



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 2025



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МИНИСТЕРСТВО НА ЗЕМЕДЕЛИЕТО И ХРАНИТЕ



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This study was conducted by specialists at the Institute of Fish Resources (IFR), Varna, Agricultural Academy (AA), under a contract with EAFA/D-154/27.03.2025, 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 2025-2026.

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 2025 in the Bulgarian waters of the Black Sea and covered the following fishing activities: gillnet fishery, pelagic trawling, and beam trawling. 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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Проект № BG14MFPR001-1.002-0002 „Събиране, управление и използване на данни за целите на научния анализ и изпълнението на Общата политика в областта на рибарството за периода 2025-2026 г.“, финансиран от Програмата за морско дело, рибарство и аквакултури, съфинансирана от Европейския съюз чрез Европейския фонд за морско дело, рибарство и аквакултури.



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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 2025

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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 of the Bulgarian fishing fleet. The 2025 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.

The current study included 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. The absolute and standard lengths of bycatch organisms were measured, as were their individual weights, and otoliths were 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 certain fish species.

Based on the conducted field and laboratory studies, the dynamics of the total amount of bycatch compared to the target catch, the quantity and seasonal dynamics of the bycatch species, the size–age structure of the catches, and the main species in the bycatch were characterised, and the nutritional spectrum of some bycatch species 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, 2025) 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
 - Name of the fishing vessel
 - Type of vessel
 - Vessel length (m).

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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 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.

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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, and (3) beam trawls for rapa whelk.

The preliminary research plan was based on the following information:

- vessel activity during the previous three years (2022–2024); therefore, the survey should cover actively operating vessels that make a significant contribution to the individual types of fishing activities.

- estimated monthly activity;

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

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 (2020) "Technical Guidelines for Scientific Research in the Mediterranean and Black Sea."

2.1.1 Vessels with gill nets

The study covered 30 fishing days on five fishing vessels, including two fishing segments, DFN VL0006 (1 vessel, 3 fishing days) and DFN VL0612 (4 vessels, 27 fishing days) (Table 1 & 2).

Table 1.

Characteristics of gill net vessels.

Name of fishing vessel	Specifications	Fishing segment
ВН 7919	2.15 GT, 6.5 m, 58.84 kW	DFN VL0612
ШБ 5861	4.34 GT, 9 m, 38.98 kW	DFN VL0612
ШБ 6056	1.12 GT, 6.5 m, 11.13 kW	DFN VL0612
КВ 6245	1 GT, 6.3 m, 23.54 kW	DFN VL0612
ШБ 5916	0.45 GT, 5 m, 2.58 kW	DFN VL0006

The study was conducted using gillnets with the following functional and technical parameters: mesh size of the net up to 400 mm; average length of the net, 1000 m; average soak time, 13.9 days $\pm$ 0.8 SE.

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Gillnet fishing follows a cyclical pattern consisting of setting the nets, a prolonged soak time, and subsequent catch harvesting. The total catch weight is recorded at a given landing port after the end of the full fishing operation. Therefore, a methodological distinction is needed between the net soak time and vessel activity. For the purposes of this analysis, a fishing day is defined as the calendar day on which the vessel actively collects the catch and completes the formalities for landing, thus marking the end of the full cycle of the process. This definition is in line with regulatory reporting standards that consider the active effort of the vessel rather than the passive soak time.

Data on gillnet fishing expeditions, including the dates and coordinates of the surveyed regions, are presented in Table 2. The surveys were concentrated in the area between Shabla and Durankulak (Fig. 1).

Table 2.

Gillnet fishery observations in 2025.

Date	Fishing segment	Latitude	Longitude	Soak time (days)	Net length (m)	Availability of Acoustic Deterrent Devices (ADDs)
31.3.2025 a	DFN VL0612	43.845	28.790	11	1000	+
31.3.2025 b	DFN VL0612	43.845	28.842	10	1000	+
31.03.2025 c.	DFN VL0612	43.853	28.994	14	1000	+
3.4.2025 a	DFN VL0612	43.655	28.907	9	1000	+
3.4.2025 b	DFN VL0612	43.913	28.783	11	1000	+
5.4.2025	DFN VL0612	43.713	28.751	15	1000	+
8.4.2025	DFN VL0612	43.870	28.818	14	1000	+
9.4.2025 a	DFN VL0612	43.640	28.823	10	1000	+
9.04.2025 b	DFN VL0612	43.856	28.648	10	1000	+
9.4.2025 c	DFN VL0612	43.775	28.679	14	1000	+
10.04.2025	DFN VL0612	43.949	28.854	11	1000	+
13.4.2025 a	DFN VL0612	43.571	28.757	22	1000	+
13.4.2025 b	DFN VL0612	43.773	28.781	8	1000	+
13.4.2025 c	DFN VL0612	43.716	28.737	9	1000	+
13.04.2025 d	DFN VL0612	43.799	28.783	10	1000	+
26.06.2025 a	DFN VL0612	43.930	28.763	10	1000	+
26.06.2025 b	DFN VL0006	43.745	28.818	10	1000	+
27.6.2025 a	DFN VL0612	43.844	28.980	22	1000	+
27.06.2025 b	DFN VL0612	43.599	29.006	12	1000	+
04.07.2025	DFN VL0612	43.719	28.763	15	1000	+

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07.07.2025	DFN VL0612	43.792	28.974	6	1000	+
12.07.2025 a	DFN VL0612	43.751	28.809	15	1000	+
12.7.2025 b	DFN VL0006	43.805	28.848	18	1000	+
25.07.2025	DFN VL0612	43.757	28.969	20	1000	+
27.07.2025	DFN VL0612	43.700	28.720	15	1000	+
05.08.2025	DFN VL0612	43.680	28.686	14	1000	+
13.11.2025	DFN VL0612	43.706	28.865	18	1000	+
14.11.2025	DFN VL0612	43.870	28.689	21	1000	+
16.11.2025 a	DFN VL0612	43.782	28.890	20	1000	+
16.11.2025 b	DFN VL0006	43.841	28.809	22	1000	+

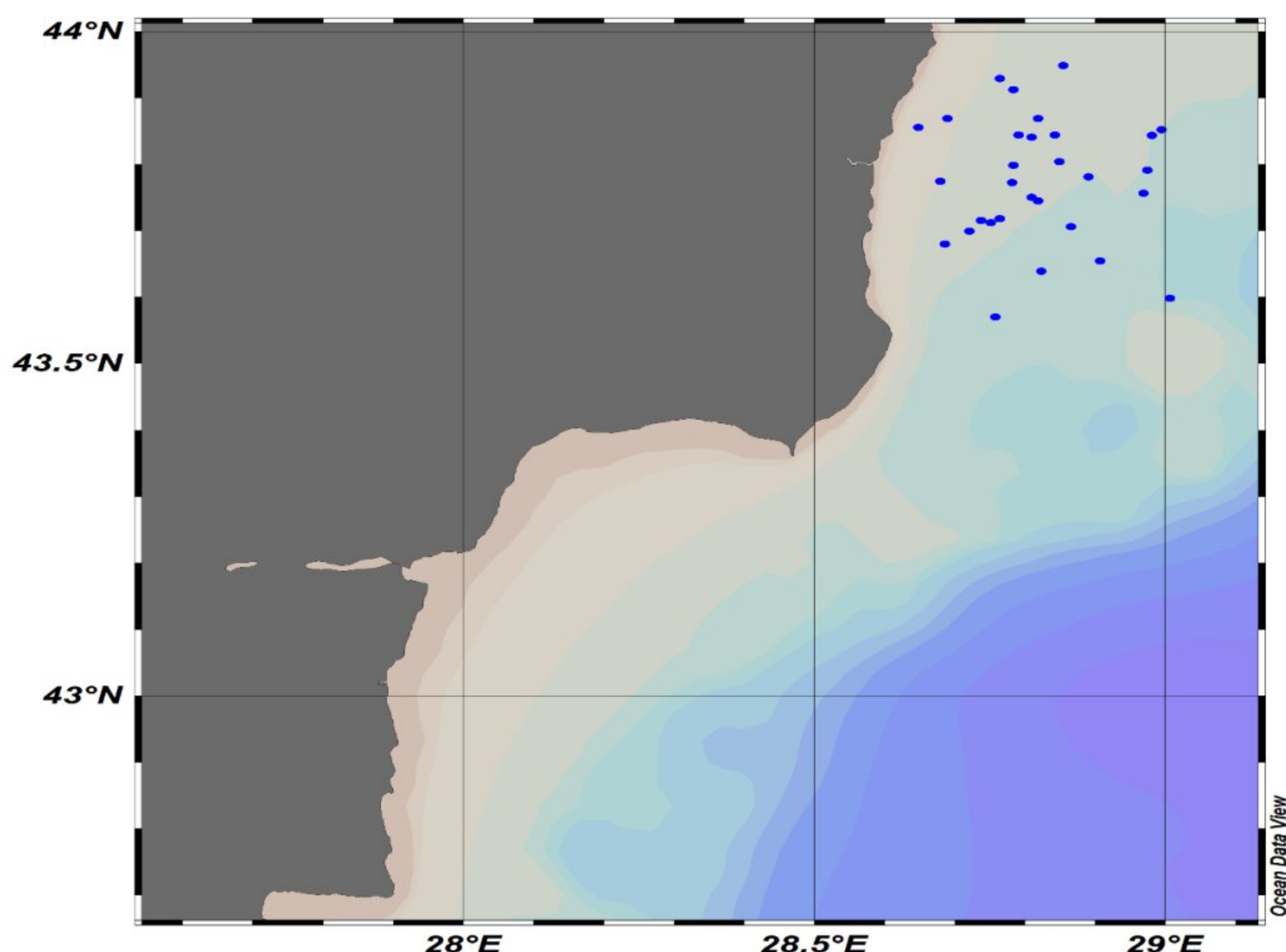


Fig. 1. Map of observed gillnet fishing expeditions.

2.1.2 Pelagic trawl vessels

The study covers 45 fishing days, on board 9 fishing vessels (Table 3, Fig. 2), during the period V-XI.2025. The fishing vessels belong to three segments - TM VL1218 (4 vessels, 18 fishing

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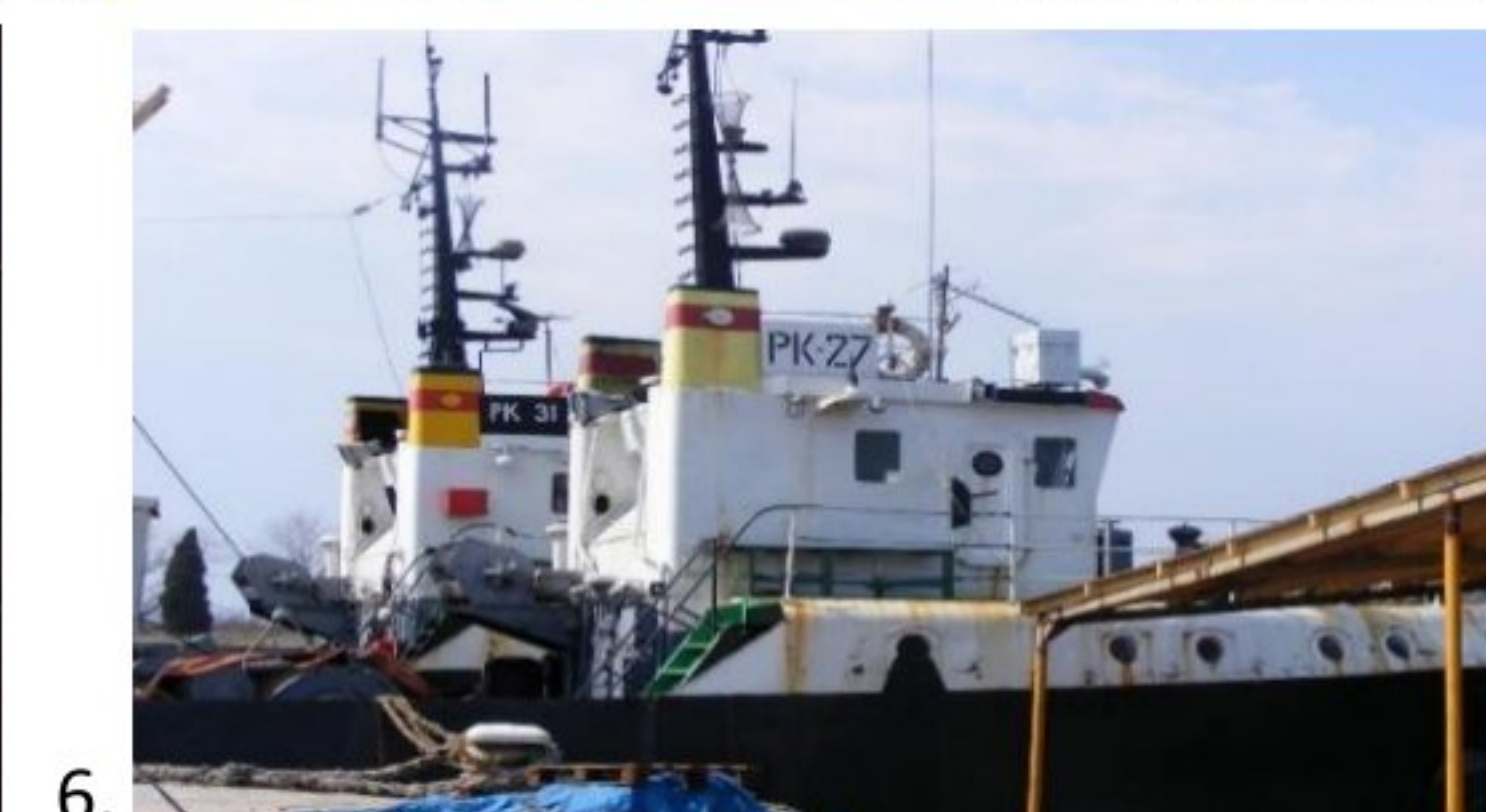
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days), TM VL1824 (1 vessel, 8 fishing days); TM VL2440 (4 vessels, 19 fishing days). 109 trawling operations were monitored within the study.

Table 3.

Characteristics of pelagic net vessels.

Name of fishing vessel	Fishing vessel number	Specifications	Fishing segment
RK 27	BH 4562	14 GT, 16.2m, 133.86 kW	TM VL1218
PK Viking	BH 8406	30.6 GT, 14.52 m, 132.39 kW	TM VL1218
Egeo 2	BH 8195	33.6 GT, 17.23 m, 320 kW	TM VL1218
Iva 1	BH 8194	15.79 GT, 14 m, 159 kW	TM VL1218
RK Lefer	BH 03	68.51 GT, 24 m, 530 KW	TM VL1824
RK 26	BC 219	117.4 GT, 25.5 m, 220.7 kW	TM VL2440
RK 28	BC 221	117.36 GT, 25.5 m, 220.65 kW	TM VL2440
RK 37	BC 255	117 GT, 25.5 m, 225 kW	TM VL2440
RK Meduza 3	BC 288	117 GT, 25.45 m, 225 kW	TM VL2440



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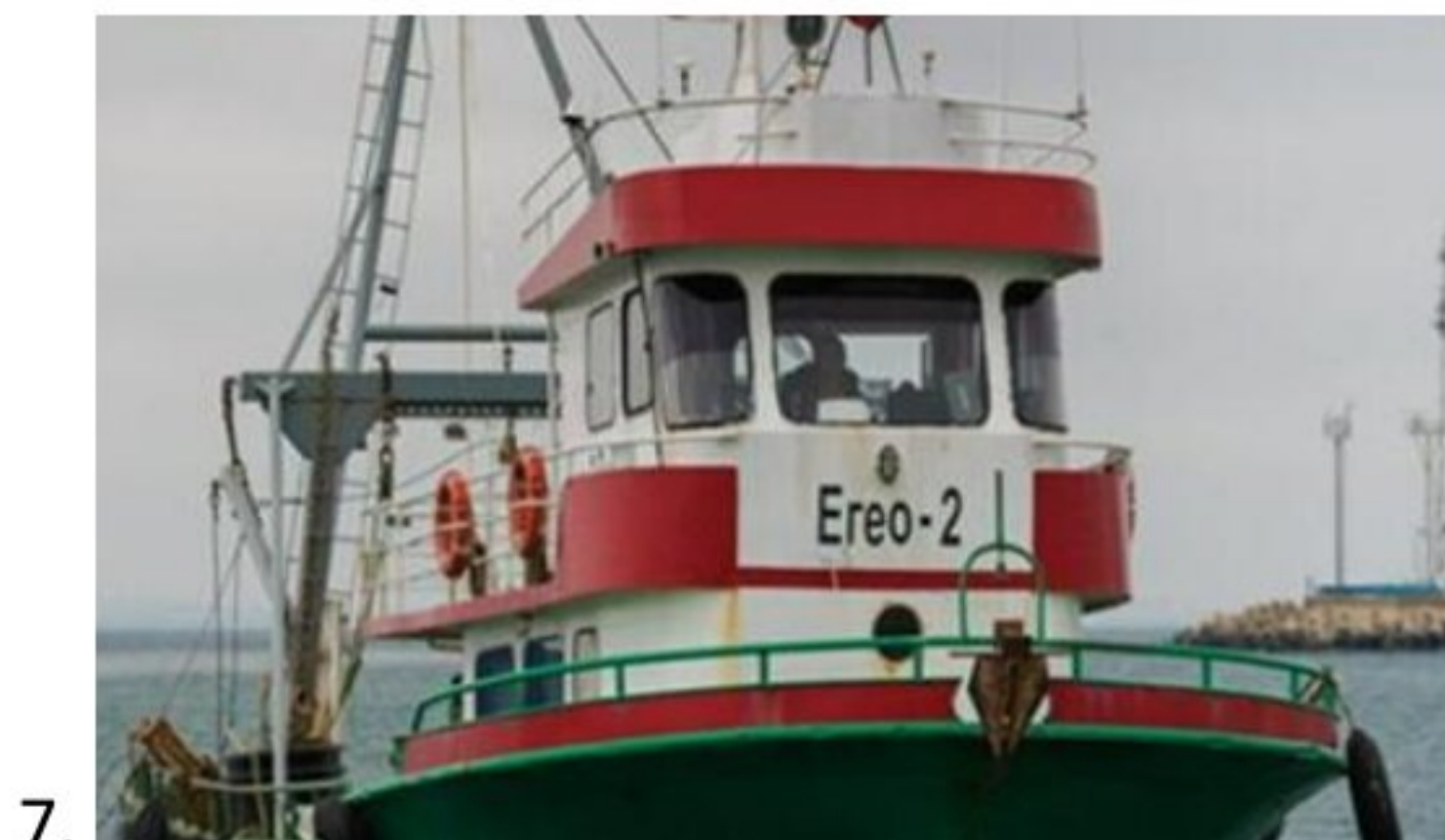


Fig. 2. Fishing vessels with pelagic trawls – Rk 26 (1), RK 28 (2), RK Медуза 3 (3), RK Викинг (4), RK 37 (5), RK 27 (6), RK Ерео 2 (7), RK Лефер (8).

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 × 8 mm; trawl length, 50 m. Trawling speed - 2 - 3.7 Nd
- 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 × 6 mm; trawl length: 50 m. Trawling speed - 2 - 3.7 Nd.
- PK 37: Vertical opening of the trawl: 10 m; horizontal opening: 34 m; size of the "eyes" of the trawl: up to 6 × 6 mm; length of the trawl: 50 m. Trawling speed: 2–3.7 Nd. Trawling speed: 2–3.7 Nd. Trawling speed - 2 - 3.7 Nd.
- 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 × 6.5 mm; trawling speed–2–3.7 Nd.
- RK Viking: vertical opening of the trawl–6 m; horizontal opening–26 m; effective part of the upper collar–21 m; size of the "eyes" of the trawl, up to 18 × 18 mm; length of the trawl, 50 m. Trawling speed: 2–3.7 Nd. Trawling speed: 2–3.7 Nd. Trawling speed - 2 - 3.7 Nd.
- RK Lefer (trawl 1): trawl length – 45 m; collar height – 3 m, vertical trawl width – 16 m; horizontal trawl width – 30 m, trawl width - 6 m, mesh size - 18 mm; trawling speed - 2–3.7 Nd.
- RK Lefer (trawl 2): Trawl length – 50 m, Collar width – 24 m, Collar height – 24 m, Vertical opening of the trawl – 12 m; Horizontal opening - 12m, mesh size – 6x6 mm; Trawling speed - 2 - 3.7 Nd.

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- RK Iva 1: trawl length, 30 m; trawl width, 12 m; trawl height, 6 m; mesh size, 18 × 18 mm; (length of the lower collar, 28 m; upper collar, 25 m); trawling speed, 2–3.7 Nd.
- PK Egeo 2: vertical trawl width, 6 m; horizontal width, 27 m; mesh size, 18 mm; trawling speed, 2–3.7 Nd 2: trawl length, 27 m; trawl width, 6 m, mesh size, 18 mm; trawling speed, 2–3.7 Nd.



Fig. 3. Pelagic trawls catch.

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

Table 4.

Observations of pelagic trawl fisheries in 2025.

Date	Target species	Fishing segment	Departure	Arrival	Trawl N	Latitude	Longitude	Trawling duration (h)	Depth (m)
12.5.2025 a	sprat	TM VL1218	Sozopol	Sozopol	1	42.4264	27.9524	3:38	40.6-48.0
12.5.2025 b	sprat	TM VL2440	Sozopol	Sozopol	1	42.4490	27.9125	3:30	38.0-42.0
12.5.2025 c	sprat	TM VL2440	Sozopol	Sozopol	1	42.4681	27.8639	4:35	37.7-35.7
12.5.2025 d	sprat	TM VL2440	Sozopol	Sozopol	1	42.4615	27.8905	3:40	35.0-46.2
13.5.2025 a	sprat	TM VL2440	Sozopol	Sozopol	1	42.4824	28.0051	3:50	47.9-49,3
13.5.2025 b	sprat	TM VL2440	Sozopol	Sozopol	1	42.4673	27.8842	3:40	37.8-36.8
13.5.2025 c	sprat	TM VL2440	Sozopol	Sozopol	1	42.4622	27.8128	4:15	35.2-40.1
13.5.2025 d	sprat	TM VL2440	Sozopol	Sozopol	1	42.4610	27.8855	4:20	35.0-36.2
14.5.2025 a	sprat	TM VL2440	Sozopol	Sozopol	1	42.4580	27.7525	3:48	34.4-35.1
14.5.2025 b	sprat	TM VL2440	Sozopol	Sozopol	1	42.4514	27.7422	3:45	36.6-35.1

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14.5.2025 c	sprat	TM VL2440	Sozopol	Sozopol	1	42.4745	27.7709	4:00	34.8-36.1
14.5.2025 d	sprat	TM VL2440	Sozopol	Sozopol	1	42.4453	27.7586	4:00	33.7-32.8
15.5.2025 a	sprat	TM VL2440	Sozopol	Sozopol	1	42.4584	27.7647	4:00	34.2- 33.7
15.5.2025 b	sprat	TM VL2440	Sozopol	Sozopol	1	42.4488	27.7375	4:00	37.2-34.7
15.5.2025 c	sprat	TM VL2440	Sozopol	Sozopol	1	42.4537	27.7248	3:50	36.2-34.8
15.5.2025 d	sprat	TM VL2440	Sozopol	Sozopol	1	42.4396	27.7486	4:00	35.0-31.8
16.5.2025 a	sprat	TM VL2440	Sozopol	Sozopol	1	42.4555	27.7520	3:50	34.6- 33.9
16.5.2025 b	sprat	TM VL2440	Sozopol	Sozopol	1	42.4547	27.7298	1:10	36.4-35.0
16.5.2025 c	sprat	TM VL2440	Sozopol	Sozopol	1	42.4586	27.7297	3:15	36.1-36.8
16.5.2025 d	sprat	TM VL2440	Sozopol	Sozopol	1	42.4357	27.7284	3:40	35.6-31.7
3.7.2025	Mixed catch	TM VL1218	Kavarna	Kavarna	1	43.3920	28.6827	2:10	12-15
					2	43.3597	28.4298	2:10	14.8-12
					3	43.3850	28.3335	2:50	11.8-15.2
4.7.2025	Mixed catch	TM VL1218	Kavarna	Kavarna	4	43.3363	28.3004	2:30	12.2-14.9
					2	43.3578	28.3978	2:40	15.5-11.2
					3	43.3365	28.3014	2:20	11-15
5.7.2025	Mixed catch	TM VL1218	Kavarna	Kavarna	1	43.3362	28.3003	2:30	11.5-15.5
					2	43.3595	28.3841	2:30	15-12.7
					3	43.3407	28.3093	2:30	12-15.2
6.7.2025	Mixed catch	TM VL1218	Kavarna	Kavarna	1	43.3425	28.2838	2:40	11-14.8
					2	43.3642	28.3978	2:40	15-11.8
					3	43.3417	28.2836	3:10	11-14.8
7.7.2025	Mixed catch	TM VL1218	Kavarna	Kavarna	1	43.3425	28.2892	2:10	11-15
					2	43.3573	28.3983	2:35	14.9-11.5
					3	43.3298	28.2783	3:10	11.5-15
20.08.2025	Mixed catch	TM VL1218	Kavarna	Kavarna	1	43.3731	28.4946	1:30	20-24
					2	43.4047	28.5347	0:55	24-24
					3	43.3691	28.4953	3:20	25-24
24.08.2025	Mixed catch	TM VL1218	Kavarna	Kavarna	1	43.3957	28.3479	1:20	12-14
					2	43.3653	28.4192	2:15	14-14
					3	43.3864	28.2965	2:00	14-14
25.08.2025	Mixed catch	TM VL1218	Kavarna	Kavarna	1	43.3967	28.3045	2:00	14-15
					2	43.3648	28.4180	1:10	14-15
					3	43.3983	28.3048	2:00	15-14
26.08.2025	Mixed catch	TM VL1218	Kavarna	Kavarna	1	43.3675	28.3928	1:20	15-15
					2	43.4070	28.6443	1:50	24-24
					3	43.3675	28.3928	2:10	24-24
27.08.2025	Mixed catch	TM VL1218	Kavarna	Kavarna	1	43.4053	28.5345	2:15	24-20
					2	43.3723	28.4942	1:20	21-24
					3	43.3722	28.4928	2:15	21-24
30.08.2025	Mixed catch	TM VL1824	Varna	Varna	1	43.1575	28.0656	3:01	20-17.3
					2	43.2698	28.2098	3:05	17.4-26.3
					3	43.2180	28.2385	3:01	23.3-21.7
31.08.2025	Mixed catch	TM VL1824	Varna	Varna	1	43.1120	28.0178	2:28	20.02-18.1
					2	43.2183	28.1249	1:11	18-19.2
3.09.2025	Mixed catch	TM VL1218	Varna	Varna	1	43.2542	28.0594	1:21	20-20.1
					2	43.3143	28.1217	1:20	20-20
					3	43.3457	28.2057	1:30	20-20.1

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					4	43.3138	28.1117	1:15	20-22.2
					5	43.2598	28.0730	1:26	20-20.3
					6	43.3117	28.1200	1:40	20-23.2
17.09.2025	Mixed catch	TM VL1218	Varna	Varna	1	42.9367	27.9500	1:12	29-30
					2	42.8717	27.9617	2:27	30.1-31.3
					3	42.8150	28.9922	1:28	31.3-36.4
					4	42.7500	28.0167	1:35	36.7-37.2
					5	42.8167	28.0667	0:10	37.8-36.2
30.09.2025	Mixed catch	TM VL1824	Varna	Varna	1	42.9021	28.1660	1:10	29.3-28.6
					2	42.9572	28.1992	1:05	22.6-22.8
					3	42.9145	28.1611	1:04	32-31.1
					4	42.9653	28.1899	1:40	19.7-30.2
5.10.2025	Mixed catch	TM VL1824	Varna	Varna	1	43.620	28.769	0:40	57.3-59.8
					2	43.535	28.836	0:10	70.2-72.4
					3	43.441	28.907	0:31	76.3-77.4
					4	43.303	28.512	0:37	50.2-50.2
6.10.2025	Mixed catch	TM VL1824	Varna	Varna	1	43.370	28.358	0:43	16.0-16.6
					2	43.372	28.328	0:37	16.8-17.7
					3	43.358	28.238	0:41	19.3-19.1
					4	43.322	28.158	0:47	20.2-21.3
					5	43.236	28.423	0:37	46.5-46.0
10.10.2025	Mixed catch	TM VL1824	Varna	Varna	1	43.0611	27.9392	1:39	20.9-24.9
					2	42.9755	27.9260	1:40	26.5-25.8
					3	43.0615	27.9436	1:57	25.4-27.5
15.10.2025	Mixed catch	TM VL1824	Varna	Varna	1	43.0579	27.9373	1:35	25.8-23.1
					2	42.9726	27.9297	2:02	28.7-25.9
					3	43.0550	27.9395	1:12	25.8-26.7
					4	42.9762	27.9194	2:21	24.7-23.5
22.10.2025	Mixed catch	TM VL1824	Varna	Varna	1	43.203	28.173	0:41	20.7-23.1
					2	43.116	28.257	0:50	35.3-34.1
					3	42.974	28.229	0:45	49.9-50.8
					4	42.965	28.084	0:40	29.6-26.1
					5	43.007	27.918	0:35	24.4-22.5
2.11.2025	Mixed catch	TM VL1218	Varna	Varna	1	43.0338	27.9143	2:00	21-25
					2	42.9682	27.9177	1:40	25-20
					3	43.1083	28.0200	1:40	20-19
8.11.2025	Mixed catch	TM VL1218	Varna	Varna	1	43.0610	27.9385	1:30	25-23
					2	42.9648	27.9920	1:00	24-26
					3	42.9167	28.0162	2:50	24-25
14.11.2025	Mixed catch	TM VL1218	Varna	Varna	1	43.1183	28.2517	1:07	35-33.2
					2	43.1725	28.2860	1:33	33.2-34.1
					3	43.1008	28.2352	1:23	34.2-33.1
					4	43.1648	28.2795	1:21	33-33.3
					5	43.1150	28.2400	1:25	33.6-33.3
15.11.2025	Mixed catch	TM VL1218	Varna	Varna	1	42.9643	27.9477	1:35	27.3-33.5
					2	42.8185	28.0242	1:35	34.2-34.5
					3	42.8923	28.0870	1:40	34.5-33.5
16.11.2025		TM VL1218	Varna	Varna	1	42.9222	28.0880	1:40	32.5-33.5

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	Mixed catch				2	42.8447	28.0375	1:25	33.5-33.5
					3	42.7970	27.9967	1:43	33.1-32.3
					4	42.9115	28.0695	2:27	31.6-32

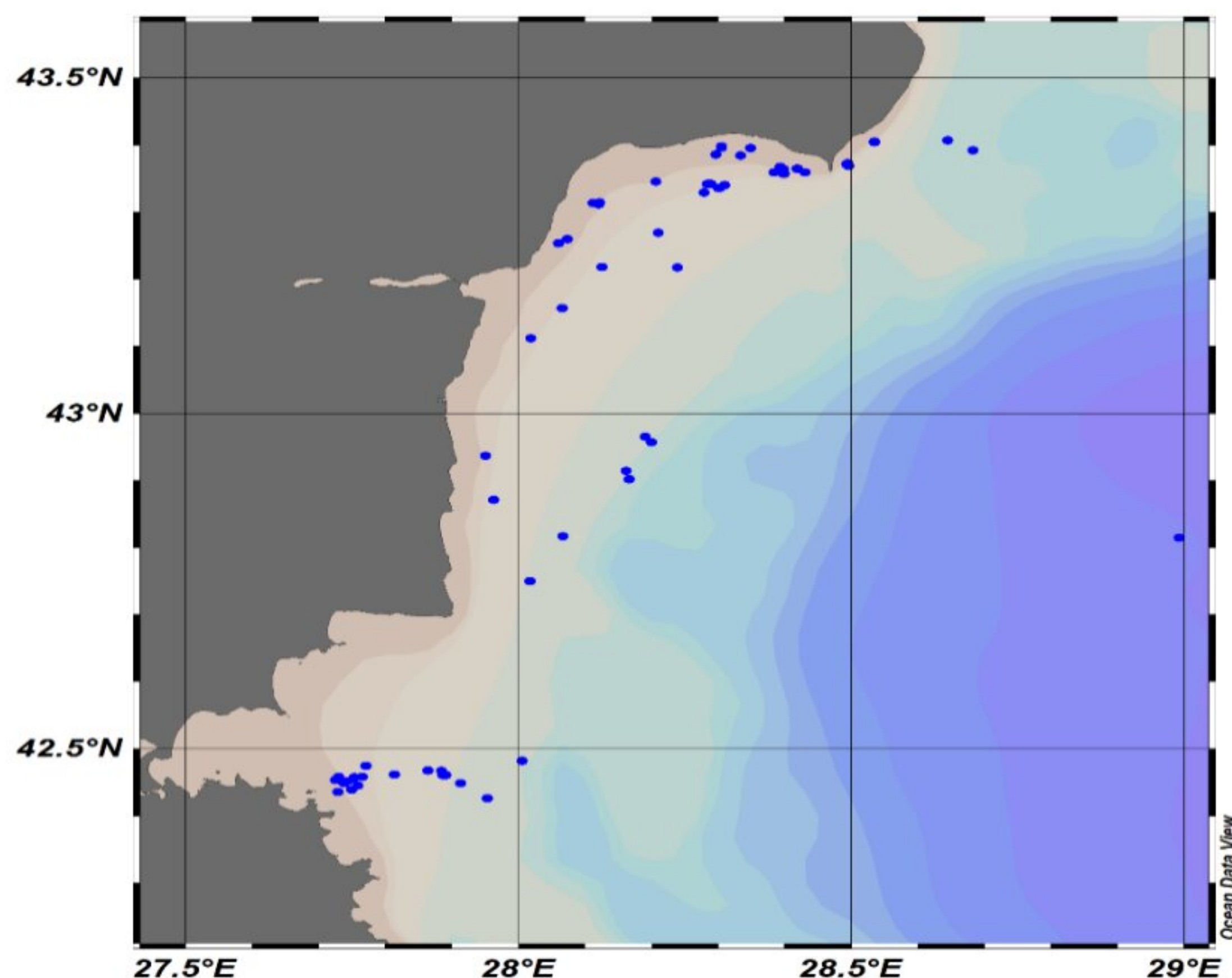


Fig. 4. Map of observed fishing expeditions with OTM.

Fishing expeditions for sprat were conducted off the southern part of the wide Burgas Bay at depths of 33.7–49.3 m, with an average duration of daily trawling of $3.738 \text{ h} \pm 0.15 \text{ SE}$. In the case of targeted catches of mixed species (red mullet and horse mackerel), the expeditions were concentrated off the central and northern coasts at depths between 11 and 50.8 m, with an average duration of daily trawling of $1.69 \text{ h} \pm 0.08 \text{ SE}$.

2.1.3 Rapa whelk fishing vessels

The beam trawl surveys for the rapa whelk fishery included 25 fishing days from May to September 2025 (Table 5, Fig. 5). Fishing vessels with lengths of 12–18 m were covered (TBB VL1218, 25 fishing days, five fishing vessels), and 97 trawls were monitored within 25 fishing days.

Table 5.

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Characteristics of fishing vessels.

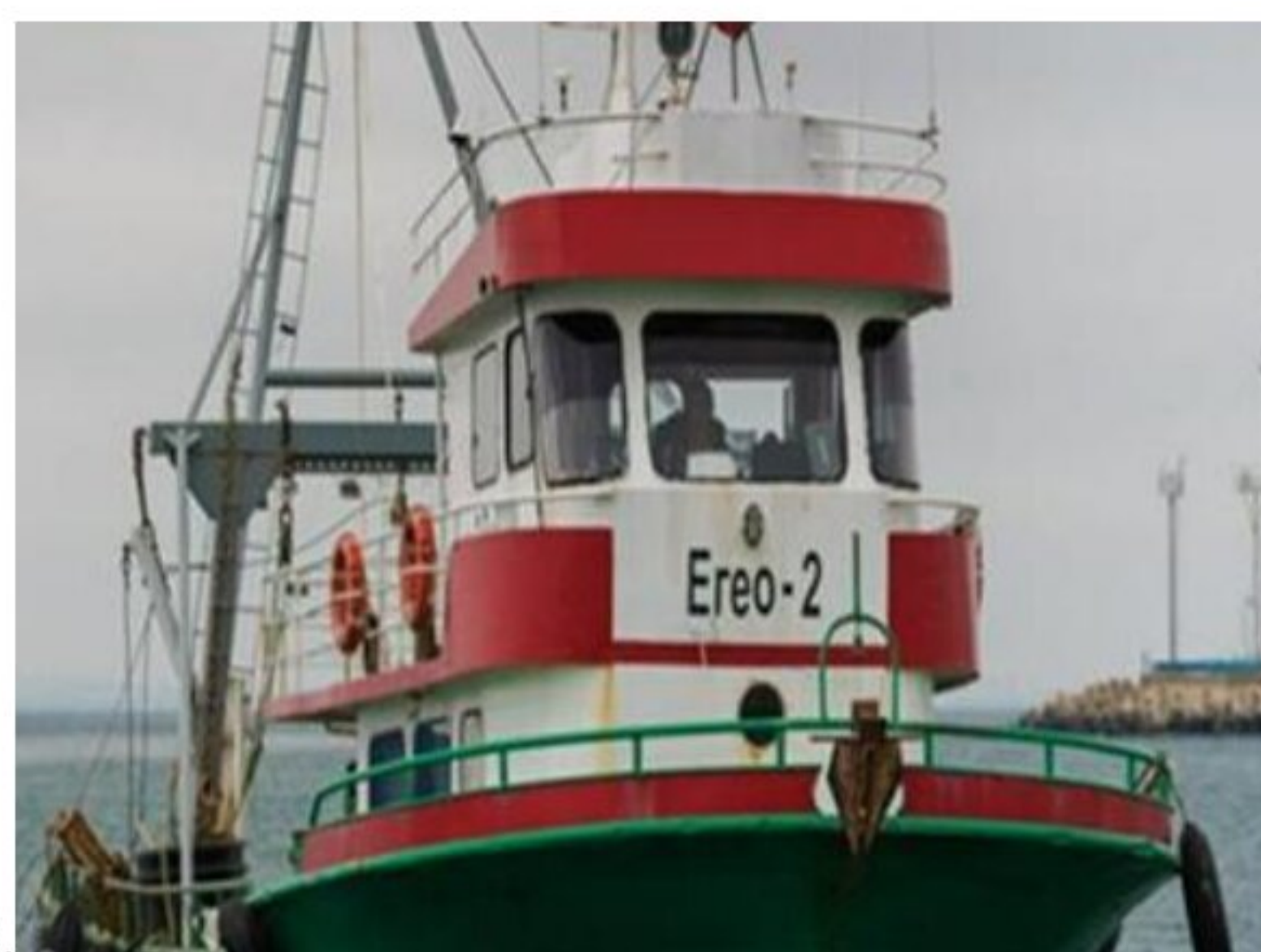
Name of fishing vessel	Fishing vessel number	Specifications	Fishing segment
Egeo 2	BH 8195	33.6 GT, 17.23 m, 320 kW	TBB VL1218
RK Iva-1	BH 8194	15.79 GT, 14 m, 159 kW	TBB VL1218
RK Elekta	BH 8042	17.12 GT, 16.5 m, 110.33 kW	TBB VL1218
RK Libra	BH 8311	17.23 GT, 14.95 m, 126 kW	TBB VL1218
RK Korsar	BH 7177	38.26 GT, 17.3 m, 283.17 kW	TBB VL1218



1.



2.



3.

Fig. 5. Rapa whelk fishery with beam trawl - RK Elekta (1), Iva 1 (2), Egeo2 (3).

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, 40 × 40 mm; and trawling speed, 3–3.6 knots.

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

Table 6.

Observations of the rapa whelk fishery in 2025.

Date	Fishing segment	Port departure	N of fishing operations	Latitude	Longitude	Depth (m)	Duration (h)
29.05.2025	TBB VL1218	Varna	1	43.0800	28.1133	20.5-20	1:40
			2	43.0872	28.1703	20-20	1:20
			3	43.1463	28.2195	20-20	1:50
			4	43.1927	28.2592	20-20	1:05
			5	43.1483	28.2227	20-20	1:10
31.05.2025	TBB VL1218	Balchik	1	43.0629	28.0873	12-12.5	0:45
			2	43.1676	28.0746	12-10.5	1:00
			3	43.2380	28.1024	11-12	0:50
6.06.2025	TBB VL1218	Varna	1	43.0800	28.1133	25-28	1:00
			2	43.0872	28.1703	28.4-28.6	0:58
			3	43.1463	28.2195	28-28	1:02
			4	43.1927	28.2592	27.5-28.7	1:00
			5	43.1483	28.2227	28-27.8	1:00
7.06.2025	TBB VL1218	Balchik	1	43.3965	28.3300	10-10.5	0:50
			2	43.3749	28.3744	12-12.5	0:40
			3	43.3838	28.3201	12-13	1:15
			4	43.3758	28.1547	12-12.5	0:50
			5	43.3454	28.0987	12-11	1:00
9.06.2025	TBB VL1218	Varna	1	43.0750	28.1133	25-28	1:05
			2	43.1033	28.1833	28-28	1:00
			3	43.1575	28.2297	28-27	0:58
			4	43.2000	28.2667	27.5-28.5	1:05
			5	43.1500	28.2242	28-28	1:02
10.06.2025	TBB VL1218	Varna	1	43.1452	28.2227	28.5-27.5	1:00
11.06.2025	TBB VL1218	Balchik	1	43.3905	28.3171	12-12.5	2:00
			2	43.3794	28.3033	13-12.5	2:10
			3	43.3820	28.3304	12-12	0:50
			4	43.3696	28.3826	12-12.5	0:50
13.06.2025	TBB VL1218	Varna	1	43.0718	28.1495	27-28	1:10
			2	43.1227	28.2000	28-28.5	1:00
			3	43.0717	28.1633	28.5-28	1:03
			4	43.1275	28.2058	28-27	1:00
			5	43.1800	28.2500	28-28.5	1:00
14.06.2025	TBB VL1218	Varna	1	43.1827	28.2562	28-25	1:10
16.06.2025	TBB VL1218	Balchik	1	43.3847	28.1505	11-11	1:00

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			2	43.3446	28.1014	12-11.5	1:00
			3	43.3795	28.1628	12-14	0:50
			4	43.3891	28.2941	12-10.5	1:00
			5	43.3883	28.3679	11.5-13	1:00
17.06.2025a	TBB VL1218	Varna	1	43.1442	28.1858	25-29	1:00
			2	43.1733	28.2567	29-27	1:00
			3	43.2232	28.2950	27-28.5	1:00
			4	43.1750	28.2575	29-27.5	1:00
			5	43.2255	28.3000	27-28	1:00
17.06.2025 b	TBB VL1218	Balchik	1	43.3829	28.1462	11-11.5	1:00
			2	43.3404	28.0966	12-11	1:00
			3	43.3807	28.1496	12-11.5	1:00
			4	43.3439	28.0986	12-11.5	1:00
18.06.2025	TBB VL1218	Varna	1	43.1872	28.2602	28-28	1:05
21.06.2025	TBB VL1218	Balchik	1	43.3850	28.1483	11-11.5	1:30
			2	43.3546	28.1036	11-12	1:30
			3	43.3396	28.0999	13-12	1:00
			4	43.3806	28.1602	11.5-12	1:00
			5	43.3411	28.1022	13-12	1:00
30.06.2025	TBB VL1218	Balchik	1	43.3851	28.1471	10.5-11	1:00
			2	43.3418	28.1008	13-12	1:00
			3	43.3766	28.1478	12-12	0:55
			4	43.3461	28.1007	12-11	1:00
1.07.2025	TBB VL1218	Balchik	1	43.3845	28.1488	11-11	1:00
			2	43.3477	28.0964	12-11	1:10
			3	43.3756	28.1527	12-11	1:00
			4	43.3792	28.1495	12-11	1:30
2.07.2025	TBB VL1218	Kavarna	1	43.3921	28.3323	11-12	1:00
			2	43.3864	28.2916	12-12.5	0:50
			3	43.3798	28.2891	15-13.5	0:55
			4	43.3823	28.3002	13-10.5	1:00
			5	43.3870	28.3594	11-10.5	1:20
3.07.2025 a	TBB VL1218	Balchik	1	43.3840	28.1477	11-11	1:00
			2	43.3392	28.1012	13-12	1:05
			3	43.3773	28.1572	12-20	1:00
			4	43.2983	28.1751	20-20	1:00
3.07.2025 b	TBB VL1218	Kavarna	1	43.3908	28.3350	11-13	0:55
			2	43.3735	28.2680	13-11	1:15
			3	43.3890	28.3037	12-12	1:00
7.07.2025	TBB VL1218	Balchik	1	43.3835	28.1478	11-12	1:00
			2	43.3443	28.1021	13-12	1:00
			3	43.3779	28.1473	12-11.5	1:00
			4	43.3424	28.0976	12.5-13	1:10
11.07.2025	TBB VL1218	Balchik	1	43.3857	28.1460	11-11.5	1:10
			2	43.3389	28.0965	12.5-12	1:05
			3	43.3795	28.1603	12.5-12	1:00
27.07.2025	TBB VL1218	Kavarna	1	43.3458	28.3292	16.5-18	1:10
			2	43.3428	28.4315	19.5-17.5	1:05

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19.08.2025	TBB VL1218	Kavarna	3	43.3503	28.3608	16.5-18	1:05
			4	43.3437	28.3958	16-17.5	1:05
			5	43.3467	28.3420	16.5-17	1:05
			1	43.3400	28.4372	16.5-17	0:50
			2	43.3467	28.4383	16.5-17	1:20
30.08.2025	TBB VL1218	Kavarna	3	43.3485	28.3372	17-17	1:00
			4	43.3380	28.4145	16.5-17.5	1:05
			1	43.2123	28.2284	20-25	1:10
			2	43.2551	28.3035	25-20	1:40
			3	43.1865	28.2120	20-20	1:20
7.09.2025	TBB VL1218	Kavarna	1	43.3921	28.3275	11-12	1:15
			2	43.3789	28.2323	12.5-13	1:00
			3	43.3685	28.1718	14-13.5	1:10
			4	43.3761	28.2740	13.5-12	1:10

Fishing expeditions were concentrated off the central and northern parts of the Bulgarian coast (in the Kalikara–Kamchia area, at depths of 11–28.5 m, with an average time for one trawl of $1.09 \text{ h} \pm 0.02 \text{ SE}$).

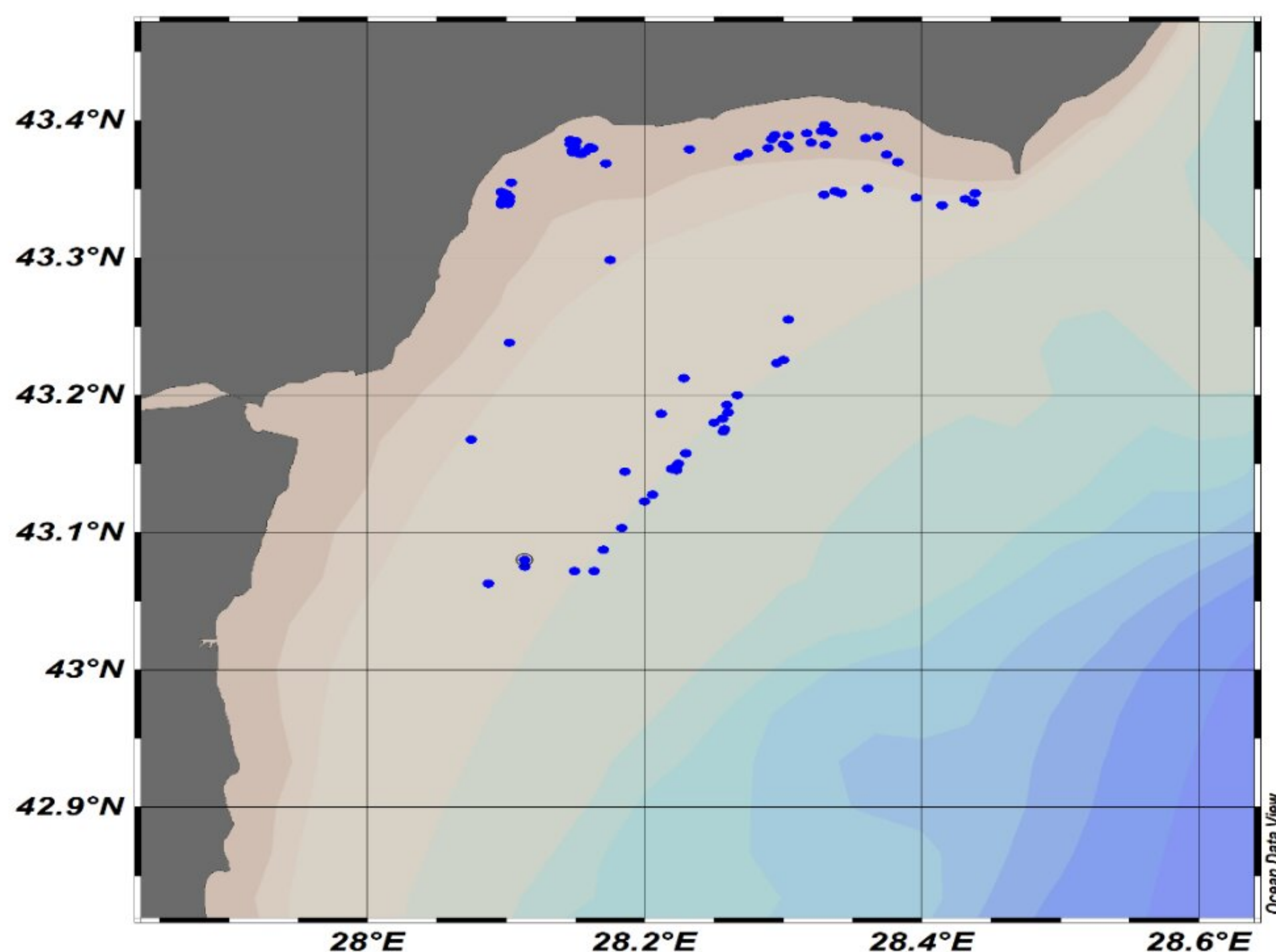


Fig. 6. Map of observed beam trawl fishing expeditions.

2.1.4 Summary of collected Information

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In 2025, the surveys with observers on vessels from the Bulgarian fishing fleet cover 100 fishing days, 30 days on gillnet vessels, 45 days on pelagic trawl vessels, 25 days on beam trawl vessels (Table 7.1).

The observations included 20 fishing vessels belonging to the following fishing segments: DFN VL0006 (1 vessel, 3 fishing days), DFN VL0612 (4 vessels, 27 fishing days), TM VL1218 (4 vessels, 18 fishing days), TBB VL1824 (1 vessel, 8 fishing days), TM VL2440 (4 vessels, 19 fishing days), and TBB VL1218 (5 vessels, 25 fishing days) (Table 7.2).

Table 7.

Summary data on scientific observations of fishing activities (1) and fisheries segments (2) in 2025.

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 observed days per month
III.2025	3			3
IV.2025	12			12
V.2025		20	2	22
VI.2025	4		13	17
VII.2025	6	5	7	18
VIII.2025	1	7	2	10
IX.2025		3	1	4
X.2025		5		5
XI.2025	4	5		9
<i>Total</i>	30	45	25	100

2.

Fishing segment	Number of days	Number of fishing vessels
DFN VL0006	3	1
DFN VL0612	27	4
TM VL1218	18	3
TM VL1824	8	2
TM VL2440	19	4
TBB VL1218	25	5

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Total	100	20
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In the case of fishing with anchored gillnets, the target species is turbot; in beam trawls, the target species is rapa whelk; and in trawling with pelagic trawls, the target species are sprat, red mullet, and horse mackerel.

In spatial terms, the observations covered the entire Bulgarian coast from Durankulak to Sozopol, with gillnet catches being conducted in the area in front of Shabla–Durankulak, pelagic trawl surveys were concentrated in the southern part of the wide Burgas Bay and off the northern coasts, and beam trawls for rapa whelk fishing were concentrated off the northern and central coasts in the Kalikara–Kamchia area.

During the survey, no discards were detected in the marine environment, and bycatch mainly comprised fish, mollusks, and crustaceans.

2.2 Sample processing

The quantities of priority catches and bycatches were measured onboard the fishing vessel, and the species identification of the bycatch organisms was performed. If possible, the absolute and standard lengths and 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 main catch of turbot (a valuable market species), the assessment of sex, age, and gonad maturity stages is not feasible because it would require the formation of a statistically significant sample, compromising the integrity and market value of the specimens. Accordingly, in the bycatch, this species is mostly encountered as small individuals that must be returned alive to the sea in accordance with the Fisheries Act (Law on Fisheries and Aquaculture). Overall, the development of gonads in these immature individuals is difficult to identify, which makes the process challenging, even for specimens that are collected already dead. Therefore, assessing sex, age, and gonadal maturity stages in turbot is not feasible, regardless of whether they are in the main catch or bycatch.

In cartilaginous fish species (Elasmobranchia), sex is determined based on external sexual dimorphism. However, because of the small number of individuals caught during isolated bycatch events, which are often spread across different seasons, it is not possible to form a representative sample. As a result, any analyses of sex composition lack reliability and are, therefore, not included in the report. Additionally, determining age and gonad maturity stages in Elasmobranchia is not feasible in this context, as it would require compromising specimen integrity and affecting market appearance.

Determining the sex, age, and gonad maturity stages of Acipenseridae requires euthanising the specimens. However, according to the Fisheries Act, live individuals must be returned to the water; therefore, these parameters are not applicable to live sturgeon specimens.

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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.

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 and sensitive species, as well as expensive bycatch species, were measured directly on board the fishing vessel. For other bycatch species for which weight and linear dimensions could not be measured directly on board the fishing vessel, samples were collected, labelled, numbered, and frozen for laboratory processing. Under laboratory conditions, the length and weight of the bycatch specimens were determined (Fig. 7), 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 least-squares method and according to the equation $\log W = \log a + b \cdot \log L$, 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 (384 turbot specimens, with a total weight of 947.6 kg) were measured and weighed, and the data were used to create length and weight histograms. Size and weight data covered 100 % of the registered catch.

Data on the main catches of pelagic species in pelagic trawl fisheries: We processed 26 ichthyological samples from the main catches and 168 bycatch samples. Ichthyological samples were randomly collected from the main catch, and each sample contained at least 200 specimens. The size–age structure was analysed using standard methodology. The

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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 each species was analysed using otolith readings under a binocular microscope. The condition factor (K) of the measured fish species was determined individually and distributed according to size class and sex. Length–weight relationships were also estimated.



Fig. 7. Laboratory processing of bycatch samples in 2025.

Microscopic analyses of gonad maturity allow the differentiation of the following stages:

- Stage 1- individuals are sexually immature, with underdeveloped gonads that are not yet functional;
- Stage 2 - gonads begin to differentiate.
- Stage 3 - the fish are fully mature and ready to reproduce, with well-developed gonads filled with gametes.
- After spawning, individuals enter stage 4, in which the gonads shrink and deplete following reproduction.

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- Stage 5 - a resting phase in which the gonads regress and prepare for the next reproductive cycle in relation to the characteristics of seasonal spawning.

The biological parameters related to the von Bertalanffy equation are determined by the formula: $L(a) = L_{\infty}(1 - \exp(-k(a - a_0)))$, 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: We processed 400 rapa whelk specimens (with a total weight of 15.04 kg, 0.1% of the total catch of 16280 kg) from the main catches obtained with beam trawls. For each specimen, we measured the following basic biometric parameters: total mass of the specimen (total weight—weight with the shell, TW, g) and shell length (SL, cm).

The following sources were used for processing and analysing ichthyological samples: Kasapoglu et al., al. (2015); Ozdemir et. al., (2025); Aydin et. al, (2013); Kuzminova et. al, (2014); Banaru et. al, (2017); Kasapoglu et. al, (2016); Carbonara et. al (2025), 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 (60 ind.), sprat (17 ind.), spiny dogfish (8 ind.), and thornback ray (18 ind.). The absolute length (TL, with an accuracy of 0.1 cm) and weight (with an accuracy of 0.01 g) were measured for the specimens. 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 the full and empty stomachs.

To determine the species composition of the food and the number of food objects, 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: $ISF = (Weight\ of\ stomach\ contents / Weight\ of\ fish\ body) \times 100$
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).

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2.4 Analytical methods

General statistical data on the quantity of priority species, bycatch weight, bycatch rate, and 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): $Bycatch (\%) = bycatch / (bycatch + main\ catch) \times 100$. This method was used as an indicator of the impact of different fishing techniques on marine species. The bycatch percentages were calculated based on the weights of the total catch and 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 the total number of fishing days.

To assess 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) ($N = \sum n_{ii}$), 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 following formula: $CV = SD \times A \times 100$, where SD is the standard deviation, and A is the mean value of the respective parameter.

XLSTAT software was used to process the data and display linear/weighted histograms of the 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.



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3. Results

3.1 Fishery with gill nets

3.1.1 Main catch, bycatch, total catch

When analysing gillnet catches, a fishing day is defined as the calendar day on which the vessel collects the catch and completes the landing formalities, thus marking the end of the full cycle of the process (setting the nets, a prolonged soak period in water, and subsequent collection of the catch).

The main catch from the anchored gillnets was turbot (*Scophthalmus maximus*), and the bycatch consisted mainly of black mussels (*Mytilus galloprovincialis*), thornback rays (*Raja clavata*), common stingrays (*Dasyatis pastinaca*), spiny dogfish (*Squalus acanthias*), and rapa whelks (Table 8). The study covered two fishing segments, DFN VL0006 and DFN VL0612; however, as no statistically significant differences in the main catches and bycatch between the segments were found, the analyses below are presented together for both segments.

Table 8

Monthly data on the average quantities of the main catch (*S. maximus*, kg/day) and bycatch (kg/day) in gillnet fisheries in 2025.

Survey period/ number of days at sea (DaS) per month	Main catch - <i>S.</i> <i>maximus</i> (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
		<i>D.</i> <i>pastinaca</i>	<i>S.</i> <i>acanthias</i>	<i>R. clavata</i>	<i>M.</i> <i>galloprovincialis</i>	Other			
II. 2025/3	35.333	5.133	0.000	6.483	7.167	0.000	18.78	54.12	37.12
IV. 2025/12	32.833	0.600	1.267	0.979	5.208	0.025	8.08	40.91	23.00
VI. 2025/4	27.500	0.000	2.863	1.913	2.500	0.000	7.28	34.78	24.95
VII. 2025/6	27.267	1.150	0.533	3.067	3.167	0.000	7.92	35.18	32.70
VIII. 2025/1	24.000	0.000	0.000	0.000	23.000	0.000	23.00	47.00	48.94
XI. 2025/4	37.500	8.600	1.400	1.550	5.875	0.000	14.93	52.43	30.73

The summary statistics from the daily observations on the quantities of catches and bycatches in gillnet fishing are presented in Table 9. For the study period, the average amount of the main catch of *S. maximus* was 31.6 kg/day $\pm$ 3.66 SE (standard error), with an average amount of bycatch of 10.42 kg/day $\pm$ 1.25 SE, weight of the total catch of 42.01 kg/day $\pm$ 3.75 SE, and an average percentage share of bycatch from the total catch of 28.51 % $\pm$ 3.52 SE (Table 9).

Table 9

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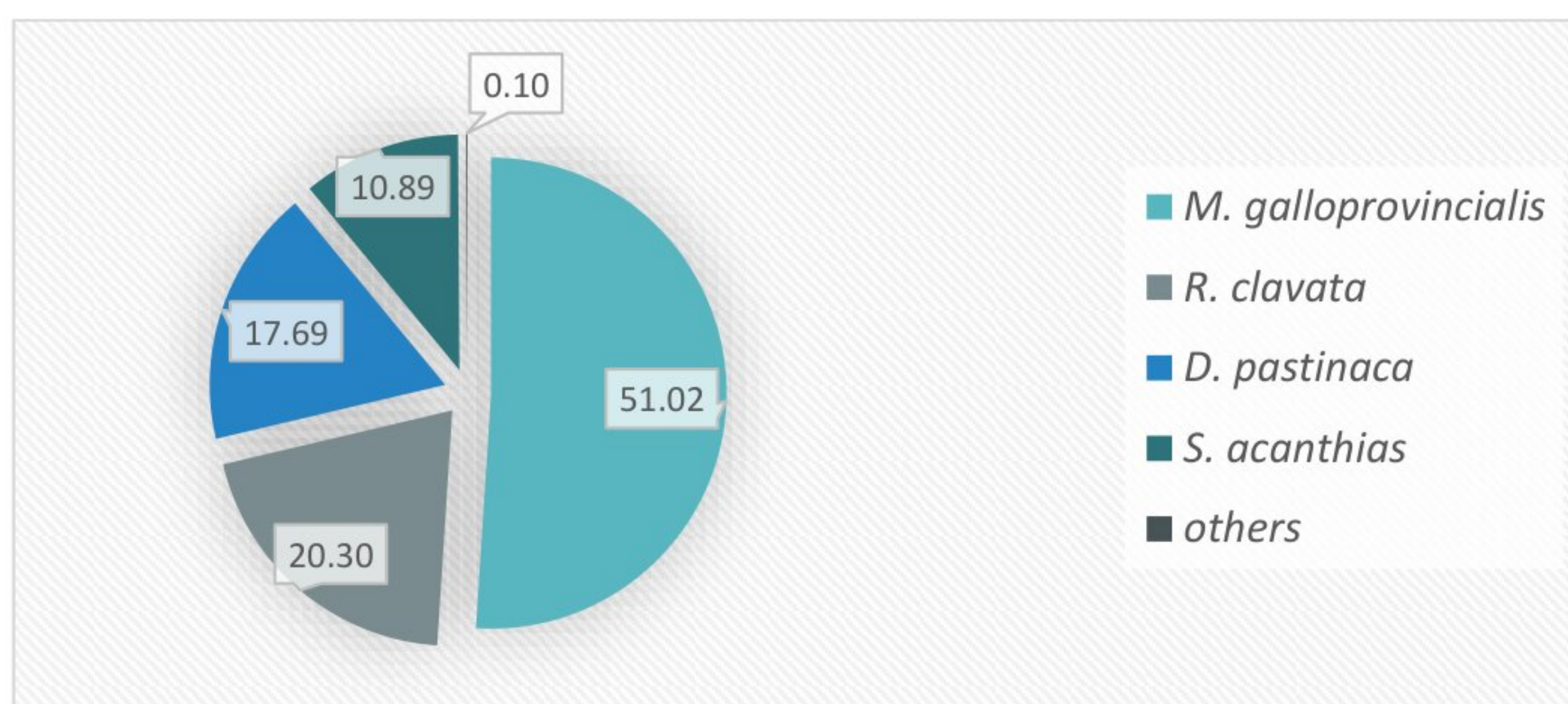


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Summary statistics of the total weight (kg/day) of the main catch of turbot (*S. maximus*), weight of bycatch (kg/day), total weight of catch (catch + bycatch) (kg/day), and percentage share (%) of bycatch based on observations in 2025.

	Main catch (kg/day) <i>S. maximus</i>	Bycatch weight (BC, kg/day))	Total catch weight (TC, catch + bycatch) (kg/day)	BC, % of bycatch of the total catch
Average value	31.59	10.42	42.01	28.51
Standard error	3.66	1.25	3.75	3.52
Median	23.00	9.35	40.98	25.96
Mode	19.00	0.00	#N/A	0.00
Standard deviation	20.02	6.87	20.55	19.26
Sample Variance	400.88	47.23	422.23	371.11
Kurtosis	-0.68	0.07	0.14	-0.87
Skewness	0.73	0.63	0.81	0.26
Minimum	5.00	0.00	10.00	0.00
Maximum	74.00	26.40	91.70	67.95
Sum	947.60	312.60	1260.20	855.27
Number	30.00	30.00	30.00	30.00
Confidence interval (95.0%)	7.48	2.57	7.67	7.19
Coefficient of variation (CV)	63.39	65.95	48.92	67.57

The weight of bycatch in gillnet fishing is formed mainly by black mussel - 51.02%, with the participation of common stingray (*R. clavata*) - 20.3%, thornback ray (*D. pastinaca*) - 17.7%, spiny dogfish, *S. acanthias* - 10.9% (Fig. 8).



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Fig. 8. Percentage participation of bycatch species in the formation of total bycatch weight (kg/day) in gillnet fisheries in 2025.

Fishing with anchored gillnets can result in significant bycatch because large organisms, mainly sensitive species, are caught in the nets. This year, the average bycatch weight was highest in August (23 kg/day) and lowest in June (7.28 kg/day) (Fig. 9).

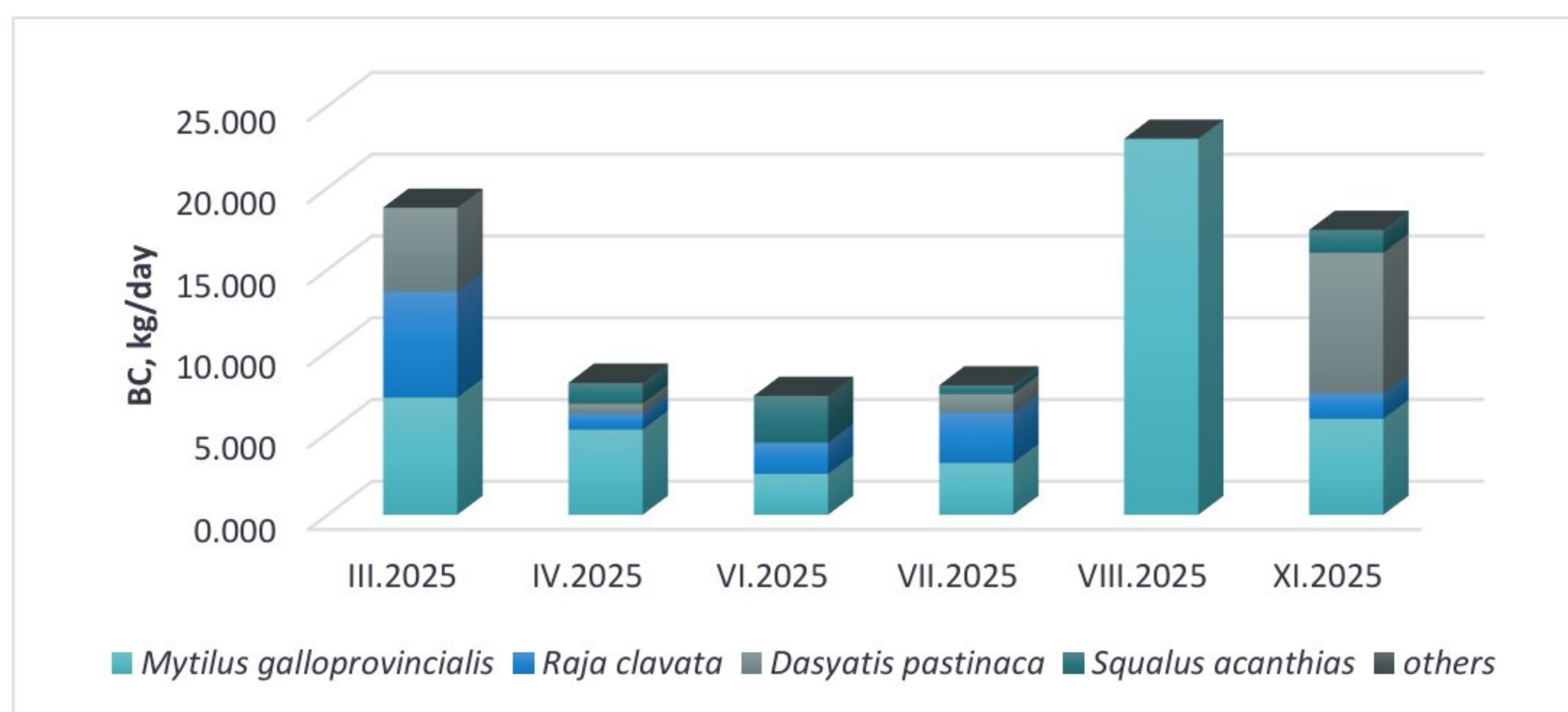


Figure 9. Average monthly data on the composition and weight of bycatch (kg/day) in gill net fishing in 2025.

Based on the percentage share of individual species forming the bycatch weight by month, distinct seasonal patterns in bycatch species composition in gill net fishing can be distinguished. *M. galloprovincialis* was present throughout the monitoring period, dominating the bycatch in August (100% BCW) and showing elevated levels in April (64.47% BCW, Fig. 10).



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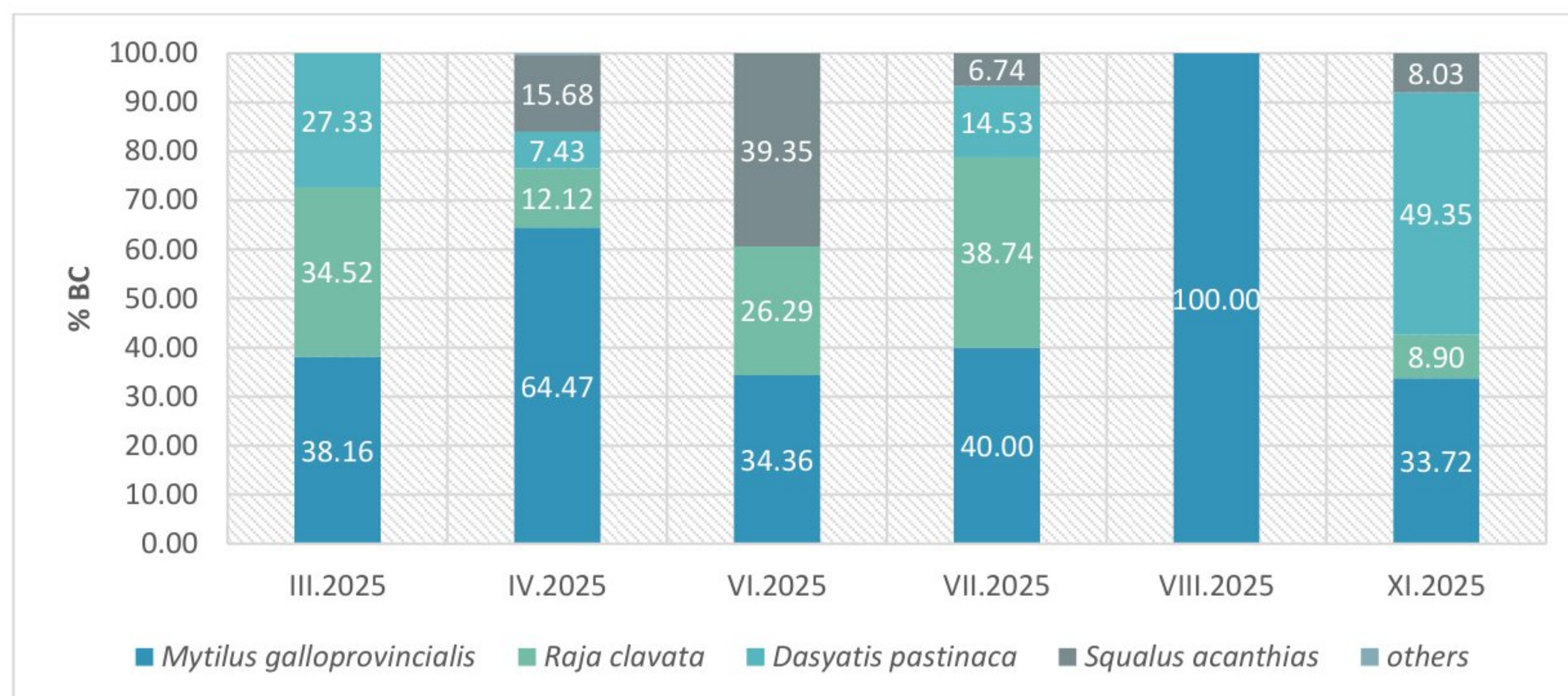


Figure 10. Monthly dynamics of bycatch species composition (% in the formation of bycatch weight, BC, kg/day) in gill net fishing in 2025.

Among the sensitive elasmobranch species, *R. clavata* demonstrated a relatively stable presence in the bycatch weight from March to July (26.29–38.74% BCW), with the highest share in July. *S. acanthias* peaked in June (39.35% BCW), but the species' presence was minimal or absent in other months. *D. pastinaca* showed pronounced seasonal variations, with minimal presence in the bycatch during spring and summer months, but reaching a maximum in November (49.35% BCW).

3.1.2 Dynamics of biological parameters

A total of 364 specimens of the main turbot catch were measured, with a mean size of 53.262 cm $\pm$ 8.31 SD and a mean weight of 2468.59 g TW $\pm$ 598.57 SD (Fig. 11).

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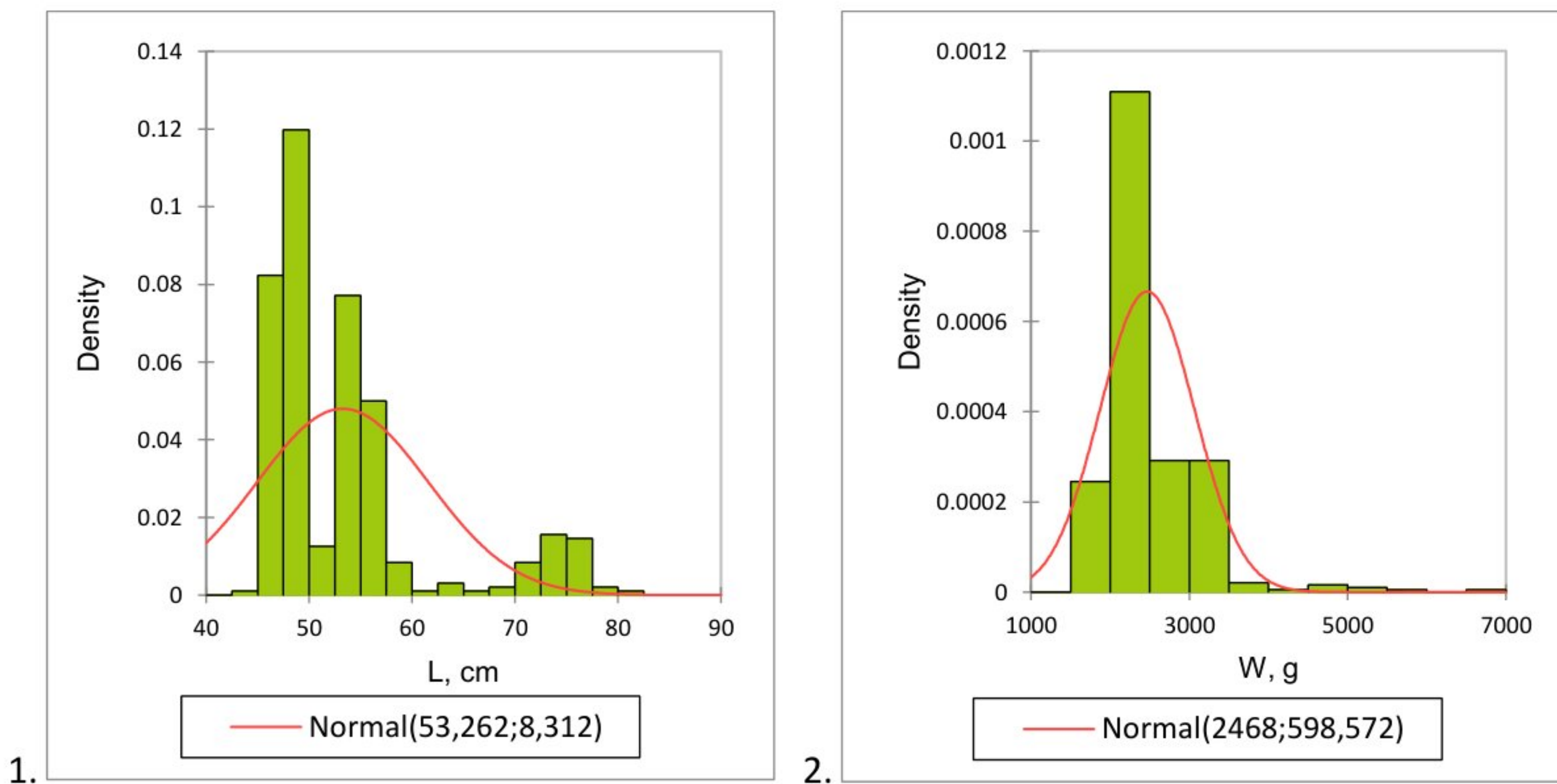


Fig. 11. Distribution of *S. maximus* by class according to absolute length (L, cm, 1) and individual weight (W, g, 2) in 2025.

The most significant size group in the catches was 45–50 cm, which comprised 50.52% of the measured turbot specimens. Accordingly, the 2000–2500 g weight group played a leading role in the catch, with 55.5% of the measured turbot specimens (Table 10).

Table 10

Statistics of the distribution of turbot weight classes (g) for 2025.

Lower limit	Upper limit	Frequency	Relative frequency	Density
1500.000	2000.000	47.0	0.122	0.164
2000.000	2500.000	213.0	0.555	0.304
2500.000	3000.000	56.0	0.146	0.292
3000.000	3500.000	56.0	0.146	0.145
3500.000	4000.000	4.0	0.010	0.037
4000.000	4500.000	1.0	0.003	0.005
4500.000	5000.000	3.0	0.008	0.000
5000.000	5500.000	2.0	0.005	0.000
5500.000	6000.000	1.0	0.003	0.000
6500.000	7000.000	1.0	0.003	0.000

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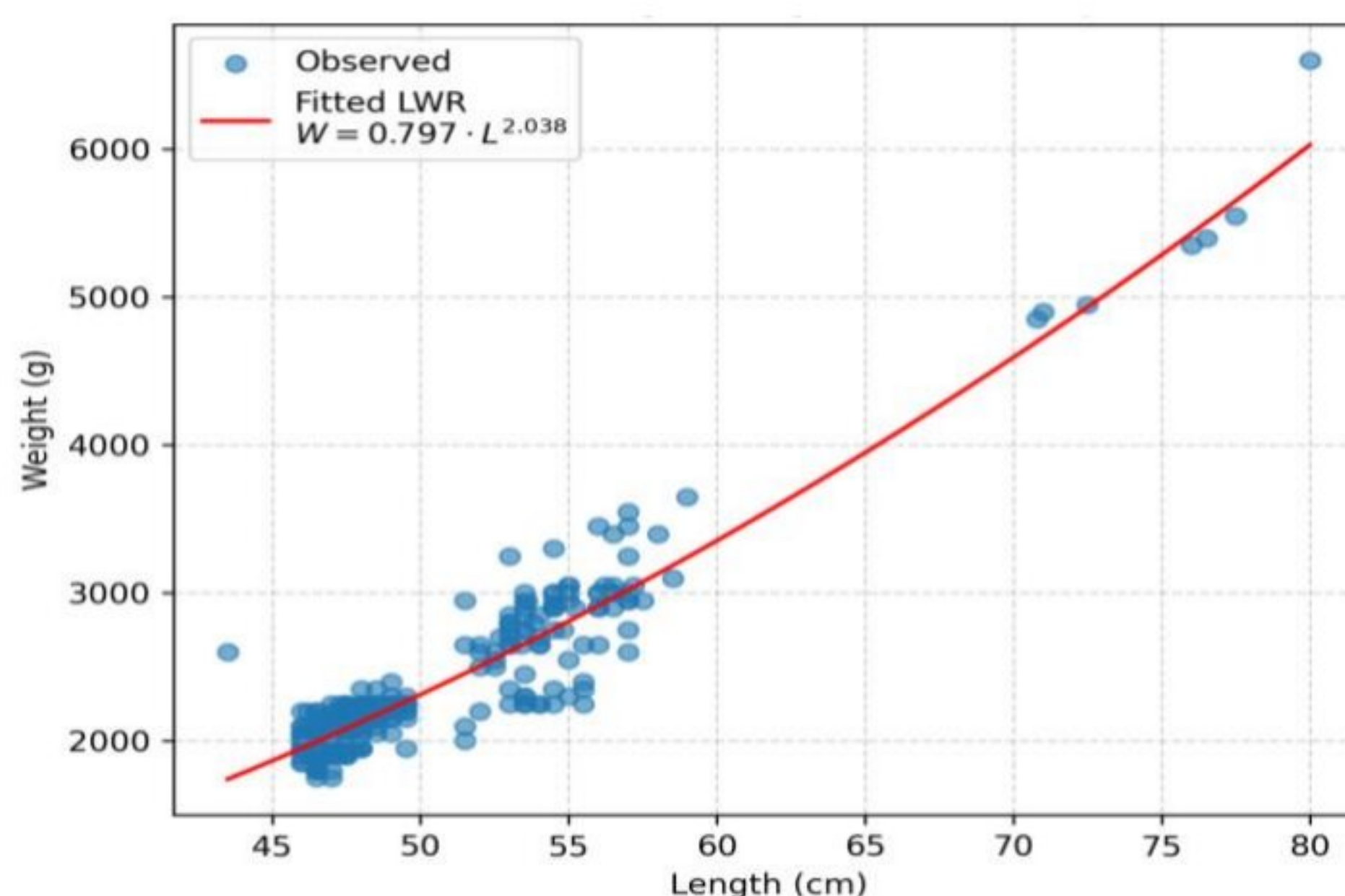


Fig. 12. Length–weight relationship of turbot in 2025.

The length-weight relationship in turbot is described as: $W=0.797 \cdot L^{2.038}$ ($R^2=0.857$), Fig. 12. The coefficient $b=2.04$ indicates negative allometry, which may reflect regional morphological adaptations or seasonal variations in the condition of the specimens. While typical coefficients in turbot range from 2.9 to 3.2 (Tserkova et al., 2023), lower values have been documented in stressed or isolated populations.

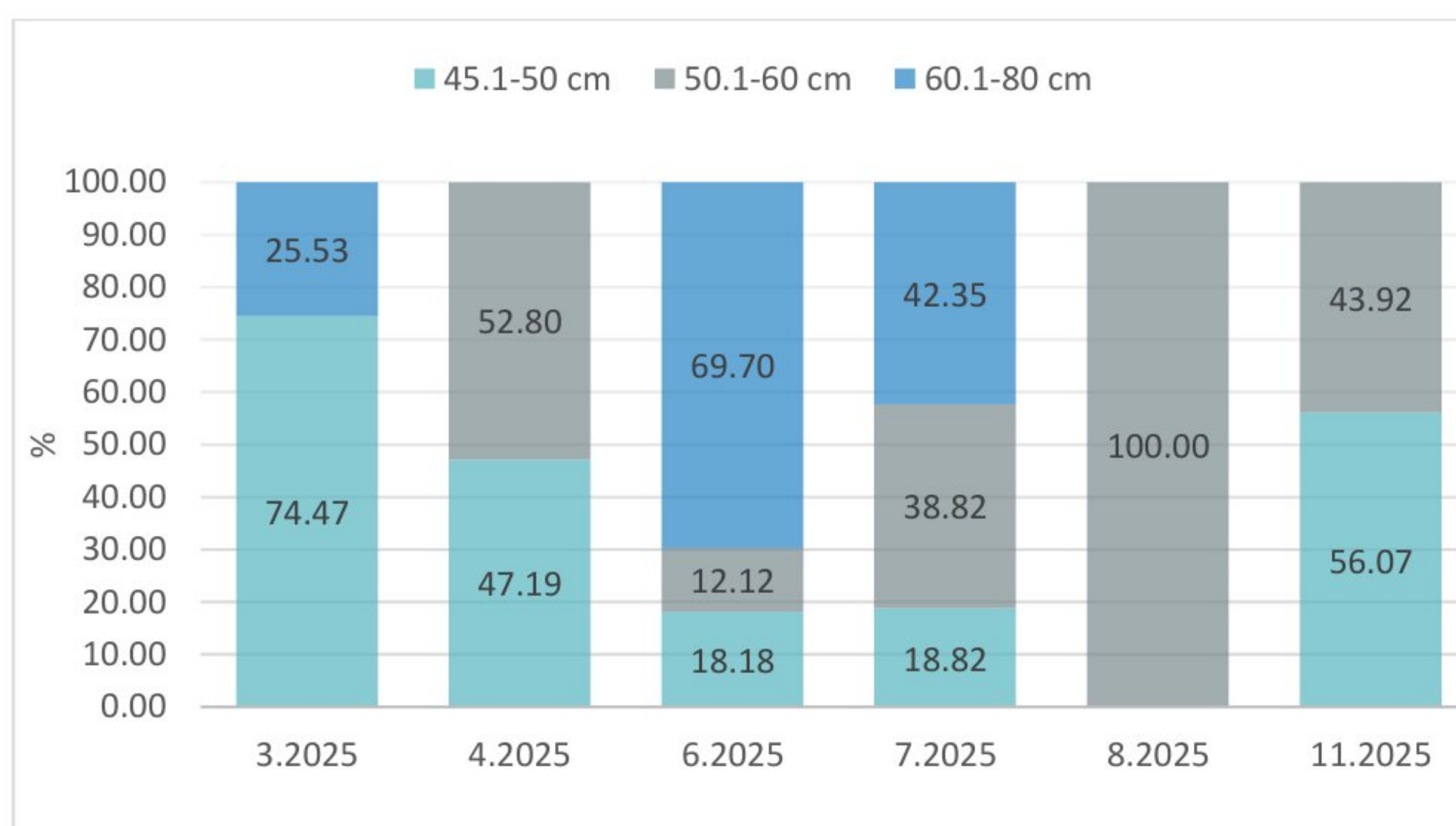


Figure 13. Monthly fluctuations of the main size classes of turbot (*S. maximus*) - 45.1-50 cm, 50.1-60 cm, and 60.1-80 cm (% of the total quantity in the catch)) in the gillnet fishery in 2025.

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Analysing the monthly dynamics of the biological parameters of the main turbot catch, we found that the specimens with the smallest individual sizes (45.1–50 cm) formed a maximum in spring and autumn, whereas in summer, the proportion of large specimens in the catch increased (Fig. 13).

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

Data on sensitive species, including the total number of individuals caught, average weight, and average size in gillnet bycatch, are presented in Table 11. All sensitive species caught (43 individuals) were dead when removed from the nets. During the study period, the highest bycatch rate was recorded for thornback rays, with $T = 0.87$ ind/day.

Table 11

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 2025.

Bycatch species	IUCN status	Total number	Bycatch coefficient (ind/day)	Mean length (cm)	Mean weight (g)
<i>Dasyatis pastinaca</i>	VU (Vulnerable)	8	0.27	73.21	6733.33
<i>Raja clavata</i>	NT Near threatened)	26	0.87	73.52	2517.31
<i>Squalus acanthias</i>	EN (Endangered)	9	0.3	124.11	3783.33

The bycatch coefficient of thornback rays increased in March (2.7 ind/day), that of common stingrays in March-November (0.7 -1 ind/day), and that of spiny dogfish in April - June (Fig. 14, Table 12).

The mean length and weight of the three elasmobranch species (*Raja clavata*, *Dasyatis pastinaca*, and *Squalus acanthias*) showed different patterns of variability during the study period. *R. clavata* demonstrated the most stable mean length, varying within narrow limits between 74.13 and 75.0 cm (variability <1%), indicating that the bycatch consistently comprised a similar size class of adult individuals. *D. pastinaca* exhibited low variability in mean length (71.5–74.25 cm) but greater fluctuations in mean weight (6450–7700 g) i. e. the collected specimens were consistently

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large adults. *S. acanthias* demonstrated the highest variability in both mean length (122–135 cm) and mean weight (3200–4200 g). This wider range may reflect the catch of several size classes, seasonal migration of different age groups, and ontogenetic changes in habitat use.

Table 12

Monthly data on the bycatch of sensitive species, total number of specimens caught by species, bycatch coefficient, mean size (cm), and mean weight (g) in the gillnet fishery in 2025.

month	Bycatch species	Total number	Monthly bycatch coefficient (ind/day)	Mean length (cm)	Mean weight (g)
III.2025	<i>Raja clavata</i>	8	2.7	74.3	2431
	<i>Dasyatis pastinaca</i>	2	0.7	74.25	7700
IV.2025	<i>Raja clavata</i>	5	0.42	74.13	2350
	<i>Dasyatis pastinaca</i>	1	0.08	72.5	7200
	<i>Squalus acanthias</i>	4	0.33	122	3800
VI.2025	<i>Raja clavata</i>	3	0.75	74.63	2550
	<i>Squalus acanthias</i>	3	0.75	122.5	3817
VII.2025	<i>Raja clavata</i>	7	1.17	74.48	2629
	<i>Dasyatis pastinaca</i>	1	0.17	71.5	6900
	<i>Squalus acanthias</i>	1	0.17	125	3200
XI.2025	<i>Raja clavata</i>	3	0.75	75	2067
	<i>Dasyatis pastinaca</i>	4	1	73.42	6450
	<i>Squalus acanthias</i>	1	0.25	135	4200

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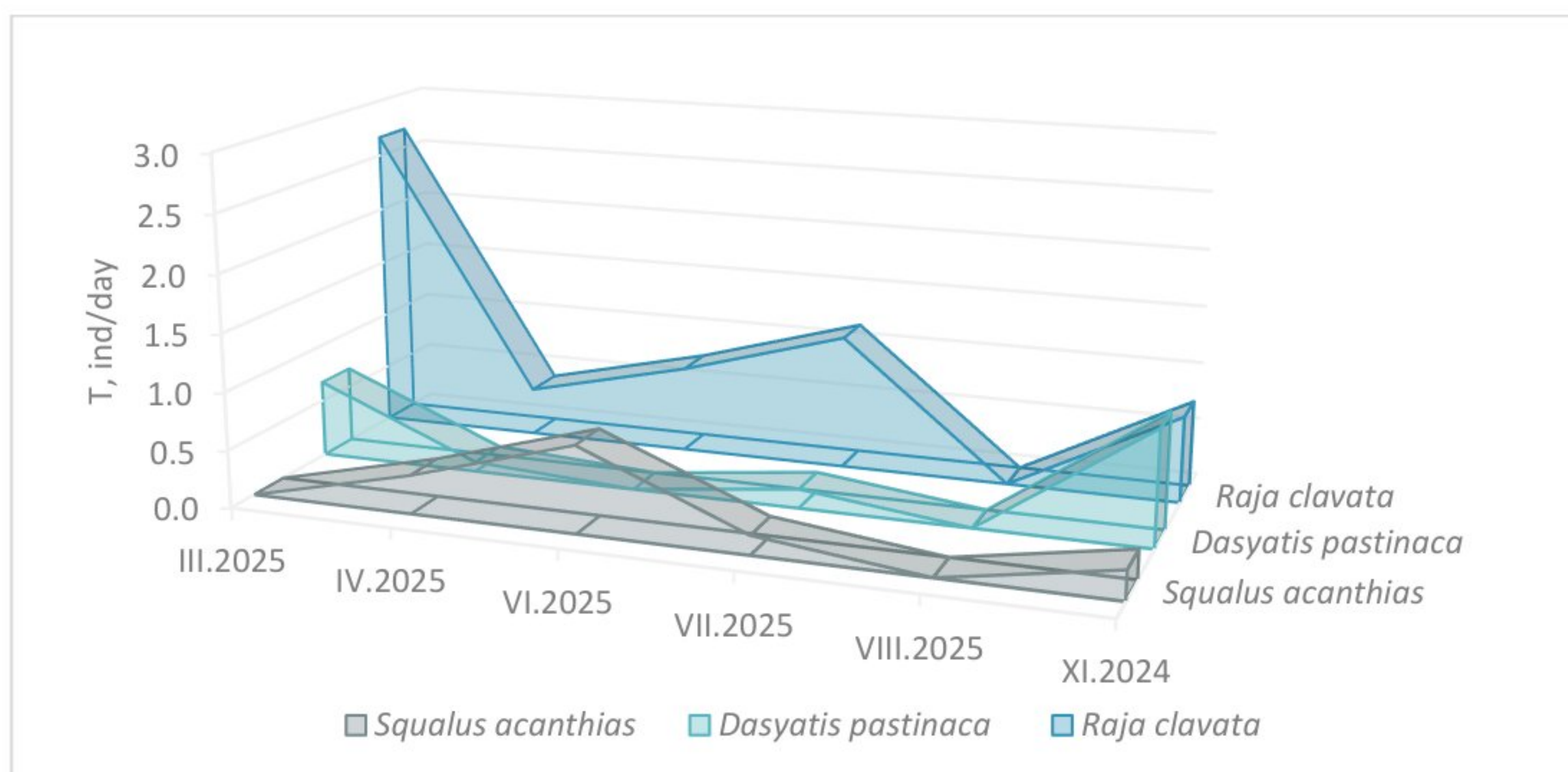


Fig. 14. Monthly fluctuations in the bycatch ratio (T , ind/day) of sensitive species in gillnet fisheries in 2025.

The bycatch of sensitive species by fishing segments is presented in Table 13. The highest number of sensitive species (41 specimens) was recorded in the DFN VL01612 segment.

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) by fishing segments (gillnet fisheries) in 2025.

1. DFN VL0006

Bycatch species	IUCN status	Total number	Bycatch coefficient (ind/day)	Mean length (cm)	Mean weight (g)
<i>Raja clavata</i>	NT (Near threatened)	2	0.67	78	3650

2. DFN VL0612

Bycatch species	IUCN status	Total number	Bycatch coefficient (ind/day)	Mean length (cm)	Mean weight (g)
<i>Raja clavata</i>	NT (Near threatened)	24	0.89	73.86	2339.58

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<i>Dasyatis pastinaca</i>	VU (Vulnerable)	8	0.30	73.02	6912.5
<i>Squalus acanthias</i>	EN (Endangered)	9	0.33	124.43	3783.33

3.2 Fishery with pelagic trawls

3.2.1 Summary data: main catch, bycatch, total catch

In 2025, surveys on pelagic trawl fishing covered both the sprat (*Sprattus sprattus*) fishery and mixed catches of horse mackerel (*Trachurus mediterraneus*) and red mullet (*Mullus barbatus*). The daily target catch reached an average of 1269.92 kg/day $\pm$ 220.40 SE, while bycatch quantities of fish and crustaceans ranged between 0.23–544.37 kg/day. The average bycatch of gelatinous zooplankton (*Aurelia aurita*) was 20.45 kg/day $\pm$ 9.49 SE. The percentage contribution of total bycatch from all marine organisms was moderate (17.97% TC $\pm$ 3.02 SE) (Table 14).

Table 14

Summary statistics of the quantities of main catch (kg/day), bycatch of fish and crustaceans (BC₁, kg/day), gelatinous zooplankton (BC₂, kg/day), total catch (catch + bycatch, kg/day), and percentage share of bycatch (% BC₃ = BC₁+BC₂) of the total pelagic trawl catch in 2025.

	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	1269.92	48.63	20.45	1339.01	17.97
Standard error	220.40	15.17	9.49	216.44	3.02
Median	426.00	10.81	5.60	672.21	15.69
Standard deviation	1478.48	101.76	63.67	1451.89	20.29
Kurtosis	0.82	14.56	37.28	0.81	2.65
Skewness	1.29	3.64	5.92	1.27	1.42
Sample variance	5592.00	544.13	420.00	5578.03	91.89
Minimum	8.00	0.23	0.00	23.35	0.01
Maximum	5600.00	544.37	420.00	5601.38	91.90
Number	45.00	45.00	45.00	45.00	45.00

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Confidence interval (95.0%)	444.18	30.57	19.13	436.20	6.09
Coefficient of variation (CV)	85.89	47.79	32.13	92.22	88.59

Statistical data by fishing segment are presented in Table 15 and show higher catches in the segment of the largest vessels (targeting sprat), whereas bycatch in this segment was the lowest.

Table 15

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 bycatch (BC3) by fishing segment with OTM in 2025.

1. TM VL1218

	Main catch (kg/day)	Bycatch weight (BC 1, kg/day)	Jellyfish bycatch (BC2, kg/day)	Total catch (catch + bycatch) (kg/day)	BC₃ = BC₁+BC₂ (% of total catch)
Average value	270.42	84.54	12.35	367.30	29.44
Standard error	83.34	30.77	3.59	90.30	3.69
Median	137.00	35.72	6.25	204.50	28.91
Standard deviation	353.60	130.57	15.21	383.11	15.66
Kurtosis	13.20	10.35	-0.31	6.04	-0.67
Skewness	3.46	3.10	0.98	2.38	0.02
Sample variance	1558.00	549.46	45.00	1519.16	58.14
Minimum	42.00	1.66	0.00	82.50	0.10
Maximum	1600.00	551.12	45.00	1601.66	58.24
Number	18.00	18.00	18.00	18.00	18.00
Confidence interval (95.0%)	175.84	64.93	7.56	190.52	7.79
Coefficient of variation (CV)	76.48	64.75	81.18	95.87	188.06

2. TM VL1824

	Main catch (kg/day)	Bycatch weight (BC 1, kg/day)	Jellyfish bycatch (BC2, kg/day)	Total catch (catch + bycatch) (kg/day)	BC₃ = BC₁+BC₂ (% of total catch)
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Average value	285.25	125.86	22.30	433.41	44.75
Standard error	105.91	39.31	12.07	126.85	8.66
Median	212.50	104.52	13.20	319.75	43.75
Standard deviation	299.56	111.19	34.15	358.79	24.50
Kurtosis	1.48	4.53	7.02	-1.31	1.66
Skewness	1.28	1.92	2.59	0.54	0.94
Sample variance	882.50	365.83	105.00	984.16	81.59
Minimum	8.00	11.35	0.00	25.35	11.79
Maximum	890.50	377.19	105.00	1009.51	93.38
Number	8.00	8.00	8.00	8.00	8.00
Confidence interval (95.0%)	250.44	92.96	28.55	299.95	20.49
Coefficient of variation (CV)	95.22	113.19	65.31	120.80	182.64

3. TM VL2440

	Main catch (kg/day)	Bycatch weight (BC 1, kg/day)	Jellyfish bycatch (BC2, kg/day)	Total catch (catch + bycatch) (kg/day)	BC₃ = BC₁+BC₂ (% of total catch)
Average value	2631.42	30.54	27.36	2689.32	2.46
Standard error	308.11	21.75	21.91	303.51	1.59
Median	2325.00	5.83	1.00	2520.31	0.44
Standard deviation	1343.03	94.83	95.49	1322.98	6.91
Kurtosis	-0.30	18.64	18.62	-0.27	17.70
Skewness	0.66	4.30	4.30	0.58	4.16
Sample variance	5012.00	419.99	420.00	5001.95	30.57
Minimum	588.00	0.57	0.00	599.43	0.01
Maximum	5600.00	420.56	420.00	5601.38	30.58
Number	19.00	19.00	19.00	19.00	19.00
Confidence interval (95.0%)	647.32	45.70	46.03	637.66	3.33
Coefficient of variation (CV)	195.93	32.21	28.65	203.28	35.65

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During the study period, 57 marine species were recorded as bycatch in the pelagic trawls. On average, approximately 13 species were found per fishing day.

The dominant species by weight in the bycatch were whiting (*M. merlangus*) and *Aurelia aurita*, with respective shares of 23% and 21% (Fig. 15). In smaller quantities, the following species were caught: black mussel (5%), turbot (3.3%), small-sized horse mackerel (3.57%), bluefish (2.9%), tub gurnard (1.56%), common stingray (1.54%), while all other species each contributed less than 1.5 % to the average bycatch weight.

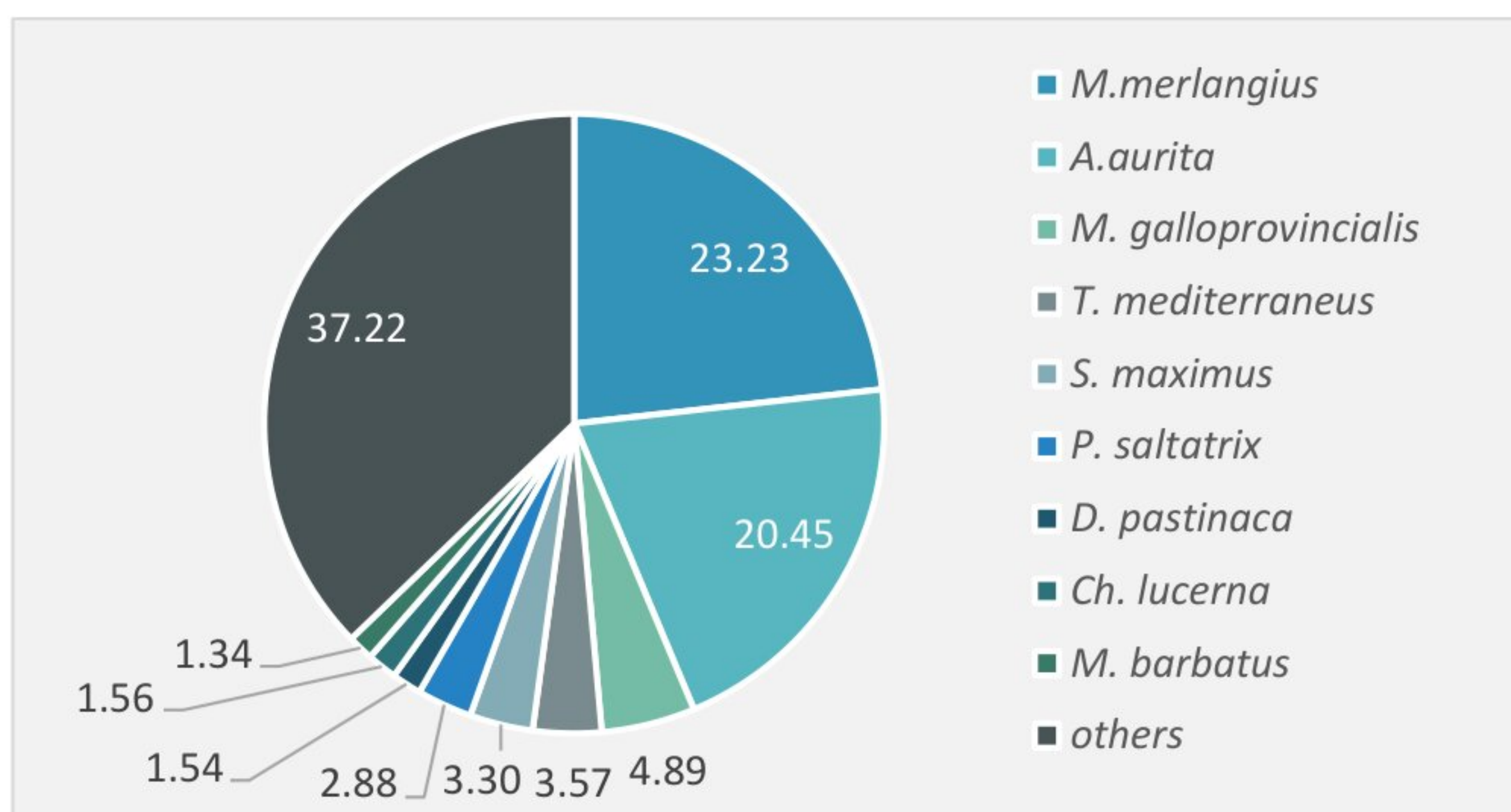


Fig. 15. Percentage participation of the dominant species in the formation of the average weight of the bycatch (kg/day) in pelagic trawl fishing in 2025

In pelagic trawl fishing, the average bycatch was maximum (394.52 kg/day) in September 2025, with a dominant presence of whiting (Table 16).

Table 16

Quantities of catch (kg/day) and bycatch (kg/day) of marine organisms in pelagic trawl fisheries by month in 2025.

Period	Mean weight of the main catch (kg/day)	Mean bycatch weight by species (kg/day)							Bycatch weight, BC1 (kg/day)	Total catch TC (kg/day)	% BC of total catch
		Moon jellyfish	Whiting	Horse mackerel (small sized)	Blue fish (small sized)	Turbot	Common stingray	Others			
5. 2025	2579.9 (sprat)	25.99	0.58	0.05	0.00	1.47	0.00	1.01	29.1	2609.00	1.12

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7. 2025	143.8 (mixed catch)	0.02	0.02	0.35	0.00	18.52	0.00	13.72	32.63	176.43	18.49
8. 2025	102.1 (mixed catch)	22.59	2.77	0.67	0.08	0.56	5.65	16.11	48.43	150.53	32.17
9. 2025	383.8 (mixed catch)	12.58	270. 89	5.38	4.03	0.42	8.59	92.63	394.52	778.32	50.69
10. 2025	366.0 (mixed catch)	32.80	27.9 1	12.48	9.70	2.27	0.00	17.49	102.65	468.65	21.90
11. 2025	226.8 (mixed catch)	8.13	12.4 7	14.94	13.70	2.02	0.82	13.51	65.59	292.39	22.43

A pronounced seasonal dynamic was observed in the species composition, contributing to the average monthly bycatch weight. The moon jellyfish (*Aurelia aurita*) shows a distinct spring peak in its contribution to the bycatch weight (Fig. 16). Turbot exhibited a summer maximum contribution to the average monthly bycatch weight (57 % BCW). Among sensitive chondrichthyan fish species, the common stingray dominates, showing its highest share in the bycatch weight during August (~12% BCW) (Fig. 16).

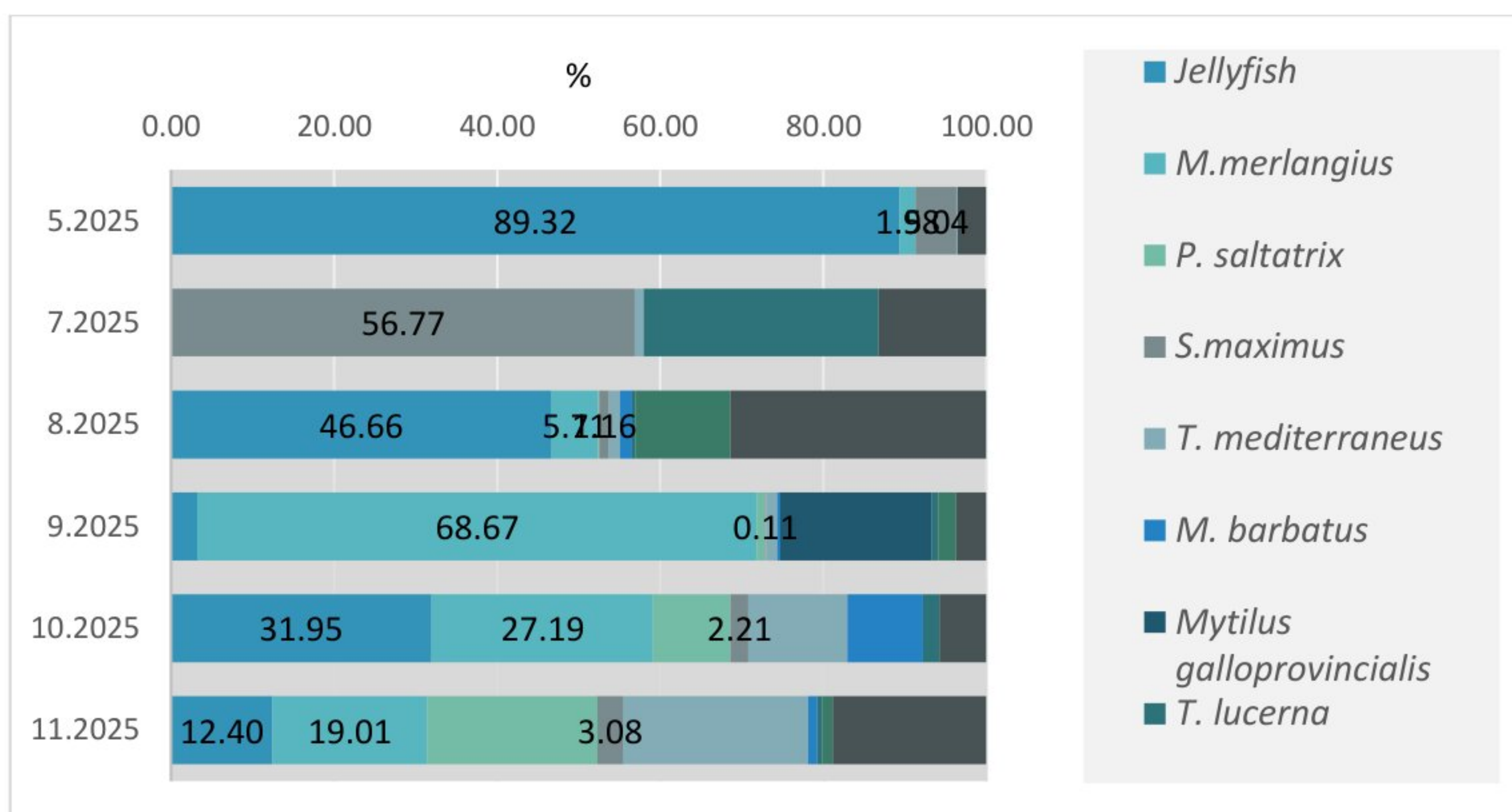


Figure 16. Percentage composition of bycatch (% of total bycatch by species) in the sprat fishery per month in 2025.

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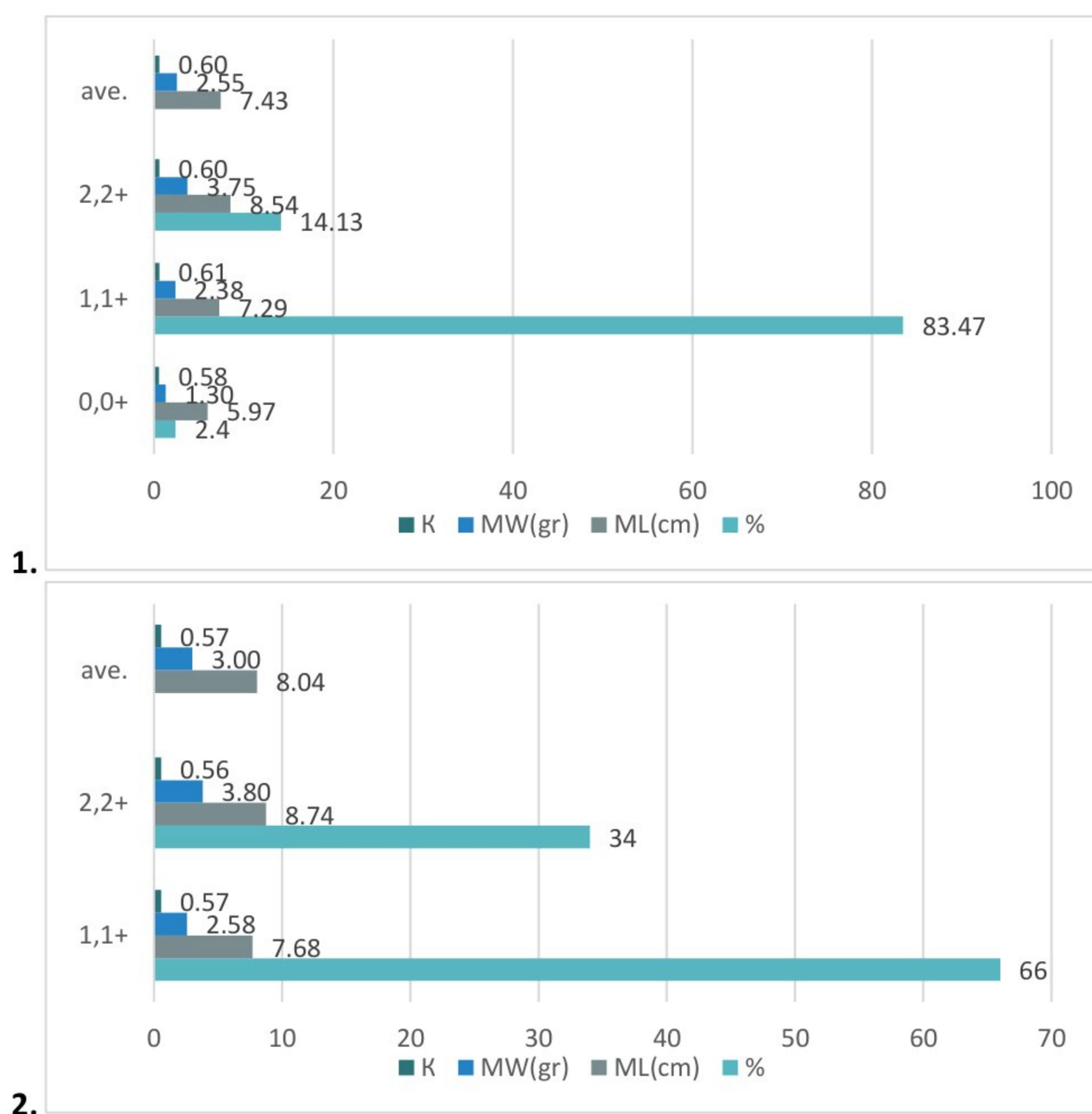
3.2.2. Dynamics of biological parameters

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

During the first and second halves of 2025, one-year-old sprat specimens dominated at 83.47% (May) and 66% (September), followed by two-year-old specimens at 14.13% and 34%, respectively.

Specimens with sizes between 5.5 and 10.6 cm were recorded in the target catch, with mean lengths of 7.43–8.04 cm and mean weights of 2.6–3.00 g. The mean condition factor values varied between 0.56-0.60 among the different age groups (Fig. 17).

Female and male specimens showed similar proportions of 49% and 46%, respectively, followed by 3% of sexually unidentified juvenile specimens.



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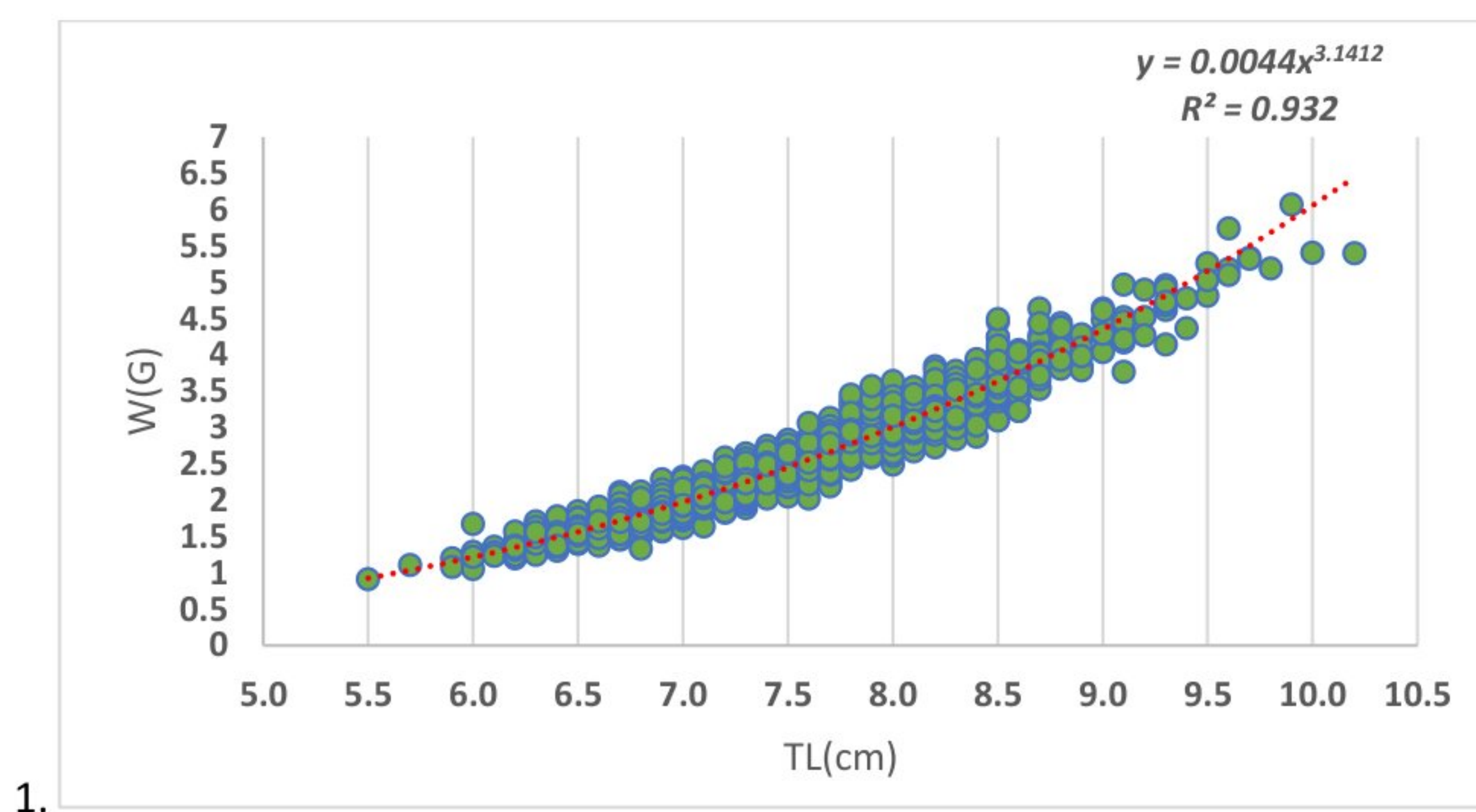
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Figure 17. *Sprattus sprattus*: age structure (%), mean size, mean weight, and condition factor by age group and average for the following periods: (1) spring 2025, and (2) autumn 2025.

During spring, individuals from age group 0,0+ (2.4%) were in Stage 1, sexually immature. Representatives of group 1,1+ (83.47%) were in Stage 3, fully mature and ready for reproduction, with well-developed gonads, as the spring season is the active phase of the winter-spring reproductive cycle of sprat. Individuals from group 2,2+ (14.13%) were in transition between Stage 3 and Stage 4; some of them were still participating in reproduction, while others had already entered the post-reproductive stage with depleted gonads after spawning. The condition index ($K = 0.60$) reflects energy investment in reproduction.

During autumn, sprat transition from an active feeding regime to preparation for winter reproduction. Group 1,1+ (66%) was in stage 2, indicating that the gonads had begun to differentiate and develop in preparation for the upcoming reproductive season. Individuals from group 2,2+ (34%) showed more advanced maturity (Stages 2–3), as older fish began earlier preparation for spawning. The condition index ($K = 0.57$) reflects the accumulation of energy reserves after the summer feeding period, which is used for reproduction during late autumn and winter.

The parameter values in the von Bertalanffy equation during spring 2025 were $a = 0.0044$, $b = 3.14$, $L_{\infty} = 10.74$ cm, and during autumn: $a = 0.0029$, $b = 3.29$, $L_{\infty} = 11.15$ cm (Fig. 18).



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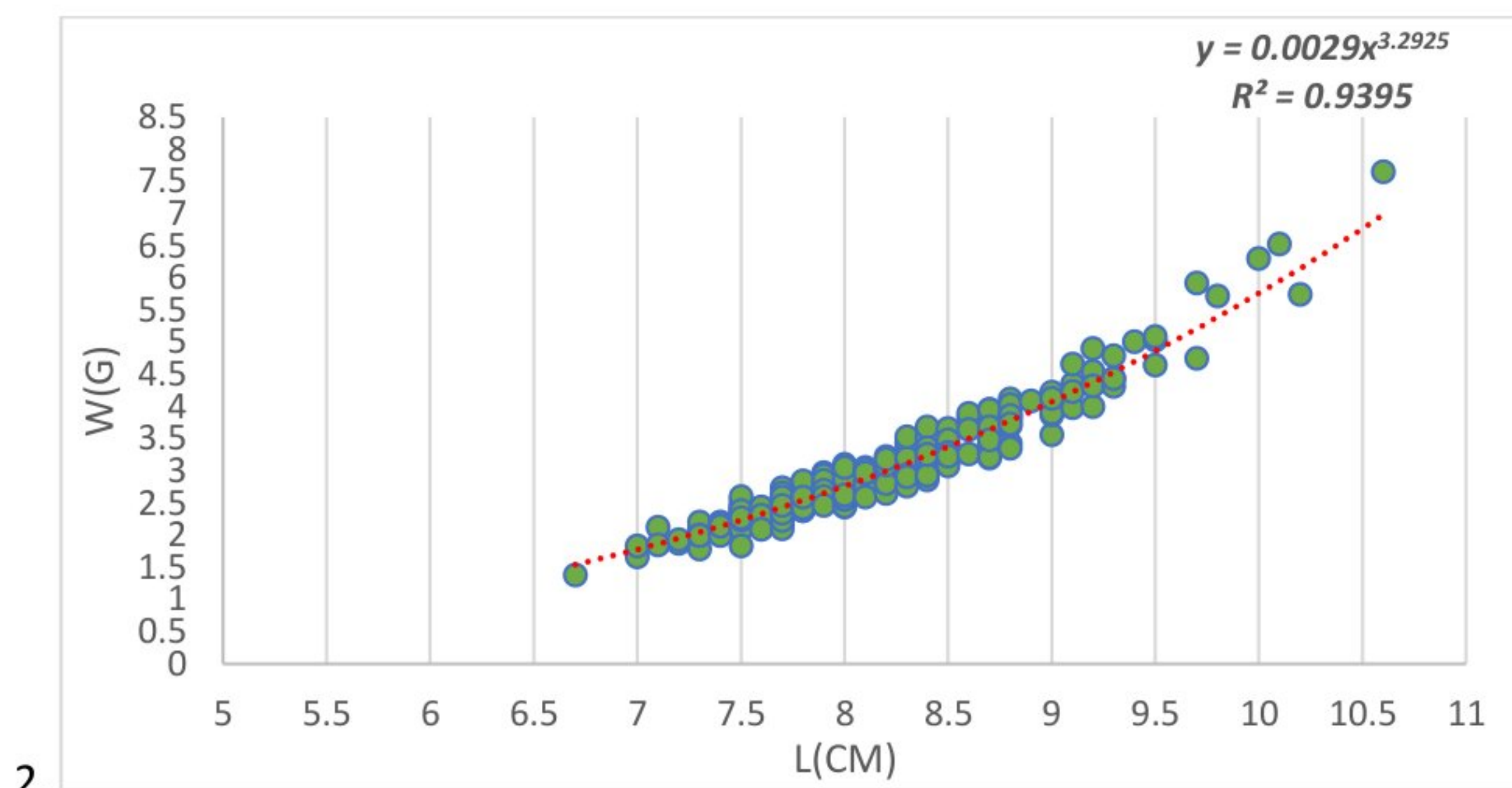


Fig. 18. Length–weight relationship (LWR) of *S. sprattus* in (1) spring 2025 and (2) autumn 2025.

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

One-year-old red mullet specimens dominated the catches, accounting for 65.9% during July-August and 68.6% during September and November. The next most numerous age group was two-year-old individuals, representing 29.3% of the catch during the summer period and 26.8% during autumn. During autumn, single specimens of older age groups, namely, three-year-old individuals, were also recorded. Zero-year-old specimens were not found in the samples, which is likely due to the selectivity of the fishing gear used. A strong dominance of female specimens was observed in the catches (75 %), whereas the proportion of male specimens was 25%.

In the target catch, individuals with body lengths in the range of 7.5–16.5 cm were recorded, with mean length values varying between 10.4 cm and 11.4 cm. The mean individual weight of the studied specimens was within the range of 11.0–16.5 g. The mean condition factor values varied between 0.90 and 1.11 (Fig. 19).

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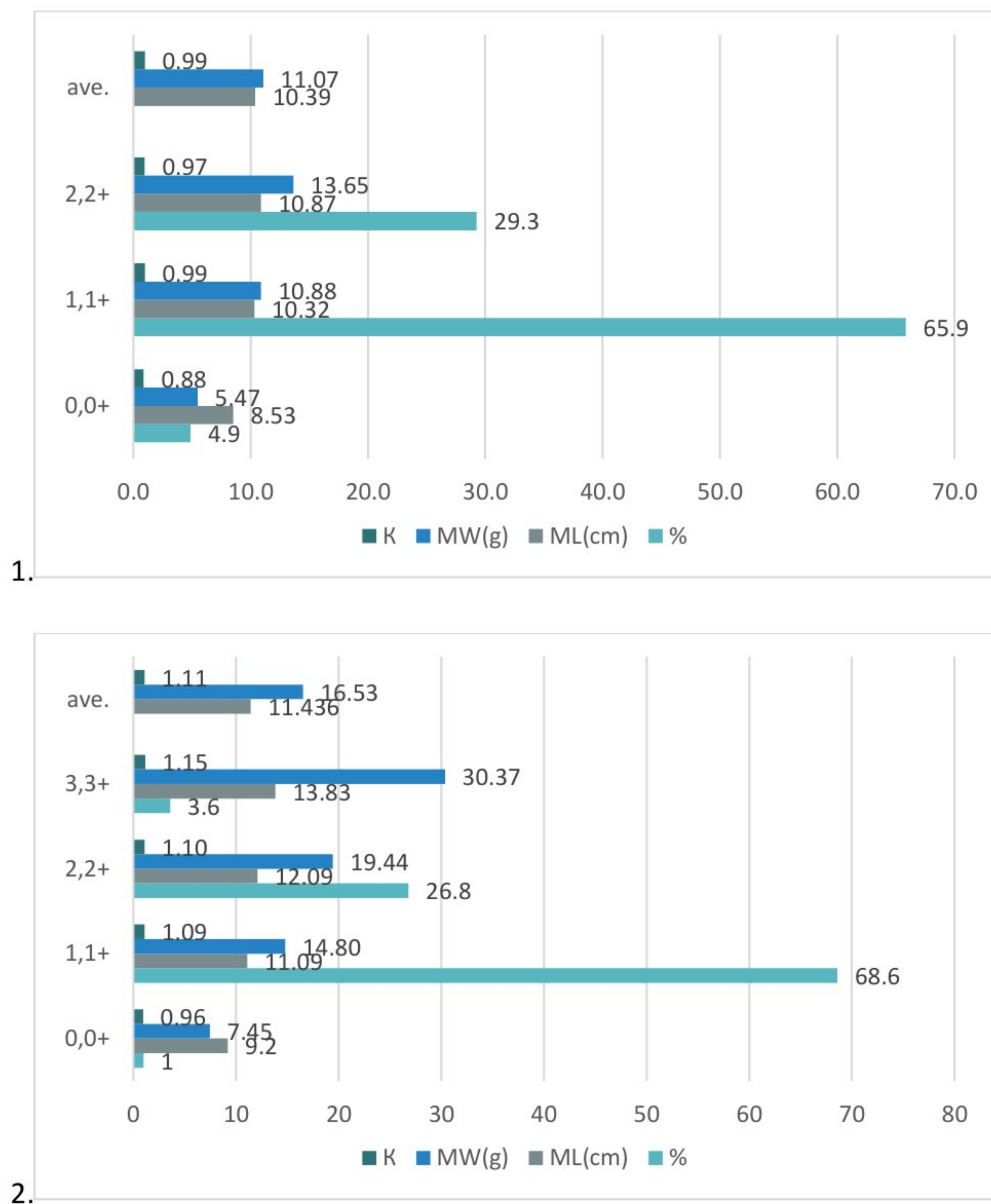


Fig. 19. *Mullus barbatus ponticus* - age structure (%), average size, average weight, and condition factor by age groups and average for the period: (1) summer 2025 and (2) autumn 2025.

During summer, individuals from age group 0,0+ (9.87%) were in Stage 1 - sexually immature. Representatives of groups 1,1+ (21.80%) and 2,2+ (29.01%) were in Stage 2–3, with differentiated gonads. Older individuals from groups 3,3+ (27.54%) and 4,4+ (8.84%) were in Stage

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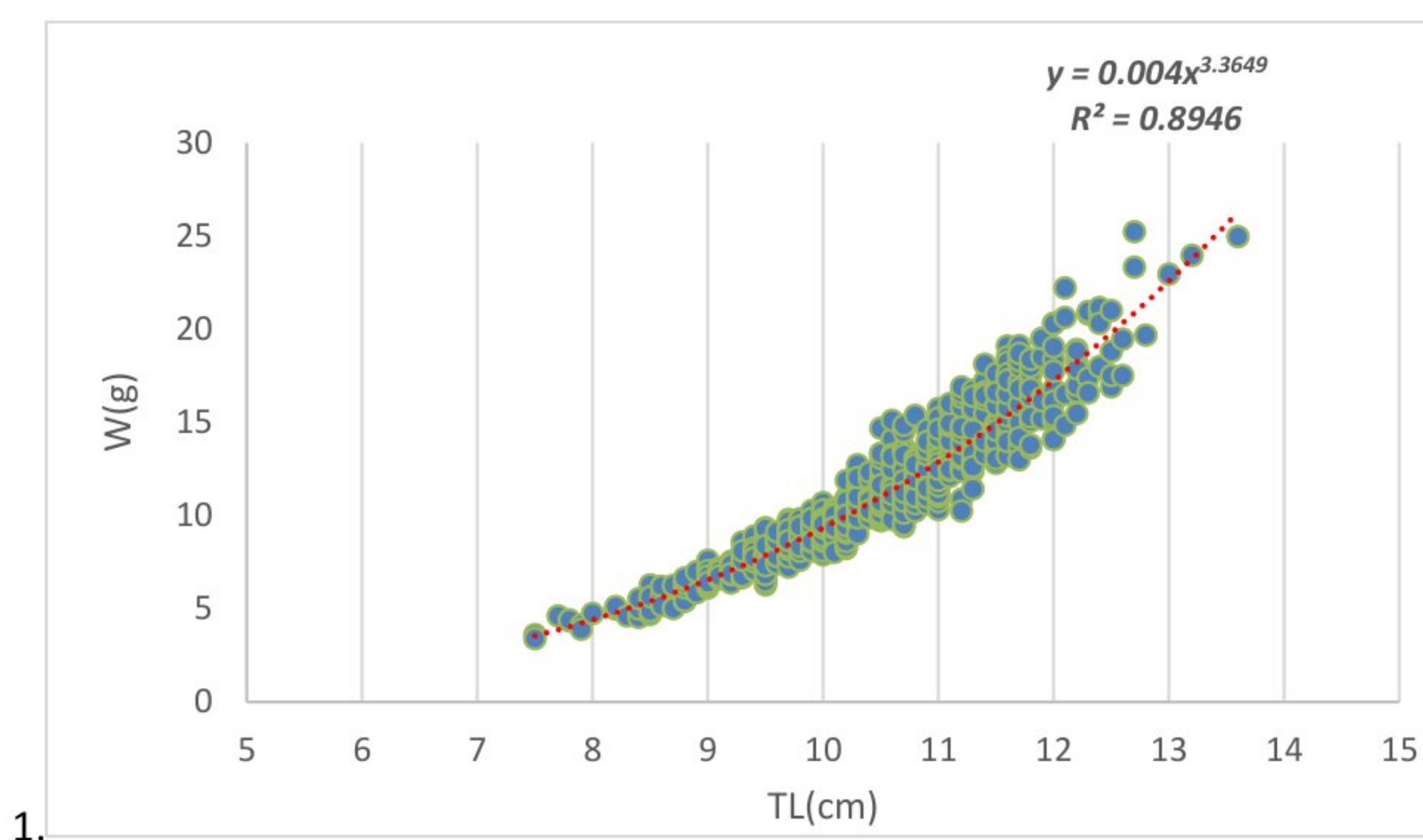


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3 - mature, with well-developed gonads. The condition index ($K = 0.73\text{--}0.78$) was relatively low, reflecting the redirection of energy toward gonadal development.

During autumn, after the completion of summer reproduction, the population showed signs of recovery. Individuals from group 0,0+ (1%) were in Stage 1, sexually immature. Group 1,1+ (68.6%) was in Stage 4, the post-reproductive stage, with depleted gonads after reproduction. Individuals from groups 2,2+ (26.8%) and 3,3+ (3.6%) were in transition between Stage 4 and Stage 5, the resting phase, in which the gonads regressed and prepared for the next reproductive cycle. The significantly higher condition index ($K = 0.96\text{--}1.15$, mean 1.11) compared to that in summer reflects active feeding and accumulation of energy reserves after the reproductive period, which is characteristic of the autumn season for this species.

The parameter values in the von Bertalanffy equation during summer 2025 were $a = 0.004$, $b = 3.36$, $L_{\infty} = 14.21$ cm, and during autumn $a = 0.008$, $b = 3.10$, $L_{\infty} = 17.37$ cm (Fig. 20).



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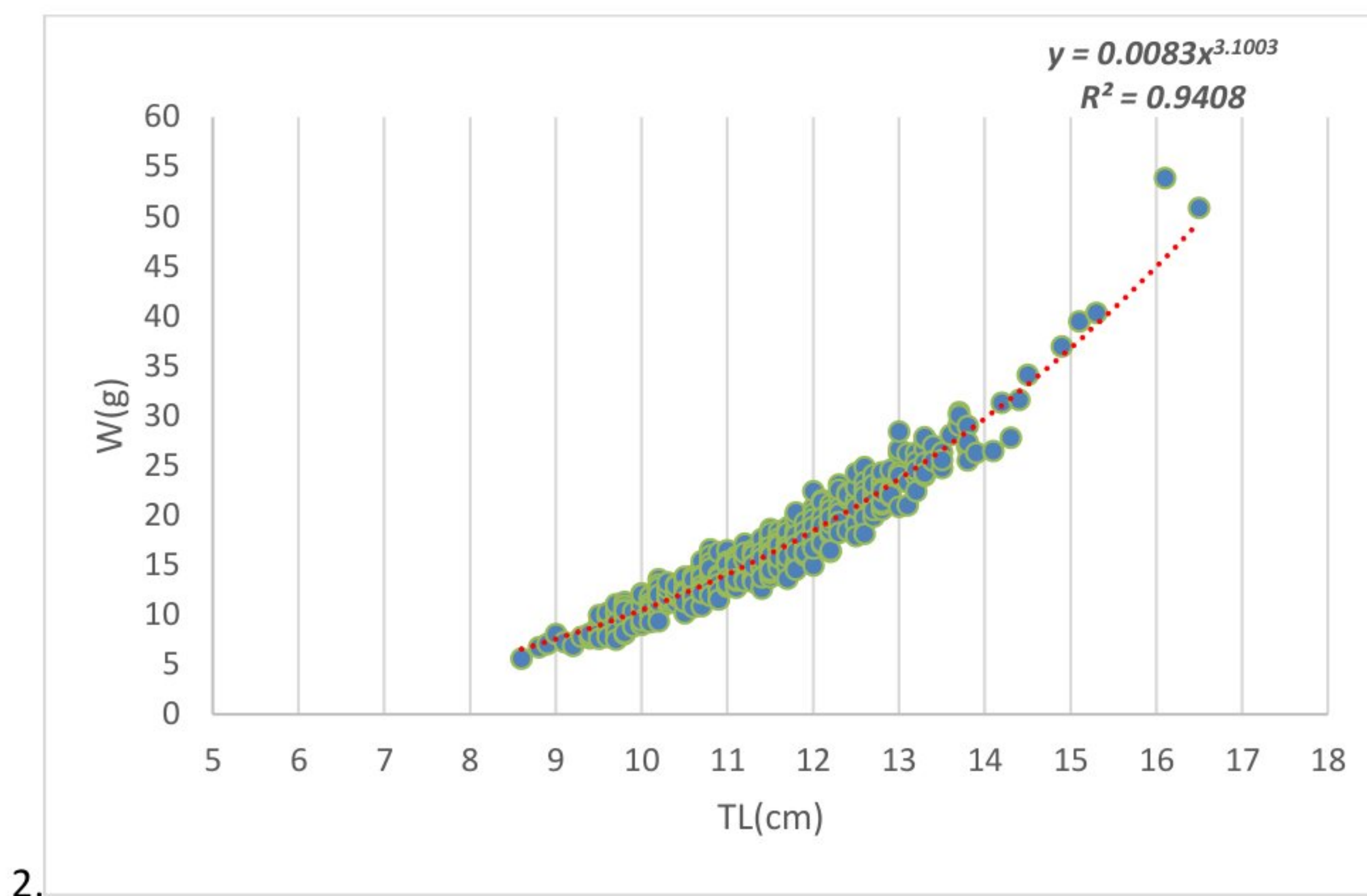


Fig. 20. Length–weight relationship (LWR) of *Mullus b. ponticus* in (1) summer 2025 and (2) autumn 2025.

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

During the second half of 2025, the age structure of Mediterranean horse mackerel catches was characterised by a clear dominance of one-year-old specimens, accounting for 67.92% of the total number of analysed individuals. The next most numerous age group was the two-year-old specimens, representing 16.01%. During autumn, single individuals of older age groups, namely, four-year-old specimens, were also recorded. Zero-year-old individuals were poorly represented in the samples, accounting for 9.19% of the total number of caught specimens. Female and male specimens accounted for 49.5% and 40.5%, respectively, while juvenile, sexually unidentified specimens represented 10%.

Individuals with body lengths in the range of 6.7–17.2 cm were recorded in the studied catches. The mean individual weight of the analysed specimens was within the range of 9.8–15.7 g. Mean condition factor values varied between 0.74 and 0.89 among the different age groups, reflecting a relatively similar physiological state of individuals within the studied population (Fig. 21).

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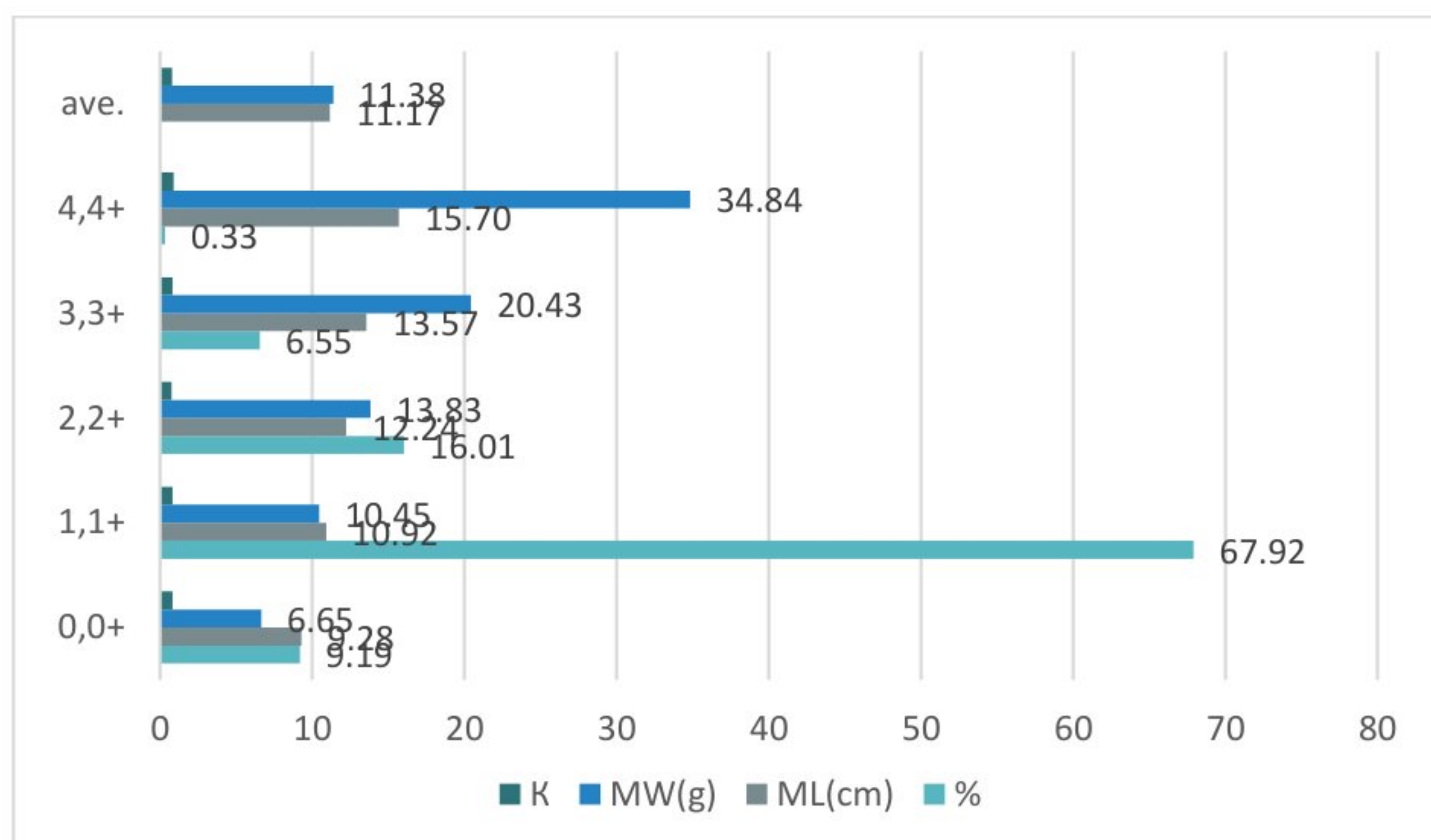


Fig. 21. Structure by age (%), average size, average weight, and condition factor of *Trachurus mediterraneus* in the age groups and averages during autumn 2025.

After the completion of the summer reproductive period (May–September), the Mediterranean horse mackerel population showed characteristic signs of post-reproductive recovery during autumn. Individuals in the age groups 0,0+ (9.19%) were in Stage 1, sexually immature. Representatives of the dominant groups 1,1+ (67.92%) and 2,2+ (16.01%) were in transition between Stages 4 and 5, a post-reproductive stage with depleted gonads after reproduction, entering a resting phase. Older individuals from groups 3,3+ (6.55%) and 4,4+ (0.33%) were also in Stages 4–5. The condition index varied between 0.74 and 0.89, with the highest values in the oldest individuals ($K = 0.89$), reflecting a more efficient accumulation of energy reserves after the reproductive period. The lower value in group 2,2+ ($K = 0.74$) may indicate more intensive participation in reproduction or slower recovery. Autumn data indicate a population in the recovery phase and preparing for the next reproductive cycle.

The relationship between the weight and linear dimensions of the Mediterranean horse mackerel is shown in Fig. 22.

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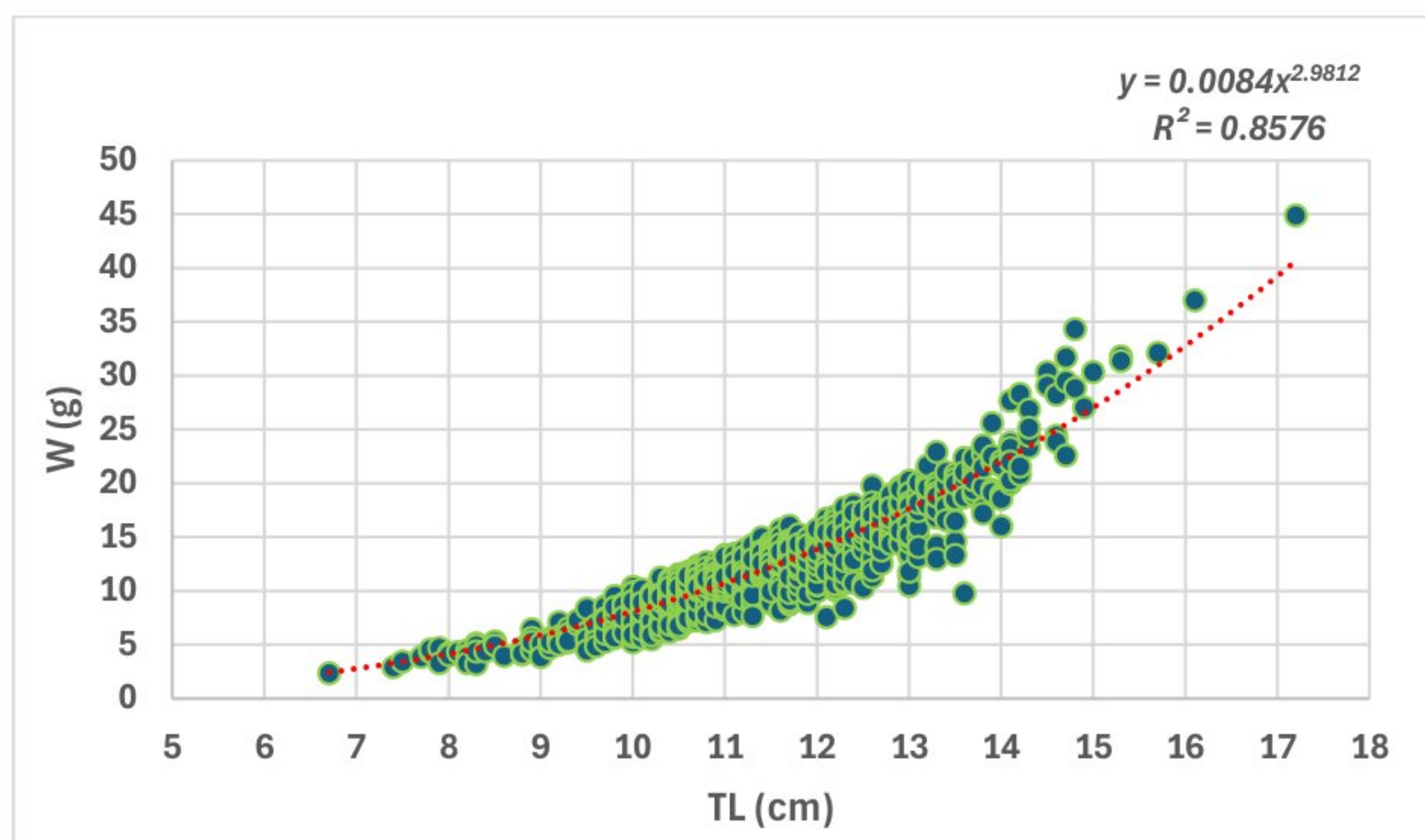
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Фиг. 22. Зависимост между дължина и тегло (LWR) на *Trachurus mediterraneus*.

D) Biological data on bycatch in pelagic trawl fisheries

Merlangius merlangus

During the first half of 2025, two- and three-year-old whiting specimens dominated the catches, accounting for 29.01% and 27.54% of the total, respectively. During the second half of the year, one- and zero-year-old individuals were dominant, accounting for 38.60% and 36.28% of the total, respectively.

Specimens of older age groups (5.5 +, 6.6 +, and 7.7 years) were recorded during the spring season but were absent during the rest of the study period. Zero-year-old individuals were recorded during the study period.

Specimens with body lengths in the range of 4.0–21.5 cm were recorded in the target catch, with the mean length varying between 10.3 and 12.62 cm. The mean individual weight ranged from 8.77 to 16.97 g. Mean condition factor values varied between 0.80 and 0.85 (Fig.23)

The observed ratios of female, male, and sexually unidentified individuals were 60.33%, 9.91%, and 29.75%, respectively.

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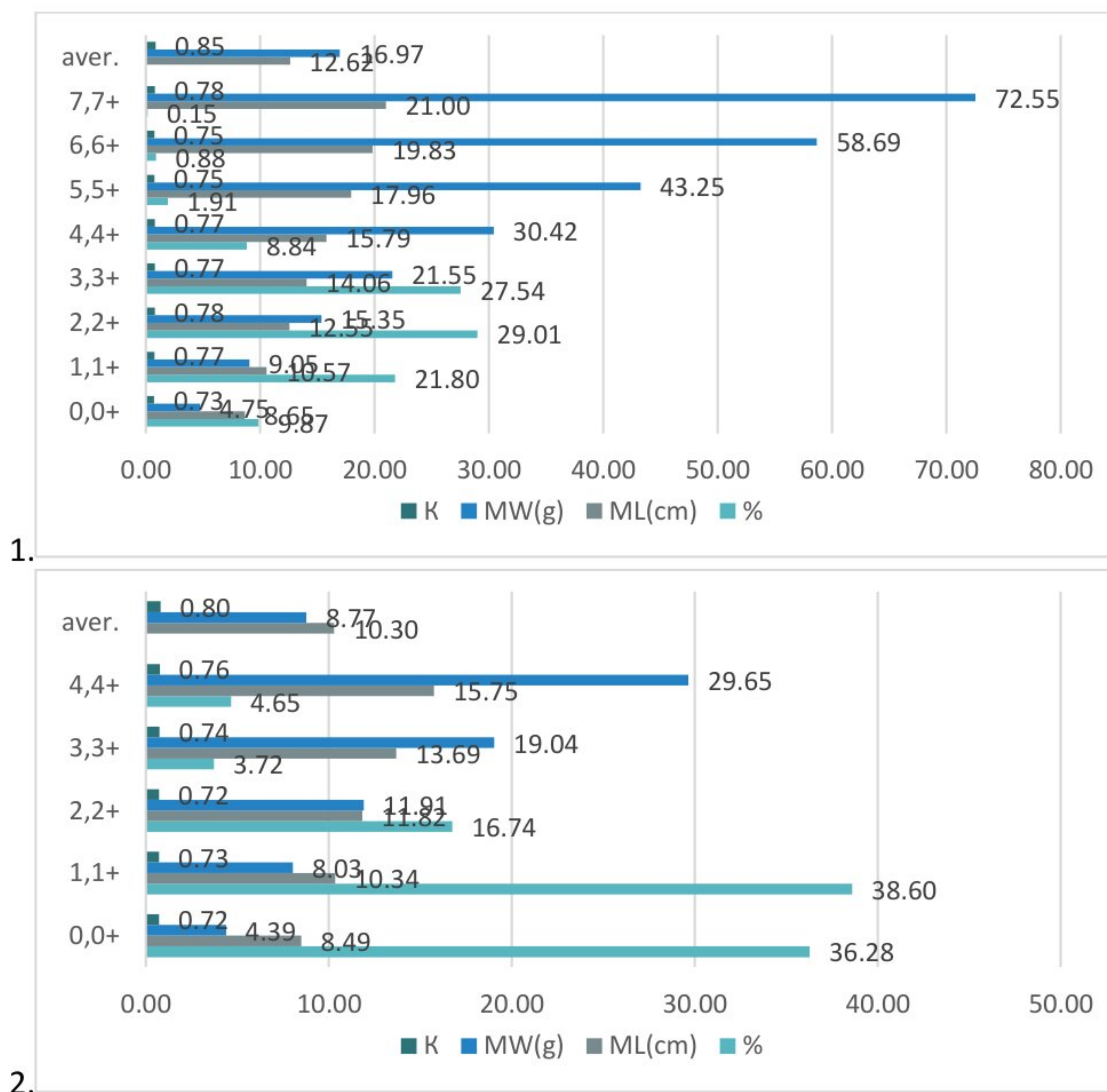


Fig. 23. *M. merlangus* - age structure (%), average size, average weight and condition factor by age group and average bycatch parameters, in 1) spring 2025 and 2) autumn 2025.r.

During spring, at the end of the prolonged reproductive season (October-May), individuals from age group 0,0+ (9.87%) were in Stage 1 - sexually immature. Representatives of group 1,1+ (21.80%) were in transition between Stage 4 and Stage 5 - a post-reproductive stage with depleted gonads after participation in winter reproduction, entering a resting phase. Individuals from older groups 2,2+ (29.01%), 3,3+ (27.54%), and 4,4+ (8.84%) were in Stage 4–5 - recovering after reproduction, with gonads regressing and preparing for the next cycle.

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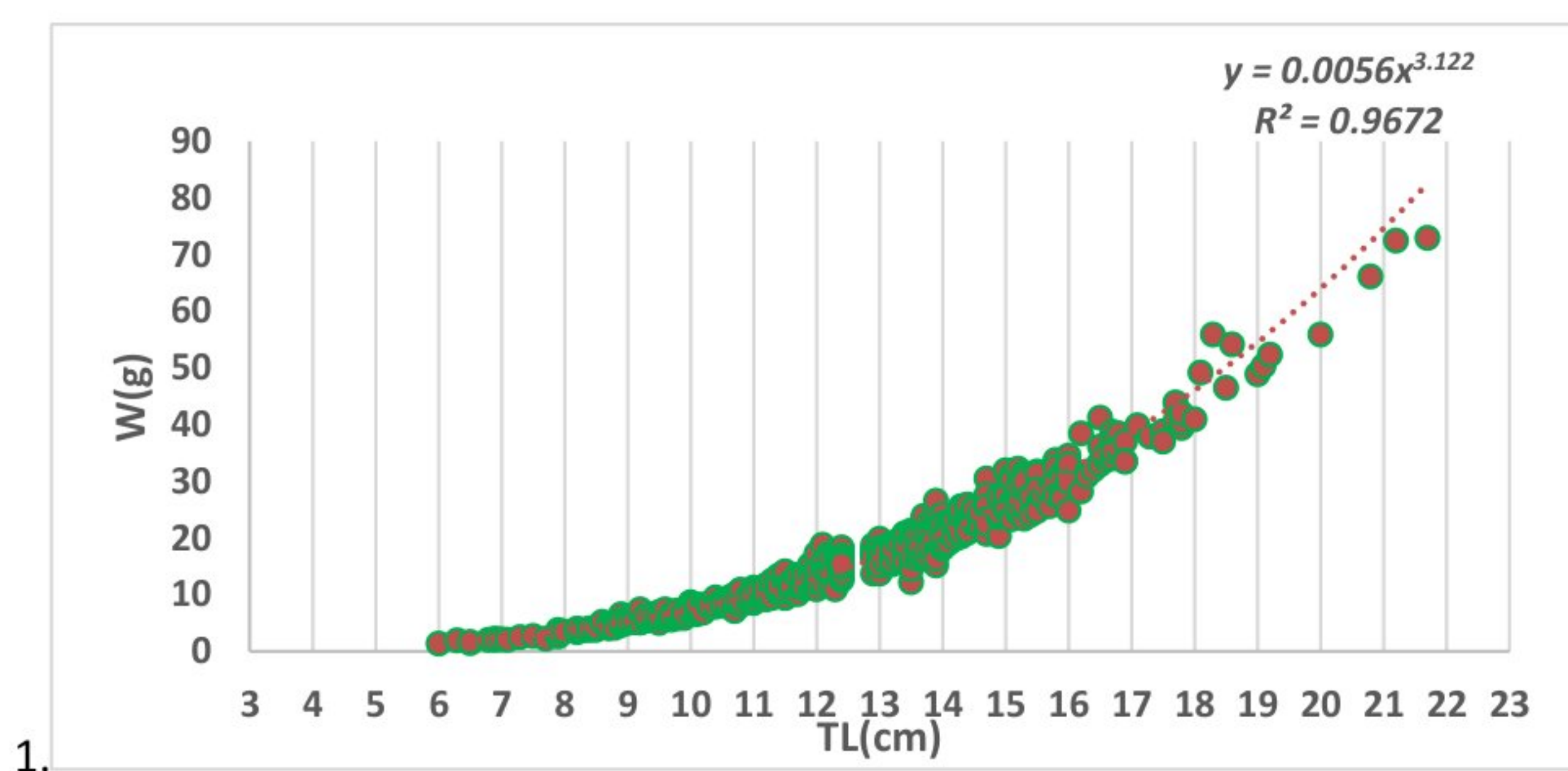


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The condition index ($K = 0.73\text{--}0.78$) was relatively low and homogeneous, reflecting energy depletion following a prolonged reproductive period.

During autumn, the population prepares for the upcoming winter reproductive seasons. Individuals from group 0,0+ (36.28%) were in Stage 1 - sexually immature. Group 1,1+ (38.60%) was in Stage 2, and the gonads began to differentiate in preparation for first-time reproduction. Individuals from group 2,2+ (16.74%) were in transition between Stage 2 and Stage 3 - advancing gonad development. Older groups 3,3+ (3.72%) and 4,4+ (4.65%) were in Stage 3 - fully mature and ready for reproduction, with well-developed gonads full of gametes. The condition index ($K = 0.72\text{--}0.76$) remained relatively low but showed a tendency toward a slight increase in older individuals ($K = 0.76$ in 4,4+), reflecting the beginning of the accumulation of energy reserves for the upcoming winter spawning.

The length-weight relationship (LWR) of *M. merlangus* in 2025 is presented in Fig. 24 and reveals positive allometric growth ($b = 3.12\text{--}3.15$) during both spring and autumn.



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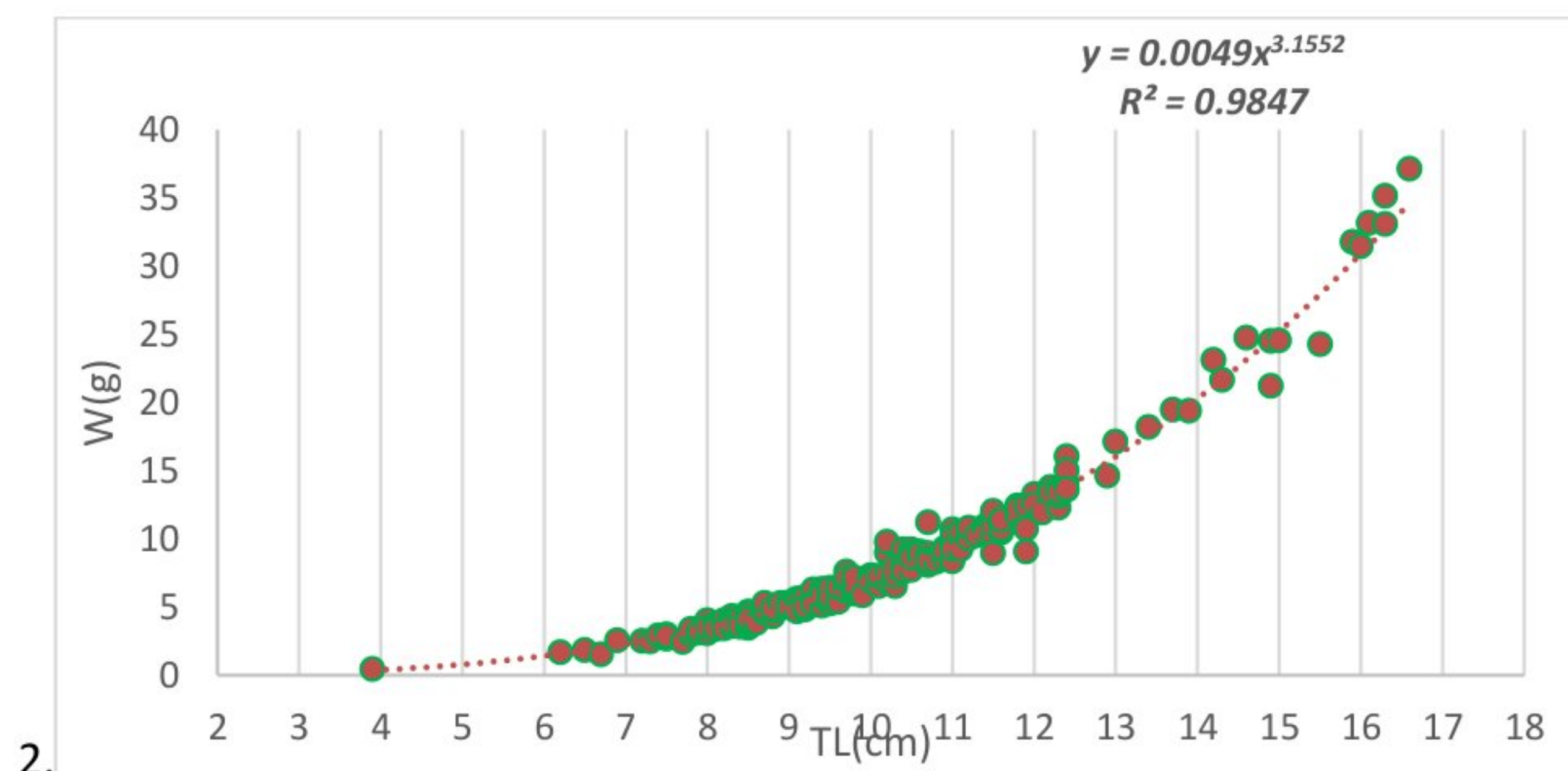


Fig. 24. Length–weight relationship (LWR) of *M. merlangus* in (1) spring 2025 and (2) autumn 2025.

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

Data on the species composition of sensitive species, total number of captured individuals, average weight, and average size in the bycatch are presented in Table 17. Upon removal from the nets, all captured sensitive species (103 individuals) were alive and had no serious injuries. The average bycatch coefficient was highest for turbot, $T = 1.18$ ind/day.

Table 17

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 2025.

Bycatch species	IUCN status	Total number	Bycatch coefficient (ind/day)	Mean length (cm)	Mean weight (g)
<i>Raja clavata</i>	NT (Near threatened)	21	0.47	49.72	1890.95
<i>Dasyatis pastinaca</i>	VU (vulnerable)	26	0.58	68.32	2670.00

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<i>Squalus acanthias</i>	EN (endangered)	2	0.04	72.70	2100
<i>Acipenseridae</i>	CR (Critically endangered)	1	0.02	41.30	250.00
<i>Scophthalmus maximus</i>	LC (Least Concern)	53	1.18	37.19	2803.96

In 2025, the species diversity of sensitive taxa in the bycatch showed seasonal fluctuations, with bycatch coefficients increasing during summer and autumn (Table 18, Fig. 25). The bycatch coefficient for turbot increased in July (6.8 ind/day) and October (4 ind/day), whereas for thornback ray and common stingray, it peaked in September (2.33 and 4 ind/day, respectively; Fig. 25, Table 18).

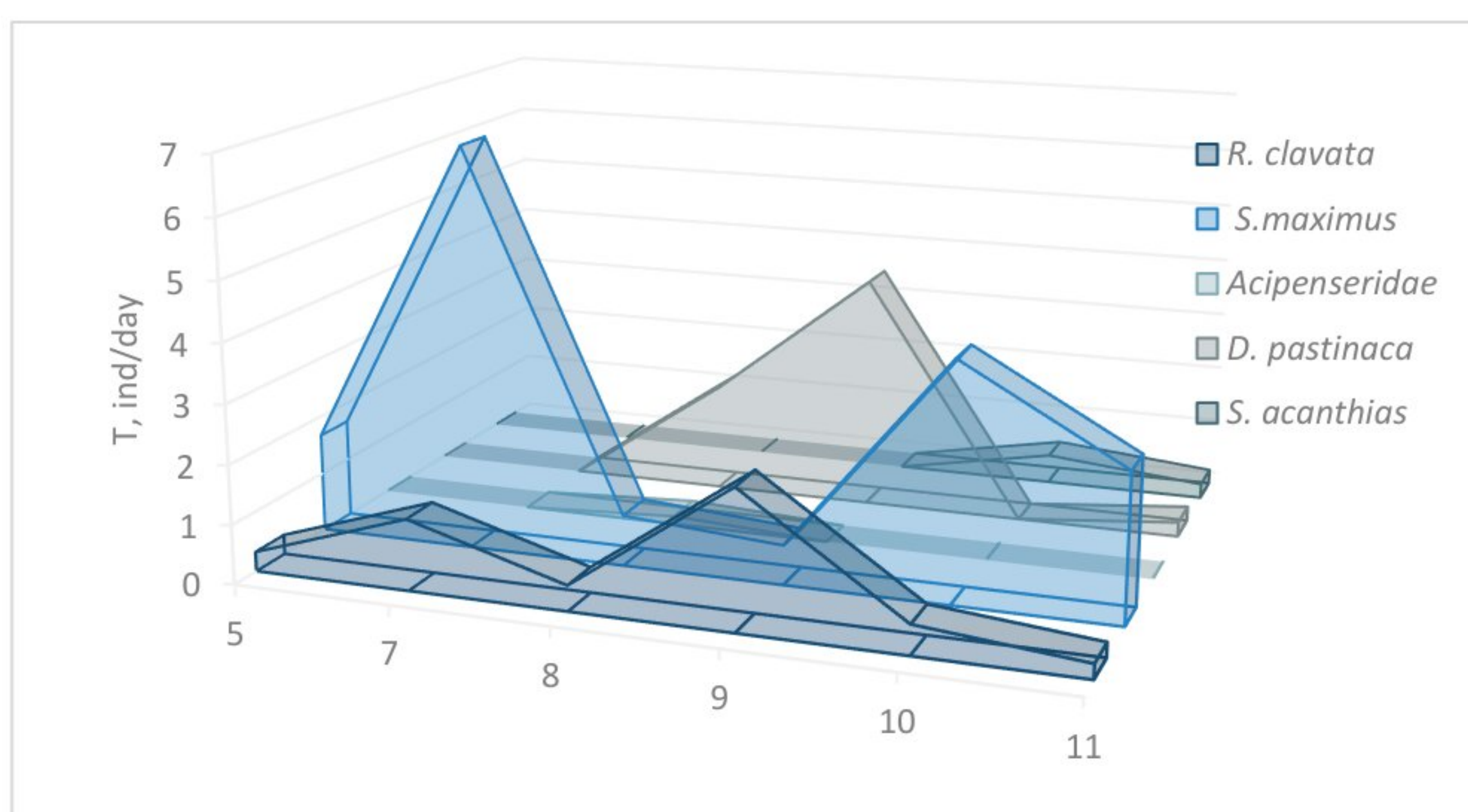


Fig. 25. Monthly fluctuations in the bycatch ratio (T, ind/day) of sensitive species during pelagic trawl fishing in 2025.

Table 18

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 2025.

Month	Bycatch species	Total number	Monthly bycatch coefficient	Mean length (cm)	Mean weight (g)
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			(ind/day)		
5.2025	<i>R. clavata</i>	3	0.33	40.63	426.6
	<i>S. maximus</i>	15	1.67	40.06	1200
7.2025	<i>R. clavata</i>	6	1.2	65.33	2013.33
	<i>S. maximus</i>	34	6.8	49.04	2723.82
8.2025	<i>Acipenseridae</i>	1	0.14	41.3	250
	<i>D. pastinaca</i>	13	1.86	68.38	3042.31
	<i>R. clavata</i>	3	0.43	53.67	2133.33
	<i>S. maximus</i>	6	0.86	28.00	656.67
9.2025	<i>D. pastinaca</i>	12	4	57.87	2147.50
	<i>R. clavata</i>	7	2.33	40.11	2378.57
	<i>S. maximus</i>	2	0.67	29.40	630.0
10.2025	<i>R. clavata</i>	1	0.5	24.2	1000
	<i>S. maximus</i>	8	4	33.11	709.38
	<i>S. acanthias</i>	1	0.5	52.40	1100
11.2025	<i>S. maximus</i>	10	2.5	36.79	2300
	<i>R. clavata</i>	1	0.25	39.80	1010
	<i>D. pastinaca</i>	1	0.25	61.8	4100
	<i>S. acanthias</i>	1	0.25	93	3100

R. clavata showed significant variability in the mean length in the bycatch, ranging from 24.2 cm (October) to 65.33 cm (July), indicating the presence of several size classes, from juveniles to adults. The mean weight varied considerably (426.6–2378.57 g), reflecting both ontogenetic and seasonal differences. Accordingly, *D. pastinaca* showed relatively stable mean length values (57.87–68.38 cm) over the three months of recording, i.e., consistent catches of large adults. *Squalus acanthias* is represented by limited data (two records) but showed marked differences in both mean length (52.40 vs. 93 cm) and mean weight (1100 vs. 3100 g).

S. maximus exhibited moderate variability in mean length (28.00–49.04 cm) but marked fluctuations in mean weight (630.0–2723.82 g). This pattern indicates that while the individuals caught belonged to a relatively consistent size range, their weight varied significantly over time, potentially due to feeding intensity, reproductive status, or seasonal migrations.

The wider size ranges observed in pelagic trawl catches, particularly for *R. clavata* and *S. maximus*, suggest that this type of gear may interact with a wider variety of life stages than gillnets.

The bycatch of sensitive species by fishing segments is presented in Table 19. The largest number of sensitive species (86 individuals) was caught by the segment of the smallest fishing vessels, TM VL1218.

Table 19

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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 2025.

1. TM VL1218

Bycatch species	IUCN status	Total number	Bycatch coefficient	Mean length (cm)	Mean weight (g)
<i>Raja clavata</i>	NT (Near threatened)	15	0.88	52.67	2175.33
<i>Scophthalmus maximus</i>	LC (Least Concern)	53	3.12	35.62	2053.02
<i>Dasyatis pastinaca</i>	VU (Vulnerable)	17	1	58.99	2401.18
<i>Squalus acanthias</i>	EN (Endangered)	1	0.06	93.00	3100

2. TM VL1824

Bycatch species	IUCN status	Total number	Bycatch coefficient	Mean length (cm)	Mean weight (g)
<i>Raja clavata</i>	NT (Near threatened)	3	0.6	35.93	1933.33
<i>Scophthalmus maximus</i>	LC (Least Concern)	8	1.6	33.11	1418.75
<i>Dasyatis pastinaca</i>	VU (Vulnerable)	9	1.8	71.36	3177.78
<i>Acipenseridae</i>	CR (Critically endangered)	1	0.2	41.3	250
<i>Squalus acanthias</i>	EN (Endangered)	1	0.2	52.40	1100

3. TM VL2440

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Bycatch species	IUCN status	Total number	Bycatch coefficient	Mean length (cm)	Mean weight (g)
<i>Raja clavata</i>	NT (Near threatened)	3	0.375	40.63	426.67
<i>Scophthalmus maximus</i>	LC (Least Concern)	14	1.75	41.56	2032.14

3.3 Rapa whelk fishery with beam trawl

3.3.1 Main catch, bycatch, total catch

During the period V - IX.2025, the studies on the catches of rapa whelk with beam trawls covered one fishing segment - TBB VL1218.

The weight of rapa whelk catches ranged between 120 and 2245 kg/day, and the weight of bycatch of marine organisms fluctuated between 0.98 and 121.44 kg/day; the total catch of marine organisms (TC₁) was 833.67 kg/day $\pm$ 101.51 SE, and the average percentage share of bycatch was 2.53 % $\pm$ 0.66 SE of this catch (Table 20.1). Accordingly, the average amount of marine debris was 1.64 kg/day $\pm$ 0.49 SE, with a percentage share of 0.21 % $\pm$ 0.06 SE of the total catch (TC₂) (Table 20.2).

Table 20

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 2025, as well as additional data on the weight of clam shells (kg/day), 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) <i>R. venosa</i>	Bycatch weight BC ₁ (kg/day)	Total catch of marine species, TC ₁ (catch + bycatch) (kg/day)	% of bycatch BC ₁ from total catch TC ₁

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Average value	814.52	19.15	833.67	2.53
Standard error	101.46	5.31	101.51	0.66
Median	690.00	6.58	736.70	1.19
Standard deviation	507.28	26.54	507.53	3.29
Kurtosis	2.10	8.71	1.95	8.59
Skewness	1.25	2.67	1.17	2.67
Sample variance	2125.00	120.46	2127.10	15.02
Minimum	120.00	0.98	120.98	0.14
Maximum	2245.00	121.44	2248.08	15.15
Number	25.00	25.00	25.00	25.00
Confidence interval (95.0%)	209.39	10.96	209.50	1.36
CV	62.28	138.58	60.88	129.70

2. Additional catch

	Weight of Bivalvia shells, Tb, (kg/day)	Weight of marine litter, T_l (kg/day)	Weight of the whole catch, TC₂ = TC₁+Tb+T_l (kg/day)	% of shells from the total catch TC₂	% of marine litter from the total catch TC₂
Average value	106.53	1.64	898.51	14.34	0.21
Standard error	12.86	0.49	100.15	0.93	0.06
Median	108.00	1.14	849.75	12.77	0.14
Standard deviation	49.81	1.84	500.74	3.60	0.23
Kurtosis	-0.45	4.81	1.50	0.77	6.80
Skewness	-0.72	2.20	0.89	1.25	2.60
Sample variance	155.00	6.65	2112.10	12.61	0.85
Minimum	15.00	0.20	135.98	10.09	0.05
Maximum	170.00	6.85	2248.08	22.70	0.90
Number	15.00	14.00	25.00	15.00	14.00
Confidence interval (95.0%)	27.59	1.06	206.69	1.99	0.13
CV	46.76	112.51	55.73	25.11	111.25

Seasonal changes in catch and bycatch quantities were monitored, with bycatch quantities peaking in June 2025 at 25.34 kg/day (Fig. 26). The average monthly share of bycatch of marine organisms, expressed as a percentage of the total catch, varied between 0.54 - 3.78 %, with a maximum in May - June (Fig. 26).

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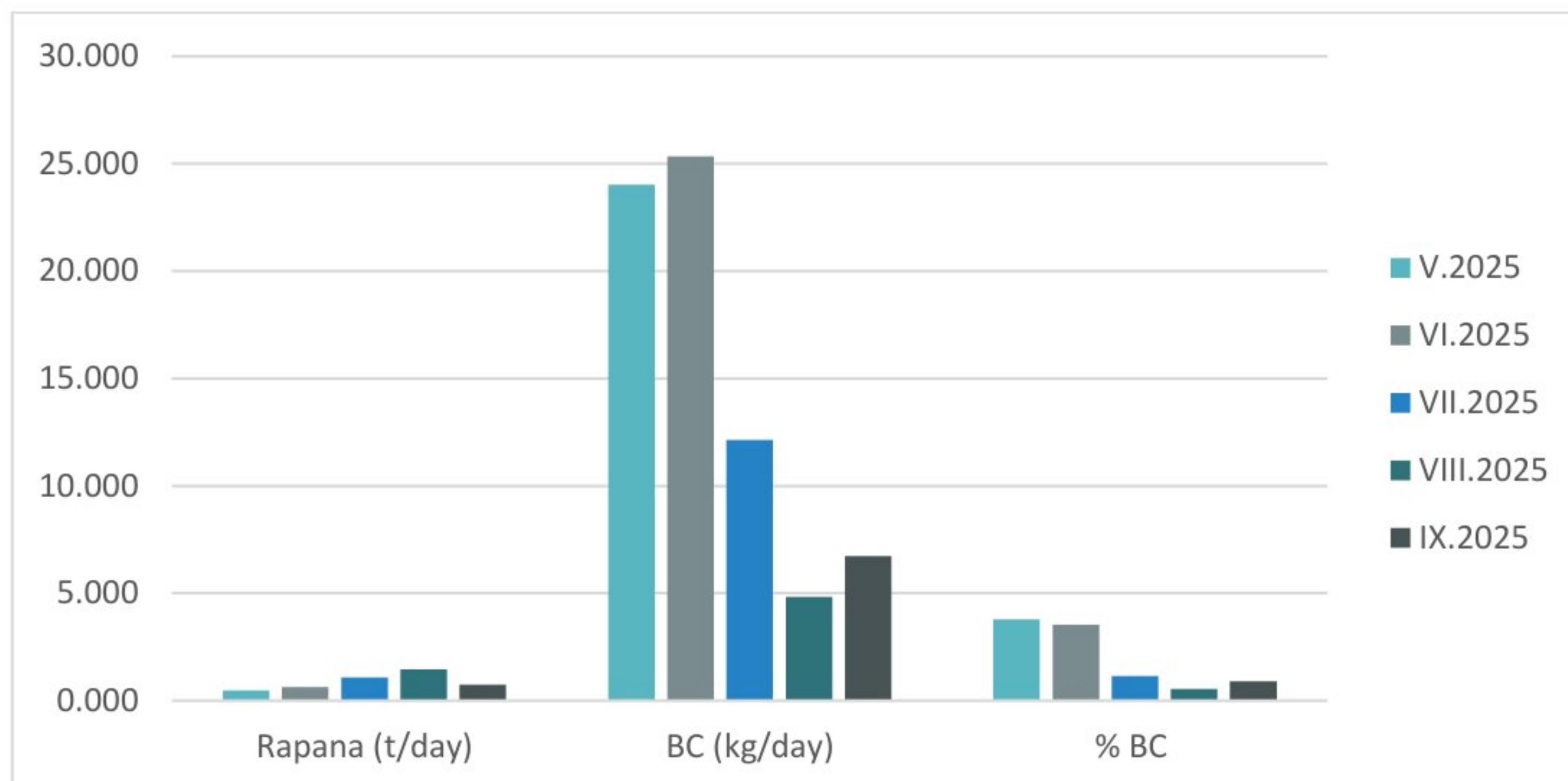


Fig. 26. Data on (1) rapa whelk catch (**t/day**), bycatch of marine organisms (**kg/day**), and % of bycatch of total TC₁, and (2) amount of marine litter (**kg/day**) in 2025.

The bycatch composition in *Rapana* fisheries is diverse, comprising 33 species - including primarily fish, crustaceans, and mollusks. A maximum of 24 different marine species were recorded per day in beam trawls, with an average of 17 species per fishing day. The most frequently encountered species in the bycatch was the stargazer (*Uranoscopus scaber*), present in 100% of daily hauls, followed by whiting (*Merlangius merlangus*) and the bivalves *Anadara kagoshimensis* and *Flexopecten glaber*, as well as the swimming crab *Polybius vernalis*, which occurred in 96% of hauls. The black goby (*Gobius niger*) and the sea anemone *Sagartia undata* were also commonly found, occurring in 84% and 76% of daily bycatch samples, respectively.

During the study period, the dominant species by weight in the bycatch was whiting (*M. merlangus*), contributing 50%, followed by *A. kagoshimensis* (24%), stargazer (16%), swimming crab (4%), and turbot (1.5%). All other species had lower individual contributions to the total bycatch biomass (Fig. 27).

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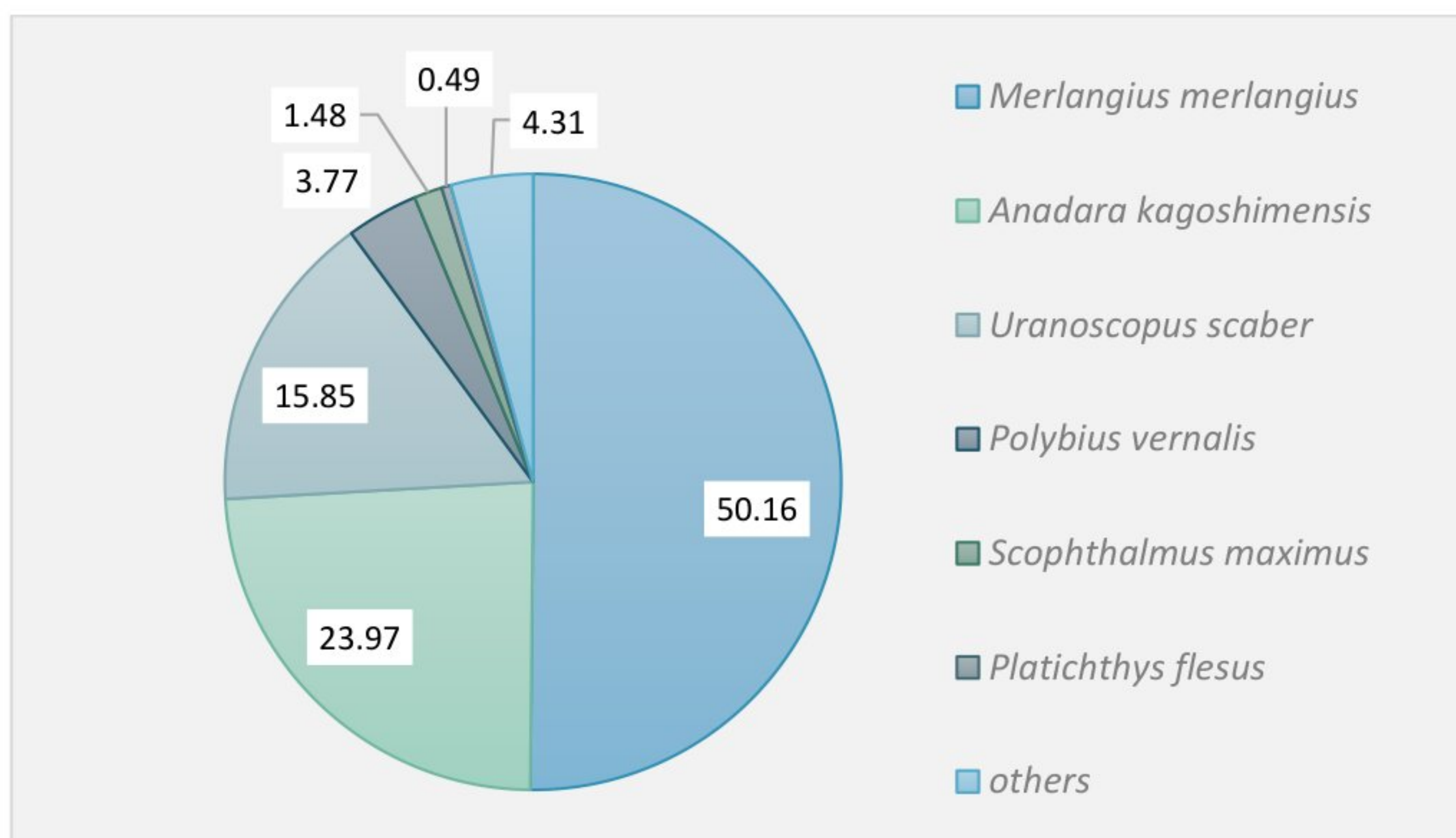


Fig. 27. Percentage participation of the dominant species in the formation of the weight of the bycatch (kg/day) in rapa whelk fishery, 2025

The dynamics of bycatch species composition based on participation in the formation of bycatch weight by month are presented in Fig. 28.

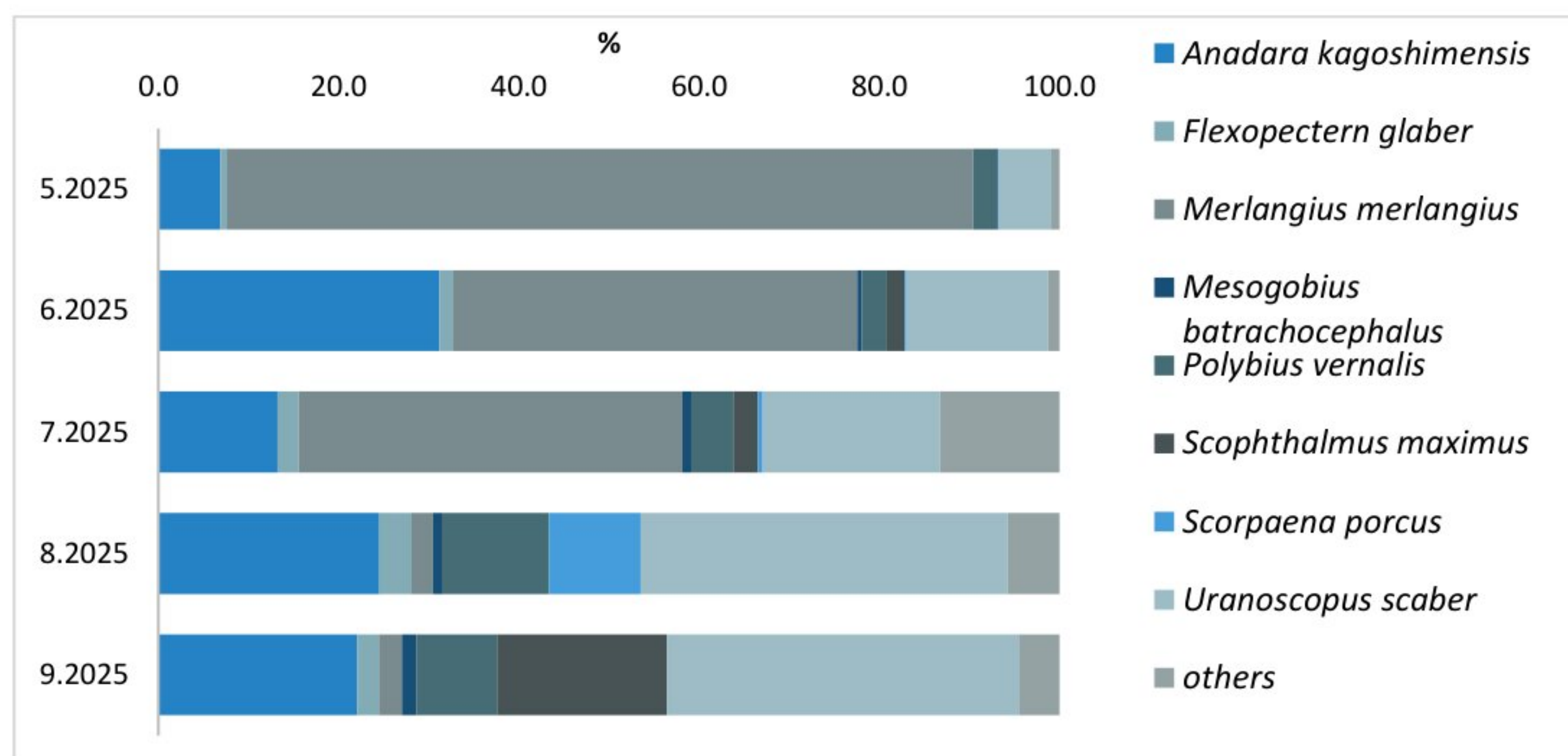


Fig. 28. Changes in bycatch species composition (% of total weight of bycatch, BCW₁, kg/day) per month in the rapa whelk fishery with beam trawls.

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The quantity of turbot in the bycatch was highest in September 2025 (19% BCW), and the contribution of whiting (*Merlangius merlangus*) peaked in spring, reaching 83% of the average monthly bycatch weight, whereas the share of *A. kagoshimensis* increased during the summer months (Fig. 24).

3.3.2. Dynamics of biological parameters

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

In 2025, the average sizes of the studied rapa whelk specimens in the target catch ranged between 59.06 - 60.730 mm, and the average weights varied between 35.74 - 37.69 g (Table 21). Accordingly, the average weight of the species was $37.61 \text{ g} \pm 15.21 \text{ SD}$, and the average size was $59.945 \text{ mm} \pm 7.81 \text{ SD}$. For comparison, during observations in 2024, the average size of *R. venosa* reached $60.21 \text{ mm} \pm 9.87 \text{ SD}$, with an average weight of $40.89 \text{ g TW} \pm 20.98 \text{ SD}$, indicating a decreasing trend in these parameters in 2025.

Table 21

Summary statistics of the data: (1) shell length (SL, cm) and (2) total weight (TW, g) of rapa whelk from the main catch in 2025.

(1) SL, mm

Date	no	Minimum SL (mm)	Maximum SL (mm)	Average SL (mm)	St. deviation
6.6.2025	100	47.000	84.000	59.600	7.253
9.6.2025	100	42.000	86.000	60.390	8.397
13.6.2025	100	46.000	89.000	59.060	7.906
18.6.2025	100	41.000	84.000	60.730	7.661

(2) TW, g

Date	no	Minimum TW (g)	Maximum TW (g)	Average TW (g)	St. deviation
6.6.2025	100	18.510	100.720	37.346	14.304
9.6.2025	100	13.030	103.640	37.688	16.314
13.6.2025	100	12.730	115.123	35.736	15.050
18.6.2025	100	12.610	103.890	39.658	15.066

During the 2025 survey period, 94.5% of the measured specimens were < 75 mm in size (Fig. 29 & 30). The most significant presence in the catches was in the size group - 50 - 70 mm (83% of the measured *Rapana* specimens, Fig. 29, Table 22.1).

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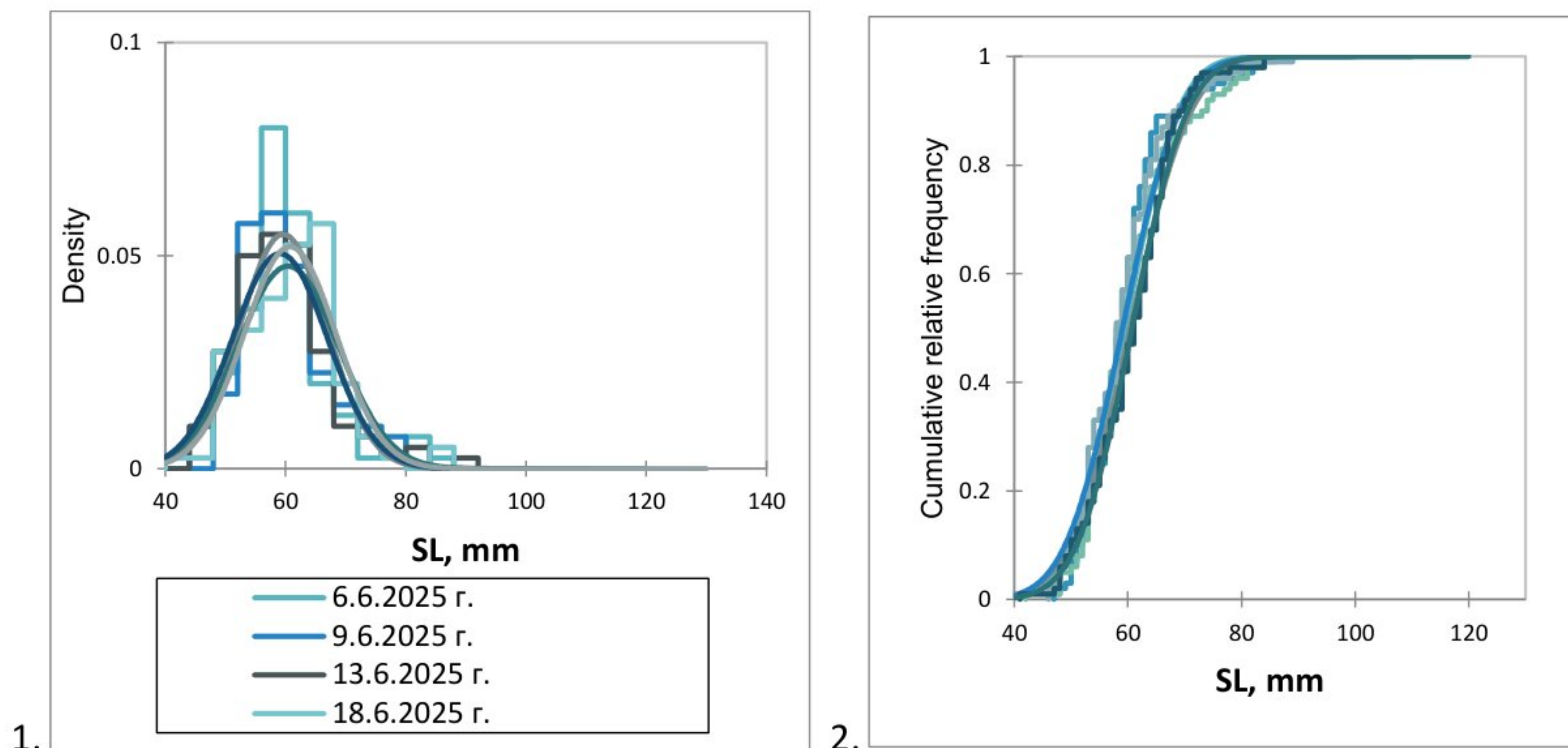


Figure 29. Distribution of *R. venosa* by length class (SL, cm, 1) and cumulative distribution (2) in 2025.

Accordingly, the 20–50 g weight group played a leading role in the catches (83 %, Fig 30, Table 22.2). During the study period, 92.5 % of the measured specimens weighed < 60 g.

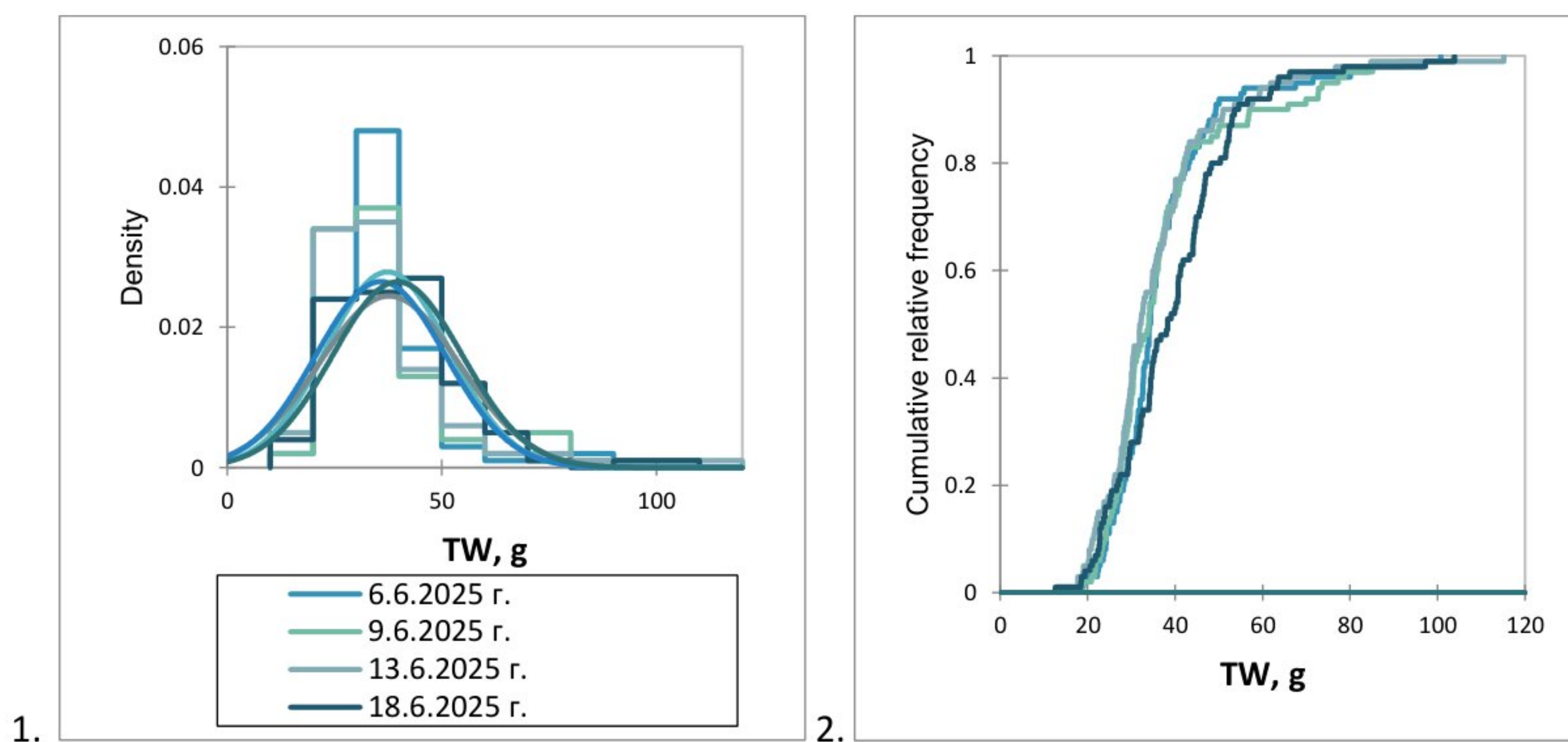


Figure 30. Distribution of *R. venosa* by weight class (TW, g, 1) and cumulative distribution by weight class (2) in 2025.

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Table 22

Statistics on the distribution of length (mm, 1) and weight (g, 2) classes of rapa whelk in 2025.

1. SL (mm)

Lower limit	Upper limit	Frequency	Relative frequency	Density
40.000	45.000	2	0.005	0.001
45.000	50.000	23	0.058	0.012
50.000	55.000	75	0.188	0.038
55.000	60.000	111	0.278	0.056
60.000	65.000	100	0.250	0.050
65.000	70.000	46	0.115	0.023
70.000	75.000	21	0.053	0.011
75.000	80.000	9	0.023	0.005
80.000	85.000	11	0.028	0.006
85.000	90.000	2	0.005	0.001

2. TW (g)

Lower limit	Upper limit	Frequency	Relative frequency	Density
10.000	20.000	13	0.033	0.003
20.000	30.000	116	0.290	0.029
30.000	40.000	145	0.363	0.036
40.000	50.000	71	0.178	0.018
50.000	60.000	25	0.063	0.006
60.000	70.000	10	0.025	0.003
70.000	80.000	9	0.023	0.002
80.000	90.000	4	0.010	0.001
90.000	100.000	3	0.008	0.001
100.000	110.000	3	0.008	0.001
110.000	120.000	1	0.003	0.000

B) Biological data on bycatch in rapa whelk fishery

Scophthalmus maximus

The turbot bycatch included specimens with an average size of 34.35 cm and an average weight of 0.954 kg. Fig. 31 presents the linear weight relationship (LWR) of *S. maximus* from the beam trawl bycatch in 2025.

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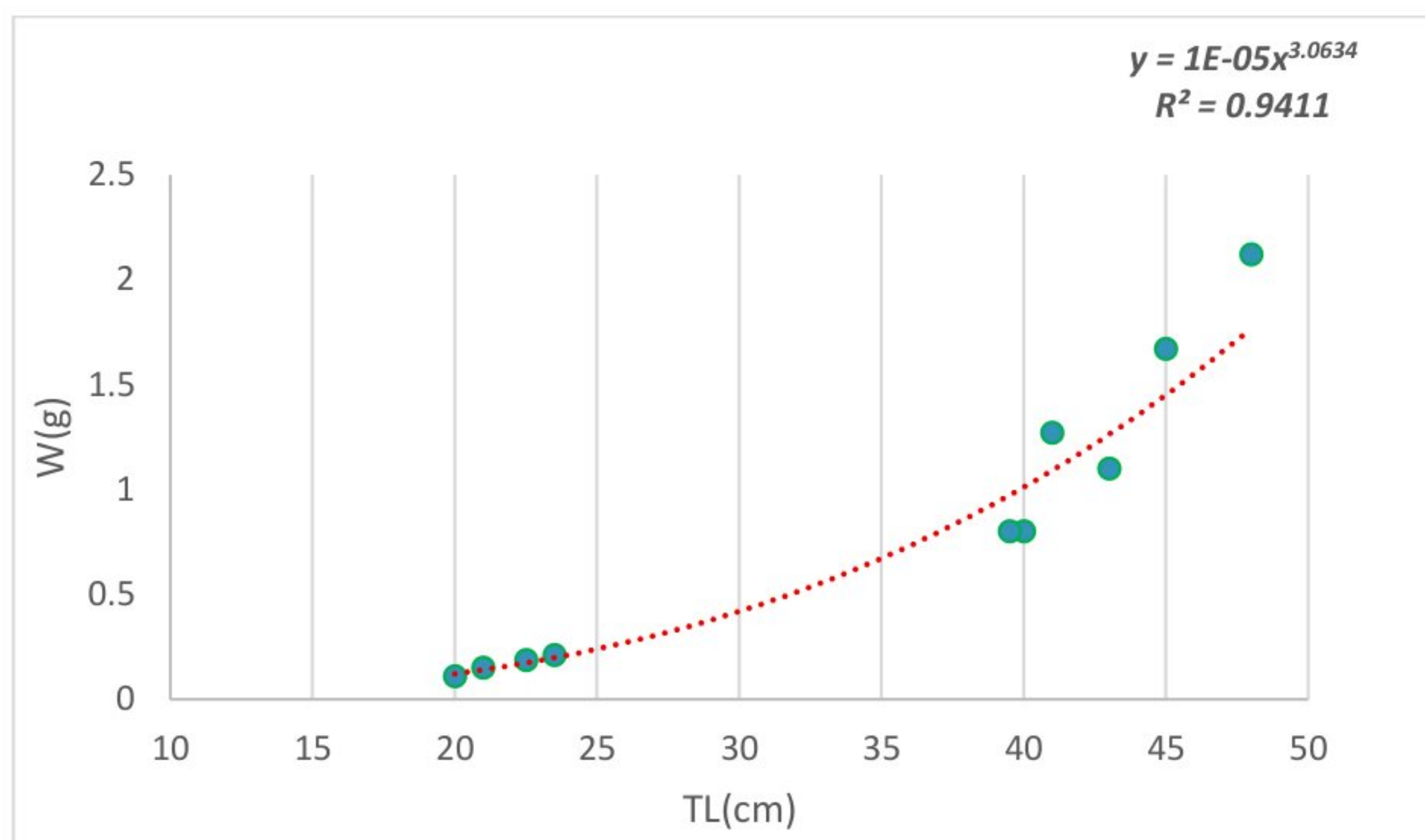


Fig. 31. LWR of *S. maximus*

P. flesus

The following average sizes and weights were measured in the bycatch of European flounder - 18.2 cm and 74.78 g; the LWR of *P. flesus* is presented in Fig. 32.

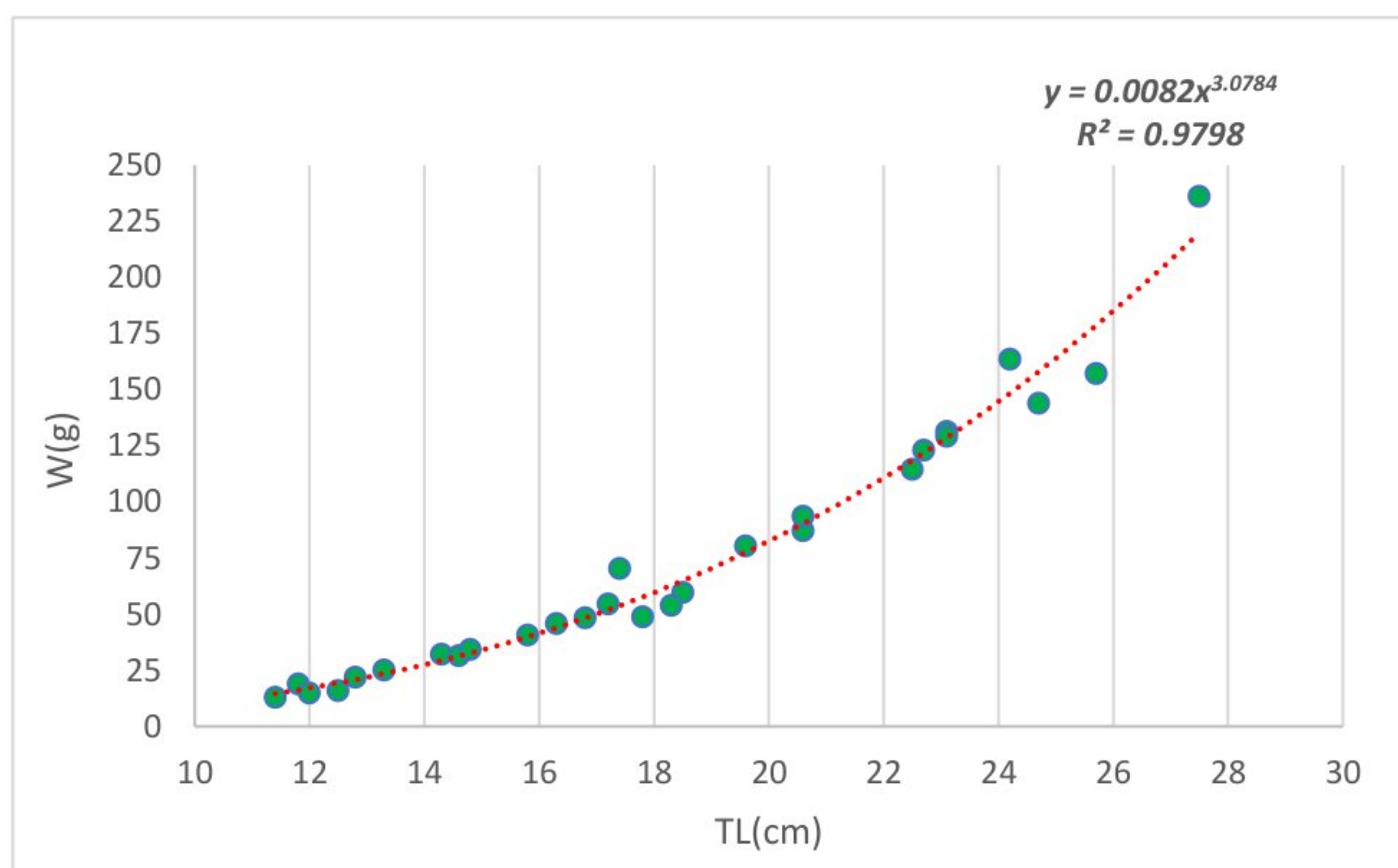


Fig. 32. LWR of *P. flesus*

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U. scaber

The average size and weight of the stargazer bycatch were 14.94 cm and 67.84 g, respectively, and the LWR of *U. scaber* and sex structure in the bycatch are presented in Fig. 33.

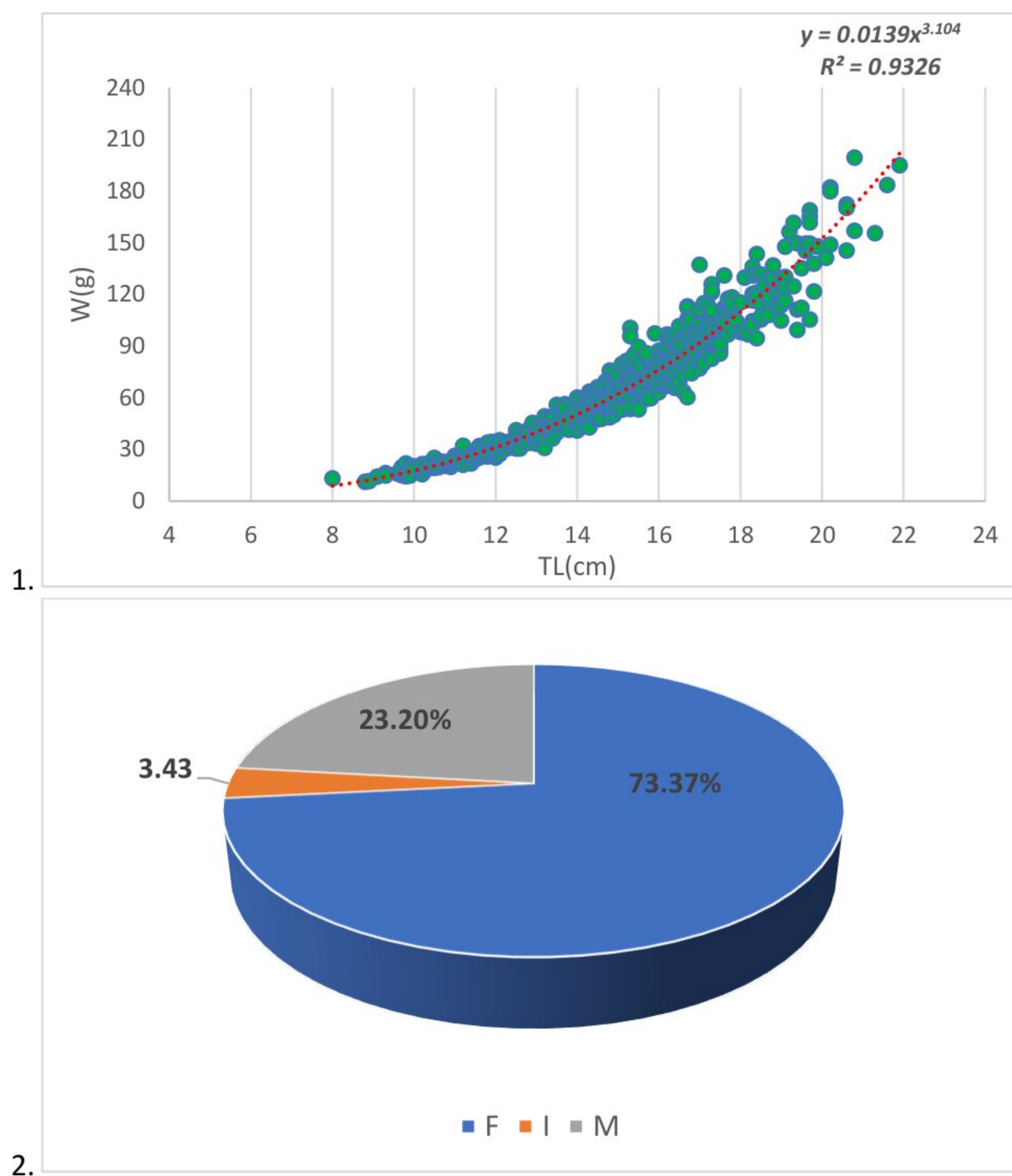


Fig. 33. (1) LWR of *U. scaber* and (2) sex composition of the bycatch.



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

In 2025, only one sensitive species was found in the bycatch - turbot (Table 23), 8 specimens, with an average bycatch coefficient $T = 0.32$ ind/day. When removed from the nets, most specimens were dead or severely injured.

Table 23

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 beam trawl fisheries in 2025.

By catch species	IUCN status	Total number	Bycatch ratio (ind/day)	Average size (cm)	Average weight (g)
<i>Scophthalmus maximus</i>	LC (Least Concern)	8	0.32	33.97	1235.71

Seasonally, turbot bycatch was higher in VI. 2025 (0.54 ind/day), and a higher average weight was recorded in VII.2025. (Table 24, Fig. 34).

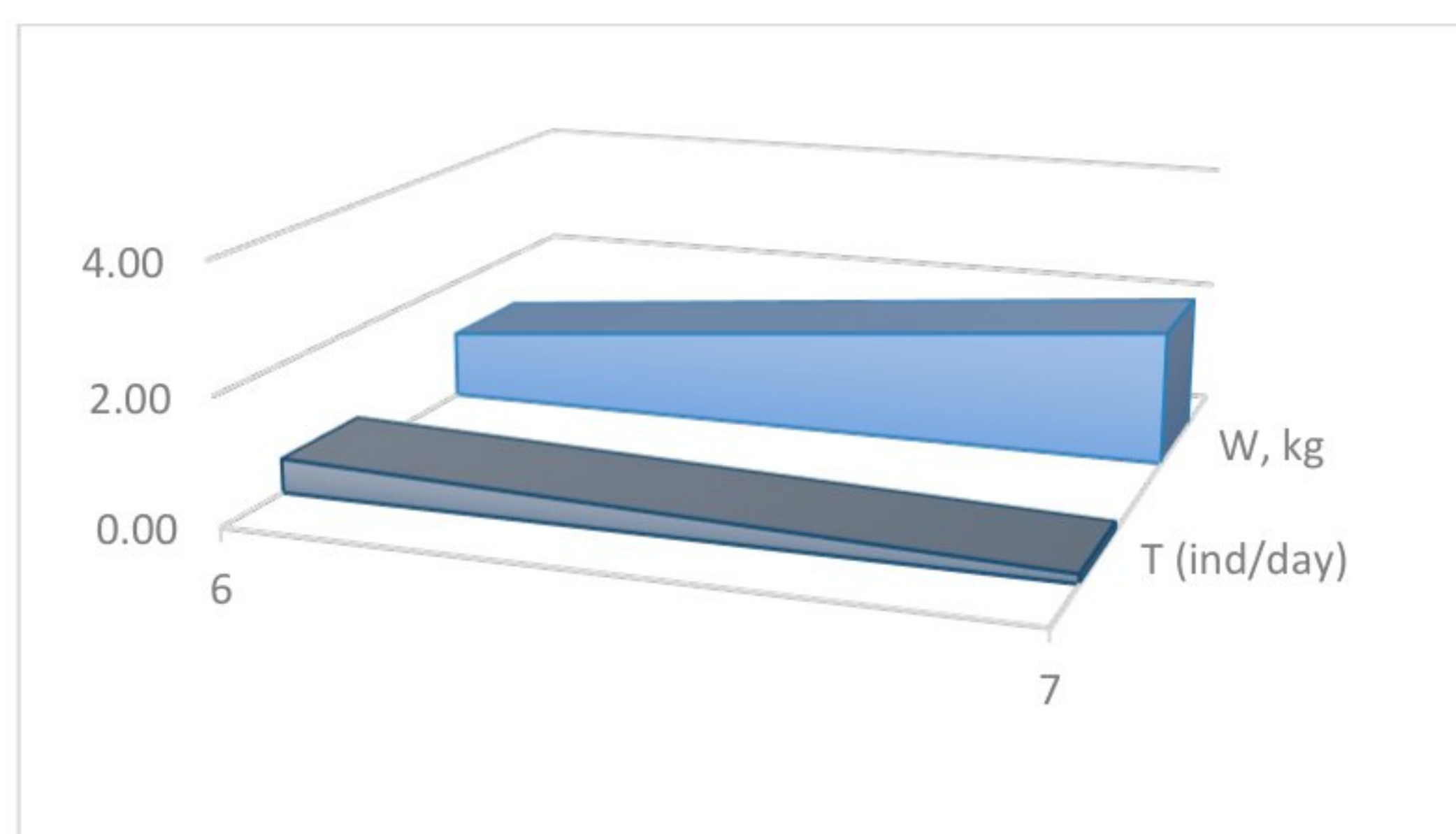


Fig. 34. Monthly fluctuations in the bycatch ratio (T , ind/day) of sensitive species in beam trawl fisheries in 2025.

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Table 24

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 beam trawl fisheries in 2025.

Month	Bycatch species	Total number	Monthly bycatch coefficient	Average size (cm)	Average weight (g)
VI.2025	<i>S. maximus</i>	7	0.54	31.63	1088.3
VII.2025	<i>S. maximus</i>	1	0.14	48.00	2120.0

3.4 Food spectrum of the bycatch species

The data regarding the sizes, weights, and stomach fullness indices of the examined specimens - sprat (*S. sprattis*), spiny dogfish [*S. acanthias*], whiting (*M. merlangus*), and thornback ray (*R. clavata*) are presented in Table 25.

In the samples for dietary spectrum analysis, the mean absolute length of sprat was 8.02 cm $\pm$ 0.22 (SD), and the mean weight was 2.9 g $\pm$ 0.4 (SD). Correspondingly, for spiny dogfish, the values were 120.13 cm $\pm$ 4.22 (SD) and 6864.4 g $\pm$ 669.1 (SD); for whiting, 12.72 cm $\pm$ 1.96 (SD) and 11.5 g $\pm$ 5.1 (SD); and for thornback ray, 69 cm $\pm$ 9.34 (SD) and 2084.4 g $\pm$ 875.2 (SD).

Table 25.

Summary data on the length (L, cm), weight (W, g), and ISF (% of BW) of the fish species in bycatch (sprat (1), spiny dogfish (2), whiting (3), and thornback ray (4)), determined by stomach content analysis in 2025.

1.Sprat

	L, cm	W, g	ISF, % BW
Average value	8.02	2.9	0.69
Standard error	0.05	0.1	0.12
Median	8.00	2.8	0.66
Mode	8.00	3.2	#N/A
Standard deviation	0.22	0.4	0.49
Kurtosis	0.05	0.1	0.24
Skewness	-0.95	-0.2	6.94
Range	-0.02	0.5	2.29
Minimum	7.70	2.4	0.22
Maximum	8.40	3.7	2.30

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Confidence interval (95.0%)	0.11	0.2	0.25
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2. Spiny dogfish

	L, cm	W, g	ISF, % BW
Average value	120.13	6864.4	0.73
Standard error	1.49	236.6	0.22
Median	120.00	6737.5	0.62
Mode	121.00	#N/A	#N/A
Standard deviation	4.22	669.1	0.62
Kurtosis	17.84	447667.4	0.39
Skewness	2.06	0.1	-2.16
Range	0.31	-0.1	0.18
Minimum	113.00	5730.0	0.00
Maximum	128.00	7870.0	1.54
Confidence interval (95.0%)	3.53	559.4	0.52

3. Whiting

	L, cm	W, g	ISF, % BW
Average value	12.72	11.5	0.41
Standard error	0.25	0.7	0.16
Median	13.10	11.0	0.00
Mode	13.40	4.6	0.00
Standard deviation	1.96	5.1	1.26
Kurtosis	3.86	25.8	1.60
Skewness	0.40	0.4	11.21
Range	-0.36	0.6	3.37
Minimum	7.80	3.1	0.00
Maximum	17.70	25.7	6.37
Confidence interval (95.0%)	0.51	1.3	0.33

4. Thornback ray

	L, cm	W, g	ISF, % BW
Average value	69.00	2084.4	0.48
Standard error	2.20	206.3	0.17
Median	68.00	1807.5	0.23
Mode	63.00	1540.0	0.00
Standard deviation	9.34	875.2	0.71
Kurtosis	87.29	765896.7	0.50

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Skewness	-0.13	0.1	2.76
Range	0.62	1.0	1.86
Minimum	56.00	1090.0	0.00
Maximum	90.00	4140.0	2.38
Confidence interval (95.0%)	4.65	435.2	0.35

According to the stomach fullness index data (% BW), *S. sprattus* exhibited the most consistent feeding pattern, with the highest median ISF (0.663% BW) and the lowest variability (variance: 0.243); all individuals demonstrated stomach content presence (minimum: 0.216% BW). *S. acanthias* showed a similar trend (median: 0.615% BW; mean: 0.733% BW) with moderate variability. In contrast, *M. merlangus* and *R. clavata* exhibited markedly different feeding patterns. For both species, 25% of the individuals had empty stomachs. *M. merlangus* exhibited the highest variability (variance: 1.599 ± 1.254 SD) and the highest maximum value (6.367% BW), suggesting highly variable feeding, with some individuals showing very high stomach fullness while most had empty stomachs. For *R. clavata*, the median value was 0.234% BW, with a maximum of 2.375% BW (Fig. 35).

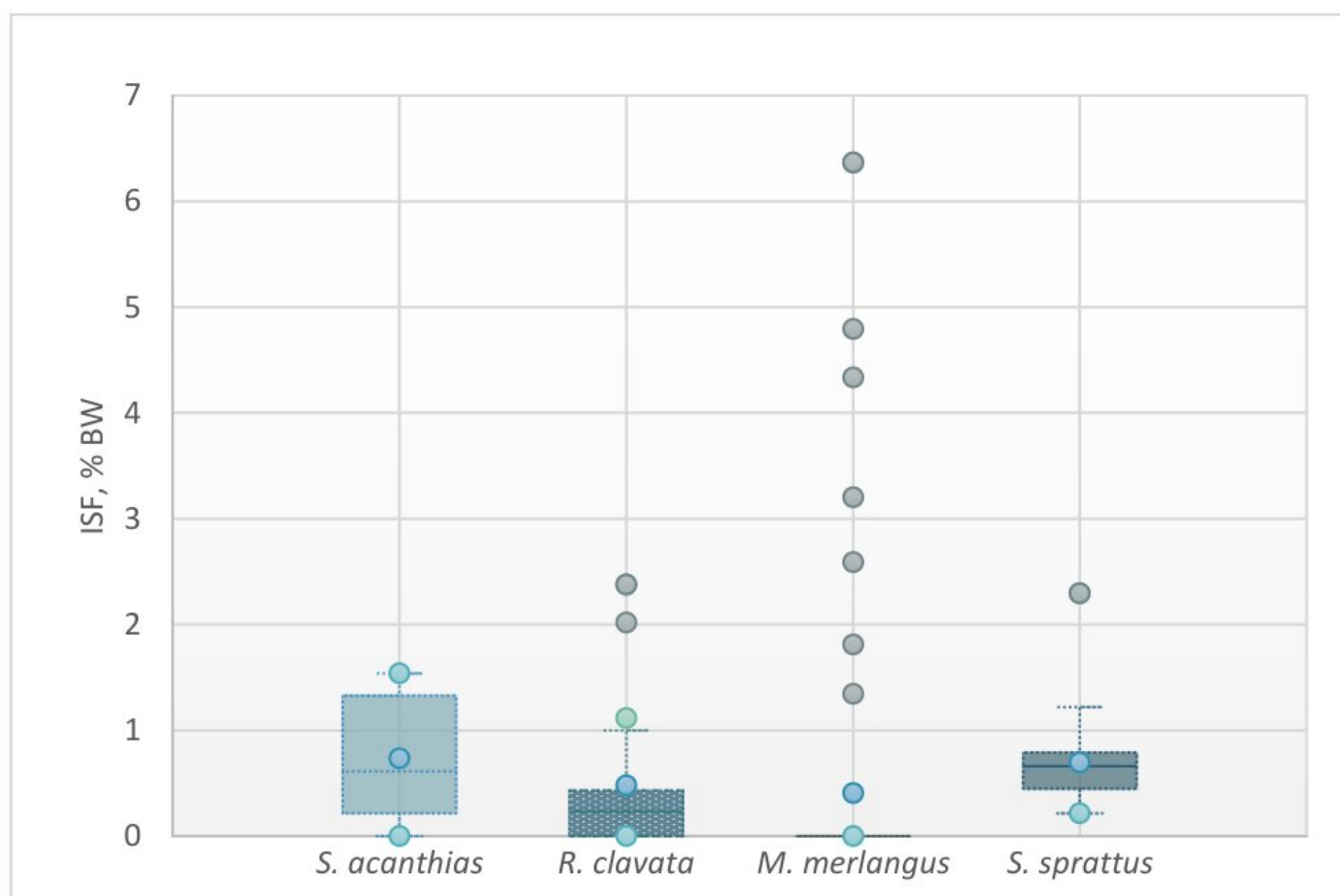


Figure 35. Box plot: ISF (%BW) in the studied fish species in the bycatch (indicated: medians, range of values: 25–75 %, minimum and maximum values)

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

Among the studied predatory fish species in the bycatch, the number of prey items in the stomachs was generally low; however, *S. sprattus*, a zooplanktivorous species, exhibited an increased number of prey items in the stomach (Fig. 36).

For *S. sprattus*, a median of 84 ind/stomach and a mean of 166 ind/stomach $\pm$ 232 SD were recorded, with exceptionally high variability (variance: 57.189); the prey numbers ranged from 2 to 895 ind/stomach, indicating highly variable consumption. In contrast to sprat, the other three species consumed considerably fewer prey items. For *S. acanthias*, a median of 2.0 ind/stomach was recorded (mean: 2.625; range: 0–6) with moderate variability. For the thornback ray, *R. clavata*, a median of 1.0 ind/stomach was established (mean: 1.667; range: 0–5), with relatively low variability.

M. merlangus demonstrated minimal prey consumption, with approximately 75% of individuals having empty stomachs. The mean value was only 0.183 ind/stomach, with a maximum of 2.0 ind/stomach, suggesting very low feeding activity during the study period.

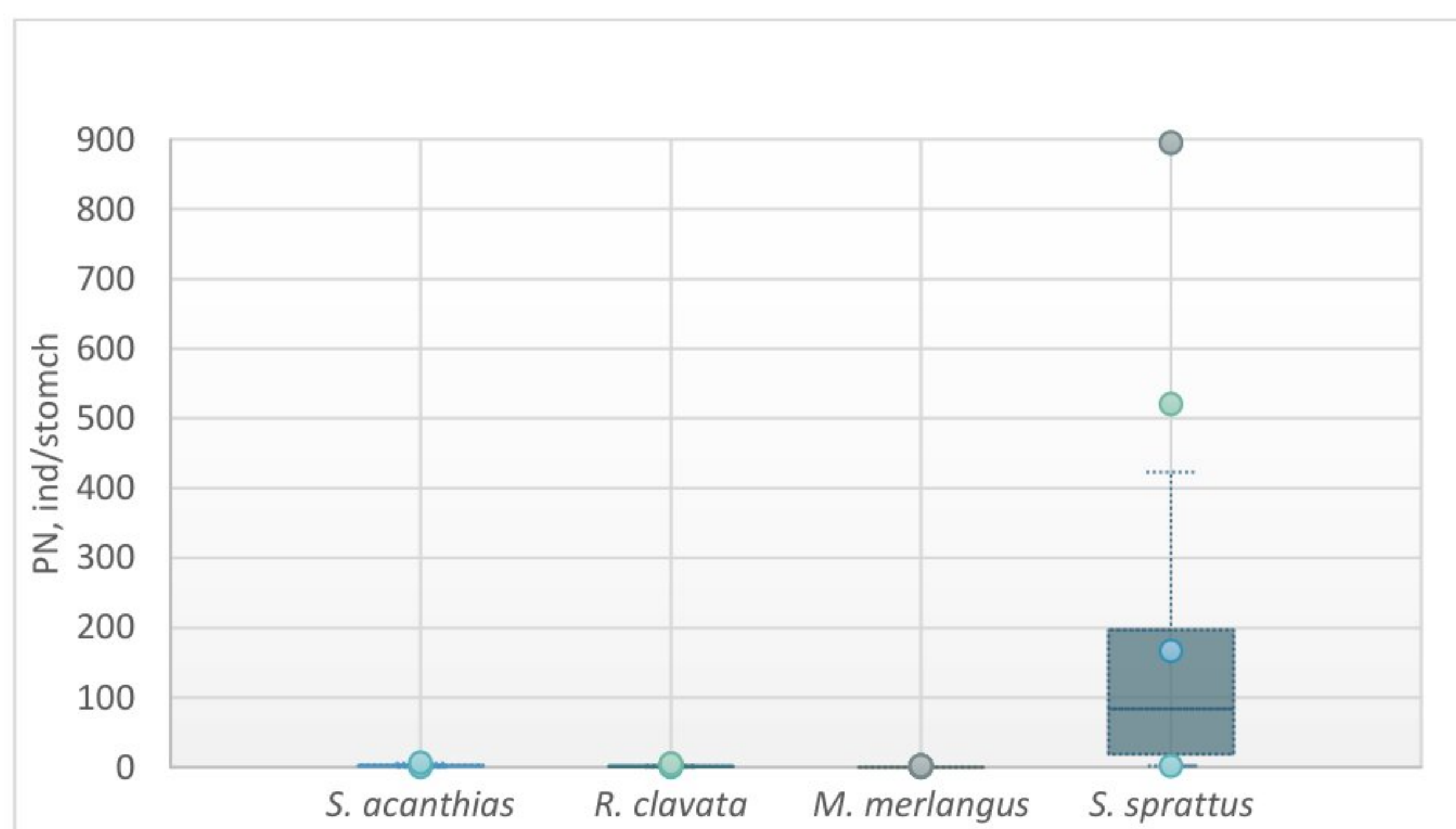


Figure 36. Box plot: Number of established food objects in the stomachs of the investigated fish species in bycatch (indicated: medians, range of values: 25–75 %, minimum and maximum values).



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The indices of relative importance of the main species in the food of the studied fish, calculated according to the percentage participation in terms of number and biomass, as well as the frequency of occurrence, are presented in Table. 26 and Fig. 37.

Table 26.

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
<i>Pseudocalanus elongatus</i>	39.41	28.96	70.59	4826.31
<i>Paracalanus parvus</i>	43.41	12.94	64.71	3646.20
<i>Decapoda larvae</i>	9.01	32.62	58.82	2448.86
<i>Parasagitta setosa</i>	2.05	21.09	17.65	408.37
<i>Acartia clausi</i>	2.62	2.72	70.59	376.30
<i>Lamellibranchia veliger</i>	1.17	0.07	41.18	51.10
<i>Oikopleura dioica</i>	1.34	0.22	17.65	27.64
Others				
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
<i>M. merlangus</i>	43.3	46.5	62.5	5615.90
<i>S. sprattus</i>	16.7	19.1	37.5	1343.06
<i>Cetacea remains</i>	5.0	7.5	12.5	155.73
<i>Engraulis encrasicolus</i>	4.2	7.2	12.5	142.27
Remains	30.8	19.7	75	3786.79
Total	100	100		
Whiting				
Food composition	N (% of the total number)	M (% of total biomass)	FO - Frequency of Occurrence	IRI - Relative Importance Index
<i>S. sprattus</i>	28.57	42.95	3.33	238.41
Remains	71.43	57.05	8.33	1070.65
Total	100	100		

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Thornback ray				
Food composition	N (% of the total number)	M (% of total biomass)	FO - Frequency of Occurrence	IRI - Relative Importance Index
M. merlangus	13.98	17.61	22.22	702.03
Polybius holsatus	4.17	2.19	5.56	35.31
Decapoda	11.30	12.08	22.22	519.43
S.sprattus	1.85	2.26	5.56	22.83
Uranoscopus scaber	5.56	5.56	5.56	61.73
Remains	63.15	60.31	100.00	12345.84
Total	100	100.00		

Based on the Index of Relative Importance (% IRI) data, the zooplanktivorous species *Sprattus sprattus* was clearly distinguished from the predatory fish (*Squalus acanthias*, *Raja clavata*, and *Merlangius merlangus*). The diet of *S. sprattus* was dominated by small crustaceans, primarily the copepods *Pseudocalanus elongatus* (41% IRI) and *Paracalanus parvus* (31% IRI), with Decapoda larvae also contributing substantially (21% IRI). Among the predatory species, a trophic cascade was evident: *M. merlangus* fed on *S. sprattus* (18% IRI), linking the planktonic and piscivorous pathways; *S. acanthias* fed predominantly on *M. merlangus* (51% IRI), indicating predation on this intermediate predator; and *R. clavata* stomachs contained primarily unidentified remains (90% IRI) and negligible amounts of benthic crustaceans, suggesting a benthic-oriented feeding strategy. The data allowed for the delineation of a bentopelagic food chain (*S. sprattus* → *M. merlangus* → *S. acanthias*), whereas *R. clavata* occupied a distinct benthic-predatory niche (Table 26, Fig. 37).

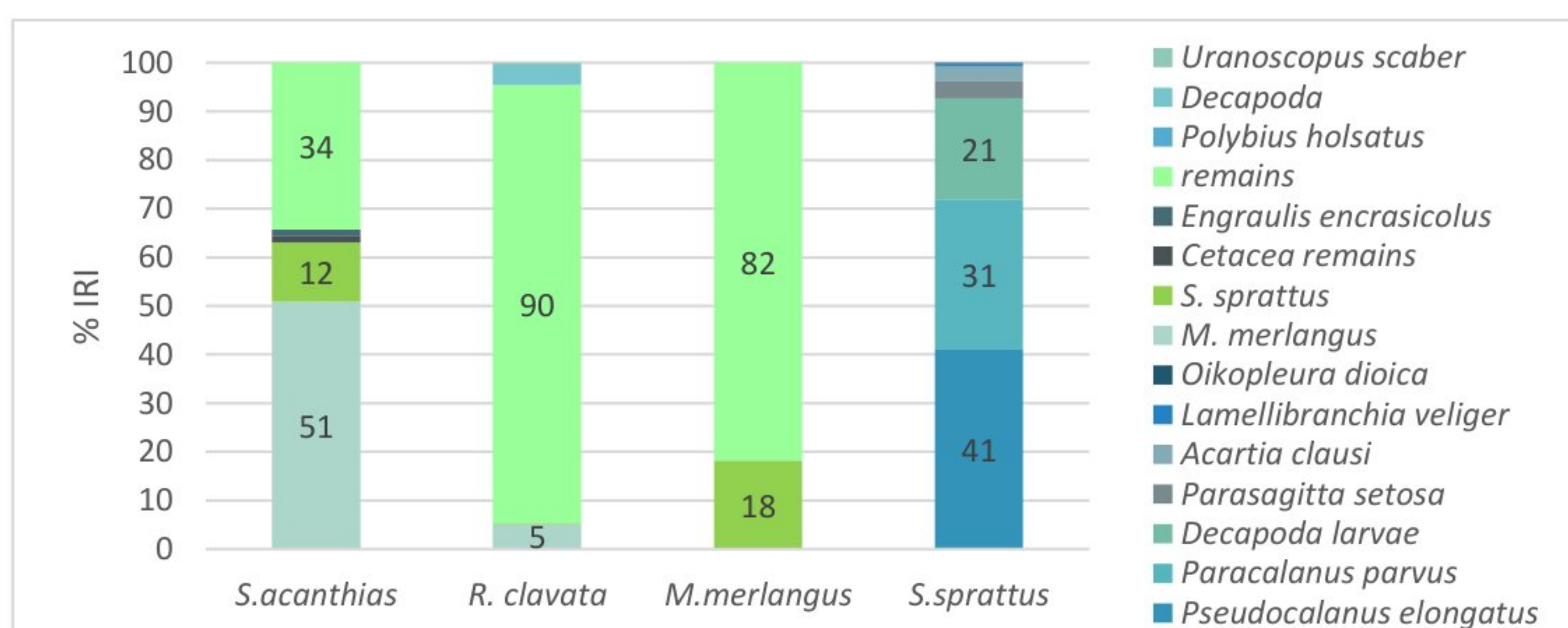


Figure 37. Food composition (% IRI) of bycatch fish species.

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3.5 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 27).

Table 27

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 the observations in 2025 and the calculations of the bycatch rate (% TC), both gillnet and pelagic trawl fisheries, particularly vessel segments with lengths < 24 m (TM VL1218 and TM VL1824), were assessed to have a very high impact on marine organisms. The TM VL1824 segment had the highest bycatch rate (44.75 %), indicating that almost half of the total catch consisted of non-target species. At the same time, the beam trawl (TBB VL 1218) and OTM fisheries in the large vessel segment had a low impact, with a bycatch rate of < 3% TC (Fig 38).



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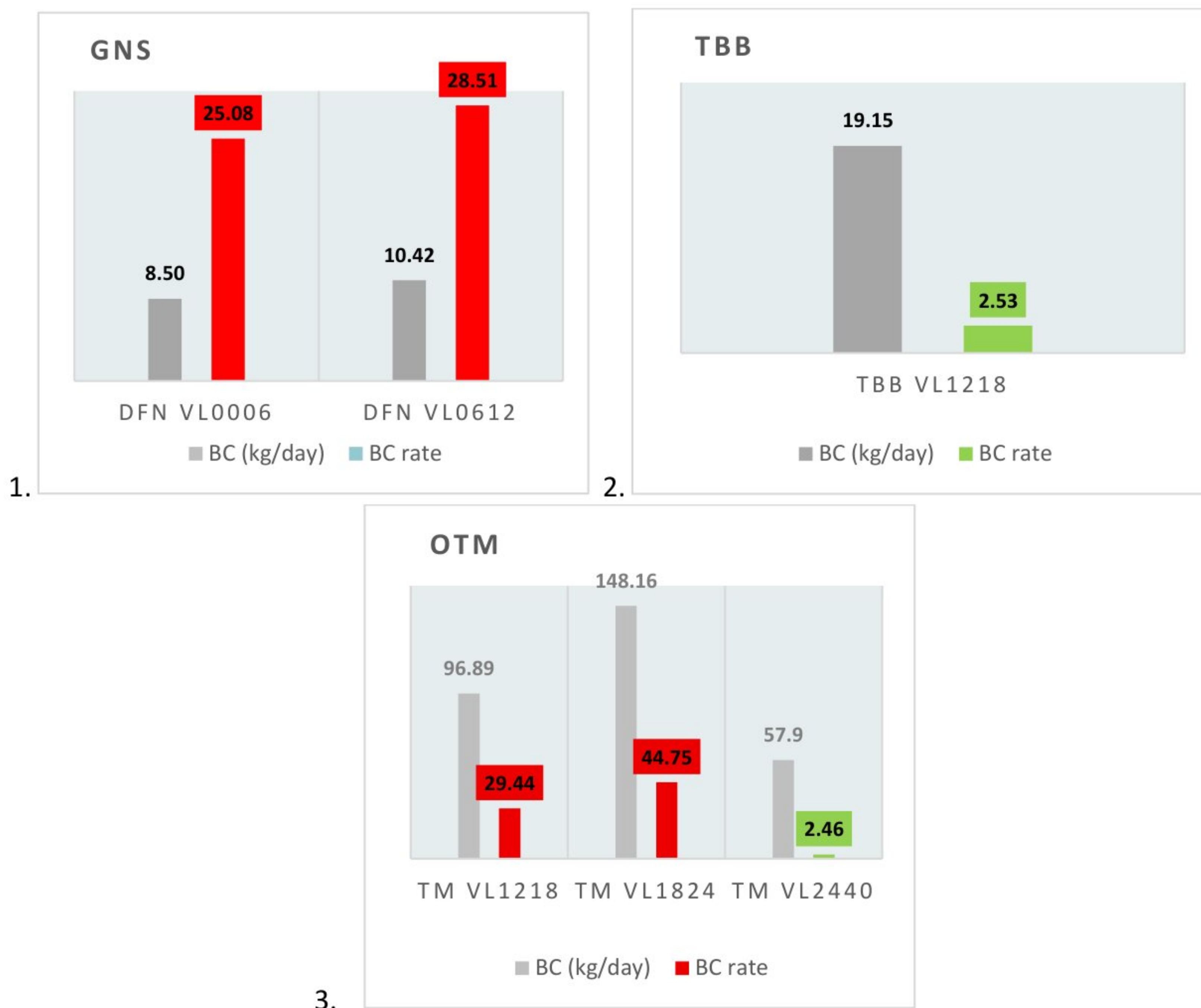


Figure 38. The bycatch rates (% TC) of the fisheries and segments by 2025 (1. GNS - gill nets, 2. PMP: polyvalent vessels (mixed catch), 3.TBB - beam trawling for rapa whelk 4. OTM: pelagic trawling).

When considering only the average daily bycatch quantities, the highest values were again observed in the segments of smaller vessels operating with pelagic trawls, with TM VL1824 generating a bycatch of 148.16 kg/day, followed by TM VL1218 with 96.89 kg/day. However, it should be noted that gelatinous zooplankton contributes significantly to the total bycatch weight (averaging 21% BCW) when pelagic trawls are used. In contrast, DFN vessel segments show considerably lower absolute bycatch quantities (8.50 - 10.42 kg/day).

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3.6 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-codb.bas.bg/rdb/bg/>.

In 2025, 154 individuals from sensitive species groups were recorded as bycatch, with their distribution across fishing activity types presented in Fig. 39.1.

Three groups of sensitive species were identified in the bycatch, with chondrichthyans being dominant (59.7%), followed by turbot (39.6%) and a negligible presence of *Acipenseridae* (0.7% of the total number) (Fig. 39.2).

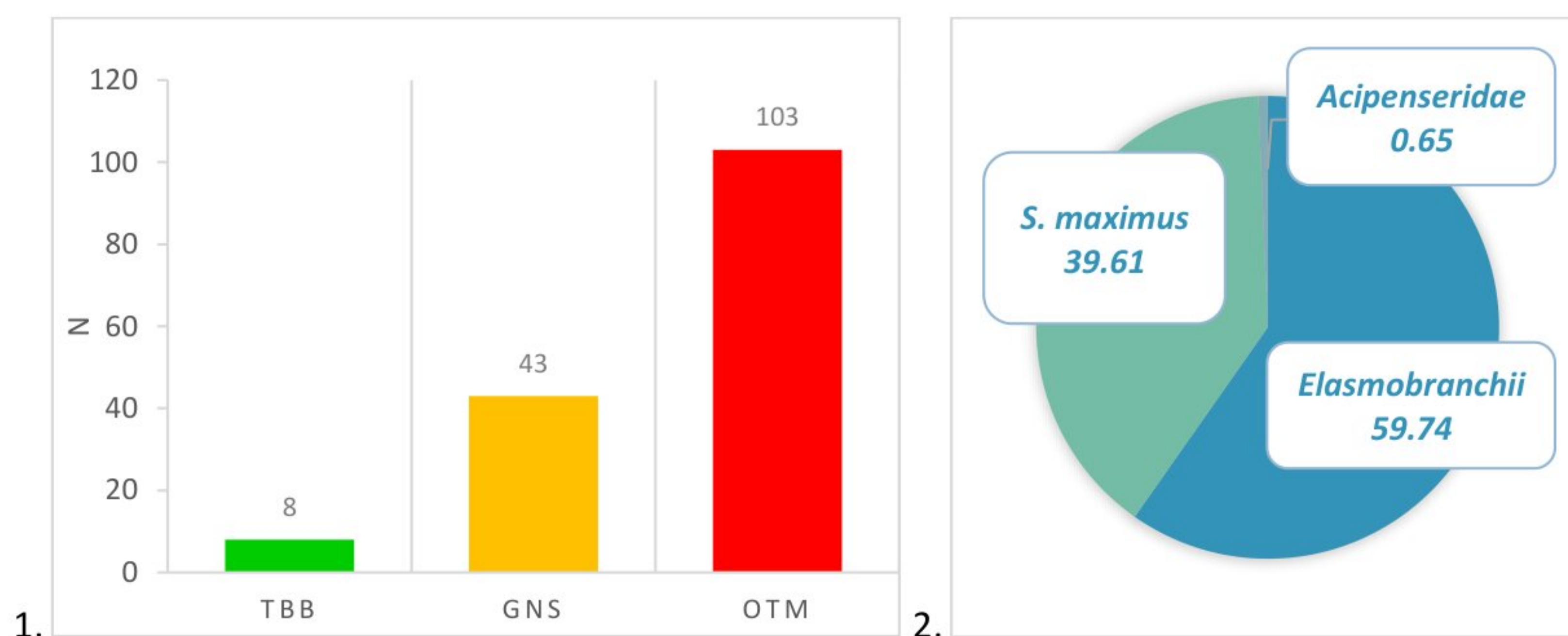


Figure 39. (1) Total number of specimens of the sensitive species group caught by fishing activity during the entire monitoring period in 2025. (2) Structure (% of the total number) of sensitive species bycatch in 2025.

The assessment of impacts on sensitive species was based on the indicator "bycatch coefficient of sensitive species" (FAO, 2019b), where the bycatch coefficient (T, for a given species and fleet segment) is calculated as: $T = N/D$, with N being the sum of individuals of each species



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caught per fishing day (n_i), so that $N = \sum n_i$, and D being the total number of observed fishing days. In 2025, the highest bycatch coefficient for individuals from the group of sensitive species (4.78 ind/day) was recorded in pelagic trawl fishing within the TM VL1218 vessel segment, whereas the lowest bycatch coefficient was observed in beam trawl fishing within the TBB VL1218 segment (0.32 ind/day; Fig. 40).

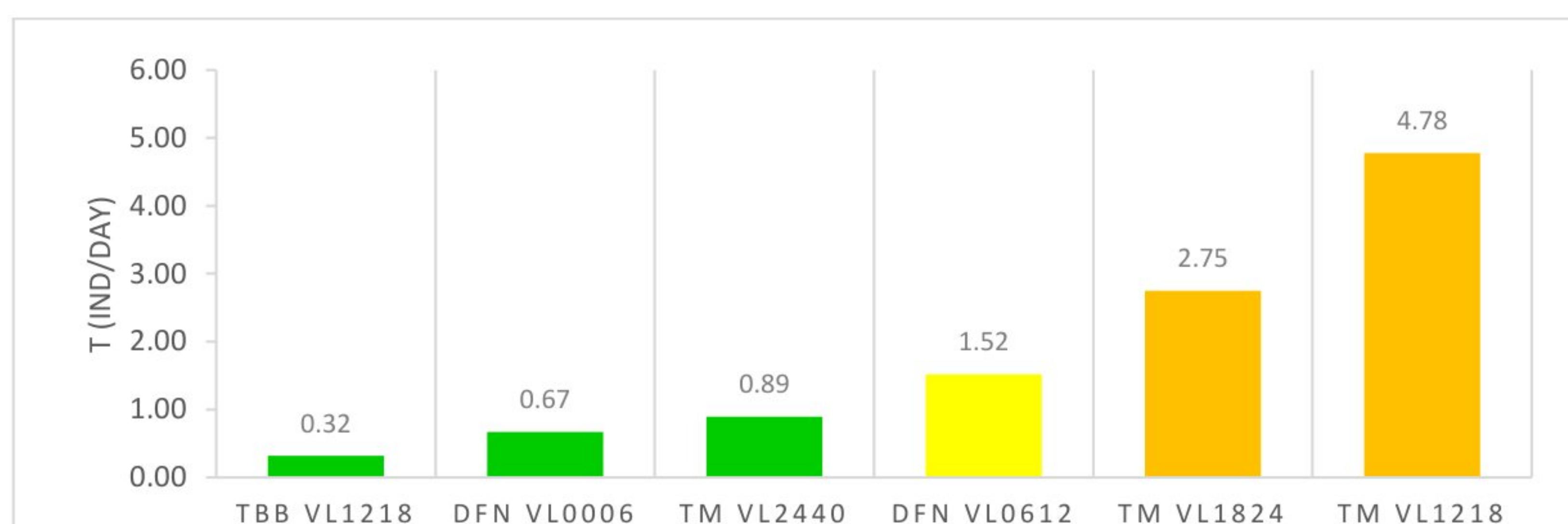


Figure 40. Coefficient of bycatch (T , ind /day) of the group of sensitive species by fishing activities and by fishing segments in 2025.

No marine mammals were recorded as bycatch in this study. From the family Acipenseridae, only a single live specimen was caught during pelagic trawling in the TM VL1824 fleet segment, and it was released back into the sea.

Overall, gillnets resulted in a higher bycatch rate of sensitive chondrichthyan species (1.44 ind/day) than OTM, which had a rate of 1.09 ind/day. Bycatch of spiny dogfish (*Squalus acanthias*) was significantly higher in gillnets (0.3 ind/day) than in pelagic trawls (0.04 ind/day), indicating a 7.5-fold difference in the bycatch coefficient. A similar trend was observed for *Raja clavata*, which also showed greater vulnerability to gillnets (0.87 ind/day) than to pelagic trawls (0.47 ind/day), making it the most frequently caught species with both gear types. In contrast, *Dasyatis pastinaca* exhibited the opposite pattern, with higher bycatch rates in pelagic trawls (0.58 ind/day) compared to gillnets (0.27 ind/day) (Fig. 41). Mortality among captured Elasmobranchii individuals was 100% in gillnet catches, whereas those caught in pelagic trawls were alive and viable upon retrieval.



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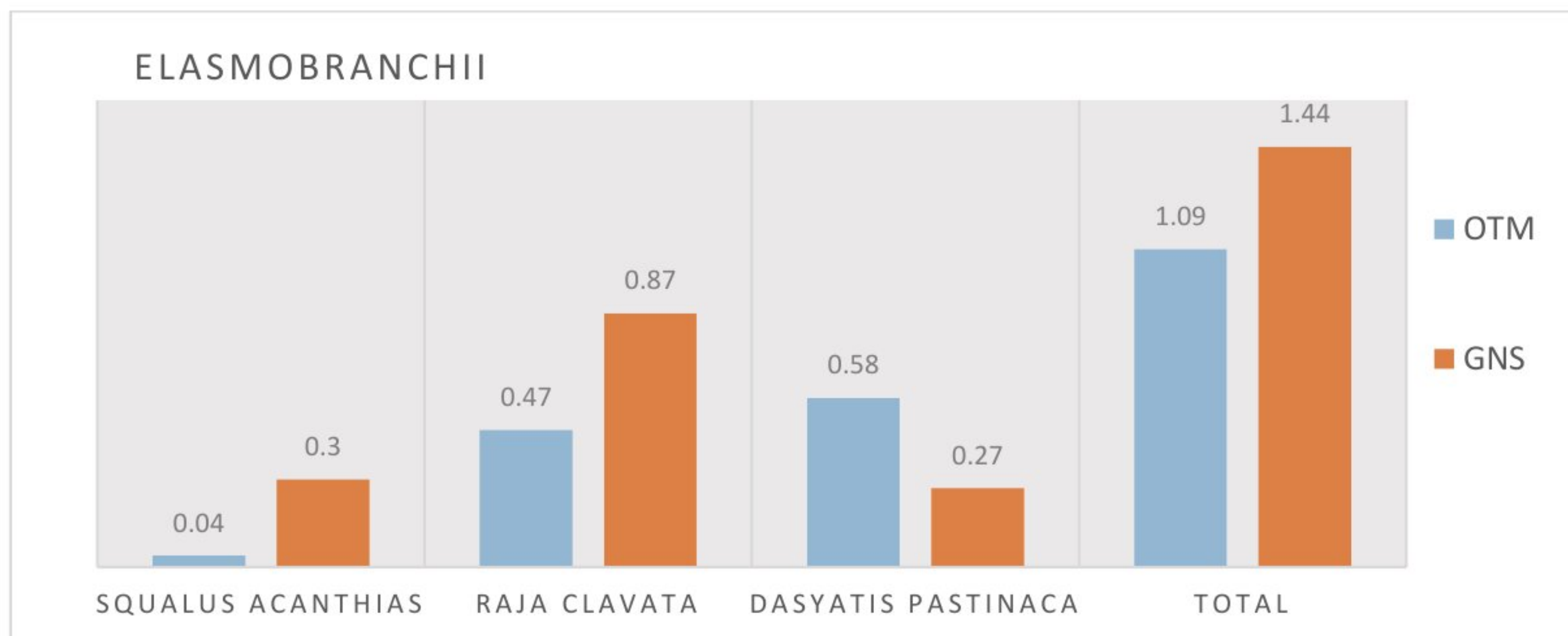
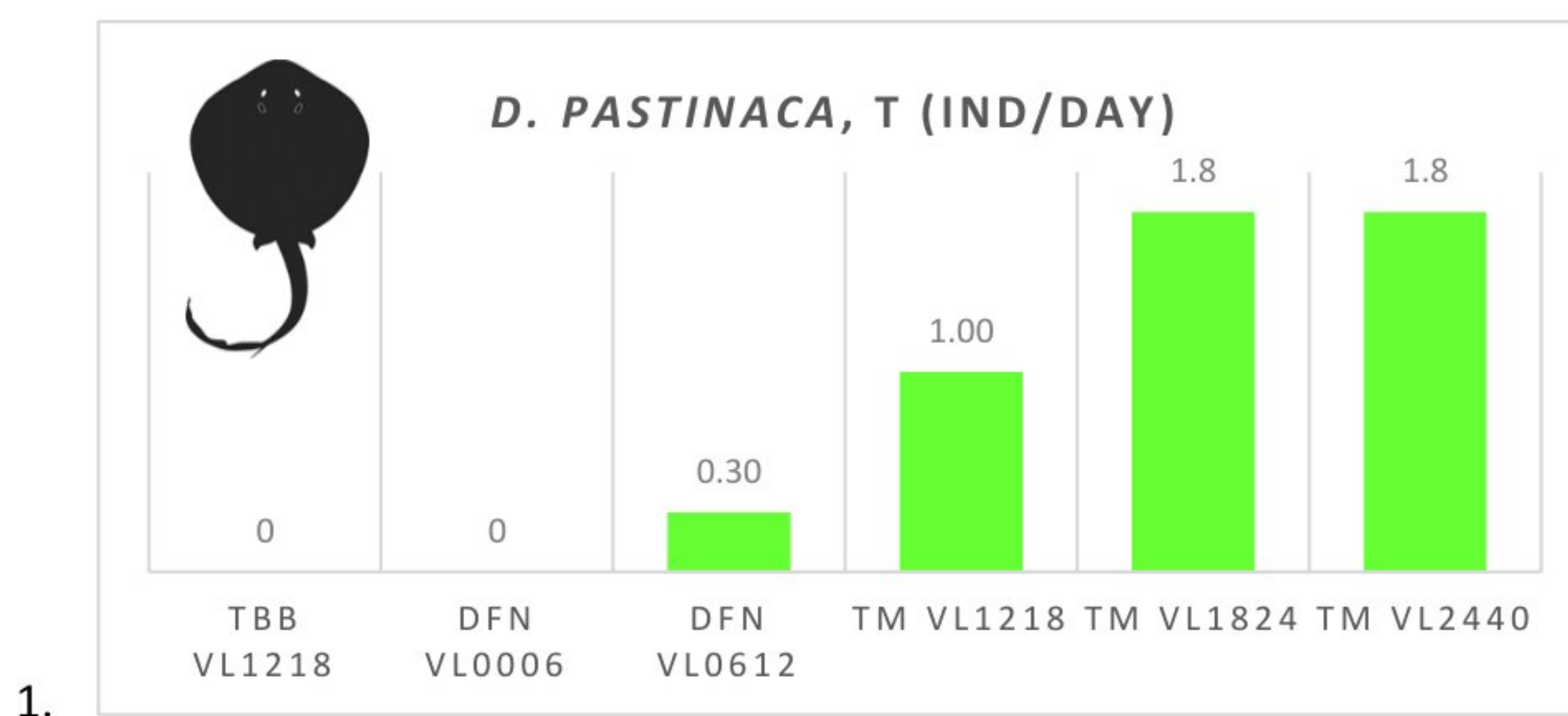


Fig. 41. Bycatch rate (T, ind/day) of Elasmobranchii species by fishing activity in 2025.

Studies on the bycatch of individual chondrichthyan species across fishing segments have shown that *D. pastinaca* has the highest bycatch coefficient in pelagic trawl fisheries within the segment of larger vessels (T = 0.88–0.89 ind/day; Fig. 42.1). For *Raja clavata* and spiny dogfish, the maximum daily bycatch coefficients were recorded in the DFN VL0612 fishing segment, with T = 0.89 ind/day (Fig. 42.2) and T = 0.33 ind/day (Fig. 42.3), respectively.



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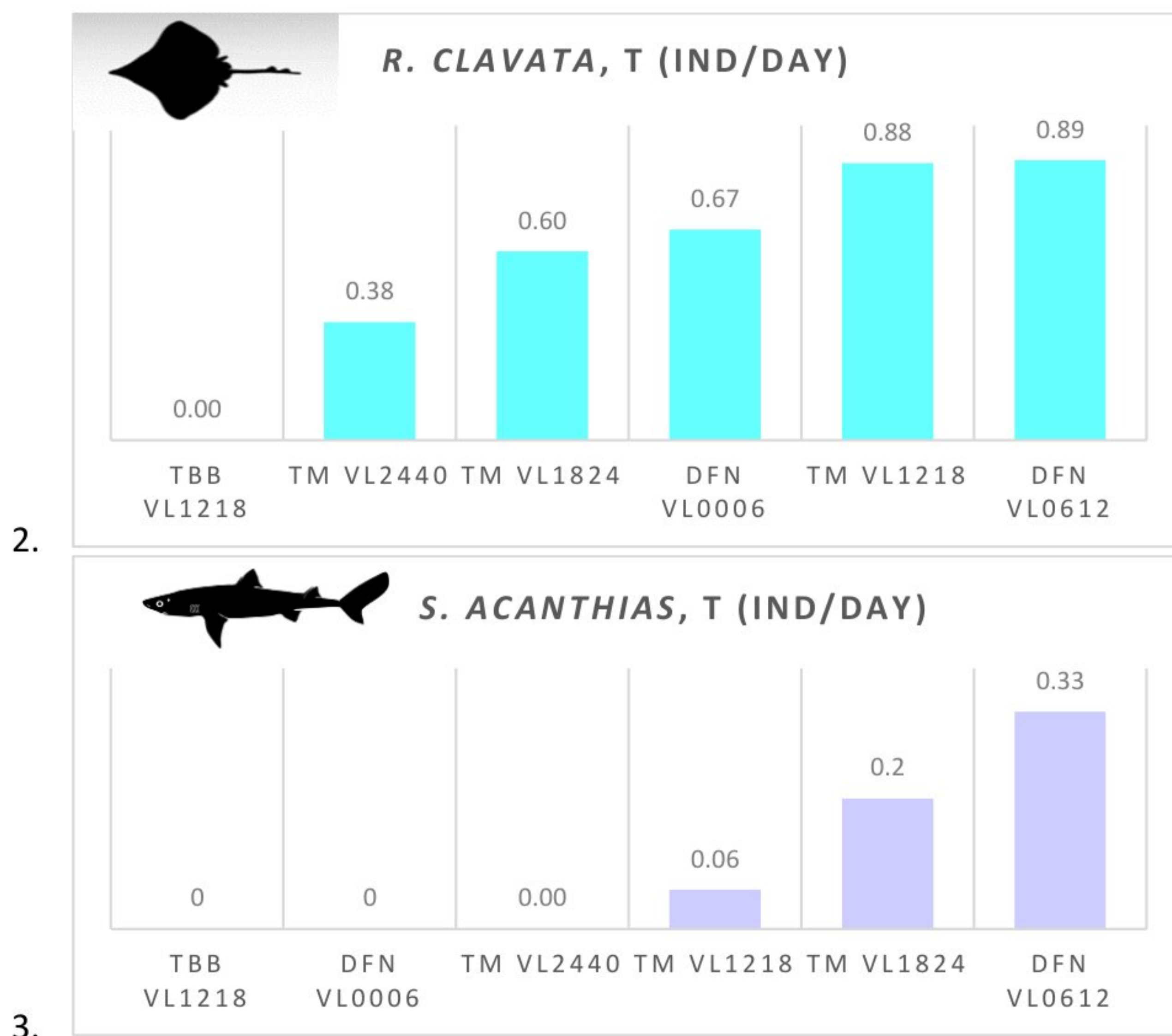


Fig. 42. Bycatch ratio (T, ind/day) of Elasmobranchii species by fishing segment in 2025: (1) *Dasyatis pastinaca*, (2) *Raja clavata*, and (3) *Squalus acanthias*.

The turbot (*Scophthalmus maximus*) is listed in the "Red Book for the Black Sea," but its current IUCN status is LC (Least Concern; Cardinale et al., 2020). In 2025, the highest bycatch coefficient for turbot was recorded in pelagic trawl fishing within the small-vessel segment TM VL1218, with $T = 3.12$ ind/day (Fig. 43.1).

In 2025, across the surveyed fishing segments, the average daily bycatch quantity of turbot ranged from 0.25 to 2.42 kg/day. The bycatch rate (% TC) varied among segments and fishing activities, reaching a maximum of 0.66% of the total catch in pelagic trawl fisheries within the TM VL1218 segment (Fig. 43.2).

The mortality of turbot in bycatch was highest in beam trawling for *Rapana* (~85%), whereas in pelagic trawl fisheries, approximately 90% of the bycaught turbot were alive and viable upon retrieval.

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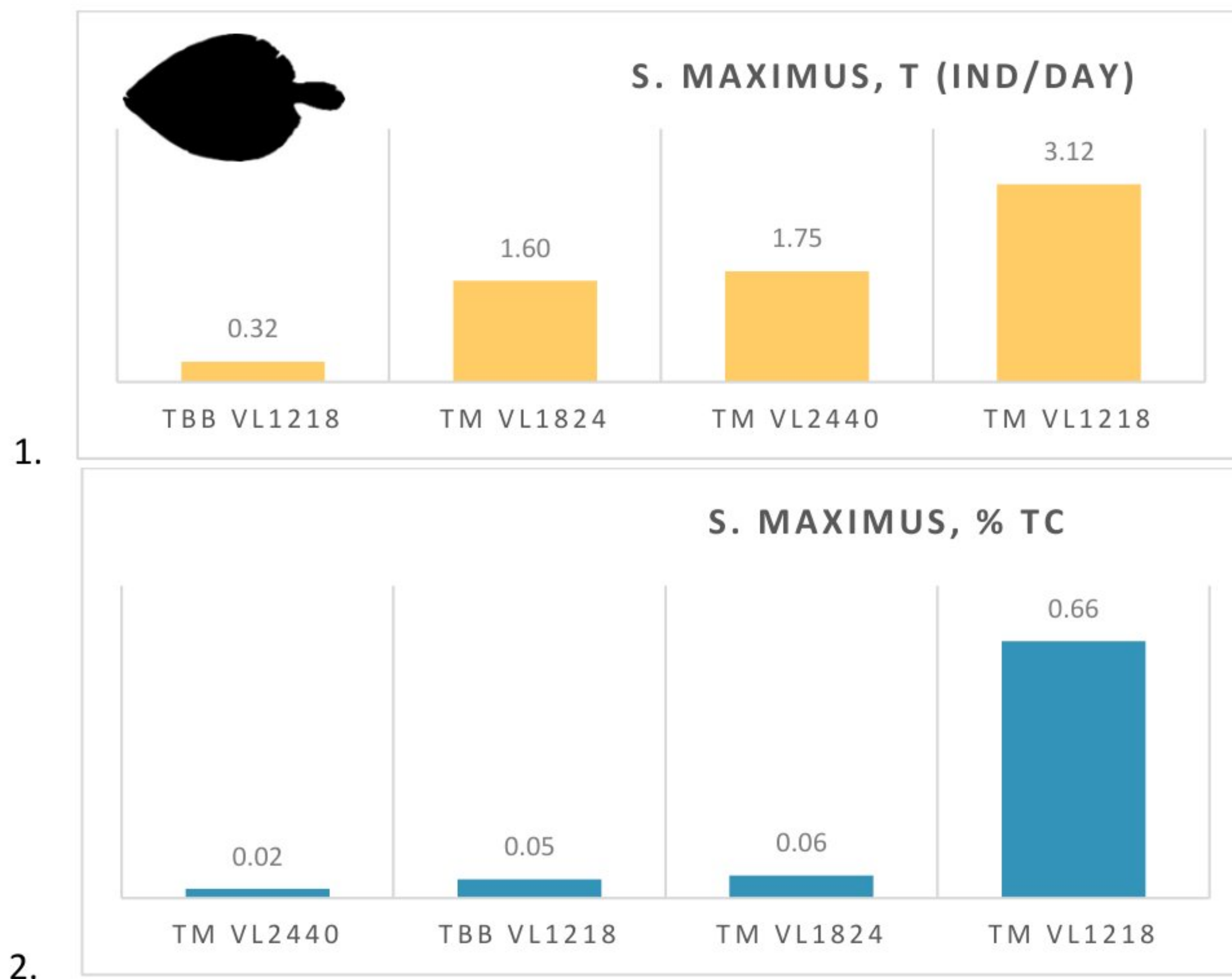


Fig. 43. Turbot bycatch by fishing segment in 2025: (1) turbot bycatch ratio (T, ind/day) and (2) percentage of bycatch by total catch (% TC).

Seasonal fluctuations in the bycatch coefficient of sensitive species were identified across different fishing activities (Fig. 44). The highest bycatch intensity was recorded in pelagic trawls, particularly during the summer months.

For turbot (*S. maximus*), the bycatch rate increased in July 2025 (6.8 ind/day), with elevated values observed again in October (4 ind/day) and November (2.5 ind/day). *Raja clavata* reached its peak bycatch in September (2.33 ind/day), with moderate occurrence in July (1.2 ind/day). *Dasyatis pastinaca* appeared only after August, showing maximum bycatch coefficients in September (4 ind/day) and August (1.86 ind/day). In pelagic trawls, spiny dogfish (*Squalus acanthias*) was caught only during autumn (October-November), at low levels (0.25-0.5 ind/day).

In gillnets, *R. clavata* showed the highest bycatch in early spring (March 2025: 2.7 ind/day), with a secondary increase in July (1.17 ind/day). The bycatch coefficient for *S. acanthias* peaked in June (0.8 ind/day), whereas that for *D. pastinaca* peaked in November (1 ind/day) and was moderate in March (0.7 ind/day), indicating an extended seasonal vulnerability.

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In beam trawl fisheries, turbot was the only sensitive species recorded in the bycatch, primarily caught in June (0.54 ind/day) and July (0.14 ind/day), with no bycatch recorded in May, August, and September.



Fig. 44. Seasonal fluctuations in the bycatch coefficient (T, ind/day) of sensitive species based on fishing activity in 2025: (1) gillnet fishery and (2) beam trawl fishery.

The data collected this year indicate that the summer months (June–September) represent a critical period for the formation of bycatch of vulnerable species, particularly in pelagic trawl fisheries. In contrast, gillnets pose a risk over a broader seasonal window, extending from early spring to late autumn.

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4. Conclusions

1. In 2025, the scientific observer coverage of the Bulgarian fishing fleet encompassed 100 fishing days: 30 days on gillnet vessels, 45 days on pelagic trawl vessels, and 25 days on beam trawl vessels. Spatially, the observations covered the entire Bulgarian Black Sea coast from Durankulak to Sozopol. Gillnet fishing operations were conducted off the Shabla-Durankulak area, pelagic trawl surveys were concentrated in the southern part of the wide Burgas Bay and off the northern coast, and beam trawling for *Rapana venosa* occurred off the northern and central coasts in the Kaliakra-Kamchia zone. No discards were observed in the marine environment during the study period, and bycatch primarily consisted of fish species, cnidarians, mollusks and crustaceans.
2. Observations on fishing with anchored gillnets covered two fleet segments - DFN VL0006 and DFN VL0612. However, as no statistically significant differences were found in the main catch and bycatch between the segments, analyses of these parameters are presented collectively. The target catches from the monitored gillnets consisted of turbot (*Scophthalmus maximus*), while the bycatch species composition primarily included Mediterranean mussel (*Mytilus galloprovincialis*), thornback ray (*Raja clavata*), common stingray (*Dasyatis pastinaca*), spiny dogfish (*Squalus acanthias*), and rapa whelk. During the study period, the average daily target catch was 31.6 kg/day $\pm$ 3.66 SE, with an average bycatch of 10.42 kg/day $\pm$ 1.25 SE, total catch weight of 42.01 kg/day $\pm$ 3.75 SE, and mean bycatch contribution to the total catch of 28.51% $\pm$ 3.52 SE. The average length of turbot in the target catch was 53.262 cm $\pm$ 8.31 SD, with a mean weight of 2468.59 g TW $\pm$ 598.57 SD. The length-weight relationship of turbot was described by $W = 0.797 \cdot L^{2.038}$ ($R^2 = 0.857$), where the coefficient $b = 2.04$ indicates negative allometry. Bycatch weight in this fishery was dominated by Mediterranean mussel (51.02%), followed by smaller contributions from thornback ray (20.3%), common stingray (17.7%), and spiny dogfish (10.9%). A total of 43 individuals from three chondrichthyan species were caught during the entire study period, all classified as sensitive species and exhibiting high mortality rates. The highest bycatch coefficient was recorded for thornback ray, $T = 0.87$ ind/day. Overall, the variability in the weight of the elasmobranch specimens in the bycatch exceeded that in length for all species. The relatively stable mean lengths for *R. clavata* and *D. pastinaca* in the bycatch suggest size-selective bycatch in adult cohorts, while the greater variability in *S. acanthias* is likely associated with seasonality in size-class distribution.
3. Research on pelagic trawl fisheries has covered both sprat and mixed catches of Mediterranean horse mackerel and red mullet. The study encompassed three fishing segments: TM VL1218 (4 vessels, 18 fishing days), TM VL1824 (1 vessel, 8 fishing days), and

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TM VL2440 (4 vessels, 19 fishing days). Mean daily catches averaged 1269.92 kg/day $\pm$ 220.40 SE, while fish and crustacean bycatch ranged between 0.23–544.37 kg/day, and bycatch of gelatinous zooplankton (*Aurelia aurita*) reached a mean of 20.45 kg/day $\pm$ 9.49 SE. Statistical data by fishing segment indicate higher catches in the segment comprising the largest vessels (TM VL2440), although the bycatch within this segment was the lowest. In the ichthyological samples from the main sprat catches during spring, one-year-old specimens dominated, accounting for 83.47% (May) and 66% (September), followed by two-year-old specimens at 14.13% and 34%, respectively. Sprat sizes in the samples ranged between 5.5–10.6 cm, with mean lengths of 7.43–8.04 cm and a mean weight of 2.6–3.0 g. The mean condition factor of sprat varied between 0.56 and 0.60 across different age groups. Female and male specimens showed similar proportions of 49% and 46%, respectively, followed by 3% juvenile sexually unidentified specimens. During spring, the dominant age group 1,1+ predominantly exhibited Gonad Maturity Stage 3, indicating active reproduction, while group 2,2+ (14.13%) was in transition between Stage 3 and 4, reflecting participation in reproduction and/or post-reproductive depletion, with the condition index ($K = 0.60$) indicating energy investment in spawning. During autumn, the population transitioned to preparation for winter reproduction, with age group 1,1+ in Stage 2 showing initial gonad differentiation, and group 2,2+ (34%) displaying more advanced maturity (Stage 2–3) at a condition index of $K = 0.57$. For red mullet (*M. barbatus ponticus*) in the main catches, one-year-old individuals dominated (65.9–68.6%), followed by two-year-olds (26.8–29.3%), with a female: male ratio of 75:25. The seasonal dynamics of maturity confirmed the summer reproductive cycle: during summer, older age groups were in Stage 3-ready for reproduction, with a low condition index ($K = 0.73–0.78$), while in autumn, the population entered post-reproductive recovery, with the dominant group 1,1+ in Stage 4 showing depleted gonads, and older individuals transitioning to Stage 5, the resting phase. For Mediterranean horse mackerel (*T. mediterraneus*) in the main catches during the second half of 2025, one-year-old individuals dominated (67.92%), followed by two-year-olds (16.01%), with zero-year-olds poorly represented (9.19%) and single four-year-old specimens recorded; the female : male :juvenile ratio was 49.5:40.5:10%. The size range (6.7–17.2 cm) and mean weight (9.8–15.7 g) reflect the capture of predominantly young age classes, whereas the condition index ($K = 0.74–0.89$) indicates a relatively homogeneous physiological state within the population. Autumn data, following the completion of the summer reproductive period (May–September), confirmed post-reproductive recovery. A total of 57 species of marine organisms were identified in the bycatch, with an average of ~13 species recorded per fishing day. The dominant species by weight in the bycatch were whiting (*M. merlangus*) at 23% and moon jellyfish (*Aurelia aurita*) at 21%. Smaller proportions included the black mussel (5%), turbot (*Scophthalmus maximus*, 3.3%), small-sized Mediterranean horse mackerel (3.57%), and bluefish (*Pomatomus saltatrix*, 2.9%), whereas all other species accounted for <2% of the mean bycatch weight. For whiting (*M. merlangus*), the main bycatch species in pelagic trawls, a seasonal shift in dominant age groups was observed: during spring, two- and three-year-

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old individuals prevailed (29.01% and 27.54%), whereas in autumn, zero- and one-year-old specimens dominated (36.28% and 38.60%). The seasonal dynamics of maturity confirmed the winter reproductive cycle: during spring, older age groups were in a post-reproductive stage (Stage 4–5) with depleted gonads and a low condition index ($K = 0.73–0.78$), whereas in autumn, the population entered a preparation phase for reproduction, with mature individuals reaching Stage 3 with well-developed gonads, and condition factor values ($K = 0.72–0.76$) indicating initial accumulation of energy reserves. A pronounced dominance of female specimens (60.33%) was observed. The total number of sensitive species caught during this fishing activity was 103 specimens representing five species (*Raja clavata*, *Dasyatis pastinaca*, *Squalus acanthias*, sturgeons Acipenseridae, and turbot *Scophthalmus maximus*); all specimens were caught alive and without serious injuries. Among the registered sensitive species in the bycatch, turbot exhibited the highest bycatch coefficient ($T = 1.18$ ind/day).

4. The study of rapa whelk (*Rapana venosa*) fishing with beam trawls covered segment TBB VL1218 (5 vessels, 25 fishing days). The catches of *R. venosa* ranged between 120 and 2245 kg/day, while bycatch quantities varied between 0.98–121.44 kg/day; total catch averaged 833.67 kg/day ± 101.51 SE, and the mean percentage share of bycatch was 2.53% ± 0.66 SE of this catch. The mean amount of marine litter was 1.64 kg/day ± 0.49 SE, representing 0.21% ± 0.06 SE of total catch. Accordingly, during the study period, the mean size of *R. venosa* was 59.945 mm ± 7.81 SD, with a mean weight of 37.61 g ± 15.21 SD. The 50–70 mm size group showed the most significant presence in catches, accounting for 83% of the measured rapa whelk specimens. The leading weight group in the target catch was 20–50 g (83% of the measured specimens). The species composition of bycatch in rapa whelk fishing is diverse, encompassing 30 species of fish, arthropods, and mollusks, with a maximum of 24 different marine organism species recorded per day in beam trawls. The most frequently occurring species in bycatch was the stargazer (*Uranoscopus scaber*), present in 100% of daily bycatch samples, followed by whiting (*Merlangius merlangus*), the clams *Anadara kagoshimensis* and *Flexopecten glaber*, and the swimming crab, each recorded in 96% of bycatch samples. The dominant species by weight in the bycatch was *M. merlangus*, accounting for 50%, followed by *A. kagoshimensis* (24%), stargazer (16%), swimming crab (4%), and turbot (1.5%), while all other species had lower shares. The turbot bycatch included specimens with a mean size of 34.35 cm and a mean weight of 0.954 kg. Among the sensitive species, eight turbot specimens were recorded in the bycatch, with a bycatch coefficient of $T = 0.32$ ind/day.
5. During the study period, the feeding ecology of the following bycatch fish species was analysed: sprat (*S. sprattus*), whiting (*M. merlangus*), spiny dogfish (*S. acanthias*), and thornback ray (*R. clavata*). The highest mean stomach fullness index values were recorded for spiny dogfish (0.73% BW) and sprat (0.69% BW), followed by thornback ray (0.48% BW), and whiting (0.41% BW). The zooplanktivorous sprat exhibited a considerably higher

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number of prey items in the stomach (median: 84 ind/stomach) than the predatory species (medians: 1.0–2.0 ind/stomach). Based on the Index of Relative Importance (% IRI), the diet of sprat was dominated by the copepods *Pseudocalanus elongatus* (41% IRI) and *Paracalanus parvus* (31% IRI), with decapod larvae also contributing substantially (21% IRI). Among the predatory species, the dietary spectrum of whiting showed a high proportion of unidentified remains (82% IRI) and consumption of sprat (18% IRI). For spiny dogfish, whiting predominated (51% IRI), whereas the diet of thornback rays was dominated by unidentified remains (90% IRI), with negligible contributions from benthic crustaceans. The data delineate a functional bento-pelagic food chain (*S. sprattus* → *M. merlangus* → *S. acanthias*), while *R. clavata* shows a distinct benthic-oriented trophic niche.

6. To assess the impact of different fishing activities and fleet segments, the bycatch rate (BCR, % TC) was used as an indicator, whereas the bycatch coefficient (T, ind/day) was applied to evaluate the effects on sensitive species. Both gillnet and pelagic trawl fisheries were assessed to have a very strong impact on marine organisms, particularly vessel segments with lengths < 24 m. The TM VL1824 segment exhibited the highest bycatch rate at 44.75%, indicating that nearly half of the total catch consisted of non-target species. In contrast, beam trawling (TBB VL1218) and OTM fisheries in the large-vessel segment showed a low impact, with bycatch rates below 3% TC.

7. In 2025, 154 individuals from sensitive species were recorded as bycatch, belonging to three main groups: chondrichthyans accounted for 59.7% of the total number, turbot (*Scophthalmus maximus*) for 39.6%, and Acipenseridae for a negligible 0.7%. No marine mammals were observed during the study period. Only one live specimen from the family Acipenseridae was caught as bycatch in a pelagic trawl (fleet segment TM VL1824) and was released back into the sea alive. The highest total number of sensitive species (103 individuals, with turbot representing 51.5%) was recorded in pelagic trawl fisheries. For chondrichthyans, the cumulative bycatch coefficient reached $T = 1.44$ ind/day in gillnet fisheries and $T = 1.09$ ind/day in pelagic trawls. Mortality among captured Elasmobranchii was 100% in gillnets, whereas a significant proportion of these species remained alive and viable when caught in pelagic trawls. The highest bycatch coefficient for turbot was recorded in pelagic trawl operations within the small-vessel segment TM VL1218 ($T = 3.12$ ind/day). Seasonal fluctuations in the bycatch coefficients of sensitive species varied across fishing gear types. Pelagic trawls showed the highest bycatch intensity during summer and

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autumn, particularly for *S. maximus* and *Raja clavata*. In contrast, gillnets exhibited peaks in early spring and early summer, with an extended seasonal vulnerability window for *Dasyatis pastinaca*. Beam trawling had limited impact, with turbot bycatch recorded only in June and July.



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