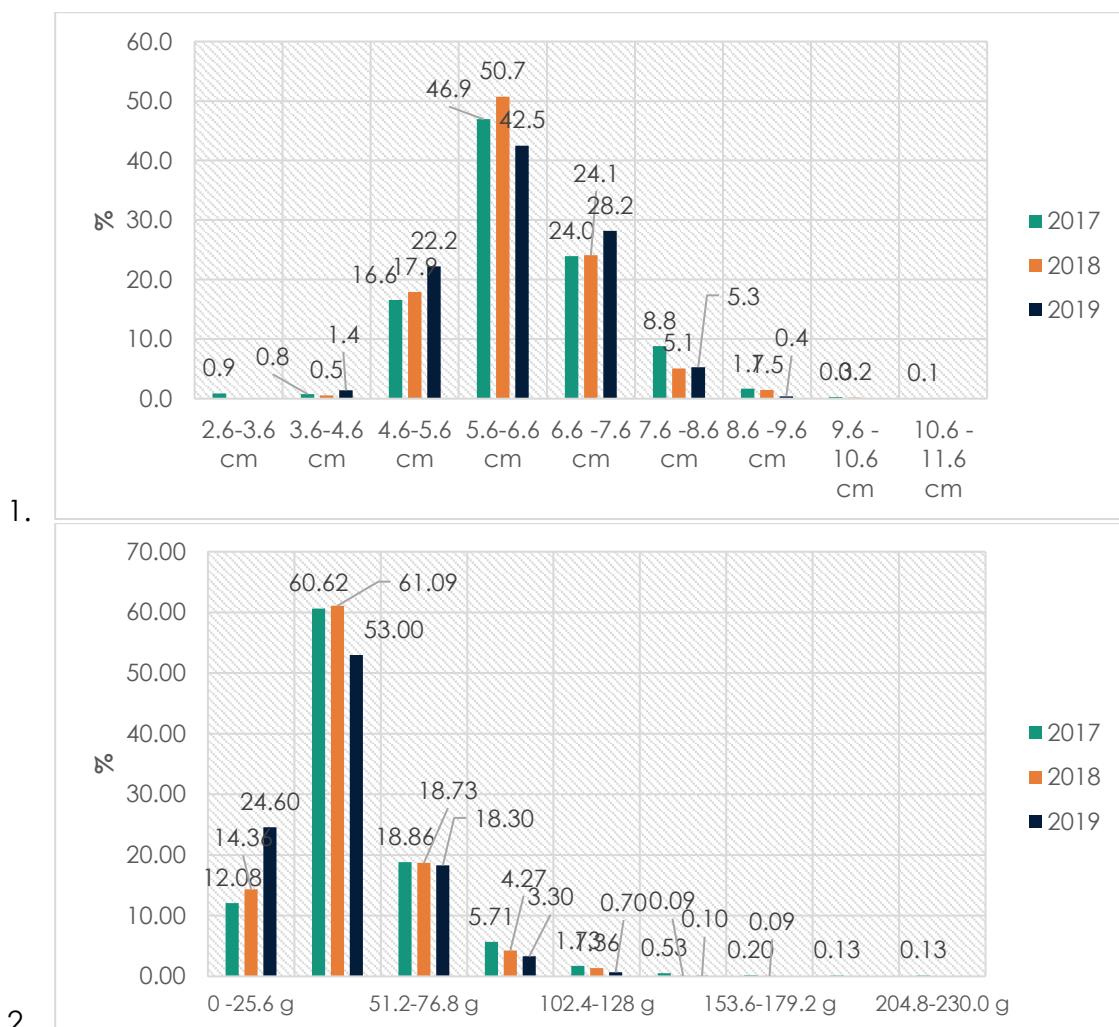


Fig.8. Percentage ratios of the main linear (1) and weight classes (2) of *Rapna* catch with beam trawls, 2017 – 2019



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Table 7

Statistical data about the distribution of the length (mm, 1) and weight (g, 2) classes of Rapa whelk, summary for 2018 - 2019

1	Lower bound	Upper bound	Frequency	Relative frequency	Density
	26	36	0	0.000	0.000
	36	46	20	0.010	0.001
	46	56	423	0.201	0.020
	56	66	975	0.464	0.046
	66	76	552	0.263	0.026
	76	86	108	0.051	0.005
	86	96	20	0.010	0.001

2	Lower bound	Upper bound	Frequency	Relative frequency	Density
		<25.6	404	0.192	0.008
	25.6	51.2	1202	0.572	0.022
	51.2	76.8	389	0.185	0.007
	76.8	102.4	80	0.038	0.001
	102.4	128	22	0.010	0.000
	128	153.6	2	0.001	0.000
	153.6	179.2	1	0.000	0.000

The summarized data about the parameters a, b of the linear-weight relationship: $TW(g) = a \cdot SL(mm)^b$ and the value of the correlation coefficient R^2 by quarters for 2017 – 2019 are presented in Table 8.

Table 8

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

$TW(g)$ $= a \cdot SL(mm)^b$	2017		2018		2019	
	I-II	III-IV	I-II	III-IV	I-II	III-IV
a	0.00000964	0.000223269	0.000587254	0.000323114	0.0000721676	0.000100416
b	3.14	2.91	2.70	2.83	3.19	3.10
R²	0.93	0.91	0.92	0.77	0.90	0.86

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The comparative analysis of the parameter b of the L-W relationship: $TW(g) = a \cdot SL(mm)^b$ shows allometric growth of *R. venosa* in all samples at a coefficient $b \neq 3$ (Fig.9).

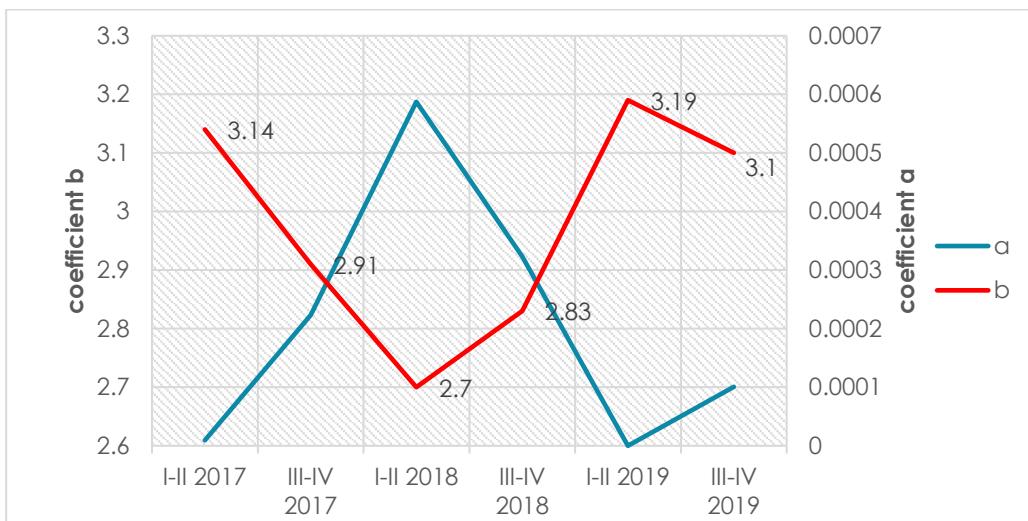


Figure 9. Parameters a , b of the linear-weight relationship: $TW(g) = a \cdot SL(mm)^b$, by quarters for 2017 – 2019 (for Rapa whelk catches with beam trawl).

The parameter $b > 3$ is an indicator for a positive allometric growth, which means that the bigger specimens grow faster in weight than in length. The coefficient b has the lowest value = 2.7 in the first half of 2018, while the highest values of $b = 3.1$ - 3.2 were observed in the samples from 2019 (Fig. 9). The negative allometric growth ($b < 3$) is an indicator that the growth in length is faster than the growth in weight. Potential causes for changes in growth pattern include availability of food, environmental condition and sex structure of the species.

The average ratio of Wd/SL is 75.01 %, with small variations by quarters in 2018 – 2019 (Fig.10). Accordingly, the ratio of AL/SL is 69.5 % and varies between 48.2 % and 71.6 % by quarters. The average value of the ratio AL/Wd (%) is 92.6 %, with significant variations between 64 % - 96.2 % by quarters in 2018-2019. (Fig. 10).



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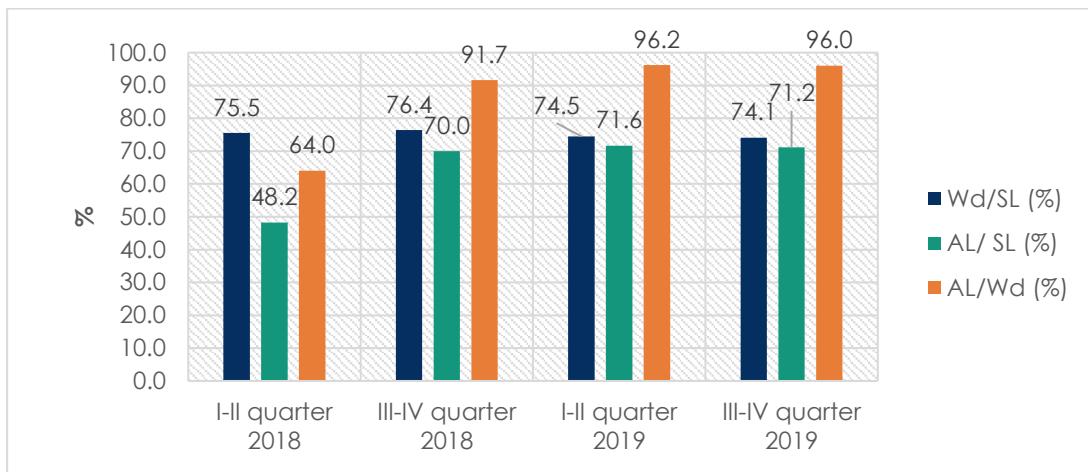


Figure 10. Percentage ratios between the width and length of the shells (Wd/SL, %) of *R. venosa*, aperture length / total shell length (AL/SL, %) and aperture length / shell width (AL/Wd, %) by quarters for 2018 - 2019

3.2. Sex structure

The sex ratio is 44.02 % ♀: 54.73 % ♂, averaged for the period 2018 – 2019; imposex forms were observed only in the 2nd half of 2018 (Fig. 11).

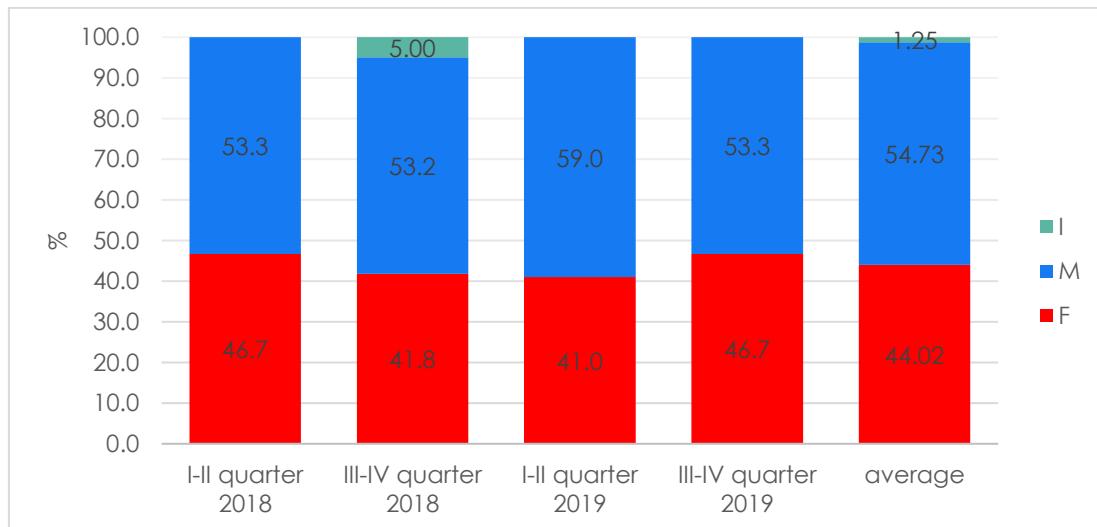


Figure 11. Sex structure of *R. venosa* by quarters for 2018 - 2019

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The average length of the male specimens is $63.99 \text{ mm} \pm 4.31 \text{ SD}$ during 2018 – 2019, the biggest length - 69.61 mm is measured in the Port Balchik in the 2nd half of 2018, while the smallest - 52.73 mm is found also in Balchik but in the 2nd half of 2019 (Table 9.1, Fig.12.1). The average weight of the male specimens is $44.45 \text{ g} \pm 8.79 \text{ SD}$ (Table 9.2, Fig.12.2).

The average length of the female specimens was $60.63 \text{ mm} \pm 3.95 \text{ SD}$, which makes a difference of 5.4 % compared to the average length of the males. The average weight of the female specimens is $37.33 \text{ g} \pm 7.29 \text{ SD}$, or 17% less than the male specimens.

Table 9

Statistical data about the length (SL, mm, 1) and weight distribution (TW, g, 2) by sex from the landings in 2018 – 2019

A. 2018

1. Shell length (SL, mm)

Date	Port	Observations number	Sex	Minimum SL, mm	Maximum SL, mm	Mean SL, mm	Std. deviation
18.06.2018	Varna	16	M	57.000	83.000	68.250	8.185
		14	F	54.000	84.000	64.714	8.324
12.07.2018	Kavrana	28	M	45.000	70.000	58.464	6.597
		22	F	45.000	71.000	58.227	5.871
27.07.2018	Varna	31	M	53.000	78.000	62.433	7.162
		18	F	53.000	64.000	58.389	3.517
28.07.2018	Balchik	23	M	53.000	90.000	69.609	9.199
		24	F	52.000	85.000	65.917	8.277
01.09.2018	Balchik	22	M	52.000	81.000	62.955	8.477
		20	F	48.000	85.000	61.150	7.768
07.11.2018	Varna	25	M	52.000	74.000	62.200	5.759
		25	F	50.000	76.000	63.760	6.809

2. Total weight (TW, g)

Date	Port	Observations number	Sex	Minimum TW, g	Maximum TW, g	Mean TW, g	Std. deviation
18.06.2018	Varna	16	M	26.000	88.500	55.000	19.235
		14	F	25.500	74.000	47.607	15.244
12.07.2018	Kavrana	28	M	13.000	51.500	34.589	11.221

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		22	F	18.000	56.500	33.682	9.449
27.07.2018	Varna	31	M	23.000	87.000	46.194	17.287
		18	F	24.000	45.000	34.361	6.266
		23	M	22.000	123.000	60.891	22.667
28.07.2018	Balchik	24	F	25.000	106.500	49.833	19.662
		22	M	17.500	88.000	42.773	17.646
		20	F	19.500	78.000	37.190	13.849
07.11.2018	Varna	25	M	14.500	67.500	38.040	12.961
		25	F	15.500	86.500	43.380	15.021

B. 2019

1. Shell length (SL, mm)

Date	Port	Observations number	Sex	Minimum SL, mm	Maximum SL, mm	Mean SL, mm	Std. deviation
23.05.2019	Varna	37	M	56.000	88.000	67.838	8.177
		19	F	57.000	71.000	62.842	4.375
31.05.2019	Varna	30	M	49.000	83.000	64.067	9.199
		20	F	51.000	81.000	60.400	7.258
14.06.2019	Varna	31	M	56.000	87.000	67.806	8.159
		19	F	56.000	69.000	60.737	3.754
22.06.2019	Kavarna	24	M	48.000	74.000	60.792	7.934
		26	F	49.000	75.000	58.115	6.719
3.07.2019	Balchik	26	M	45.000	68.000	52.731	5.869
		24	F	44.000	70.000	51.458	6.633
24.09.2019	Varna	28	M	56.000	76.000	64.143	4.912
		22	F	49.000	73.000	60.000	6.325
25.09.2019	Kavarna	22	M	59.000	80.000	67.500	4.362
		28	F	59.000	74.000	65.000	2.944
08.11.2019	Kavarna	27	M	54.000	81.000	67.481	7.095
		23	F	49.000	67.000	56.913	4.907
12.11.2019	Kavarna	27	M	46.000	83.000	64.037	10.494
		23	F	50.000	70.000	59.522	5.751
16.11.2019	Kavarna	30	M	48.000	78.000	63.567	8.593
		20	F	47.000	77.000	62.900	9.447

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2. Total weight (TW, g)

Date	Port	Observations number	sex	Minimum TW, g	Maximum TW, g	Mean TW, g	Std. deviation
23.05.2019	Varna	37	M	27.500	101.500	52.838	18.620
		19	F	31.000	66.000	43.737	9.353
31.05.2019	Varna	30	M	21.000	105.500	43.867	22.206
		20	F	19.500	89.000	36.025	15.839
14.06.2019	Varna	31	M	30.000	97.000	52.468	18.601
		19	F	28.000	64.500	38.526	8.953
22.06.2019	Kavarna	24	M	16.000	68.500	38.250	16.797
		26	F	16.000	100.000	34.942	19.439
3.07.2019	Balchik	26	M	14.500	52.000	24.404	10.246
		24	F	12.500	73.000	25.646	13.621
24.09.2019	Varna	28	M	30.000	69.500	43.286	10.042
		22	F	13.000	55.000	34.295	10.519
25.09.2019	Kavarna	22	M	34.000	87.000	50.136	12.941
		28	F	34.000	65.000	45.161	7.773
08.11.2019	Kavarna	27	M	20.000	92.500	45.963	18.140
		23	F	14.500	49.000	24.391	9.423
12.11.2019	Kavarna	27	M	15.500	93.500	40.278	23.689
		23	F	17.000	57.500	30.217	11.333
16.11.2019	Kavarna	30	M	16.500	107.500	42.150	24.957
		20	F	13.500	77.500	38.350	18.125

The biggest average lengths and weights for both sexes were measured in 1st half of 2018, followed by a significant decrease in the 2nd half of 2018. The lowest values were observed in the 2nd half of 2019 (Fig.12).

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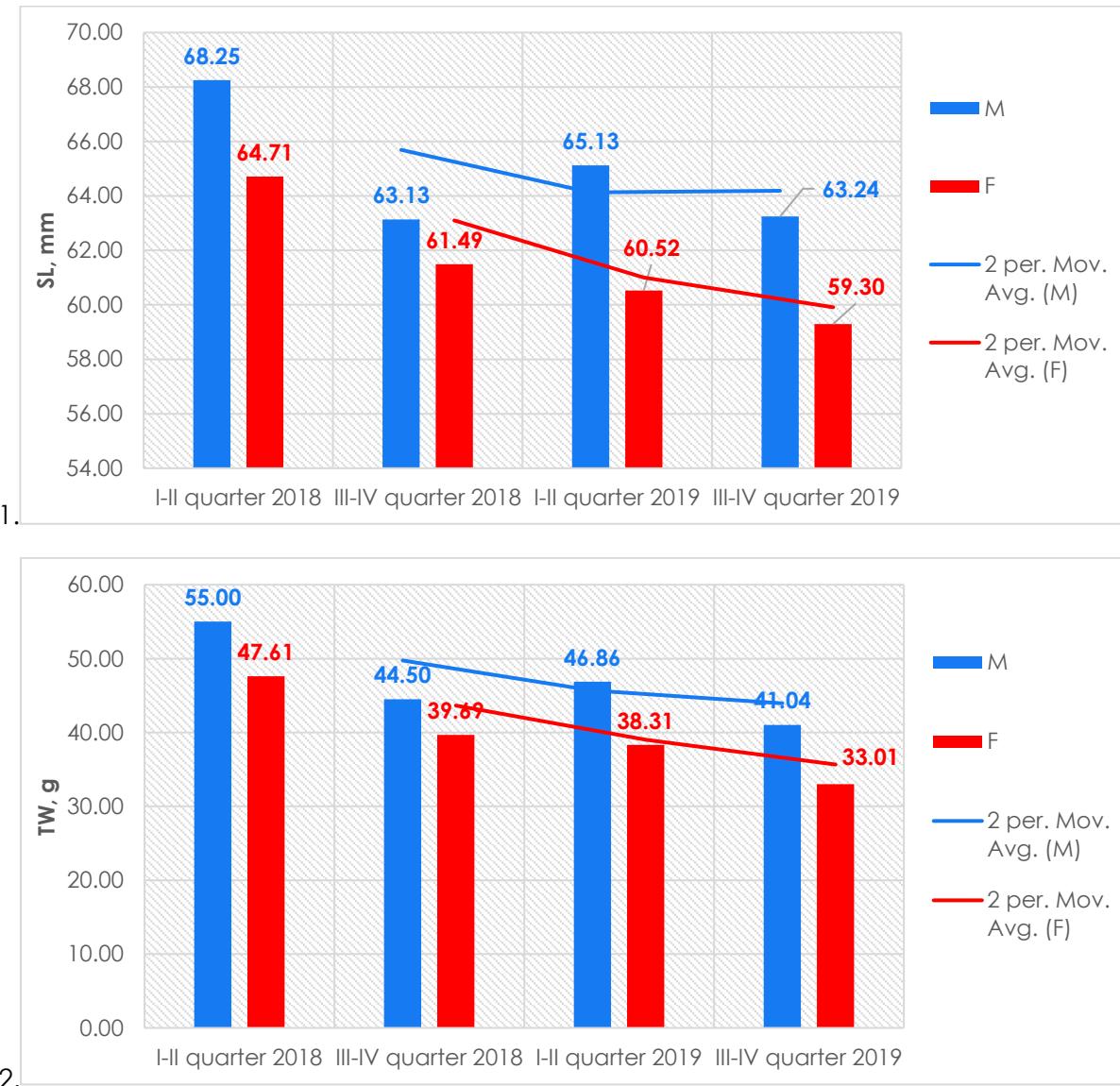


Figure 12. Summarized data about (1) average length (SL, mm) by sex of *R. venosa* and (2) average total weight (TW, g) by sex for the respective quarters 2018 – 2019

For both sexes, the dominant length class is - 56 - 66 mm, forming on average 40.64 % of the male specimens and 49.74 % of the female specimens for 2018-2019. The length class 66 - 76 mm is the second dominant in the length structure, with an average share of 30.69 % for males and 24.20 % for the female specimens (Fig. 13).



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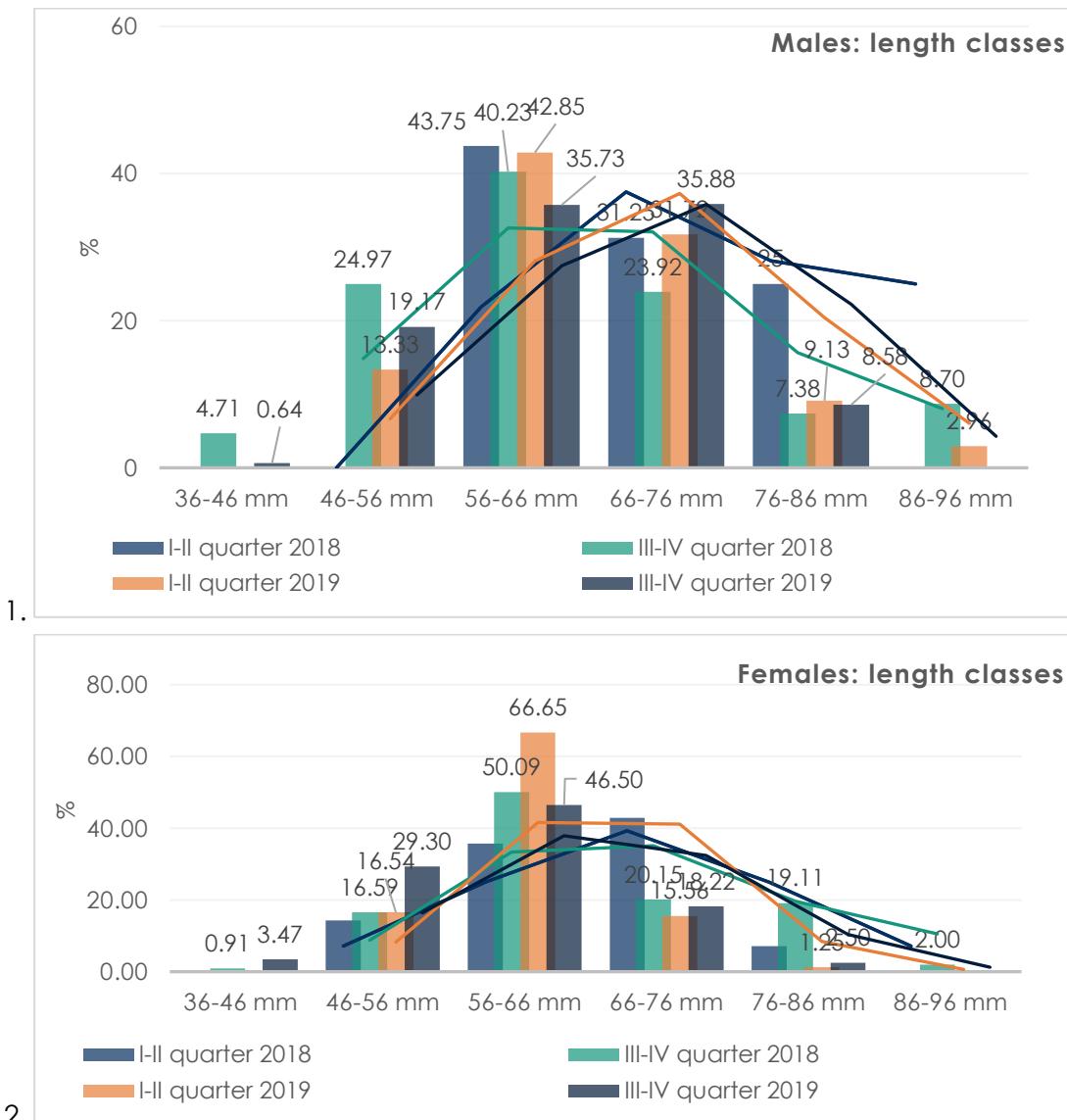


Figure 13. Percentage distribution of the length classes (SL, mm) for the males (1) and female specimens (2) in 2018-2019

The dominant weight class is - 25.6 - 51.2 g, observed in 51.5 % of the male specimens and 59.7 % of the female specimens (Fig. 14). Second by importance is the weight class 51.2 – 76.8 g, with shares - 28.6 % of the male specimens and 21.3 % of the females. The low weight class (< 26 g) is found for 12 % of the male specimens and 17.5 %

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of the female specimens, while the biggest weight class (>76.8 g) is represented by 8 % of the males' specimens and 1.5 % of the females.

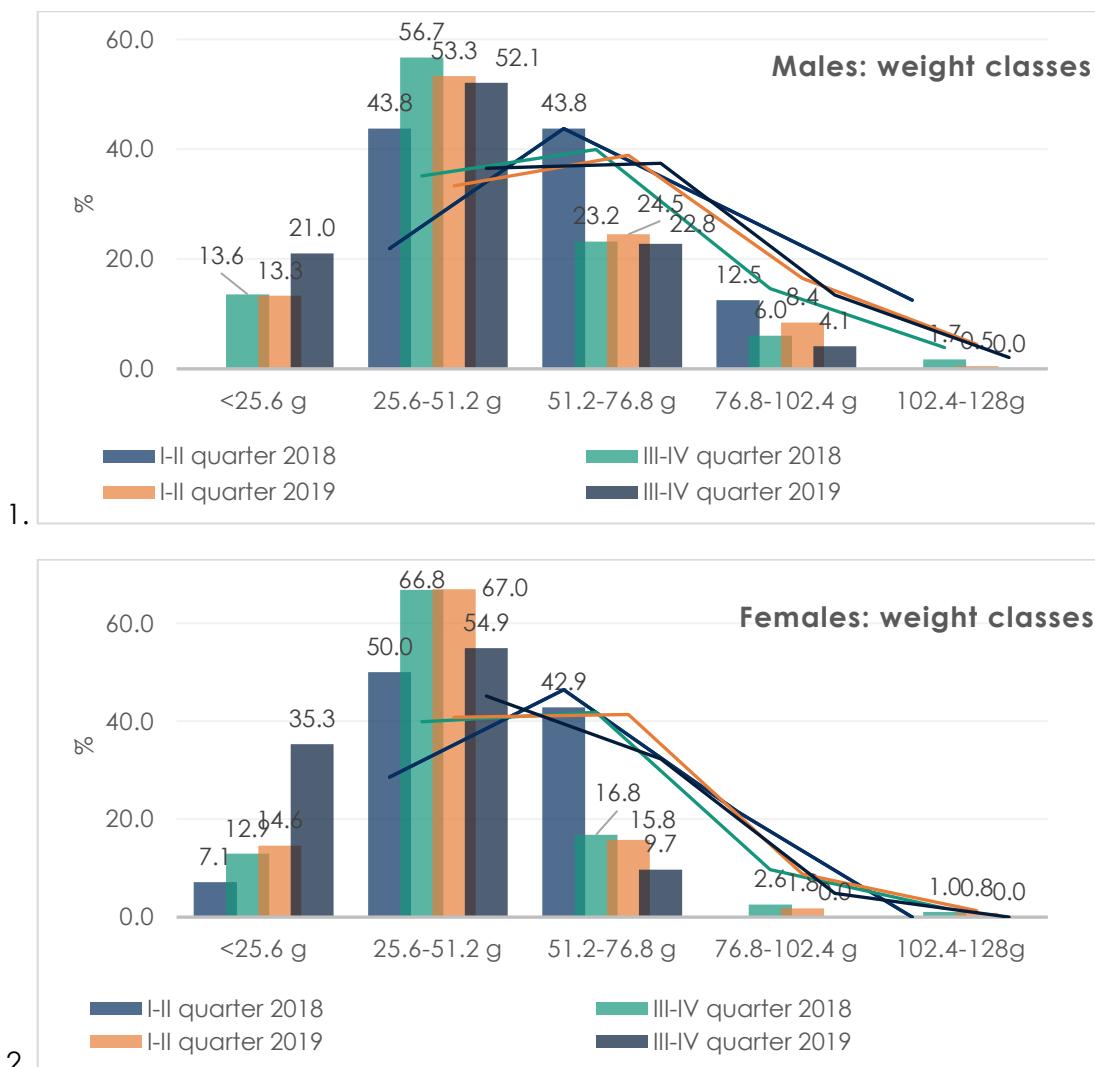


Figure 14. Percentage distribution of the weight classes (TW, g) for the males (1) and female specimens (2) in 2018 - 2019

3.2.1. Gonadosomatic index (GSI)

The summarized statistical data for the GSI dynamics for the period 2018 – 2019 are presented in Table 10.

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Table 10

Summarized statistics of the GSI (% BW) by ports, using the beam trawl technique for Rapa whelk catch, 2018 - 2019

1. XI.2018 г. - V.2019

	7.11.2018	23.05.2019	31.05.2019	14.06.2019	22.06.2019
Mean	13.98	15.36	22.84	14.96	15.07
Standard Error	0.67	0.40	0.79	0.61	0.62
Median	13.50	15.00	23.08	14.80	14.42
Mode	17.00	14.29	23.53	17.24	14.29
Standard Deviation	4.77	2.87	5.59	4.31	4.39
Sample Variance	22.78	8.21	31.22	18.57	19.25
Kurtosis	-1.02	0.39	-0.28	1.23	0.91
Skewness	0.23	-0.05	-0.35	-0.29	0.86
Range	16.50	13.79	22.62	22.06	20.88
Minimum	6.50	8.16	10.71	2.94	7.69
Maximum	23.00	21.95	33.33	25.00	28.57
Sum	699.00	783.59	1141.84	747.90	753.30
Count	50.00	51.00	50.00	50.00	50.00
Confidence Level (95.0%)	1.36	0.81	1.59	1.22	1.25

2. VII. 2019 г. – XI 2019

	3.07.2019	24.09.2019	25.09.2019	5.11.2019	12.11.2019	16.11.2019
Mean	15.90	12.22	17.53	16.45	15.58	17.20
Standard Error	0.59	0.53	0.34	0.55	0.64	0.55
Median	15.38	11.55	17.57	16.17	14.56	17.39
Mode	14.29	14.81	17.65	16.67	14.29	17.39
Standard Deviation	4.15	3.72	2.40	3.90	4.53	3.92
Sample Variance	17.26	13.82	5.76	15.18	20.53	15.40
Kurtosis	-0.28	1.50	0.12	0.84	6.40	2.77
Skewness	0.20	0.85	0.24	-0.45	1.63	0.78
Range	18.75	19.29	10.63	18.40	29.04	23.22
Minimum	6.25	5.71	12.90	5.41	6.25	7.55
Maximum	25.00	25.00	23.53	23.81	35.29	30.77
Sum	779.05	611.09	876.72	822.59	778.82	859.92
Count	49.00	50.00	50.00	50.00	50.00	50.00
Confidence Level (95.0%)	15.90	12.22	17.53	16.45	15.58	17.20

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The average value of the GSI is $16.10\% \text{ BW} \pm 5.59 \text{ SD}$ for the period 2018-2018, with a maximum of $22.84\% \text{ BW}$ in the sample from Port Varna in May 2019 and minimal value - $12.22\% \text{ BW}$ in September 2019, at the same port.

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4. Conclusions

- The total daily landings of Rapana from the observed ports ranged between 1500 - 10165 kg/day in 2018 - 2019 and were an average - 1961.33 kg/day in 2018 and 4605.5 kg/day - in 2019. The highest landings were observed at the Port Varna in May 2019. Fishing vessels with a power of 220 kW, equipped with beam trawl, may land daily up to 3810 kg Rapana, while the landings from scuba diving (and smaller vessels with power 58 kW) reached up to 985 kg/day.
- Concerning the beam trawl fishery, the average weight of a sample of 100 specimens *R. venosa* was $4.3 \text{ kg} \pm 0.2 \text{ SE}$ for 2018-2019, with a maximal value - 4.72 kg in the first half of 2018, and minimal level - 3.69 kg during the second half of 2019. By scuba diving fishery, the average weight of the sample of 100 specimens *R. venosa* was $8.80 \text{ kg} \pm 1.76 \text{ SE}$ in 2018-2019, with minimal value - 5.80 kg in 2019. A stable tendency of decreasing weight of the samples was found in 2019, especially well pronounced for scuba diving fishery and percentage difference of 69 % between the minimal and maximal weight for 2018-2019.
- The average shell length (SL, mm) of *R. venosa* by beam trawl fishery was $62.31 \text{ mm} \pm 8.29 \text{ SD}$ for 2018 - 2019. This indicator shows a slight decrease (1.1%) in 2019 to $61.97 \text{ mm} \pm 8.33 \text{ SD}$ vs. 2018 - $62.66 \text{ mm} \pm 8.25 \text{ SD}$. The maximal average length of *R. venosa* - 67.30 mm (by beam trawl fishery) was measured at the port of Balchik in July 2018. The percentage difference between the average Rapana lengths from both fishing methods was 18.5%, connected to the selection of large specimens by the scuba diving technique.
- The average weight (TW, g) of *R. venosa* by beam trawl fishery was $41.13 \text{ g} \pm 18.46 \text{ SD}$ for 2018 – 2019, with 8% decreasing in 2019 - $39.47 \text{ g} \pm 18.04 \text{ SD}$, in comparison to 2018 - $42.79 \text{ g} \pm 18.88 \text{ SD}$. The sample with the highest average weight – 54.55 g (by beam trawl fishery) was collected from the Balchik port in July 2018. The percentage difference between the average Rapana weights for the two types of fishery was 68.86 %, in favour of the scuba diving technique.
- The average body weight (BW, g) of the Rapa whelk, collected by beam trawl, was $15.80 \text{ g} \pm 3.10 \text{ SD}$ with a trend for bimodal distribution and growth in the spring and

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early autumn. The Rapana body weight was 40 % of the total weight, averaged for the whole period.

- Some intraannual variations of the Rapa whelk length and weight were established in 2017-2019, e.g, the average lengths/weights were decreasing in the 2nd half of the observed years, with 3-4 % for the lengths and 11-19% for the weights, compared to the 1st half of 2017-2019.
- Based on results from beam trawl fishery, the Rapa whelk population was dominated by length class - 56 - 66 SL mm (46.4 %), followed by length classes - 66 - 76 mm (26.3 %) and 46 - 56 mm (20.1 %). The predominant weight class was - 25.6 – 51.2 g (57.2 %), followed by weight class < 25.6 g (19.2 %) and 51.2 - 76.8 g (18.5 %). In 2019, we observed an increase in the share of the smallest weight class (< 25.6 g) - 24.6%, compared to 14.4 % in 2018.
- The mean ratio Wd/SL was 75.01 % for 2018 – 2019. Accordingly, the ratio of AL/SL was 69.5 % and varied between 48.2 % and 71.6 % by quarters. The mean ratio of the AL/Wd was 92.6 %, with a variation 64 % - 96.2 % by quarters and minimal value in the second quarter of 2018.
- Based on the L-W relationship: $W \text{ (g)} = a \cdot L \text{ (mm)}^b$ we established allometric growth of *R. venosa* in 2018-2019, at a coefficient $b \neq 3$. This coefficient was lowest - 2.7 in the 1st half of 2018, while the highest constant $b = 3.2$ was observed in the 2nd half of 2019. When the coefficient $b > 3$, it shows positive allometric growth, i.e the bigger specimens grow faster in weight than in length. The growth patterns changes might be related to food availability, ecological conditions, sex structure, growth stages, etc.
- Concerning the sex structure, the ratio between males and female specimens in 2018-2019 was 44.02 % ♀: 54.73 % ♂. The presence of imposex forms is rarely observed, mainly in the second half of 2018.
- The average shell length (SL, mm) of the male specimens is $63.99 \text{ mm} \pm 4.31 \text{ SD}$ for 2018 - 2019 г., while the average weight is $44.45 \text{ g} \pm 8.79 \text{ SD}$ (data from beam trawl fishery). The average length of the female specimens is $60.63 \text{ mm} \pm 3.95 \text{ SD}$, by a percentage difference of 5.4 % compared to males. Concerning the weight of the

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females, the pattern is similar, with an average weight of $37.33 \text{ g} \pm 7.29 \text{ SD}$ and a percentage difference of 17 % between the sexes.

- For both sexes, the most common length class was - 56 - 66 mm, forming on average 40.64 % of the male specimens and 49.74 % of the female specimens. Concerning the weight structure, the predominant weight class was – 25.6 – 51.2 g, observed for 51.5 % of the male specimens and 59.7 % of the female specimens. The second most common weight class was 51.2 – 76.8 g, or 28.6 % of the male specimens and 21.3 % of the females. The specimens with low weights < 26g were 12 % of the males and 17.5 % of the females, while the bigger specimens >76.8 g were just 8 % of the males and 1.5 % of the females.
- The mean value of the GSI for 2018 – 2019 was 16.10 % BW. The maximal value was observed in the Port Varna (31.05.2019) - 22.84 % BW $\pm 5.59 \text{ SD}$, while the minimum was observed also in Varna in September 2019.

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