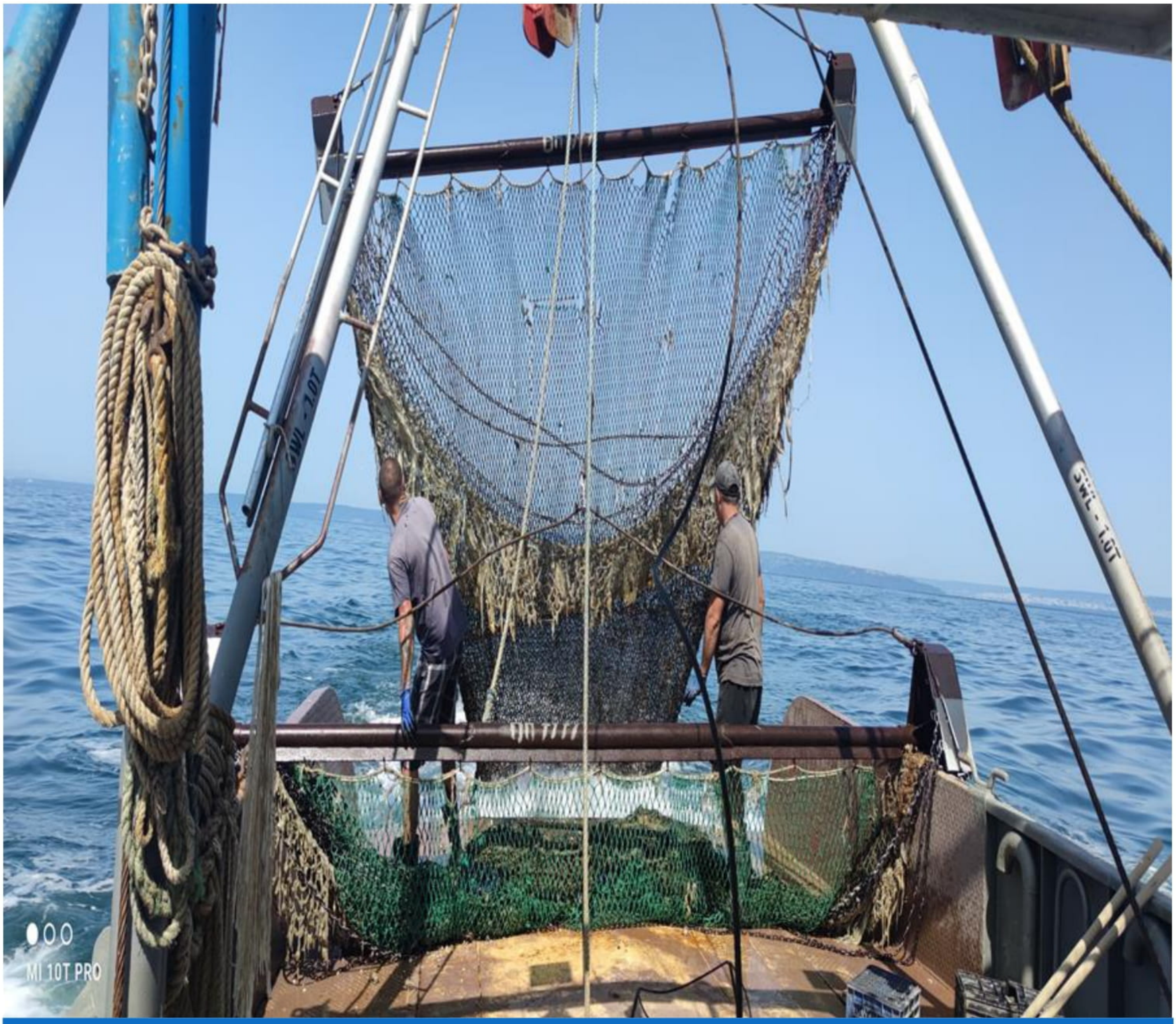

Scientific report

Scientific research to estimate catch, bycatch, discarded and landed quantities, collection of biological data on all species of fish and other marine organisms, and collection of data on vulnerable, protected and endangered species, by observers on board fishing vessels from the fleet of the Republic of Bulgaria, which carry out fishing activities in the Black Sea in 2024

Institute of Fish Resources Varna, AA

5/10/25

№ D -148 /10.03.2023

Съфинансирано от Европейския съюз

МИНИСТЕРСТВО НА ЗЕМЕДЕЛИЕТО И ХРАНИТЕ

ПРОГРАМА ЗА МОРСКО ДЕЛО, РИБАРСТВО И АКВАКУЛТУРИ

This study was conducted by specialists at the Institute of Fish Resources (IFR), Varna, Agricultural Academy (AA), under a contract with EAFA/D -148 /10.03.2023, to scientifically assess the catch, bycatch, discarded, and landed quantities of different types of fishing activities in the Bulgarian waters of the Black Sea in 2023-2024.

The study was carried out with the financial support of the European Commission in accordance with Regulation (EU) 2017/1004 of the European Parliament and Council of May 17, 2017, establishing a union framework for the collection, management, and use of data in the fisheries sector and for support in the preparation of scientific opinions in relation to the common fisheries policy, and repealing Regulation (EC) No 199/2008 of the Council (recast).

The present study was conducted in 2024 in the Bulgarian waters of the Black Sea, and covered the following fishing activities: gillnet fishery, pelagic trawling, beam trawling, and polyvalent vessels with active and passive gear. The impact of the industrial fishery was assessed according to the percentage of bycatch by fishing activities and segments, and based on the bycatch coefficient of sensitive species.

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Petrova E., Mihneva V., Tserkova F., Stoykov St., Georgiev K., Valchev S., Uzunova S., Penchev F., Nedkova L., Husein A. 2025. Scientific research on the assessment of catch, bycatch, discarded, and landed quantity, collection of biological data on all types of fish and other marine organisms, and collection of data on vulnerable, protected, and endangered species by observers on board fishing vessels from the fleet of the Republic of Bulgaria, which carries out fishing activities in the Black Sea in 2024. Report on a contractual assignment with the Executive Agency for Fisheries and Aquaculture, in connection with the National Program for the collection and management of data from the "Fisheries" sector in 2024, 89 pages.

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Съфинансирано от Европейския съюз

МИНИСТЕРСТВО НА ЗЕМЕДЕЛИЕТО И ХРАНИТЕ

ПРОГРАМА ЗА МОРСКО ДЕЛО, РИБАРСТВО И АКВАКУЛТУРИ

SCIENTIFIC RESEARCH TO ESTIMATE CATCH, BYCATCH, DISCARDED, AND LANDED QUANTITIES, COLLECTION OF BIOLOGICAL DATA ON ALL SPECIES OF FISH AND OTHER MARINE ORGANISMS, AND COLLECTION OF DATA ON VULNERABLE, PROTECTED, AND ENDANGERED SPECIES BY OBSERVERS ON BOARD FISHING VESSELS FROM THE FLEET OF THE REPUBLIC OF BULGARIA, WHICH CARRY OUT FISHING ACTIVITIES IN THE BLACK SEA IN 2024

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

1. Introduction

This study aimed to collect data and analyse the catch, bycatch, discarded, and landed quantities of marine organisms during the main types of fishing activities in the Bulgarian fishing fleet. The 2024 survey included 100 days of scientific observations of the following vessel types:

(1.) for turbot fishing by using gill nets.

(2.) for pelagic and demersal species fishing through pelagic trawling.

(3.) for rapa whelk fishing via beam-trawling.

(4.) for the fishing bottom and pelagic species using polyvalent active and passive gear, respectively.

The current report includes data on the dynamics of the total amount of the target species, as well as on the qualitative and quantitative composition of the incidental bycatch of accompanying marine organisms. Samples were collected from the target fish catch, allowing the determination of biological parameters, such as length, weight, age, and sex. Measurements were made of the absolute and standard length of bycatch organisms, their individual weight, and otoliths collected to determine the age of bycatch fish, and the sex structure and maturity stages of bycatch were analysed (when applicable). Samples were collected from the bycatch to determine the nutritional spectra of some fish species.

Based on the conducted field and laboratory studies, the dynamics of the total amount of bycatches compared to the target catches, the quantity and seasonal dynamics of the bycatch species, the size-age structure of the catches, and the main species in the bycatch were characterized, and the nutritional spectrum of some species from bycatch was analysed. The impact of commercial fishing was assessed according to the bycatch rate by fishery type and fishing segment, and the bycatch coefficient of the registered sensitive marine species by fishing activity and fishing segments was calculated.

1.1 Collected data

Several types of data were collected, as prescribed by the FAO (2019a, 2019b, 2024) and GFCM (Edited draft, VI.2018), concerning scientific observations of bycatches on board fishing vessels in the Mediterranean and Black Seas:

1. Data on the activity of fishing vessels

- Geographical coordinates
- Date of fishing expedition
- Port of departure and arrival

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- Name of the fishing vessel
- Type of vessel
- Vessel length (m).

2. Fishing gear

- Characteristics of fishing gears
- Total number of fishing operations per fishing expedition
- Depth range of fishing activities.

3. Basic biological data

- Total weight (kg) of marine organisms' bycatch
- Weight (kg) of total catch (bycatch + main catch, TC)
- Weight (kg) of discards of marine organisms
- Data on the size and weight structure of species from catches and bycatch
- Data on protected, endangered and vulnerable species (Protected, Endangered, and Threatened Species, PETS).

4. Additional data

- Biological data on sex and age
- Data on the nutritional spectrum of some species from bycatch
- In beam trawling, significant quantities of crushed mussel shells and marine debris fall into trawls, as described in separate tables.
- For the collected PETs, along with species identification and biological parameters, additional information was collected on the condition of the animals (when possible): Dead; A0: Alive (float away); A1: Alive and in good condition; A2: Alive; minor injuries/stress high probability of survival; A3: Alive; life-threatening injuries/severe stress unlikely to survive.

The results are presented in the form of tables, maps, and figures.

- Quantities of catches of priority species and bycatches by type of fishing activity and fishing segments
- Species composition and seasonal changes in bycatch
- Biological data (amount, size, sex, age, nutritional spectrum) for species in the bycatch and dynamics of quantities by fishing activities
- Percentage share of bycatch compared with total catches (target catches + bycatch) in the studied types of fishing activities
- Impact of commercial fishing by sector based on the indicator values of the bycatch rate (% TC) and determination of the bycatch coefficient of sensitive marine species.

2. Material and methodology

2.1 Sampling schemes

Scientific observers are dispatched on a random principle to fishing vessels using the following gears: (1) gill nets, (2) pelagic trawls, (3) beam trawls for rapa whelk, and (4) polyvalent gears.

The preliminary research plan was based on the following information:

- vessel activity during the previous three-year period (2020–2022); therefore, the survey should cover actively operating vessels with a significant contribution to individual types of fishing activities.

- estimated monthly activity by activity;

- тhe fishing day is considered to be the basic unit of observation (Stratoudakis et al. 1998).

The sample collection followed the recommendations of:

- FAO (2019a): “Monitoring fishing discards in the Mediterranean and Black Seas: data collection methodology”,
- FAO (2019b): Monitoring bycatch of vulnerable species in Mediterranean and Black Sea fisheries: Methodology for data collection' and
- FAO (2024) "Technical Guidelines for Scientific Research in the Mediterranean and Black Sea.”

2.1.1 Vessels with gill nets

The research covers 30 fishing days of three fishing vessels, including fishing segment DFN VL0612 (Table 1 § 2).

Table 1.

Characteristics of gill net vessels.

Name of fishing vessel	Specifications	Fishing segment
ШБ 6004	1.16 GT, 6.5 m; 33.5 kW	DFN VL0612
ШБ 5927	1.3 GT, 7 m, 16.18 kW	DFN VL0612
КВ 6245	1 GT, 6.3 m, 23.54 kW	DFN VL0612

The research was conducted with gillnets with the following functional and technical parameters: size of the trawl "eyes" of up to 400 mm; average length of the net, 900 m; and duration of water soaking, 13.9 days ± 0.71 SE.

Data on fishing expeditions with gill nets and the dates and coordinates of the study regions are presented in Table 2. These studies were concentrated in the Shabla – Durankulak region (Fig. 1).

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Table 2.

Gillnet fishery observations in 2024.

Date	Fishing segment	Latitude	Longitude	Duration of fishing operation (days)	Net length (m)	Availability of Acoustic Deterrent Devices (ADDs)
13.02.2024	DFN VL0612	43.6697	28.7769	12	900	+
04.03.2024	DFN VL0612	43.7406	28.8689	10	900	+
09.03.2024	DFN VL0612	43.7161	28.8608	26	900	+
16.03.2024	DFN VL0612	43.8483	28.6556	10	900	+
17.03.2024	DFN VL0612	43.8458	28.7875	11	900	+
29.03.2024	DFN VL0612	43.7053	28.7258	20	900	+
31.03.2024	DFN VL0612	43.8536	28.7394	18	900	+
01.04.2024	DFN VL0612	43.8342	28.9119	19	900	+
13.04.2024 a	DFN VL0612	43.6670	28.6340	12	900	+
13.04.2024 b	DFN VL0612	43.7000	28.6170	14	900	+
13.04.2024 c	DFN VL0612	43.9064	28.9033	16	900	+
14.04.2024 a	DFN VL0612	43.6830	28.6670	13	900	+
14.04.2024 b	DFN VL0612	43.7000	28.6500	15	900	+
14.04.2024 c	DFN VL0612	43.9261	28.7336	17	900	+
26.06.2024	DFN VL0612	43.7756	28.7569	10	900	+
08.07.2024	DFN VL0612	43.8922	28.7489	7	900	+
17.07.2024	DFN VL0612	43.7392	28.9067	10	900	+
21.07.2024	DFN VL0612	43.6694	28.7783	15	900	+
22.07.2024 a	DFN VL0612	43.8958	28.8378	10	900	+
22.07.2024 b	DFN VL0612	43.8958	28.8378	9	900	+
08.08.2024	DFN VL0612	43.7825	28.8975	11	900	+
04.09.2024	DFN VL0612	43.7461	28.8431	14	900	+
02.09.2024 a	DFN VL0612	43.8575	28.7783	12	900	+
02.09.2024 b	DFN VL0612	43.8550	28.9619	14	900	+
06.09.2024	DFN VL0612	43.8939	28.7439	14	900	+
8.10.2024	DFN VL0612	43.9322	28.7450	14	900	+
17.12.2024 a	DFN VL0612	43.8175	28.8328	14	900	+
17.12.2024 b	DFN VL0612	43.7094	28.8031	16	900	+
18.12.2024 a	DFN VL0612	43.7078	28.7444	18	900	+
18.12.2024 b	DFN VL0612	43.8942	28.8378	14	900	+

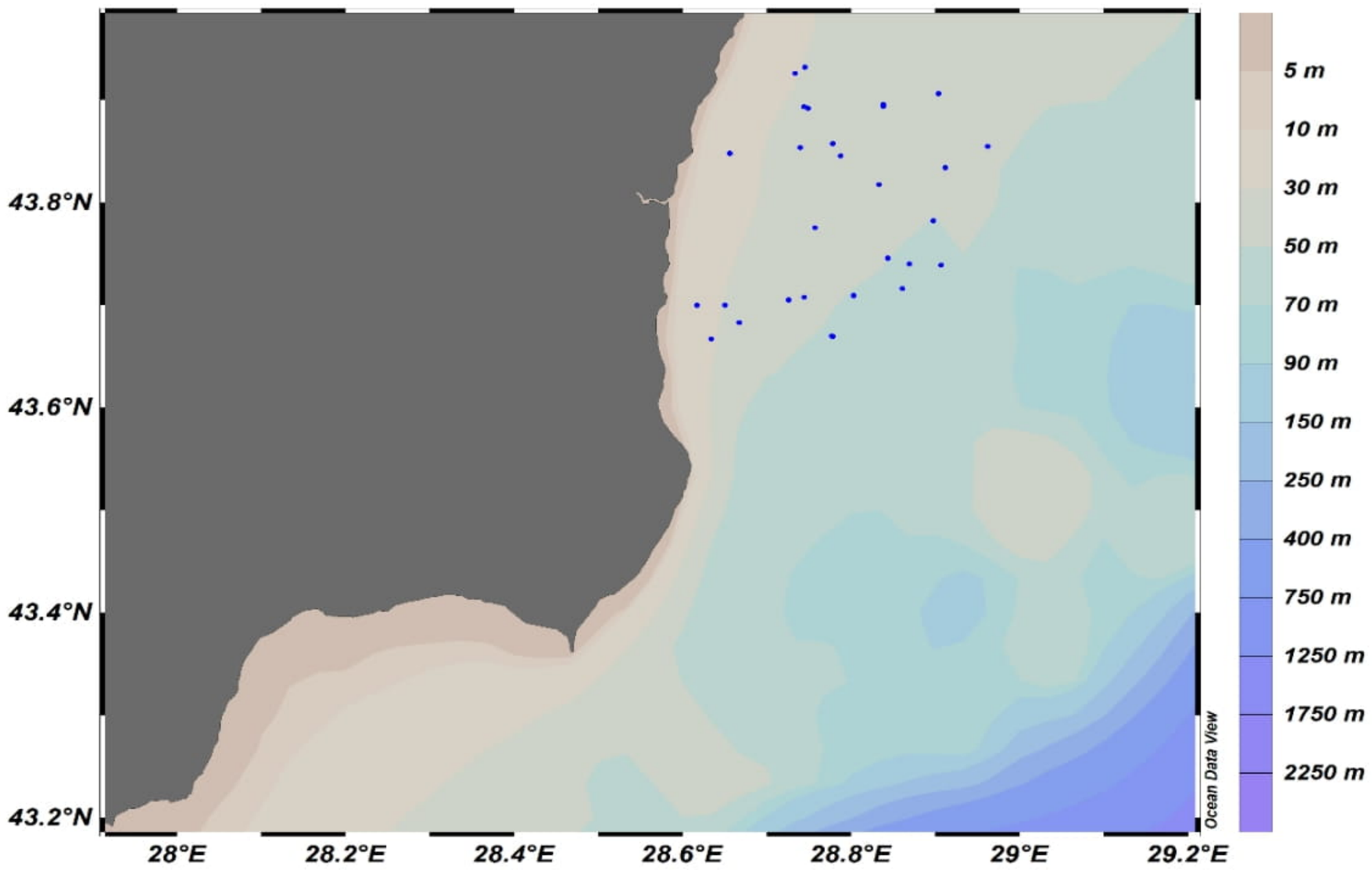

Fig. 1. Map of observed gillnet fishing expeditions.

2. 1.2 Pelagic trawl vessels

The study covers 30 fishing days, onboard four fishing vessels (Table 3, Fig. 2), trawling mainly for sprat, during the period III-XI 2024. The fishing vessels belonged to two segments: TM VL1218 (one vessel, eight fishing days) and TM VL2440 (three vessels, 22 fishing days).

Table 3.

Characteristics of pelagic net vessels.

Name of fishing vessel	Fishing vessel number	Specifications	Fishing segment
РК 26	БС 219	117.4 GT, 25.5 m, 220.7 kW	TM VL2440
РК 28	БС 221	117.36 GT, 25.5 m, 220.65 kW	TM VL2440
РК Meduza 3	БС 288	117 GT, 25.45 m, 225 kW	TM VL2440
РК Herson	ВН 7979	39.74 GT, 15.9 m, 235 kW	TM VL1218

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1. 

2. 

3. 

4. 

Fig. 2. *Fishing vessels with pelagic trawls: RK 26(1), RK 28 (2), RK Medusa 3 (3), and RK Kherson (4).*

This study was conducted using pelagic trawls with the following functional and technical parameters:

- RK 26: Vertical opening of the trawl - 5 m; Horizontal opening - 25 m; Mesh size of the trawl, up to 8 x 8 mm; Trawl length 50 m. Trawling speed - 2 - 3.7 knots
- RK 28: Vertical opening of the trawl - 4 m; Horizontal opening - 25 m; Effective length of the upper bridle – 21 m; Mesh size of the trawl, up to 6 x 6 mm; Trawl length 50 m. Trawling speed - 2 - 3.7 knots.

- RK Meduza 3: Vertical opening of the trawl - 5 m; Horizontal opening - 25 m; Trawl length - 50 m; Mesh size of the trawl, up to 6.5 x 6.5 mm; Trawling speed - 2 - 3.7 knots.
- RK Herson: Vertical opening of the trawl - 6 m; Horizontal opening - 26 m; Effective length of the upper bridle – 21 m; Mesh size of the trawl, up to 6 x 6 mm; Trawl length 50 m. Trawling speed - 2 - 3.7 knots.

1.  2. 

Fig. 3. *Catching sprat using pelagic trawls.*

Detailed data for the pelagic trawl fishing expeditions are presented in Table 4 and Fig. 4.

Table 4.

Observations of pelagic trawl fisheries in 2024.

Date	Target species	Fishing segment	Departure	Arrival	Latitude	Longitude	Trawling duration (h)	Departure
14.3.2024 a	sprat	TM VL1218	Sozopol	Sozopol	42.439	27.711	5.0	35-35.5
14.3.2024 b	sprat	TM VL2440	Sozopol	Sozopol	42.446	27.724	1.33	36.7-34.7
14.3.2024 c	sprat	TM VL2440	Sozopol	Sozopol	42.443	27.757	4.17	37.8-35.2
14.3.2024 d	sprat	TM VL2440	Sozopol	Sozopol	42.430	27.746	5.02	36.5-36.1
15.3.2024 a	sprat	TM VL1218	Sozopol	Sozopol	42.447	27.715	5.08	36-35.6

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15.3.2024 b	sprat	TM VL2440	Sozopol	Sozopol	42.434	27.718	5.33	35.6-35.7
15.3.2024 c	sprat	TM VL2440	Sozopol	Sozopol	42.447	27.715	5	36.2-35.3
15.3.2024 d	sprat	TM VL2440	Sozopol	Sozopol	42.447	27.735	5.15	36.5-36.5
16.3.2024 a	sprat	TM VL1218	Sozopol	Sozopol	42.433	27.720	4.33	36.8-40.4
16.3.2024 b	sprat	TM VL2440	Sozopol	Sozopol	42.436	27.717	4.75	35.7-34.8
16.3.2024 c	sprat	TM VL2440	Sozopol	Sozopol	42.444	27.754	4.17	37.7-39
16.3.2024 d	sprat	TM VL2440	Sozopol	Sozopol	42.448	27.717	4.62	36.6-36.4
17.3.2024 a	sprat	TM VL1218	Sozopol	Sozopol	42.456	27.722	5.17	36-32.2
17.3.2024 b	sprat	TM VL2440	Sozopol	Sozopol	42.442	27.666	4.67	21.8-35
17.3.2024 c	sprat	TM VL2440	Sozopol	Sozopol	42.441	27.749	4.17	38.1-36.9
17.3.2024 d	sprat	TM VL2440	Sozopol	Sozopol	42.424	27.768	4.25	36.6-37.2
18.3.2024 a	sprat	TM VL1218	Sozopol	Sozopol	42.452	27.719	5	36.1-35.5
18.3.2024 b	sprat	TM VL2440	Sozopol	Sozopol	42.430	27.714	4.75	32.2-35.7
18.3.2024 c	sprat	TM VL2440	Sozopol	Sozopol	42.433	27.722	4.5	38.2-37
18.3.2024 d	sprat	TM VL2440	Sozopol	Sozopol	42.439	27.766	4.25	36.5-36.6
31.10.2024 a	sprat	TM VL2440	Sozopol	Sozopol	42.439	27.749	4.5	37.7-39.8
31.10.2024 b	sprat	TM VL2440	Sozopol	Sozopol	42.448	27.744	5	36.2-43.3
31.10.2024 c	sprat	TM VL2440	Sozopol	Sozopol	42.449	27.732	5.08	36.1-37.8
1.11.2024 a	sprat	TM VL2440	Sozopol	Sozopol	42.450	27.951	3.17	41.3-56.5
1.11.2024 b	sprat	TM VL2440	Sozopol	Sozopol	42.447	27.906	2.33	37.6-49.7
1.11.2024 c	sprat	TM VL1218	Sozopol	Sozopol	42.464	27.903	3.58	38.1-52
2.11.2024 a	sprat	TM VL2440	Sozopol	Sozopol	42.447	27.979	3.08	45.5-50.2
2.11.2024 b	sprat	TM VL2440	Sozopol	Sozopol	42.434	27.973	3.58	44.4-41.3
2.11.2024 c	sprat	TM VL1218	Sozopol	Sozopol	43.417	27.617	3.5	43.6-43
07.11.2024	sprat	TM VL1218	Sozopol	Sozopol	42.425	27.726	5.17	36,6-26

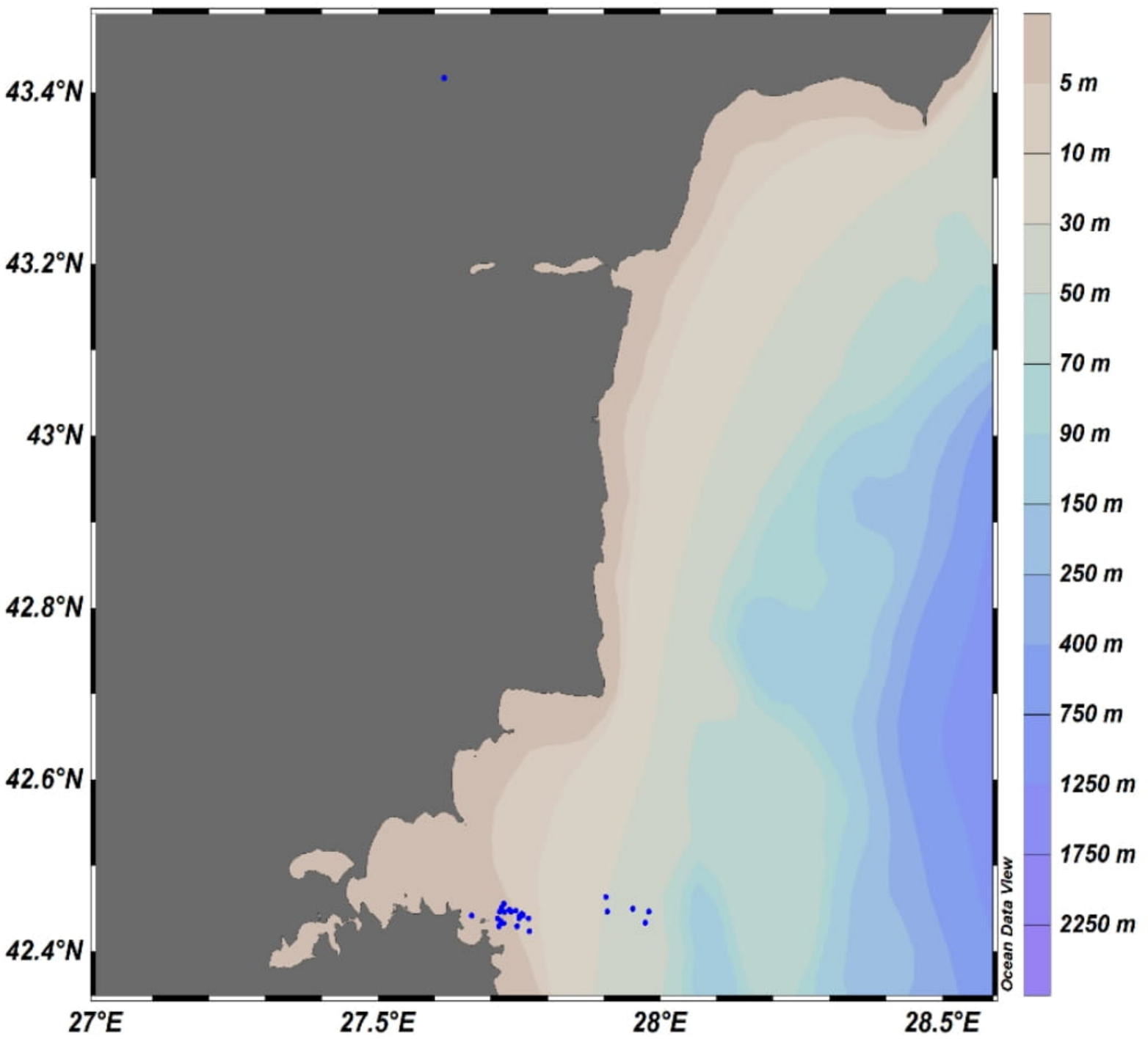


Fig. 4. Map of observed fishing expeditions with OTM.

Fishing expeditions for sprats are carried out in front of the southern part of the wide Burgas Bay, at depths of 21.8 – 56.5 m, with an average trawling duration of 4.32 h ± 0.17 SE.

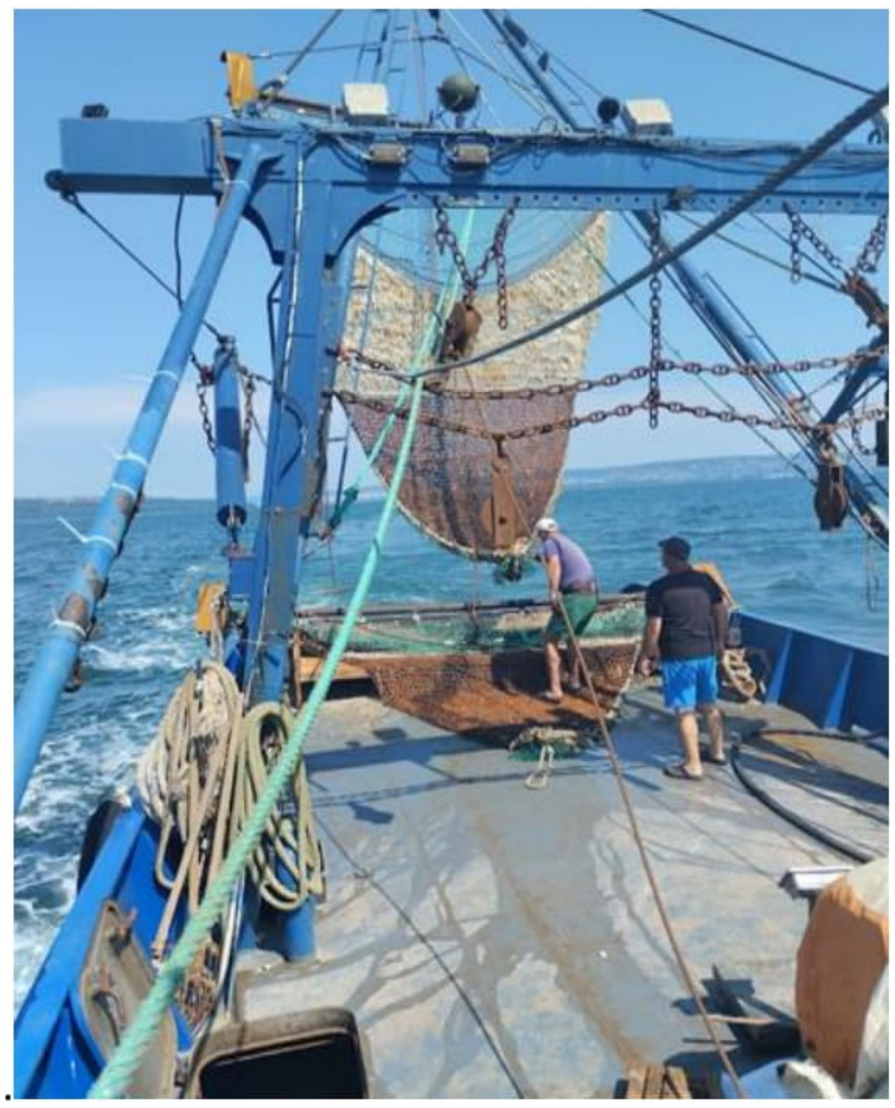
2. 1.3 Rapa whelk fishing vessels

Beam-trawl surveys for rapa whelk fishery included 20 fishing days during the period IV - VI. 2024 (Table 5, Fig. 5). Two fishing segments were covered: vessels 18–24 m long (TBB VL1824, one vessel, 8 fishing days) and vessels 12-18 m long (TBB VL1218, 12 fishing days, two fishing vessels). A total of 106 trawls were monitored for 20 fishing days.

Table 5.

Characteristics of fishing vessels.

Name of fishing vessel	Fishing vessel number	Specifications	Fishing segment
PK Tais	BH 393	46 GT, 19.4 m, 378 kW	TBB VL1824
PK Viking	BH 8406	30.6 GT, 14.52 m, 132.39 kW	TBB VL1218
PK Barbun	BH 7979	19.74 GT, 15.97 m, 235 kW	TBB VL1218



1.

2.

Fig. 5. *Rapa whelk fishery with beam trawl, RK "Tais."*

A standard beam trawl was used, with the following functional and technical parameters: effective part of the trawl - 4.8 m; mesh of the net – 40X40 mm; trawling speed, 3 - 3.6 Nd; and duration of trawling, 1.52 h ±0.04 SE.

The coordinates of the study regions and their corresponding depths are presented in Table 6 and Fig. 6, respectively.

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Table 6.

Observations of rapa whelk fishery in 2024.

Date	Fishing segment	Port departure	N of fishing operations	Latitude	Longitude	Depth	Date
25.04.2024	TBB VL1218	Kavarna	1	43.344	28.342	17-16.7	1.5
			2	43.34	28.422	16.9-16.7	2.5
26.04.2024	TBB VL1218	Kavarna	1	43.345	28.343	17-18	1.5
			2	43.342	28.432	19.6-17.7	1.67
			3	43.349	28.361	16.7-18	1.5
			4	43.342	28.395	16.1-16	1.58
			5	43.347	28.342	16.7-16.8	1.33
27.04.2024	TBB VL1218	Kavarna	1	43.341	28.438	16.5-17.1	2
			2	43.34	28.437	16.8-17	1.17
			3	43.348	28.343	17.1-17.5	1.67
			4	43.341	28.415	16.8-17.5	1.5
			5	43.336	28.345	17.3-16.5	1
30.05.2024	TBB VL1824	Varna	1	43.043	27.96	25-24	1
			2	43.036	27.95	24-25	3.5
			3	43.051	27.98	25-24.5	1.75
			4	43.054	27.98	23.5-24	1.25
			5	43.033	28.145	22-22.5	1.42
31.05.2024	TBB VL1824	Varna	1	42.968	28.087	26-26	1.5
			2	43.035	28.142	26-26	1.1
			3	43.042	28.146	26-26.3	2
			4	43.028	28.14	27-27	1.52
			5	42.91	28.038	22-22.5	2.67
2.06.2024	TBB VL1824	Varna	1	43.06	27.953	21-22	0.75
			2	43.021	27.946	22-23	0.67
			3	42.984	27.943	23-23	0.83
			4	43.043	27.948	21-21.5	1.17
			5	43.021	27.944	22-22.5	0.83
			6	43.076	27.967	20.5-21	1.25
3.06.2024	TBB VL1824	Varna	1	43.02	27.945	26-26.5	1.33
			2	43.019	27.981	27-26	1.25
			3	43.082	27.959	27-27	1.77
			4	43.003	27.952	22-22.5	2.1
			5	43.004	28.082	26-27	1.58
4.06.2024	TBB VL1824	Varna	1	43.039	28.13	22-23	1.5
			2	43.04	28.12	22-23	1.67
			3	43.032	28.127	24-24.5	1.67
			4	43.04	28.138	23-23.5	1.67
			5	43.081	28.128	24-24	2.67

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5.06.2024 a	TBB VL1824	Varna	1	43.032	28.124	23-23.5	1.67
			2	42.953	28.069	23-23.5	0.83
			3	43.075	28.124	24-24.5	2.08
			4	43.147	28.169	22.5-22	3
			5	42.968	28.06	21-22	1.83
5.06.2024 b	TBB VL1218	Varna	1	43.131	28.035	19.8-	1.45
			2	43.076	28.117	25-25	1.37
			3	43.146	28.185	25-25	1.07
			4	43.193	28.229	25.5-25	1.21
			5	43.135	28.167	25.5-25	1.35
			6	43.196	28.227	25.8-25.3	1.17
			7	43.135	28.17	25.6-25.6	1.33
			8	43.185	28.225	26.4-25.3	1.33
			9	43.137	28.169	25.7-25.5	1.25
			10	43.189	28.222	25-25	1.44
6.06.2024	TBB VL1218	Varna	1	43.134	28.161	25-24.7	1.42
			2	43.195	28.223	24.5-25	2.58
			3	43.108	28.132	24.7-20.4	1.62
9.06.2024	TBB VL1218	Varna	1	43.129	28.033	19.8-25.4	1.55
			2	43.086	28.12	25.1-25	1.33
			3	43.156	28.175	24.4-24.6	1.03
			4	43.201	28.231	24.7-25	1.5
			5	43.136	28.158	25-26.3	1.33
			6	43.071	28.121	26.3-26.4	1.38
			7	43.136	28.184	26.6-25.7	1.5
			8	43.141	28.169	25.9-25.4	1.33
			9	43.136	28.17	26.4-26.1	1.5
			10	43.076	28.121	25.8-19.9	1.67
10.06.2024	TBB VL1218	Varna	1	43.125	28.043	20-25.6	1.33
			2	43.076	28.119	25.6-26	1.33
			3	43.134	28.039	19.9-19.8	1.17
12.06.2024	TBB VL1218	Varna	1	43.081	28.103	19.6-16.3	1.33
			2	43.081	28.109	25.1-25.4	1.38
			3	43.143	28.172	25.1-25.4	1.45
			4	43.081	28.107	24.4-25	1.33
			5	43.135	28.159	25-26.1	1.42
			6	43.076	28.133	25.8-26.6	1.37
			7	43.134	28.183	26.2-26	1.48
			8	43.081	28.116	25.6-21.3	0.92
16.06.2024	TBB VL1218	Varna	1	43.079	28.11	25.1-26.5	1.5
			2	43.138	28.178	25.7-25.3	1.53
			3	43.056	28.094	26.8-27.1	1.45
			4	42.979	28.061	27.1-21.7	1.42
			5	43.024	27.981	21.8-25.1	1.87
			6	42.978	28.036	25.6-22	1.35
			7	43.027	27.972	22-26.3	1.53
			8	42.97	28.038	26-21.6	1.5

			9	43.02	27.982	21.8-27.4	1.48
17.06.2024 a	TBB VL1218	Varna	1	43.001	28.079	27-21.6	1.43
			2	43.021	27.984	21.4-26.9	1.38
			3	43.005	28.074	26.6-21.1	1.43
17.06.2024 b	TBB VL1824	Varna	1	43.008	27.97	24-24	0.50
23.06.2024	TBB VL1218	Varna	1	43.11	28.059	20.9-25.4	1.75
			2	43.121	28.147	24.7-24.8	1.37
			3	43.182	28.206	24.4-24.7	1.83
			4	43.105	28.123	24.5-25.2	1.42
			5	43.181	28.209	24.6-25.3	1.47
			6	43.118	28.149	25-25.1	1.35
			7	43.177	28.206	25.2-25.1	1.12
			8	43.117	28.137	24.5-25.5	1.52
			9	43.053	28.095	25.2-26.5	1.4
24.06.2024	TBB VL1218	Varna	1	42.981	28.056	26.6-21.6	1.58
			2	43.023	27.979	21.4-21.1	1.87
			3	43.087	28.066	21.2-22.1	1.85
27.06.2024 b	TBB VL1824	Varna	1	43.209	28.089	18-18.5	2
			2	43.266	28.222	18.3-18.1	1.92
			3	43.189	28.112	18-18.2	2.5
			4	43.232	28.27	23-23.1	1.83

Fishing expeditions were concentrated off the central and northern parts of the Bulgarian coast (in Kalikara - Byala zone), at depths of 16.1 - 27.1 m, with an average time for one trawling of 91.20 min ± 27.06 SD.

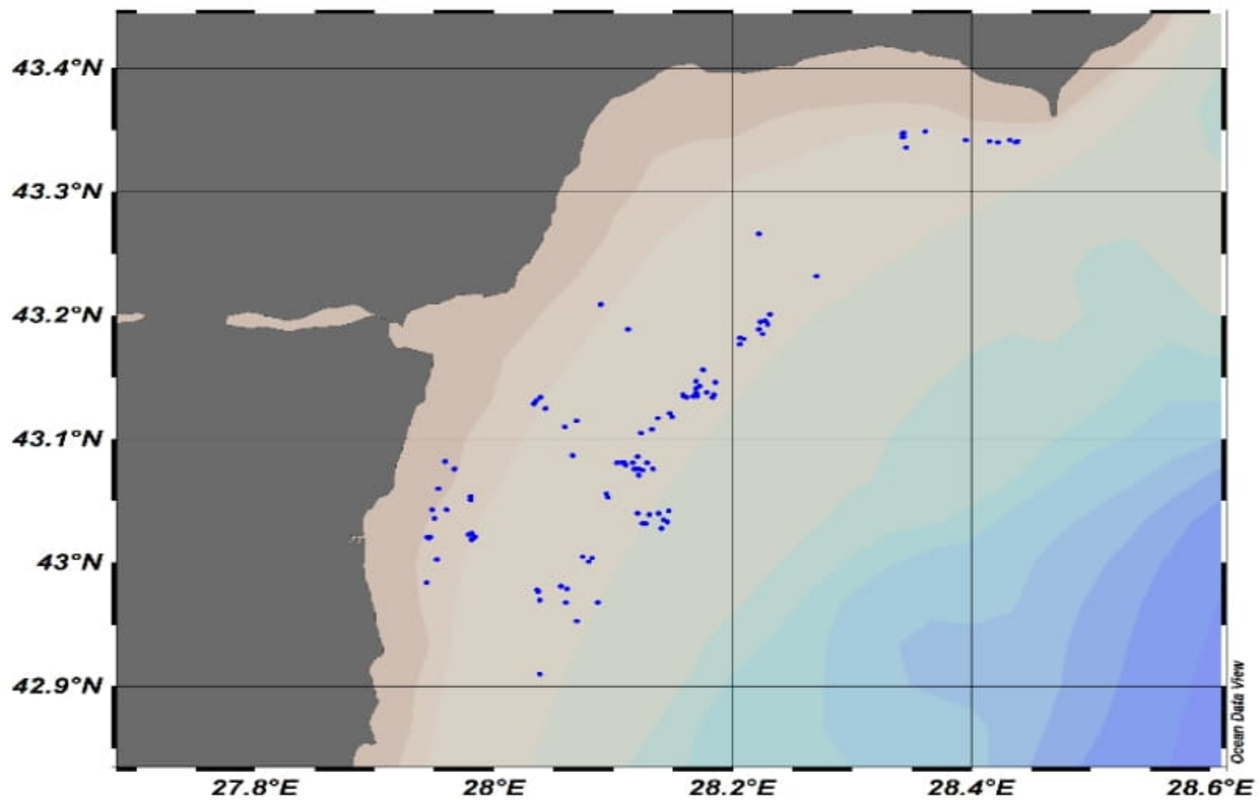

Fig. 6. Map of observed beam trawl fishing expeditions.

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2.1.4 Polyvalent vessels

A survey of polyvalent vessels was conducted between August and October 2024 and mixed catches of migratory fish species (horse mackerel and red mullet) were monitored.

In 2024, the study included 20 days on board four fishing vessels belonging to fishing segments PMP VL1218 (three vessels, 17 days) and PMP VL1824 (one vessel, 3 days) (Table 7, Fig. 7).

Table 7.

Characteristics of fishing vessels with polyvalent gear.

Name of fishing vessel	Fishing vessel number	Specifications	Fishing segment
RK Barbun	BH 7979	19.74 GT, 15.97 m, 235 kW	PMP VL1218
RK Egeo 2	BH 8195	33.6 GT, 17.23 m, 320 kW	PMP VL1218
RK Laefer	BH 03	68.51 GT, 24 m, 530 KW	PMP VL1824
PK Iva-1	BH 8194	15.79 GT, 14 m, 159 kW	PMP VL1218

1. 

2. 
3. 

Fig. 7. Polyvalent vessels: RK Barbun (1), RK Egeo 2 (2), and RK Iva-1 (3).

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Pelagic trawl catches were tracked using gears with the following functional and technical parameters:

• RK Barbun: Trawl length - 40 m; Trawl width - 12 m, Trawl height - 10 m, mesh size – 16 x 16 and 18 x 18 mm; (lower bridle length 32 m, upper bridle 26 m);

• RK Egeo 2: Trawl length - 45 m; Trawl width - 20 m, Trawl height - 6 m, mesh size – 18 x 18 mm; (lower bridle length 30 m, upper bridle 28 m).;

• RK Lefer: Trawl length - 40 m; Trawl width - 12 m, Trawl height - 10 m, mesh size – 16 x 16 and 18 x 18 mm; (lower bridle length 32 m, upper bridle 26 m).

• RK Iva - 1: Trawl length - 30 m; Trawl width - 12 m, Trawl height - 6 m, mesh size – 18 x 18 mm; (lower bridle length 28 m, upper bridle 25 m).;

82 trawls were tracked for 20 fishing days. Detailed information about the study areas is presented in Table 8 and Fig. 8.

Table 8.

Observations of the polyvalent vessel fishery in 2024.

Date	Fishing vessels	Port. departure	Target species	Fishing operations no	Latitude	Longitude	Depth (m)	Duration of trawling (h)
1.08.2024	PMP VL1218	Varna	Mixed catch	I	43.112	28.205	31.0-31.2	0.5
				II	43.210	28.090	18.5-18.3	0.58
				III	43.261	28.067	22.3-22.5	0.67
				IV	43.155	28.026	20.1-19.8	0.75
3.9.2024	PMP VL1824	Varna	Mixed catch	I	43.111	28.267	36.8-36.7	1.33
				II	43.044	28.224	36.7-36.9	1.83
				III	43.123	28.276	36.9-36.7	1.83
				IV	43.045	28.217	35.0-25.5	3.33
5.9.2024	PMP VL1218	Varna	Mixed catch	I	42.867	28.031	30.9-30.7	1.45
				II	42.802	27.985	31.5-34.4	1.25
				III	42.742	27.983	34.7-31.0	1.7
				IV	42.832	27.980	29.9-34.4	1.83
6.9.2024	PMP VL1218	Varna	Mixed catch	I	42.747	27.989	35.0-30.5	1.67
				II	42.820	27.980	30.7-35.2	1.58
				III	42.771	27.973	33.0-28.2	2
				IV	42.909	27.947	32.0-24.4	1.67
11.9.2024	PMP VL1824	Varna	Mixed catch	I	42.860	28.175	40.0-39.0	1.5
				II	42.890	28.132	40.0-41.0	1.33
				III	42.874	28.087	39.0-38.5	1.55
				IV	42.949	28.124	39.0-38.5	1.62
				V	42.902	28.084	36.0-37	1

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12.9.2024	PMP VL1218	Varna	Mixed catch	I	42.992	28.130	30.6-32.5	1.25
				II	42.947	28.097	30.7-29.5	2
				III	42.897	28.032	29.2-29.1	1.67
				IV	42.960	28.089	29.1-28.8	1.5
				V	43.062	28.137	26.7-26.4	1.37
25.9.2024	PMP VL1218	Varna	Mixed catch	I	43.140	28.245	31.0-32.2	1.67
				II	43.198	28.307	32.0-31.4	1.83
				III	43.143	28.253	31.2-32.7	1.78
				IV	43.073	28.041	33.1-31.4	1.42
26.9.2024	PMP VL1218	Varna	Mixed catch	I	43.127	28.232	30.4-30.2	2.22
				II	43.025	28.158	32.1-31.4	1.17
				III	43.972	28.128	30.4-30.2	1.55
				IV	43.042	28.150	30.1-30.3	2.5
27.9.2024 a	PMP VL1218	Varna	Mixed catch	I	43.027	28.115	28.2-28.0	1.58
				II	42.970	28.078	28.1-29.2	1.62
				III	42.908	28.092	33.1-33.2	1.58
				IV	42.965	28.112	30.2-28.2	1.75
27.9.2024 b	PMP VL1218	Varna	Mixed catch	I	43.003	28.104	28.7-28.3	2
				II	42.912	28.041	30.4-28.2	1.5
				III	42.925	28.003	26.3-25.9	1.83
				IV	42.968	28.081	29.1-27.6	2
27.9.2024 c	PMP VL1824	Varna	Mixed catch	I	42.997	28.037	29.0-31.0	2.17
				II	42.893	28.036	30.0-28.5	1.08
				III	42.839	28.087	40.0-40.5	1
				IV	42.922	28.067	29.0-30	2.33
27.9.2024 d	PMP VL1218	Varna	Mixed catch	I	43.171	28.277	31.1-31.2	1.75
				II	43.230	28.330	31.1-30.2	1.75
				III	43.168	28.262	30.3-30.2	1.83
3.10.2024	PMP VL1218	Varna	Mixed catch	I	43.043	27.922	21.3-22.7	0.58
				II	42.870	28.113	39.0-40.0	1.17
				III	42.820	28.114	45.5-46.0	1
				IV	42.858	28.139	46.1-46.3	1.8
				V	42.939	28.192	46.0-45	1.33
5.10.2024	PMP VL1218	Varna	Mixed catch	I	42.962	28.208	45.2-48.5	1.2
				II	42.895	28.172	48.1-47.3	1.42
				III	42.962	28.172	47.0-46.8	1.92
6.10.2024	PMP VL1218	Varna	Mixed catch	I	42.932	28.160	40.0-40.3	1.17
				II	42.877	28.127	38.2-40.5	1.58
				III	42.867	28.113	38.9-40.1	1.83
				IV	42.943	28.170	39.8-38.2	1.28
8.10.2024 a	PMP VL1218	Varna	Mixed catch	I	42.528	28.115	40.2-42.1	0.75
				II	42.832	28.067	36.3-36.1	0.6
				III	42.783	28.050	37.4-38.5	1.33
				IV	42.743	28.044	40.0-39.4	1.5
				V	42.807	28.079	40.3-37.3	1.33
8.10.2024 b	PMP VL1218	Varna	Mixed catch	I	42.927	28.147	38.6-42.2	2
				II	42.850	28.074	36.2-37.0	1.33

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				III	42.775	28.040	37.5-41.7	1.33
				IV	42.731	28.042	41.5-39.1	2.67
10.10.2024	PMP VL1218	Varna	Mixed catch	I	42.862	28.046	32.6-35.1	1.5
				II	42.735	27.989	42.4-27.6	1.25
				III	42.741	27.988	35.9-30.7	1.75
				IV	42.785	27.979	32.6-29.9	2.17
11.10.2024	PMP VL1218	Varna	Mixed catch	I	43.172	28.129	20.9-26.7	2.08
				II	43.222	28.290	27.3-28.6	1.5
				III	43.201	28.271	28.5-29.0	1.92
				IV	43.123	28.203	29.1-29.7	1.67
29.10.2024	PMP VL1218	Varna	Mixed catch	I	42.040	27.924	24.6-27.4	2.12
				II	42.948	27.948	32.2-34.3	1.5
				III	42.950	27.947	27.4-24.7	2.32
				IV	43.061	27.939	24.3-24.8	2.83

Fishing expeditions were carried out in the area between St. Constantine and Helena and Emine, at depths of 18.3 – 48.5 m, with an average duration of one trawling operation of 1.59 h ± 0.06 SE.

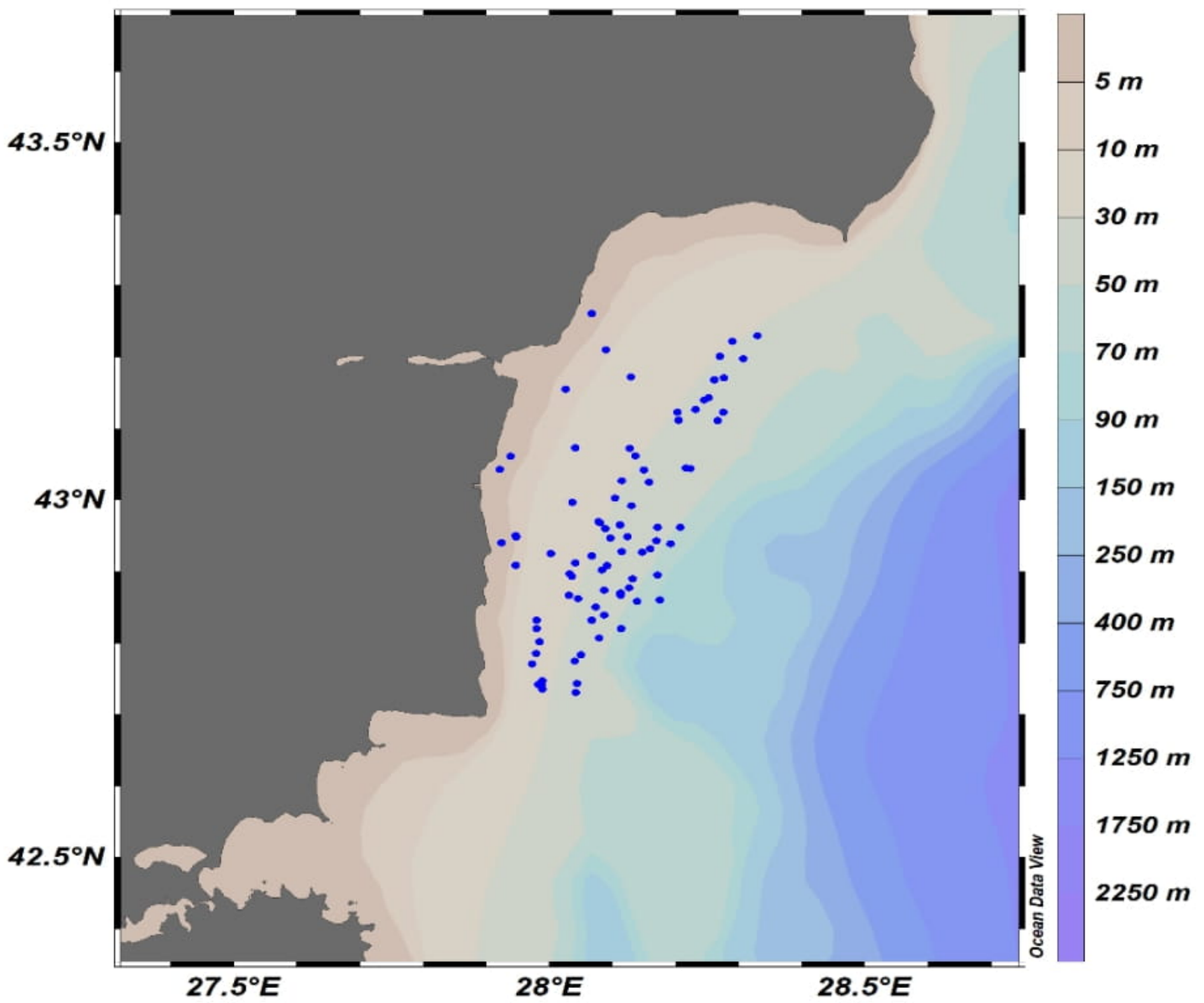

Fig. 8. Map of observed fishing expeditions with polyvalent vessels in 2024

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2.1.5 Summary of collected Information

In 2024, surveys with scientific observers of fishing vessels in the Bulgarian fleet covered 100 fishing days: 30 days for gillnet vessels, 30 days for pelagic trawl vessels, 20 days for beam trawl vessels, and 20 days for polyvalent vessels (Table 9.1).

The observations included 14 fishing vessels belonging to the following fishing segments: DFN VL0612 (3 vessels, 30 fishing days); TM VL1218 (1 vessel, 7 fishing days), TM VL2440 (3 vessels, 23 fishing days); TBB VL1218 (2 vessels, 12 fishing days); TBB VL1824 (1 vessel, 8 fishing days), PMP VL1218 (3 vessels, 17 fishing days), and PMP VL1824 (1 vessel, 3 fishing days) (Table 9.2).

Table 9.

Summary data on scientific observations of fishing activities (1) and fisheries segments (2) in 2024.

1.

	Number of days on gill net vessels (GNS)	**Number of days on pelagic trawlers (OTM)**	**Number of rapa whelk fishing days (TBB)**	**Number of fishing days with polyvalent vessels (PMP)**	**Number of observed days per month**
II.2024	1				**1**
III.2024	6	20			**26**
IV.2024	7		3		**10**
V.2024			2		**2**
VI.2024	1		15		**16**
VII.2024	5				**5**
VIII.2024	1			1	**2**
IX.2024	4			11	**15**
X.2024	1	3		8	**12**
XI.2024	4	7			**11**
Total	***30***	***30***	***20***	***20***	***100***

2.

Fishing segment	Number of days	Number of fishing vessels
DFN VL0612	30	3
TM VL1218	7	1
TM VL2440	23	3
TBB VL1218	12	2
TBB VL1824	8	1
PMP VL1218	17	3
PMP VL1824	3	1
total	100	14

In the gill net observations, the target species is turbot, the pelagic trawl target species is mainly sprat, the beam trawls target rapa whelk, the catch by polyvalent vessels is mixed and includes 2-3 commercial species (most often red mullet and horse mackerel).

In a spatial aspect, the observations covered the entire Bulgarian coast from Durankulak to Tsarevo, as gillnet catches were carried out in the area in front of Shabla – Durankulak, pelagic trawl studies were concentrated in the southern part of the wide Burgas Bay; beam trawl trawling for rapa whelk was concentrated in front of the central and northern coasts (Kalikara - Byala), and research with polyvalent vessels was oriented in the area St. Constantine and Elena - Emine.

During the study period, no discards into the marine environment were detected, and the bycatch consisted mainly of other fish species, mollusks, and crustaceans.

2.2 Sample processing

The quantities of priority catches and bycatches were measured onboard the fishing vessel and species identification of the bycatch organisms was performed. If possible, the absolute and standard lengths as well as the individual weights of the bycatch species were measured, and ichthyological samples were collected from the priority catch and bycatch. Each ichthyological sample comprised at least 200 specimens.

For the collected PETs, along with species identification and biological parameters, when possible, additional information on the condition of the animals was collected: Dead; A0: Alive (float away), A1: Alive and in good condition, A2: Alive, minor injuries/stress, high probability of survival; A3: Alive, life-threatening injuries/severe stress, unlikely to survive. To determine the nutritional spectrum of some fish species, live specimens were separated from the bycatch, fixed with 10 % formaldehyde solution, and stored for laboratory processing.

2.3 Laboratory analysis

Ichthyological samples of the target species from different types of fishing activities were processed, and detailed data were collected on the biological parameters of the bycatch specimens, as well as on the nutritional spectrum of some fish species in the bycatch.

Bycatch data in the investigated fisheries: Large, sensitive species and expensive species in the bycatch were measured directly onboard the fishing vessel. For other bycatch species for which weight and linear dimensions cannot be measured directly onboard the fishing vessel, samples are collected, labelled, numbered, and frozen in a freezer for laboratory processing. Under laboratory conditions, the length and weight of the bycatch specimens were determined (Fig. 9) and the percentage distribution by size class was calculated. The age of the bony fish species in the catch was determined by examining otoliths using a binocular microscope. The condition factor was determined (Fulton's condition factor, K) for the studied fish species, and the data were summarised by age class and sex. The length-weight relationships were determined (when possible) by applying the method of least squares and according to the equation $Log\ W = Loga + b*LogL$, where W is weight, L is size, and a and b are constants.

Crustaceans in the bycatch were measured under laboratory conditions according to FAO guidelines 2019a: "Monitoring discards in Mediterranean and Black Sea fisheries, methodology for data collection." Carapace length ("Cl") was measured from the rostrum to the posterior end of the carapace using a digital calliper. Established crustacean species have no industrial importance for fishing in Bulgaria.

Data for the main catch (turbot) during gillnet fishing - 321 turbot specimens were measured and weighted, and the data were used to create length and weight histograms.

Data on the main catches of pelagic species in pelagic trawl fisheries: A total of 66 ichthyological samples from the main catches and 141 bycatch samples were processed. Ichthyological samples were randomly collected from the main catch, and each sample contained at least 200 specimens. Analysis of the size-age structure was performed according to a standard methodology. The absolute length of each specimen was measured and data processing was performed by constructing variation rows with a class interval of 0.5 cm. The age of the species was analysed by otolith reading using a binocular microscope. The condition factor of the measured fish species (K) was determined individually and distributed according to the size class and sex. The length -weight relationships were estimated.

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Fig. 9. Laboratory processing of bycatch samples in 2024.

The biological parameters related to the von Bertalanffy equation are determined by the formula: $L(a) = L\infty(1 - \exp(-k(a - a0)$, where *a* is the age, *k* is growth factor, a_0 - size value at initial age, and L_∞ - asymptotic length.

Data on the main rapa whelk catches: 585 specimens of rapa whelk were processed from the main catches with beam trawl in the summer and autumn of 2024. For each specimen, the following basic biometric parameters were individually measured: total mass of the

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specimen (total weight–weight with the shell, TW, g) and length of the shell (shell length, SL, cm).

The following sources were used in the processing and analysis of the ichthyological samples: Kasapoglu et. al (2015); Ozdemir et. al., (2024); Aydin et. al, (2013); Kuzminova et. al, (2014); Banaru et. al, (2017); Kasapoglu et. al, (2016); Carbonara et. al (2024), Creteanu et. al, (2006); Pajuelo et. al, (2011); Bilgin et. al, (2009); Rizkalla et. al, (2009); Mehanna et. al, (2015); Mesa et. al, (2010); Velkov et. al, (2014); Filiz et. al (2009); Rozdina et. al, (2013); Yildiz et. al (2012); Kolarov, (1960); Stoyanov et al., (1963); Karapetkova et al., (2010); Svetovidov, (1964).

Studies on the dietary spectrum include the following fish species from bycatch: whiting (30 ind.), sprat (10 ind.), spiny dogfish (4 ind.), and thornback ray (10 ind.). Under laboratory conditions, the absolute length (TL, with an accuracy of 0.1 cm) and weight (with an accuracy of 0.01 g) of the collected specimens were measured. The stomachs of the studied organisms were weighed using a balance, and the food mass of each individual was calculated as the difference between the weights of full and empty stomachs.

To determine the species composition of the food and the number of food objects, the stomach contents were examined under a microscope. Prey biomass in fish stomachs was determined by measuring individual weights and their number.

The following indices were defined:

1. Stomach fullness index (ISF) as a percentage of body mass: ISF = (*Weight of stomach contents/Weight of fish body*) × 100
2. Index of relative importance (IRI; Pinkas et al., 1971): $IRI = (N + M) \times FO$, where N is the proportion of the taxon (species) of the prey in the food by number, M is the proportion of the taxon (species) of the prey in the food by biomass, and FO is the frequency of occurrence of the taxon (species).

2.4 Analytical methods

General statistical data on the quantities of priority species, bycatch weight, and bycatch rate, as well as the main biological parameters of catch/bycatch, are presented. The bycatch rate was calculated as the percentage of the total catch. According to FAO (2019a): “Monitoring discards in Mediterranean and Black Sea fisheries: methodology for data collection ", the share of the bycatch is determined by dividing the weight of the bycatch (kg) by the total weight of the catch (landed catch + bycatch):

Bycatch (%) = bycatch / (bycatch + main catch) x 100

This method was used as an indicator of the impact of different fishing techniques on the marine species. The bycatch percentages were calculated based on the weights of the total catch and the bycatch per fishing day (Borges et al.., 2005; Rochet and Trenkel, 2005). From the daily

data, the calculations could be transferred to the annual level, considering the total weight of the annual catch and total number of fishing days.

When assessing the impact on fishing activities, the following scale was adopted based on expert evaluation: bycatch rate (BCR) > 25 % TC was assessed as extremely high (i.e. an indicator of a strong impact on marine organisms), in the range of 10–25 % TC was considered high, the impact in the range of 3–10 % TC was considered moderate, and BCR < 3 % TC was considered weak.

Regarding sensitive species, FAO (2019b) proposes the use of an indicator bycatch coefficient for these species, based on the following methodology: the bycatch ratio (T, for species and segment of the fleet) is determined by the formula: $T = N/D$, where – N, sum of the number of individuals of each species caught on each fishing day (ni) ($N = \Sigma\, nii$), D - number of fishing days surveyed. Subsequently, from the bycatch coefficient it is possible to estimate the number of individuals caught (I) by a given fleet by the formula: $I = T \cdot F$, where F is the total number of fishing trips made in the reference year by the fleet segment analysed.

For all catches and bycatches, the coefficient of variation (CV, %) was determined using the formula: $CV = SD \times A \times 100$, where SD is the standard deviation and A is the mean value of the respective parameter.

The XLSTAT software was used to process the data and display linear/weighted histograms of bycatch and bycatch structures. The statistics for the different classes presented in the histograms include the lower- and upper-class limits, frequency, relative frequency, and density.

Boxplot graphs were generated using the same software to show the variability of biological traits, with information for the mean values, median, 25–75% hinge, and minimal and maximal observed values.

3. Results

3.1 Fishery with gill nets

3.1.1 Main catch, bycatch, total catch

The main catch from the anchored gill nets was turbot (*Scophthalmus maximus*) and the bycatch was mainly composed of black mussels (*Mytilus galloprovincialis*), common stingrays (*Dasyatis pastinaca*), and thornback rays (*Raja clavata*) (Table 10).

In July 2024, a specimen of the European lobster (*Homarus gammarus*) was found.

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Table 10

Monthly data on the average quantities of the main catch (*S. maximus*, kg/day) and bycatch (kg/day) of gillnet fisheries in 2024 (segment DFN VL0612).

Survey period/ number of days at sea (DaS) per month	Main catch - S. maximus (kg/day)	Weight of the main bycatch species, kg / day					Total weight of bycatch, BC (kg/day))	Total weight of catch and bycatch (kg/day	% BC of total catch
		D. pastinaca	*S. acanthias*	*R. clavata*	*M. galloprovincialis*	*други*			
II. 2024/1	33.00	0.00	0.00	6.50	18.50	0.00	25.00	58.00	43.103
III. 2024/6	25.17	0.00	0.00	7.85	17.83	0.00	25.68	50.85	50.508
IV. 2024/7	39.00	13.02	0.00	2.33	16.21	0.00	31.56	70.56	44.728
VI. 2024/1	17.40	0.00	0.00	0.00	6.00	0.00	6.00	23.40	25.641
VII. 2024/5	22.56	8.70	0.00	3.75	9.10	5.5	27.05	49.61	54.525
VIII. 2024/1	20.00	0.00	0.00	0.00	17.00	0.00	17.00	37.00	45.946
IX. 2024/4	28.75	13.50	0.00	3.50	12.00	0.00	29.00	57.75	50.216
X. 2024/1	9.00	0.00	0.00	0.00	0.00	0.00	0.00	9.00	0.000
XII. 2024/4	48.00	16.00	0.00	5.00	0.00	0.00	21.00	69.00	30.435

The summary statistics from daily observations of the quantities of catches and by-catches in gillnet fishing are presented in Table 11. For the period of the studies, the average amount of the main catch of S. maximus was 30.77 kg/day ± 2.83 SE (Standard Error), with an average amount of by-catch – 17.22 kg/day ± 2.51 SE, weight of the total catch - 47.99 kg/day ± 4.04 SE and an average percentage share of by-catch from the total catch – 32.84 % ± 3.81 SE. Data on bycatch weight showed a high coefficient of variation (CV = 80.83 %) during the study period (Table 11).

Table 11

Summary statistics of the total weight (kg/day) of the main catch of turbot (*S. maximus*), weight of bycatch (kg/day), total weight of catches (catch + bycatch) (kg/day), and percentage share (%) of bycatch based on daily observations in 2024 (segment DFN VL0612).

	Main catch (kg/day) *S. maximus*	Bycatch weight (BC, kg/day))	Total catch weight (TC, catch + bycatch) (kg/day)	BC, % of bycatch of the total catch
Average value	30.773	17.217	47.990	32.835
Standard error	2.830	2.541	4.040	3.806

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Median	25.000	15.500	44.750	35.094
Mode	25.000	0.000	49.700	0.000
Standard deviation	15.499	13.915	22.127	20.847
Sample Variance	240.205	193.636	489.588	434.601
Kurtosis	2.889	0.235	2.801	-0.646
Skewness	1.485	0.746	1.222	-0.310
Minimum	73.000	52.500	110.300	72.414
Maximum	9.000	0.000	9.000	0.000
Sum	82.000	52.500	119.300	72.414
Number	30.000	30.000	30.000	30.000
Confidence interval (95.0%)	5.787	5.196	8.262	7.784
Coefficient of variation (CV)	50.364	80.825	46.107	63.491

The weight of bycatch in gillnet fishing is formed mainly by black mussels (63.8 %), with the participation of common stingrays (*D. pastinaca*) at 18% and thornback rays (*R. clavata*) at 16% (Fig. 10).

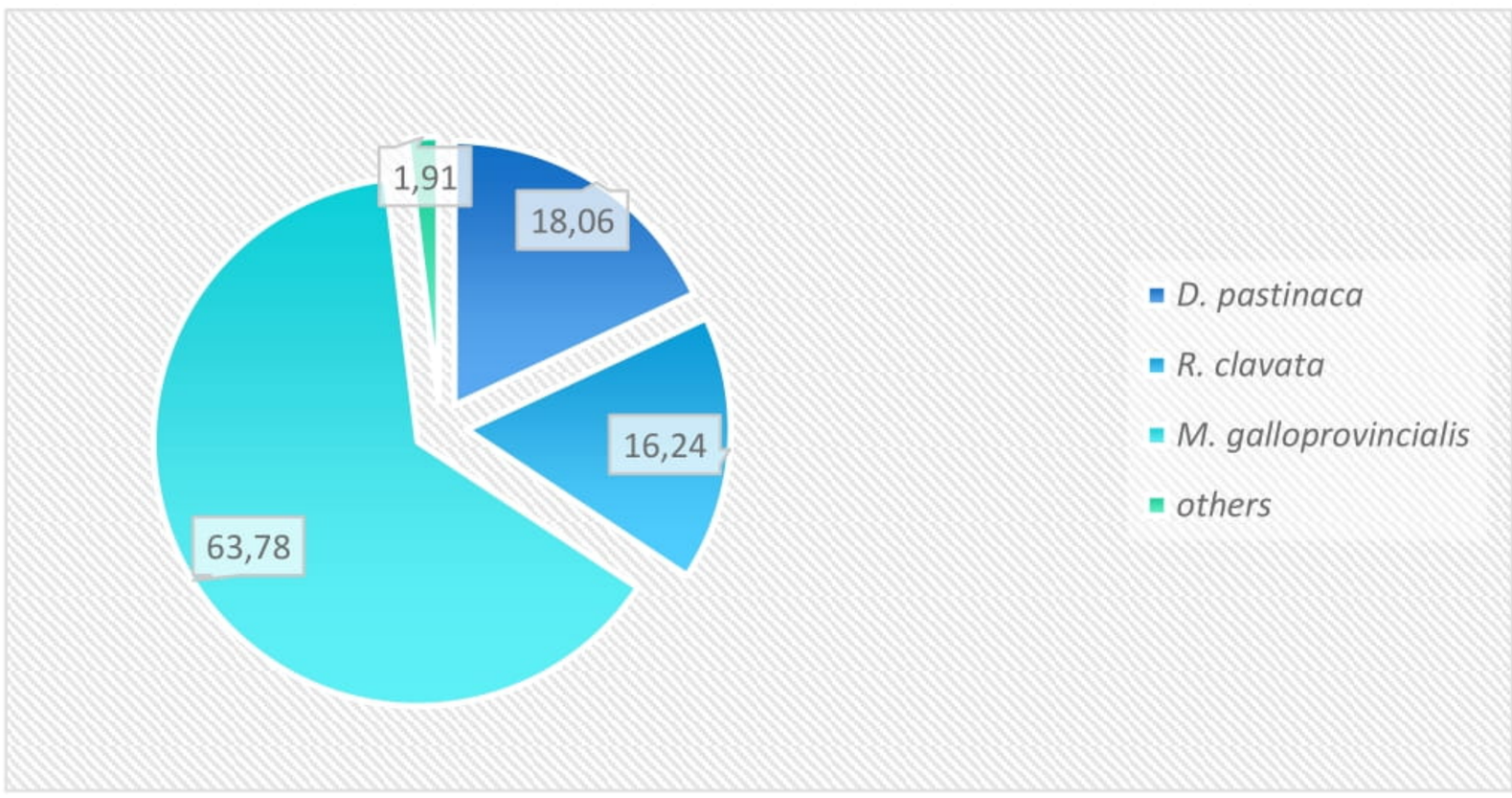

Fig. 10. Percentage participation of bycatch species in the formation of total bycatch weight (kg/day) in gillnet fisheries in 2024.

A fishery with anchored gillnets can form a significant bycatch because large organisms, which are mainly sensitive species, are caught in the nets. In the current year, the average weight

of bycatch was highest in February-March - 25.34 kg/day, and lowest levels - 14.5 kg/day in September-October (Figure 11).

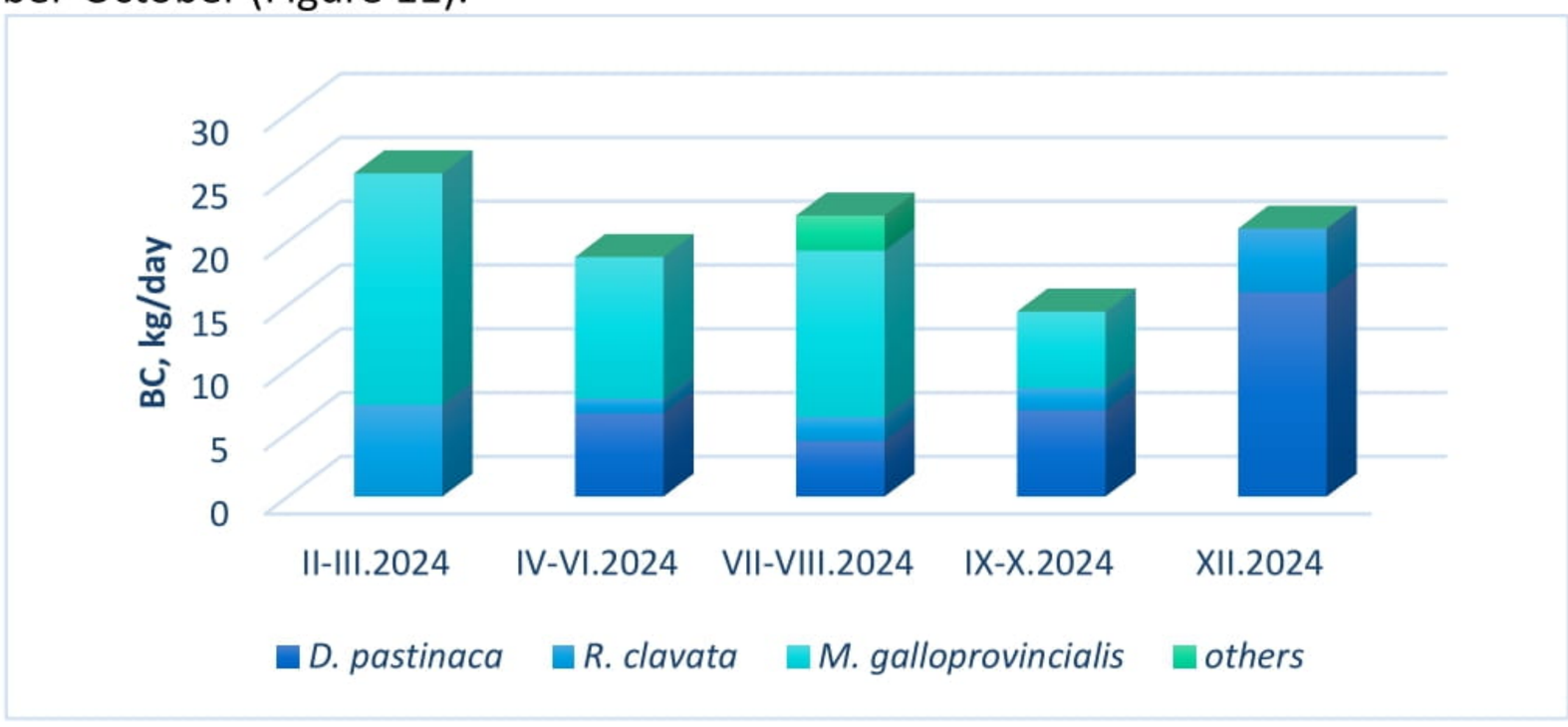

Figure 11. Average monthly data on the composition and weight of bycatch (kg/day) in gill net fishing from IV to XII.2024.

According to the percentage share of individual species forming the weight of bycatch by month in 2024, the common stingray is found almost year-round with a maximum in autumn of 76% BCW, and the thornback ray is found mainly in winter and autumn (28 and 23% BCW, respectively, Fig. 12). The proportion of black mussels was highest in the winter months (up to 72% BCW).

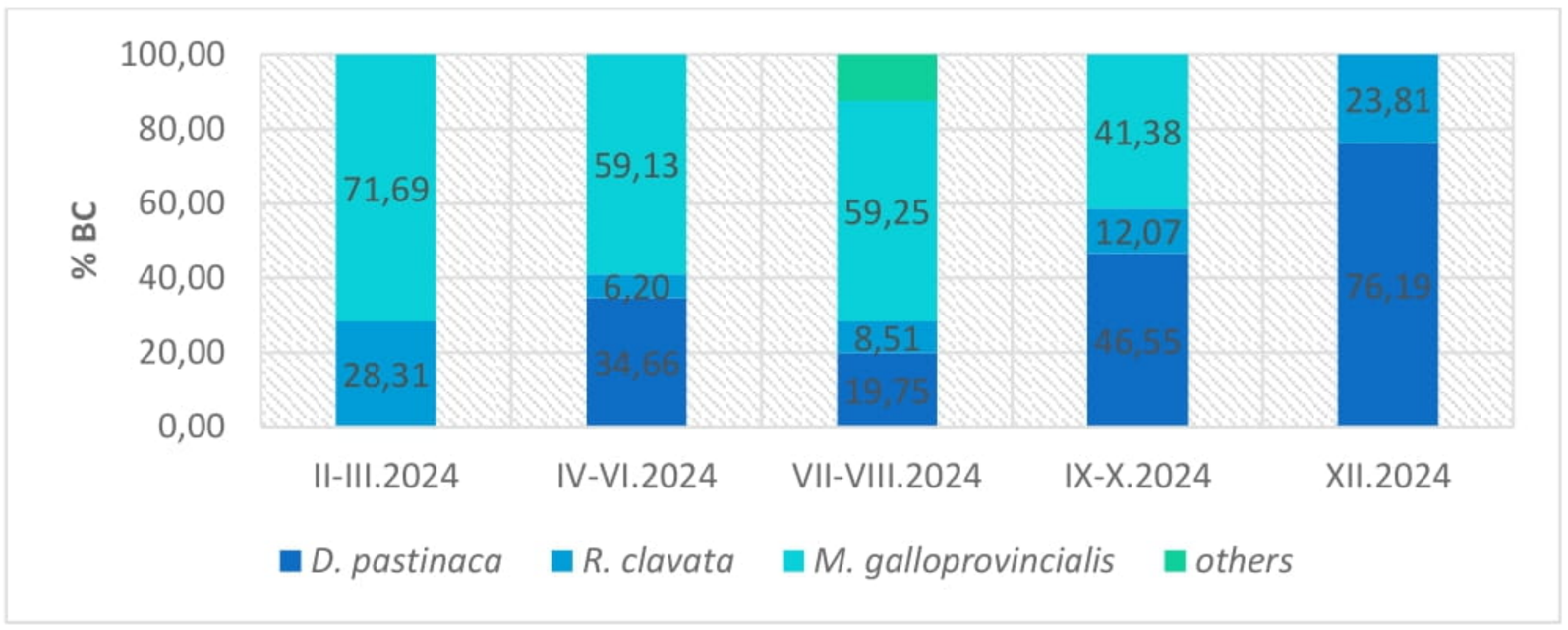

Figure 12. Monthly dynamics of bycatch species composition (% participation in the formation of bycatch weight, BC, kg/day) in gill net fishing in 2024.

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3.1.2 Dynamics of biological parameters

A total of 321 turbot catch specimens were measured, with a mean size of 52.388 cm ± 4.893 SD and a mean weight of 2312.773 g TW ± 632.437 SD (Fig. 13).

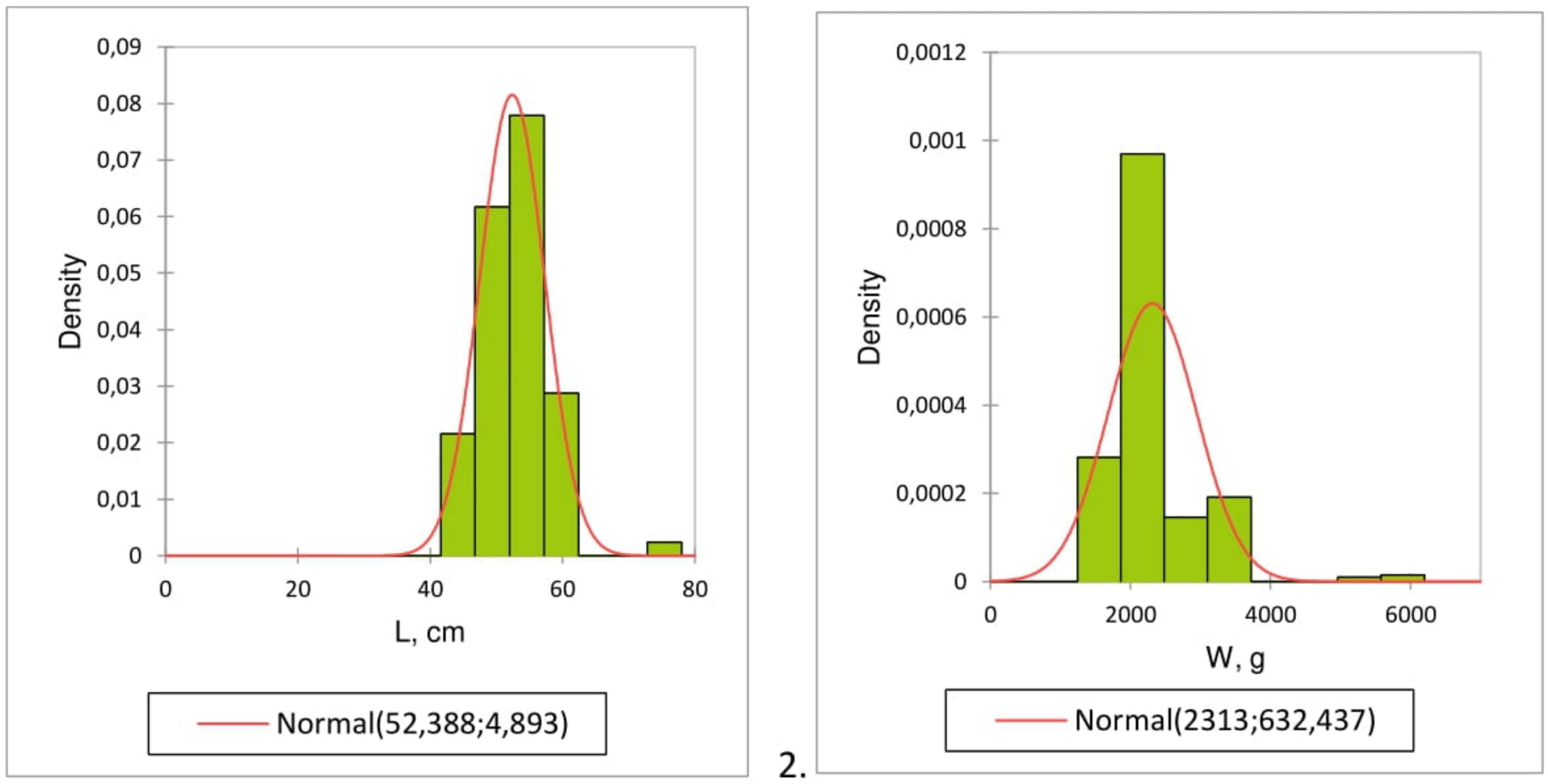

Fig. 13. Distribution of *S. maximus* by class according to absolute length (L, cm, 1) and individual weight (TW, g, 2) in 2024.

The 50 – 55 cm size group (39.05 % of the measured turbot specimens) had the most significant presence in catches. Accordingly, weight groups 1500 – 3000 played a leading role in the catches (87.039 % of the measured turbot specimens, Table 12).

Table 12

Statistics of the distribution of turbot weight classes (g) for 2024.

Lower limit	Upper limit	Frequency	Relative frequency	Density
1500.000	2000.000	88	0.274	0.211
2000.000	2500.000	161	0.502	0.306
2500.000	3000.000	23	0.072	0.245
3000.000	3500.000	39	0.121	0.108

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3500.000	4000.000	5	0.016	0.026
4000.000	4500.000	0	0.000	0.004
4500.000	5000.000	0	0.000	0.000
5000.000	5500.000	1	0.003	0.000
5500.000	6000.000	3	0.009	0.000
6000.000	6500.000	1	0.003	0.000

The research on the monthly dynamics of the biological parameters of the main turbot catch showed that specimens with the smallest individual sizes - 45.1 - 50 cm form two maxima - during the winter months and in July, while during the period August - December the catches are formed entirely by specimens with a size of 50.1 - 60 cm (Fig. 14).

Figure 14. Monthly fluctuations of the main size classes of turbot (*S. maximus*) - 45.1-50 cm, 50.1-60 cm, 60.1-80 cm (% of the total quantity in the catch)–in the gillnet fishery in 2024.

3.1.3. Biological parameters of bycatch of sensitive species in gill net fisheries

Data on sensitive species, including the total number of specimens caught, average weight, and average size of the gillnet bycatches, are presented in Table 13. When removed from the nets, all the sensitive species caught (35 specimens) were dead. During the study period, the highest bycatch ratio was recorded for thornback rays (T = 0.67 ind/day).

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Table 13

Data on the status (according to the International Union for the Conservation of Nature (IUCN)) of sensitive species in bycatch, total number of specimens caught, bycatch coefficient, average length (cm), and average weight (g) of gillnet fisheries in 2024.

Bycatch species	IUCN status	Total number	Bycatch coefficient	Mean length (cm)	Mean weight (g)
Dasyatis pastinaca	VU (Vulnerable species)	15	0.5	77.714	7782.143
Raja clavata	NT (Near threatened species)	20	0.67	74.583	3814.39

The bycatch coefficient of the thornback rays increased in February - March (2-1.5 ind/day), and of the common stingrays – 1.43 ind/day in April) (Fig. 15, Table 14).

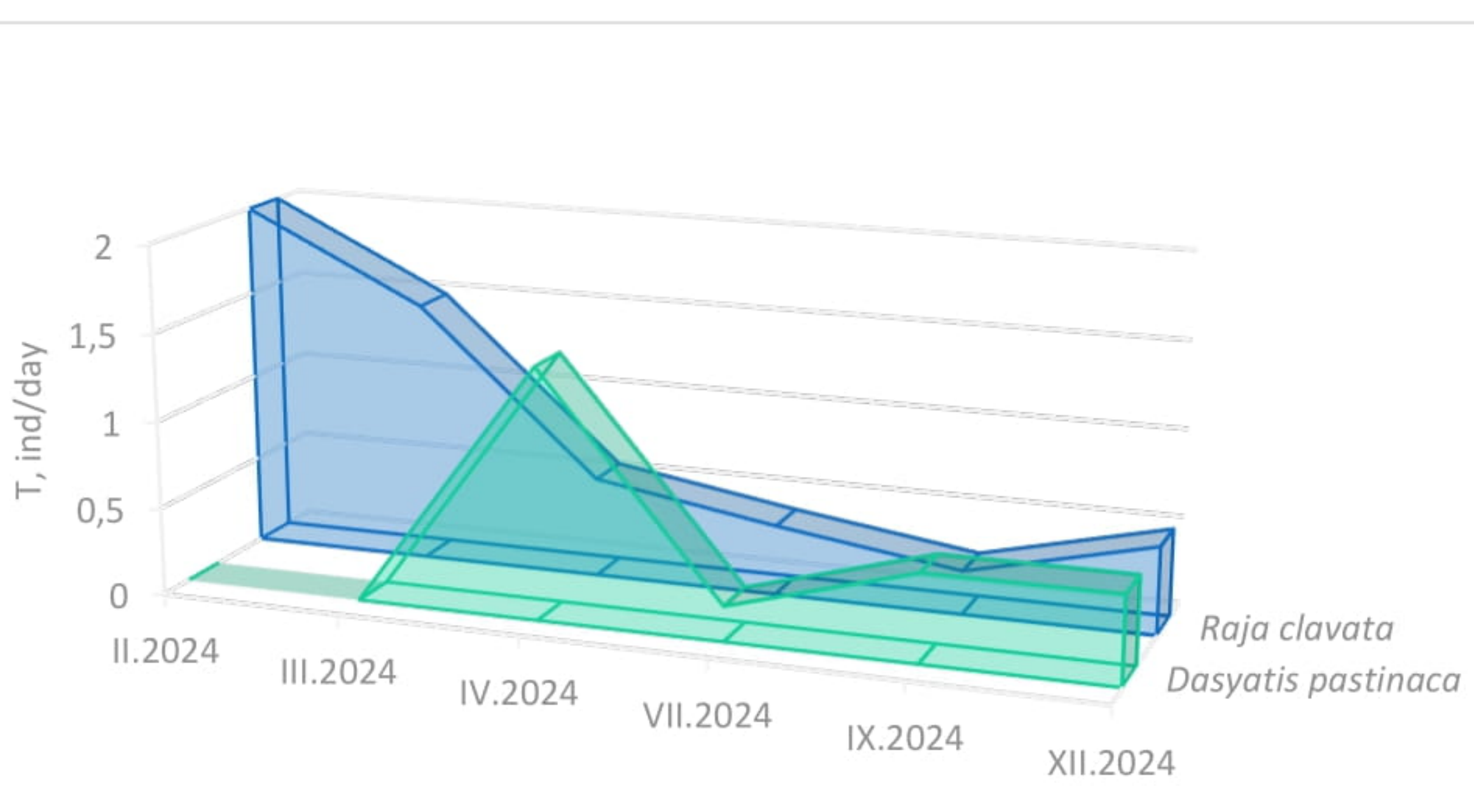

Fig. 15. Monthly fluctuations in the bycatch ratio (T, ind/day) of sensitive species in the gillnet fishery in 2024.

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Table 14

Monthly data on the bycatch of sensitive species, total number of specimens caught by species, bycatch ratio, mean size (cm), and mean weight (g) in the gillnet fishery (DFN VL0612) in 2024.

month	Bycatch species	Total number	Monthly bycatch coefficient (ind/day)	Mean length (cm)	Mean weight (g)
II.2024	*Raja clavata*	2	2	72.00	3250
III.2024	*Raja clavata*	9	1.50	72.67	3408
IV.2024	*Raja clavata*	4	0.57	73.75	4075
	Dasyatis pastinaca	10	1.43	77.25	7756
VII.2024	*Raja clavata*	2	0.40	76.00	3750
	Dasyatis pastinaca	1	0.20	82.00	8700
IX.2024	*Raja clavata*	1	0.25	75.00	3500
	Dasyatis pastinaca	2	0.50	71.00	6750
XII.2024	*Raja clavata*	2	0.50	78.50	5000
	Dasyatis pastinaca	2	0.50	82.00	8000

3.2 Fishery with pelagic trawls

3.2.1 Summary data: main catch, bycatch, total catch

During 2024, research on fishing with pelagic trawls primarily covered the catch of sprat (*S. sprattus*), but occasionally significant amounts of horse mackerel and bluefish were also found in the catches. The daily catches average 2227.93 kg/day ± 210.18 SE, while the quantities of bycatch of fish and crustaceans' range between 0-– 57.09 kg/day. The average bycatch of jelly-like zooplankton (*A. aurita*) is 20.33 kg/day ± 5.56 SE. The percentage of bycatch from all marine organisms was moderate (4.06% TC ± 2.74 SE) (Table 15).

Table 15

Summary statistics of the quantities of main catch (kg/day), bycatch of fish and crustaceans (BC1, kg/day), gelatinous zooplankton (BC_2, kg/day), total catch (catch + bycatch, kg/day), and percentage share of bycatch (% $BC_3 = BC_1+Bc_2$) of the total pelagic trawl catch in 2024.

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	Sprat catch (kg/day)	Bycatch (BC_1, kg/day)	Jellyfish bycatch (BC_2, kg/day)	Total catch (TC, kg/day)	$BC_3 = BC_1+BC_2$ (% from total catch)
Average value	2227.93	5.496	20.33	2253.75	4.06
Standard error	208.84	2.020	5.56	210.18	2.74
Median	2550.00	2.437	8.00	2551.61	0.65
Standard deviation	1143.86	11.062	0.00	1151.23	14.99
Kurtosis	-0.75	17.122	30.46	-0.76	29.18
Skewness	-0.60	3.916	3.55	-0.60	5.37
Sample variance	4095.20	57.085	1.97	4090.35	82.92
Minimum	4.80	0.000	120.00	28.11	0.00
Maximum	4100.00	57.085	0.00	4118.45	82.92
Number	30.00	30.000	120.00	30.00	30.00
Confidence interval (95.0%)	427.12	4.130	30.00	429.87	5.60
Coefficient of variation (CV)	51.34	201.260	11.37	51.08	368.99

The statistical data by fishing segment are presented in Table 16 and indicate higher catches and bycatches in the segment of larger vessels.

Table 16

Summary statistics of the main catch weight (kg/day), fish/crustacean bycatch weight (BC1, kg/day), gelatinous zooplankton (BC2, kg/day), total catch weight (catch + bycatch) (kg/day), and percentage share (%) of by-catch (BC3) by fishing segment with OTM in 2024.

1. TM VL1218

	Main catch (kg/day)	**Bycatch weight (BC_1, kg/day)**	**Jellyfish bycatch (BC2, kg/day)**	**Total catch (catch + bycatch) (kg/day)**	**$BC_3 = BC_1+BC_2$ (% of total catch)**
Average value	1508.33	2.02	1.33	1511.7	0.81
Standard error	379.99	0.64	1.33	379.7	0.61
Median	1150.00	2.50	0.00	1150.0	0.11
Standard deviation	1139.98	1.91	4.00	1139.1	1.84
Kurtosis	-1.88	-1.56	9.00	-1.9	8.43
Skewness	0.13	0.23	3.00	0.1	2.88
Sample variance	2930.00	5.00	12.00	2925.0	5.66
Minimum	200.00	0.00	0.00	210.0	0.00

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Maximum	3130.00	5.00	12.00	3135.0	5.66
Number	9.00	9.00	9.00	9.0	9.00
Confidence interval (95.0%)	876.27	1.47	3.07	875.6	1.41
Coefficient of variation (CV)	75.58	94.50	300.00	75.4	227.38

2. TM VL2440

	Main catch (kg/day)	**Bycatch weight (BC 1, kg/day)**	**Jellyfish bycatch (BC_2, kg/day)**	**Total catch (catch + bycatch) (kg/day)**	**$BC_3 = BC_1+BC_2$ (% of total catch)**
Average value	2536.32	7.54	29.19	2571.78	5.46
Standard error	223.02	2.83	7.15	223.47	3.89
Median	2775.00	2.51	18.00	2793.61	0.90
Standard deviation	1022.00	12.98	32.79	1024.05	17.82
Kurtosis	0.73	11.07	1.91	0.72	20.62
Skewness	-1.02	3.13	1.56	-1.03	4.52
Sample variance	4095.20	57.09	120.00	4090.35	82.85
Minimum	4.80	0.00	0.00	28.11	0.07
Maximum	4100.00	57.09	120.00	4118.45	82.92
Number	21.00	21.00	21.00	21.00	21.00
Confidence interval (95.0%)	465.21	5.91	14.92	466.14	8.11
Coefficient of variation (CV)	40.29	172.17	112.34	39.82	326.62

During the study period, in pelagic trawl nets used for hake fishing, a total of 28 marine species were recorded as bycatch, with an average of ~6 species found per fishing day in the bycatch.

The dominant species in the bycatch by weight was moon jellyfish (80.65 %) (Fig. 16). In smaller quantities, the bycatch includes turbot (6.55 %), whiting (4.84 %), Gobidae (1.75 %), and thornback ray (1.58 %), whereas the share of all other species is < 5 % of the average weight of the bycatch.

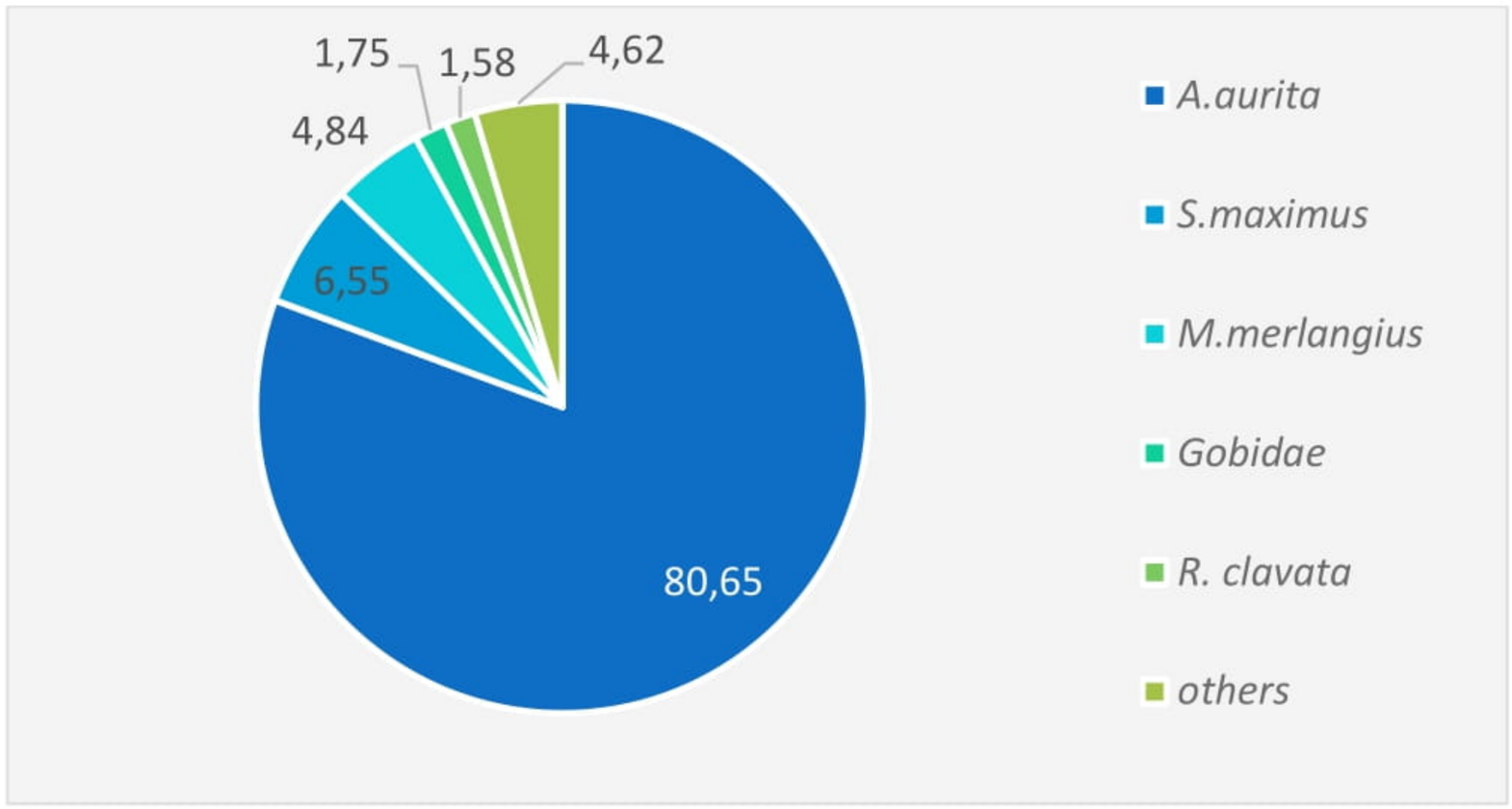

Fig. 16. Percentage participation of the dominant species in the formation of the average weight of the bycatch (kg/day) in pelagic trawl fishing in 2024

During pelagic trawl fishing, the average amount of bycatch is maximal (32.49 kg/day) in March 2024, but it is composed almost entirely of moon jellyfish (Table 17).

Table 17

Quantities of catch (kg/day) and bycatch (kg/day) of marine organisms in pelagic trawl fisheries by month in 2024.

Date	Mean weight of the main catch (kg/day)	Mean bycatch weight by species (kg/day)							Bycatch weight, BC_1 (kg/day)	Total catch TC (kg/day)	% BC of total catch
		Moon jellyfish	Whiting	Red mullet	Gobies	Turbot	Thorn-back ray	Other			
March 2024	2499.60	29.90	0.52	0.03	0.07	1.43	0.00	0.54	32.49	2532.09	1.28
October 2024	553.33	2.00	8.55	0.62	8.39	0.00	2.29	1.76	23.61	576.94	4.09
November 2024	1502.87	3.00	0.20	0.56	0.06	3.16	0.77	0	7.75	1510.62	0.51

A clear seasonal dynamic was observed in the bycatch species composition. The moon jellyfish showed a pronounced spring peak (Fig. 17). An increase in the proportion of whiting in the bycatch was registered during the summer (36 % BCW), while the quantity of turbot had an autumn

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peak in the bycatch (41 % BCW). The sensitive cartilaginous fish species are represented only by thornback rays, which appear in the bycatch only during autumn (~9.7 % BCW) (Fig. 17).

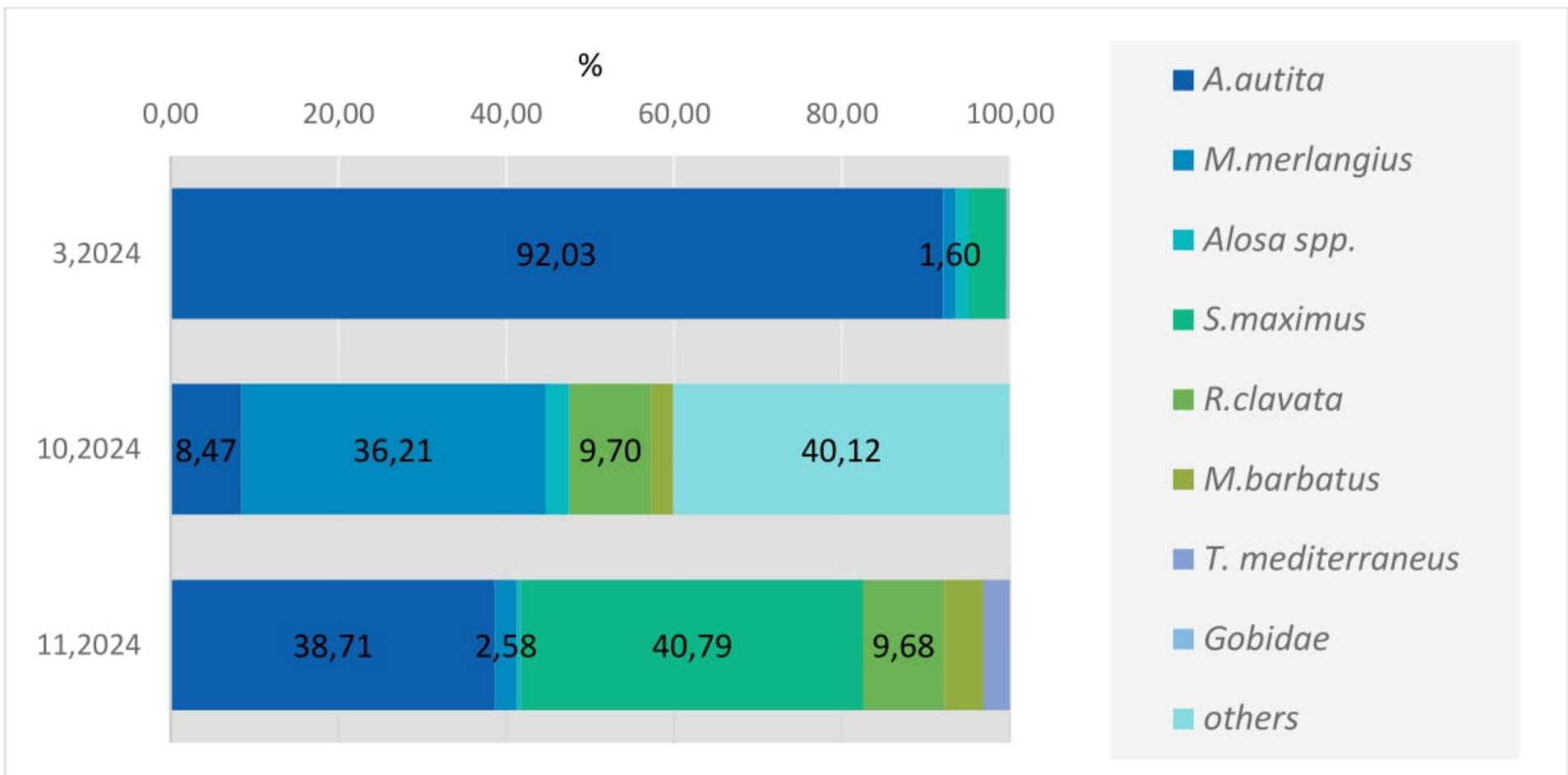


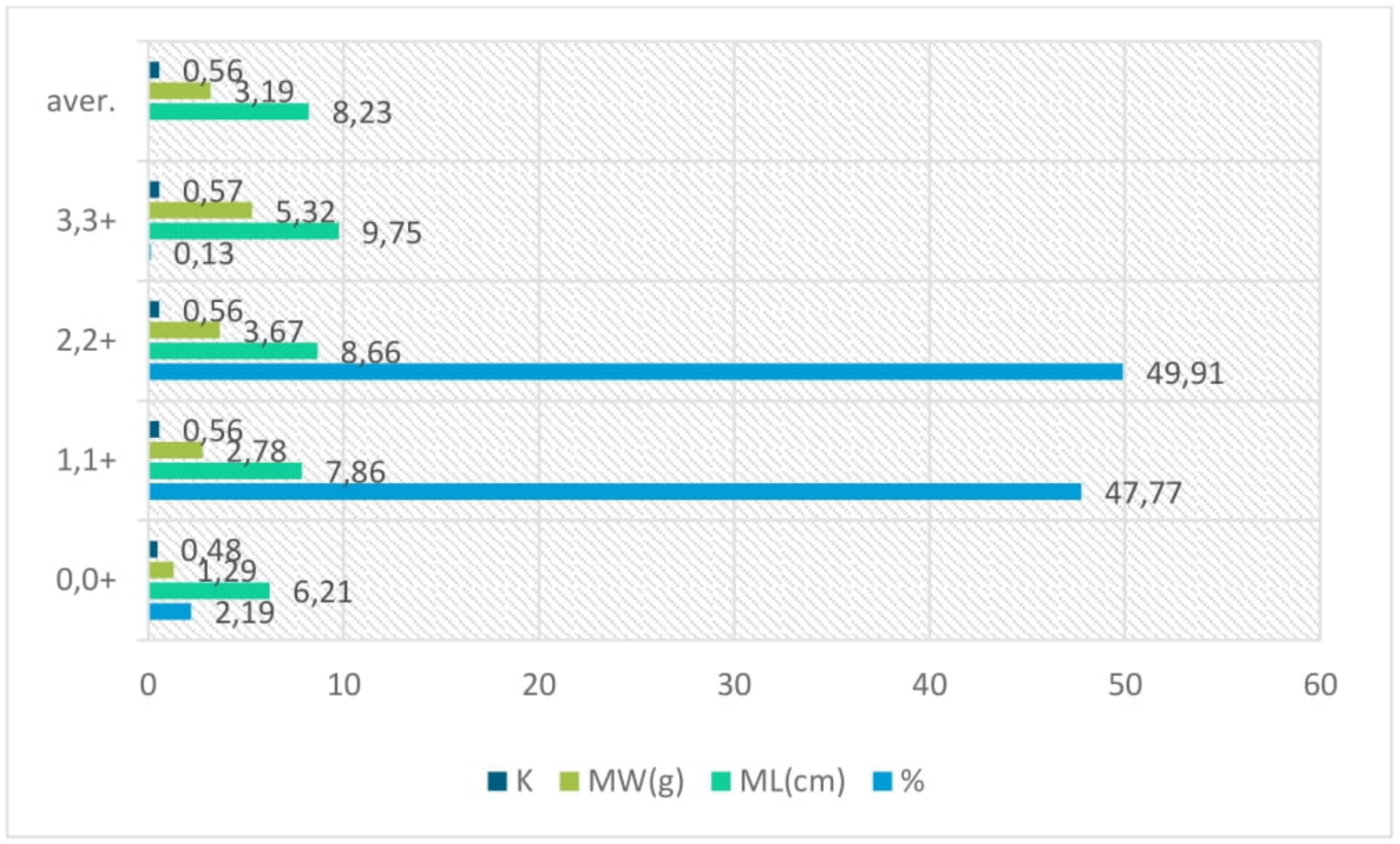
Figure 17. Percentage composition of bycatch (% of total bycatch by species) in the sprat fishery by month in 2024.

3.2.2. Dynamics of biological parameters

A) *Sprattus sprattus* - age structure, linear dimensions and weights, condition factor

During the first and second halves of 2024, two-year-old horse mackerel dominated the catches, accounting for 49.91% (in March) and 70.42% (October-November), followed by one-year-old individuals at 47.77 % and 26.9 %, respectively.

In the target catch, specimens with sizes ranging from 5.3–10.6 cm were recorded, with average lengths of 8.3–8.5 cm and an average weight of 3.2–3.6 g. The mean value of the condition factor varied between 0.48 – 0.58 across different age groups (Fig. 18).



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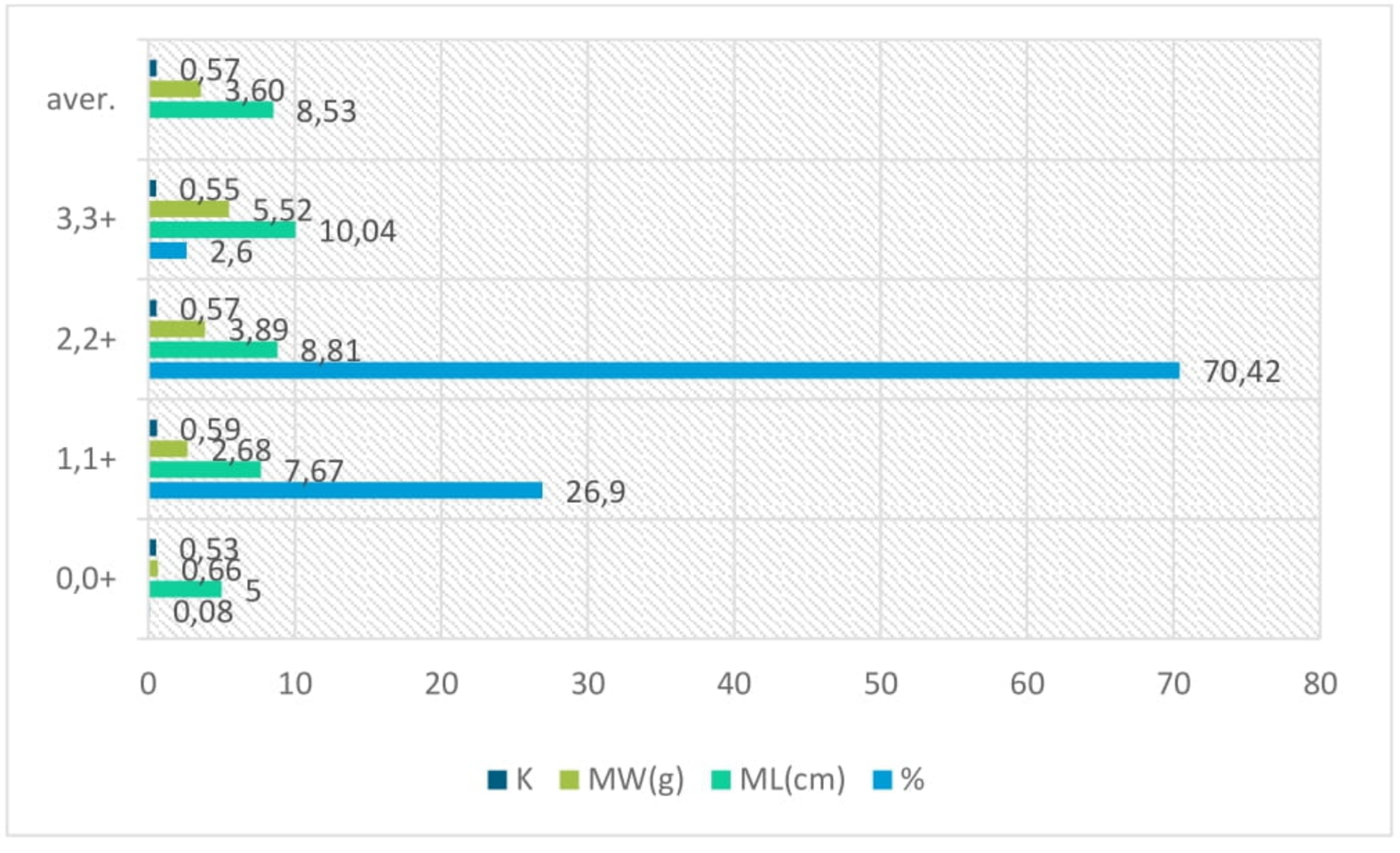

2.

Figure 18. *Sprattus sprattus*: age structure (%), mean size, mean weight, and condition factor by age group and average for periods: 1) spring 2024 and 2) autumn 2024.

The parameter values in the von Bertalanffy equation during the spring of 2024 are: a = 0.0034, b = 3.22, $L\infty$ = 10.63 cm; and during the autumn: a = 0.0064, b = 2.93, $L\infty$ = 11.16 cm). The

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relationships between the weight and linear sizes of horse mackerel during the first and second halves of 2024 are shown in Fig. 19.

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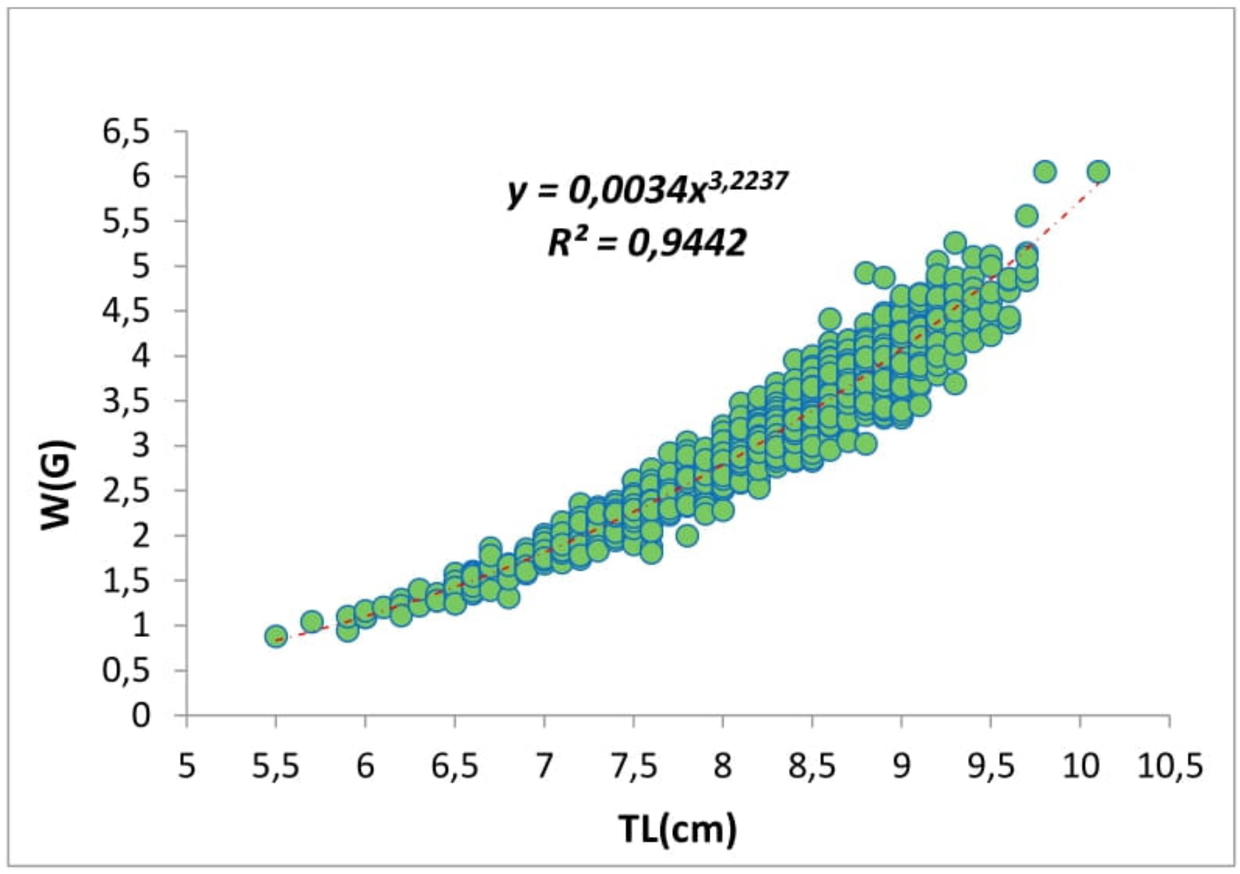

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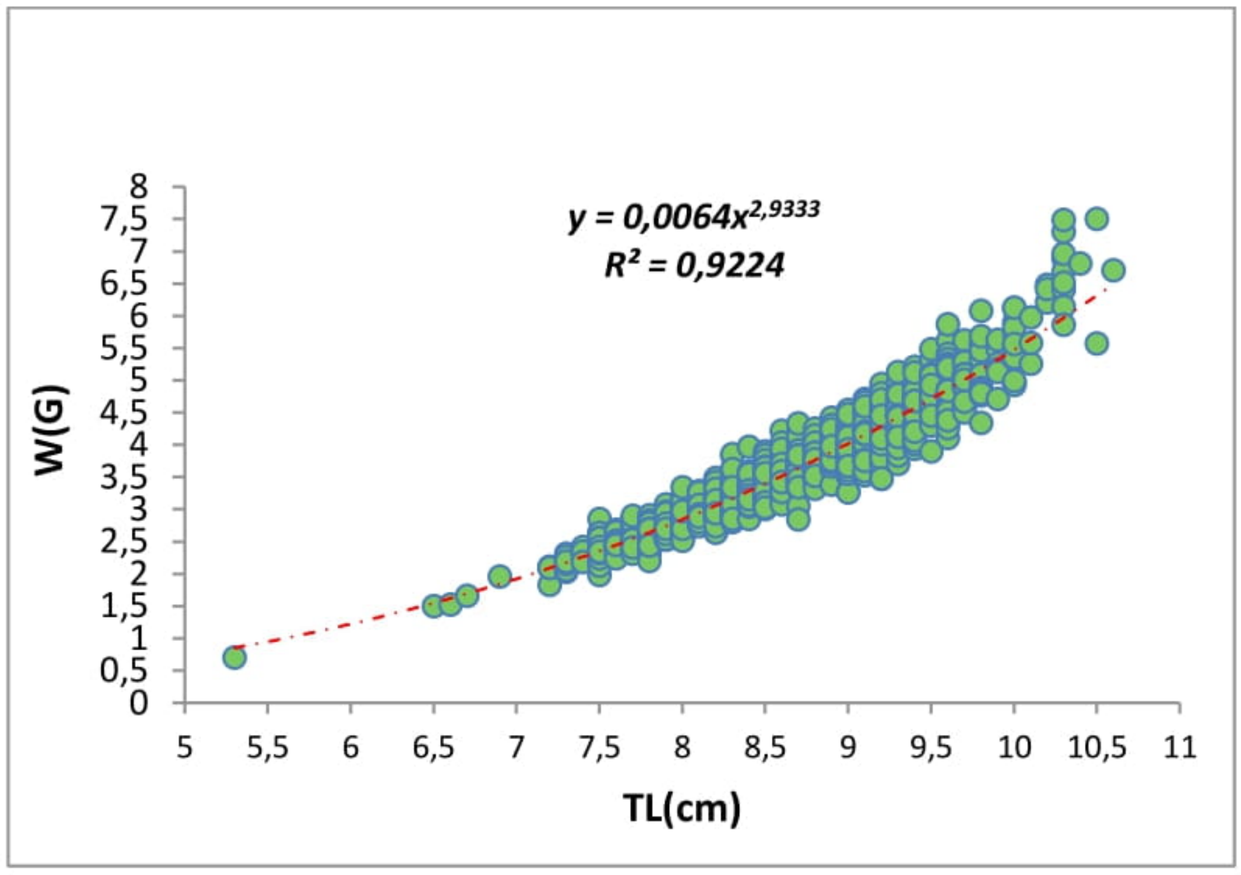

Fig.19. Length-weight relationship (LWR) of *S. sprattus* during 1) spring 2024 and 2) autumn 2024.

3.2.2 Biological data on bycatch in pelagic trawl fisheries

B) Biological data on the main bycatch in sprat fishery

Merlangius merlangus

In 2024, the age composition of the bycatch of whiting includes 1–4-year-old individuals, with average sizes ranging between 10.4 – 17.20 cm and average weights from 7.9 – 18.2 g. The mean value of the condition factor is 0.66, varying between 0.34 – 0.73 across different age groups (Fig. 20).

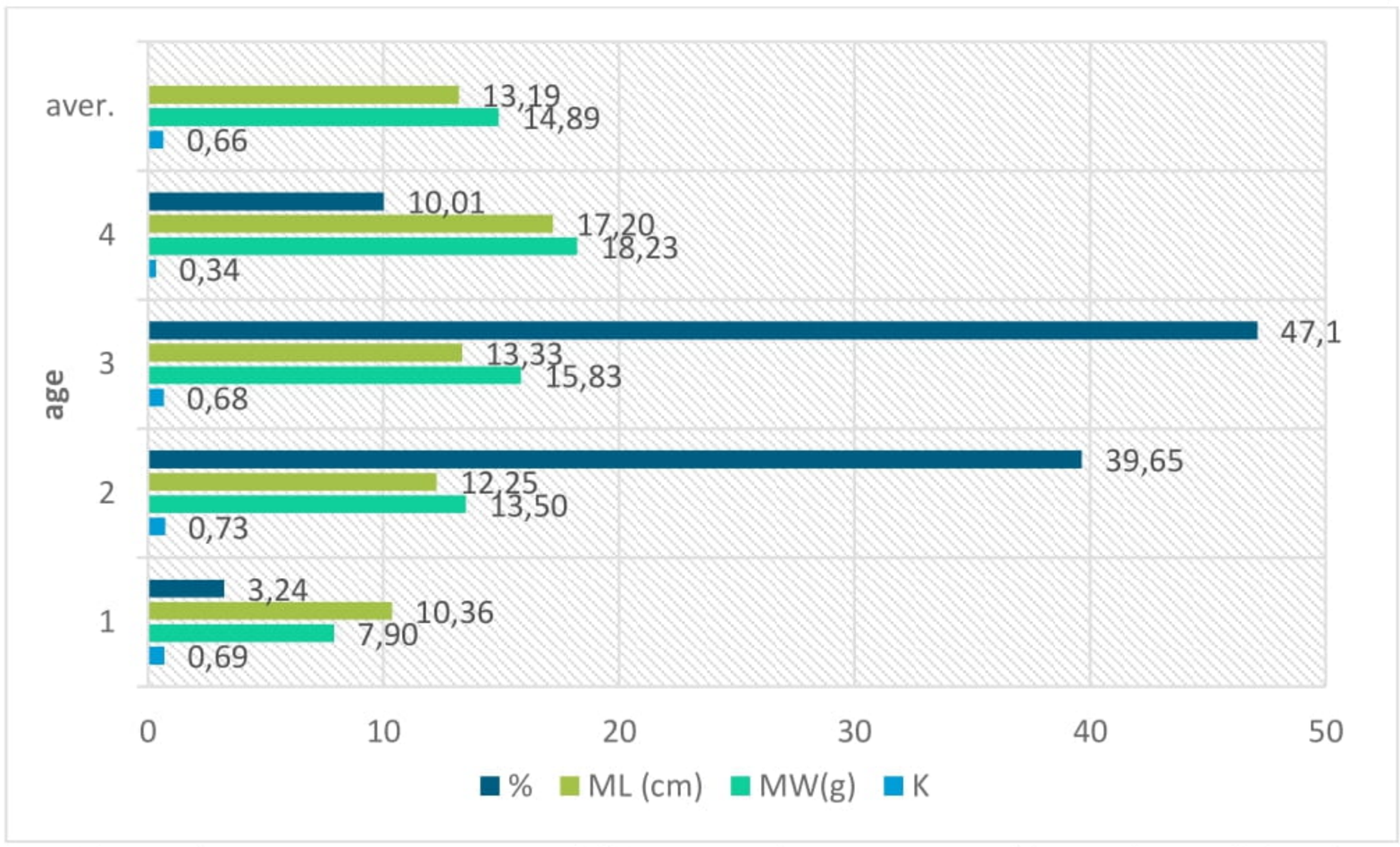

Figure 20. *M. merlangus* - age structure (%), mean size, mean weight and condition factor by age groups and mean parameters for bycatch, 2024.

The length-weight relationship (LWR) for *M. merlangus* in 2024 is presented in Fig. 21 and reveals positive allometric growth (b = 3.09).

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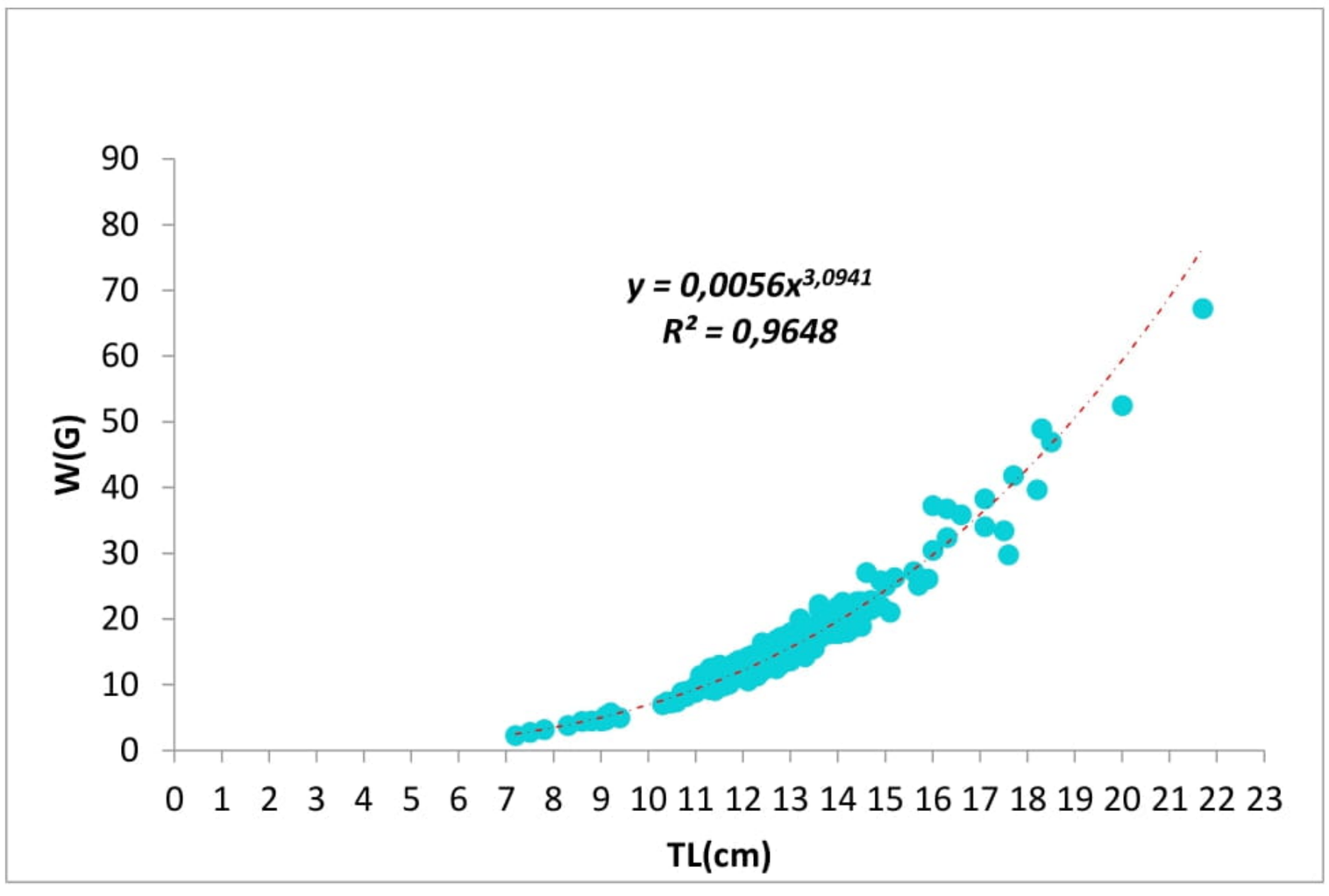

Figure 21. The LWR of M. merlangus in 2024.

3.2.3 Biological parameters of bycatch of sensitive species in pelagic trawl fisheries

Data regarding the species composition of the sensitive species, the total number of captured individuals, their average weight, and average sizes in the bycatch are presented in Table 18. Upon removal from the nets, all the captured sensitive species (30 individuals) were alive, with no serious injuries. The average bycatch coefficient was highest for turbot, T = 0.8 ind/day.

Table 18

Data on the status (according to the International Union for the Conservation of Nature (IUCN)) of sensitive species in bycatch, total number of specimens caught, average size (cm), and average weight (g) in the pelagic trawl fishery in 2024.

Bycatch species	IUCN status	Total number	Bycatch coefficient (ind/day)	Average length (cm)	Average weight (g)
Raja clavata	NT	6	0.2	68.00	2040

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	(Near threatened species)				
Scophthalmus maximus	LC (Least Concern)	24	0.8	43.57	2113.75

In 2024, the species diversity of sensitive species in the bycatch showed seasonal fluctuations, with bycatch coefficients increasing in autumn (Table 19, Fig. 22). Specifically, the bycatch coefficient for turbot increased in November to 1.57 ind/day, while that for the thornback ray was maximal in October (T = 1 ind/day) (Fig. 22, Table 19).

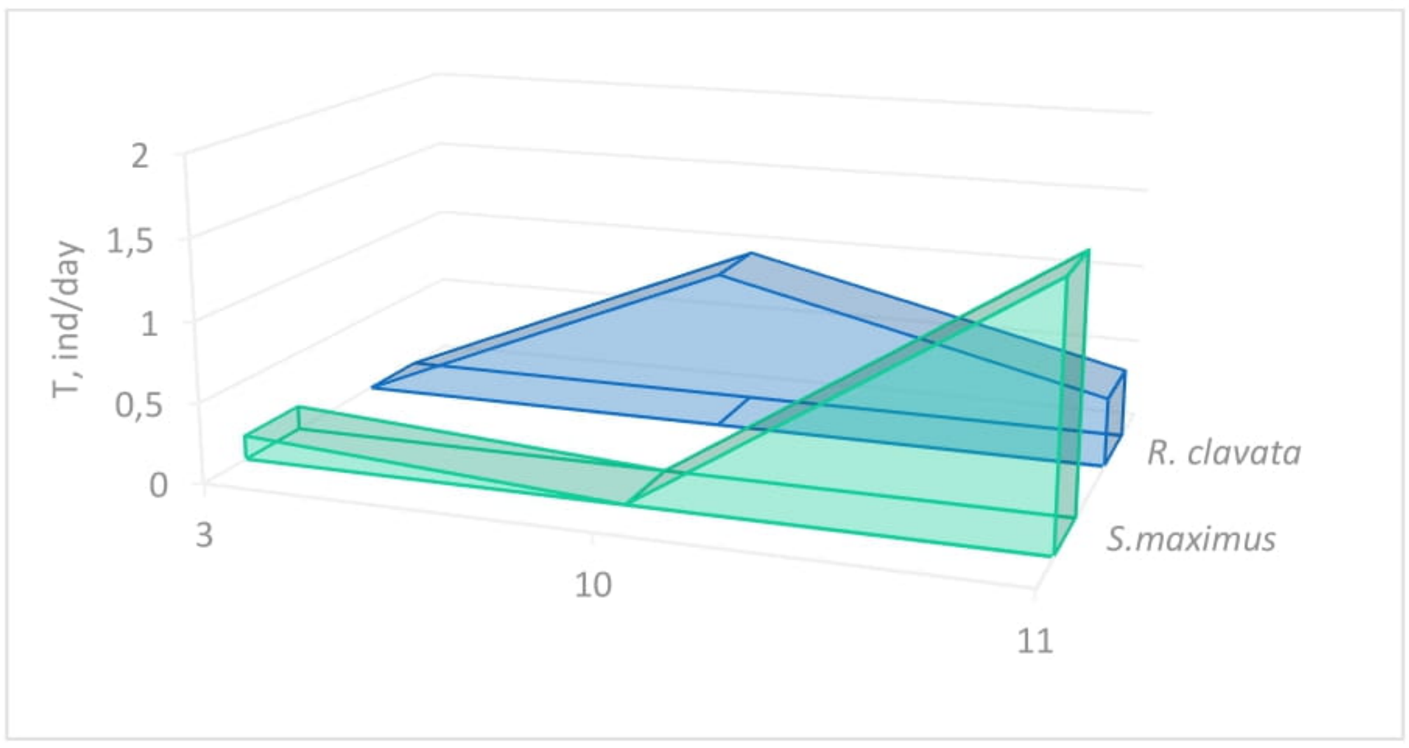

Fig. 22. Monthly fluctuations in the bycatch ratio (T, ind/day) of sensitive species during pelagic trawl fishing in 2024.

Table 19

Monthly data on the bycatch of sensitive species, total number of specimens per species, bycatch ratio, average size (cm), and average weight (g) from the pelagic trawl fishery in 2024.

Month	Bycatch species	Total number	Monthly bycatch coefficient (ind/day)	Mean length (cm)	Mean weight (g)
III.2024	*S. maximus*	16	0.15	42.07	1787.50
VI.2024	*R. clavata*	3	1	72.75	2286.67
XI.2024	*S. maximus*	8	1.57	49.07	2766.25
	R. clavata	3	0.43	63.25	1793.33

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The bycatch of the sensitive species by fishing segment is shown in Table 20. A large number of sensitive species (26 individuals) were caught in the segment of the large fishing vessels, TM VL2440.

Table 20

Data on the status (according to the International Union for the Conservation of Nature (IUCN)) of sensitive species in bycatch, total number of specimens caught, average size (cm), and average weight (g) in pelagic trawl fisheries (by fishing segment) in 2024.

1. **TM VL1218**

Bycatch species	IUCN status	Total number	Bycatch coefficient (ind/day)	Mean length (cm)	Mean weight (g)
Raja clavata	NT (Near threatened species)	2	0.29	61.0	1450
Scophthalmus maximus	LC (Least Concern)	2	0.29	39.5	1250

2. **TM VL2440**

Bycatch species	IUCN status	Total number	Bycatch coefficient (ind/day)	Mean length (cm)	Mean weight (g)
Raja clavata	NT (Near threatened species)	4	0.17	70.33	2335
Scophthalmus maximus	LC (Least Concern)	22	0.96	44.25	2192

3.3 Rapa whelk fishery with beam trawl

3.3.1 Main catch, bycatch, total catch

During the intervals IV - VI. 2024, studies on beam trawl catches of rapa whelk covered two fishing segments: TBB VL1824 and TBB VL1218.

Rapa whelk catches range between 40 - 2090 kg/day, and bycatch amounts of marine organisms fluctuate between 2.39 - 174.25 kg/day; the total catch of marine organisms (TC1) was 1151.00 kg/day ± 133.18 SE, and the average percentage share of bycatch of marine organisms was 2.96 % ± 0.68 SE of this catch (Table 21.1). Accordingly, the average amount of marine litter was 55.31 kg/day ± 16.18 SE, with a percentage share of 3.86 % ± 1.08 SE of the total catch (TC2) (Table 21.2).

Table 21

Summary statistics on the total weight of the main catch of *R. venosa* (kg/day), weight of bycatch (kg/day), total weight of catches (catch + bycatch) (kg/day), and percentage share (%) of bycatch during 2024, as well as additional data on the weight of clam shells (kg/day) and marine litter (kg/day) and the percentage share of the total amount caught in trawls (2).

1. Main catch and bycatch

	Main catch (kg/day) R. venosa	**Bycatch weight BC1 (kg/day)**	**Total catch of marine species, TC1 (catch + bycatch) (kg/day)**	**% of bycatch BC1 from total catch TC_1**
Average value	1115.75	35.25	1151.00	2.96
Standard error	127.30	11.08	133.18	0.68
Median	1252.50	6.25	1274.99	1.05
Standard deviation	569.31	49.53	595.61	3.03
Kurtosis	-0.76	2.65	-0.65	-1.36
Skewness	-0.09	1.80	0.01	0.64
Sample variance	2050.00	171.86	2185.38	8.46
Minimum	40.00	2.39	42.57	0.19
Maximum	2090.00	174.25	2227.95	8.65
Number	20.00	20.00	20.00	20.00
Confidence interval (95.0%)	266.45	23.18	278.76	1.42
CV	51.03	140.52	51.75	102.09

2. Additional catch

	Weight of Bivalvia shells, Tb, (kg/day)	Weight of marine litter, Tl (kg/day)	Weight of the whole catch, TC2 = TC1+Tb+Tl (kg/day)	% of shells from the total catch TC2	% of marine litter from the total catch TC2
Average value	81.84	55.31	1288.15	5.77	3.86
Standard error	18.16	16.18	150.86	0.93	1.08
Median	46.50	11.01	1413.35	5.57	0.63
Standard deviation	81.21	72.38	674.68	4.15	4.83
Kurtosis	0.64	-0.44	-0.59	0.67	0.14
Skewness	1.12	1.05	0.00	0.76	1.11
Sample variance	280.00	210.00	2468.12	15.73	15.58
Minimum	2.00	0.00	44.57	0.66	0.00
Maximum	282.00	210.00	2512.69	16.40	15.58
Number	20.00	20.00	20.00	20.00	20.00
Confidence interval (95.0%)	38.01	33.88	315.76	1.94	2.26
CV	99.22	130.87	52.38	71.95	125.30

The data for fishing segments are listed in Table 22. Daily catches of rapa whelk were 1.07 times higher in the large vessel segment, averaging 1161.88 kg/day ± 193.98 SE. At the same time, the average daily amount of bycatch of marine organisms is 4.7 times higher in vessels from segment TBB VL1218 - 51.44 kg/day ± 16.64 SE. Accordingly, in this segment, the percentage share of bycatch of marine organisms (3.69 % ± 0.89 SE) exceeds by 2 times the percentage share registered in large vessels.

Table 22

Summary statistics on the total weight of the main catch of *R. venosa* (kg/day), weight of bycatch (kg/day), total weight of catch (catch + bycatch) (kg/day), and percentage share (%) of bycatch by fishing segment in 2024 as well as additional data on the weight of clam shells (kg/day), marine litter (kg/day), and percentage share of the total amount caught in trawls.

1.TBB VL1218: main catch and bycatch

	Main catch (kg/day) R. venosa	Bycatch BC1 (kg/day)	Total catch of marine species, TC1 (catch + bycatch) (kg/day)	% of bycatch BC1 from total catch TC1
Average value	1085.00	51.44	1136.44	3.69
Standard error	174.57	16.64	187.90	0.89
Median	920.00	36.57	926.20	2.80
Standard deviation	604.73	57.66	650.90	3.07

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Kurtosis	-1.22	0.45	-1.18	-1.65
Skewness	0.42	1.20	0.47	0.38
Sample variance	1810.00	171.66	1944.46	8.12
Minimum	280.00	2.58	283.48	0.53
Maximum	2090.00	174.25	2227.95	8.65
Number	12.00	12.00	12.00	12.00
Confidence interval (95.0%)	384.23	36.63	413.56	1.95
CV	55.74	112.08	57.28	83.14

2. TBB VL1218: additional catch

	Weight of Bivalvia shells, Tb (kg/day)	**Weight of marine litter, Tl (kg/day)**	**Weight of the whole catch, $TC_2 = TC_1+Tb+Tl$ (kg/day)**	**% of shells from the total catch TC_2**	**% of marine litter from the total catch TC_2**
Average value	62.15	26.54	1225.14	4.39	2.57
Standard error	23.06	15.12	203.75	0.96	1.40
Median	41.75	5.46	1084.70	4.27	0.43
Standard deviation	79.87	52.39	705.82	3.32	4.85
Kurtosis	5.34	5.18	-0.81	-0.09	4.69
Skewness	2.25	2.39	0.53	0.71	2.26
Sample variance	277.50	168.58	2203.20	10.55	15.54
Minimum	4.50	0.42	309.48	0.67	0.05
Maximum	282.00	169.00	2512.69	11.22	15.58
Number	12.00	12.00	12.00	12.00	12.00
Confidence interval (95.0%)	50.75	33.29	448.46	2.11	3.08
CV	128.50	197.38	57.61	75.72	189.10

3. TBB VL1824: main catch and bycatch

	Main catch (kg/day) *R. venosa*	**Bycatch BC_1 (kg/day)**	**Total catch of marine species, TC_1 (catch + bycatch) (kg/day)**	**% of bycatch BC_1 from total catch TC_1**
Average value	1161.88	10.97	1172.84	1.88
Standard error	193.98	6.25	192.43	0.99
Median	1292.50	4.57	1299.51	0.40
Standard deviation	548.66	17.68	544.27	2.80
Kurtosis	2.32	7.32	2.65	0.08

Skewness	-1.22	2.68	-1.28	1.43
Sample variance	1855.00	51.71	1856.11	6.54
Minimum	40.00	2.39	42.57	0.19
Maximum	1895.00	54.10	1898.68	6.73
Number	8.00	8.00	8.00	8.00
Confidence interval (95.0%)	458.69	14.78	455.02	2.34
CV	47.22	161.21	46.41	149.04

4.TBB VL1824: additional bycatch

	Weight of Bivalvia shells, Tb (kg/day)	**Weight of marine litter, Tl (kg/day)**	**Weight of the whole catch, $TC_2 = TC_1+Tb+Tl$ (kg/day)**	**% of shells from the total catch TC_2**	**% of marine litter from the total catch TC_2**
Average value	111.38	98.45	1382.67	7.84	5.80
Standard error	27.87	28.20	233.35	1.63	1.55
Median	117.50	101.00	1546.51	7.64	6.29
Standard deviation	78.83	79.76	660.02	4.61	4.39
Kurtosis	-0.19	-1.57	2.53	1.34	-1.41
Skewness	-0.02	0.05	-1.02	0.45	-0.07
Sample variance	238.00	210.00	2304.11	15.73	12.07
Minimum	2.00	0.00	44.57	0.66	0.00
Maximum	240.00	210.00	2348.68	16.40	12.07
Number	8.00	8.00	8.00	8.00	8.00
Confidence interval (95.0%)	65.90	66.68	551.79	3.85	3.67
CV	70.78	81.02	47.74	58.77	75.74

Seasonal changes in the quantities of catch and bycatch were tracked, with bycatch quantities peaking in June 2024 at 45.334 kg/day (Fig. 23.1). The average monthly share of bycatch of marine organisms, expressed as a percentage of the total catch, varied between 0.29 – 3.74 %, with a maximum occurring in June (Fig. 23.1).

The amount of marine litter increased in the spring, reaching an average of 158.50 kg/day (Fig. 23.2).

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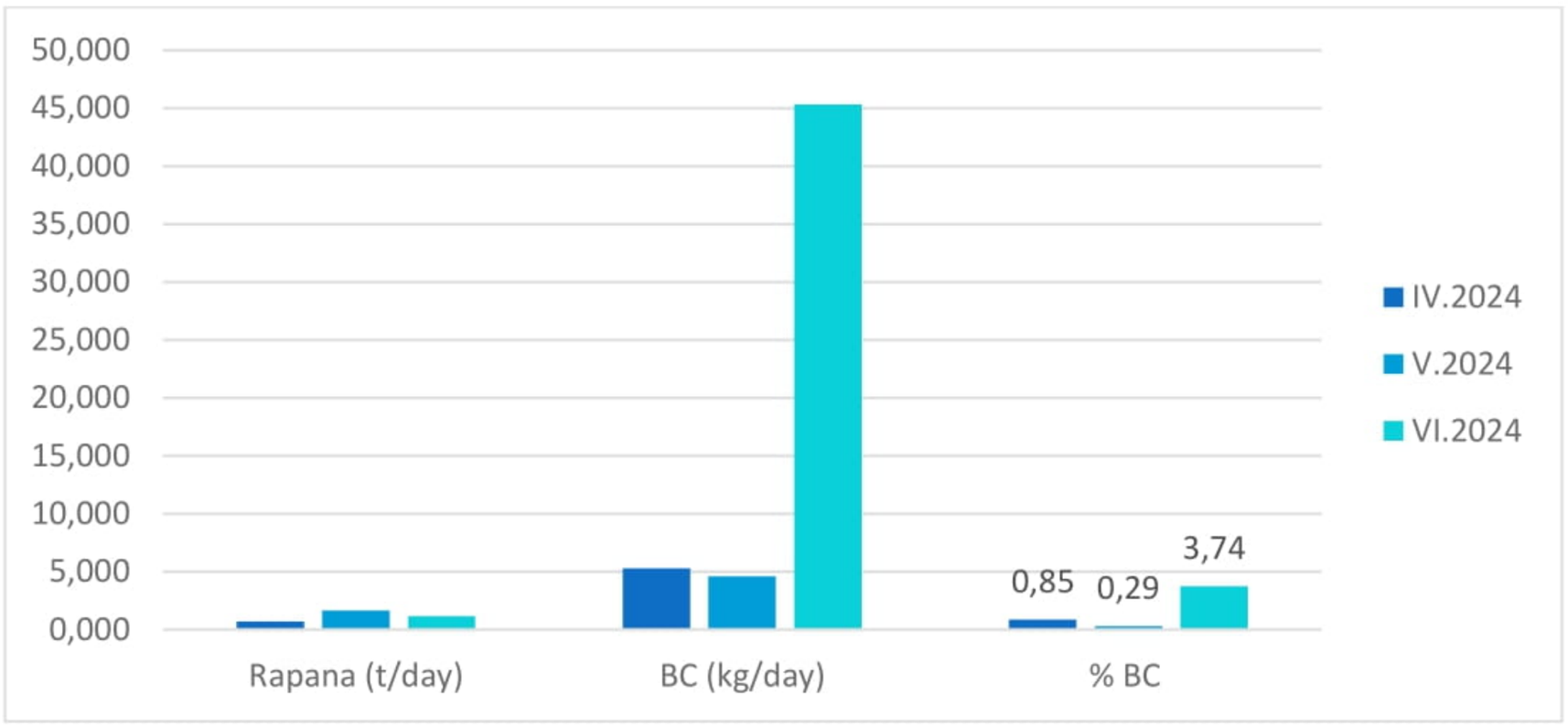

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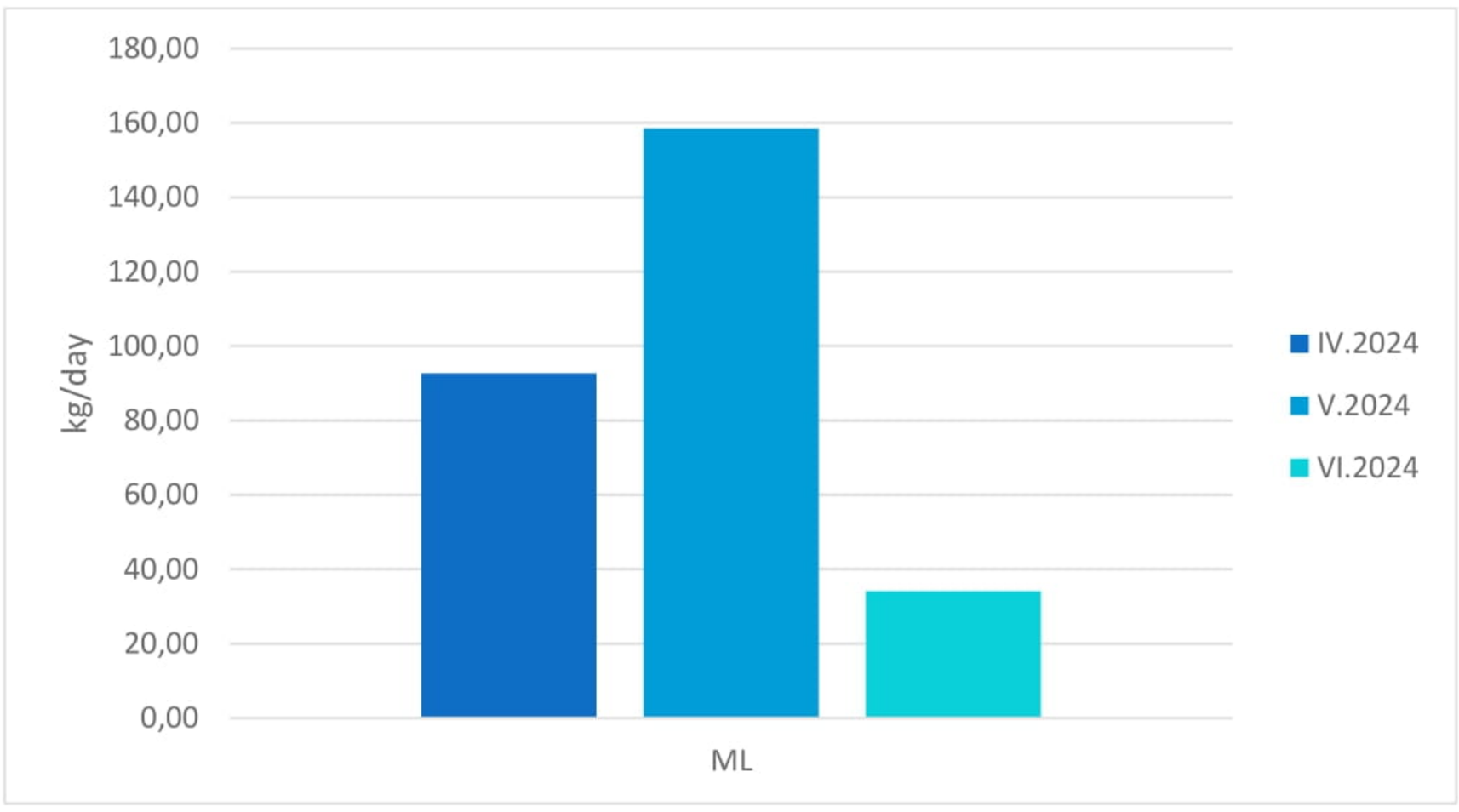

Fig. 23. Data on (1) Rapa whelk catch (**t/day**), bycatch of marine organisms (**kg/day**), % of bycatch of total TC_1, and (2) amount of marine litter (**kg/day**) during the summer-autumn period of 2024.

The species composition of the by-catch in rapa whelk fishery was diverse and included 30 species - mainly fish, arthropods and mollusks, and a maximum of 20 different species of marine organisms being found in beam trawls per day, and the average number of species in the bycatch per day is 11 species. The most common bycatch is the stargazer (*Uranoscopus scaber*), 95% of the daily bycatch and the swimming crab (*Polybius vernalis*) at 90 %, while the mussel *Anadara kagoshimensis* and the flounder *P. flesus* were found in 80 % of the daily bycatch.

During the study period, the dominant bycatch species by weight was *A. kagoshimensis* (83 %), followed by turbot and stargazer (4 %), black mussel, swimming crab (3 %), and thornback ray (1 %) (Fig. 24).

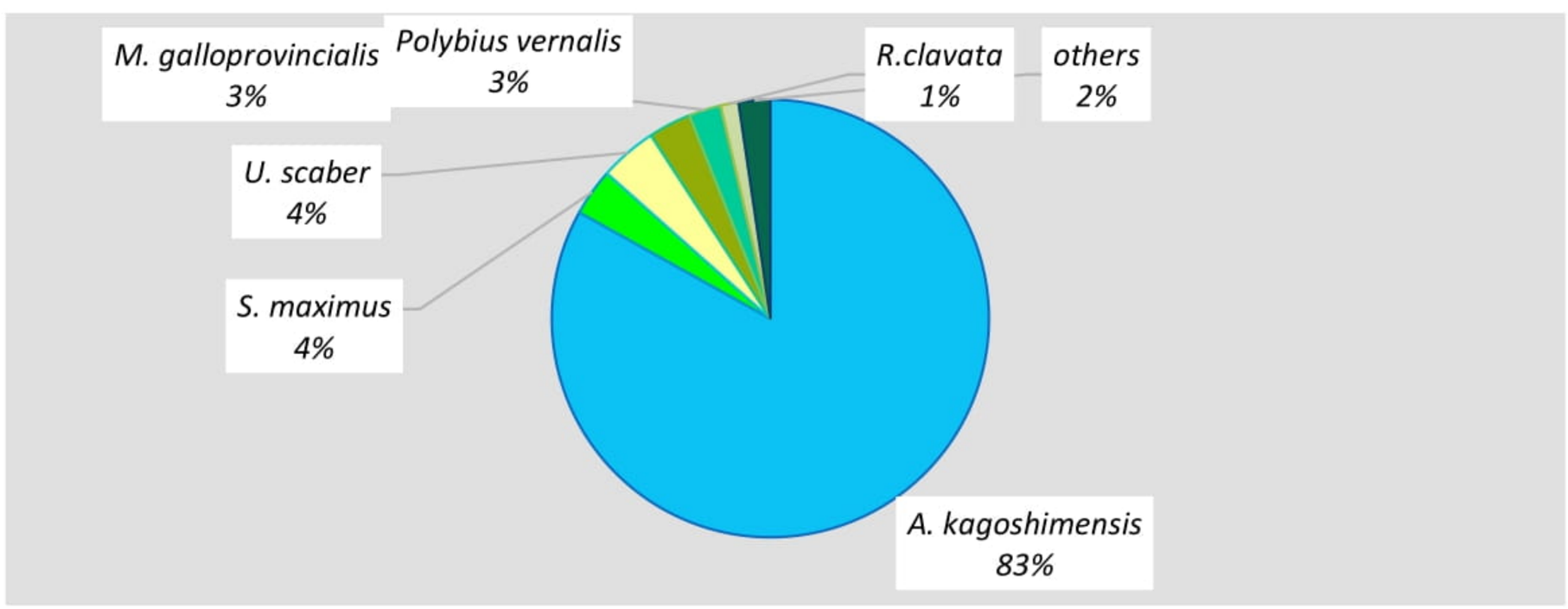

Fig. 24. Percentage participation of the dominant species in the formation of the weight of the bycatch (kg/day) in rapa whelk fishery, 2024

The dynamics of bycatch species composition based on participation in the formation of bycatch weight by month is presented in Fig. 25.

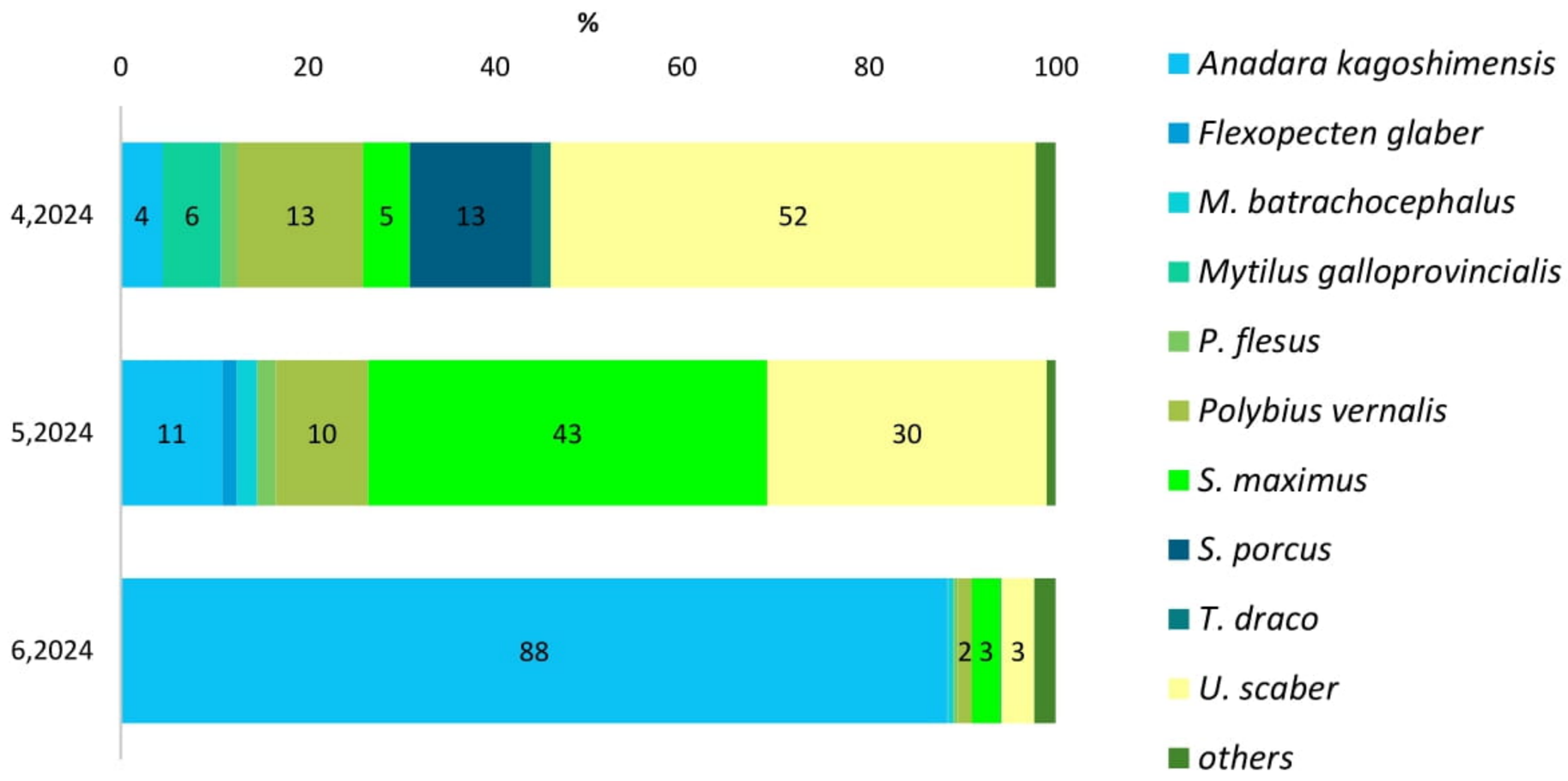

Figure 25. Changes in bycatch species composition (% of total weight of bycatch, BCW_1, kg/day) per month in rapa whelk fishery with beam trawls.

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The quantity of turbot in the bycatch was the most significant in August 2024 (33 % BCW) and May 2024 (30 % BCW), and the share of *A. kagoshimensis* mussels increased in the summer, reaching a maximum of 88 % BCW (Fig. 25).

3.3.2. Dynamics of biological parameters

A) *Rapa whelk main catch* – size and weight structure of catches

The average size of the studied rapa whelk specimens ranged between 54.100 - 64.924 mm, and the average weights varied between 28.135- 48.651 g (Table 23).

Table 23

Summary statistics of data: (1) shell length (SL, cm) and (2) total weight (TW, g) of rapa whelk from the main 2024 catch.

(1) SL, mm

Date	no	Minimum SL (mm)	Maximum SL (mm)	Average SL (mm)	St. deviation
25.4.2024	100	40.000	77.000	54.100	6.351
26.4.2024	100	43.000	84.000	61.290	7.943
27.4.2024	100	35.000	94.000	60.910	13.034
30.5.2024	100	43.000	89.000	56.950	10.223
02.6.2024	100	47.000	101.000	63.460	9.480
17.6.2024	92	52.000	90.000	64.924	5.917

(2) TW, g

Date	no	Minimum TW (g)	Maximum TW (g)	Average TW (g)	St. deviation
25.4.2024	100	11.110	82.190	28.135	10.027
26.4.2024	100	13.330	78.640	37.479	13.675
27.4.2024	100	7.520	148.390	46.006	28.519
30.5.2024	100	12.810	127.590	36.400	22.398
02.6.2024	100	17.880	180.880	49.285	22.820
17.6.2024	92	25.500	103.970	48.651	12.927

During the 2024 research period, 98.64 % of the measured specimens were < 85 mm in size. The average size of *R. venosa* reached 60.209 mm ± 9.87 SD, with an average weight of 40.889 g TW ± 20.98 SD (Fig. 26 & 27). The most significant presence in the catches was the 45–70 mm size group (79.9 % of the measured rapa whelk specimens, Fig. 26, Table 24.1).

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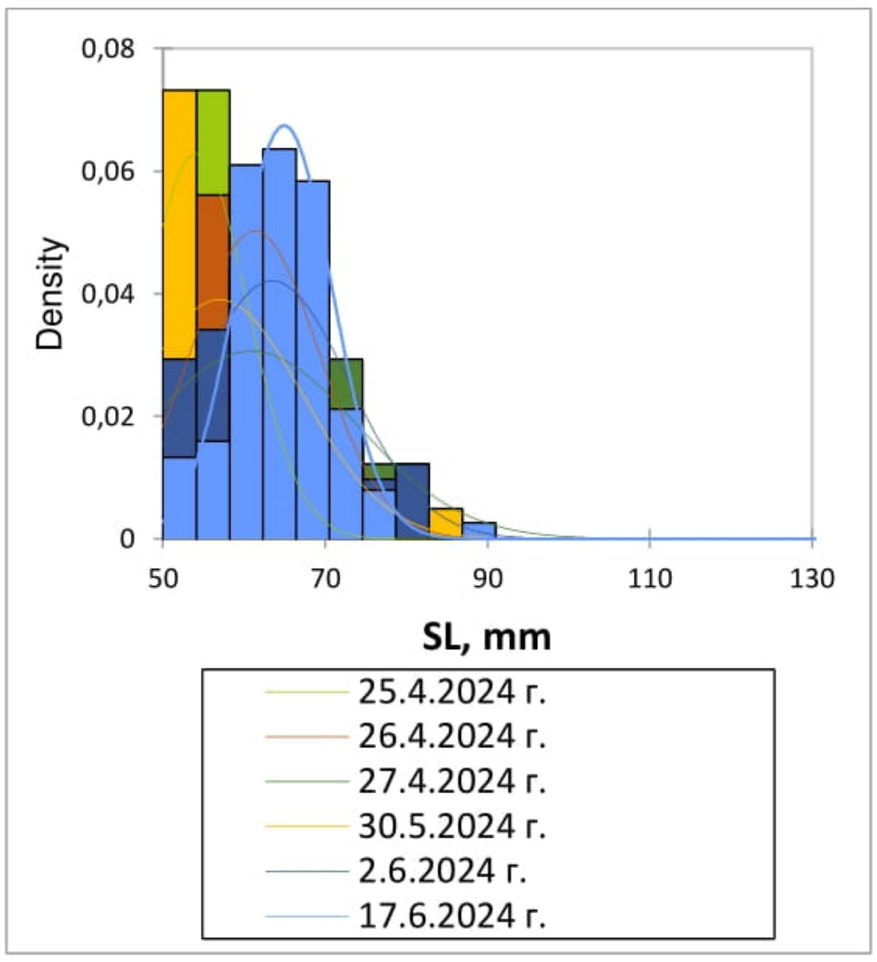

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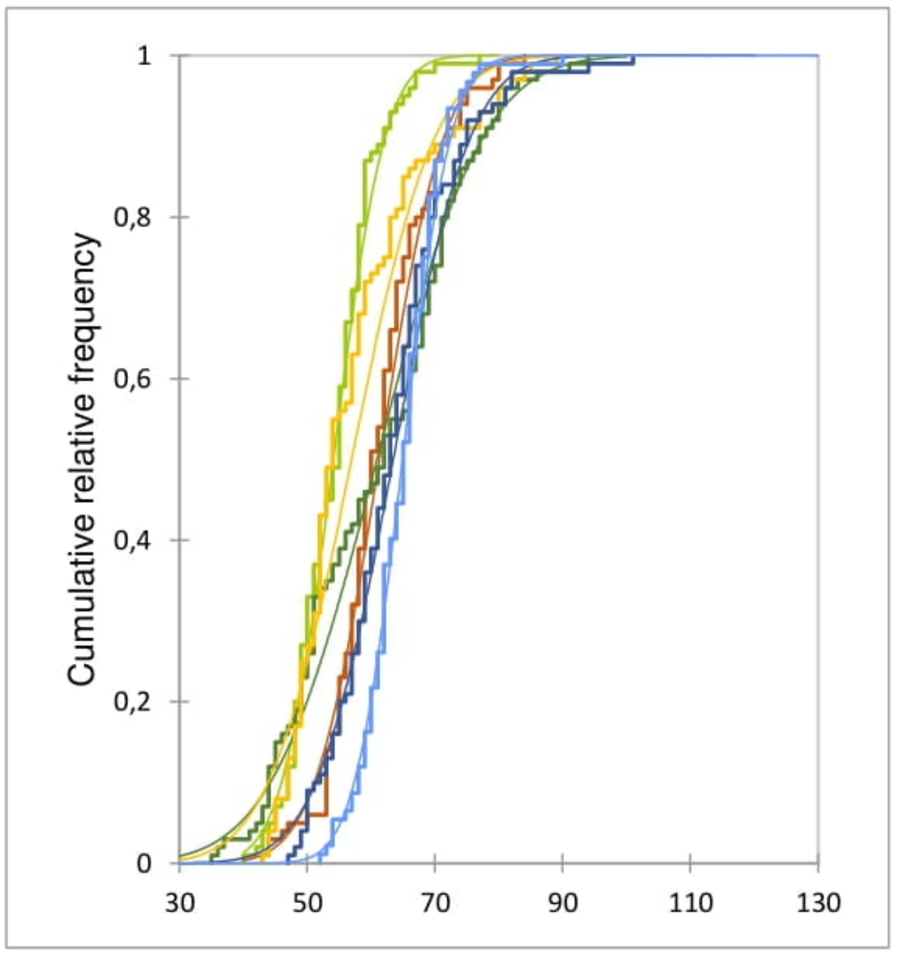

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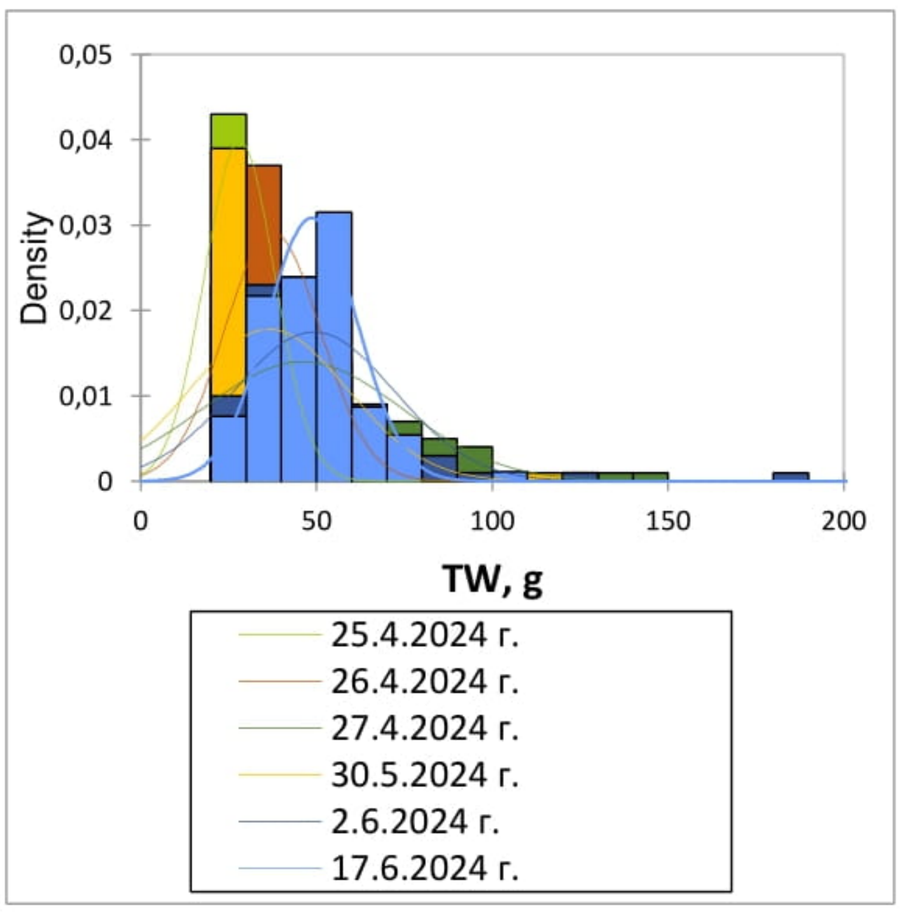
Figure 26. Distribution of *R. venosa* by length classes (SL, cm, 1), and cumulative distribution (2) in summer-autumn 2024.

Accordingly, the 20–60 g weight groups (85.64 %) played a leading role in the catches (74.83 %, Fig. 27, Table 24.2). During the study period, 91.05 % of the measured specimens weighed < 70 g.



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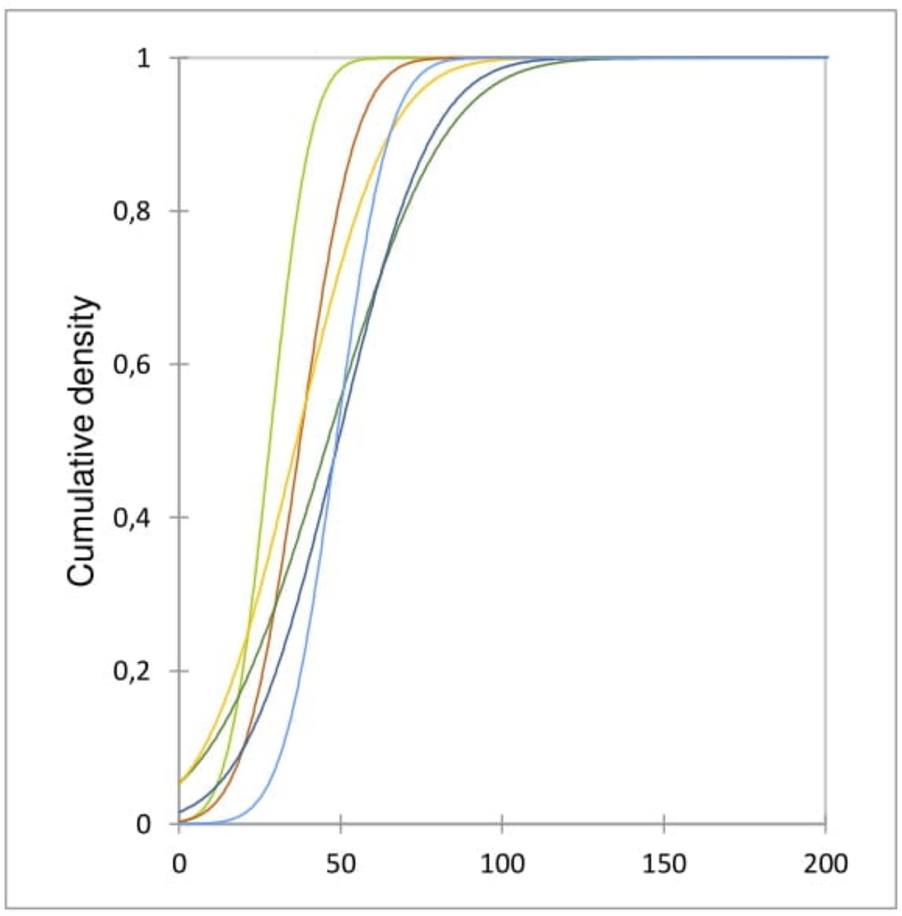

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Figure 27. Distribution of *R. venosa* by weight classes (TW, g, 1) and cumulative distribution by weight class (2) in summer-autumn of 2024.

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Table 24

Statistics on the distribution of length (mm, 1) and weight (g, 2) classes of rapa whelk in 2024.

1. SL (mm)

Lower limit	Upper limit	Frequency	Relative frequency	Density
35.000	40.000	3	0.005	0.001
40.000	45.000	21	0.035	0.007
45.000	50.000	60	0.101	0.020
50.000	55.000	94	0.159	0.032
55.000	60.000	124	0.209	0.042
60.000	65.000	99	0.167	0.033
65.000	70.000	96	0.162	0.032
70.000	75.000	50	0.084	0.017
75.000	80.000	21	0.035	0.007
80.000	85.000	16	0.027	0.005
85.000	90.000	3	0.005	0.001
90.000	95.000	4	0.007	0.001
95.000	100.000	0	0.000	0.000
100.000	105.000	1	0.002	0.000

2. TW (g)

Долна граница	Горна граница	Честота	Относителна честота	Плътност
10.000	20.000	60	0.101	0.010
20.000	30.000	141	0.238	0.024
30.000	40.000	136	0.230	0.023
40.000	50.000	94	0.159	0.016
50.000	60.000	72	0.122	0.012
60.000	70.000	33	0.056	0.006
70.000	80.000	25	0.042	0.004
80.000	90.000	12	0.020	0.002
90.000	100.000	6	0.010	0.001
100.000	110.000	3	0.005	0.001
110.000	120.000	1	0.002	0.000
120.000	130.000	3	0.005	0.001
130.000	140.000	1	0.002	0.000

140.000	150.000	1	0.002	0.000
180.000	190.000	1	0.002	0.000

B) Biological data on bycatch in rapa whelk fishery

Scopthalmus maximus

The bycatch of turbot includes specimens with an average size of 31.55 cm and an average weight of 0.8 kg. Figure 28 presents the length-weight relationship (LWR) of S. maximus from bycatch with a beam trawl in 2024.

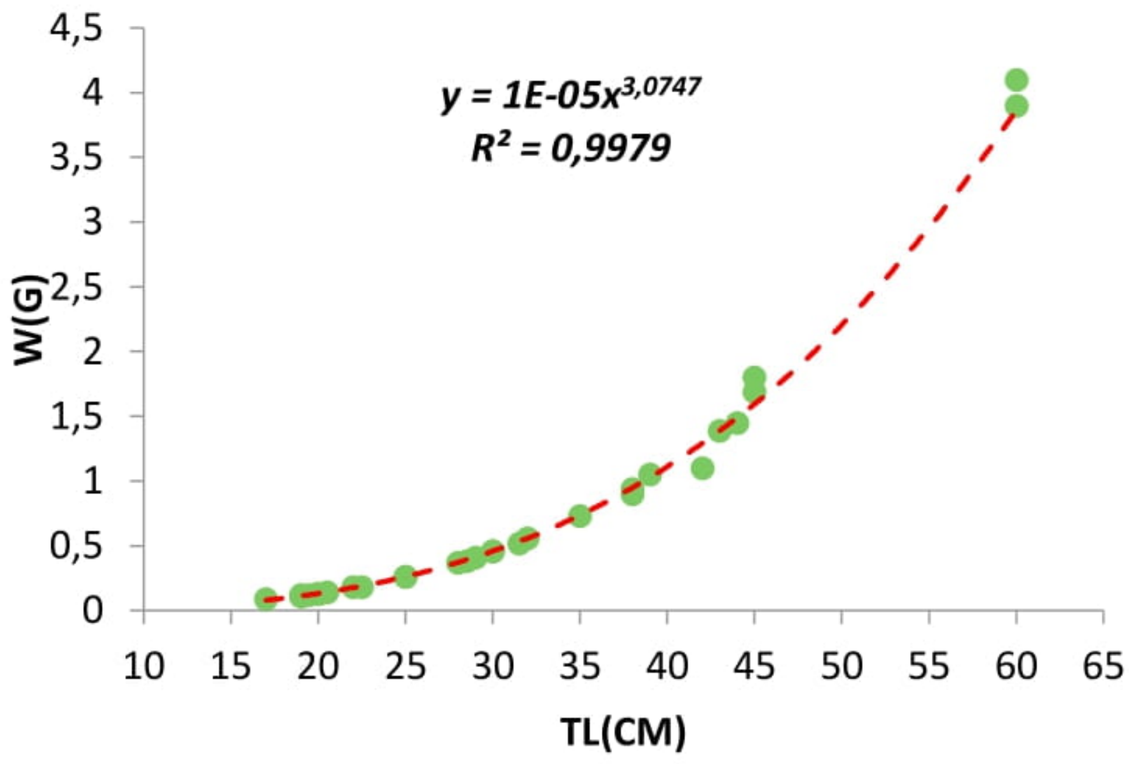

Fig. 28. LWR of *S. maximus*

P. flesus

The following average sizes and weights were measured in the bycatch of European flounder: 17 cm and 54.21 g. The length-weight relationship (LWR) of *P. flesus* is presented in Fig. 29.

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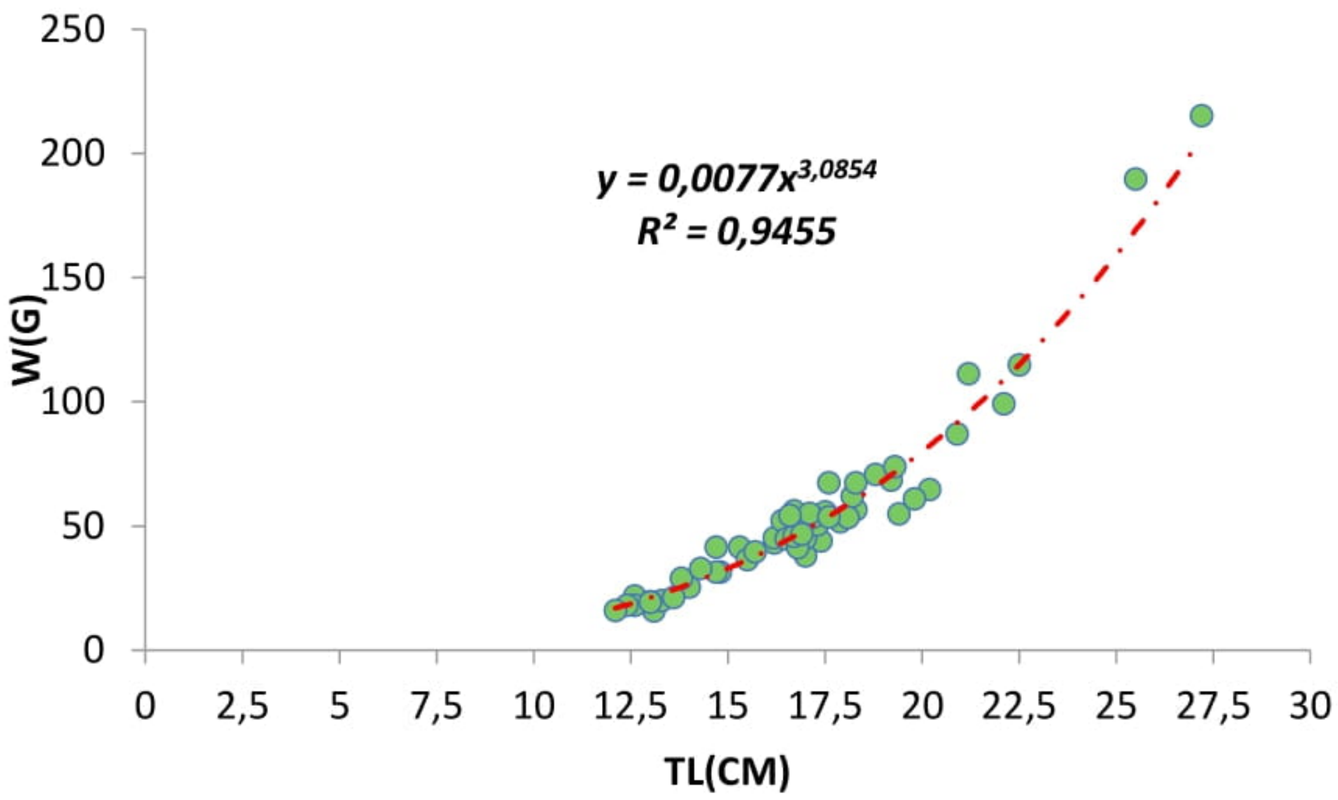

Fig. 29. LWR of *P. flesus*

U. scaber

The average sizes and weights in the bycatch of stargazer are as follows: 15.7 cm and 77.19 g. The length-weight relationship (LWR) of *U. scaber* is presented in Fig. 30.

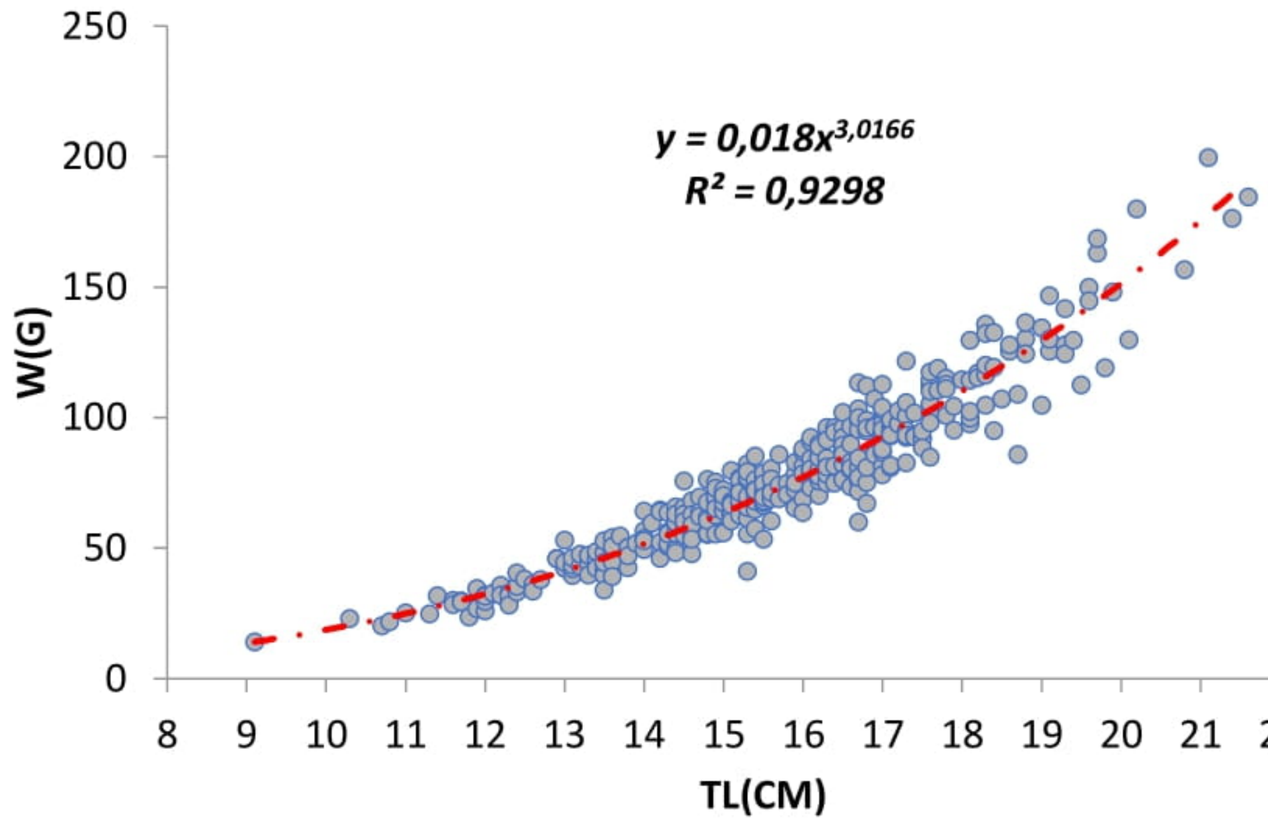

Fig. 30. LWR of *U. scaber*

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3.3.3 Biological data on bycatch of sensitive species in beam trawl fisheries

Data on the composition of the sensitive species in the bycatch in this type of fishing, the total number of specimens caught, their average weight, and average size are presented in Table 25.

The total number of sensitive species caught in bycatch was 47, with turbot having the highest proportion (63.83 %). The average bycatch coefficient was the highest for turbot (T = 1.5 ind/day) and thornback rays (T = 0.75 ind/day). When removed from the nets, a large proportion of the sensitive species (mainly turbot) was dead or severely injured.

Table 25

Data on the status (according to the International Union for the Conservation of Nature, IUCN) of sensitive species in bycatch, total number of specimens caught, average length (cm), and average weight (g) from the beam trawl fishery in 2024.

By catch species	IUCN status	Total number	Bycatch ratio (ind/day)	Average size (cm)	Average weight (g)
Squalus acanthias	EN (Endangered species)	2	0.1	68.250	1555.00
Raja clavata	NT (Near threatened species)	15	0.75	43.885	588.85
Scophthalmus maximus	LC (Least Concern)	30	1.5	30.942	794.36

In 2024, the diversity of sensitive species in bycatch was not high; a maximum of 2-3 sensitive species were identified, with bycatches of all sensitive species increasing in June (Table 26, Fig. 31).

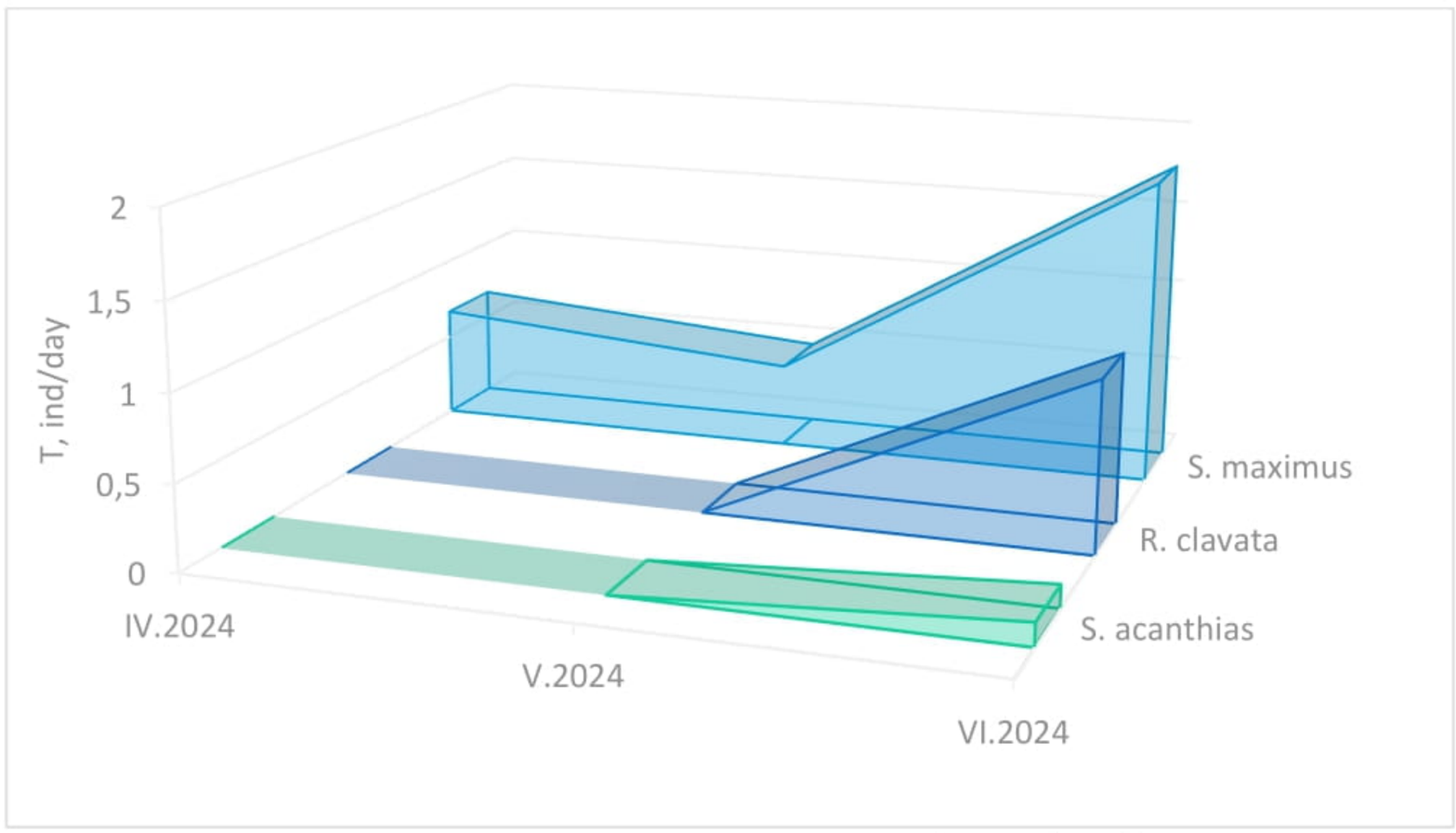

Fig. 31. Monthly fluctuations in the bycatch ratio (T, ind/day) of sensitive species in the beam trawl fishery in 2024.

Table 26

Monthly data on the bycatch of sensitive species, total number of specimens caught by species, bycatch ratio, average size (cm), and average weight (g) of the beam trawl fishery in 2024.

Month	Bycatch species	Total number	Monthly bycatch coefficient	Month	Bycatch species
IV.2024	*S. maximus*	2	0.6667	22.500	195.0
V.2024	*S. maximus*	1	0.5000	60.000	3900.0
VI.2024	*S. acanthias*	2	0.1333	68.250	1555.0
	R. clavata	15	1.0000	43.885	588.85
	S. maximus	27	1.8000	30.333	699.02

The bycatches of sensitive species by fishing segment are listed in Table 27. The number of sensitive species (39 individuals) caught in the segment of fishing vessel TBB VL1218 was higher.

Table 27

Data on the status (according to the International Union for the Conservation of Nature (IUCN)) of sensitive species in bycatch, total number of specimens caught, average size (cm), and average weight (g) by fishing segment in the beam trawl fishery in 2024.

1.TBB VL1218

Bycatch species	IUCN status	Total number	Bycatch ratio (ind/day)	Average size (cm)	Average weight (g)
Squalus acanthias	EN (Endangered species)	2	0.167	68.250	1555.000
Raja clavata	NT (Near threatened species)	12	1.000	43.200	551.500
Scophthalmus maximus	LC (Least Concern)	25	2.083	27.926	496.685

2.TBB VL1824

Bycatch species	IUCN status	Total number	Bycatch ratio (ind/day)	Average size (cm)	Average weight (g)
Raja clavata	NT (Near threatened species)	3	0.375	46.167	713.333
Scophthalmus maximus	LC (Least Concern)	5	0.625	41.800	1866.000

3.4 Fishery with polyvalent vessels

3.4.1 Main catch, bycatch, total catch

The main catch during fishing with polyvalent vessels in the study period of 2024 was mixed and consisted mainly of red mullet, horse mackerel, anchovy, and whiting. The average daily catches of target species are 417.40 kg/day ± 64.01 SE (Table 28.1), the average weight of bycatch is 118.60 kg/day ± 20.85 SE, with a total catch weight of 536.00 kg/day ± 68.07 SE. The average percentage share of bycatch was 24.50 % ± 3.41 SE of the total catch (Table 28.1).

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The high coefficient of variability of the bycatch amount (62.29 %) indicated significant fluctuations in the daily average values.

In 2024, two fishing segments were studied: PMP VL1218 (3 vessels, 17 days) and PMP VL1824 (1 vessel, 3 days), and the data for the main catches and bycatch by segments are presented in Tables 28.2 and 28.3. In the segment of larger vessels, PMP VL1824, the quantity of main catches was 1.5 times lower, but the bycatch was 1.4 times higher. As a result, the average percentage share of bycatch in this segment is 35.29 % ± 9.09 SE, which is 1.6 times higher than that registered in the PMP VL1218 segment.

Table 28

Summary statistics on the total weight of the main catch (kg/day), bycatch (kg/day), total weight of the catch (catch + bycatch, kg/day), and percentage share (%) of bycatch in fisheries with polyvalent vessels in 2024. Data for fishing segments PMP VL1218 (2) and PMP VL1824 (3).

1. General data on fishery with polyvalent vessels (PMP VL1218)

	Target catch (kg/day)	Bycatch (kg/day)	Total catch weight (catch + bycatch) (kg/day)	% of bycatch of the total catch
Mean	417.40	118.60	536.00	24.50
Standard Error	64.01	20.85	68.07	3.41
Median	337.00	98.45	433.60	21.48
Standard Deviation	286.26	93.26	304.44	15.26
Kurtosis	0.95	5.30	-0.30	0.43
Skewness	1.22	1.93	0.85	0.86
Sample Variance	1010.00	412.26	985.08	59.52
Minimum	140.00	11.10	176.84	1.03
Maximum	1150.00	423.36	1161.92	60.55
Count	20.00	20.00	20.00	20.00
Confidence Level (95.0%)	133.97	43.65	142.48	7.14
Coefficient of variation, CV	68.58	78.64	56.80	62.29

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2. Data for fishing segment PMP VL1218

	Target catch (kg/day)	Bycatch (kg/day)	Total catch weight (catch + bycatch) (kg/day)	% of bycatch of the total catch
Mean	440.12	112.46	552.58	22.59
Standard Error	73.81	23.81	79.53	3.60
Median	354.00	98.22	455.46	18.34
Standard Deviation	304.33	98.16	327.92	14.83
Kurtosis	0.31	6.02	-0.83	1.32
Skewness	1.01	2.17	0.67	1.08
Sample Variance	92615.24	9634.90	107529.69	219.89
Minimum	140.00	11.10	176.84	1.03
Maximum	1150.00	423.36	1161.92	60.55
Count	17.00	17.00	17.00	17.00
Confidence Level (95.0%)	156.47	50.47	168.60	7.62
Coefficient of variation, CV	69.15	87.28	59.34	65.63

3. Data for fishing segment PMP VL1824

	Target catch (kg/day)	Bycatch (kg/day)	Total catch weight (catch + bycatch) (kg/day)	% of bycatch of the total catch
Mean	288.67	153.35	442.01	35.29
Standard Error	52.62	33.75	39.45	9.09
Median	320.00	160.24	411.74	30.80
Standard Deviation	91.13	58.46	68.32	15.75
Kurtosis	NA	NA	NA	NA
Skewness	-1.36	-0.52	1.60	1.18
Sample Variance	8305.33	3417.86	4668.08	247.96
Minimum	186.00	91.74	394.06	22.28
Maximum	360.00	208.06	520.24	52.80
Count	3.00	3.00	3.00	3.00
Confidence Level (95.0%)	226.39	145.23	169.72	39.12
Coefficient of variation, CV	31.57	38.12	15.46	44.62

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During the study, 25 species of marine organisms, primarily fish and crustaceans, were identified as bycatch, with an average of 12 different species recorded per day.

In addition to smaller representatives of the main catches, the bycatch most frequently included *Neogobius melanostomus* (100 % of daily catches) and *Trachinus draco* (90 %), followed by *Uranoscopus scaber* (85 %), *Gobius niger* (70 %), and turbot (70 %).

In terms of quantities, the bycatch from fishing with polyvalent vessels mainly consists of small-sized horse mackerel (29.27 %) and bluefish (21.42 %), black mussel (20.13%), common stingray (7.24%), and in smaller amounts, small-sized whiting and other species (Fig. 32).

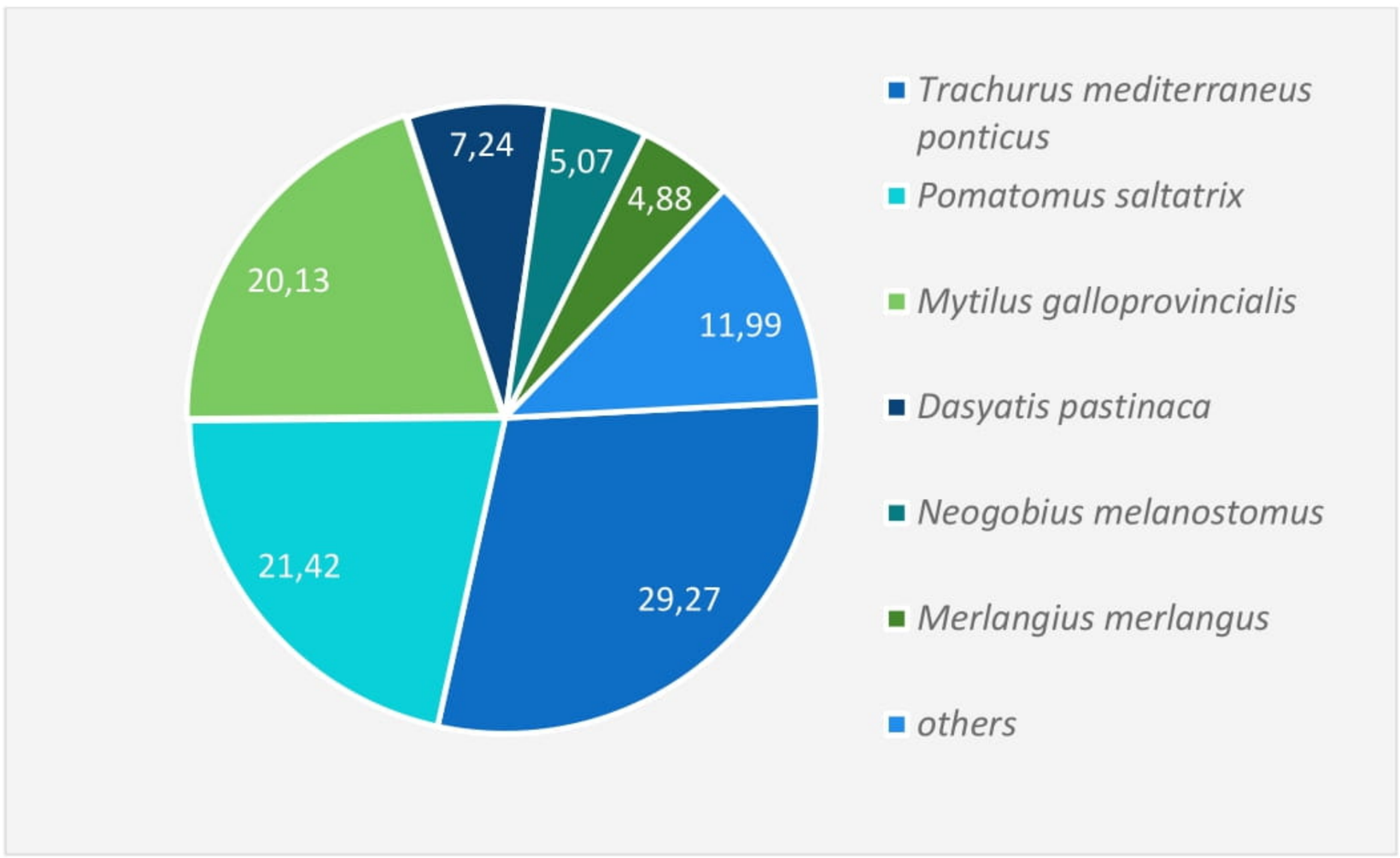


Figure 32. Percentage composition of the main species in bycatch (% BCW) based on daily quantities (kg/day) in fisheries with polyvalent vessels in VIII–X. 2024.

The dynamics of species composition according to their contribution to the weight of bycatch per month is presented in Fig. 33.

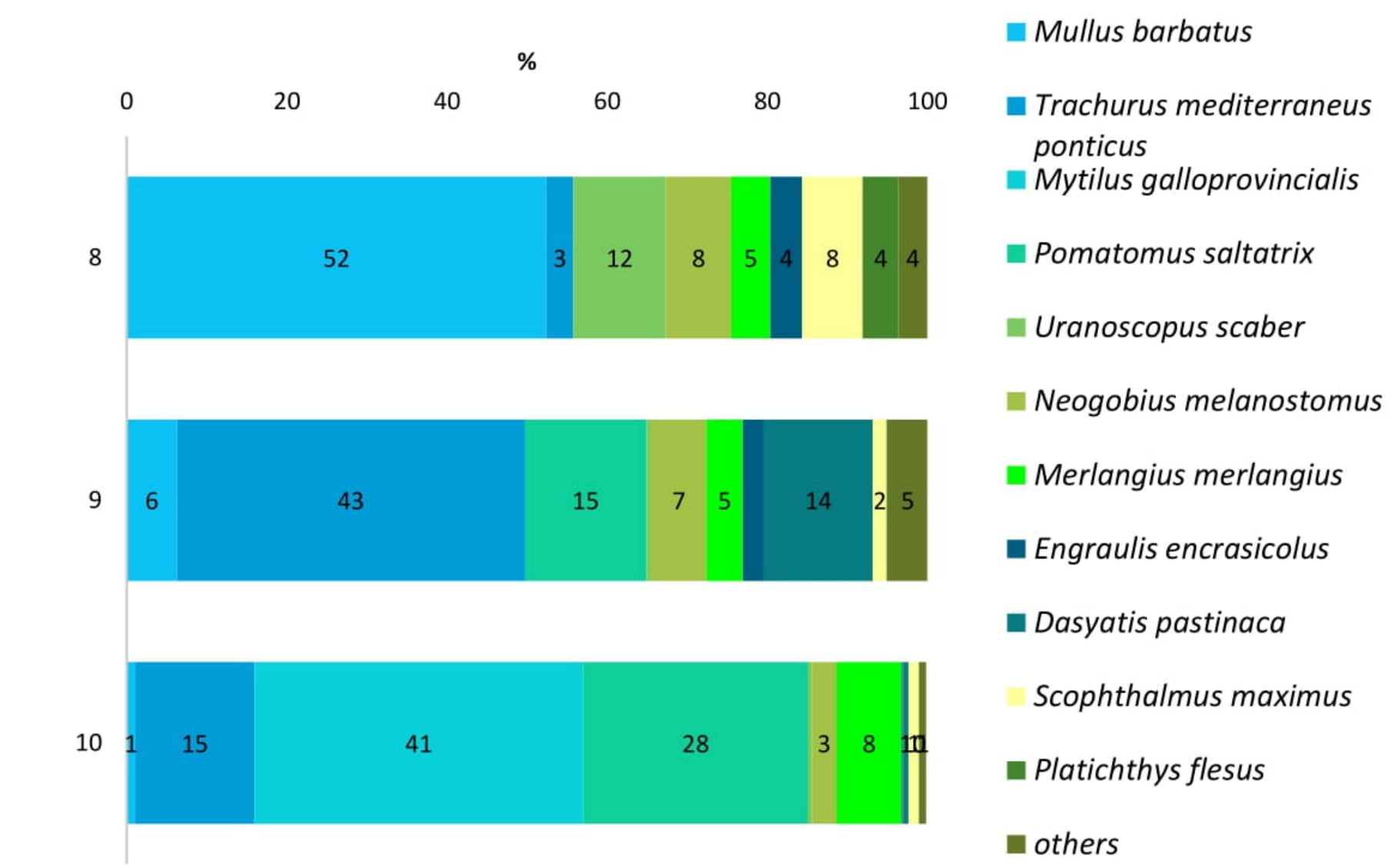


Fig. 33. Changes in the species composition of bycatch (% of total bycatch weight, BCW1, kg/day) by month during fishing with polyvalent vessels in 2024.

The quantity of turbot in the bycatch is most significant in August 2024 (8% BCW), when the proportion of small-sized red mullet in the bycatch is at its maximum (52% BCW). In September, the presence of small-sized horse mackerel increases (40% BCW), while in October, the bycatch was dominated by black mussels (41% BCW) and small-sized bluefish (28% BCW) (Fig. 33).

3.4.2 Dynamics of biological parameters

A) *Trachurus mediterraneus* - age structure, linear dimensions and weights, condition factor

In the autumn of 2024, the measured specimens of horse mackerel from the target catch are sized between 7.9 – 15.6 cm with weights ranging from 4.0 – 34.4 g. The average value of the condition factor is 0.86. Two-year-old individuals dominate the catch (54.94 %, Fig. 34), followed by three-year-olds at 27.9 %.

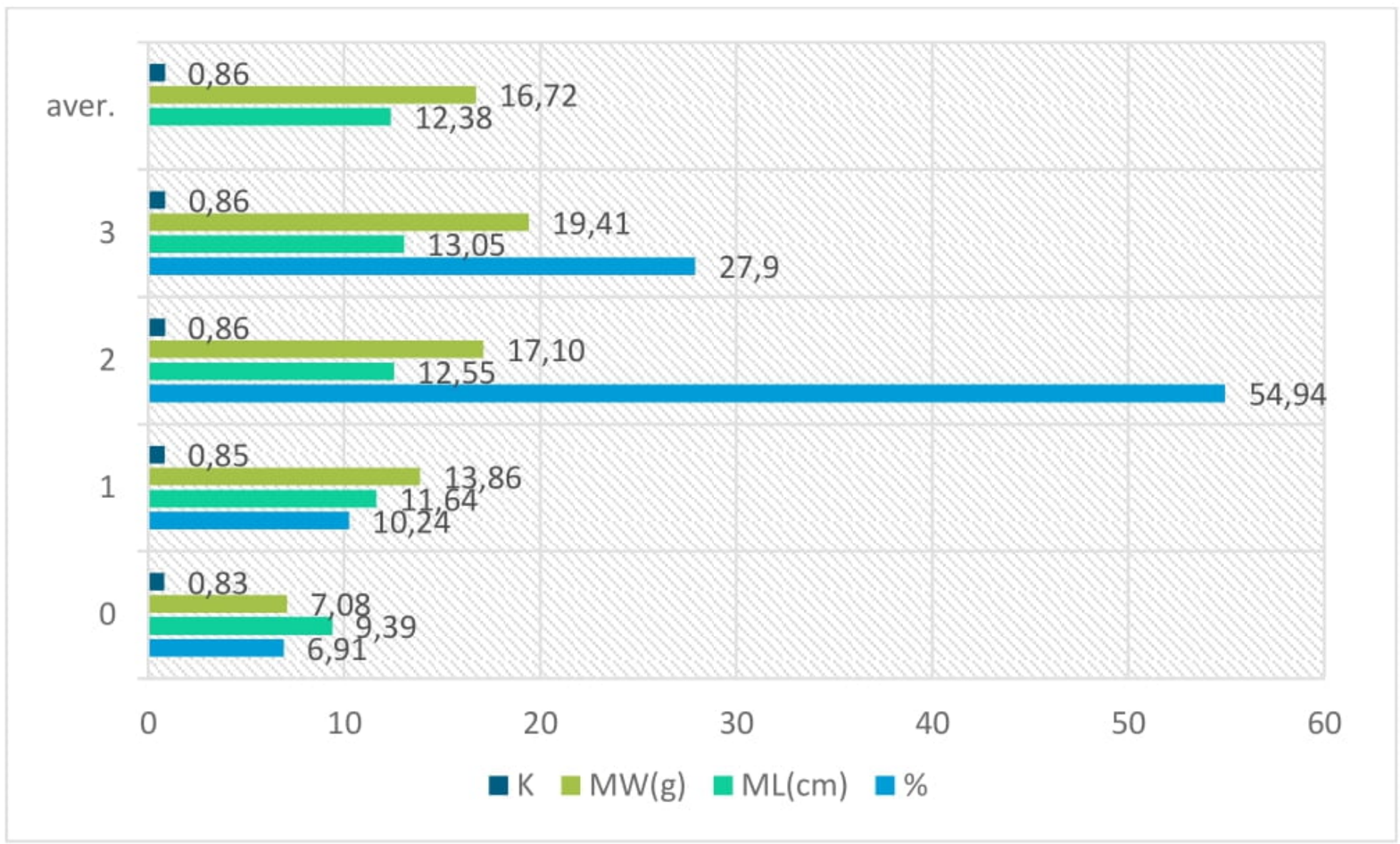
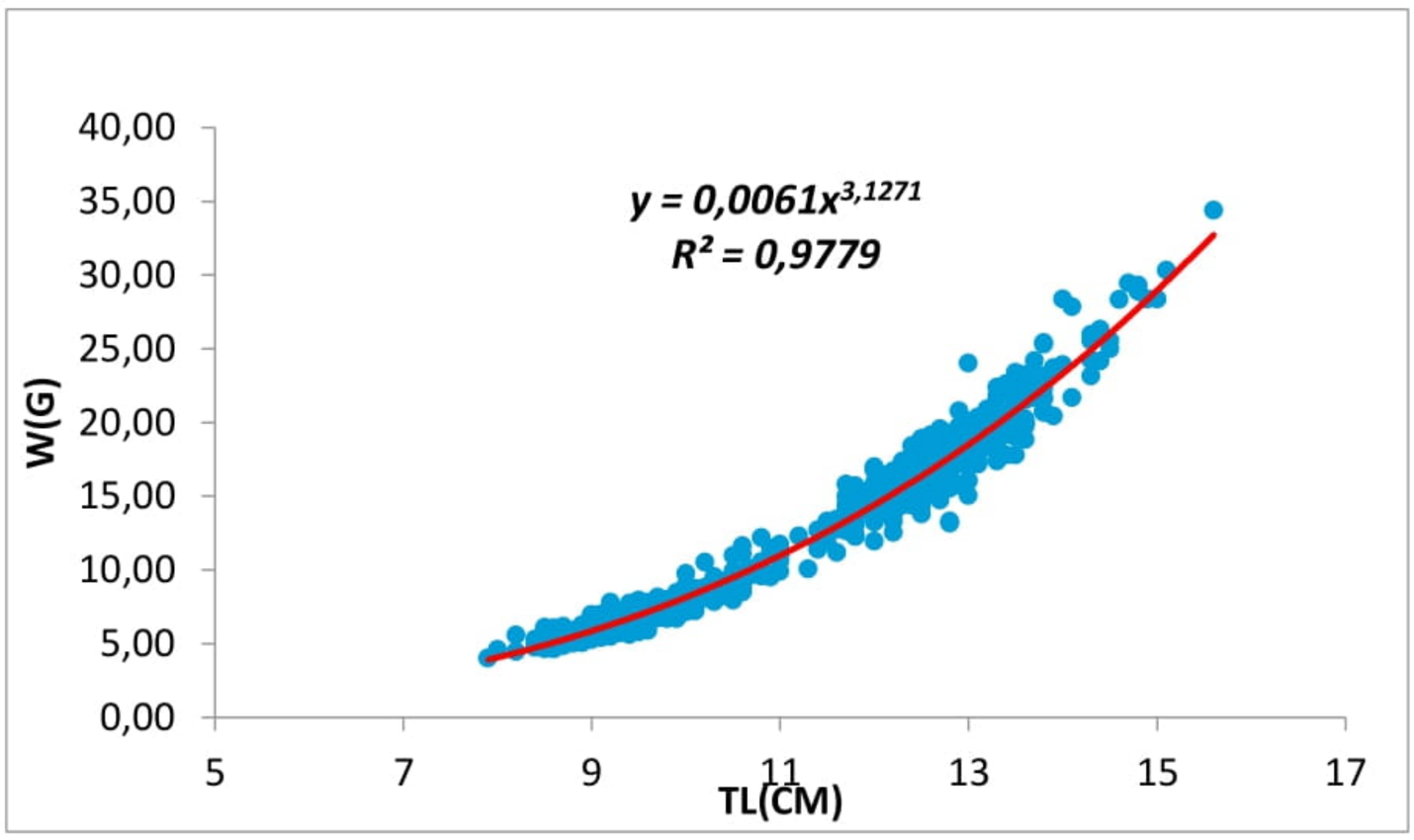


Fig. 34. *T. mediterraneus* - age structure (%), average size, average weight, and condition factor by age groups, along with mean parameters for the autumn season of 2024.

The length-weight relationship (LWR) for the species *T. mediterraneus* is presented in Fig. 35.



Figr. 35. LWR of *T. mediterraneus* during autumn 2024.

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B) *Mullus barbatus* - age structure, linear dimensions and weights, condition factor

In the autumn of 2024, the measured specimens of red mullet from the target catch are sized between 7.9 – 17.5 cm, with weights ranging from 3.96 – 53.45 g. The average value of the condition factor varies between 0.99 – 1.05 across age groups. Two-year-old individuals dominate the catches, accounting for 52.79 % (Fig. 36).

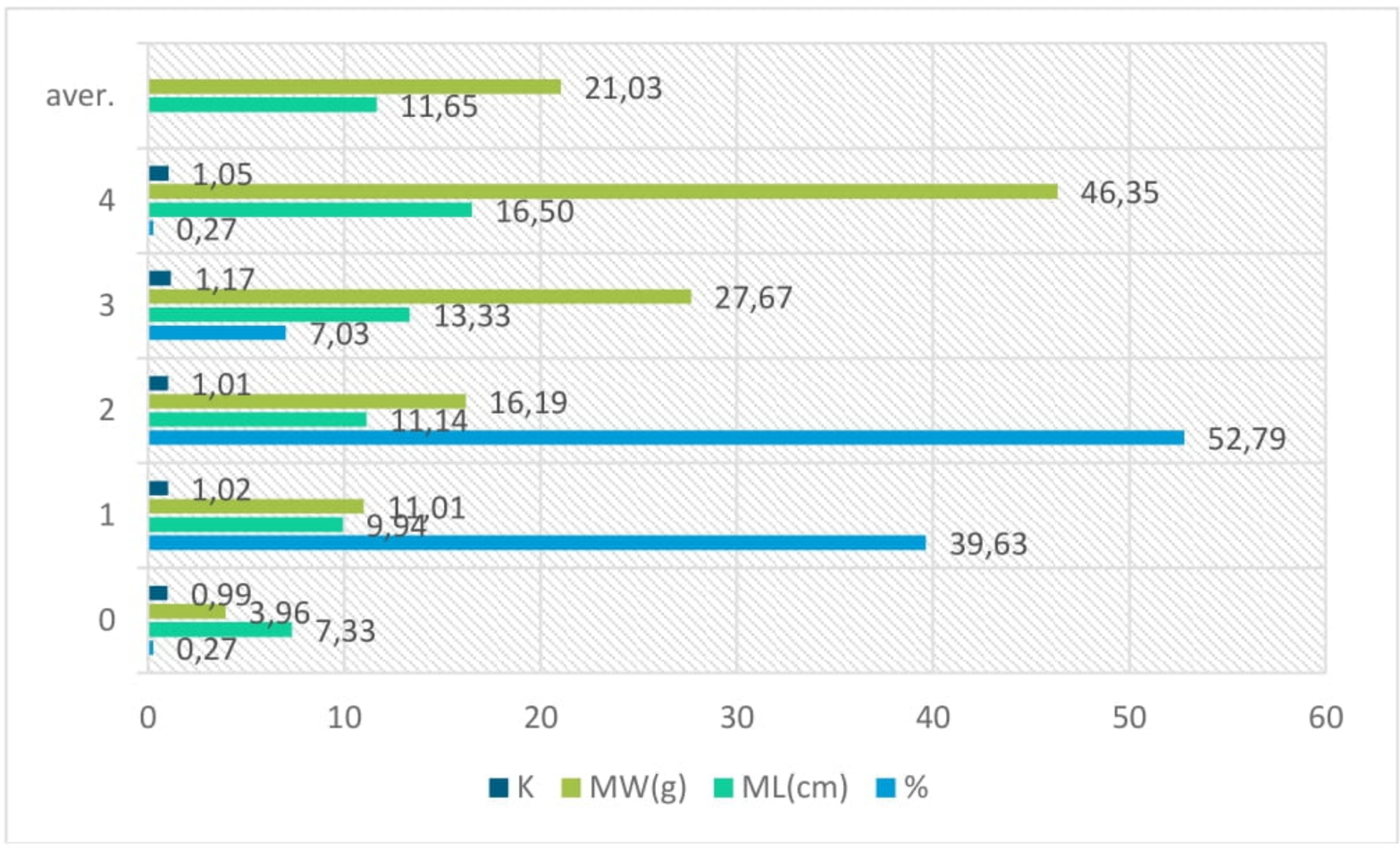

Fig. 36. *M. barbatus* - age structure (%), average size, average weight, and condition factor by age groups, along with mean parameters during the autumn of 2024.

The length-weight relationship (LWR) for the species *M. barbatus* during the autumn season of 2024 is presented in Fig. 37.

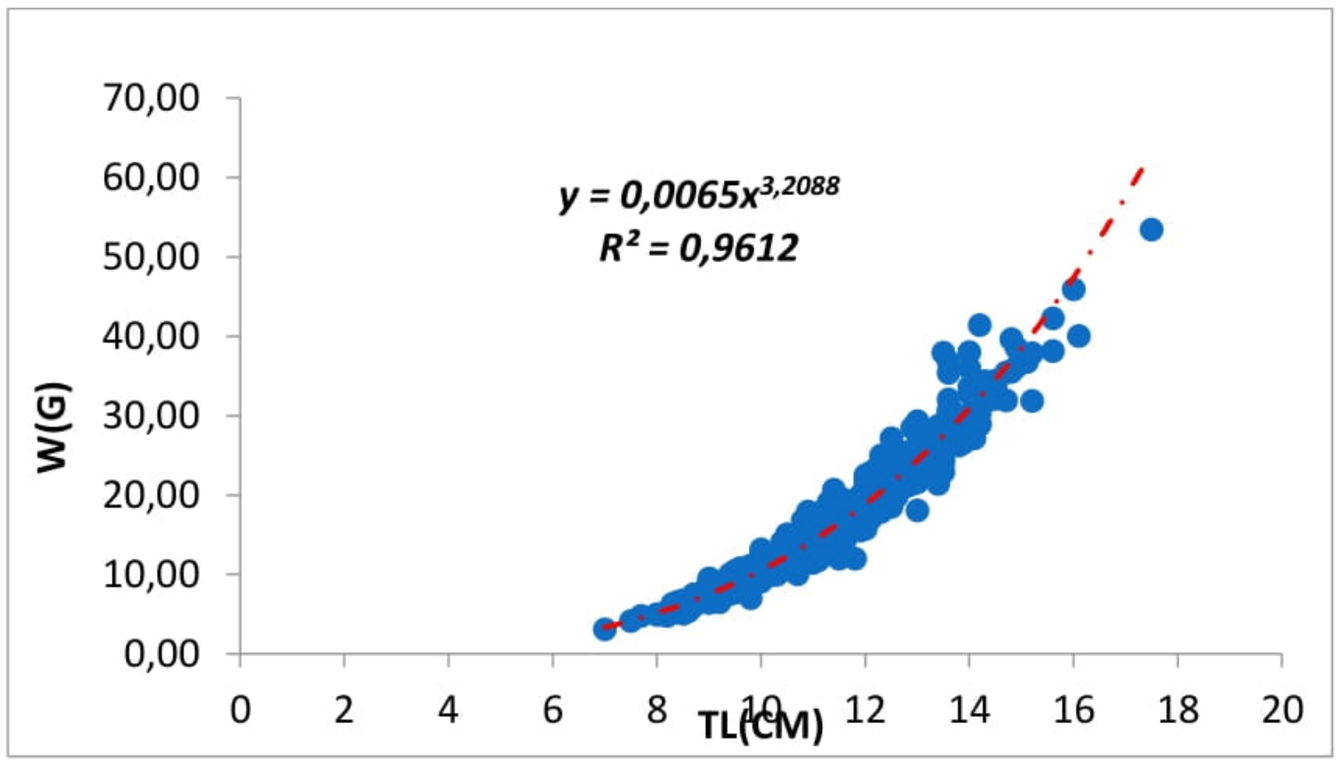

Fig. 37. The length-weight relationship (LWR) for the species *M. barbatus.*

3.4.3 Biological data on bycatch

A) Bycatch species

P. saltatrix

In the autumn of 2024, the bluefish (*P. saltatrix*) was recorded in bycatch from polyvalent vessels, with average sizes of 11.5 cm and weights of 15.19 g. The length-weight relationship (LWR) for the species *P. saltatrix* during the autumn season of 2024 is presented in Fig. 38.

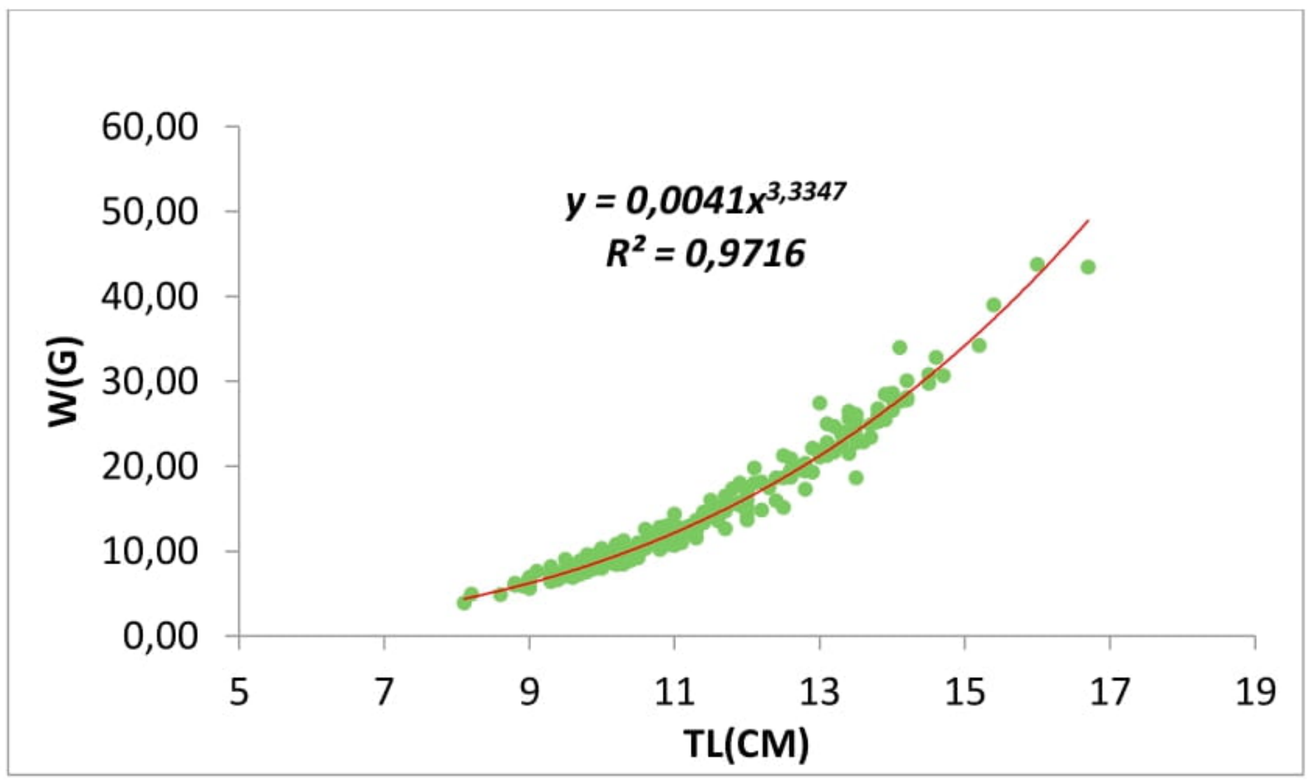

Fig. 38. The length-weight relationship (LWR) for the species *P. saltatrix.*

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3.4.3 Biological data on bycatch of sensitive species when fishing with polyvalent gears

In 2024, during observations of fishing with polyvalent vessels, 97 individuals from a group of sensitive species were recorded (Table 29).

When the nets were removed, a large portion of the sensitive species caught were alive and viable. The bycatch coefficient was highest for the common stingray (T = 2.35 ind/day, and lowest for spiny dogfish (T = 0.05 ind/day.

Table 29

Data on the status (according to the International Union for the Conservation of Nature (IUCN)) of sensitive species in bycatch, the total number of specimens caught, average size (cm), and average weight (g) from fisheries with polyvalent vessels in 2024.

Bycatch species	IUCN status	Total number	Bycatch coefficient (ind/day)	Average size (cm)	Average weight (g)
Dasyatis pastinaca	VU (Vulnerable species)	47	2.35	62.74	2310.30
Raja clavata	NT (Near threatened species)	7	0.35	45.8	1832
Scophthalmus maximus	LC (Least Concern)	42	2.1	28.67	791.67
Squalus acanthias	EN (Endangered species)	1	0.05	112	8421.39

The monthly variations in the bycatch coefficient of the sensitive species during fishing with polyvalent vessels from August to October 2024 are presented in Table 30 and Figure 39.

The bycatch coefficient for turbot varies between 1.6 – 2.5 ind/day, with a peak in September 2024. During this month, the highest bycatch coefficient for the common stingray was also recorded, T = 3.82 ind/day. The bycatch of spiny dogfish was noted only in October 2024, with a monthly coefficient of T = 0.13 ind/day (Fig. 39, Table 30).

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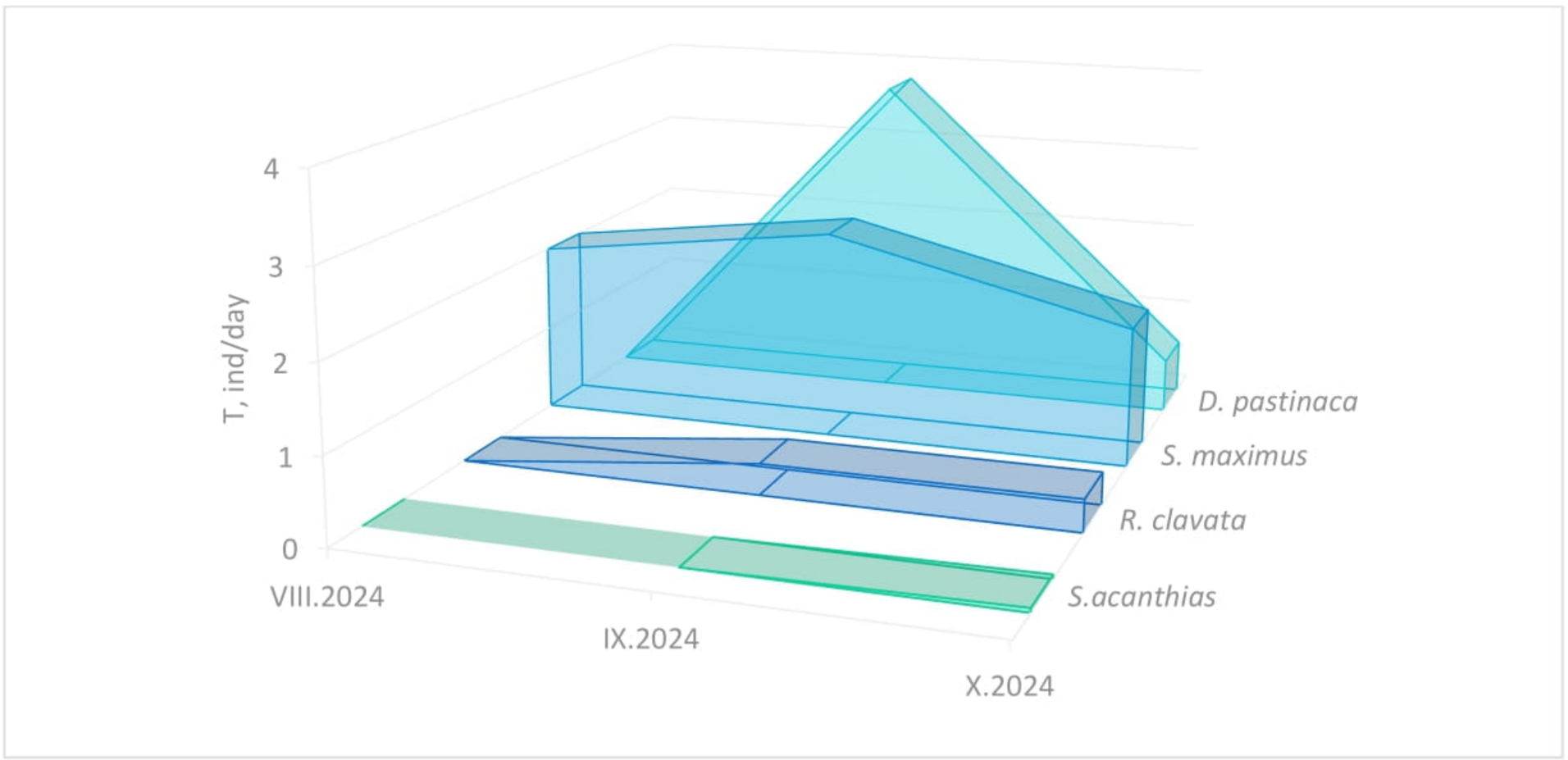

Fig. 39. Monthly variations in the bycatch coefficient (T, ind/day) of sensitive species during fishing with polyvalent vessels in 2024.

Table 30

Data regarding the status (according to the International Union for Conservation of Nature, IUCN) of sensitive species in bycatch, total number of individuals caught, average size (cm), and average weight (g) during fishing with polyvalent vessels in 2024.

Month	Bycatch species	Total number	Monthly bycatch coefficient (ind/day)	Average size (cm)	Average weight (g)
VIII.2024	*S. maximus*	2	2.0	21.3	450.00
IX.2024	*S. maximus*	27	2.5	33.4	754.07
	R. clavata	4	0.36	50.6	1570
	D. pastinaca	42	3.82	63.86	3900.24
X.2024	*S. acanthias*	1	0.13	112	8421.39
	R. clavata	3	0.38	47.05	2110
	S. maximus	13	1.6	37.8	1180.77
	D. pastinaca	5	0.63	61.63	1580.00

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The bycatch of the sensitive species by fishing segment is presented in Table 31. The number of sensitive species caught in the segment of large fishing vessels PMP VL1824 was higher (50 individuals), considering that this segment includes only three days at sea. This affects the bycatch coefficients recorded within the PMP VL1824 segment.

Table 31

Data regarding the status (according to the International Union for Conservation of Nature (IUCN)) of sensitive species in bycatch, total number of individuals caught, average size (cm), and average weight (g) during fishing with polyvalent vessels (by fishing segments) in 2024.

1. **PMP VL1218**

Bycatch species	IUCN status	Total number	Bycatch coefficient (ind/day)	Average size (cm)	Average weight (g)
Raja clavata	NT (Near threatened species)	5	0.29	40.375	2064
Squalus acanthias	EN (застрашен вид)	1	0.06	112	8421.39
Scophthalmus maximus	LC (Least Concern)	21	1.24	34.28	1023.81
Dasyatis pastinaca	VU (Vulnerable species)	20	1.18	60.216	2265.5

2. **PMP VL1824**

Bycatch species	IUCN status	Total number	Bycatch coefficient (ind/day)	Average size (cm)	Average weight (g)
Raja clavata	NT (Near threatened species)	2	0.67	67.5	1340

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Scophthalmus maximus	LC (Least Concern)	21	7	35.81	719.52
Dasyatis pastinaca	VU (Vulnerable species)	27	9	66.615	4681.48

3.5 Food spectrum of the bycatch species

The data regarding the sizes, weights, and fullness indices of the stomachs of the examined specimens — sprat (*S. sprattis*), spiny dogfish (*S. acanthias*), whiting (*M. merlangus*), and thornback ray (*R. clavata*) — are presented in Table 32.

In the samples analysed for dietary spectrum, the average length of the sprat was 7.55 cm ± 0.53 (SD), with an average weight of 2.59 g ± 6.69 (SD). Respectively, for spiny dogfish, the values were 129.75 cm ± 8.88 (SD) and 9955.00 g ± 3190.14 (SD); for the whiting, 11.49 cm ± 1.18 (SD) and 8.85 g ± 3.20 (SD); and for the thornback ray, 52.25 cm ± 4.467 (SD) and 896.0 g ± 336.69 (SD).

Table 32.

Summary data on the length (L, cm), weight (W, g), and ISF (% of BW) of the studied fish species in bycatch: sprat (1), spiny dogfish (2) whiting (3), and thornback ray (4), determined by stomach content analysis in 2024.

1.Sprat

	L, cm	W, g	ISF, % BW
Average value	7.550	2.590	0.269
Standard error	0.166	0.218	0.191
Median	7.350	2.350	0.052
Mode	7.200	2.100	0.000
Standard deviation	0.525	0.690	0.603
Kurtosis	-0.789	-1.048	8.853
Skewness	0.698	0.586	2.937
Range	1.500	2.000	1.950
Minimum	7.000	1.800	0.000
Maximum	8.500	3.800	1.950
Confidence interval (95.0%)	0.376	0.494	0.432

2.Spiny dogfish

	L, cm	W, g	ISF, % BW

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Average value	129.750	9955.000	1.632
Standard error	4.442	1595.068	0.928
Median	131.500	10575.000	0.967
Mode	#N/A	#N/A	#N/A
Standard deviation	8.884	3190.136	1.857
Kurtosis	-0.407	-2.699	3.312
Skewness	-0.876	-0.582	1.765
Range	20.000	6650.000	4.131
Minimum	118.000	6010.000	0.232
Maximum	138.000	12660.000	4.363
Confidence interval (95.0%)	14.136	5076.218	2.955

3.Whiting

	L, cm	**W, g**	**ISF, % BW**
Average value	11.493	8.854	1.055
Standard error	0.216	0.583	0.293
Median	11.500	9.120	0.410
Mode	11.400	#N/A	0.000
Standard deviation	1.182	3.195	1.605
Kurtosis	1.397	10.208	2.576
Skewness	0.028	1.328	2.040
Range	-0.115	-0.014	1.745
Minimum	9.300	1.120	0.000
Maximum	14.300	17.460	5.633
Confidence interval (95.0%)	0.441	1.193	0.599

4.Thornback ray

	L, cm	**W, g**	**ISF, % BW**
Average value	52.250	896.000	0.430
Standard error	1.413	106.471	0.111
Median	51.500	830.000	0.530
Mode	50.000	#N/A	0.000
Standard deviation	4.467	336.690	0.350
Kurtosis	3.568	6.221	-1.375
Skewness	1.630	2.376	-0.038
Range	16.000	1140.000	0.919

Minimum	47.000	640.000	0.000
Maximum	63.000	1780.000	0.919
Confidence interval (95.0%)	3.196	240.853	0.251

The highest mean stomach fullness index was recorded in the piked dogfish, 1.28 % BW ± 0.50 (SE), and the whiting, 0.93 % BW ± 0.21 (SE), followed by the thornback ray, with mean ISF levels of 0.62 % ± 0.13 (SE). The index of stomach fullness of red mullet was lowest at 0.23 % BW (Fig. 40).

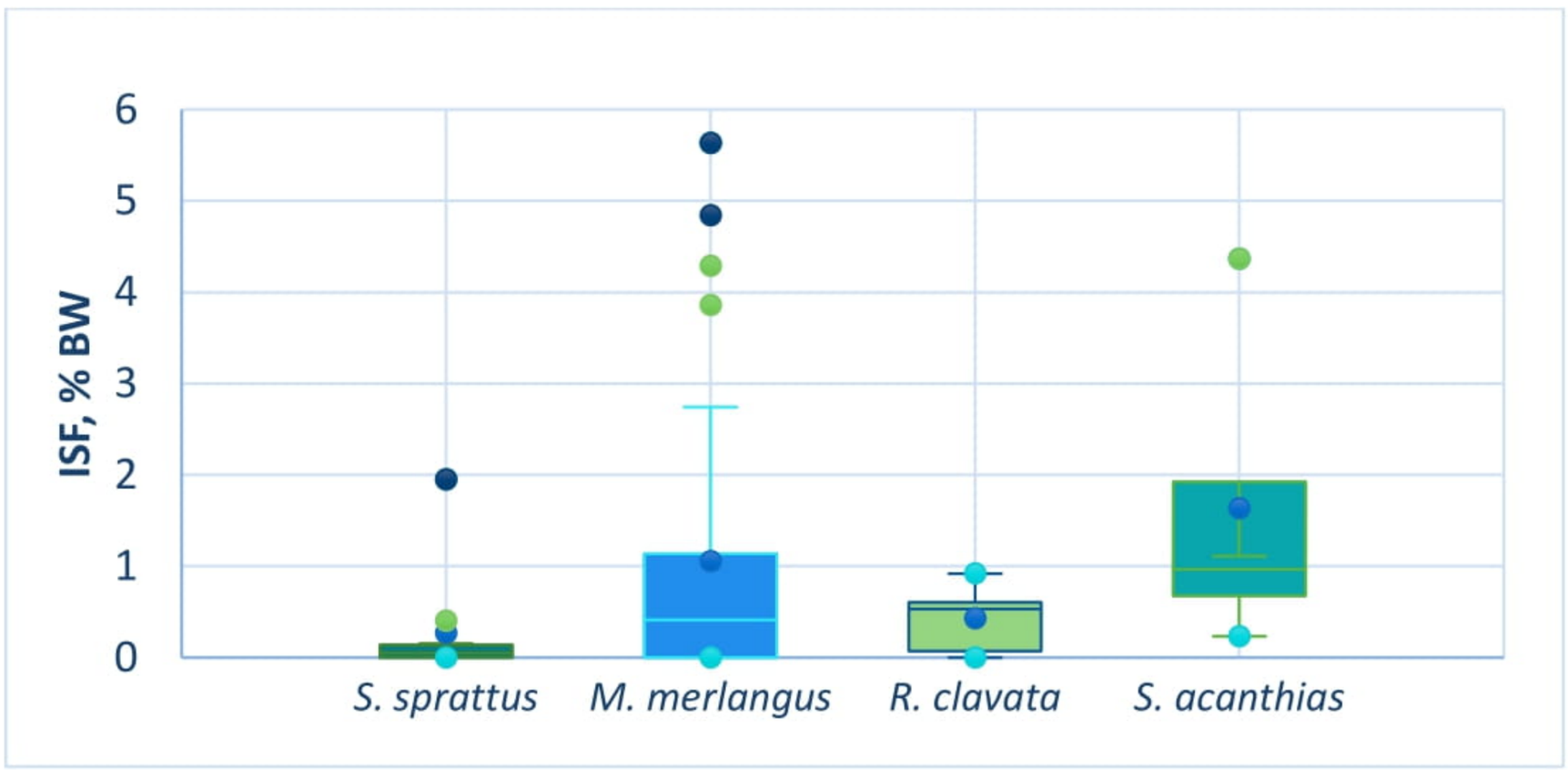

Figure 40. Box plot: ISF in the studied fish species in the bycatch (indicated: medians, range of values: 25–75 %, minimum and maximum values)

Number of preys (prey number, PN), species composition of food and index of relative importance (index of relative importance, IRI)

The number of food items in the stomach was not high among the predatory fish species examined in the catch. However, in the case of sprat, which is a zooplanktivorous species, an increased number of food items in the stomachs was observed (Fig. 41).

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Accordingly, among the observed species, the most active feeding was recorded for the sprat (22 ind/stomach ± 8.581 SE) and spiny dogfish – 4.5 ind/stomach ± 0.87 SE, followed by the thornback ray – 1.3 ind/stomach ± 0.34 SE, while in the whiting, the average number of prey items was low – 0.6 ind/stomach.

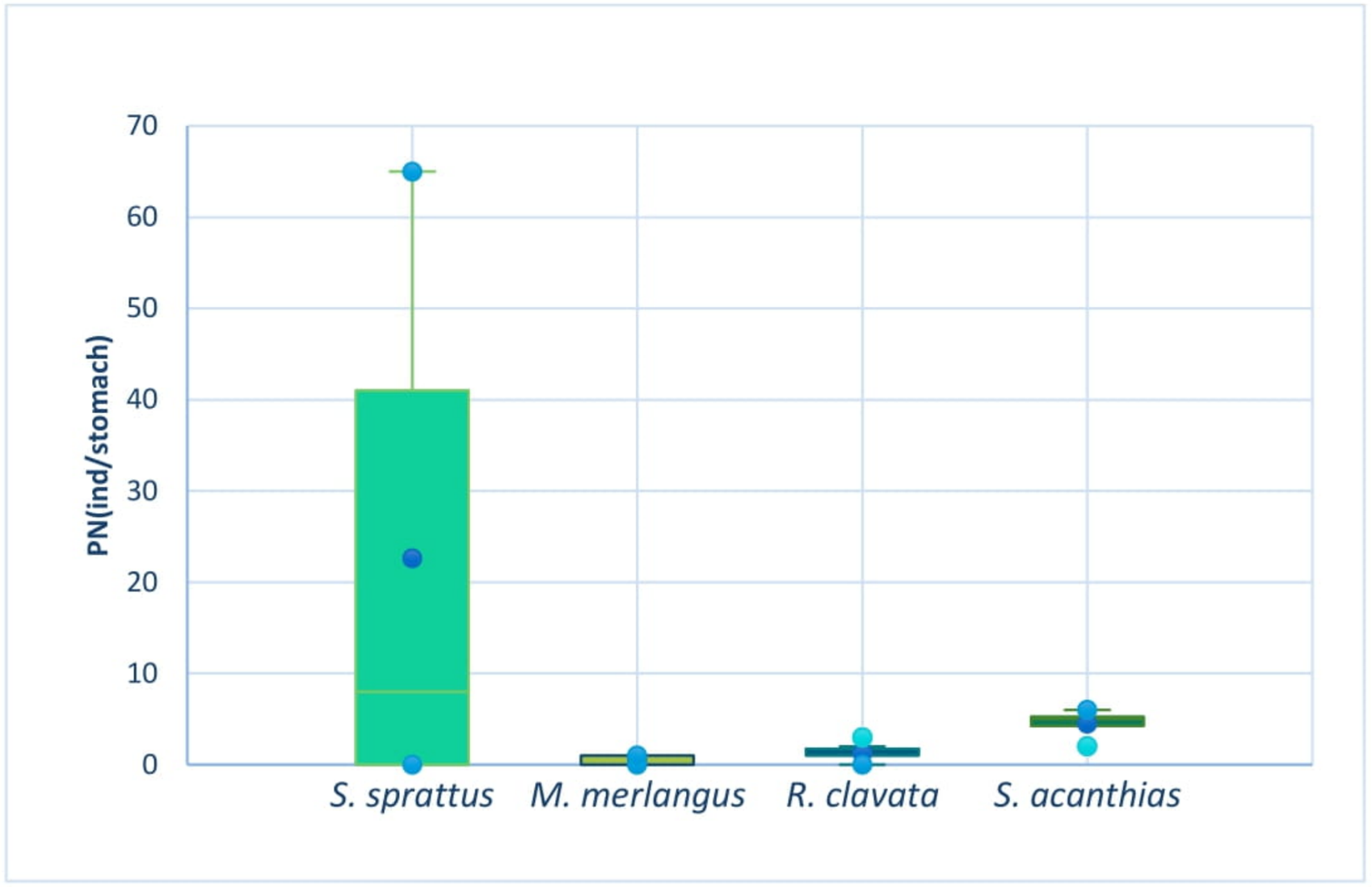

Figure 41. Box plot: Number of established food objects in the stomachs of the investigated fish species in bycatch (indicated: medians, range of values:25–75 %, minimum and maximum values).

The indices of relative importance of the main species in the food of the studied fish, calculated according to the percentage participation in numbers and biomass, as well as the frequency of occurrence, are presented in Table. 33 and Fig. 42.

Table 33.

Food composition of the studied fish species in the bycatch.

Sprat				
Food composition	**N (%, of the total number)**	**M (%, of total biomass)**	**FO - Frequency of Occurrence**	**IRI - Relative Importance Index**
Calanus euxinus	32.74	92.20	40	**4997.9**
Acartia.clausi	13.72	1.37	30	**452.7**
Copepoda copepodit	13.27	1.42	30	**440.9**
Lamellibranchia veliger	13.72	0.10	30	**414.6**
Pseudocalanus elongatus	16.81	1.35	20	**363.3**
Calanus copepodit	5.31	3.33	30	**259.2**
Copepoda ova	1.327	0.001	20	**26.6**
Others	3.103	0.229		
Total	100.00	100.00		

Spiny dogfish				
Food composition	**N (%, of the total number)**	**M (%, of total biomass)**	**FO - Frequency of Occurrence**	**IRI - Relative Importance Index**
Merlangus merkangus	50.00	15.71	75	**4928.27**
Cetaceans	16.67	65.89	75	**6191.90**
Engraulis encrasicolus	5.56	0.58	25	**153.36**
Upogebia pusilla	5.56	1.28	25	**170.98**
Remains	22.22	16.53	100	**3875.72**
Total	100	100		

Whiting				
Food composition	**N (%, of the total number)**	**M (%, of total biomass)**	**FO - Frequency of Occurrence**	**IRI - Relative Importance Index**
Decapoda spp.	5.263	0.033	3.330	**17.635**
Remains	94.737	99.967	60.000	**11682.239**
Total	100	100		

Thornback ray				
Food composition	**N (%, of the total number)**	**M (%, of total biomass)**	**FO - Frequency of Occurrence**	**IRI - Relative Importance Index**
Decapoda spp.	53.846	79.831	70.000	**9357.411**
Polybius vernalis	23.077	7.763	30.000	**925.188**
Engraulis encrasicolus	7.692	5.277	10.000	**129.690**
Останки	15.385	7.129	20.000	**450.281**
Total	100	100.00		

In the sprat diet, the zooplankton species *Calanus euxinus* was dominant (72% IRI). Among the studied predatory fish species in the bycatch, a high proportion of remains was found in the dietary spectrum of the whiting (99% IRI), while a high proportion of crustaceans was also identified in the diet of the thornback ray (94% IRI). In the spiny dogfish diet, whiting predominates (32 %), and a significant proportion of cetacean remains were also registered (40 %) (Table 31, Fig. 42).

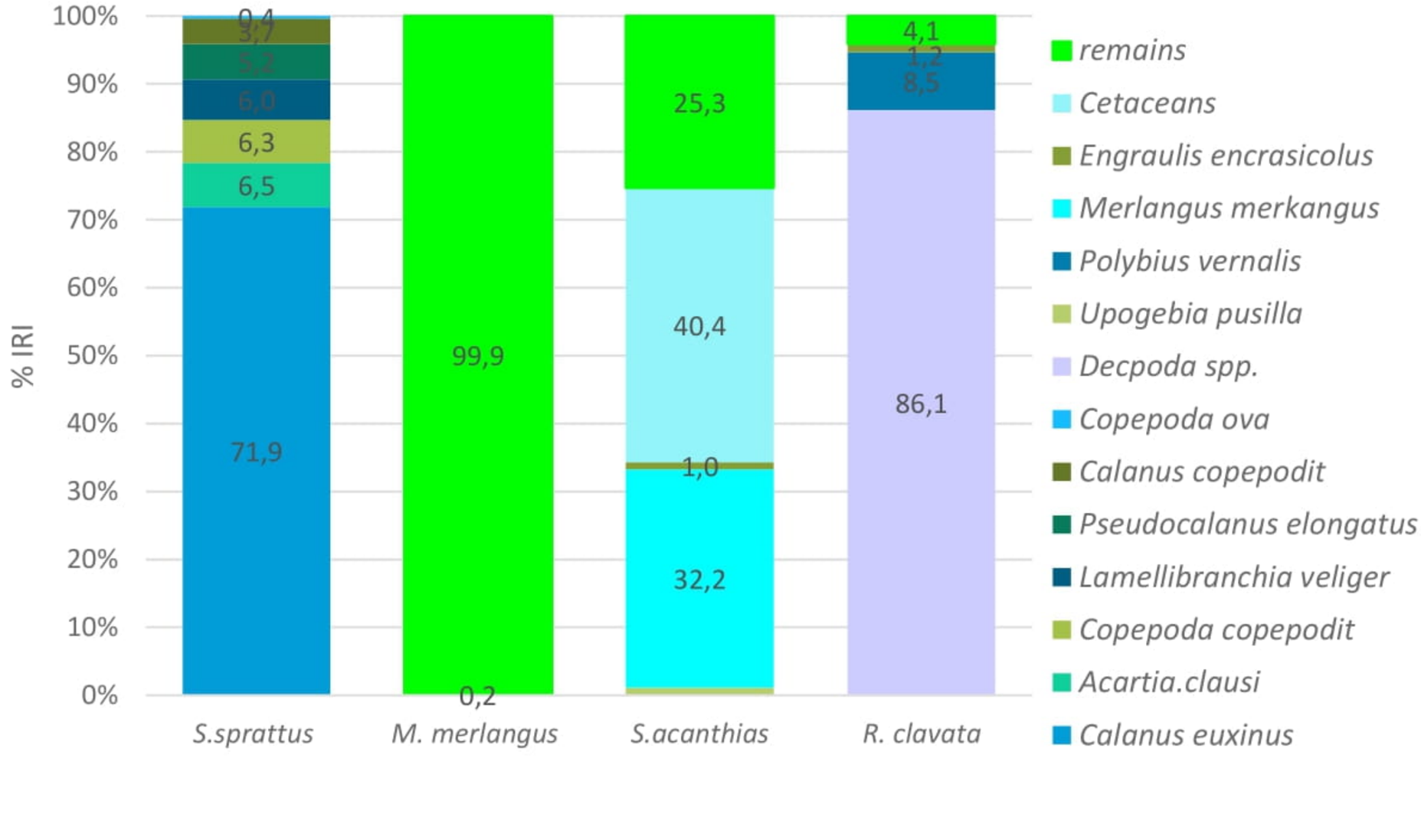

Figure 42. Food composition (% IRI) of bycatch fish species.

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3.6 Assessment of the impact of commercial fishing by fishing techniques

The bycatch rate (BCR, % TC) was used as an indicator to assess the impact of different types of fishing activities on marine organisms. Based on expert assessment, the bycatch rate (BCR) > 25% TC was assessed as extremely high (i.e. an indicator of a very strong impact on marine organisms); in the range of 10 - 25 % TC, for high impact, the impact in the range of 3 – 10 % TC was considered as moderate; and BCR < 3 % TC, was considered as weak (Table 34).

Table 34

Scale for assessing the effects of different types of fishing activities and fleet segments on marine organisms.

Bycatch rate (BCR, % TC)	Effect on marine organisms
> 25% TC	Very strong influence
10-25% TC	Strong influence
3-10% TC	Moderate influence
< 3 % TC	Weak influence

Based on observations in 2024 and calculations of bycatch rates (% TC), both fishing with gillnets (fishing segment DFN VL0612) and fishing with polyvalent vessels, particularly the segment of large vessels (PMP VL1824), have been assessed as having a very strong impact on marine organisms. For gillnet fishing, the average bycatch rate was 32.84 % TC, with an average daily bycatch quantity of 17.22 kg (Fig. 43.1). Respectively, the PMP VL1824 segment generates a significant average bycatch of 153.35 kg/day, with an average daily bycatch rate of 35.29 % TC (Fig. 41.2). The other segment, PMP VL1218, for polyvalent vessel fishing was evaluated as having a strong impact, with an average bycatch rate of 22.59 % TC and an average daily bycatch quantity of 112.46 kg (Fig. 43.2).

The data on the impact of the rapa whelk fishery with beam trawls also show variation in the degree of impact depending on the fishing segment. The impact of the TBB VL1218 segment was assessed as moderate, with a bycatch rate of 3.69 % TC, whereas for the segment of larger vessels, TBB VL1824, the impact was rated as low — TBB VL1824 — 1.88 % TC (Fig. 43.3). Overall, however, this activity had a more significant effect on some benthic and sensitive species (see Section 3.7).

Fishing with pelagic trawls also exerts varying impacts on marine organisms, ranging from low to moderate. The average bycatch rate for the two studied fishing segments varies between 0.81 % TC and 5.46 % TC, with daily bycatch quantities ranging from 2.02 to 7.54 kg/day, Fig. 43.4.

Figure 43. The bycatch rates (% TC) of the fisheries and segments by 2024 (1. GNS - gill nets, 2. PMP: polyvalent vessels (mixed catch), 3.TBB - beam trawling for rapa whelk 4. OTM: pelagic trawling.

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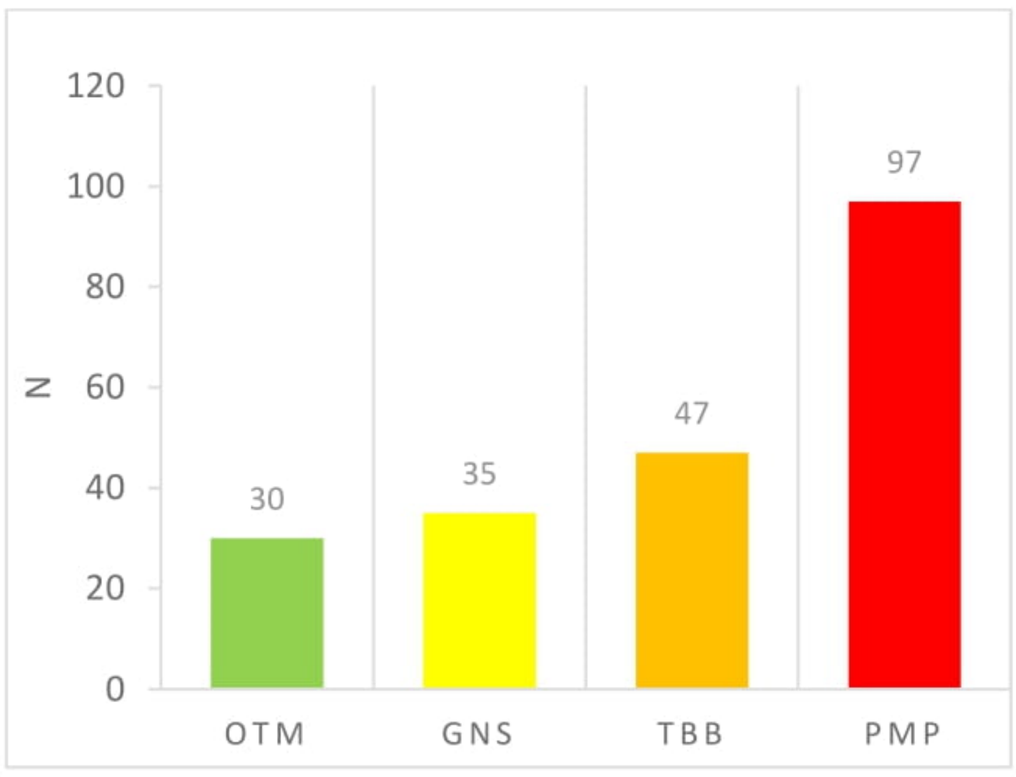
3.7 Sensitive marine species and assessment of the commercial fishing impact

in the Bulgarian waters of the Black Sea, we refer to the group of sensitive seabirds, marine mammals, cartilaginous fish species, turbot, and f. Acipenseridae. No Black Sea List of Sensitive Benthic Invertebrate Species has been developed, but information on the conservation status of some benthic habitats can be found in:

- Biserkov V. and others. (ed.), 2015. Red Book of the Republic, Bulgaria. Volume 3. Natural habitats. BAS & Ministry of Education, Sofia.; http://e-ecodb.bas.bg/rdb/bg/.

In 2024, 209 individuals from the group of sensitive species were recorded in the bycatch, and their distribution across types of fishing activities is presented in Fig. 44.1.

The bycatch included two groups of sensitive species with similar proportions relative to overall abundance: cartilaginous fish accounted for 54%, while turbot made up 46% of the total number (Fig. 44.2).



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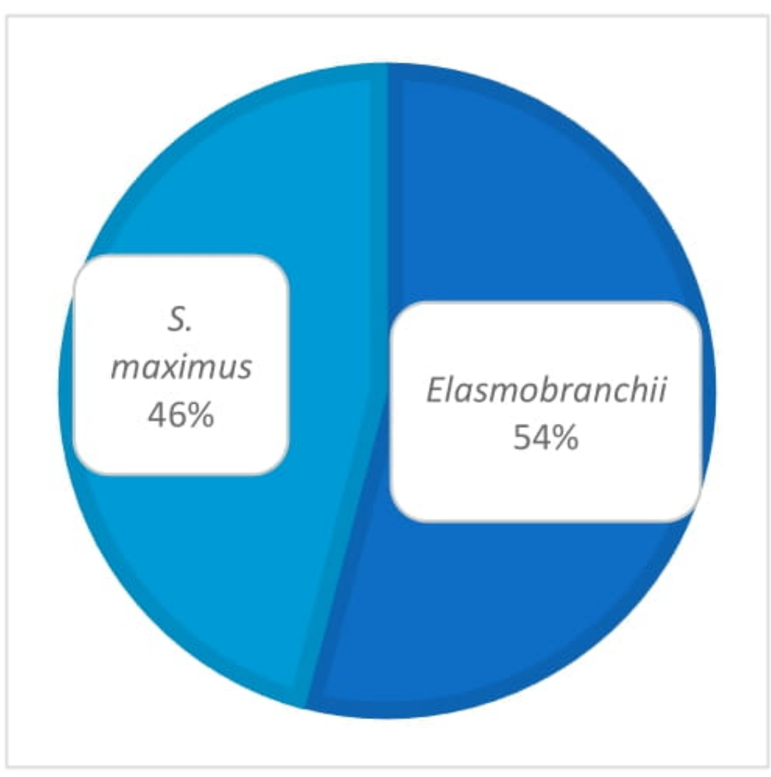

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Figure 44. (1) Total number of specimens of the sensitive species group caught by fishing activity during the entire monitoring period in 2024. (2) Structure (% of the total number) of sensitive species bycatch in 2024.

The impact on sensitive species was assessed using the "sensitive species bycatch coefficient" indicator from FAO (2019 b). The bycatch coefficient (T, for a species and fleet segment) is calculated using the formula: $T = N/D$, where N is the total number of individuals of each species caught on each fishing day ($N = \Sigma ni$), and D is the number of surveyed fishing days.

In 2024, the highest bycatch coefficient for individuals from the sensitive species (16.7 ind/day) was recorded in multipurpose vessel fishing, specifically in the segment of larger vessels, while the lowest bycatch coefficient was observed in the TM VL1218 segment (0.57 ind/day, Fig. 45).

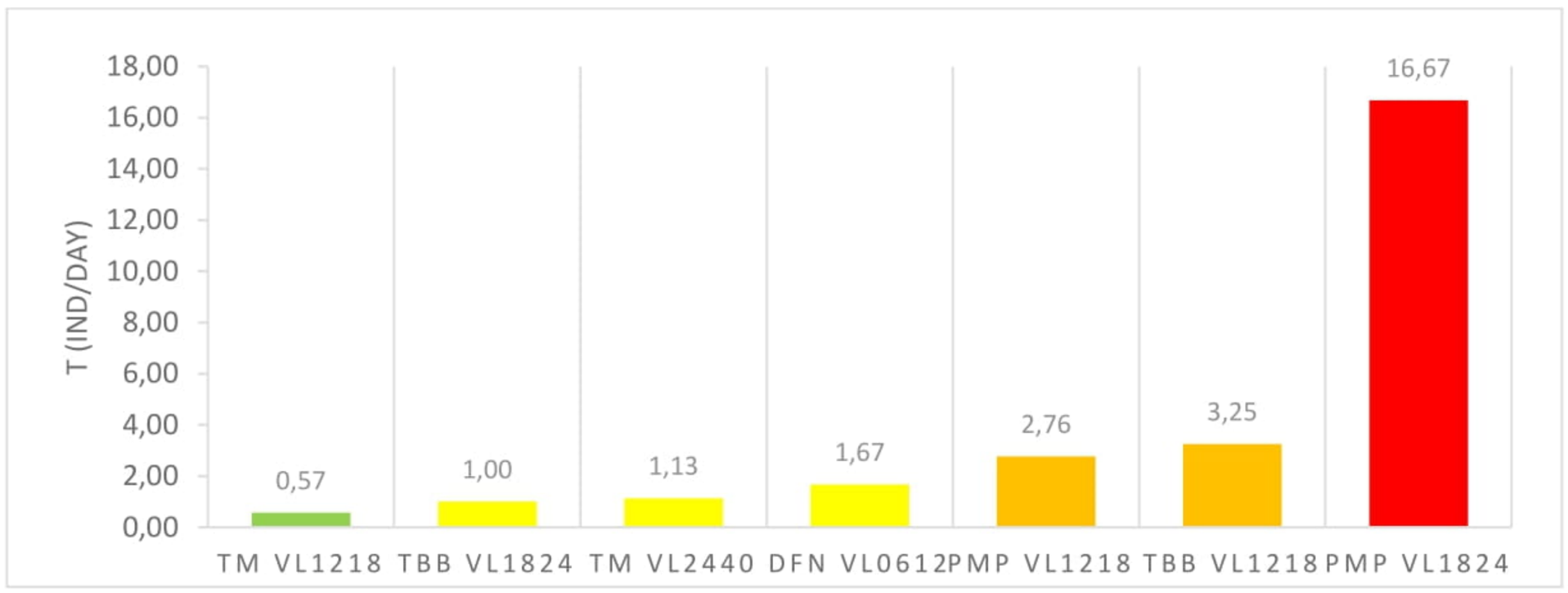

Figure 45. Coefficient of bycatch (T, ind /day) of the group of sensitive species by fishing activities and by fishing segments in 2024.

No marine mammals or species from the family Acipenseridae were recorded in bycatch during the current year.

Among the cartilaginous fish species, *R. clavata* was observed in all monitored fishing activities in 2024, while *D. pastinaca* was only recorded in catches using gillnets and polyvalent vessels with pelagic trawls. *S. acanthias* was found in bycatch during beam trawl fishing and polyvalent vessel operations. The highest total bycatch coefficient for cartilaginous fish was recorded in multipurpose vessel fishing (T = 2.75 ind/day), while the lowest was recorded in pelagic trawl fishing, T = 0.2 ind/day (Fig. 46).

The mortality of sensitive species from the class Elasmobranchii is highest in gillnet fishing (100 %), whereas in pelagic trawl fishing, these species are alive and viable. In beam trawl fishing, a large portion of these sensitive species are alive, but injured.

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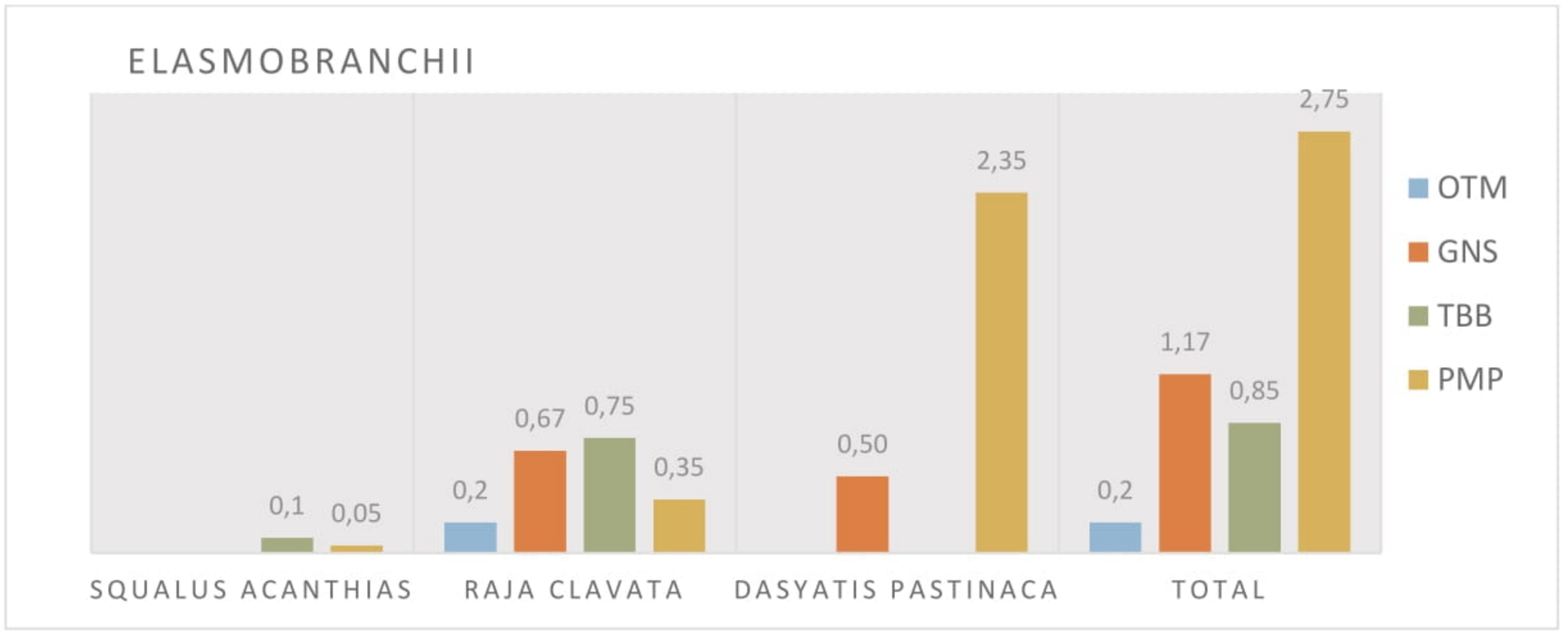

Figure 46. Bycatch rate (T, ind/day) of Elasmobranchii species by fishing activity in 2024.

Studies on the bycatch of individual species from the group of cartilaginous fish by fishing segments showed that *D. pastinaca* had the highest bycatch coefficient in the fishing segment PMP VL1824 (T = 9 ind/day, Fig. 47.1). Regarding *R. clavata* and spiny dogfish, the maximum daily bycatch coefficients were recorded in the fishing segment TBB VL1218, with respective values of T = 1.00 ind/day (Fig. 47.2) for thornback rays, and T = 0.17 ind/day for spiny dogfish (Fig. 47.3).

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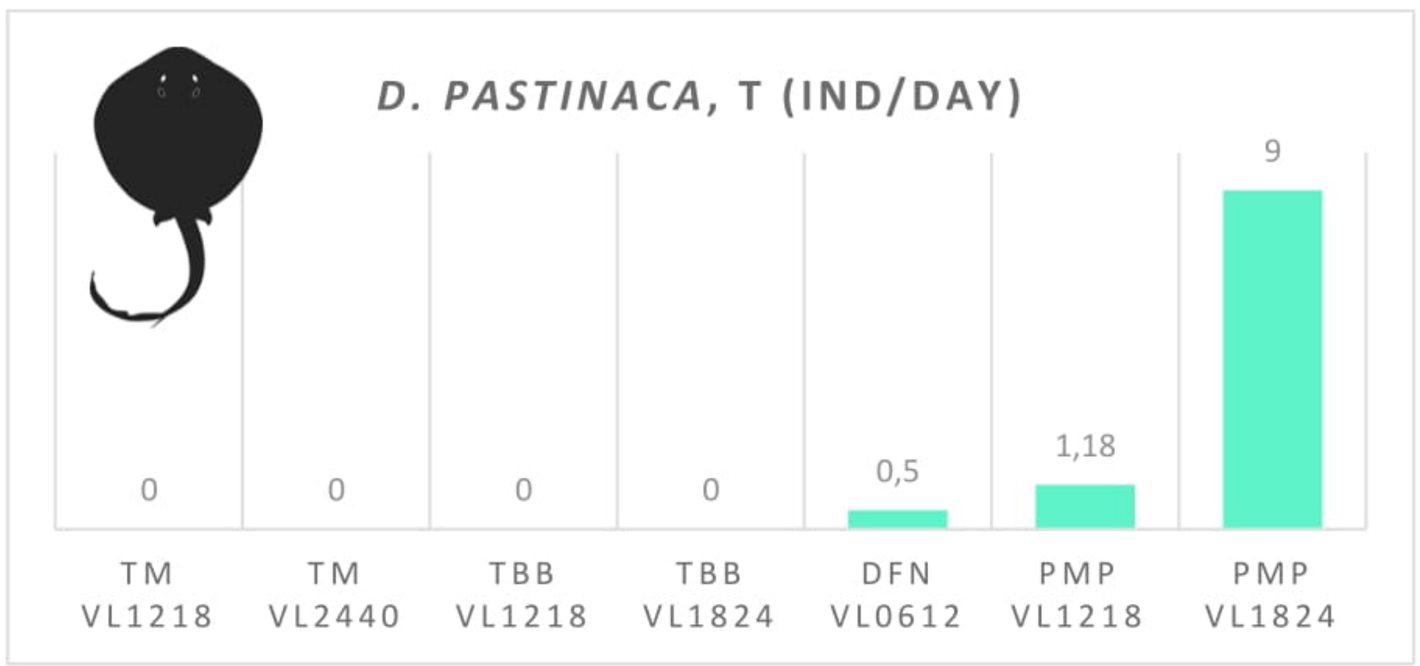

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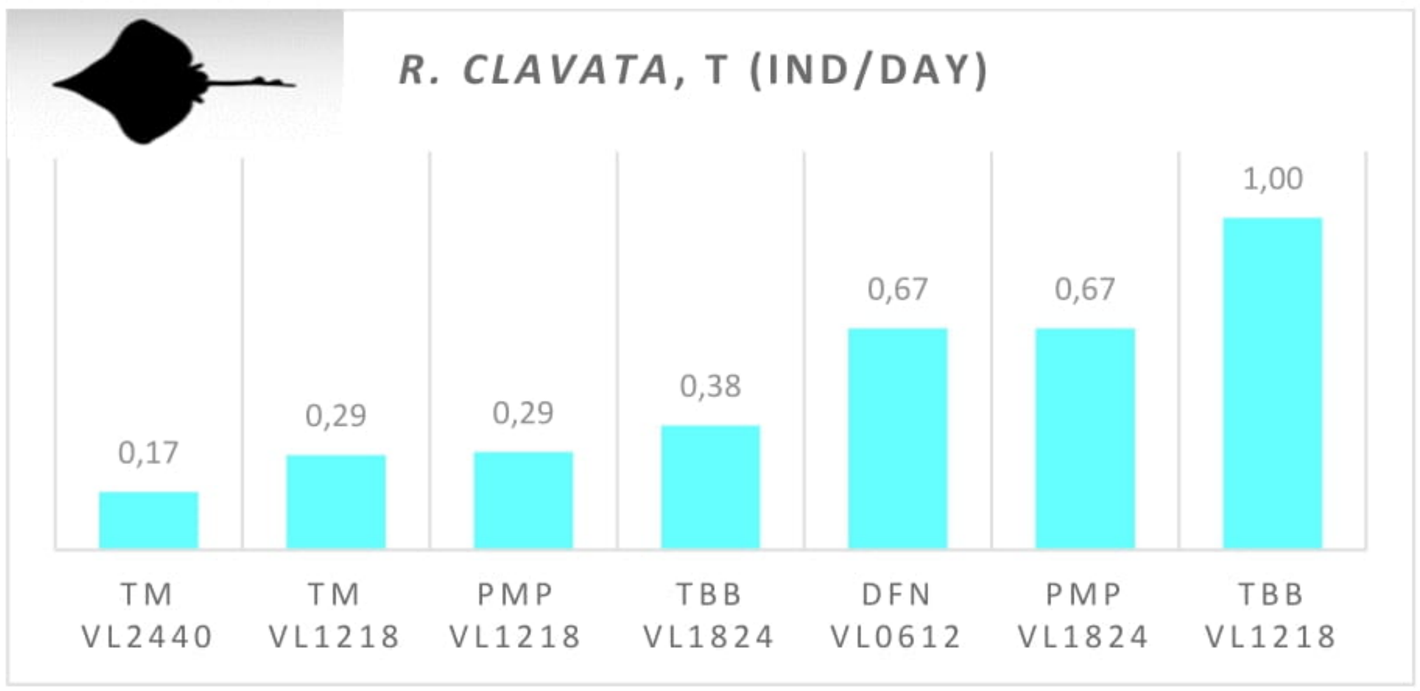

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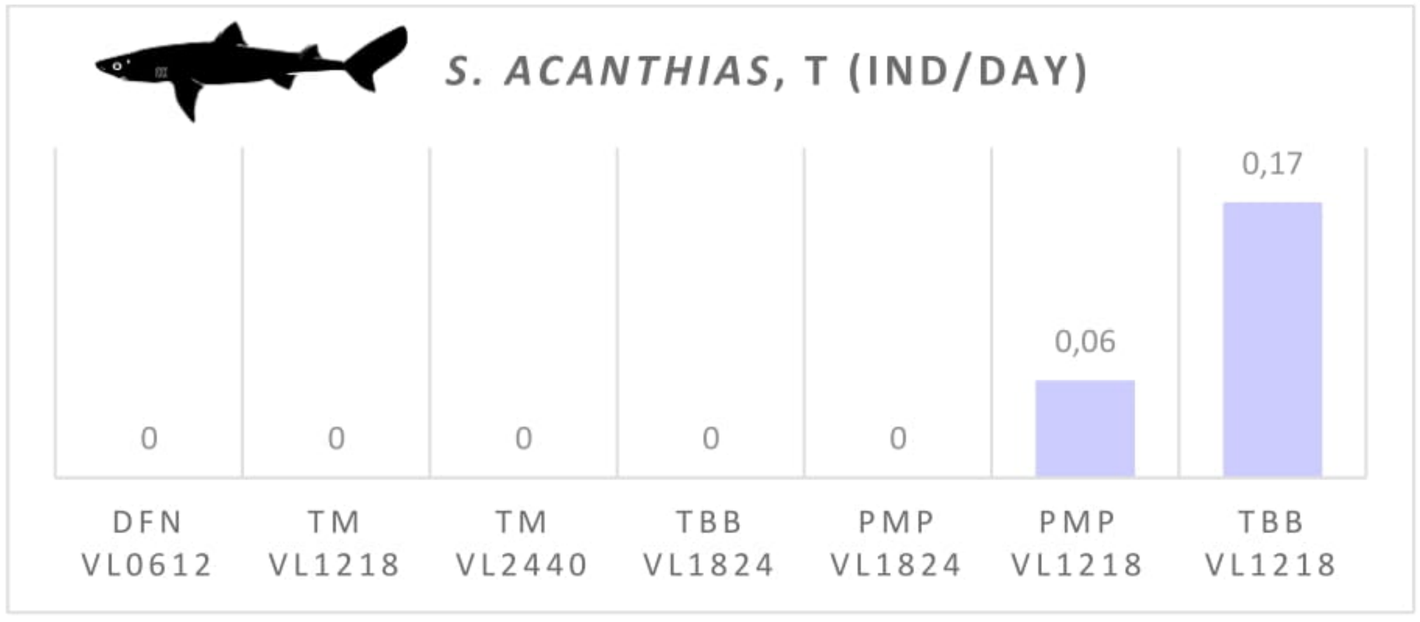

Figure 47. Bycatch ratio (T, ind/day) of Elasmobranchii species by fishing segment in 2024: (1) *Dasyatis pastinaca*, (2) *Raja clavata*, and (3) *Squalus acanthias*.

Turbot (*S. maximus*) is included in the "Red Book of the Black Sea", but its current IUCN status is LC (Cardinale et al., 2020). In 2024, the highest bycatch coefficient for turbot was recorded during beam trawl fishing in a segment of larger vessels, with T = 7 ind/day (Fig. 48.1).

In 2024, within the studied fishing segments, the average daily quantities of turbot bycatch varied between 2.5 – 48.22 kg/day, while the bycatch rate (% TC) showed significant variation across segments and fishing activities, reaching a maximum of 3.89 % of the total catch during rapa whelk fishing with beam trawl in the TBB VL1218 segment, as well as 3.42% of the total catch during fishing with polyvalent vessels (PMP VL1824, Fig. 48.2).

The mortality of turbot in the bycatch is highest during beam trawl fishing for rapa whelks (~80 %), whereas in fishing with polyvalent vessels and pelagic trawls, approximately 90 % of the turbot bycatch is alive and viable).

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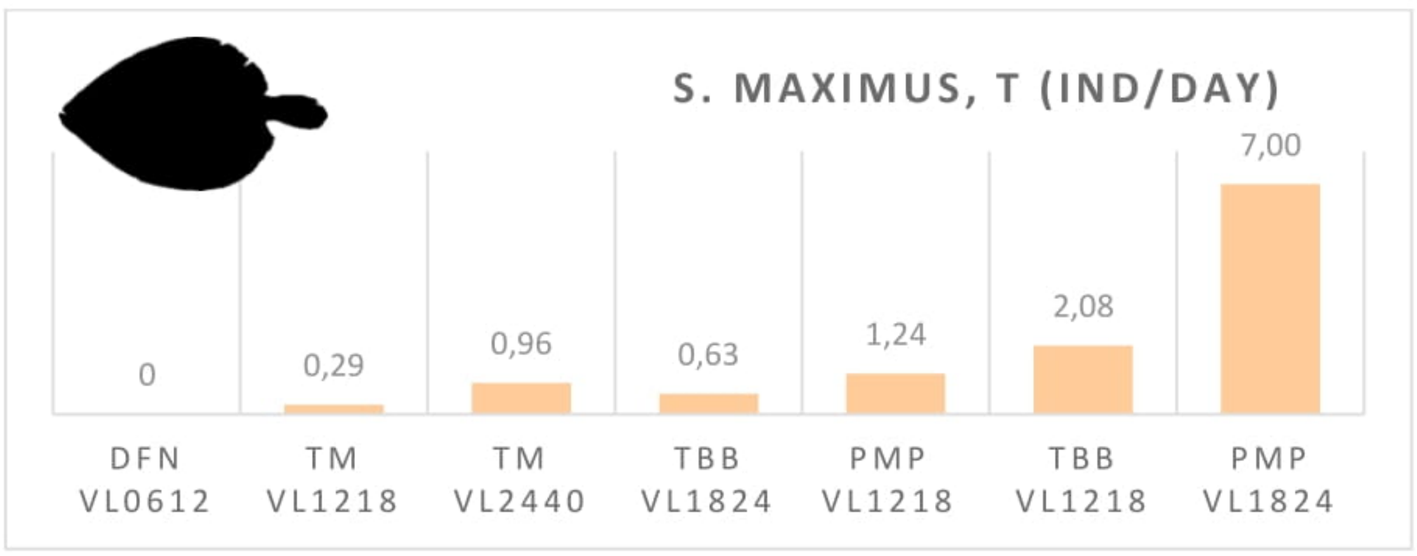

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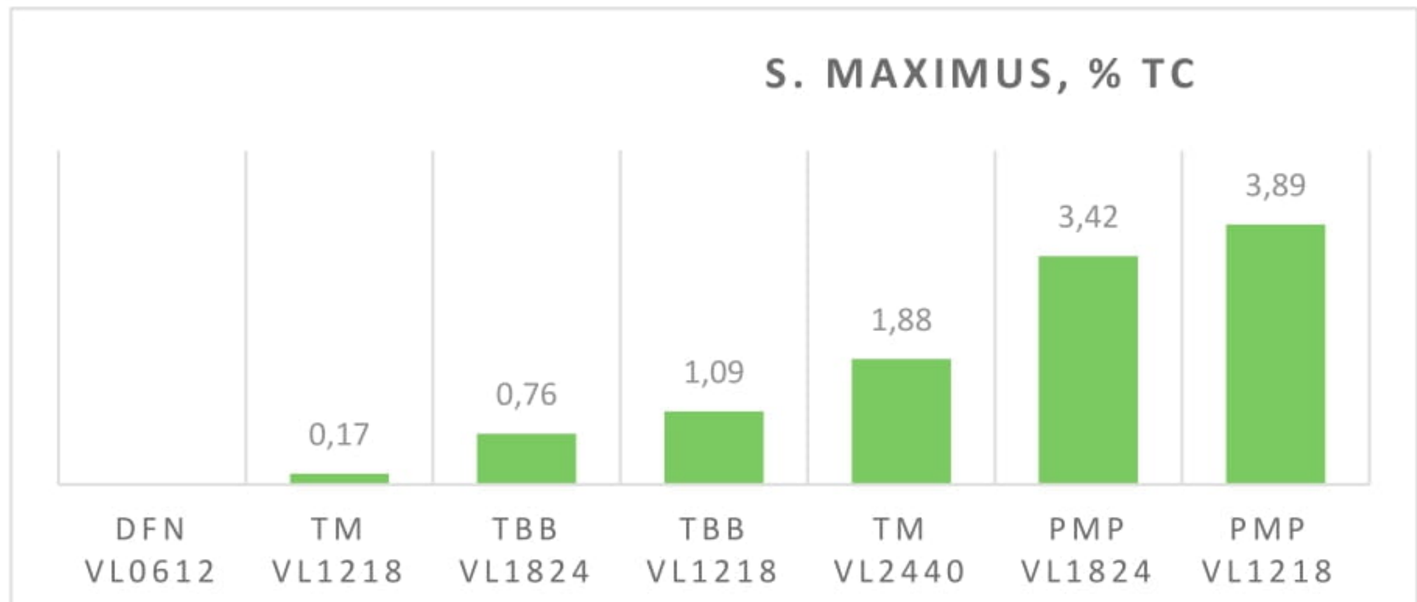

Figure 48. Turbot bycatch by fishing segment in 2024: (1) turbot bycatch ratio (T, ind/day) and (2) percentage of bycatch by total catch (% TC).

The seasonal fluctuations in the bycatch coefficient for the sensitive species during different fishing activities are shown in Fig. 49.

For spiny dogfish, the bycatch coefficient is generally low, and the presence of species in the bycatch is mainly registered during summer and autumn in beam trawl fishing and with polyvalent vessels. Bycatch of *D. pastinaca* occurs primarily during late spring and early autumn in fishing with gillnets and polyvalent vessels. The bycatch coefficient for the thornback ray showed an increase during the winter-spring period in gillnet fishing. The bycatch coefficient for small turbot specimens reached high values in autumn during fishing with polyvalent vessels, as well as at the beginning of summer during beam trawl fishing.

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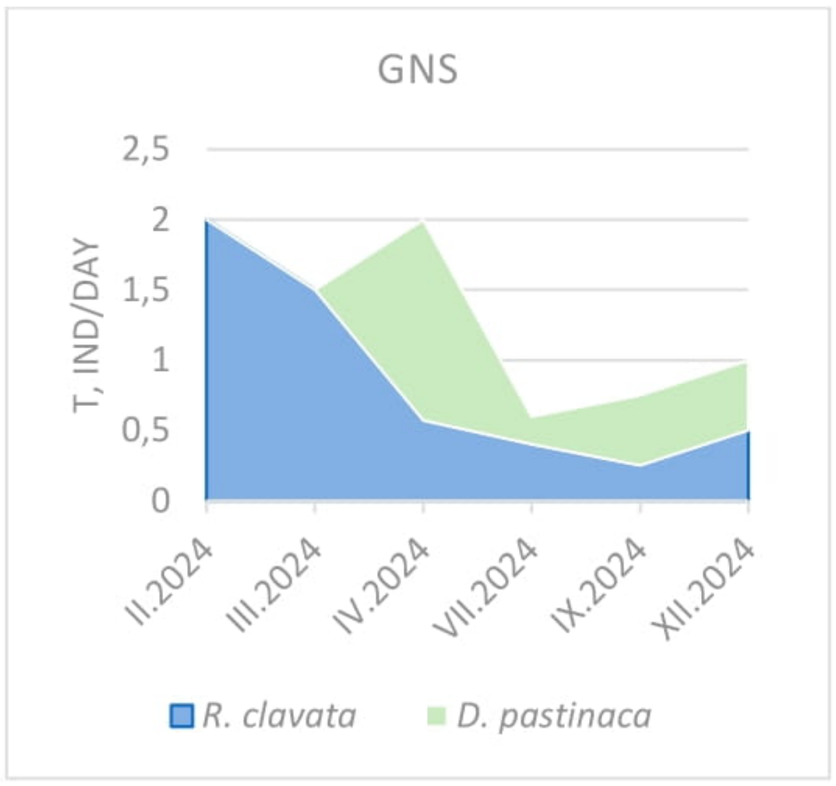

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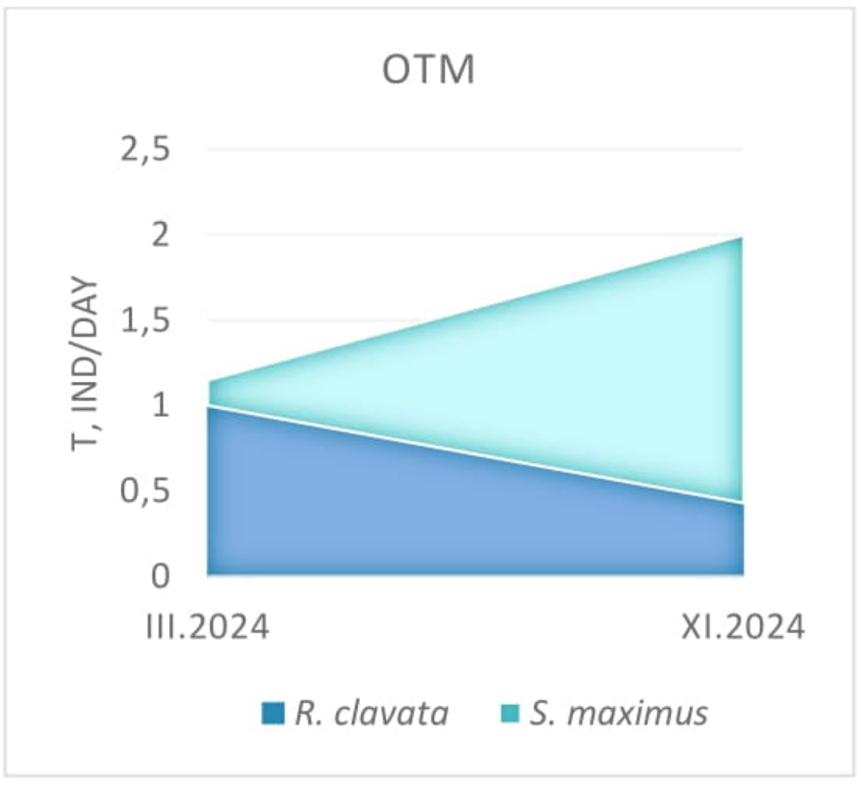

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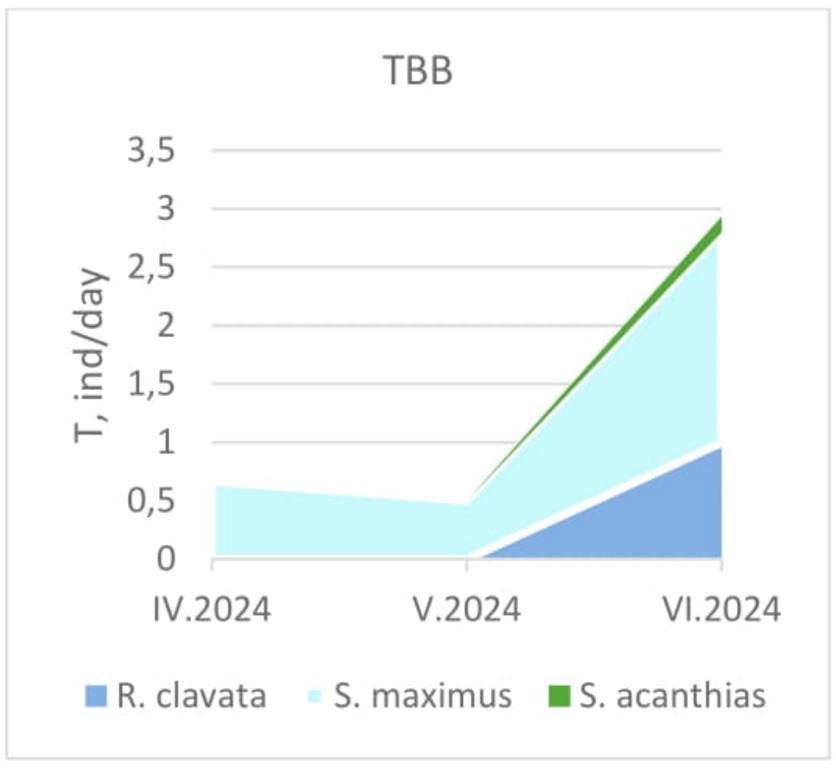

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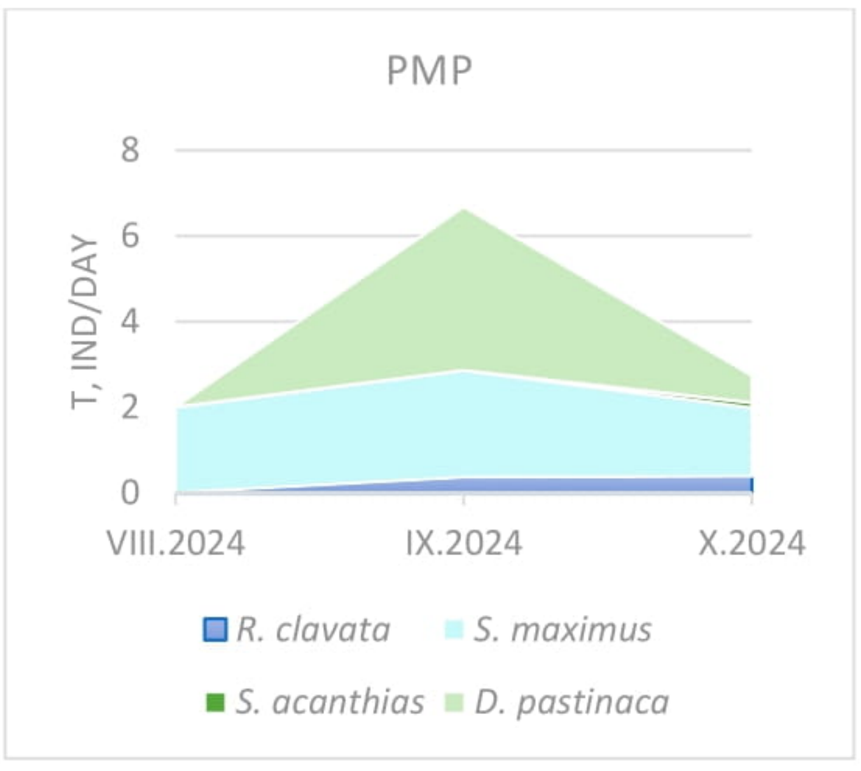

Fig. 49. Seasonal fluctuations in the bycatch coefficient (T, ind/day) of sensitive species by fishing activity in 2024: (1) gillnet fishery and (2) beam trawl fishery.

4. Conclusions

1. In 2024, scientific observations onboard vessels from the Bulgarian fishing fleet covered 100 fishing days: 30 days for vessels using gill nets, 30 days for vessels using pelagic trawls, 20 days for vessels using beam trawls, and 20 days for polyvalent vessels. Spatially, the observations encompassed the entire Bulgarian coastline, from Durankulak to Tsarevo, as fishing with gill nets encompassed the area off Shabla – Durankulak, pelagic trawl surveys focus on the southern part of the wide Burgas Bay, beam trawl operations for rapa whelk were concentrated off the central and northern coasts (Kalinkara–Byala), and research using polyvalent vessels was conducted in the area between St. Konstantin and Elena, and Emona. During the study period, no discards into the marine environment were observed, and the bycatch mainly consisted of other fish species, mollusks, and crustaceans.

2. Observations of fishing with gill nets include fishing segment DFN VL0612. The target catch from the observed gill nets is turbot (*S. maximus*), whereas the bycatch species composition primarily includes black mussel (*Mytilus galloprovincialis*), common stingray (*Dasyatis pastinaca*), and thornback ray (*Raja clavata*). In July 2024, a specimen of the rare non-native species European lobster (*Homarus gammarus*) was recorded. During the study period, the average quantity of the target catch was 30.77 kg/day ± 2.83 SE, with an average bycatch quantity of 17.22 kg/day ± 2.51 SE, total catch weight of 47.99 kg/day ± 4.04 SE, and an average percentage of bycatch in the total catch of 32.84% ± 3.81 SE. The average size of turbot in the target catch was 52.39 cm ± 4.89 SD, with an average weight of 2312.77 g TW ± 632.44 SD. The bycatch weight was predominantly composed of black mussels (63.8 %), followed by smaller quantities of stingrays (18 %), and thornback rays (16 %). The total number of sensitive species caught during the entire study period was 35, representing two species (stingray and thornback ray) with a high mortality rate. The highest bycatch coefficient was recorded for the thornback ray (T = 0.67 ind/day).

3. In 2024, research on pelagic trawl fisheries focused mainly on the catch of sprat and covered two fishing segments, TM VL1218 (1 vessel, 7 fishing days) and TM VL2440 (3 vessels, 23 fishing days). The daily catches averaged 2227.93 kg/day ± 210.18 SE, while bycatch of fish and crustaceans ranged between 0 - 57.09 kg/day, and the bycatch of gelatinous zooplankton (*A. aurita*) reached an average of 20.33 kg/day ± 5.56 SE. Statistical data from fishing segments indicated higher catches and bycatch in the segment with larger vessels. In the ichthyological samples from the main catch, two-year-old sprat dominate, accounting for 49.91 % (in March) and 70.42 % (October-November), followed by one-year-

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old individuals at 47.77 % and 26.9 %, respectively. The sizes of sprat in the samples range between 5.3 – 10.6 cm, with an average size of 8.2 – 8.5 cm and an average weight of 3.2 – 3.6 g. The mean value of the condition factor for sprat varies between 0.48 – 0.58 across different age groups. A total of 28 species of marine organisms were identified in the bycatch, with an average of ~6 species found in the bycatch per fishing day. Moon jellyfish (80.65 %) was the dominant bycatch species by weight. In smaller quantities, the bycatch includes turbot (6.55 %), whiting (4.84 %), gobies (1.75 %), and thornback ray (1.58 %), whereas the share of all other species is < 5 % of the average bycatch weight. In the bycatch of whiting, the age composition includes 1–4-year-old individuals, with average sizes ranging between 10.3 – 17.20 cm and average weights between 7.9 – 18.2 g across different age groups. The average size of whiting in the bycatch is 13.19 cm, and the average weight is 14.89 g. The mean value of the condition factor is 0.66, varying between 0.34 – 0.73 across different age groups. The total number of sensitive species caught during this fishing activity was 30 individuals from two species (thornback ray and turbot); all individuals were caught alive without serious injuries. Among the registered sensitive species in the bycatch, the highest bycatch coefficient was for turbot, T = 0.8 ind/day.

4. In 2024, the study of rapa whelk catches using beam trawl covered two fishing segments: vessels with lengths of 18–24 m (TBB VL1824, one vessel, eight fishing days) and vessels with lengths of 12–18 m (TBB VL1218, 12 fishing days, two fishing vessels). The catches of *Rapana venosa* range from 40 to 2090 kg/day, whereas bycatch quantities vary between 2.39 and 174.25 kg/day. The total catch averages 1151.00 kg/day ± 133.18 SE, with an average percentage of bycatch accounting for 6.05 % ± 2.32 SE of this catch. The average quantity of marine litter is 55.31 kg/day ± 16.18 SE, representing 3.86 % ± 1.08 SE of the total catch. The average size of the sampled rapa whelk individuals range from 54.100 to 64.924 mm, with average weights varying between 28.135 and 48.651 g. For the study period, the average size of *R. venosa* is 60.209 mm ± 9.87 SD, with an average weight of 40.889 g TW ± 20.98 SD. The most significant presence in the catch corresponded to the size group of 45 – 70 mm (79.9 % of the measured rapa whelk specimens), while the dominant weight group in the target catch was 20–60 g (85.64 % of the measured specimens). The species composition of the bycatch during rapa whelk fishing is diverse and includes 30 species of fish, crustaceans, and mollusks, with up to 20 different marine organisms identified daily in beam trawl samples. The most frequently encountered species in the bycatch were the stargazer (*Uranoscopus scaber*), present in 95% of daily bycatches, and the swimming crab (*Polybius vernalis*), found in 90 % of daily bycatches. The ark clams *Anadara kagoshimensis* and flounder (*P. flesus*) were observed in 80 % of daily bycatches. The dominant species in the bycatch were ark clam *A. kagoshimensis* (83 %), followed by turbot and stargazer (4 %), black mussel and swimming crab (3 %), and thornback rays (1 %). The bycatch of turbot includes specimens with an average size of 31.55 cm and an average weight of 0.8 kg. The total number of sensitive species caught in the bycatch was

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47, including turbot, thornback rays, and spiny dogfish. Turbot constituted the highest proportion (63.83 %) of the total count of sensitive species in bycatch, with a bycatch coefficient of T = 1.5 ind/day.

5. The study using polyvalent vessels covered 20 days aboard four fishing vessels belonging to two fishing segments: PMP VL1218 (3 vessels, 17 days) and PMP VL1824 (1 vessel, 3 days). The main catch is mixed and consists primarily of red mullet, horse mackerel, anchovy, and whiting, with the average daily catch of target species being 417.40 kg/day ± 64.01 SE. The average weight of bycatch is 118.60 kg/day ± 20.85 SE, with a total catch weight of 536.00 kg/day ± 68.07 SE. In the segment of larger vessels, PMP VL1824, the quantity of the main catches was 1.5 times lower, but the bycatch was 1.4 times higher. Accordingly, the average percentage share of bycatch in this segment is 35.29 % ± 9.09 SE, which is 1.6 times higher than that recorded in the PMP VL1218 segment. In the main catches of horse mackerel during the autumn of 2024, specimens with average sizes between 9.39 - 13.05 cm and weights ranging from 7.08 – 19.41 g were recorded across age classes. The mean value of the condition factor is 0.86. Two-year-old individuals dominate the catch (54.94 %), followed by three-year-olds (27.9 %). In the autumn catches of red mullet, two-year-old specimens dominate (52.79 %). The average sizes of measured red mullet specimens from the target catch vary between 7.33–16.5 cm, with weights ranging from 3.96 – 46.35 g across age groups. The mean value of the condition factor varies between 0.99 – 1.05 across age groups. A total of 25 species of marine organisms, mainly fish and crustaceans, were identified as bycatch, with an average of 12 different species recorded per day. In addition to small-sized representatives of the main catches, the most frequently encountered species in the bycatch were *N. melanostomus* (100 % of daily catches) and *T. draco* (90 %), followed by *U. scaber* (85 %), *G. niger* (70 %), and turbot (70 %). Regarding the quantities of bycatch, the dominant species are small-sized horse mackerel (29.27 %) and bluefish (21.42 %), black mussel (20.13 %), common stingray (7.24 %), and in smaller amounts, gobies and small-sized whiting. The bluefish in the bycatch has an average size of 11.5 cm and an average weight of 15.19 g. A total of 98 individuals from the sensitive species group, including common stingray, thornback ray, turbot, and spiny dogfish, were registered. The highest bycatch coefficient was for the stingray, T = 2.35 ind/day, and the lowest for spiny dogfish (T = 0.05 ind/day. The mortality rate of sensitive species in bycatch is not high, and upon removal from the nets, a large proportion of the caught sensitive species are alive and viable.

6. In 2024, the feeding patterns of the following fish species in bycatch were analyzed: sprat (*S. sprattus*), whiting (*M. merlangus*), red mullet (*M. barbatus*), spiny dogfish (*S. acanthias*), and thornback ray (*R. clavata*). The highest average stomach fullness index was recorded for the spiny dogfish, 1.632 % BW ± 0.928 SE, followed by whiting with 1.055 % BW ± 0.293

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SE, and thornback ray with an average ISF value of 0.430 % ± 0.111 SE. The lowest stomach fullness index was observed in sprat, at 0.269 % BW. Among the studied predatory fish species in bycatch, the number of food items in the stomachs was not high, except for sprats, which, as a zooplanktivorous species, exhibited a higher number of food items in the stomach. Specifically, the sprat diet was dominated by the zooplankton species *Calanus euxinus* (72% IRI). For the predatory fish species analysed, the dietary spectrum of whiting included a high proportion of fish remains (99 % IRI). Crustaceans constituted a significant portion of the thornback-ray diet (94 % IRI). In the diet of the spiny dogfish, whiting was predominant (32 %), alongside a notable proportion of cetacean remains (40 %).

7. To assess the impact of different types of fishing activities and segments, indicator values for bycatch rates (BCR, %TC) were applied, and the effect on sensitive species was evaluated using a bycatch coefficient (T, ind/day). Both gillnet fishing (fishing segment DFN VL0612) and fishing with polyvalent vessels, particularly segments of large vessels (PMP VL1824), are rated as having a very strong impact on marine organisms. In gillnet fishing, the average bycatch rate was 32.84 % TC, with an average daily bycatch quantity of 17.22 kg. Accordingly, the PMP VL1824 segment generated a significant average bycatch, of 153.35 kg/day, with an average daily bycatch rate of 35.29 % TC. The other segment of polyvalent vessel fishing, PMP VL1218, had a strong impact, with an average bycatch rate of 22.59 % TC and an average daily bycatch quantity of 112.46 kg. Beam trawl fishing for rapa whelk also showed variations in the degree of impact depending on the fishing segment. The impact of the TBB VL1218 segment was rated as moderate, with a bycatch rate of 3.69 % TC, whereas in the segment of large vessels, TBB VL1824, the impact was low (TBB VL1824; 1.88 % TC). Pelagic trawl fishing exerts an impact ranging between weak and moderate, with the average bycatch rate of the two studied fishing segments varying between 0.81 - 5.46 % TC and the daily bycatch quantities ranging from 2.02 to 7.54 kg/day.

8. In 2024, a total of 209 specimens of sensitive species were recorded in bycatch, belonging to two main groups, with cartilaginous fish accounting for 5 4% and turbot for 46 % of the total number of sensitive species. The largest total number of sensitive species, 97 specimens (with a 43 % share of turbot), were recorded during fishing with polyvalent vessels. Among cartilaginous fish, the highest overall bycatch coefficient occurred during fishing with polyvalent vessels, T = 2.75 ind/day, and the lowest during pelagic trawl fishing, T = 0.2 ind/day. The mortality of sensitive Elasmobranchii species is highest in gillnet fishing (100 %), whereas during fishing with polyvalent vessels and pelagic trawls, a significant portion of sensitive species are alive and viable. The bycatch coefficient for turbot was

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highest during fishing with polyvalent vessels in the PMP VL1824 segment (T = 7 ind/day). Seasonal fluctuations in the bycatch coefficients of the sensitive species were observed. For spiny dogfish, the bycatch coefficient is generally low, and the species is mainly recorded as bycatch during summer and autumn in beam trawl and polyvalent vessel fishing. The bycatch of *D. pastinaca* is primarily found in late spring and early autumn during fishing with gillnets and polyvalent vessels. The bycatch coefficient for the thornback ray showed an increase in values during the winter-spring period in gillnet fishing. The bycatch coefficient for small-sized turbot increased in autumn during fishing with polyvalent vessels, as well as at the beginning of summer in beam trawl fishing.

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