



**ASSESSMENT OF THE CAUGHT, DISCARDED AND LANDED QUANTITIES
AND BIOLOGICAL DATA COLLECTION OF FISH SPECIES AND OTHER
MARINE ORGANISMS THROUGH SCIENTIFIC OBSERVATIONS ON BOARD
OF BULGARIAN FLEET FISHING VESSELS**



ЕВРОПЕЙСКИ СЪЮЗ
ЕВРОПЕЙСКИ ФОНД ЗА
МОРСКО ДЕЛО И РИБАРСТВО



МИНИСТЕРСТВО НА ЗЕМЕДЕЛИЕТО, ХРАНИТЕ И
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This study is carried out by researchers from the Institute of Fish Resources – Varna, Agricultural Academy (AA), within Contract NAFA-Burgas/D-158/16.05.2018 and is focused on the scientific assessment of the quantities and species composition of the main catch and bycatch in different fishing activities for 2018-2019 in the Bulgarian Black Sea coastal waters.

This research was performed with the financial support from the European Commission in accordance with Regulation №199/2008 of the Council and Decision 2010/93/EC of the Commission, allocated to support member states for the development of a common framework for collection, management and use of data in the fisheries' sector and to support the scientific consultations as regards the overall policy in the fisheries' field.

The current research was conducted between 01.VI - 30. VIII. 2018, in the Bulgarian Black Sea territorial waters, onboard fishing vessels using pelagic trawls, gill nets, beam trawls and polyvalent gears for fishing.

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Проектно предложение № BG14MOP001-3.003-0001, „Събиране, управление и използване на данни за целите на научния анализ и изпълнението на Общата политика в областта на рибарството за периода 2017-2019 г.“, финансирано от Програмата за морско дело и рибарство, съфинансирана от Европейския съюз чрез Европейския фонд за морско дело и рибарство.



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ГОРИТЕ



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Scientific team	1
1. Introduction	3
1.1 Fishing with gill nets	3
1.2 Pelagic and bottom species fishing with pelagic trawl.....	4
1.3 Rapana fishing with beam trawl.....	4
1.4 Fishing with polyvalent active and passive gears	5
1.5 Collected data	5
2. Material and methodology	6
2.1 Sampling schemes	6
2.1.1 Fishing vessels with gill nets.....	7
2.1.2 Fishing vessels with pelagic trawl.....	8
2.1.3 Fishing vessels for rapana	10
2.1.4 Fishing vessels with polyvalent gears	15
2.1.5 Summary of the collected information	17
2.2 Sampling processing	18
2.3 Laboratory analysis	18
2.4 Statistical methods	20
3. Results	20
3.1 Fishing with gill nets	20
3.2 Fishing with pelagic trawls	24
3.3 Rapana catch.....	38
3.4 Fishing with polyvalent gears.....	54
4. Conclusions	57
5. References	61

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Проектно предложение № BG14MOP001-3.003-0001, „Събиране, управление и използване на данни за целите на научния анализ и изпълнението на Общата политика в областта на рибарството за периода 2017-2019 г.“, финансирано от Програмата за морско дело и рибарство, съфинансирана от Европейския съюз чрез Европейския фонд за морско дело и рибарство.



ЕВРОПЕЙСКИ СЪЮЗ
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МОРСКО ДЕЛО И РИБАРСТВО



МИНИСТЕРСТВО НА ЗЕМЕДЕЛИЕТО, ХРАНИТЕ И
ГОРИТЕ



1. Introduction

Bycatch during fishing is common because of the fact that fishing areas are vast and inhabited by many different species and fishing methods and gears are not perfectly selective (Clucas, 1997).

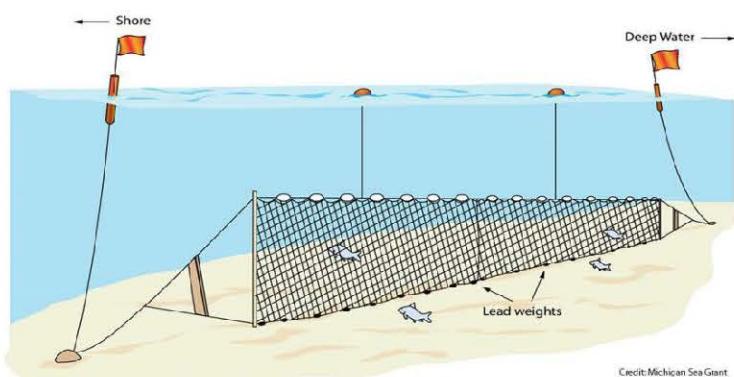
The assessment of the bycatch by different types of fishing is a priority within the Mid-term strategy (2017–2020) towards the sustainability of Mediterranean and Black Sea fisheries, approved by the General Fisheries Commission for the Mediterranean and Black Sea (GFCM), Resolution GFCM/40/2016/2, specific goal No 4 "Minimize and mitigate unwanted interactions between fisheries and marine ecosystems and environment", result "Reduced bycatch rates in the Mediterranean and the Black Sea fisheries". The purpose of this study is to collect data for the bycatch of marine species by different types of fishing activities of the Bulgarian fisheries' fleet. The study was carried out between 01. IV. - 30.XII.2018 and the following types of fishing vessels were observed:

- (1.) turbot fishing with gillnets;
- (2.) pelagic and bottom species fishing with pelagic trawl;
- (3.) rapana fishing with beam trawl;
- (4.) pelagic and bottom species fishing with polyvalent active and passive gears.

This report includes data about the total catch of the target species, as well as qualitative and quantitative classes of the bycatch of marine species. The dynamics of the main catches and bycatches are presented in terms of species composition, percentage share from the total catch, size and age structure. The absolute and standard lengths of the species were measured, together with their individual weight. In addition, otoliths were collected in order to analyze the age, when possible gender structure and mature stages of the bycatch' species are also analysed.

1.1 Fishing with gill nets

Anchored gill nets for turbot fishing are used all year round with the exception of the 60-day ban, which covers the period of the active spawning off the Bulgarian Black Sea coast - 15. IV - 15.VI. The intensity of using such nets increases in the autumn-winter period.



Credit: Michigan Sea Grant

Fig. 1. Fishing with anchored gill nets (<http://www.friopescaburela.com/artepeca.html>)

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ЕВРОПЕЙСКИ ФОНД ЗА
МОРСКО ДЕЛО И РИБАРСТВО



МИНИСТЕРСТВО НА ЗЕМЕДЕЛИЕТО, ХРАНИТЕ И
ГОРИТЕ



1.2 Pelagic and bottom species fishing with pelagic trawl

Pelagic trawls, for sprat and some seasonal species (horse mackerel, red mullet and anchovy), are used all year round. Sprat fishing is most intensive in the period April – November, while seasonal species are being fished in May – October. The industrial fishing is focused on mid-scale fishing vessels with lengths between 15 and 40 m, equipped with pelagic trawls „Midwater otter trawl” and mesh size of 0.6 cm (Fig.2).

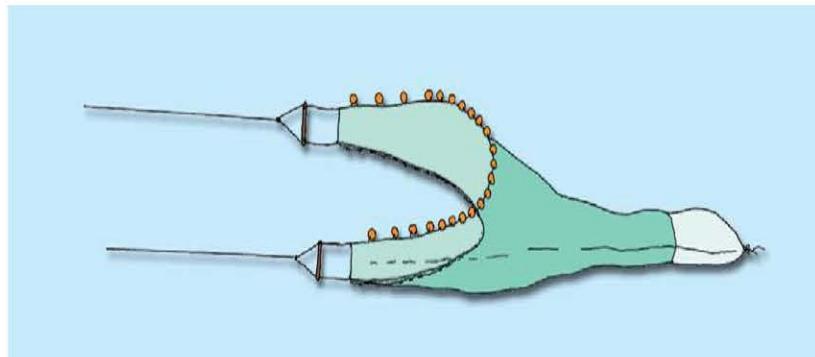


Fig. 2. Pelagic trawl „Midwater otter trawl” (Korsgaard et al., 2007).

1.3 Rapana fishing with beam trawl

Beam trawls (Fig. 3) are used for rapana fishing. The technical specifications of the beam trawls are as following; maximum length of beam 10 m, a maximum height of the opening 500mm; rail size: minimum 200 mm wide, minimum 500 mm long, number of chains up to 5, a diameter of chain blocks 10 mm, minimum size of the mesh 40 mm.

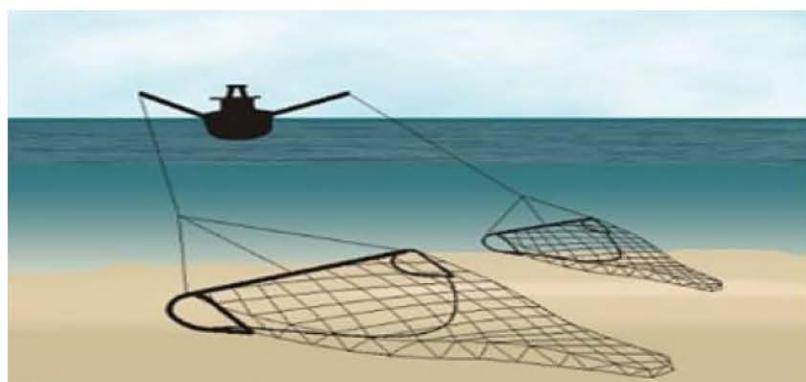


Fig. 3. Rapana fishing with beam trawl (<https://www.maritime.bg/wp-content/uploads/2013/08/biim-tral.jpg>).



ЕВРОПЕЙСКИ СЪЮЗ
ЕВРОПЕЙСКИ ФОНД ЗА
МОРСКО ДЕЛО И РИБАРСТВО



МИНИСТЕРСТВО НА ЗЕМЕДЕЛИЕТО, ХРАНИТЕ И
ГОРИТЕ



The fishing season for the rapana covers the period from the end of April until the mid of October. The fishing is concentrated in the coastal areas with depths up to 35-40 m, inhabited by many bottom species such as gobies, flounder, and by juvenile stages of some endangered species such as turbot and shark. These juvenile forms are nursed and live in the shallow coastal areas before growing and migrating into deeper waters. The collected data allows monitoring the dynamics of the beam trawls bycatch in the Bulgarian territorial waters of the Black Sea.

1.4 Fishing with polyvalent active and passive gears

This fishing activity covers a wide range of vessels, which may use different fishing gears depending on the season, both active and passive gears, with the requirement that each gear is not used for more than 50 % of the total fishing days for the relevant one-year period.

The passive fishing gears are - gill nets for turbot and long-lines for sharks; the active are: beam trawl for rapana and pelagic trawls for pelagic and bottom fish species.

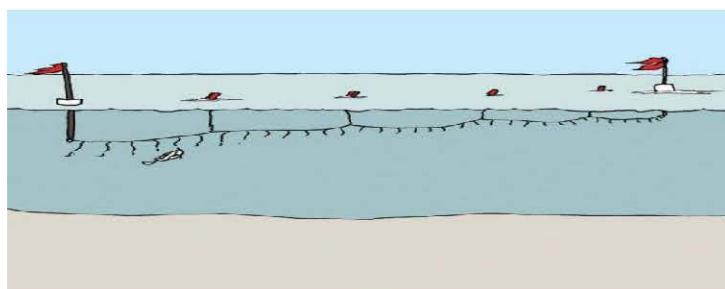


Fig. 4. Long lines (Korsgaard et al., 2007).

1.5 Collected data

Following the recommendations of the GFCM (Draft report, VI.2018), different types of data related to the methodology of observing bycatches onboard the vessels in the Mediterranean and the Black Sea were collected in this study:

1. Information on the fishing vessels' activities
 - Geographical coordinates
 - Date of expedition/survey
 - Departure Port
 - Arrival port
 - Fishing vessel's name
 - Vessel's type
 - Vessel's length (m)



ЕВРОПЕЙСКИ СЪЮЗ
ЕВРОПЕЙСКИ ФОНД ЗА
МОРСКО ДЕЛО И РИБАРСТВО



МИНИСТЕРСТВО НА ЗЕМЕДЕЛИЕТО, ХРАНИТЕ И
ГОРИТЕ



2. Used gears

- Total number of fishing attempts
- Depth range of the fishing attempts

3. Basic biological data

- Weight (kg) of the total catch (primary catch + bycatch)
- The total weight (kg) of the caught species (landed)
- The total weight (kg) of the bycatch of sea species (fish, mammals and others)
- Total weight of the priority species landed at the port
- Total weight of the priority species' bycatch
- Sizes of the priority species
- Size classes of the priority species' bycatch

4. Additional biological data

- Total weight of other industrial species
- Total weight of the bycatch of industrial species
- Size data about other industrial species
- Size data about other industrial species in the bycatch
- Gender and age

The results from this study are presented in the form of tables and maps for:

- Quantities of the catches of primary species and bycatch for all types of fishing activities
- Type species and spatial distribution of the bycatch based on all types of fishing activities
- Biological data (size, sex, age, quantities) for all caught fish species and monthly variations based on all types of fishing activities
- The percentage share of the bycatches in relation to the target species based on all types of fishing activities.

2. Material and methodology

2.1 Sampling schemes

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

The action plan for the study is based on the following information:

- the activity of the fishing vessel for a past period of time (2015-2017), in order to identify vessels with significant contribution to relevant fishing activities;
- forecasted monthly activity for all types of fishing activities;
- the fishing day is the main unit used in the observations (Stratoudakis, Fryer and Cook, 1998).



ЕВРОПЕЙСКИ СЪЮЗ
ЕВРОПЕЙСКИ ФОНД ЗА
МОРСКО ДЕЛО И РИБАРСТВО



МИНИСТЕРСТВО НА ЗЕМЕДЕЛИЕТО, ХРАНИТЕ И
ГОРИТЕ



2.1.1 Fishing vessels with gill nets

The expeditions included 20 fishing days in IV- XII.2018 onboard the following fishing vessels (Table 1, Fig. 5).

Table 1.

Technical specifications of the fishing vessels with gill nets

Fishing vessel's name	The fishing vessel's No	Tech. specification
Egeo - 3	ВН8195	33.6 GT, 17.23 m, 320 kV
Шб 6018	Шб 6018	2.69 GT, 7.5 m, 55 kV
Шб 5861	Шб 5861	4.34 GT, 9 m, 38.98 kV
Шб 6012	Шб 6012	0.68 GT, 4.2 m, 5.88 kV



Fig. 5. A fishing vessel with gill nets - "Egeo-3".

These expeditions cover the catch with anchored gill nets with an eye size of 400 mm, maximum length up to 2.7 km (marked at every 100 m). The nets were placed at depths around 35 - 70 m.

Some data, collected within the expeditions with registered by-catch are presented in Table 2.

Table 2.

Fishing expeditions with registered by-catch from gill nets in 2018.

Date	Port of departure	Port of arrival	Latitude	Depth (m)
03.04.2018	Crapes	Shabla	43.604	40-50
12.04.2018	Crapes	Shabla	43.621	40-50
12.04.2018	Crapes	Shabla	43.62	40-50
22.06.2018	Shabla	Shabla	43.427	40-50
02.07.2018	Varna	Crapes	43.648	70

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ЕВРОПЕЙСКИ СЪЮЗ
ЕВРОПЕЙСКИ ФОНД ЗА
МОРСКО ДЕЛО И РИБАРСТВО



МИНИСТЕРСТВО НА ЗЕМЕДЕЛИЕТО, ХРАНИТЕ И
ГОРИТЕ



03.07.2018	Crapec	Crapec	43.59	70
04.07.2018	Crapec	Varna	43.607	70
22.06.2018	Shabla	Shabla	43.568	40-50
03.11.2018	Shabla	Shabla	43.67	35
27.11.2018	Crapec	Shabla	43.607	40-50
09.12.2018	Shabla	Shabla	43.563	35

2.1.2 Fishing vessels with pelagic trawl

These expeditions are carried out between VII-XII.2018 (10 days), using 4 fishing vessels - PK 40, PK "Niko", PK "Barbun", PK "Lavrak" (Table 3, Fig. 7, 8).

Table 3.

Technical parameters of the fishing vessels with pelagic netsизследването.

Fishing vessel's name	Fishing vessel's No	Tech. specification
RK 40	БС258	117.36 GT, 25.5 m, 220.65 kV
RK "Niko"	БС152	18.23 GT, 15.7 m, 264.78 kV
RK "Barbun"	ВН 7979	39.74 GT, 15.9 m, 235 kV
RK "Lavrak"	ВН7149	20 GT, 15.73 m, 250.07 kV



1.



2.



3.



4.

Fig. 6. Fishing vessels with pelagic trawls - PK 40 (1), PK "Niko"(2), PK "Barbun" (3), PK "Lavrak" (4)

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ЕВРОПЕЙСКИ СЪЮЗ
ЕВРОПЕЙСКИ ФОНД ЗА
МОРСКО ДЕЛО И РИБАРСТВО



МИНИСТЕРСТВО НА ЗЕМЕДЕЛИЕТО, ХРАНИТЕ И
ГОРИТЕ



The pelagic trawls used during the study are characterised by following functional and technical parameters:

- PK 40: Vertical opening - 6 m; Horizontal opening- 26 m; Upper collar effective part – 24 m; Eye sizes of the trawl - to 66 mm; Trawl length - 38 m; Trawl velocity- 2 - 3.7 Nd.
- PK NIKO: Vertical opening - 6 m; Horizontal opening- 26 m; Upper collar effective part – 24 m; Eye sizes of the trawl to 66 mm; Trawl length - 38 m; Trawl velocity- 2 - 3.7 Nd.
- PK Lavrak: OTM, Upper collar effective part -16 m, Trawl length 40 m (Fig. 7).

The average duration of sprat fishing is 3 hours, while for horse mackerel it is 5 hours. Trawls were used at 19 to 40 m depths in the coastal areas.



Fig. 7. Horse mackerel fishing with pelagic trawl on vessel „Lavrak”.

Detailed data about the fishing expeditions with pelagic trawls are presented below in Table 4 and Fig. 9.

Table 4.

Fishing expeditions with pelagic trawls VII-XII. 2018.

Date	Target species	Departure	Arrival	Trawl No	Latitude	Longitude	Trawl [h]	Depth [m]
03.07.2018	sprat	Nessebar	Nessaber	I	42.67	27.87	2.40	25
03.07.2018	sprat	Nessebar	Nessaber	II	42.601	27.93	3.40	40
04.07.2018	sprat	Nessebar	Nessaber	I	42.64	27.74	3.10	24.5
04.07.2018	sprat	Nessebar	Nessaber	II	42.62	27.75	2.50	25
05.07.2018	sprat	Nessebar	Nessaber	I	42.643	27.81	3.05	25
05.07.2018	mackerel	Nessebar	Nessaber	II	42.625	27.713	5.30	25
07.08.2018	mackerel	Varna	Varna	I	43.70	29.216	5.50	19
14.08.2018	mackerel	Varna	Varna	I	43.194	28.326	4.30	23



ЕВРОПЕЙСКИ СЪЮЗ
ЕВРОПЕЙСКИ ФОНД ЗА
МОРСКО ДЕЛО И РИБАРСТВО



МИНИСТЕРСТВО НА ЗЕМЕДЕЛИЕТО, ХРАНИТЕ И
ГОРИТЕ



15.08.2018	mackerel	Varna	Varna	I	43.359	28.272	3.50	20.7
16.08.2018	mackerel	Varna	Varna	I	43.214	28.057	6.30	20.3
04.09.2018	sprat	Nessebar	Nessebar	I	42.631	27.811	3.40	32
14.12.2018	sprat	Nessebar	Nessebar	I	42.551	27.762	2.40	30
14.12.2018	sprat	Nessebar	Nessebar	II	42.568	27.762	2.30	32

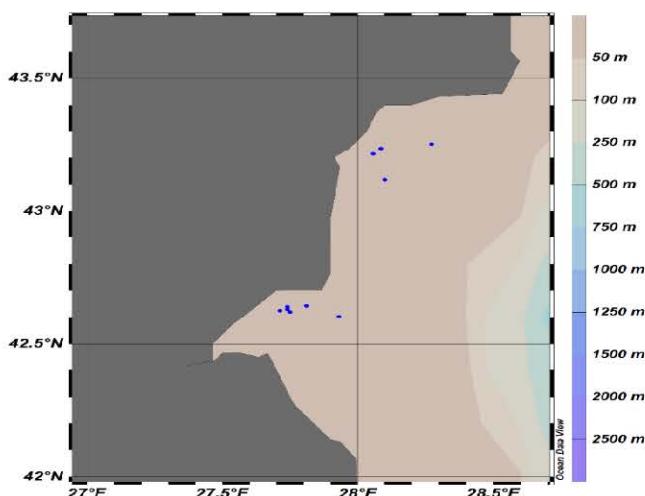


Fig. 9. Sprat and horse mackerel expeditions map.

2.1.3 Fishing vessels for rapana

Bottom trawling was carried out for 20 days in the period VII-XI.2018 with 4 fishing vessels - "Viking", "Elekta", RK 4 and RK 5 (Table 5, Fig. 10).

Table 5.

Technical specifications of the fishing boats for rapana catch.

Fishing vessel's name	Fishing vessel's No	Tech. specification
Viking	BH 8406	30.6 GT, 14.52 m lenght, 132.39 kW
Electa	BH 8042	17.12 GT, 16.5 m lenght, 110.33 kW
RK 4	BH 7599	24.46 GT, 12.58 m, 4.42 m width, 220.59 kW
RK 5	BH 8186	24.91 GT, 14.90 m, 4.40 m width, 200 kW



ЕВРОПЕЙСКИ СЪЮЗ
ЕВРОПЕЙСКИ ФОНД ЗА
МОРСКО ДЕЛО И РИБАРСТВО



МИНИСТЕРСТВО НА ЗЕМЕДЕЛИЕТО, ХРАНИТЕ И
ГОРИТЕ



Fig. 10. Fishing vessels for rapana - "Elekta", RK 4 and RK5.

Standard beam trawl technique was used to collect all the field data by trawl duration between 30 - 115 minutes.

The geographical coordinates of the observed monitoring zones with registered by-catch are presented on Table 6, Fig. 11.

Table 6.

Monitoring data for rapana fishing VII - XI. 2018

Date	Departure	Arrival	Trawl No	Latitude	Longitude	Trawl [h]	Depth [m]
12.07.2018	Kavarna	Kavarna	I	43.37	28.59	1.05	16
12.07.2018	Kavarna	Kavarna	II	43.498	28.639	1.15	17
12.07.2018	Kavarna	Kavarna	III	43.33	28.65	1.55	17
12.07.2018	Kavarna	Kavarna	IV	43.52	28.622	1.20	16
12.07.2018	Kavarna	Kavarna	V	43.419	28.58	1.30	16
12.07.2018	Kavarna	Kavarna	VI	43.34	28.554	1	16
12.07.2018	Kavarna	Kavarna	VII	43.49	28.574	1.15	16
12.07.2018	Kavarna	Kavarna	VIII	43.57	28.635	1	16
12.07.2018	Kavarna	Kavarna	IX	43.517	28.586	1.10	16
27.07.2018	Balchik	Balchik	I	43.379	28.575	1.10	17
27.07.2018	Balchik	Balchik	II	43.448	28.618	1.10	18.9
27.07.2018	Balchik	Balchik	III	43.554	28.631	1	16.7
27.07.2018	Balchik	Balchik	IV	43.445	28.602	1.05	16.3

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ЕВРОПЕЙСКИ СЪЮЗ
ЕВРОПЕЙСКИ ФОНД ЗА
МОРСКО ДЕЛО И РИБАРСТВО



МИНИСТЕРСТВО НА ЗЕМЕДЕЛИЕТО, ХРАНИТЕ И
ГОРИТЕ



27.07.2018	Balchik	Balchik	V	43.519	28.654	1.05	17
27.07.2018	Balchik	Balchik	VI	43.424	28.669	1.10	16.3
27.07.2018	Balchik	Balchik	VII	43.536	28.689	1.10	17
27.07.2018	Balchik	Balchik	VIII	43.441	28.562	1.20	16.4
27.07.2018	Balchik	Balchik	IX	43.478	28.665	1.15	16.8
27.07.2018	Balchik	Balchik	X	43.437	28.657	1.35	16.4
28.07.2018	Balchik	Balchik	I	43.525	28.633	1	19.3
28.07.2018	Balchik	Balchik	II	43.327	28.521	1	16.5
28.07.2018	Balchik	Balchik	III	43.455	28.591	1	16.6
28.07.2018	Balchik	Balchik	IV	43.477	28.643	1.2	16
28.07.2018	Balchik	Balchik	V	43.562	28.664	1.55	16.8
28.07.2018	Balchik	Balchik	VI	43.411	28.468	1	16.4
28.07.2018	Balchik	Balchik	VII	43.492	28.593	1	16.5
28.07.2018	Balchik	Balchik	VIII	43.623	28.665	1	18
28.07.2018	Balchik	Balchik	IX	43.395	28.567	1.05	17.3
28.07.2018	Balchik	Balchik	X	43.37	28.347	1.50	16
28.07.2018	Balchik	Balchik	XI	43.375	28.358	0.91	16
29.07.2018	Balchik	Balchik	I	43.554	28.617	1.50	15
29.07.2018	Balchik	Balchik	II	43.384	28.341	1.10	15
29.07.2018	Balchik	Balchik	III	43.529	28.667	1.05	15.8
29.07.2018	Balchik	Balchik	IV	43.432	28.626	1.00	16.5
29.07.2018	Balchik	Balchik	V	43.402	28.314	1.00	16.3
29.07.2018	Balchik	Balchik	VI	43.318	28.274	1.00	19.2
29.07.2018	Balchik	Balchik	VII	43.491	28.599	1.15	18
29.07.2018	Balchik	Balchik	VIII	43.39	28.569	1.10	18.6
29.07.2018	Balchik	Balchik	IX	43.348	28.462	1.50	19
29.07.2018	Balchik	Balchik	X	43.557	28.621	1.05	18.2

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ЕВРОПЕЙСКИ СЪЮЗ
ЕВРОПЕЙСКИ ФОНД ЗА
МОРСКО ДЕЛО И РИБАРСТВО



МИНИСТЕРСТВО НА ЗЕМЕДЕЛИЕТО, ХРАНИТЕ И
ГОРИТЕ



29.07.2018	Balchik	Balchik	XI	43.469	28.618	1.10	19
01.09.2018	Balchik	Balchik	I	43.344	28.151	1.00	17.5
01.09.2018	Balchik	Balchik	II	43.336	28.161	1.10	18
01.09.2018	Balchik	Balchik	III	43.292	28.194	1.15	17.5
01.09.2018	Balchik	Balchik	IV	43.274	28.24	1.10	17
01.09.2018	Balchik	Balchik	V	43.3	28.3	1.10	16.9
01.09.2018	Balchik	Balchik	VI	43.302	28.311	1.10	17
01.09.2018	Balchik	Balchik	VII	43.288	28.272	1.10	16.5
01.09.2018	Balchik	Balchik	VIII	43.314	28.334	1.20	17.5
01.09.2018	Balchik	Balchik	IX	43.308	28.282	1.05	18.2
01.09.2018	Balchik	Balchik	X	43.330	28.177	1.05	18.8
04.11.2018	Varna	Varna	I	43.299	28.155	1.10	20
04.11.2018	Varna	Varna	II	43.323	28.206	0.67	20.2
04.11.2018	Varna	Varna	III	43.291	28.152	1.00	19.9
04.11.2018	Varna	Varna	IV	43.296	28.15	1.05	19.8
04.11.2018	Varna	Varna	V	43.320	28.204	1.00	19.8
05.11.2018	Varna	Varna	I	43.296	28.154	1.00	19.7
05.11.2018	Varna	Varna	II	43.3	28.155	0.92	20.0
05.11.2018	Varna	Varna	III	43.333	28.216	1.00	20.1
05.11.2018	Varna	Varna	IV	43.31	28.180	1.15	20.3
07.11.2018a	Varna	Varna	I	43.308	28.174	0.83	20.2
07.11.2018a	Varna	Varna	II	43.302	28.173	0.83	20.0
07.11.2018a	Varna	Varna	III	43.306	28.14	0.75	19.9
07.11.2018a	Varna	Varna	IV	43.298	28.154	0.91	20.9
07.11.2018a	Varna	Varna	V	43.314	28.168	0.83	21.0
07.11.2018a	Varna	Varna	VI	43.297	28.152	1.05	20.1
07.11.2018b	Varna	Varna	I	43.296	28.138	1.30	20

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ЕВРОПЕЙСКИ СЪЮЗ
ЕВРОПЕЙСКИ ФОНД ЗА
МОРСКО ДЕЛО И РИБАРСТВО



МИНИСТЕРСТВО НА ЗЕМЕДЕЛИЕТО, ХРАНИТЕ И
ГОРИТЕ



07.11.2018b	Varna	Varna	II	43.323	28.175	0.50	20
07.11.2018b	Varna	Varna	III	43.3	28.15	1.00	20
07.11.2018b	Varna	Varna	IV	43.286	28.137	1.00	20.5
07.11.2018b	Varna	Varna	V	43.324	28.189	1.10	20.5
07.11.2018b	Varna	Varna	VI	43.330	28.205	1.00	21
07.11.2018b	Varna	Varna	VII	43.332	28.173	1.00	20.5
07.11.2018b	Varna	Varna	VIII	43.331	28.17	1.00	21
08.11.2018a	Varna	Varna	I	43.328	28.122	0.92	20.5
08.11.2018a	Varna	Varna	II	43.332	28.2	1.00	20.5
08.11.2018a	Varna	Varna	III	43.329	28.138	1.00	21
08.11.2018b	Varna	Varna	I	43.286	28.141	1.00	19.8
08.11.2018b	Varna	Varna	II	43.288	28.136	1.00	19.9
08.11.2018b	Varna	Varna	III	43.283	28.126	0.83	20.7
08.11.2018b	Varna	Varna	IV	43.298	28.154	1.20	20.9

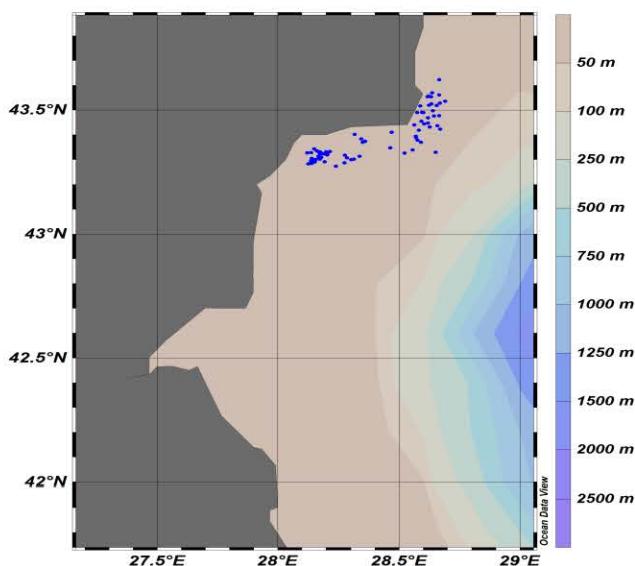


Fig. 11. Map of beam trawling for rapana.



ЕВРОПЕЙСКИ СЪЮЗ
ЕВРОПЕЙСКИ ФОНД ЗА
МОРСКО ДЕЛО И РИБАРСТВО



МИНИСТЕРСТВО НА ЗЕМЕДЕЛИЕТО, ХРАНИТЕ И
ГОРИТЕ



2.1.4 Fishing vessels with polyvalent gears

The expeditions cover 10 days in the period VII - IX.2018 with fishing vessel "Lavrak" and "Elekta" (Table 7, Fig. 12).

Table 7.

Technical specifications of fishing vessel with polyvalent gears.

Fishing vessel's name	Fishing vessel's No	Tech. specification
Electa	BH 8042	17.12 GT, 16.5 m lenght, 110.33 kW
RK "Lavrak"	BH7149	20 GT, 15.73 m, 250.07 kW

Rapana catches were collected with standard beam trawl by average trawling duration 60-115 min. When fished data were collected by pelagic trawl the average trawl duration was 280 min.

The geographical coordinates of the monitoring zones with registered by-catch are presented in Table 8, Fig. 13.

Table 8.

Fishing expeditions with registered by-catch with polyvalent gears during VII – XI.2018.

Date	Departure	Arrival	Trawl No	Latitude	Longitude	Trawl [h]	Depth [m]
27.07.2018	Balchik	Balchik	I	43.379	28.575	1.10	17
27.07.2018	Balchik	Balchik	II	43.448	28.618	1.10	18.9
27.07.2018	Balchik	Balchik	III	43.554	28.631	1	16.7
27.07.2018	Balchik	Balchik	IV	43.445	28.602	1.05	16.3
27.07.2018	Balchik	Balchik	V	43.519	28.654	1.05	17
27.07.2018	Balchik	Balchik	VI	43.424	28.669	1.10	16.3
27.07.2018	Balchik	Balchik	VII	43.536	28.689	1.10	17
27.07.2018	Balchik	Balchik	VIII	43.441	28.562	1.20	16.4
27.07.2018	Balchik	Balchik	IX	43.478	28.665	1.15	16.8
27.07.2018	Balchik	Balchik	X	43.437	28.657	1.35	16.4
28.07.2018	Balchik	Balchik	I	43.525	28.633	1	19.3
28.07.2018	Balchik	Balchik	II	43.327	28.521	1	16.5
28.07.2018	Balchik	Balchik	III	43.455	28.591	1	16.6
28.07.2018	Balchik	Balchik	IV	43.477	28.643	1.2	16

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ЕВРОПЕЙСКИ СЪЮЗ
ЕВРОПЕЙСКИ ФОНД ЗА
МОРСКО ДЕЛО И РИБАРСТВО



МИНИСТЕРСТВО НА ЗЕМЕДЕЛИЕТО, ХРАНИТЕ И
ГОРИТЕ



28.07.2018	Balchik	Balchik	V	43.562	28.664	1.55	16.8
28.07.2018	Balchik	Balchik	VI	43.411	28.468	1	16.4
28.07.2018	Balchik	Balchik	VII	43.492	28.593	1	16.5
28.07.2018	Balchik	Balchik	VIII	43.623	28.665	1	18
28.07.2018	Balchik	Balchik	IX	43.395	28.567	1.05	17.3
28.07.2018	Balchik	Balchik	X	43.37	28.347	1.50	16
28.07.2018	Balchik	Balchik	XI	43.375	28.358	0.91	16
29.07.2018	Balchik	Balchik	I	43.554	28.617	1.50	15
29.07.2018	Balchik	Balchik	II	43.384	28.341	1.10	15
29.07.2018	Balchik	Balchik	III	43.529	28.667	1.05	15.8
29.07.2018	Balchik	Balchik	IV	43.432	28.626	1.00	16.5
29.07.2018	Balchik	Balchik	V	43.402	28.314	1.00	16.3
29.07.2018	Balchik	Balchik	VI	43.318	28.274	1.00	19.2
29.07.2018	Balchik	Balchik	VII	43.491	28.599	1.15	18
29.07.2018	Balchik	Balchik	VIII	43.39	28.569	1.10	18.6
29.07.2018	Balchik	Balchik	IX	43.348	28.462	1.50	19
29.07.2018	Balchik	Balchik	X	43.557	28.621	1.05	18.2
29.07.2018	Balchik	Balchik	XI	43.469	28.618	1.10	19
14.08.2018	Varna	Varna	I	43.252	28.273	4.30	23
15.08.2018	Varna	Varna	I	43.118	28.100	3.50	20.7
16.08.2018	Varna	Varna	I	43.214	28.057	6.30	20.3
01.09.2018	Balchik	Balchik	I	43.344	28.151	1.00	17.5
01.09.2018	Balchik	Balchik	II	43.336	28.161	1.10	18
01.09.2018	Balchik	Balchik	III	43.292	28.194	1.15	17.5
01.09.2018	Balchik	Balchik	IV	43.274	28.24	1.10	17
01.09.2018	Balchik	Balchik	V	43.3	28.3	1.10	16.9
01.09.2018	Balchik	Balchik	VI	43.302	28.311	1.10	17

www.eufunds.bg

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ЕВРОПЕЙСКИ СЪЮЗ
ЕВРОПЕЙСКИ ФОНД ЗА
МОРСКО ДЕЛО И РИБАРСТВО



МИНИСТЕРСТВО НА ЗЕМЕДЕЛИЕТО, ХРАНТИТЕ И
ГОРИТЕ



01.09.2018	Balchik	Balchik	VII	43.288	28.272	1.10	16.5
01.09.2018	Balchik	Balchik	VIII	43.314	28.334	1.20	17.5

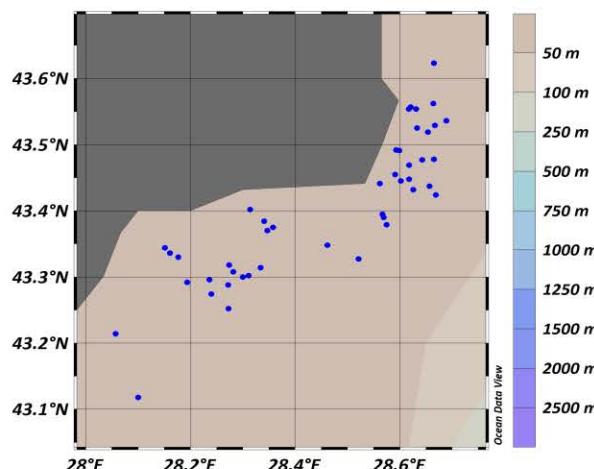


Fig. 13. Map of polyvalent gears' expedition

2.1.5 Summary of the collected information

The expeditions with observers onboard took 60 days in 2018 - x 20 days on vessels with gill nets and beam trawls, x 10 days - on vessels with pelagic trawls and on polyvalent vessels. The most frequent observations were carried out in July 2018 - a total of 20 fishing days, in September - 13 fishing days, in November - 9 days, and 8 fishing days in August (Table 9).

Table 9.

Data about scientific observations by different fishery segments in 2018.

	Days on vessels with gill nets	Days on vessels with pelagic trawls	Days on vessels with beam trawls	Days on polyvalent vessels	Days per month
IV.2018	5				5
V.2018					
VI.2018	3				3
VII.2018	4	4	7	5	20
VIII.2018		4		4	8
IX.2018	4	1	7	1	13
X.2018					
XI.2018	3		6		9
XII.2018	1	1			2
Total	20	10	20	10	60



ЕВРОПЕЙСКИ СЪЮЗ
ЕВРОПЕЙСКИ ФОНД ЗА
МОРСКО ДЕЛО И РИБАРСТВО



МИНИСТЕРСТВО НА ЗЕМЕДЕЛИЕТО, ХРАНИТЕ И
ГОРИТЕ



In 2018, the fishing with gill nets targeted turbot catch, trawling with pelagic trawls was focused on sprat and horse mackerel, and rapana was the main catch by beam trawling. The polyvalent vessels were equipped with beam trawls for rapana and pelagic trawls for pelagic fish species.

In spatial aspect, the bottom trawling took place in the northern part of the coastline, near Kavarna-Golden sands, the surveys on vessels with gill nets were performed in the zone of Shabla, and those on vessels with pelagic trawls for horse mackerel included the area Balchik - Chernomorec, while pelagic trawling for sprat was concentrated in front of the Cape Emine. The observations with polyvalent vessels were performed in front of northern coasts

2.2 Sampling processing

The catch of the primary species and the bycatch, as well as the species identification are performed on the fishing boat. The absolute and the standard sizes are measured if possible, together with the individual weight of the bycatch. In addition, ichthyological samples are taken. The samples consist of random species from the total catch, which means no specific selection is necessary. Each sample has not less than 200 individuals. The collected samples are further processed under laboratory conditions.

2.3. Laboratory analyses

The ichthyological samples from the target species and from the by-catch, collected by the different types of fishing activities, are analysed under laboratory conditions, allowing accumulation of data about the biological parameters.

1. **Data about the by-catch from different fishing segments** - In case when it was not possible to measure the weight and size onboard, the samples were marked, frozen and prepared for laboratory analysis. In the laboratory, the bycatch length and weight are measured (Fig. 14), statistical parameters (mean, minimum, maximum) were calculated and the percentage distribution for size, age and weight classes was derived.



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ЕВРОПЕЙСКИ СЪЮЗ
ЕВРОПЕЙСКИ ФОНД ЗА
МОРСКО ДЕЛО И РИБАРСТВО



МИНИСТЕРСТВО НА ЗЕМЕДЕЛИЕТО, ХРАНИТЕ И
ГОРИТЕ



Fig. 14. Laboratory analysis of bycatch from beam trawls - turbot, flounder, knout goby, round goby, stargazer, picked dogfish and red mullet, scorpionfish and black goby.

The age of the by-catch species is estimated by otolith reading with a binocular microscope. The condition factor (coefficient of Fulton (K) is estimated and data are analysed by different sexes and age classes.

2. **Data for target species from a fishery with pelagic trawls** - in July - December 2018 are gathered and analysed seven ichthyological samples from sprat (2944 ind) and two samples horse mackerel (461 ind). The estimation of the length-weight structure is based on standard measurements, and data analysis includes the generation of variation rows with a class frequency of 0.5 cm. The age of the species is analyzed by otoliths reading through binocular microscopes. The condition factor (Fulton condition's factor) is estimated and relevant data are summarized for age classes and gender. Biological parameters, related to the von Bertalanffy growth function are calculated: $L(a) = L_{\infty}(1 - \exp(-k(a - a_0))$, where a is age, k is the growth coefficient, a_0 is a value used to calculate size when age is zero, and L_{∞} is the asymptotic size.
3. **Data for main rapana catches** - collected and measured are 1200 individuals from the main catches with beam trawls. For each specimen, the total weight (weight with shell, TW, g) and length (shell length, SL, cm) is measured.
4. **Length-weight relationships** are estimated (when possible), using the least squares method and the following equation: $\log W = \log a + b * \log L$, where, W – weight; L – size; a, b – constants.

The analyses of ichthyological samples are based on the following literature sources: Kasapoglu et. al (2015); Ozdemir et. al., (2018); Aydin et. al, (2013); Kuzminova et. al, (2014); Banaru et. al, (2017); Kasapoglu et. al, (2016); 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); Stoianov et. al, (1963); Karapetkova et. al, (2010); Svetovodov (1964).



ЕВРОПЕЙСКИ СЪЮЗ
ЕВРОПЕЙСКИ ФОНД ЗА
МОРСКО ДЕЛО И РИБАРСТВО



МИНИСТЕРСТВО НА ЗЕМЕДЕЛИЕТО, ХРАНИТЕ И
ГОРИТЕ



2.4 Statistical methods

General statistical data about the quantities of the priority species, bycatch weight and weight-size parameters are presented. The quantity of the bycatch is calculated as a percentage of the primary catch from the priority species. The percentage of the bycatch relative to the total catch of rapana is presented as an average per trawling day.

According to the requirements of GFCM (Draft report, VI.2018), the proportion of particular species in a fishing expedition, is derived as the total species catch (kg) divided by the total catch (landed + bycatch): $\text{Bycatch (\%)} = \text{bycatch}/(\text{bycatch} + \text{catch}) \times 100$.

The result of the total bycatch is determined by the division of the bycatch quantities of a particular species into total caught quantity (landed and discarded) sea species (GFCM, Draft report, VI.2018).

XLSTAT software is used for the linear-weight histograms of the bycatch structures, as well as for the primary catches. The statistical data about the different classes, presented in the histograms, include – lower and upper limits of the classes, frequency, relative frequency and density.

3. Results

3.1. Fishing with gill nets

3.1.1 Primary catch and bycatch

The primary catch with the anchored gill nets is formed by turbot (*Scophthalmus maximus*), and bycatches by common stingray (*Dasyatis pastinaca*), black mussel (*Mytilus galloprovincialis*), shark (*Squalus acanthias*), thornback ray (*Raja clavata*) and rapana (*R. venosa*) (Table 10). Some mammals, such as harbour porpoise (*Phocoena phocoena*), can be rarely observed.

Table 10
Primary catches (*S. maximus*, kg/day) and bycatch (kg/day) of marine species in fishing with gill nets in VII – XII.2018.

Investigated time period	Primary catch – <i>S. maximus</i> (kg/day)		Species weight in bycatch (kg/day)						By-catch weight (kg)	Total weight	% total catch
			<i>R. clavata</i>	<i>S. acanthias</i>	<i>D. pastinaca</i>	<i>R. venosa</i>	<i>M. edulis</i>	<i>Ph. phocoena</i>			
Mean for IV	92.5		1.75	14.53	0.26	7.15			23.69	116.19	17.60
Mean for VI	10.5			61.4					61.4	71.9	85.40
Mean for VII	75.0	3.0		21.3				16.5	40.7	115.7	26.0
Mean for IX	107.5						48		48	138.37	30.87
Mean for XI	101.83	2.85		32.1		40.98			75.93	172.06	40.13
Mean for XII	126.6		5.15			33.6			38.75	165.35	23.44



ЕВРОПЕЙСКИ СЪЮЗ
ЕВРОПЕЙСКИ ФОНД ЗА
МОРСКО ДЕЛО И РИБАРСТВО



МИНИСТЕРСТВО НА ЗЕМЕДЕЛИЕТО, ХРАНИТЕ И
ГОРИТЕ



The summary statistical data from the observations of the gill net fishery are presented in Table 11. For the whole period, the average weight of the main catch of *S. maximus* reach 83.26 kg/day \pm 43.35 SD, bycatch weight - 43.97 kg/day \pm 36.98 SD, total catch weight - 127.23 kg/day \pm 59.72 SD and average percentage of the bycatch - 32.80% \pm 25.00 SD from the total catch (TC).

Таблица 11

Summary statistical data for the turbot catch (kg/day), bycatch weight (kg/day), total catch weight (catch + bycatch) (kg/day) and bycatch percentage (%) with gill nets in 2018.

	Main catch (kg/day) <i>S. maximus</i>	Bycatch weight (kg/day)	Total catch weight (catch + bycatch) (kg/day)	% of the bycatch from the total catch
Mean	83.26	43.97	127.23	32.80
Standard Error	13.71	11.69	18.88	7.91
Median	99.00	42.54	152.15	29.58
Standard Deviation	43.35	36.98	59.72	25.00
Sample Variance	1878.86	1367.59	3566.32	624.94
Kurtosis	-1.06	3.78	-0.66	1.05
Skewness	-0.62	1.51	-0.05	0.97
Range	125.00	133.00	196.32	85.40
Minimum	10.50	0.00	32.68	0.00
Maximum	135.50	133.00	229.00	85.40
Confidence Level (95.0%)	31.01	26.45	42.72	17.88
Coefficient of variation (CV) (SD/average*100)	52.07	84.10	46.94	76.22

The turbot catches reach maximal quantities - 126.6 - 135.5 kg/day in autumn and early spring (before the onset of the seasonal spring ban period for turbot fishing). In spring, the average daily catch is around 93 kg/day, then it decreases in summer to 41 kg/day, and increases again in autumn to 108.03 kg/day (Fig 13).

The gill net fishing generates a substantial bycatch, because of the fact that big fish and mammals can be caught. In spring, the mean weight of the bycatch reached 23.69 kg/day, it increases in summer up to 34.03 kg/day and reaches maximal values in autumn - 66.64 kg/day. The maximal weight of the bycatch is registered in autumn - 133 kg/day, due to the significant bycatch of black mussel and common stingray (Fig. 14). Among all parameters, the by-catch weight shows the highest variance (the highest coefficient of variation) during the study period.

The bycatch, represented as a percent share from the total catch (TC = catch+bycatch) created 17.60 % TC in spring, increases up to 45.82 % in summer and slightly decreases in autumn to 35.96 %. Presented as a percent share from the total daily catch, the maximal percentage of the by-catch is registered in June 2018 - 85.40 %, due to low main catch of turbot - 10.5 kg/day and significant presence of large species such as stingray *Dasyatis pastinaca* in the bycatch composition (Fig.13 & 14).



ЕВРОПЕЙСКИ СЪЮЗ
ЕВРОПЕЙСКИ ФОНД ЗА
МОРСКО ДЕЛО И РИБАРСТВО



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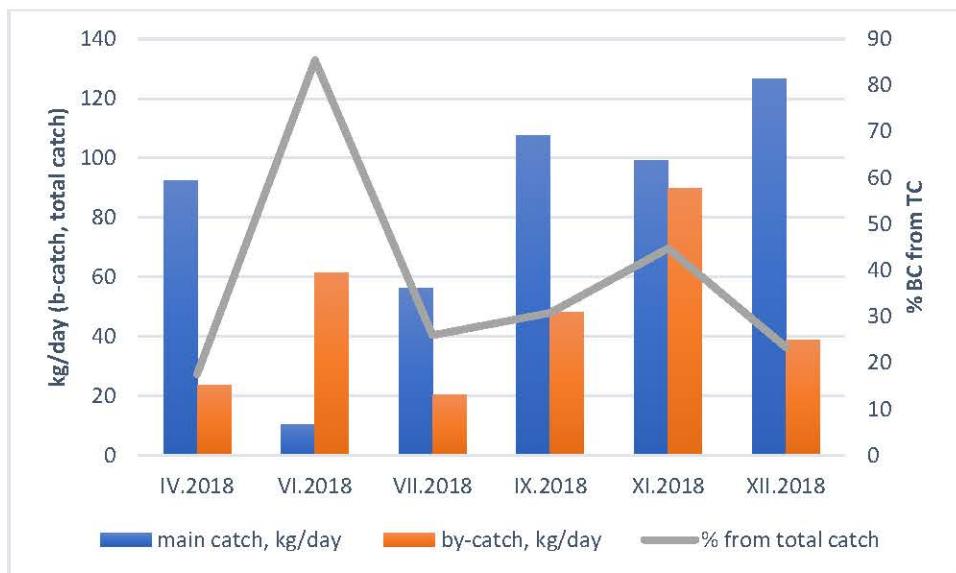


Figure 13. Dynamics of the main catch (*S. maximus*) (kg/day), bycatch (kg/day) and percentage of the bycatch in total catch by fisheries with gill nets in IV-XII.2018.

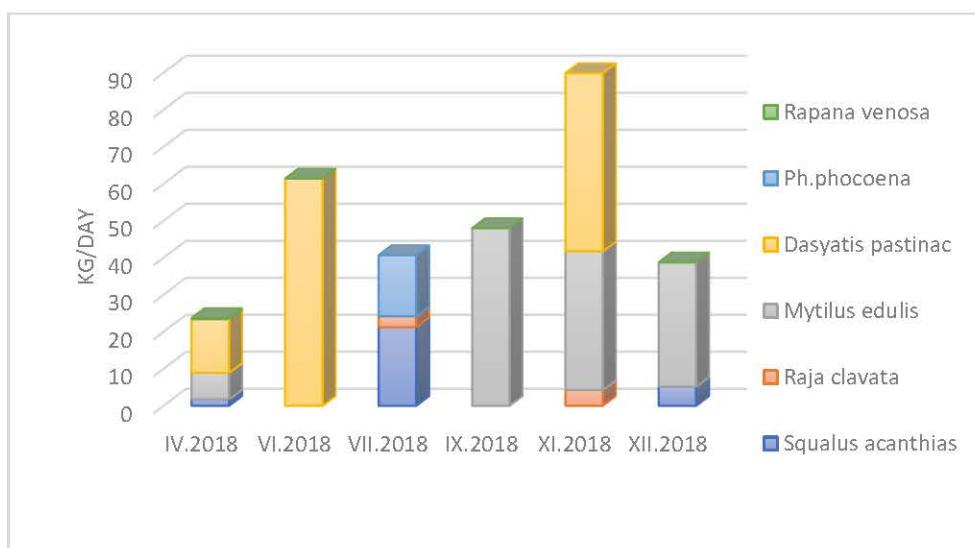


Fig 14. Composition and weight of the bycatch (kg/day) by gillnet fishery during IV – XII.2018.

For the whole period of gill net fishery observations, the by-catch species composition is formed mostly by black mussel – 43%, common stingray – 36 % and Black Sea shark – 12 % (Figure 15).



ЕВРОПЕЙСКИ СЪЮЗ
ЕВРОПЕЙСКИ ФОНД ЗА
МОРСКО ДЕЛО И РИБАРСТВО



МИНИСТЕРСТВО НА ЗЕМЕДЕЛИЕТО, ХРАНИТЕ И
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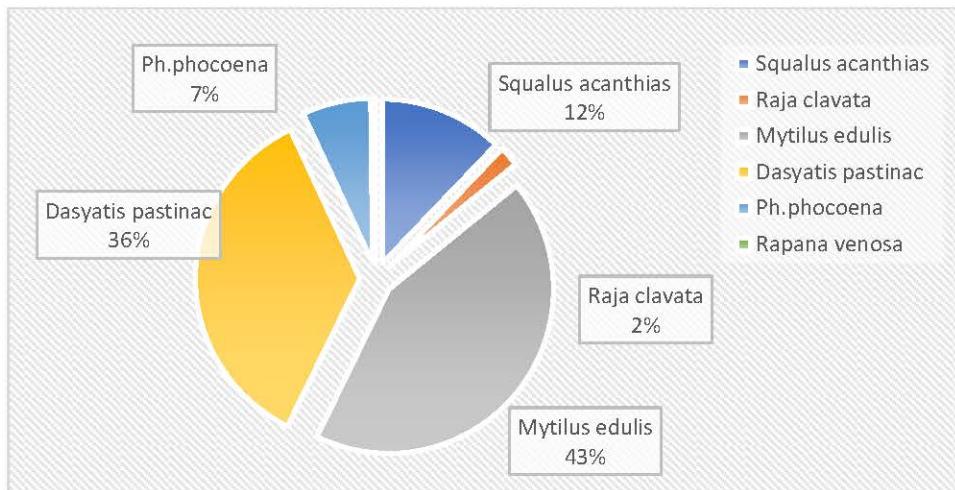


Figure 15. Species composition of the bycatch (as percent shares from the bycatch weight (kg/day) in gillnet fishing during 2018

The diversity in the by-catch species composition is subject to seasonal changes – in spring and summer we found mostly common stingray and the shark as by-catch in the gill nets, while in autumn the black mussels dominate the bycatch (Fig.16).

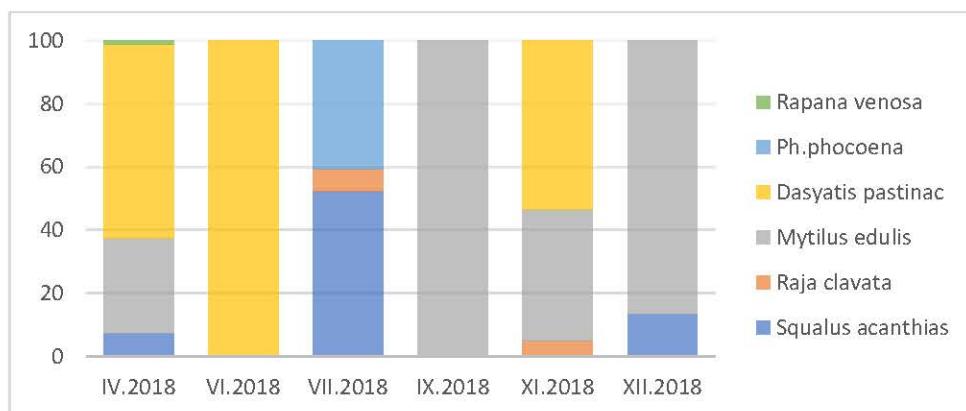


Figure 16. Monthly changes of the bycatch species composition (% from the bycatch weight, kg/day) by gillnet fishing in 2018.

3.1.2 Dynamics of biological parameters of the turbot catch

Analysis of the length structure of the turbot catches shows significant presence of the small-sized specimens < 50 cm, that forms 41.38 % of the spring catches and 49 % - in autumn. The percent share of small-sized turbot specimens is maximal in catches during the summer months - 58.29 % on

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ЕВРОПЕЙСКИ СЪЮЗ
ЕВРОПЕЙСКИ ФОНД ЗА
МОРСКО ДЕЛО И РИБАРСТВО



МИНИСТЕРСТВО НА ЗЕМЕДЕЛИЕТО, ХРАНИТЕ И
ГОРИТЕ



average. The large specimens *S. maximus*, with length > 80 cm, are detected mostly in spring months but they form a small portion - 5.68 % in the main catch (Fig. 17).



Figure 17. Monthly changes of the main size classes in turbot catch - 45.1-50 cm, 50.1-60 cm, 60.1-80 cm, > 80 cm (% from abundance) in gillnet fishing during 2018.

3.2 Fishing with pelagic trawls

3.2.1 Main catch, by-catch, total catches

Pelagic trawl fishing is focused on two target species – sprat (*Sprattus sprattus*) and horse mackerel (*Trachurus mediterraneus*). The average catch of these species per fishing day reached - 1112 kg/day ± 219 SE sprat and 563 kg/day ± 177.22 SE horse mackerel.

The bycatches in sprat fishing were 0.5 - 2.8 kg/day, however, while fishing horse mackerel they increased to 15.08 - 41 kg/day (Fig. 17, Table 12). Up to 9 different species may be observed while fishing with pelagic trawls (Table 12).

Table 12

General statistics about main catches quantities (kg/day), total catch (TC=catch+bycatch, kg/day), by-catch of marine species (kg/day) and percentage of the bycatch in the TC during fishing with pelagic trawls: (1) for sprat and (2) for horse mackerel during VII-XII.2018.

1. Sprat fishery (fishing vessels length - 15.7 m - 24.5 m)

	Sprat catch (kg/day)	Total catch (kg/day)	Bycatch (kg/day)	% Bycatch from the total catch
Mean	1112.00	1113.35	1.37	0.11
Standard Error	219.52	219.93	0.44	0.02
Median	1025.00	1026.15	1.17	0.12
Mode	#N/A	#N/A	#N/A	0.05

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ЕВРОПЕЙСКИ СЪЮЗ
ЕВРОПЕЙСКИ ФОНД ЗА
МОРСКО ДЕЛО И РИБАРСТВО



МИНИСТЕРСТВО НА ЗЕМЕДЕЛИЕТО, ХРАНИТЕ И
ГОРИТЕ



Standard Deviation	537.72	538.72	1.08	0.05
Sample Variance	289144.00	290214.08	1.18	0.00
Kurtosis	-1.78	-1.78	-2.38	-2.09
Skewness	0.36	0.36	0.28	-0.01
Range	1278.00	1280.60	2.55	0.13
Minimum	522.00	522.20	0.24	0.05
Maximum	1800.00	1802.80	2.79	0.18
Sum	6672.00	6680.10	8.19	0.66
Confidence Level (95.0%)	564.30	565.35	1.14	0.06

Coefficient of variation (CV)	48.36	48.39	78.83	45.45
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2. Horse mackerel fishery (fishing vessels length - 15.7 m)

	Horse mackerel catch (kg/day)	Total catch (kg/day)	Bycatch (kg/day)	% Bycatch from the total catch
Mean	562.50	590.51	28.04	6.33
Standard Error	177.22	177.83	6.25	2.70
Median	500.00	517.60	27.60	4.09
Standard Deviation	354.44	355.66	12.51	5.40
Sample Variance	125625.00	126495.90	156.46	29.21
Kurtosis	-2.67	-2.45	-3.89	3.50
Skewness	0.56	0.63	0.11	1.86
Range	750.00	743.25	26.74	11.54
Minimum	250.00	291.80	15.10	2.80
Maximum	1000.00	1035.05	41.84	14.34
Sum	2250.00	2362.05	112.14	25.32
Confidence Level (95.0%)	563.99	565.94	19.90	8.60

Coefficient of variation (CV)	63.01	60.23	44.61	85.31
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In pelagic trawls, we establish 1-9 different fish species as daily by-catch (Table 13 & 14).

Table 13

The main catches (sprat, horse mackerel, kg/day) and by-catches from different fish species (kg/day) by pelagic trawl fishing during VII-XII.2018 г.

Date	Length of the fishing vessel (m)	Main catch (kg/day)	Weight of the different species in the by-catch (kg/day)									By-catch (kg/day)	Total catch (catch + bycatch, kg /day)	% by-catch from the total catch
			Whiting	Red mullet	Gobies	Horse mackerel	Pontic shad	Greater weever	Anchovy	Sturgeon	Others			
03.07.18	25.5	1700 Sprat	0.856	0.237	0.921	0.09	0.07	0.1	0.045	0	0	2.32	1702.3	0.14
04.07.18	15.7	1800	1.249	0	0.818	0.096	0.47	0.16	0	0	0	2.79	1802.8	0.15

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ЕВРОПЕЙСКИ СЪЮЗ
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МОРСКО ДЕЛО И РИБАРСТВО



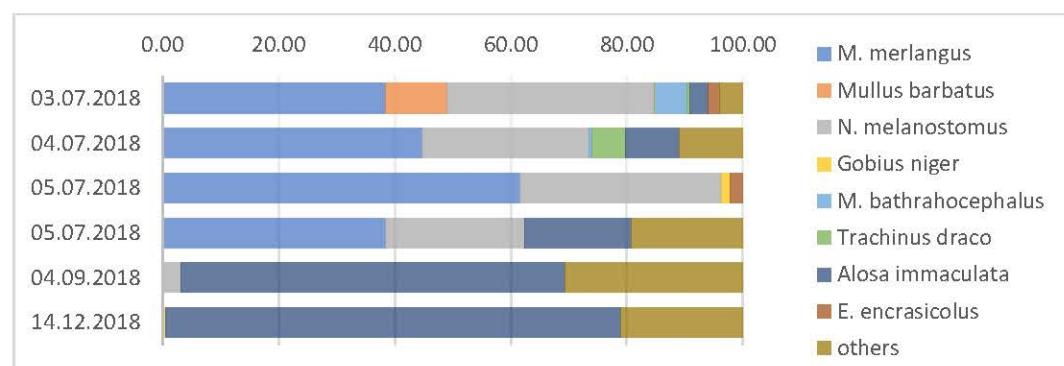
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ГОРИТЕ



		Spart													
05.07.18a	25.5	600 Sprat	0.317	0	0.187	0	0	0	0.011	0	0	0.515	600.5	0.09	
05.07.18b	15.7	1050 Sprat	0.192	0	0.12	0	0.092	0	0	0	0.01	0.50	1050.5	0.05	
07.08.18	15.97	250 Horse mackerel	0	0.163	0.475		0	0	40	0	1.20	41.84		14.34	
14.08.18	15.7	700 Horse mackerel	0	0	0		20.15	0	0	0	0	20.146	720.1	2.8	
15.08.18	15.7	300 Horse mackerel	0	0	0		15.1	0	0	0	0	15.1	315.1	4.79	
16.08.18	15.7	1000 Horse mackerel	0	0	0.017		0	0	0.018	35	0.02	35.054	1035.05	3.39	
04.09.18	25.5	522 Sprat	0	0	0.007 6	0	0.204		0	0	0.03	0.243	522.2	0.05	
14.12.18	25.5	1000 Sprat	0.002	0	0.006	0	1.818		0	0	0	1.826	1001.8	0.18	

In sprat fishing, the percent share of the bycatch is low - $0.11\% \pm 0.02$ SE (Standard Error) (Fig.18.1). The average share of the by-catch increases up to $6.33\% \pm 2.70$ SE by horse mackerel fishing (Fig. 18.2, Table 13), due to longer trawling duration.

The bycatches in the sprat catch in July 2018 are formed mainly by whiting (*Merlangius merlangus*) - 45.77 % from total bycatch, gobies (mainly *Neogobius melanostomus* and *Mesogobius batrachocephalus*) - 32.26 %, and pontic shad (*Alosa immaculata*) – 7.71 %. Rare species in the bycatches are black goby (*Gobius niger*), Stargazer (*Uranoscopus scaber*), common stingray (*Dasyatis pastinaca*) and greater weever (*Trachinus draco*) (Fig.18.1, Table 12). In September, pontic shad (*Alosa immaculata*) and round goby (*N. melanostomus*) are found in the bycatch, and in December 2018, the by-catch includes only pontic shad (*Alosa immaculata*) and *Alosa caspia*.



1.



ЕВРОПЕЙСКИ СЪЮЗ
ЕВРОПЕЙСКИ ФОНД ЗА
МОРСКО ДЕЛО И РИБАРСТВО



МИНИСТЕРСТВО НА ЗЕМЕДЕЛИЕТО, ХРАНИТЕ И
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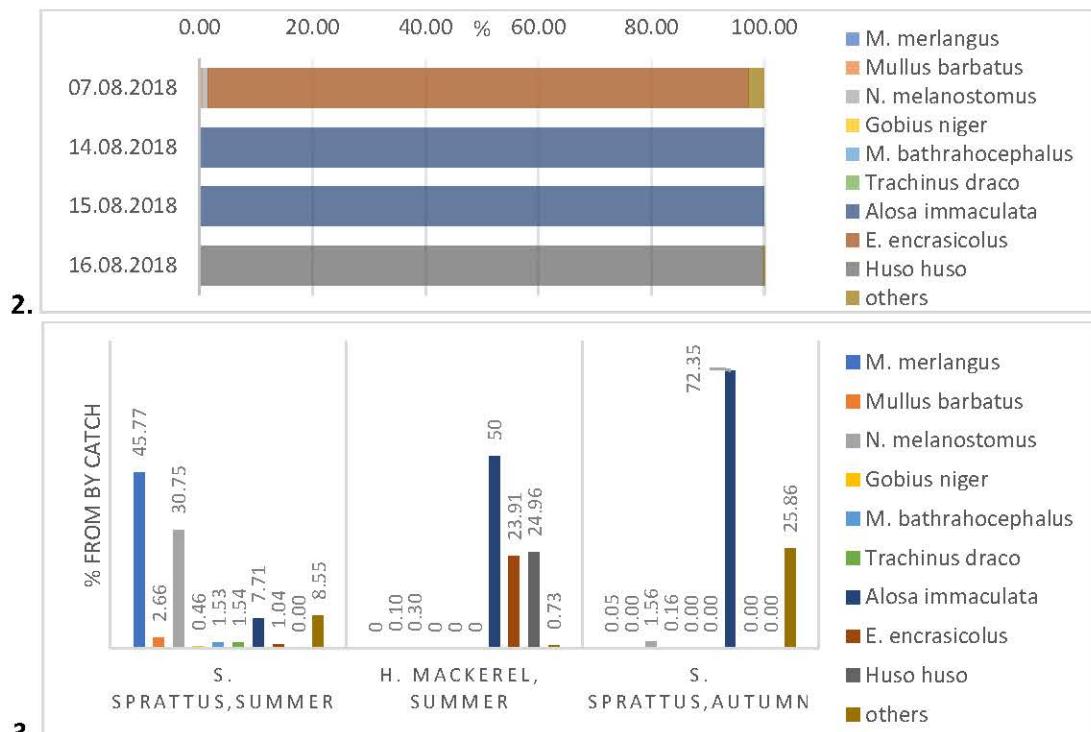


Fig. 19. Dynamics of the bycatch species composition (% from the total catch, kg/day) by fishing for (1) sprat, (2) horse mackerel and (3) averaged seasonal data in 2018.

The bycatches in the mackerel catch in August are formed mainly by the pontic shad (*A. Immaculata*) - 50 % from the bycatch and anchovy (*E. encrasicolus*) – 23.91 %, also common stingray *Dasyatis pastinaca* (Fig. 18.2, Table 11). One rare species - sturgeon (*Huso huso*), 35 kg in weight and 170 cm in length – was found on 16.08.2018 and released back into the sea (Fig.19).



Fig. 18. Sturgeon (*Huso huso*) bycatch during horse mackerel fishing.

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ЕВРОПЕЙСКИ СЪЮЗ
ЕВРОПЕЙСКИ ФОНД ЗА
МОРСКО ДЕЛО И РИБАРСТВО



МИНИСТЕРСТВО НА ЗЕМЕДЕЛИЕТО, ХРАНИТЕ И
ГОРИТЕ



Detailed data about the bycatch types, sizes and weights of the species in the bycatch with pelagic trawl is presented in Table 14.

Table 14

Species composition of the bycatches with pelagic trawl, quantities, average size and weight (\pm SE) of the species in the bycatches during fishing days in VII - XII.2018.

Date	FV length (m)	Primary catch species	Species composition of bycatch	Total bycatch [kg/day]	Average size (cm) \pm SE	Average weight (g)
03.07.2018	25.5	Sprat	1.M. merlangus	0.856	12.057 \pm 0.31	19.45 \pm 3.086
			2.N. melanostomus	0.79	11.71 \pm 0.58	23.94 \pm 12.72
			3.Mullus barbatus	0.237	10.938 \pm 0.85	14.806 \pm 9.07
			4.T. mediterraneus	0.09	13 \pm 1	25 \pm 5
			5.E. encrasiculus	0.045	12 \pm 0.5	12.85
			6.Alosa immaculata	0.07	15.75	35
			7.Gobius niger	0.006	8	6
			8.M. bathrahocephalus	0.125	24.5	125
			9.Trachinus draco	0.01	17.25	50
				2.23		
04.07.2018	15.7	Sprat	1.M. merlangus	1.249	12.947 \pm 0.476	18.64 \pm 8.057
			2.N. melanostomus	0.8041	10.66 \pm 0.309	17.86 \pm 4.308
			3.Alosa immaculata	0.26	18.15 \pm 0.664	47 \pm 6.527
			4.Alosa caspia	0.21	18.375	52.5
			4.T. mediterraneus	0.0957	15.83 \pm 0.441	31.9 \pm 0.67
			5.Trachinus draco	0.16	18.433 \pm 4.43	53.33 \pm 13.64
			6.M. batrachocephalus	0.014	12	14
				2.79		
05.07.2018	25.5	Sprat	1.M. merlangus	0.317	11.66 \pm 0.810	12.725 \pm 14.011
			2.N. melanostomus	0.179	10.68 \pm 0.55	48.75 \pm 9.563
			3.Gobius niger	0.008	9	8
			4.E. encrasiculus	0.011	11.5	11
				0.515		
05.07.2018	15.7	Sprat	1.M. merlangus	0.192	12.36 \pm 0.78	28.82 \pm 8.934
			2.N. melanostomus	0.12	10.56 \pm 0.513	22.375 \pm 4.571
			3.Alosa immaculata	0.092	9	8
			4.Uranoscopus scaber	0.096	16.5	96
				0.5		
07.08.2018	15.97	Horse mackerel	1.E. encrasiculus	40	9.00 \pm 0.58	4.17 \pm 3.76
			2.Dasyatis pastinaca	1.19223	28.33	397
			3.Mullus barbatus	0.163	10.31 \pm 0.47	11.64 \pm 1.56
			4.N. melanostomus	0.475	9.00 \pm 0.58	8.56 \pm 1.53
			5.Pomatomus saltatrix	0.0097	11.75	4.85
				41.840		

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ЕВРОПЕЙСКИ СЪЮЗ
ЕВРОПЕЙСКИ ФОНД ЗА
МОРСКО ДЕЛО И РИБАРСТВО



МИНИСТЕРСТВО НА ЗЕМЕДЕЛИЕТО, ХРАНИТЕ И
ГОРИТЕ

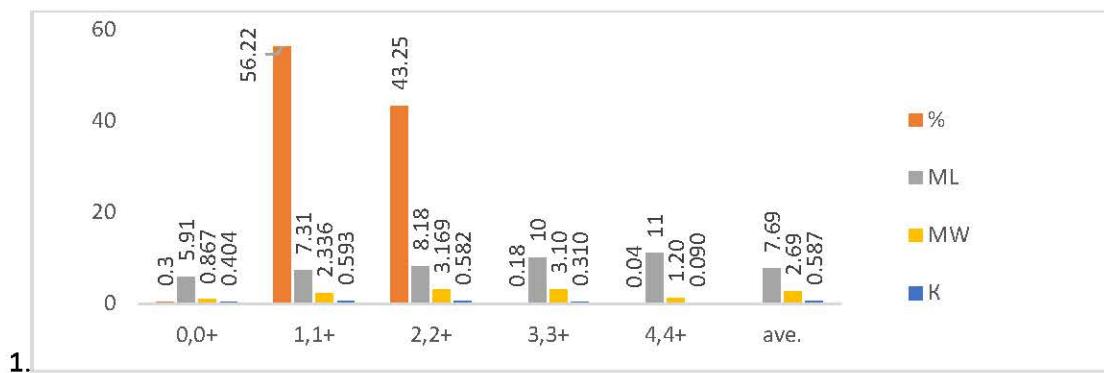


14.08.2018	15.73	Horse mackerel	1.Alosa immaculata	20.146	18 ±0.58	44.6 ±1.958
				20.146		
15.08.2018	15.73	Horse mackerel	1.Alosa immaculata	15.1	22	77
				15.1		
16.08.2018	15.73	Horse mackerel	1.Huso huso	35	170	35000
			2.N. melanostomus	0.017	11.5	17
			3.E. encrasiculus	0.018	9	6
			4.Pomatomus saltatrix	0.019	12	19
				35.054		
04.09.2018	25.5	Spart	1.Alosa immaculata	0.161	17.75	40.25
			2.Alosa caspia	0.043	19	43
			3.N. melanostomus	0.0076	7.25	3.8
			4.Scorpaena porcus	0.029	11.5	29
			5.Gasterosteus aculeatus	0.0023	6.5	2.3
				0.243		
14.12.2018	25.5	Sprat	1.M. merlangus	0.002	7	2
			2.Gobius niger	0.006	8.5	6
			3.Alosa immaculata	1.432	20.79	68.19
			4.Alosa caspia	0.386	16.86	35.09
				1.826		

3.2.2. Dynamics of the biological parameters

A) Main catch: *Sprattus sprattus* - age, length and weight structure, Fulton condition factor

In the period VII-XII.2018, the sprat catches were dominated by 1-year class - 64.02 %, followed by the 2-year class - 35.04 % (Fig.20).





ЕВРОПЕЙСКИ СЪЮЗ
ЕВРОПЕЙСКИ ФОНД ЗА
МОРСКО ДЕЛО И РИБАРСТВО



МИНИСТЕРСТВО НА ЗЕМЕДЕЛИЕТО, ХРАНИТЕ И
ГОРИТЕ

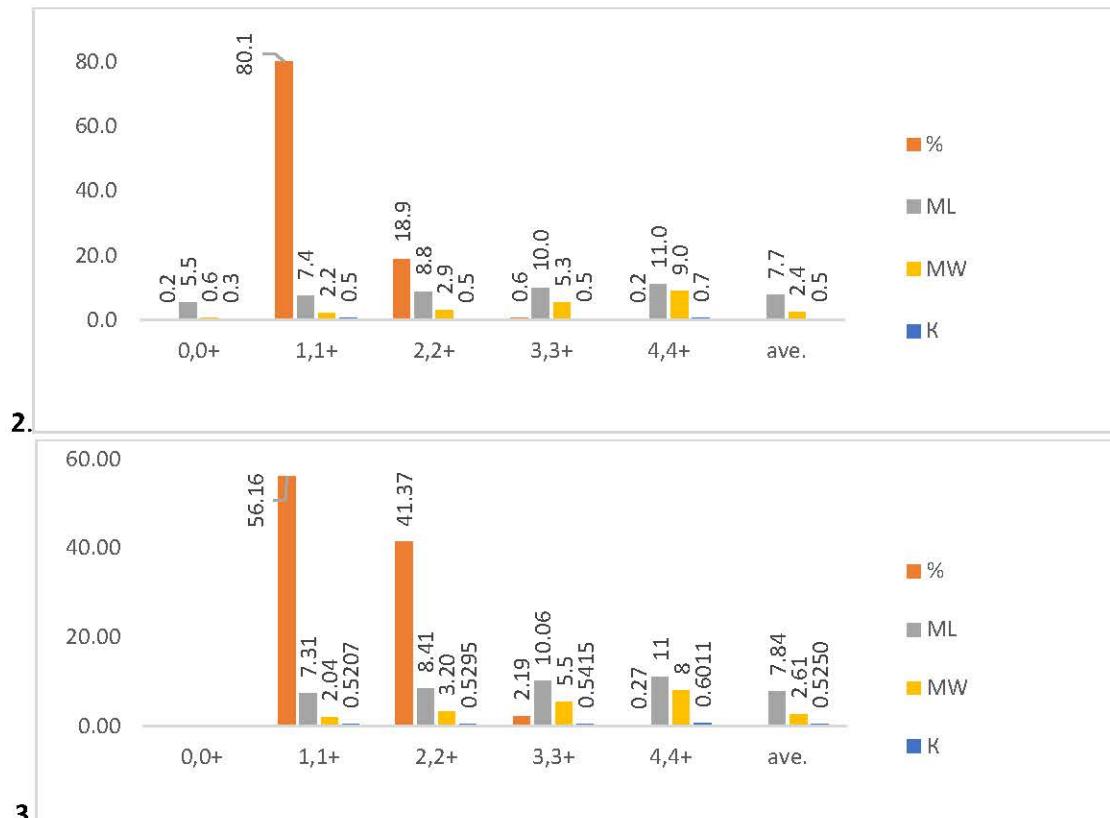


Figure 20. *Sprattus sprattus* – age structure (%), mean length and weight and Fulton coefficient by age groups and by months - (1) July 2018, (2) September 2018 and (3) December 2018.

The percent distribution of the 1-year old class by months was as follows: - VII.2018 - 56.22 %, IX.2018 - 80.12 % and XII.2018 - 56.16 %, by 2-year group - VII.2018 - 43.25 %, IX.2018 - 18.92 % and XII.2018 - 41.37 % (Fig.20).

The length structure included classes - 5.5 cm - 11.0 cm TL. The size classes - 7.3 - 8.24 cm were dominant, and their weights were - 2.25 g (7.3 cm) and 3.06 g (8.24 cm). The Fulton condition factor (K) is useful criterion for the physiological state of fish and points relatively good condition in 2018, with values 0.50 - 0.59 (Fig. 20).

When the length classes distribution was plotted against the mean weight classes it proved lack of large size group > 11.5 cm, especially in the summer period (Fig. 21).



ЕВРОПЕЙСКИ СЪЮЗ
ЕВРОПЕЙСКИ ФОНД ЗА
МОРСКО ДЕЛО И РИБАРСТВО



МИНИСТЕРСТВО НА ЗЕМЕДЕЛИЕТО, ХРАНИТЕ И
ГОРИТЕ

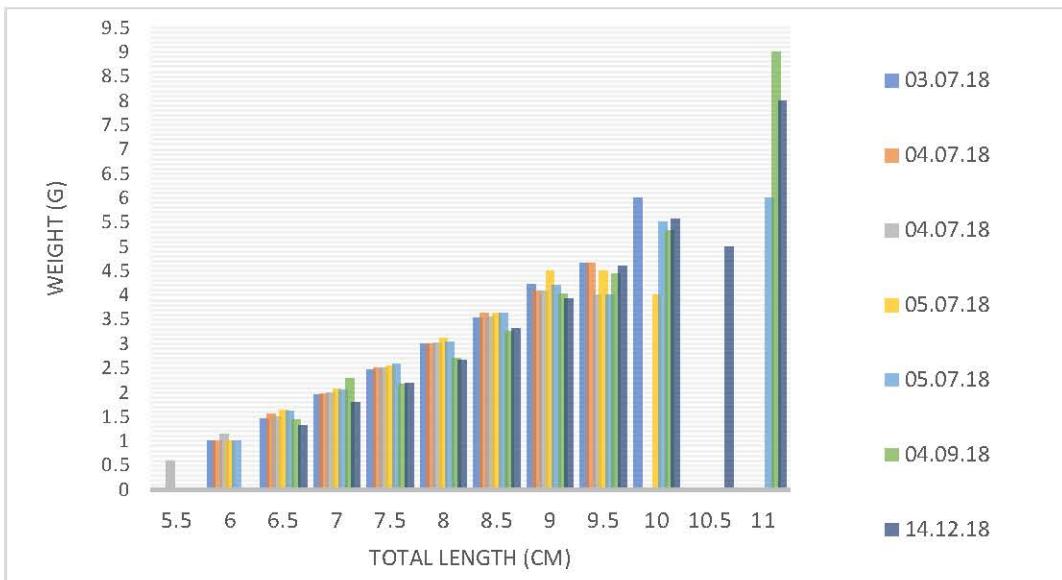


Figure 21. *Sp. sprattus*: length classes plotted against mean weight classes during different sampling periods of 2018.

The length-weight relationship: $WW=a.SL^b$ was calculated, and the coefficient b varied between a minimum of 2.81 in July, to 3.11 in September -December.

For 2018, the parameters of von Bertalanffy equation were estimated:

$$L_{\infty} = 11.58 \text{ cm},$$

$$k = 0.327,$$

$$t_0 = -0.18,$$

$$q = 0.014$$

$$b = 2.36.$$

The asymptotic length was relatively low in the current year, due to the lack (or low share) of the elder age classes with large linear sizes.

B) The main catch: *Trachurus mediterraneus* - age, length and weight structure, Fulton condition factor

The samples from horse mackerel were representative for August 2018 (samples were collected from the region of Varna).

The catches were dominated by 1- year age group - 97.31 %, by the low presence of 2- and 3-year classes - 2.24 % and 0.45 % (Fig.22).

The length structure included classes from 11.5 cm to 17.0 cm TL; by the dominant position of the length classes - 12.3 cm and 13.9 cm, with mean weights - 16.59 g and 17.15 g, and average Fulton condition factor - 0.8706 (Fig.22).



ЕВРОПЕЙСКИ СЪЮЗ
ЕВРОПЕЙСКИ ФОНД ЗА
МОРСКО ДЕЛО И РИБАРСТВО



МИНИСТЕРСТВО НА ЗЕМЕДЕЛИЕТО, ХРАНИТЕ И
ГОРИТЕ



The coefficient b of the length-weight (L-W) relationship (based on TL) varied from 2.09 to 3.16, with highest levels at the beginning of August 2018.

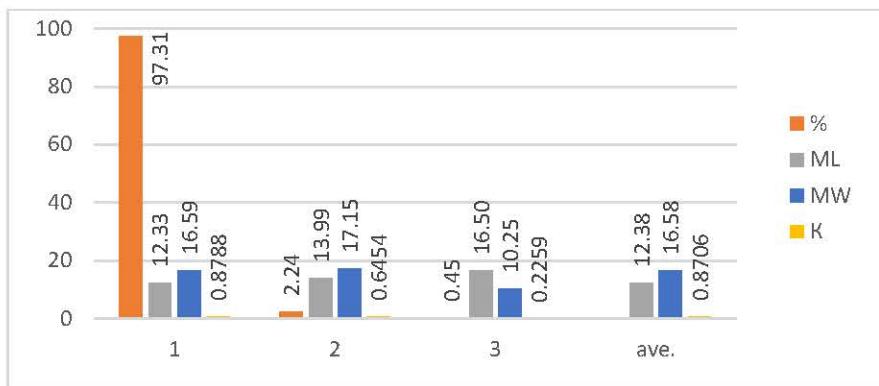


Figure 22. *T. mediterraneus* - age structure (%), mean length and weight and Fulton coefficient by age groups in August 2018.

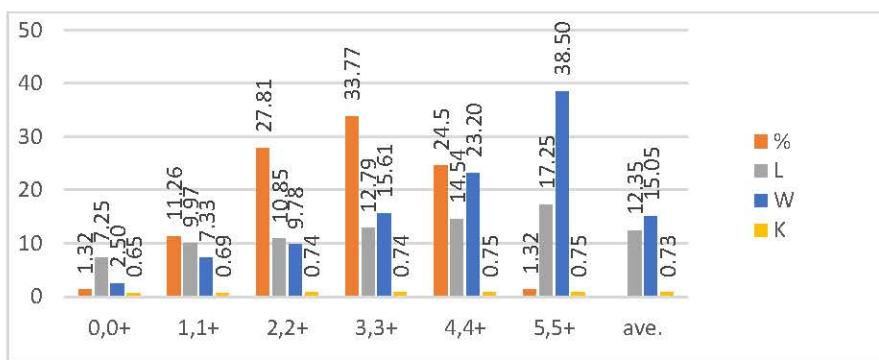
The analysis of sex structure shows the domination of female (63 %) over the male specimens (37 %).

C) Bycatch gathered by fishing with pelagic trawls

C.1. By-catch in sprat fishing

Merlangius euxinus

The bycatch in sprat fishing is created mostly from whiting (*Merlangius merlangus*) - 30.29 % from the by-catch weight (kg/day).



Фигура 23. *Merlangius euxinus* - age structure (%), mean length and weight, and Fulton coefficient by age groups and average values of the biological parameters.



ЕВРОПЕЙСКИ СЪЮЗ
ЕВРОПЕЙСКИ ФОНД ЗА
МОРСКО ДЕЛО И РИБАРСТВО



МИНИСТЕРСТВО НА ЗЕМЕДЕЛИЕТО, ХРАНИТЕ И
ГОРИТЕ



The age structure included 0,0+ to 5,5+ year old classes, with sizes between 7.25 - 17.5 cm, and weights - 2.5 - 38.5 g.

The mean size of whiting was 12.35 cm, with mean weight - 15.05 g (Fig. 23). The Fulton coefficient varied between 0.58 - 0.75 and an average level of 0.69, and the coefficient b of the L-W relationship was 3.19, proving positive allometric growth of whiting.

f. Gobiidae

The gobies (*Neogobius melanostomus* and *Mesogobius batrachocephalus*) created around 22.13 % of the by-catch weight by sprat fishing.

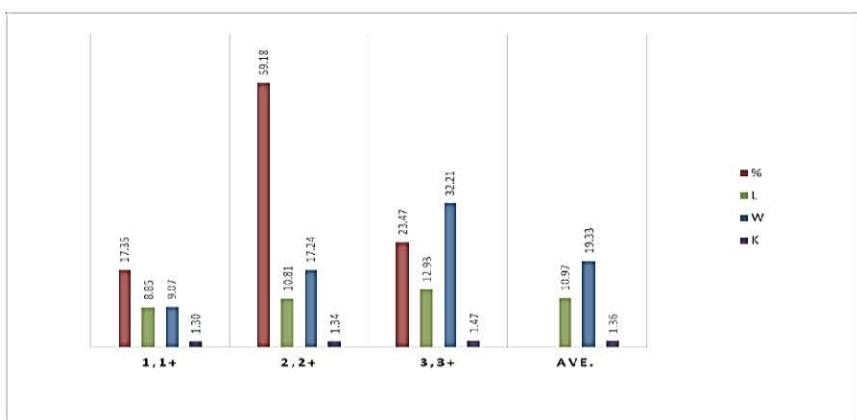


Figure 24. *N. melanostomus* - age structure (%), mean length and weight, and Fulton coefficient by age groups and average values of the biological parameters.

The age structure of *N. melanostomus* included 1,1+ - 3,3+ year classes. In the catches, we found mostly 2-year age class - 59.18 %, followed by 3-years and 1-year classes, with respective shares - 23.47 % and 17.35 %. The sizes varied between - 8.85 - 10.97 cm; the weight was - 9.07 - 19.33 g, and Fulton coefficient - 1.30 - 1.47 (Fig.24). The coefficient b = 3.29 proved positive allometric growth.

Only two specimens *M. batrachocephalus* were collected as bycatch during the sprat fishing - 12 cm, 14 g, 1-year old, and 24.5 cm, 125 g, 4 years old.

f. Clupeidae

The pontic shad *Alosa immaculata* comprised 37 % from the bycatch in sprat fishing. The age structure included 1,1+ - 3,3+ year groups, with dominant position of the 2-years - 67.95 %, followed by the 3-years class - 24.7%.



ЕВРОПЕЙСКИ СЪЮЗ
ЕВРОПЕЙСКИ ФОНД ЗА
МОРСКО ДЕЛО И РИБАРСТВО



МИНИСТЕРСТВО НА ЗЕМЕДЕЛИЕТО, ХРАНИТЕ И
ГОРИТЕ

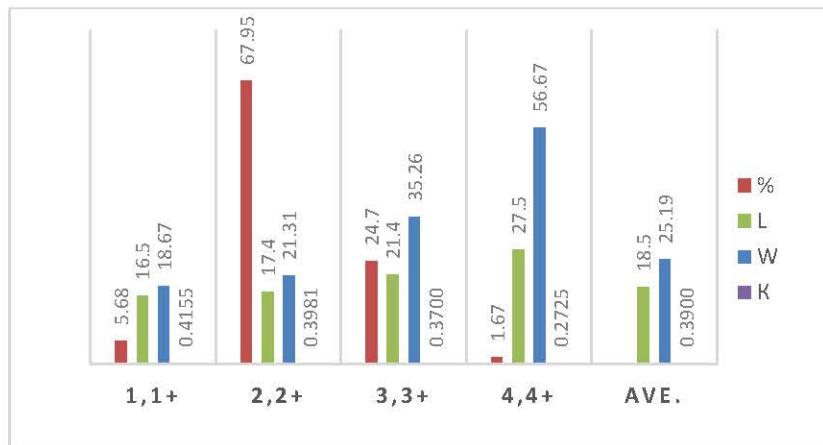


Figure 25. *Alosa immaculata* - age structure (%), mean length and weight, and Fulton coefficient by age groups and average values of the biological parameters.

The dominant age group of *A. immaculata* reached a linear size of 10.81 cm, by weight 17.24 g. The sizes of the gathered specimens varied between 8.85 – 12.93 cm, weights - 9.07 - 32.21 g; as the mean size is 10.97 cm, by the mean weight of 19.33 g (Fig.25). The Fulton condition factor was between 0.27 - 0.42, with mean lvalue of 0.39; and coefficient b = 3.1 (Fig.26).

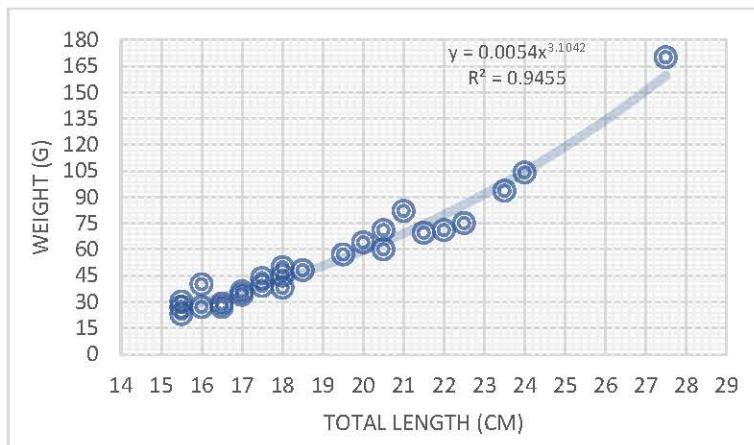


Fig 26. *Alosa immaculata*: Length-weight relationship.

Another species from the f. Clupeidae was *Alosa caspia*, producing 7.73 % of the bycatch weight (kg/day). The 2-year old group created 87.5 % of all gathered specimens (Fig.27); linear sizes varied between 11.5 - 20 cm, by the mean size of 17.09 cm, while weight was - 16.5 - 54 g, with mean value 40.97 g; Fulton condition factor was between 0.67 - 1.08, with mean level of 0.82.



ЕВРОПЕЙСКИ СЪЮЗ
ЕВРОПЕЙСКИ ФОНД ЗА
МОРСКО ДЕЛО И РИБАРСТВО



МИНИСТЕРСТВО НА ЗЕМЕДЕЛИЕТО, ХРАНИТЕ И
ГОРИТЕ

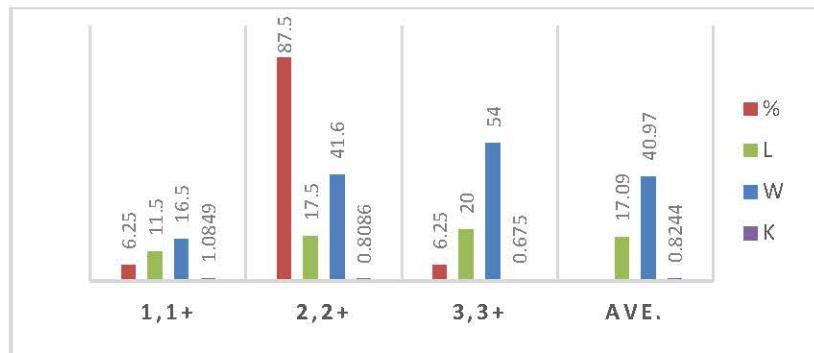


Figure 27. *A. caspia* - age structure (%), mean length and weight, and Fulton coefficient by age groups and average values of the biological parameters.

Mullus ponticus

The red mullet produced 1.67 % of the bycatch in sprat fishing. The age structure was created by 2,2+ - 4,4+ year groups, with high presence of 2-year class - 68.75 %, with a mean size of 8.79 cm and mean weight - 7.40 g. they were followed by the 3-year group - 18.75 %, with mean parameters - 11.17 cm and 14.49 g, and 4 -year group - 13.88 cm and 27.16 g. The average size and weight in the bycatches were 10.82 cm and 14.55 g (Fig. 28), while the mean Fulton condition factor was 1.0368, and the coefficient $b = 2.83$, show negative allometric growth.

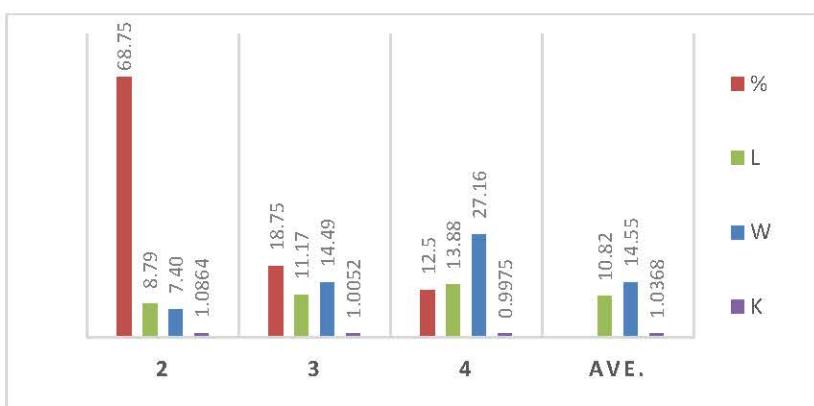


Figure 28. *Mullus ponticus* - age structure (%), mean length and weight, and Fulton coefficient by age groups and average values of the biological parameters.



ЕВРОПЕЙСКИ СЪЮЗ
ЕВРОПЕЙСКИ ФОНД ЗА
МОРСКО ДЕЛО И РИБАРСТВО



МИНИСТЕРСТВО НА ЗЕМЕДЕЛИЕТО, ХРАНИТЕ И
ГОРИТЕ



Trachurus mediterraneus

Horse mackerel creates around 1.22 % of the by-catch in sprat fishing. We found 1 – 4-year classes as by-catch, the 3-year group was missing and the most abundant was the group of 1-year class - 50 % of all collected specimens, with mean linear size 10.5 cm and weight - 7.14 g.

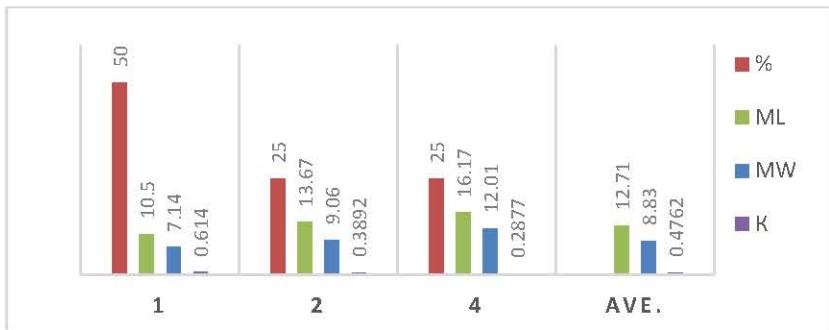


Figure 29. *Trachurus mediterraneus* - age structure (%), mean length and weight, and Fulton coefficient by age groups and average values of the biological parameters.

2-and 4-years classes have equal proportions - x 25 % in the age structure. The mean length and weight of all measured specimens were - 12.71 cm and 8.83 g; average Fulton condition factor of 0.476 (Fig.29).

As rare species in the bycatch were found black goby (*G. niger*), stargazer (*U. scaber*) and greater weever (*T. draco*) (Table 15).

Table 15

Rare species as by-catch in sprat fishing- age structure (%), mean length and weight, and Fulton coefficient by age groups.

Bycatch	Age	Mean Length (cm)	Men Weight (g)	K
<i>Gobius niger</i>	1,1+	8.5	7.0	1.135
<i>Uranoscopus scaber</i>	3	16.5	96	2.137
<i>Trachinus draco</i>	4	18	52	0.870

C.2. By-catch in horse mackerel fishing

Alosa immaculata

In horse mackerel fishing, the by-catch in August 2018 was produced mostly by pontic shad (*A. immaculata*) - 50 % from the bycatch weight. The linear sizes of the collected specimens were between 17 - 22 cm, by mean length and weight - 18.8 cm and 38.36 g, and condition factor of 0.605 - 0.723.



ЕВРОПЕЙСКИ СЪЮЗ
ЕВРОПЕЙСКИ ФОНД ЗА
МОРСКО ДЕЛО И РИБАРСТВО



МИНИСТЕРСТВО НА ЗЕМЕДЕЛИЕТО, ХРАНИТЕ И
ГОРИТЕ



Engraulis ponticus

Anchovy (*E. encrasiculus*) produced 23.91 % from the by-catch in horse mackerel fishing, with dominating proportion of the 2-year classes - 91.3% in the by-catch.

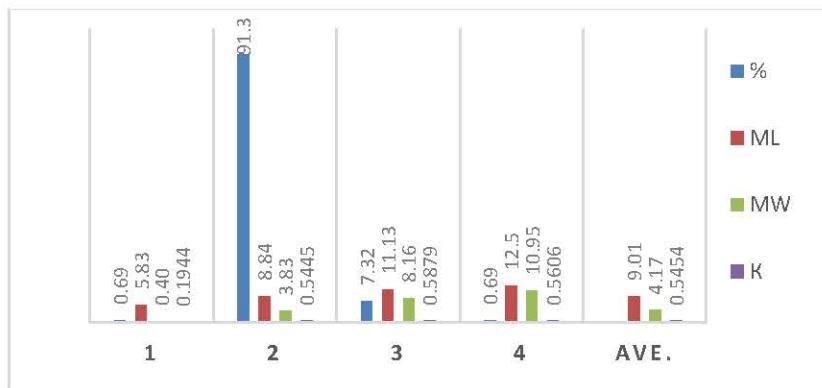


Figure 30. *Engraulis ponticus* - age structure (%), mean length and weight, and Fulton coefficient by age groups and average values of the biological parameters.

The mean length and weight of this age group reached 8.84 cm, 3.83 g. For all collected specimens the mean parameters were - 9.01 cm and 4.17 g; Fulton condition factor - 0.1944 – 0.2879, with a mean level of 0.5454 (Fig.30).

Neogobius melanostomus

The round goby has low importance as by-catch in horse mackerel fishing - 0.3 % from the by-catch weight.

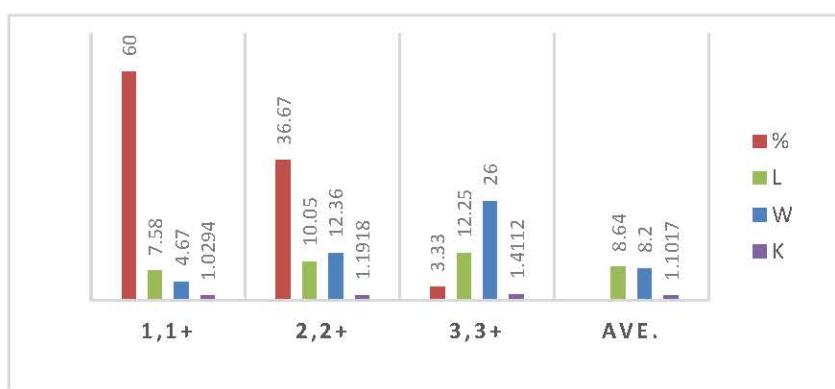


Figure 31. *N. melanostomus* - age structure (%), mean length and weight, and Fulton coefficient by age groups and average values of the biological parameters.



ЕВРОПЕЙСКИ СЪЮЗ
ЕВРОПЕЙСКИ ФОНД ЗА
МОРСКО ДЕЛО И РИБАРСТВО



МИНИСТЕРСТВО НА ЗЕМЕДЕЛИЕТО, ХРАНИТЕ И
ГОРИТЕ



The age structure includes 1,1+ - 3,3+ age classes with the dominant position of the 1-year group – 60 % with average size and weight - 7.58 cm, 4.67 g. For the all gathered specimens, the average parameters are - 8.64 cm, 8.2 g, condition factor - 1.1017 (Fig.31).

Mullus ponticus

The red mullet bycatch is with a small proportion in the by-catch weight - 0.10 %. We found two age groups, and a high proportion of 3-year group - 71.43%, with mean parameters - 11.05 cm and 13.1 g. The average length and weight of all collected specimens reach - 10.43 cm, 11.64 g, by Fulton condition factor of 1.02 (Fig.32).

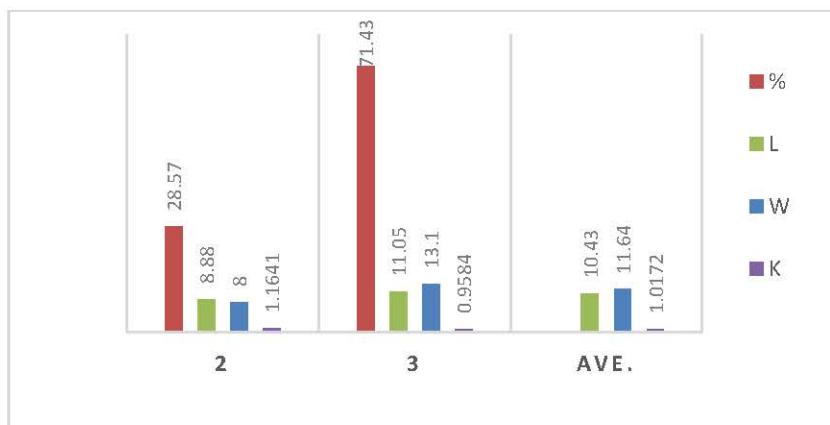


Figure 32. *Mullus ponticus* - age structure (%), mean length and weight, and Fulton coefficient by age groups and average values of the biological parameters.

Rare species in the bycatch in the horse mackerel fishing

Three specimens of common stingray (*Dasyatis pastinaca*) are gathered, with sizes - 40 cm, 878.41 g, 25 cm - 208.49 g, 20 cm - 105.33 g.

Another rare species is the sturgeon (*Huso huso*), one specimen with weight 35 kg and length - 170 cm, released immediately back into the sea.

3.3 Rapana catch

3.3.1 Main catch, bycatch, total catch

In VII-XI.2018 г., the rapana catches vary between 880 - 2060 kg/day, and the quantities of the by-catches of marine organisms range from 0.14 to 17.40 kg/day; while the total catch reaches on average 1513.64 ± 117.13 SE. The mean percentage of the by-catch is $0.29\% \pm 0.10$ SE from the total catch (Table 16). The coefficient of variation of the by-catch weight, generated by this fishing segment, has the highest variance, compared with other fishing activities.

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ЕВРОПЕЙСКИ СЪЮЗ
ЕВРОПЕЙСКИ ФОНД ЗА
МОРСКО ДЕЛО И РИБАРСТВО



МИНИСТЕРСТВО НА ЗЕМЕДЕЛИЕТО, ХРАНИТЕ И
ГОРИТЕ

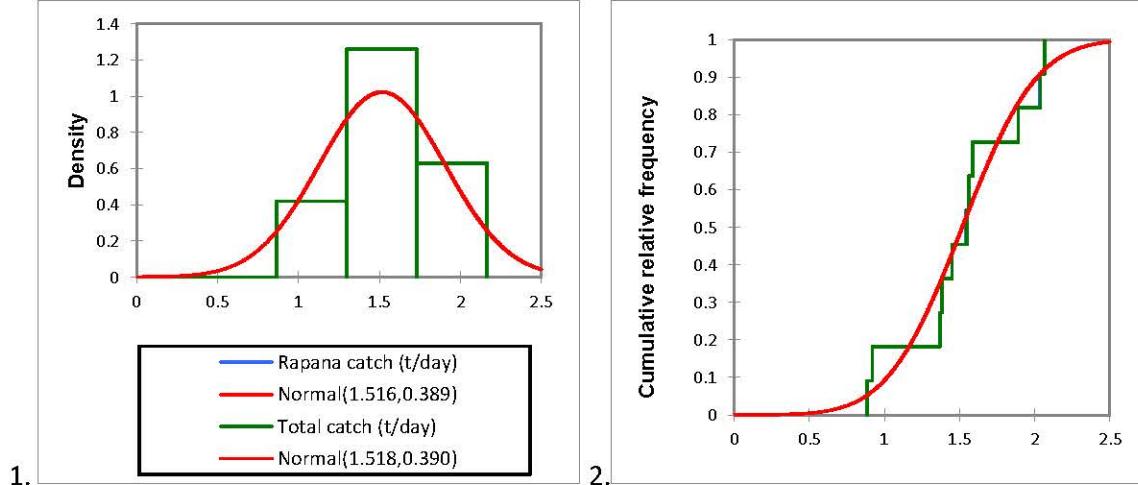


Table 16

Summary statistics of the main catches of *R. venosa* (kg/day), by-catch weight (kg/day), total catches (by-catch +catch) (kg/day) and percent share (%) of the by-catch in 2018.

	Main catch (kg/day) <i>R. venosa</i>	Bycatch weight (kg/day)	Total catch weight (catch + bycatch) (kg/day)	% of the bycatch from the total catch
Mean	1513.64	4.21	1517.85	0.29
Standard Error	117.13	1.62	117.71	0.10
Median	1540.00	1.58	1548.67	0.18
Mode	#N/A	#N/A	#N/A	0.05
Standard Deviation	388.49	5.37	390.41	0.32
Sample Variance	150925.45	28.88	152416.59	0.10
Kurtosis	-0.41	2.86	-0.42	3.68
Skewness	-0.24	1.76	-0.25	1.84
Range	1180.00	17.27	1182.76	1.08
Minimum	880.00	0.14	881.58	0.02
Maximum	2060.00	17.40	2064.34	1.10
Confidence Level (95.0%)	260.99	3.61	262.28	0.22
Coefficient of variation (CV)	25.67	127.55	25.72	110.34

For the whole studied interval in 2018, 54 % of the daily rapana catches ranged between 1.30 - 1.73 t/day, and 27 % of the catches are higher - 1.73 - 2.16 t/day, while the levels are below the average - 0.87 - 1.3 t/day by 18 % of the records (Fig.33).



Фигура 33. Histogram of the rapana catches and total catches, (CPUE, t/day), by classes (1) and cumulative distribution (2) during 2018.



ЕВРОПЕЙСКИ СЪЮЗ
ЕВРОПЕЙСКИ ФОНД ЗА
МОРСКО ДЕЛО И РИБАРСТВО



МИНИСТЕРСТВО НА ЗЕМЕДЕЛИЕТО, ХРАНИТЕ И
ГОРИТЕ



The highest daily rapana catches are registered in September - 1890 kg/day but in November they show a decreasing trend with 33 % to 1350 kg/day. In August, the total catches attain 1810 kg/day and decrease with 29 % in autumn, to 1351 kg/day (Table 17).

Table 17

The primary catches (rapana, kg/day) and the bycatches (kg/day) of sea species with beam trawls in 2018

Time period	Main catch (kg/day)	Species weight in bycatch [kg/day]										Bycatch (kg/day)	Total catch (kg/day)	% of the bycatch from the TC
		Turbot	Flounder	Goby	Red mullet	Sole	Shark	scorpionfish	Stargazer	others				
Mean for VII	1800	6.30	0.48	0.29	0.15	0.09	0.21	0.18	0.15	1.94	9.78	1809.78	0.57	
Mean for IX	1890	0.5		0.49	0.04			0.20	0.03	0.21	1.49	1891.49	0.08	
Mean for XI	1350	0.28		0.60	0.01			0.03	0.05	0.04	1.00	1351.00	0.12	

The bycatch weight is 9.78 kg/day on average in July 2018, and it decreases with 155 % in autumn to 1.25 kg/day. Presented as a percentage from the total catch, the bycatch is around 0.57 % in summer and decreases 4.3 times to 0.13 % in autumn (Table 17, Fig. 34).

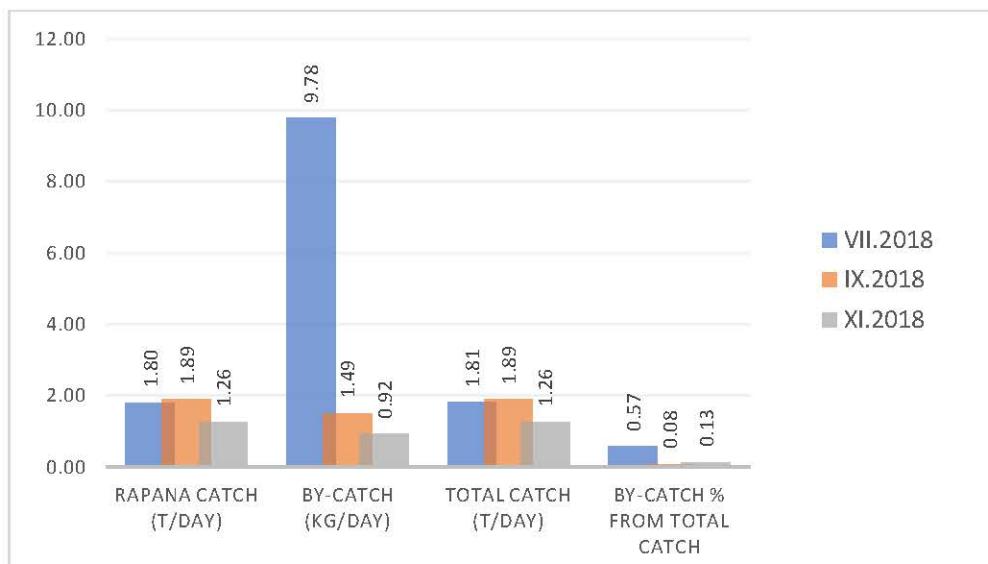


Figure 34. Rapana catch (t/day), bycatch (kg/day), total catch (t/day) and percentage share (%) of the sea species bycatch from the total catch (catch + bycatch) in 2018.



ЕВРОПЕЙСКИ СЪЮЗ
ЕВРОПЕЙСКИ ФОНД ЗА
МОРСКО ДЕЛО И РИБАРСТВО



МИНИСТЕРСТВО НА ЗЕМЕДЕЛИЕТО, ХРАНИТЕ И
ГОРИТЕ



The species composition of the bycatch in rapana fishing is diverse and includes 22 fish species and crustaceans, as in the bottom trawls are registered between 1 - 14 different marine organisms per day. Most often, as by-catch are registered - turbot (*Scophthalmus maximus*), gobies (mostly *Neogobius melanostomus* and *Mesogobius batrachocephalus*), flounder (*Platichthys flesus*), horse mackerel (*Trachurus mediterraneus*), whiting (*M. merlangus*), red mullet (*Mullus barbatus*) and stargazer (*Uranoscopus scaber*). In addition, species such as greater weever (*Trachinus draco*), scorpionfish (*Scorpaena porcus*), sand sole (*Solea lascaris*), shark (*Squalus acanthias*) and rusty blenny (*Parablennius sanguinolentus*) are also observed, however with few individuals. Rare species include garfish (*Belone belone*), sailfin dragonet (*Callionymus pusillus*), sea needle (*Syngnathus acus*), common stingray (*Dasyatis pastinaca*) and seahorse (*Hippocampus spp.*). Some crustaceans are found in the bycatch – mostly warty crab (*Eriphia verucosa*), as well as - *Liocarcinus vernalis* and *Brachynotus sexdentatus*.

Detailed data about the species composition, sizes and weights of the species in the bycatch (beam trawl fishing), may be found in Table 18 and Fig. 35 & 36.

Table 18

Bycatch species, quantities, average size and weight (\pm SE) by separate fishing days with registered bycatch in 2018.

Date	Fishing vessel length (m)	Primary catch (kg)	Species composition of bycatch	Total bycatch (kg)	Average size (cm) \pm SE	Average weight (g)
12.07.2018	14.52	1540	1.S. maximus	4.494	26.35 \pm 3.848	499.41 \pm 176.667
			2.Platichthys flesus	1.4912	15.1 \pm 1.71	78.48 \pm 35.74
			3.Scorpaena porcus	0.633	17.9 \pm 0.33	126.68 \pm 10.93
			4.Mullus barbatus	0.544	10.36 \pm 0.45	10.77 \pm 2.78
			5.Uranoscopus scaber	0.387	15.5 \pm 0.40	64.51 \pm 6.19
			6.N. melanostomus	0.383	8.7 \pm 0.36	8.56 \pm 1.63
			7.M. batrachocephalus	0.356	14.41 \pm 1.02	32.36 \pm 9.207
			8.Solea lascaris	0.355	15.19 \pm 0.46	38.99 \pm 7.65
			9.G. niger	0.102	7.92 \pm 0.302	5.53 \pm 1.49
			10.Trachinus draco	0.033	16.5	33.3
			11.Syngnathus acus	0.029	27 \pm 2.07	7.27 \pm 1.28
			12.B. sanguinolentus	0.027	8.1 \pm 0.43	5.48 \pm 1.22
			13.M. merlangus	0.0067	10	6.7
			14.Callionymus pusillus	0.0032	6	5.48 \pm 1.22
total				8.8441		
27.07.2018	16.5	1570	1.S. maximus	16.6	39.38 \pm 2.16	1255.38 \pm 176.07
			2.T. mediterraneus	0.509	13.35 \pm 0.45	17.18 \pm 2.77
			3.M. merlangus	0.0288	13.25 \pm 0.25	14.4 \pm 1.1
			4.N. melanostomus	0.0445	9.75 \pm 0.48	11.13 \pm 2.17
			5.M. batrachocephalus	0.2531	17.33 \pm 4.41	84.37 \pm 64.66
			6.Platichthys flesus	0.153	14.3 \pm 0.64	30.6 \pm 5.15
			7.G. niger	0.0089	7	3
			8.Uranoscopus scaber	0.025	11	25

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ЕВРОПЕЙСКИ СЪЮЗ
ЕВРОПЕЙСКИ ФОНД ЗА
МОРСКО ДЕЛО И РИБАРСТВО



МИНИСТЕРСТВО НА ЗЕМЕДЕЛИЕТО, ХРАНИТЕ И
ГОРИТЕ



			9.Scorpaena porcus	0.092	17	92
<i>total</i>				17.7143		
28.07.2018	16.5	2060	1.S. maximus	3.27	38.25 ± 1.38	817.5 ± 69.21
			2.Platichthys flesus	0.264	17 ± 1.75	52.8 ± 14.74
			3.Uranoscopus scaber	0.19	17 ± 0.5	95 ± 8
			4.T. mediterraneus	0.384	12.07 ± 0.25	16.4 ± 3.29
			5.Mullus barbatus	0.06	11.4 ± 0.48	12.6 ± 1.29
			6.Callionymus pusillus	0.01	5.5	8
			7.Eriphia verrucosa	0.226	8.454	0.226
			8.Liocarcinus vernalis	0.144	14	3.55
<i>total</i>				4.548		
29.07.2018	16.5	2030	1.S. maximus	0.83	24 ± 8.47	412.5 ± 18.87
			2.Dasyatis pastinaca	6.16	92	6160
			3.Squalus acanthias	0.82	53 ± 3	410 ± 10
			4.T. mediterraneus	0.19	15.3 ± 0.82	38 ± 5.73
			5.Mullus barbatus	0.01	13	17
<i>total</i>				8.01		
01.09.2018	16.5	1890	1 S. maximus	0.52	22.67 ± 0.33	173.33 ± 3.33
			2. M. batrachocephalus	0.466	17.79 ± 1.52	77.75 ± 15.58
			3. N. melanostomus	0.018	6.5 ± 5.5	9.15 ± 2.85
			4. Mullus barbatus	0.0377	12.5 ± 1.5	18.5 ± 1.00
			5. T. mediterraneus	0.092	11.23 ± 0.29	11.5 ± 0.71
			6. Scorpaena porcus	0.204	17.25 ± 0.25	102.25 ± 15.75
			7. Uranoscopus scaber	0.032	12	32
			8. Alosa immaculata	0.016	11.5	16.5
			9. Hippocampus spp.	0.001	6.5	1.5
			10. Gobius niger	0.002	5.5	2
			11.Portunus holsatus	0.103	3.81 ± 0.15	9.36 ± 0.86
<i>total</i>				1.4917		
04.11.2018	12.58	1560	1. S. maximus	0.47	22 ± 1.00	235 ± 65.00
			2. M. batrachocephalus	0.195	19.33 ± 0.44	65 ± 4.04
			3. Uranoscopus scaber	0.119	15.75 ± 1.25	59.5 ± 10.5
<i>total</i>				0.784		
05.11.2018	12.58	1380	1. S. maximus	0.36	24	360
			2. Belone belone	0.069	32.5 ± 1	34.5 ± 0.5
			3. Uranoscopus scaber	0.041	13.4	41
			4. N. melanostomus	0.114	15.5 ± 3	57 ± 32.00
			5. M. batrachocephalus	0.14	18.95 ± 0.45	70 ± 6.00
<i>total</i>				0.724		
07.11.2018 a	12.58	1370	1. S. maximus	0.35	24	350
			2. N. melanostomus	0.061	17	61
			3. M. batrachocephalus	1.236	21.93 ± 0.43	162.28 ± 29.54
<i>total</i>				1.647		
07.11.2018 b	14.9	1300	1. S. maximus	0.29	21	290
			2. N. melanostomus	0.02	7	9.8 ± 2.37
			3. M. batrachocephalus	0.335	13.81 ± 0.83	30.14 ± 8.37
<i>total</i>				0.645		
08.11.2018 a	14.9	920	1. M. batrachocephalus	0.135	18.75 ± 2.25	67.5 ± 2.5
<i>total</i>				0.135		

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ЕВРОПЕЙСКИ СЪЮЗ
ЕВРОПЕЙСКИ ФОНД ЗА
МОРСКО ДЕЛО И РИБАРСТВО

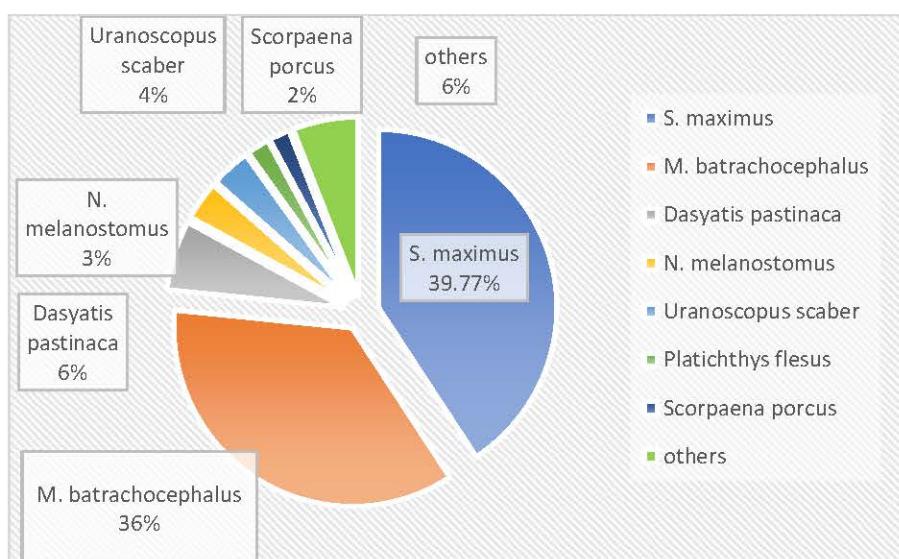


МИНИСТЕРСТВО НА ЗЕМЕДЕЛИЕТО, ХРАНИТЕ И
ГОРИТЕ



08.11.2018 b	12.58	880	1. N. melanostomus	0.167	17±1	83.5±14.5
			2. M. batrachocephalus	1.291	21±0.76	92.21±10.23
			3. Uranoscopus scaber	0.126	15.75±0.75	63±9
total				1.584		

The predominant species in the bycatch is the turbot. It forms 39.77 % from the bycatch weight, followed by knout goby *Mesogobius batrachocephalus* (35.39 %) (Fig. 35). The species *Dasyatis pastinaca* forms high quantitative share by weight because of the big sizes of the caught species, however, this species is found rarely in bottom trawls. Some small fish species, although often found, have a small share in the bycatch weight due to their low individual weight.



Фигура 35. Species composition of the bycatch (as % from the by-catch weight (kg/day) in rapana fishing during 2018.

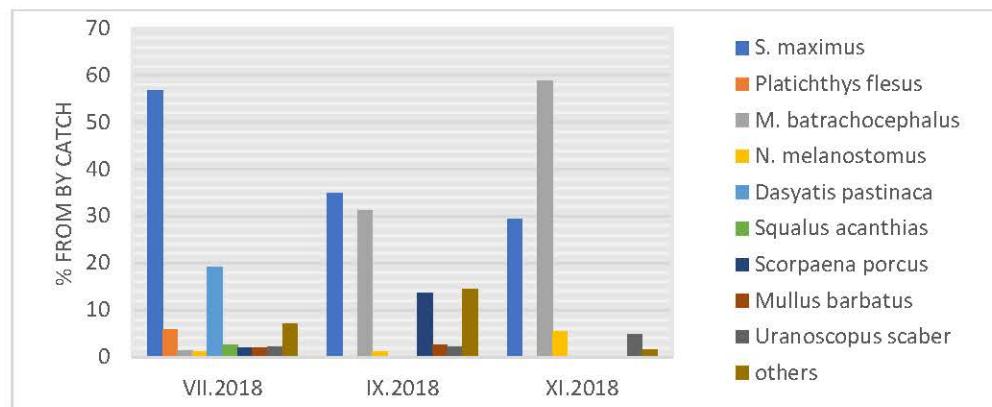
The bycatch species composition varies significantly by seasons (Fig.36), for example, turbot dominates strongly the bycatches weight during the summer period - 59.69 %, but the share of this species decreases two times in autumn. In autumn, when the bycatch weight decreases almost 10 times compared to summer, the share of knot goby increases in the bycatch weight - 54.85 % in rapana fishing.



ЕВРОПЕЙСКИ СЪЮЗ
ЕВРОПЕЙСКИ ФОНД ЗА
МОРСКО ДЕЛО И РИБАРСТВО



МИНИСТЕРСТВО НА ЗЕМЕДЕЛИЕТО, ХРАНИТЕ И
ГОРИТЕ



Фигура 36. Monthly changes in the bycatch species composition (as % from by-catch weight, kg/day) in rapana catch with beam trawl in 2018.

The calculations of the percent shares from the total catch (rapana + bycatch) show that in summer the average turbot bycatch is $0.38\% \pm 0.22$ SE (from the total catch). It varies between 0 - 1.05 % per fishing day (Fig. 23, Tables 13 and 14). In autumn, the turbot by-catch forms 0.02 % of the total catch, varying between 0 - 0.03 % (Fig. 37, Tables 15 and 16).

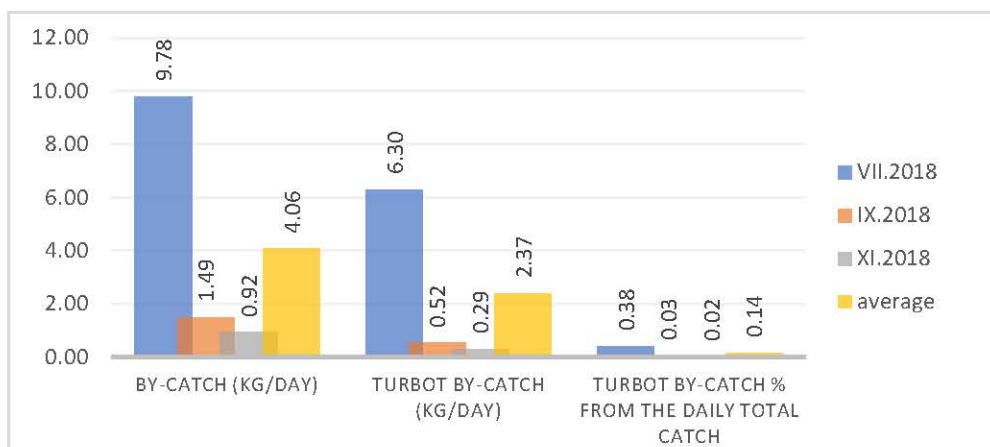


Figure 37. Bycatch weight (kg/day), turbot bycatch (kg/day) and percentage distribution (%) of turbot related to the total catch (catch + bycatch) kg/day in 2018.

In 2018, the percentage of turbot bycatch reached 0.14 % of the total catch in rapana fishing - a lower value than in 2017, when the percentage was 0.31 %, due to the low rapana catches - 256 kg/day in the previous year. In comparison with 2017, the average rapana catch has increased 6 times in 2018 - up to 1513.64 kg/day, and the weight of the turbot bycatch raised three times - 2.4 kg/day, but the percent share is lower than in 2017.



ЕВРОПЕЙСКИ СЪЮЗ
ЕВРОПЕЙСКИ ФОНД ЗА
МОРСКО ДЕЛО И РИБАРСТВО



МИНИСТЕРСТВО НА ЗЕМЕДЕЛИЕТО, ХРАНИТЕ И
ГОРИТЕ



3.3.2. Biological parameters dynamics

A) *Rapana venosa* – length and weight structure of the main catches

The rapana catches in summer were dominated by specimens from the size group - 5.62 - 6.16 cm (27.25 % of all measured individuals), followed by the size group - 6.16 - 6.7 cm (22.25 %) (Fig 38, Table 19.1). In this period, 93 % of the measured specimens had size < 7.78 cm. The average *R. venosa* length reached $6.5 \text{ cm} \pm 0.82 \text{ SD}$, by mean weight - $49.61 \text{ g TW} \pm 19.67 \text{ SD}$, and the minimal and maximal individual weights varied between 22 - 133 g TW (Fig.39, Table 19.2).

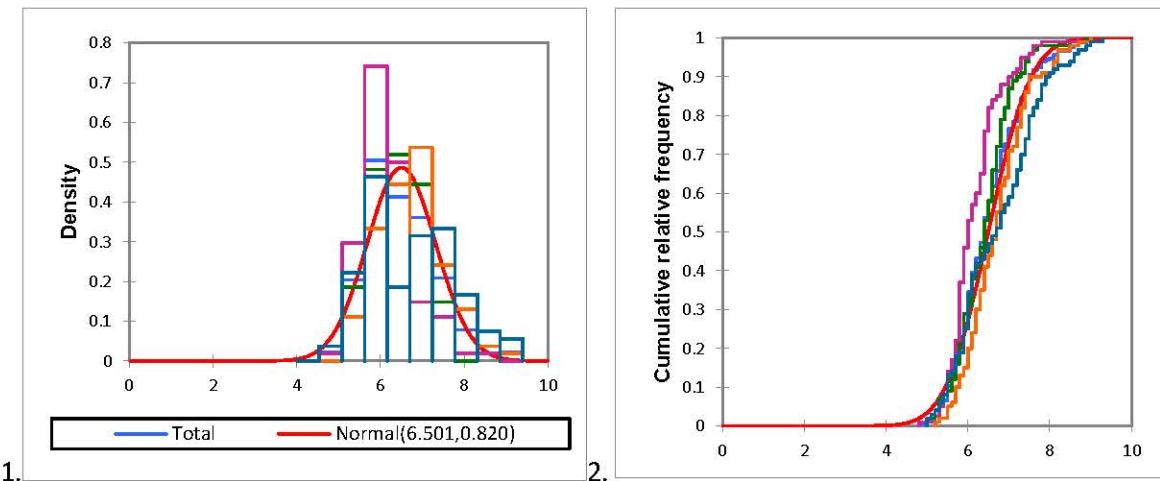


Figure 38. Distribution of *R. venosa* by classes according to the shell length (SL, cm, 1), and cumulative distribution by classes (2) in summer 2018.

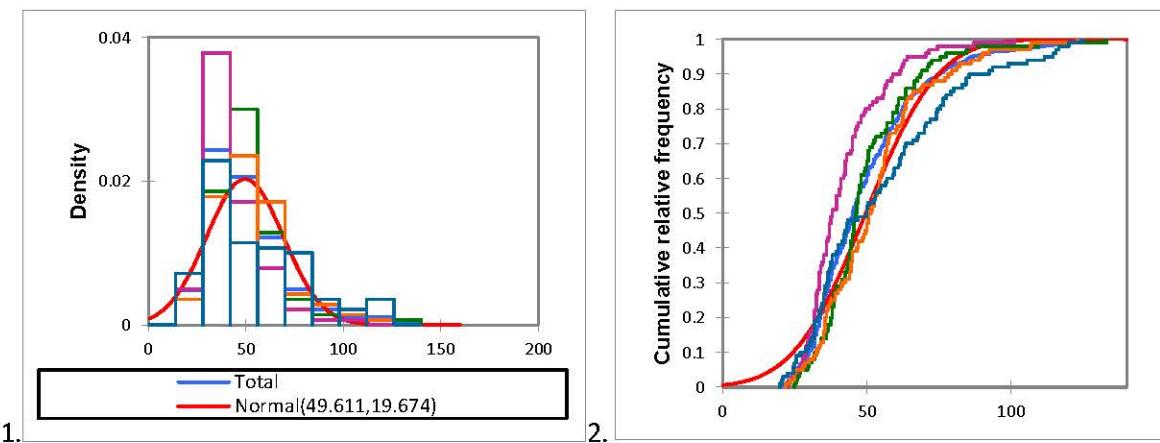


Figure 39. Distribution of *R. venosa* by classes according to the total weight (TW, g, 1), cumulative distribution by classes (2) in summer 2018.



ЕВРОПЕЙСКИ СЪЮЗ
ЕВРОПЕЙСКИ ФОНД ЗА
МОРСКО ДЕЛО И РИБАРСТВО



МИНИСТЕРСТВО НА ЗЕМЕДЕЛИЕТО, ХРАНИТЕ И
ГОРИТЕ



Table 19

Statistical data about the distribution of the size (cm, 1) and weight (g, 2) classes of rapana catch in summer 2018.

1. SL (cm)

Lower bound	Upper bound	Frequency	Relative frequency	Density
4	4.54	0	0.000	0.000
4.54	5.08	5	0.013	0.023
5.08	5.62	44	0.110	0.204
5.62	6.16	109	0.273	0.505
6.16	6.7	89	0.223	0.412
6.7	7.24	78	0.195	0.361
7.24	7.78	45	0.113	0.208
7.78	8.32	17	0.043	0.079
8.32	8.86	8	0.020	0.037
8.86	9.4	5	0.013	0.023

2. TW (g)

Lower bound	Upper bound	Frequency	Relative frequency	Density
0	14	0	0.000	0.000
14	28	27	0.068	0.005
28	42	136	0.340	0.024
42	56	115	0.288	0.021
56	70	68	0.170	0.012
70	84	28	0.070	0.005
84	98	12	0.030	0.002
98	112	7	0.018	0.001
112	126	6	0.015	0.001
126	140	1	0.003	0.000

In autumn 2018, we observed some increase of the small-size classes in the length structure of *R. venosa*. The catches were dominated by length groups - 5.62 - 6.16 cm (27.43 %) and 6.16 – 6.7 cm (24.71%), and the size group - 5.08 - 5.62 cm took the 3rd place by importance (20.86 %) (Fig. 40, Table 20.1). In this time, 97 % of all measured specimens were with length < 7.78 cm and the mean size reached 6.15 cm ± 0.79 SD, by mean weight - 39.32 g TW ± 17.500 SD (Fig.41, Table 20.2). Thus, the mean rapana weight has decreased by 23.15 % in autumn and the rapana size was reduced with 6 % in comparison with the summer data.



ЕВРОПЕЙСКИ СЪЮЗ
ЕВРОПЕЙСКИ ФОНД ЗА
МОРСКО ДЕЛО И РИБАРСТВО



МИНИСТЕРСТВО НА ЗЕМЕДЕЛИЕТО, ХРАНИТЕ И
ГОРИТЕ

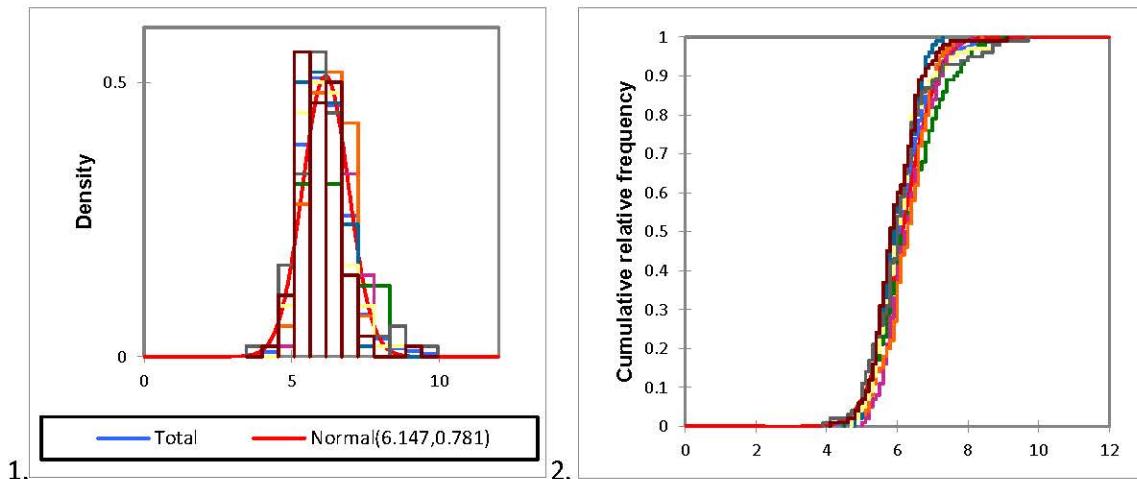


Figure 40. Distribution of *R. venosa* by classes according to the shell length (SL, cm, 1), cumulative distribution by classes (2) in autumn 2018.

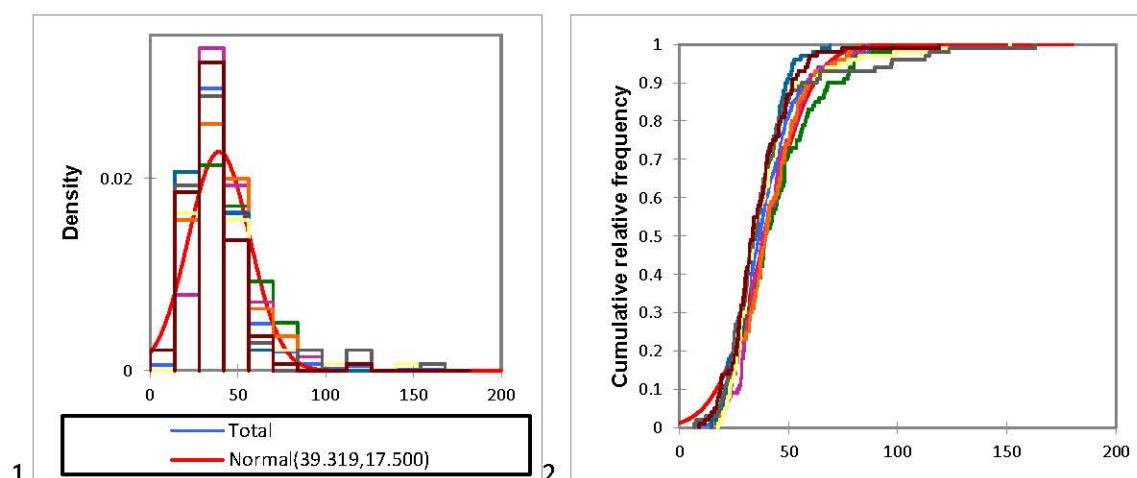


Figure 41. Distribution of *R. venosa* by classes according to the total weight (TW, g, 1), cumulative distribution by classes (2) in autumn 2018.

Table 20

Statistical data about the distribution of the size (cm, 1) and weight (g, 2) classes of rapana catch in autumn 2018.

1. SL (cm)

Lower bound	Upper bound	Frequency	Relative frequency	Density
3.46	4.00	1.0	0.001	0.003
4.00	4.54	3.0	0.004	0.008



ЕВРОПЕЙСКИ СЪЮЗ
ЕВРОПЕЙСКИ ФОНД ЗА
МОРСКО ДЕЛО И РИБАРСТВО



МИНИСТЕРСТВО НА ЗЕМЕДЕЛИЕТО, ХРАНИТЕ И
ГОРИТЕ



4.54	5.08	35.0	0.050	0.093
5.08	5.62	146.0	0.209	0.386
5.62	6.16	192.0	0.274	0.508
6.16	6.70	173.0	0.247	0.458
6.70	7.24	97.0	0.139	0.257
7.24	7.78	29.0	0.041	0.077
7.78	8.32	12.0	0.017	0.032
8.32	8.86	6.0	0.009	0.016
8.86	9.40	4.0	0.006	0.011
9.40	9.94	2.0	0.003	0.005

2. TW (g)

Lower bound	Upper bound	Frequency	Relative frequency	Density
0	14	6	0.009	0.001
14	28	161	0.230	0.016
28	42	288	0.411	0.029
42	56	162	0.231	0.017
56	70	48	0.069	0.005
70	84	19	0.027	0.002
84	98	7	0.010	0.001
98	112	2	0.003	0.000
112	126	5	0.007	0.001
126	140	0	0.000	0.000
140	154	1	0.001	0.000

B) Biological parameters of the bycatch species in rapana fishing

S. maximus

A total of 41 turbot specimens were gathered as by-catch in rapana fishing during 2018, 33 ind – in summer (56.70 % from the bycatch weight) and 8 ind. – in autumn (30.11 %).

The size and weight of the collected specimens varied from 5.5 cm, 0.8 g to 52 cm, 1920 g. In the by-catch was estimated the presence of 0 - to 4-year classes, with a prevalence of 0 - year class (48.78 %), followed by 3 - year old group (24.39 %). The average size and weight of all collected specimens were 29.26 cm and 0.66 kg (Fig. 42). The mean parameters of 0- year class were - 18.88 cm, 0.200 kg, and for 4- year old class - 50 cm - 2.163 kg. The Fulton condition factor was 1.5 for 1-year class, and 2.14 for the 4-year group. The L-W dependence was calculated, with coefficients a = 0.01 and b = 3.165, showing positive allometric growth (Fig. 43).

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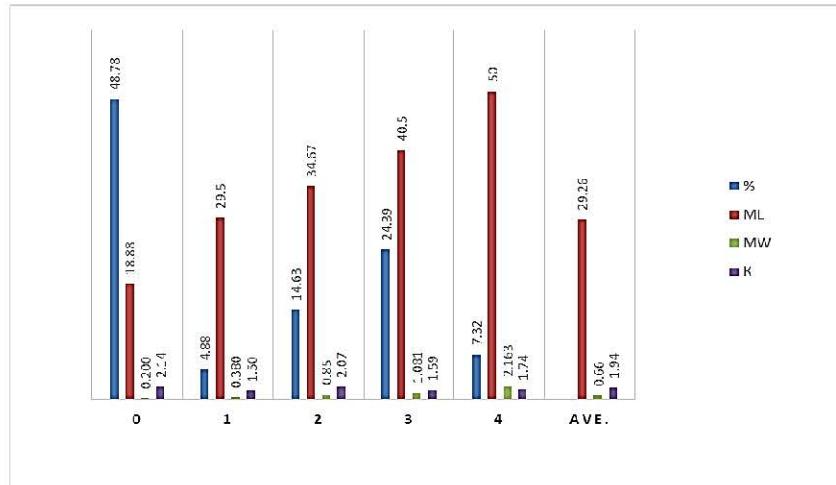
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ЕВРОПЕЙСКИ СЪЮЗ
ЕВРОПЕЙСКИ ФОНД ЗА
МОРСКО ДЕЛО И РИБАРСТВО



МИНИСТЕРСТВО НА ЗЕМЕДЕЛИЕТО, ХРАНИТЕ И
ГОРИТЕ



Фигура 42. *S. maximus* - age structure (%), mean length and weight, and Fulton coefficient by age groups and average values of the biological parameters.

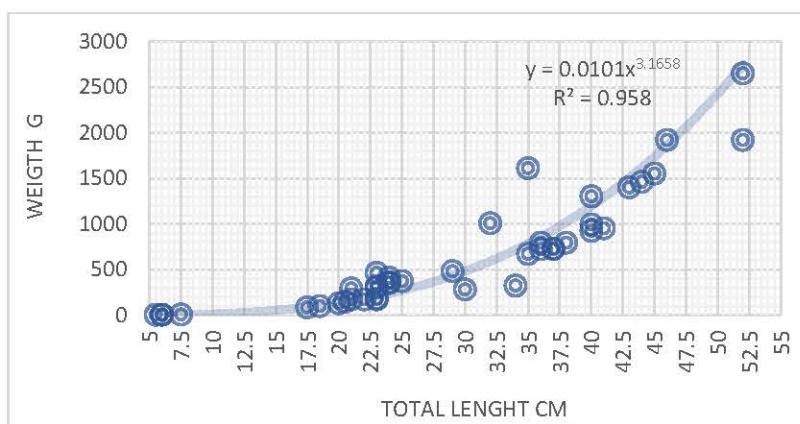


Figure 43. *S. maximus*: L-W relationship.

Platichthys flesus

P. flesus was observed in the rapana fishing bycatch only in summer (5.88 % of by-catch weight). The age structure included from 2 - to 6- year classes, with a high presence of 2- and 3 -year groups - 44.61 % and 47.5 %. The mean size and weight of these age groups were 13.54 cm, 17 cm, and 22.35 g, and 27.70 g, and the largest collected specimen was with size 38.5 cm and weight 587 g. The Fulton condition factor was in limits 0.51 – 0.86, with mean value 0.68 (Fig. 44). The coefficients in the L-W relationship were a=0.01 и b=3.00.



ЕВРОПЕЙСКИ СЪЮЗ
ЕВРОПЕЙСКИ ФОНД ЗА
МОРСКО ДЕЛО И РИБАРСТВО



МИНИСТЕРСТВО НА ЗЕМЕДЕЛИЕТО, ХРАНИТЕ И
ГОРИТЕ

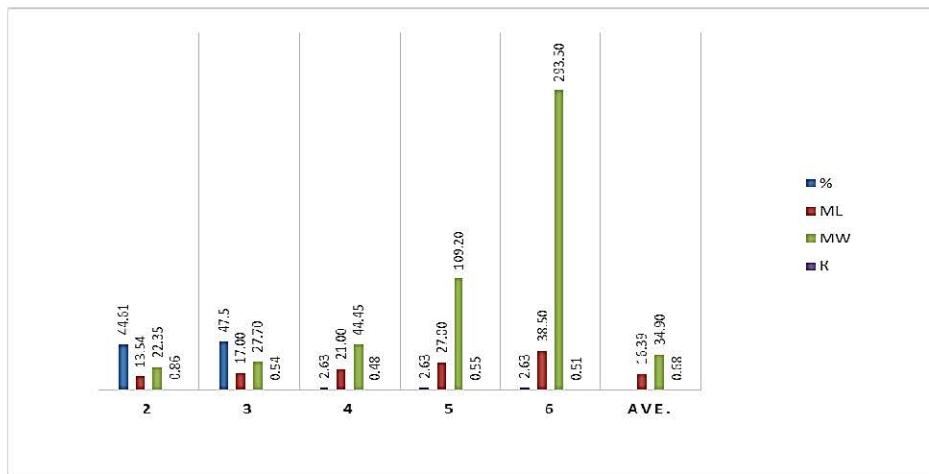


Figure 44. *Platichthys flesus* - age structure (%), mean length and weight, and Fulton coefficient by age groups and average values of the biological parameters.

M. batrachocephalus

Knot goby was found mostly in the autumn by-catches during rapana fishing with share 54.85 % of the by-catch weight. In summer, only small-sized individuals were spotted - 10.5 - 15 cm, while in autumn, the sizes have increased up to 12.5 - 27 cm. A total of four age classes were detected: 1,1+ - 4,4+, with the dominant position of the 3-year old class - 49.06 %, followed by 1- and 2- year old groups – with equal shares of 20.75 %.

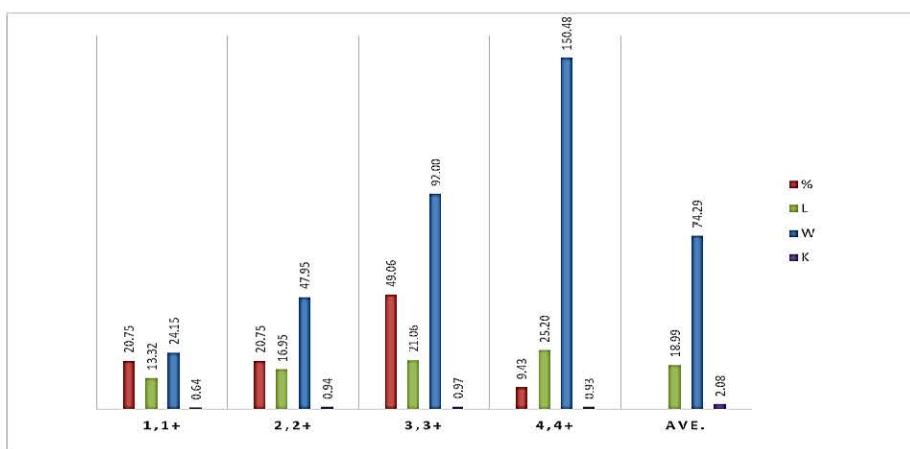


Figure 45. *M. batrachocephalus* - age structure (%), mean length and weight, and Fulton coefficient by age groups and average values of the biological parameters.



ЕВРОПЕЙСКИ СЪЮЗ
ЕВРОПЕЙСКИ ФОНД ЗА
МОРСКО ДЕЛО И РИБАРСТВО



МИНИСТЕРСТВО НА ЗЕМЕДЕЛИЕТО, ХРАНИТЕ И
ГОРИТЕ



The average size and weight of all individuals reached 18.99 cm and 74.29 g, and Fulton condition factor was 2.08 (Fig.45). The L-W relationship was calculated for different time periods and the coefficient b is around 2.9 in autumn (Fig. 46).

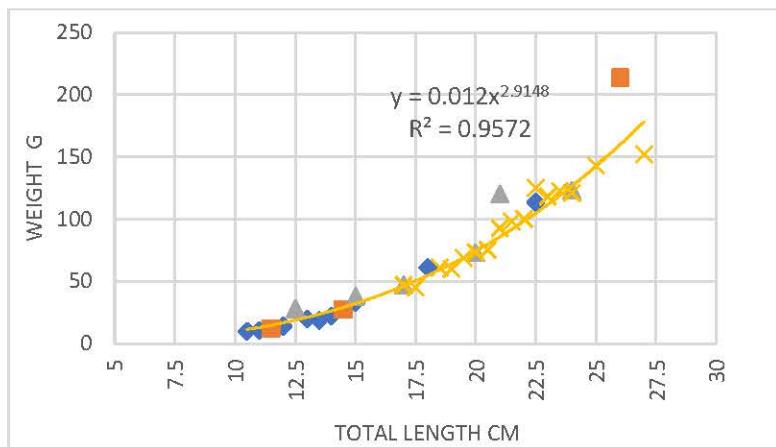


Figure 46. *M. batrachocephalus* - L-W relationship.

N. melanostomus

The round goby was observed in the by-catch during the entire observations period, however in summer the most specimens had the size of 6 - 13.5 cm and weight of 2.83 – 34.5 g., while larger individuals were detected in autumn - up to 18.5 cm, and 89 g.

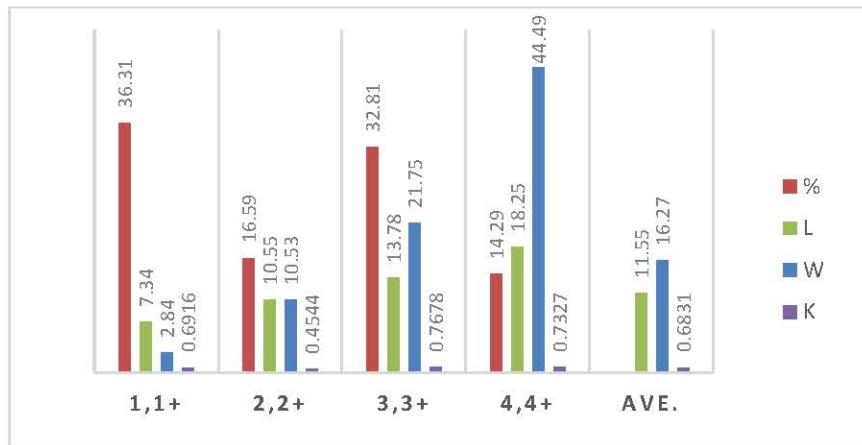


Figure 47. *N. melanostomus* - age structure (%), mean length and weight, and Fulton coefficient by age groups and average values of the biological parameters.

In autumn, *N. melanostomus* produced 4.9 % of the by-catch weight in rapana fishing, and four age groups were presented - 1,1+ -4,4+, and high importance of 1-and 3-year old classes -36.31% and



ЕВРОПЕЙСКИ СЪЮЗ
ЕВРОПЕЙСКИ ФОНД ЗА
МОРСКО ДЕЛО И РИБАРСТВО



МИНИСТЕРСТВО НА ЗЕМЕДЕЛИЕТО, ХРАНИТЕ И
ГОРИТЕ



32.81% (Fig. 47). The average parameters for all specimens reached -11.55 cm, 16.27 g, and condition factor was 0.6831. The coefficient b of the L-W relationship varied between 3.01 - 3.4.

Dasyatis pastinaca

One specimen common stingray (92 cm, 6.16 kg) was caught near Balchik in July 2018. The common stingray was a rare species as by-catch in this type of fishing but it could generate a high proportion by weight (6 %), connected to the large sizes of the collected individuals.

Squalus acanthias

As bycatch, two specimens were collected in Balchik region - 50 cm, 400 g, and 56 cm, 460 g.

Scorpaena porcus

Scorpionfish were found in the bycatch only in summer, with share 1.92 % of the by-catch weight. Four age groups were detected, from three to 6-year old classes, with dominant role of the 3-year group (41.67 %), followed by 4- and 5-year classes (33.33% and 16.67%), and by the low share of 6- year group - 8.33%. The mean size and weight for all collected specimens were - 17.5 cm, 107.44 g, and Fulton condition factor was 1.1966 (Fig.48).

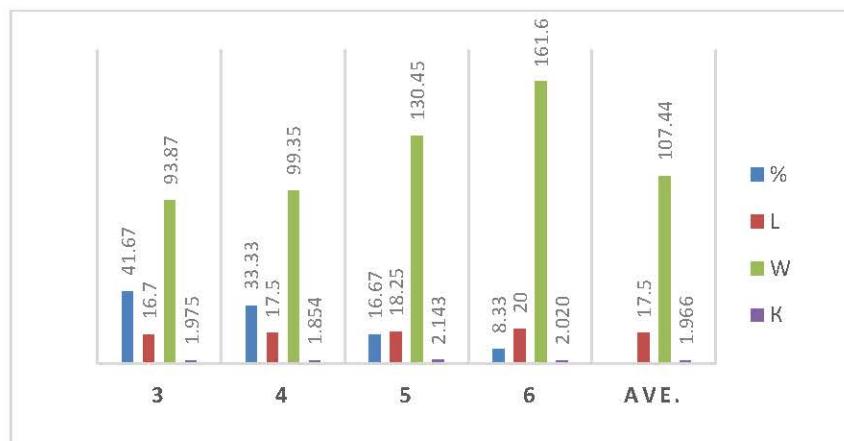


Figure 48. *Scorpaena porcus* - age structure (%), mean length and weight, and Fulton coefficient by age groups and average values of the biological parameters.

Mullus barbatus

The red mullet was spotted as by-catch in rapana fishing during the summer and early autumn months (1.9 % from the by-catch weight).



ЕВРОПЕЙСКИ СЪЮЗ
ЕВРОПЕЙСКИ ФОНД ЗА
МОРСКО ДЕЛО И РИБАРСТВО



МИНИСТЕРСТВО НА ЗЕМЕДЕЛИЕТО, ХРАНИТЕ И
ГОРИТЕ

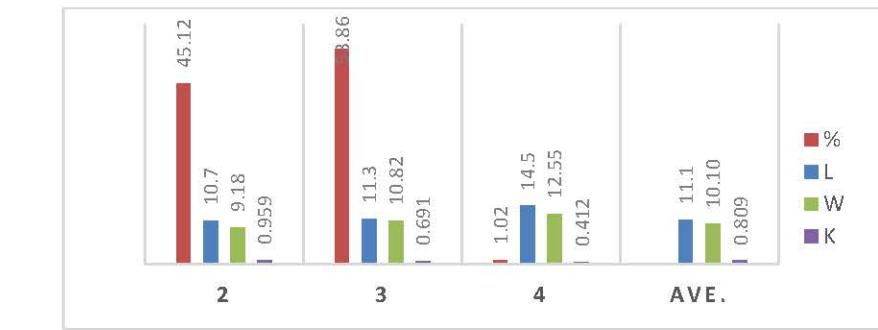


Figure 49. *Mullus barbatus* - age structure (%), mean length and weight, and Fulton coefficient by age groups and average values of the biological parameters.

We estimated 3 age groups, with dominance of the 3-year old class - 53.86 %, followed by the two years - 45.12%. The mean size and weight of all gathered specimens reached 11.1 cm, 10.10 g., Fulton condition factor - 0.809 (Fig. 49).

Uranoscopus scaber

The stargazer was spotted as bycatch in summer and autumn, with respective shares from the by-catch weigh - 2.17 % (summer) and 4.4 % (autumn)

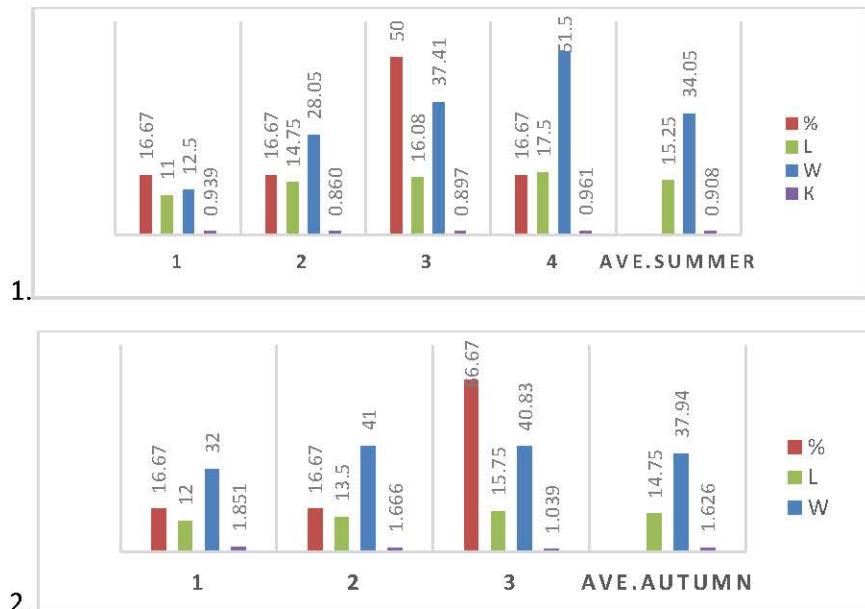


Figure 50. *Uranoscopus scaber* - age structure (%), mean length and weight, and Fulton coefficient by age groups and average values of the biological parameters (1) summer 2018 and (2) autumn 2018.



ЕВРОПЕЙСКИ СЪЮЗ
ЕВРОПЕЙСКИ ФОНД ЗА
МОРСКО ДЕЛО И РИБАРСТВО



МИНИСТЕРСТВО НА ЗЕМЕДЕЛИЕТО, ХРАНИТЕ И
ГОРИТЕ



During the summer season, four age groups - 1 - 4-year old classes were found, versus three age groups in autumn. The 3-year old group dominates during the both seasons, with shares - 50 % and 66.67 %, while 1- and 2-year groups have created equal proportions in the by-catch. In summer, the 4-year group formed 16.67 % of all collected specimens. The mean size and weight during the both seasons are as follows - 15.25 cm, 34.05 g - in summer, then in autumn the linear size has decreased, but the weight increased - 14.75 cm, 37.95 g (Fig. 50). The coefficient b was the highest 2.93 in summer, and lower in autumn - 2.04, showing negative allometric growth.

3.4 Fishing with polyvalent gears

The observations onboard of the polyvalent vessels allow collecting information about the exploitation of two types active gears – beam trawls for rapana fishing (in VII-IX.2018) and pelagic trawls for horse mackerel fishing (in VIII.2018).

The main catch of *R. venosa* with polyvalent vessels reaches $1887.76 \text{ kg/day} \pm 112.13 \text{ SE}$ (Table 21.1). The dominant group (38.09 %) of the main catch are with weight of 168 - 182 kg/trawl, followed by the weight class 196 - 210 kg/trawl (16.67 %) and 154 - 168 kg/trawl (14.29 %). Low catches <112 - 140 kg/trawl comprise 4.76 %, and the highest catches >238 kg/trawl are 4.76 % of all records. The by-catch weight is $8.21 \text{ kg/day} \pm 3.29 \text{ SE}$ on average, while the total catch weight attains $1895.71 \text{ kg/day} \pm 109.41 \text{ SE}$. The average percentage of by-catch is $0.47 \% \pm 0.22 \text{ SE}$ from the total catch (Table 21.1).

Table 21

Summary statistics of the main catches (kg/day), by-catch weight (kg/day), total catches (by-catch + catch) (kg/day) and percent share (%) of the by-catch during fishing with polyvalent vessels in 2018.

1. Beam trawl fishing for rapana by polyvalent vessels

	Main catch (kg/day) <i>R. venosa</i>	Bycatch (kg/day)	Total catch (catch + bycatch) (kg/day)	% of the bycatch from the total catch
Mean	1887.50	8.21	1895.71	0.47
Standard Error	112.13	3.29	109.41	0.22
Median	1960.00	6.16	1965.47	0.30
Standard Deviation	224.26	6.59	218.81	0.44
Sample Variance	50291.67	43.40	47879.49	0.19
Kurtosis	1.60	1.80	1.38	2.86
Skewness	-1.42	1.43	-1.37	1.70
Range	490.00	14.61	476.77	0.95
Minimum	1570.00	2.95	1587.57	0.16
Maximum	2060.00	17.57	2064.34	1.11
Confidence Level(95.0%)	356.84	10.48	348.18	0.70
Coefficient of variation	11.88	80.27	11.54	93.62



ЕВРОПЕЙСКИ СЪЮЗ
ЕВРОПЕЙСКИ ФОНД ЗА
МОРСКО ДЕЛО И РИБАРСТВО



МИНИСТЕРСТВО НА ЗЕМЕДЕЛИЕТО, ХРАНИТЕ И
ГОРИТЕ



1. Pelagic trawl fishing for horse mackerel by polyvalent vessels

	Horse mackerel catch (kg/day)	Bycatch (kg/day)	Total catch (kg/day)	% Bycatch from the total catch
Mean	666.67	23.43	690.10	3.66
Standard Error	202.76	5.99	208.37	0.59
Median	700.00	20.15	720.14	3.39
Standard Deviation	351.19	10.38	360.91	1.02
Sample Variance	123333.33	107.65	130258.95	1.04
Skewness	-0.42	1.28	-0.37	1.11
Range	700.00	19.95	719.95	1.99
Minimum	300.00	15.10	315.10	2.80
Maximum	1000.00	35.05	1035.05	4.79
Confidence Level(95.0%)	872.40	25.77	896.56	2.54

Coefficient of variation	52.68	44.30	52.30	27.87
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By fishing with pelagic trawls on polyvalent vessels, the target horse mackerel catch reaches 666.67 kg/day \pm 202.76 SE on average (Table 21.2). The by-catch weight is 23.43 kg/day \pm 5.99 SE, and total catch attains 690.10 kg/day \pm 208.37 SE. The average percent share of the by-catch reaches 3.66 % \pm 0.59 SE from the total catch (Table 21.2).

During the study, we found a total of 16 different species and crustaceans as by-catch, and between 5 - 11 different marine organisms are detected daily (Table 23, Fig. 51).

Таблица 23

The primary catches (rapana, kg/day) and the bycatches (kg/day) of sea species in polyvalent vessels during 2018.

Data	Main catch - rapana/horse mackerel kg/day	Weight of the different species in the by-catch kg/day									By-catch kg/day	Total catch kg/day	% of the by-catch from the total catch	
		Turbot	Flounder	Gobies	Red mullet	Shark	Scorpion-fish	Stargazer	Pontic shad	Other				
Average for VII	1800 rapana	6.22	0.48	0.3	0.15	0.21	0.18	0.153		2.03	9.72	1809.7	0.54	
Average for VIII	666.7 horse mackerel			0.01						11.75	11.7	23.43	690.10	3.40
Average for IX	1890 rapana	0.52		0.5	0.04		0.2	0.03		0.21	1.50	1891.5	0.08	

The following fish species are mainly spotted as by-catch in rapana fishing - turbot (*S. maximus*), flounder (*P. flesus*), gobies (*N. melanostomus* and *M. batrachocephalus*), horse mackerel (*T. mediterraneus*), whiting (*M. merlangus*) and red mullet (*M. barbatus*). Sporadically, we found - greater weever (*T. draco*), scorpionfish (*S. porcus*), stargazer (*U. scaber*) and picked dogfish (*S. acanthias*) in



ЕВРОПЕЙСКИ СЪЮЗ
ЕВРОПЕЙСКИ ФОНД ЗА
МОРСКО ДЕЛО И РИБАРСТВО



МИНИСТЕРСТВО НА ЗЕМЕДЕЛИЕТО, ХРАНИТЕ И
ГОРИТЕ



the by-catch. As rare species are observed sailfin dragonet (*C. pusillus*) and common stingray (*D. pastinaca*), as well as some crustaceans - warty crab (*E. verucosa*) etc. Turbot is the dominant by-catch in fishing for rapana with polyvalent vessels, producing 49.3 % of the by-catch weight, and followed by the gobies – 18.2 % of the by-catch (Fig.51.1). The turbot by-catch comprises 0.3 ± 0.13 SE of the total catch (main catch+bycatch) in rapana fishing with polyvalent vessels, ranging between 0 - 1.03 % for a fishing day.

By horse mackerel fishing with polyvalent vessels in August, the by-catches are formed mostly by pontic shad (*A. immaculata*) - 75.11 % by weight (Fig. 51.2).

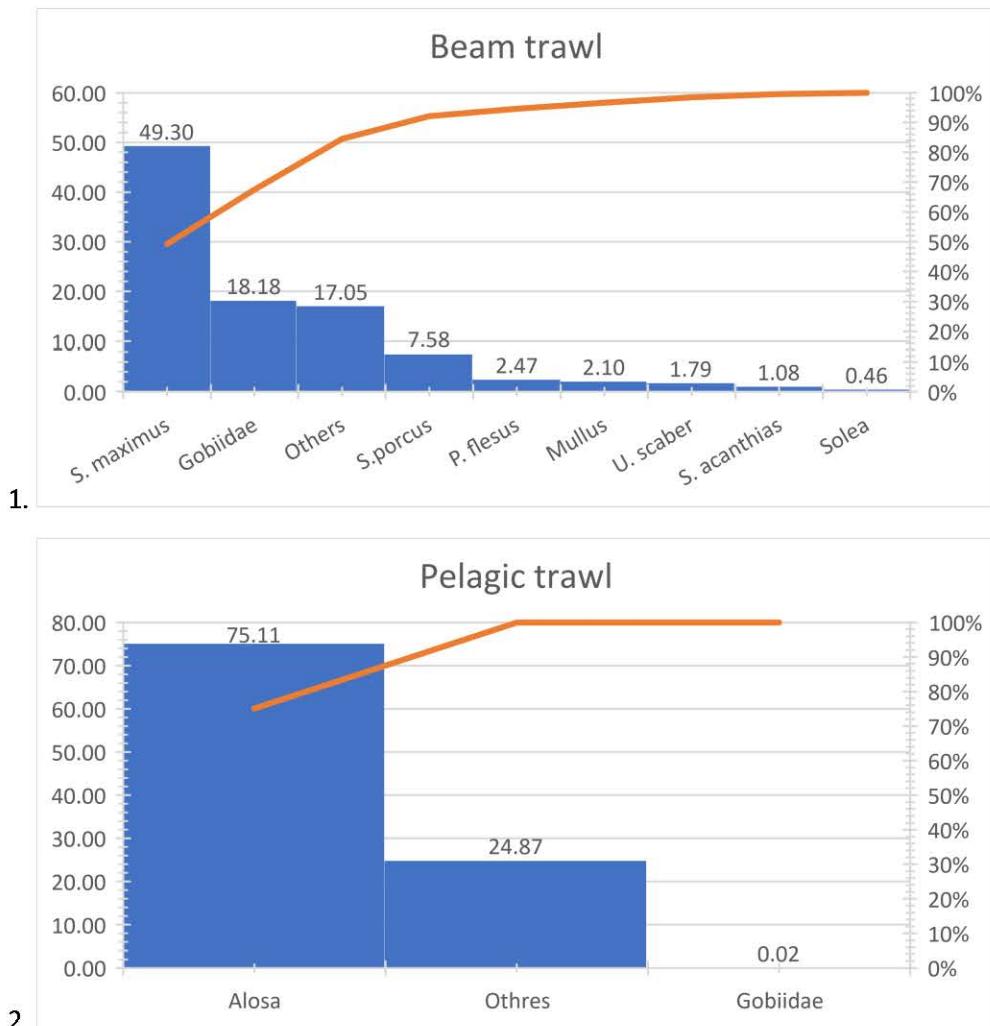


Figure 51. Percent structure of the by-catch in fishing with polyvalent vessels (1) beam trawling in VII-IX.2018 and (2) fishing with pelagic trawls in VIII.2018.



ЕВРОПЕЙСКИ СЪЮЗ
ЕВРОПЕЙСКИ ФОНД ЗА
МОРСКО ДЕЛО И РИБАРСТВО



МИНИСТЕРСТВО НА ЗЕМЕДЕЛИЕТО, ХРАНИТЕ И
ГОРИТЕ



4. Conclusions

- The expeditions with observers onboard took 60 fishing days in 2018 - X 20 days on fishing vessels with gillnets and bottom trawls and - X 10 days on the polyvalent vessels and vessels with pelagic trawls. The most frequent observations took part in July 2018 - a total of 20 fishing days, in September - 13 fishing days, in November - 9 days, and 8 fishing days - in August. In 2018, gill nets were used to catch turbot, trawling with pelagic trawls was focused on sprat and horse mackerel, and rapana was the main catch by bottom trawling. The polyvalent vessels were equipped with beam trawls for rapana and pelagic trawls for pelagic fish species. In spatial aspect, the bottom trawling took place in the northern part of the coastline, near Kavarna-Golden sands, the surveys on vessels with gill nets were performed in the zone of Shabla, those on vessels with pelagic trawls for horse mackerel included the region Balchik - Chernomorec, while pelagic trawling for sprat were concentrated in front of the Cape Emine. The observations with polyvalent vessels were performed in front of northern coasts.
- The primary catch with the anchored gill nets is formed by turbot (*S. maximus*) and the by-catch included common stingray (*Dasyatis pastinaca*), black mussel (*Mytilus galloprovincialis*), picked dogfish (*Squalus acanthias*), thornback ray (*Raja clavata*) and rapana (*R. venosa*). Some mammals, such as harbour porpoise (*Phocoena phocoena*), can be rarely observed. This type of fishing activity produced a bycatch with high weight, due to the fact that some large fish species and marine mammals could be caught in the gill nets. During the observations in 2018, the mean catches of *S. maximus* attained $83.26 \text{ kg/day} \pm 43.35 \text{ SD}$, the by-catch weight was $43.97 \text{ kg/day} \pm 36.98 \text{ SD}$ on average, and the weight of the total catch reached $127.23 \text{ kg/day} \pm 59.72 \text{ SD}$. The average percent share of the by-catch was $32.80\% \pm 25.00 \text{ SD}$ from the total catch. The by-catch in gillnets was dominated by weight by black mussel – 43 %, common stingray – 36 % and picked dogfish – 12 %. The by-catch species composition displayed some seasonal changes, and the common stingray and shark were detected mainly in spring and summer, while in autumn the black mussels dominated. The analysis of the length structure of the main catch (*S. maximus*) indicated a high proportion of small-sized individuals < 50 cm TL, forming 41.38 % in spring and 48.58 % - in autumn. The large specimens *S. maximus*, with length > 80 cm, were observed mainly in spring but generated a small share of the catch - 5.68 %.
- In VII-XII.2018, fishing with pelagic trawls was focused on sprat (*S. sprattus*) and horse mackerel (*T. mediterraneus*). The average catch of these species per fishing day reached - $1112 \text{ kg/day} \pm 219 \text{ SE}$ sprat and $563 \text{ kg/day} \pm 177.22 \text{ SE}$ horse mackerel. The by-catch weight was between 0.24 - 2.8 kg/day in sprat fishing and increased up to 15 - 41 kg/day in horse mackerel fishing. The average weight of the by-catch was $1.4 \text{ kg/day} \pm 0.4 \text{ SE}$ – in sprat fishing and $28.04 \text{ kg/day} \pm 6.3 \text{ SE}$ – in horse mackerel fishing. The sprat fishery produced the lowest by-catch of marine organisms if presented as a percent from the total catch - $0.11\% \pm 0.02 \text{ SE}$. In horse mackerel fishery, this share of the by-catch has increased up to $6.33\% \pm 2.70 \text{ SE}$, due to the

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Проектно предложение № BG14MFOP001-3.003-0001, „Събиране, управление и използване на данни за целите на научния анализ и изпълнението на Общата политика в областта на рибарството за периода 2017-2019 г.“, финансирано от Програмата за морско дело и рибарство, съфинансирана от Европейския съюз чрез Европейския фонд за морско дело и рибарство.



ЕВРОПЕЙСКИ СЪЮЗ
ЕВРОПЕЙСКИ ФОНД ЗА
МОРСКО ДЕЛО И РИБАРСТВО



МИНИСТЕРСТВО НА ЗЕМЕДЕЛИЕТО, ХРАНИТЕ И
ГОРИТЕ



long trawling prolongation. In the pelagic trawls, we estimated between 1- 9 different fish species per day. In sprat fishery, the by-catches in July were produced by whiting (*M. merlangus*) - 45.77 % TC, gobies (*N. melanostomus* и *M. batrachocephalus*) - 32.28 %, and pontic shad (*A. immaculata*) - 7.71 %. Rare species in the bycatches are black goby (*Gobius niger*), stargazer (*Uranoscopus scaber*), common stingray (*Dasyatis pastinaca*) and greater weever (*Trachinus draco*). In September, pontic shad (*Alosa immaculata*) and round goby (*N. melanostomus*) dominate the bycatch composition, and in December, the by-catch included only *A. immaculata* and *Alosa caspia*. The bycatches in the horse mackerel fishery in August were formed by the pontic shad (*A. Immaculata*) - 50 % and anchovy (*E. encrasikolus*) – 23.91 %, while rare species included common stingray (*D. pastinaca*) and sturgeon (*H. huso*). In 2018, the main sprat catches were dominated by 1-year class - 64.02 %, followed by the 2-year group - 35.04 %, and the length structure encompassed size classes from 5.5 cm to 11.0 cm TL. The size classes 7.3 - 8.24 cm dominated the sprat catches, and the average weights of these groups were as follows - 2.25 g (7.3 cm) and 3.06 g (8.24 cm). The physiological condition of sprat was relatively good, by average Fulton condition factor between 0.50 - 0.59. The ichthyological samples horse mackerel were representative for August; the 1- year class prevailed the main catch - 97.31 %, by the small presence of 2- and 3-year olds - 2.24 % and 0.45 %. The length structure of the horse mackerel catches encompassed size classes from 11.5 cm to 17.0 cm TL, by the dominant role of the size classes - 12.3 cm and 13.9 cm, with average weights - 16.59 g and 17.15 g, and mean Fulton condition factor - 0.87. The analysis of the sex structure revealed the dominance of the female specimens (63 %) over the males - 37 %.

- In VII-XI.2018, the rapana catches with beam trawls ranged between 880 - 2060 kg/day, and by-catch weight was 0.14 - 17.40 kg/day; the total catches reached 1513.64 ± 117.13 SE on average, while the mean percent share of the by-catch was $0.29 \% \pm 0.10$ SE from the total catch. Around 54 % of all catches were in limits 1.30 - 1.73 t/day, and 27 % of the catches ranged between 1.73 - 2.16 t/day. The highest daily catch of *R. venosa* was registered in September - 1890 kg/day on average, then, in November the quantities have decreased by 33 %. In summer, the total catches reached 1810 kg/day on average and their weight decreased with 29 % in autumn. The by-catch weight attained 9.81 kg/day in July and decreased in November up to 1.01 kg/day. Thus, the by-catch proportion, expressed as a percentage share from the total catch attained 0.54 % in summer but decreased 5 times in autumn. The species composition of the by-catch was diverse, encompassing 22 fish species and crustaceans and between 1 - 14 different marine organisms could be detected as daily by-catch. Most often, the by-catch included turbot (*S. maximus*), gobies (mostly *N. melanostomus* and *M. batrachocephalus*), flounder (*P. flesus*), horse mackerel (*T. mediterraneus*), whiting (*M. merlangus*), red mullet (*M. barbatus*) and stargazer (*U. scaber*). In addition, species such as greater weever (*Trachinus draco*), scorpionfish (*Scorpaena porcus*), sand sole (*Solea lascaris*), shark (*Squalus acanthias*) and rusty blenny (*Parablennius sanguinolentus*), were also observed, however with few individuals. Rare species included garfish (*Belone belone*), sailfin dragonet (*Callionymus pusillus*), sea-needle (*Syngnathus acus*), common stingray (*Dasyatis pastinaca*)

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ЕВРОПЕЙСКИ СЪЮЗ
ЕВРОПЕЙСКИ ФОНД ЗА
МОРСКО ДЕЛО И РИБАРСТВО



МИНИСТЕРСТВО НА ЗЕМЕДЕЛИЕТО, ХРАНИТЕ И
ГОРИТЕ



and seahorse (*Hippocampus spp.*). Some crustaceans were found in the bycatch, mostly warty crab (*Eriphia verucosa*), as well as - *Liocarcinus vernalis* and *Brachynotus sexdentatus*. In 2018, dominant species in the by-catch by weight was turbot - 39.77 %, followed by knot goby (*M. batrachocephalus*) -36 %. In 2018, the percent share of turbot was 0.14 % of the total catch in fishing with bottom trawls and this share was lower than in 2017 (0.31 %). In fact, in 2018, the daily rapana catches have increased almost 6 times in comparison with 2017, and the average turbot bycatch has increased 3 times - 2.37 kg/day but expressed as a percent share form the total catch it has a lower value than in 2017. The species composition of the by-catch was subject to seasonal changes, and turbot dominated the by-catch in summer (59.69 %), but its share has decreased almost 2 times in autumn. During the autumn season, the substantial reduction of the by-catch weight was accompanied by the increased importance of knot goby in the by-catch (54.85 %). Thus, the turbot produced $0.39 \% \pm 0.22$ SE of the total catch in summer, and this proportion was only 0.02 % in autumn. The sizes and weights of the turbot as by-catch varied between 5.5 cm (0.8 g) and 52 cm (1920 g). The age structure of the turbot by-catch encompassed 0-to 4-year classes, with prevalence of 0 age group (48.78 %) and 3-year-olds (24.39 %). In summer, the size composition of the main rapana catches was dominated by the size class 5.62 - 6.16 cm (27.25 %). During this period, the mean length of *R. venosa* reached $6.5 \text{ cm} \pm 0.82$ SD, by mean weight of $49.61 \text{ g TW} \pm 19.67$ SD, and minimal and maximal individual weights - 22 - 133 g TW. In autumn, by a certain increase of the small-size class in length structure of *R. venosa*, the mean length was reduced to $6.15 \text{ cm} \pm 0.79$ SD, by mean weight - $39.32 \text{ g TW} \pm 17.50$ SD, while minimal and maximal individual weights were - 6.50 - 163 g TW.

- By fishing on polyvalent vessels with pelagic trawls, the main catch of horse mackerel reached $666.67 \text{ kg/day} \pm 202.76$ SE; the mean weight of the by-catch was $23.43 \text{ kg/day} \pm 5.99$ SE, and the total catch attained $690.10 \text{ kg/day} \pm 208.37$ SE. The mean percent share of the by-catch was $3.66 \% \pm 0.59$ SE from the total catch. By fishery with polyvalent vessels, the catches of *R. venosa* with bottom trawls reached $1887.76 \text{ kg/day} \pm 112.13$ SE, the by-catch weight was $8.21 \text{ kg/day} \pm 3.29$ SE, while the total catches attained $1895.71 \text{ kg/day} \pm 109.41$ SE. The average percentage of the by-catch was $0.47 \% \pm 0.22$ SE from the total catch. During the study, 16 different fish species and crustaceans were detected as by-catch in this fishing segment. As by-catch in rapana fishing, the following fish species were spotted - turbot (*S. maximus*), flounder (*P. flesus*), gobies (*N. melanostomus* and *M. batrachocephalus*), horse mackerel (*T. mediterraneus*), whiting (*M. merlangus*) and red mullet (*M. barbatus*). Sporadically, we found in the by-catch - greater weever (*T. draco*), scorpion fish (*S. porcus*), stargazer (*U. scaber*) and picked dogfish (*S. acanthias*). As rare species are observed sailfin dragonet (*C. pusillus*) and common stingray (*D. pastinaca*), etc. Turbot was the dominant species in the rapana fishing with polyvalent vessels, producing 49.3 % of the by-catch weight, followed by the gobies -18.2 % of the by-catch weight. The turbot by-catch comprises on average $0.3 \% \pm 0.13$ SE of the total catch (main catch+bycatch) in rapana fishing with polyvalent vessels, ranging between 0 -



ЕВРОПЕЙСКИ СЪЮЗ
ЕВРОПЕЙСКИ ФОНД ЗА
МОРСКО ДЕЛО И РИБАРСТВО



МИНИСТЕРСТВО НА ЗЕМЕДЕЛИЕТО, ХРАНИТЕ И
ГОРИТЕ



1.03 % for a fishing day. In summer, by horse mackerel fishing with polyvalent vessels, the by-catches included mostly pontic shad (*A. immaculata*) - 75.11 % by weight.

- In 2018, the highest by-catch was generated by fishing with gill nets for turbot – 43.97 kg/day on average, followed by the pelagic trawling for horse mackerel, that produced a daily by-catch of 28.04 kg/day during the active season, while rapana fishing generated a low daily by-catch - 4.21 kg/day. The by-catches, created by the rapana fishing with beam trawls show the highest coefficient of variation (pointing the highest variance) in comparison with all other fishing activities. The lowest by-catch was registered in sprat fishing with pelagic trawls, and the by-catch quantities ranged between 0.24 - 2.8 kg/day. The polyvalent vessels could generate significant by-catch when operating with pelagic trawls for horse mackerel fishing - 23.43 kg/day, but the by-catch has decreased to 8.21 kg/day by rapana fishing with bottom trawls on board of polyvalent vessels.



ЕВРОПЕЙСКИ СЪЮЗ
ЕВРОПЕЙСКИ ФОНД ЗА
МОРСКО ДЕЛО И РИБАРСТВО



МИНИСТЕРСТВО НА ЗЕМЕДЕЛИЕТО, ХРАНИТЕ И
ГОРИТЕ



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ЕВРОПЕЙСКИ СЪЮЗ
ЕВРОПЕЙСКИ ФОНД ЗА
МОРСКО ДЕЛО И РИБАРСТВО



МИНИСТЕРСТВО НА ЗЕМЕДЕЛИЕТО, ХРАНИТЕ И
ГОРИТЕ



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ЕВРОПЕЙСКИ СЪЮЗ
ЕВРОПЕЙСКИ ФОНД ЗА
МОРСКО ДЕЛО И РИБАРСТВО



МИНИСТЕРСТВО НА ЗЕМЕДЕЛИЕТО, ХРАНИТЕ И
ГОРИТЕ



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