Distribution of Certain Commercially Important Species in Small-Scale Fisheries Along the Montenegrin Coast

Zdravko Ikica, Olivera Marković, Ana Pešić, Nikola Đorđević, and Jovana Tomanić

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Abstract The study focuses on data collected from fisheries with two dominant types of fishing nets used in small-scale fisheries along the Montenegrin coast, gillnets and trammel nets, through the Data Collection Reference Programme supported by the Ministry of Agriculture and Rural Development of Montenegro. The data is presented through total catch and CPUE (given as weight of the catch in kg per 100 m of net used), separately for gillnets and trammel nets, as well as for selected species caught in each net. A total catch of 942.52 kg was recorded in net catches, of which 458.75 kg (48.7%) from gillnet catches, and 483.77 kg (51.3%) from trammel nets. The most dominant species was Little tunny (*Euthynnus alletteratus*), with a total recorded catch of 129.6 kg. Total CPUE of gillnets ranged from 0.003 kg/100 m to 8.00 kg/100 m. Average CPUE was 0.59 ± 1.24 kg/100 m. Trammel net CPUE ranged from 0.02 kg/100 m to 4.14 kg/100 m, with an average of 0.30 ± 0.58 kg/100 m of net.

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1 Introduction

Small-scale fisheries have been a tradition of the coastal area of Montenegro for centuries, particularly in the Boka Kotorska Bay [1]. Similar to most Adriatic countries, the exact definition of small-scale fishery in Montenegro is not clear, but under the umbrella of the AdriaMed FAO regional project for the Adriatic Sea, member countries have agreed to use the following definition: "commercial fishing carried out by all gears excluding trawlers, purse seiners targeting small pelagic and tuna fisheries" [2].

The Montenegrin legal framework recognises three categories of fisheries: commercial, sport and recreational, and scientific and research fisheries [3]. The commercial fisheries are further divided into large-scale and small-scale commercial fisheries, and the difference between the two is in vessel length and type and number of fishing gears permitted. Small-scale commercial fishery is defined as the fishery carried out using a vessel smaller than 12 m length over all (LOA), using the following fishing tools and gears:

- Fixed nets (gillnets and trammel nets, up to two nets,[1] with artificial lights of up to 2,000 W/2,000 cd allowed with certain kind of gillnets)
- Pots and traps for catching fish (up to 10 pcs)
- Harpoons (with or without artificial lights of up to 2,000 W/2,000 cd)
- Long-lines (set and demersal, up to 250 hooks) and other hooks (rods, hooks and lines, etc.) (up to 4 pcs)
- Beach seines for pilchard (*srdelara*, 12 mm mesh size)
- Chinese nets (1 pc) and *grib*[2] (1 pc), as well as collecting shellfish and other marine organisms [3, 4].

For purposes of this study, any vessel of less than 12 m LOA and using the tools listed above is considered part of the small-scale or artisanal fleet.

Gillnets and trammel nets are traditionally divided according to the target species and mesh size, and the types that can be licenced according to [3, 4] are:

- gillnet for bogue (*bukvara*, mesh size 40–52 mm)

[1] Up to 500 m of any one kind of fixed net if used on the open sea, or up to 160 m if used in the Boka Kotorska Bay, is considered as "one net" for legal purposes [4].

[2] *Grib* is a type of beach seine net specific to the Montenegrin coast, especially for the area around the River Bojana estuary. Two types of *grib* exist, one for catching meagre (*Argyrosomus regius*), shi drum (*Umbrina cirrosa*), and sturgeon (*Acipenser* spp.), and the other for mullets (Mugilidae) [5]. It is now very rarely in use.

- gillnet for sand smelt (*gavunara*, minimum mesh size 20 mm)
- gillnet for picarel (*girara*, minimum mesh size 30 mm)
- gillnet for picarel (*menulara*, mesh size 32–40 mm)
- gillnet for crabs (*rakovica*, minimum mesh size 300 mm)
- gillnet for demersal fish (*prostica*, minimum mesh size 56 mm)
- gillnet for small pelagic fish (*vojga*, minimum mesh size 32 mm)
- gillnet for rays (*sklatara*, minimum mesh size 80 mm)
- gillnet for sharks (*psara*, minimum mesh size 120 mm)
- gillnet for bonito[3] (*polandara*, minimum mesh size 80 mm)
- trammel net *popunica* (minimum mesh size on central net 56 mm)
- trammel net for flatfish (*listarica*, mesh size on central net 72 mm).

Two types of combined gillnet-trammel nets are permitted in Montenegro, both primarily used to catch salema (*Sarpa salpa*), two part gillnet-trammel net, and three-part trammel net-gillnet-trammel net. Minimum mesh size for both gillnets and inner netting of trammel nets is 80 mm [3, 4].

There are also three types of fixed nets traditionally used to catch mullets (Mugilidae): *ciplarica*, *ciplara,* and *tavan*. Surrounding net *ciplarica*, with a minimum mesh size of 52 mm, can be used with or without the special trammel net *skakalo* (plural: *skakala*; minimum mesh size of central net of 56 mm), which float flat on the sea surface over the *ciplarica* head-rope, and are used to catch mullets that try to escape the net by leaping over it [4, 6]. This type of net is used mostly along the Velika plaža area and around the Bojana River estuary.

Ciplara is a long (300–2,000 m) net used to surround a school of mullets, and then other nets are used to catch the fish from the enclosure. It can be used with or without *skakala*. This type of fishery requires a lot of manpower and vessels, and is only rarely encountered [4, 6].

Tavan is a combination of *prostica* gillnet and a trammel net with a minimum mesh opening of 56 mm on the central net. The gillnet is set in a spiral using poles to support it. The poles emerge 1–2 m above surface, and support the trammel net, forming the *tavan.*[4] The fish trying to leap out of the water get entangled in the trammel net section [4, 6].

Of the listed net types, the most common in licensed vessels are gillnet for demersal fish (*prostica*), gillnet for bogue (*bukvara*), and *popunica* trammel net. Some such as *gavunara*, *girara*, *menulara*, *rakovica*, *vojga*, *sklatara*, *psara* and the fixed nets targeting mullets are only rarely encountered.

[3] *Polandara* is an exception for the maximum length of 160 m for one net in the Boka Kotorska Bay, with 400 m considered as one net inside the Bay.

[4] *Tavan* means "attic" or "the upper floor" in Montenegrin.

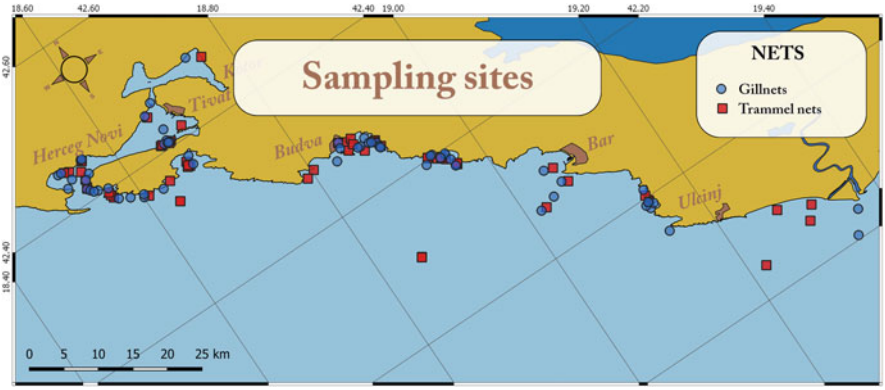

Fig. 1 Sampling sites for gillnet (blue circles) and trammel net (red squares)

1.1 Study Area

The data analysed were all collected within the territorial waters of Montenegro, the belt stretching 12 n.m. from the coast. Small-scale fishery vessels traditionally operate in the narrow strip along the coastline, only rarely venturing beyond 3 n.m. off the coast and/or 50 m depth. Virtually all fishing activity in small-scale fisheries in Montenegro takes place within the 3 n.m. off the coast (Fig. 1) [7].

2 Material and Methods

The data analysed was collected within the frame of Data Collection Reference Framework (DCRF) programme [8], performed in Montenegro since 2017 through support by Ministry of agriculture and rural development [9]. Within the DCRF, several fishing fleet segments are sampled on a quarterly basis, among them segments using fixed nets, i.e. gillnets and trammel-nets (Table 1) [9].

As long-lines were added to the DCRF sampling scheme only in 2019, that left gillnets and trammel nets as sampled fishing gears in small-scale fisheries with a long-enough time-series of data to be analysed.

At each sampling, geographic location of each net was recorded by a hand-held GPS device. Total catch was recorded, as was the catch of each species in the catch.

During data processing, catch per unit of effort (CPUE) values were calculated according to the following formula:$\text{CPUE} = \frac{W_{\text{catch}}}{L_{\text{net}} \times 100}$ where W_{catch} is the weight of the catch in kg, and L_{net} is the length of sampled net, in metres. The result is thus expressed as catch per 100 m of net.

CPUE was calculated based on both catch per species and total catch for each individual sampling.

Table 1 Metier and fleet segment combinations used in DCRF sampling in Montenegro for 2020

Metier	Fleet segment
LLS_LLD__0_0	L-02 – Vessels using set or drift long-lines 6–12 m
GTR_DEF__0_0, GNS_DEF_>=16_0_0	P-05 – Small-scale vessels with engine using passive gear <6 m
GTR_DEF__0_0, GNS_DEF_>=16_0_0	P-06 – Small-scale vessels with engine using passive gears 6–12 m
GTR_DEF__0_0, GNS_DEF_>=16_0_0	P-09 – Polyvalent vessels <6 m
GTR_DEF__0_0, GNS_DEF_>=16_0_0	P-10 – Polyvalent vessels 6–12 m
PS_SPF_>=14_0_0	S-01 – Purse seiners <6 m
PS_SPF_>=14_0_0	S-03 – Purse seiners 12–24 m
OTB_DEF_>=40_0_0	T-10 – Trawlers 6–12 m
OTB_DEF_>=40_0_0	T-11 – Trawlers 12–24 m

The maps were created using QGIS 3.14 (π) Open Source Geospatial Foundation Project software [10], using Inverse distance weighting (IDW) interpolation method on each sampling site's CPUE value.

3 Results

A total of 130 gillnet and trammel net samplings were carried out from April 2017 to June 2020. Gillnets were sampled 67 times in total, while trammel nets were sampled 63 times. A total of 97 species were recorded in catches, of which 84 were present in gillnet catches, and 87 in trammel net catches.

Gillnets sampled ranged in length from 50 m to 1,200 m, with an average length of 409.18 ± 249.70 m. Altogether, 24,415 m of gillnets were sampled from April 2017 to June 2020. Median length was 360 m (meaning that 50% of the sampled nets were longer than 360 m, and 50% were shorter).

Sampled trammel nets were 90 m to 1,400 m in length, with a mean length of 392.86 ± 218.35 m, and a combined total length of 24,750 m. Median length was 400 m.

A total catch of 942.52 kg was recorded in net catches, of which 458.75 kg (or 48.7% of the total catch) were from gillnet catches, and 483.77 kg (51.3%) were from trammel nets. The most dominant species was Little tunny (*Euthynnus alletteratus*), with a total recorded catch of 129.6 kg, but the catch was unevenly distributed between the two types of net, with 117.99 kg found in gillnets (Fig. 2), and 11.56 kg in trammel nets (Fig. 2). This is not surprising, since *polandara* type of gillnet (with a minimum stretched mesh size of 80 mm) is designed to catch species such as Little tunny, Bullet tuna (*Auxis rochei*) or Atlantic bonito (*Sarda sarda*).

Bogue (*Boops boops*) was represented with 68.04 kg (15%) in the gillnet catches, and Common dentex (*Dentex dentex*) with 33.03 kg (7.3%). Other species given in

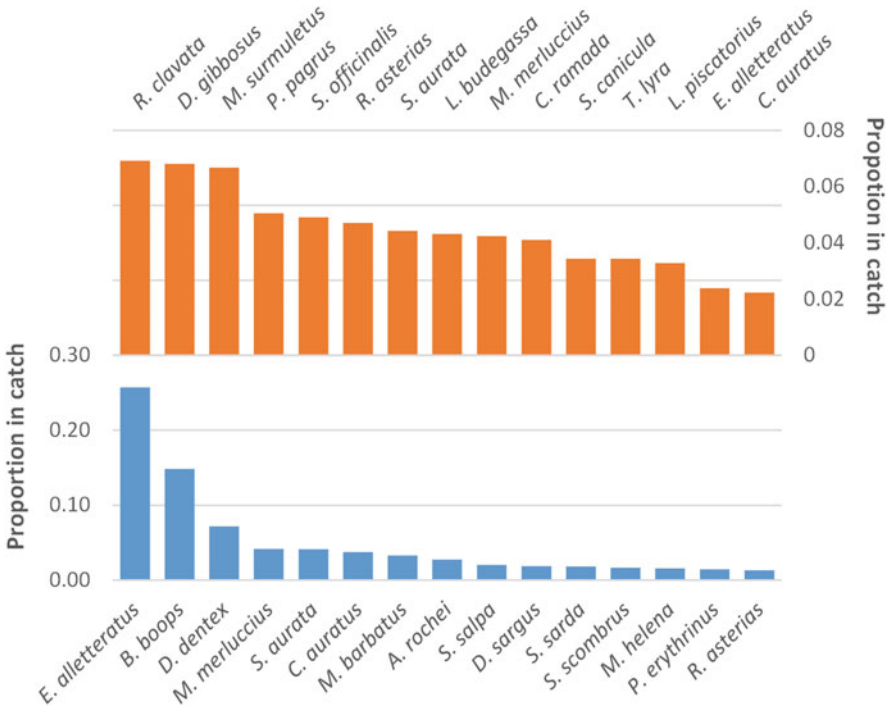

Fig. 2 Most frequent species in trammel net (orange) and gillnet (blue) catches (DCRF 2017–2020)

Fig. 2 had less than 5% of the share in total gillnet catches – Sea bream (*Sparus aurata*) 19.07 kg (4.2%), European hake (*Merluccius merluccius*) 18.91 kg (4.2%), Golden grey mullet (*Chelon aurata*) 16.16 kg (3.55%), Red mullet (*Mullus barbatus*) 15.15 kg (3.33%), Bullet tuna (*Auxis rochei*) 12.6 kg (2.77%), Salema (*Sarpa salpa*) 9.39 kg (2.07%), White seabream (*Diplodus sargus*) 8.72 kg (1.92%), Atlantic mackerel 7.42 kg (1.63%), Moray eel (*Muraena helena*) 7.26 kg (1.60%), Common pandora (*Pagellus erythrinus*).

Sixty-five species in gillnet catches were represented with less than 1% of the total catch each (i.e. 4.2 kg or less in the total catch, each). The total catch weight for these species is 74.15 kg, or 16.31%, which means that the most represented 20 species' catch weight was 380.43 kg or, in other words, 83.69% of the total gillnet catch.

Trammel nets had a much more uniform distribution of catches among species (Fig. 2), which is both the result of a much smaller variation of mesh size in use, and the fact that trammel nets have lower selectivity than gillnets. The species with the highest catch in trammel nets was Thornback ray (*Raja clavata*), with 33.46 kg or 6.92%. Chondrichthyan species were relatively frequent in trammel net catches (18.98%), while rare in gillnet catches (2.38%). Trammel nets also had a greater share of cephalopods and crustaceans (6.23% and 3.30%, respectively) compared to

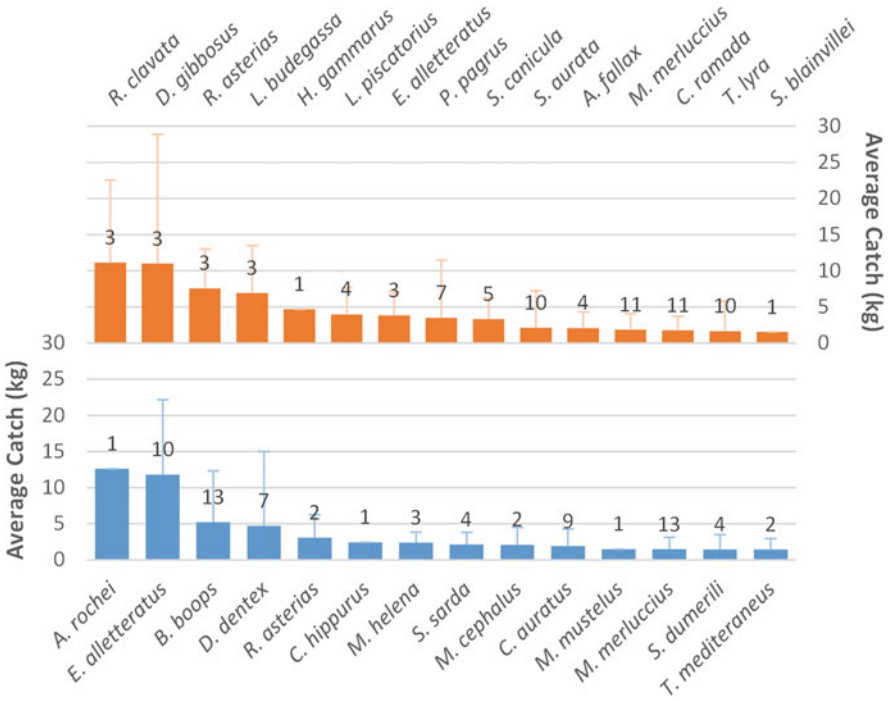

Fig. 3 Average catch per species for trammel nets (orange) and gillnets (blue) with standard deviation (orange/blue lines), with a number of samplings the species was present in (DCRF, 2017–2020)

gillnets (1.36% and 1.40%). The second species by weight in trammel nets by catch was Pink dentex (*Dentex gibbosus*), with 32.97 kg or 6.82%.

An overview of the average catch of the 15 species for both trammel nets and gillnets (Fig. 3) shows that in regard to the mean catch value, the situation in trammel nets is not significantly different from total catches on Fig. 2 above. Thornback ray and Pink dentex still have the highest values, however, striped red mullet (*M. surmuletus*) is now only at position no. 19, with an average catch of 1.29 ± 1.60 kg, as it was found in 15 samplings, with a catch weight ranging from 0.04 to 6.70 kg. Thornback ray, on the other hand, was found in just three samplings, with catch weights of 3.16, 6.10, and 24.20 kg.

Comparison between average (Fig. 3) and total catches (Fig. 2) in gillnets shows somewhat similar situation. Bullet tuna (*A. rochei*) emerges first, as it was present in only one sampling, with a catch of 12.60 kg, compared to Little tunny's 10 samples with catch weights ranging from 0.7 to 32.0 kg.

3.1 Gillnets

Total catch of gillnets during the sampling period (April 2017 – June 2020) was 458.75 kg, with a minimum of 0.03 kg and a maximum of 33.35 kg. Mean value of catch was 7.17 ± 7.83 kg, and median catch was 4.515 kg. Almost 80% of the catches were below 11 kg in weight, with only 3.13% above 31 kg (Table 2).

Catch per unit of effort of gillnets and trammel nets can be expressed as the weight of the catch (kg) per 100 m of net used. Total CPUE (i.e. CPUE for each individual sampling) of gillnets ranged from 0.003 kg/100 m to 8.00 kg/100 m. Average CPUE was 0.59 ± 1.24 kg/100 m, with a median of 0.20 kg/100 m.

Figure 4 shows spatial distribution of gillnet CPUE along the Montenegrin coast. The area with the highest value, just in front of Dobra Luka Cove on Luštica Peninsula, is the site of 32 kg catch of *E. alletteratus*, which strongly weighted the distribution towards that point.

Table 3 provides details on total gillnet catch per species, number of samples the species was found in, average CPUE per species, and the percent ratio of that CPUE among all species found in samples.

Little tunny, *E. alletteratus*, had the highest CPUE in gillnet catches, 2.84 (Table 3, Fig. 5), which was present in 20 samples with total weight of 117.99 kg, representing also the highest gillnet catch (Fig. 6). The total catch of the species does

Table 2 Percentage proportions of gillnet catch by weight (DCRF, 2017–2020)

Catch weight [kg]	Percentage [%]
>31	3.13
21–31	6.25
11–21	12.50
6–11	21.88
1–6	39.06
<1	17.19

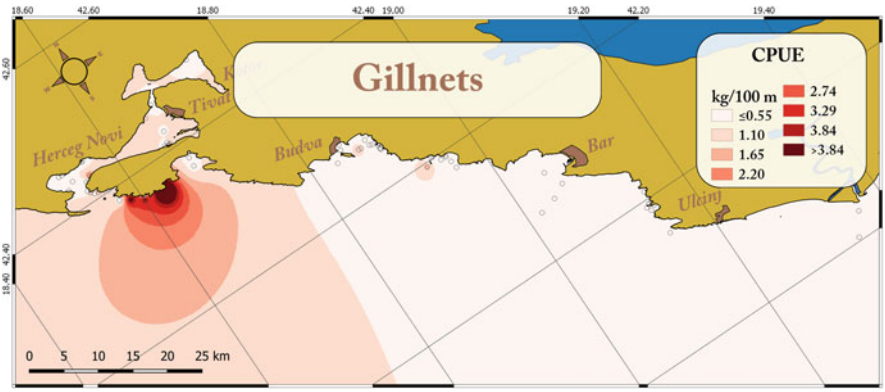

Fig. 4 Spatial distribution of average CPUE (kg/100 m of net) of gillnets, circles mark individual samplings (DCRF 2017–2020)

Table 3 List of species in gillnet catches, with total catch per species (kg), number of samples the species was present in, average CPUE (kg per 100 m of net used), and percentage of the CPUE per species

Species	Total catch (kg)	No. of samples	Average CPUE	Percent of CPUE (%)
Euthynnus alletteratus	117.99	20	2.84	12.25
Boops boops	68.04	24	2.43	10.50
Auxis rochei	12.60	2	2.00	8.63
Dentex dentex	33.03	13	1.15	4.97
Raja asterias	6.21	3	0.75	3.26
Chelon auratus	17.22	17	0.73	3.16
Myliobatis aquila	2.86	4	0.66	2.86
Octopus vulgaris	3.62	7	0.65	2.82
Dentex gibbosus	0.65	2	0.57	2.44
Mugil cephalus	4.20	3	0.56	2.41
Trachinotus ovatus	0.60	2	0.52	2.25
Coryphaena hippurus	2.45	2	0.51	2.20
Mustelus mustelus	1.50	2	0.50	2.16
Seriola dumerilii	5.86	8	0.49	2.13
Muraena helena	7.26	6	0.45	1.93
Callinectes sapidus	1.93	4	0.42	1.82
Mullus barbatus	15.15	28	0.41	1.78
Sarpa salpa	9.39	16	0.39	1.70
Merluccius merluccius	19.26	26	0.37	1.61
Scomber scombrus	7.61	12	0.37	1.61
Sarda sarda	8.52	7	0.31	1.35
Chelon ramada	4.60	10	0.30	1.28
Trachurus mediterraneus	2.88	4	0.29	1.24
Sphyraena sphyraena	5.49	14	0.27	1.16
Lichia amia	1.32	4	0.26	1.14
Sparus aurata	19.07	43	0.23	0.98
Eledone moschata	0.44	2	0.22	0.95
Trachinus araneus	0.42	2	0.21	0.91
Alosa fallax	3.42	8	0.19	0.81
Phycis phycis	5.98	12	0.18	0.78
Spicara flexuosa	1.63	8	0.17	0.74
Trachurus trachurus	5.82	27	0.17	0.74
Maja squinado	1.64	6	0.16	0.69
Scomber colias	1.04	4	0.15	0.67
Trachinus draco	0.89	4	0.15	0.65
Diplodus vulgaris	1.87	12	0.14	0.58
Spondylosoma cantharus	1.16	4	0.13	0.55
Spicara maena	0.15	2	0.13	0.54

(continued)

Table 3 (continued)

Species	Total catch (kg)	No. of samples	Average CPUE	Percent of CPUE (%)
Dicentrarchus labrax	1.86	6	0.12	0.53
Diplodus sargus	8.72	26	0.12	0.52
Loligo vulgaris	0.28	2	0.12	0.50
Scorpaena scrofa	2.05	6	0.11	0.49
Pagellus erythrinus	6.64	36	0.11	0.47
Palinurus elephas	1.10	4	0.11	0.45
Solea solea	1.55	13	0.10	0.42
Oblada melanura	1.46	15	0.10	0.42
Sciaena umbra	1.75	8	0.10	0.41
Mullus surmuletus	4.02	29	0.09	0.40
Pagrus pagrus	1.41	8	0.09	0.40
Labrus viridis	1.43	6	0.09	0.40
Conger conger	0.80	2	0.08	0.35
Dentex macrophthalmus	0.48	6	0.08	0.34
Uranoscopus scaber	3.98	29	0.08	0.34
Sepia officinalis	1.91	10	0.08	0.33
Pagellus acarne	1.32	14	0.07	0.32
Diplodus puntazzo	0.49	4	0.07	0.31
Spicara smaris	0.40	4	0.07	0.28
Sardinella aurita	1.31	8	0.06	0.26
Diplodus annularis	1.53	15	0.06	0.26
Scyliorhinus canicula	0.12	2	0.06	0.26
Zeus faber	0.58	6	0.06	0.25
Symphodus tinca	0.99	10	0.06	0.25
Symphodus roissali	0.12	2	0.05	0.24
Raja miraletus	0.21	2	0.05	0.23
Gobius sp.	0.31	2	0.05	0.22
Squilla mantis	1.35	14	0.05	0.21
Serranus scriba	0.56	12	0.04	0.17
Citharus linguatula	1.56	20	0.04	0.17
Scorpaena porcus	1.75	21	0.04	0.17
Lithognathus mormyrus	0.26	6	0.03	0.15
Scorpaena notata	0.55	4	0.03	0.15
Trachinus radiatus	0.37	4	0.03	0.14
Serranus cabrilla	0.50	10	0.03	0.14
Epinephelus marginatus	0.06	2	0.03	0.12
Synodus saurus	0.14	2	0.03	0.12
Gobius cobitis	0.06	2	0.03	0.12
Chelidonichthys lastoviza	0.22	2	0.02	0.09

(continued)

Table 3 (continued)

Species	Total catch (kg)	No. of samples	Average CPUE	Percent of CPUE (%)
Penaeus kerathurus	0.38	8	0.02	0.08
Chelidonichthys lucerna	0.07	2	0.02	0.08
Bothus podas	0.18	4	0.02	0.07
Sardina pilchardus	0.08	4	0.01	0.03
Microchirus ocellatus	0.03	2	0.00	0.02
Pagurus prideaux	0.04	4	0.00	0.02
Dactylopterus volitans	0.01	2	0.00	0.01
Total	**458.75**	**84**	–	**100.00**

The bold value in the third column represents the number of species sampled per fishing gear (gill- or trammel nets). The bold value in the second column gives the total value of caught fish of all listed species in kilograms, and the value is correct. The fourth column does not have a final value in the last row, as this parameter cannot be summed or averaged. The final column is the sum of all the percentages given per species, and should equal 100 (%)

Fig. 5 Little tunny (*Euthynnus alletteratus*). (Photo by J.T. Williams, CC BY 2.5)

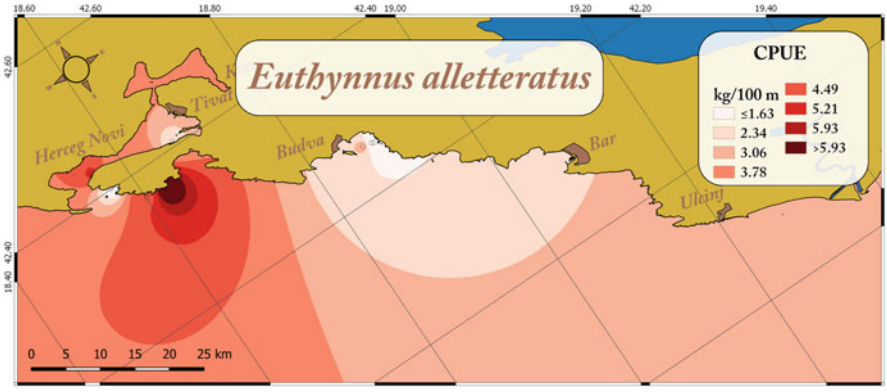

Fig. 6 CPUE spatial distribution of gillnet catches of *E. alletteratus*, circles mark individual samplings (DCRF data 2017–2020)

Fig. 7 Bogue (*Boops boops*). (Photo by Branko Dragičević)

not have to correlate to the CPUE value, as is the case with *Auxis rochei*. This species was ranked eighth, according to the highest total catch, yet in regard to the CPUE, it is ranked third (Fig. 2, Table 3).

Bogue (*B. boops*) (Fig. 7) is mostly caught in the Boka Kotorska Bay and in the area just in front of it. It is a common species in Montenegrin small-scale fisheries, although it is generally not considered the staple seafood it once was. Its importance in small-scale fisheries is indicated by one of the most common types of gillnet in use today in Montenegro – *bukvara*, gillnet for Bogue, with stretched mesh size from 40 to 52 mm, and net height no greater than 300 meshes [4].

The highest CPUE of Bogue (10.00 kg/100 m) was recorded at the entrance to the Boka Kotorska Bay, in front of the Dobreč Cove (Fig. 8), while the lowest (0.004 kg/100 m) was found in front of Utjeha (Municipality of Bar). The species was present in 13 samplings, with catch weights ranging from 0.02 to 20 kg, a total catch of 68.04 kg, and an average catch of 5.23 ± 7.09 kg.

Golden grey mullet, *C. auratus* (Fig. 9), is another common species in gillnet fisheries. It was present in 9 samplings, catches ranging from 0.62 to 7.73 kg. Mean catch weigh was 1.91 ± 2.39 kg. The average CPUE of the species was 17.22 kg/100 m (Table 3), but it ranged from 0.15 kg/100 m to 1.72 kg/100 m. Catch effort is concentrated in the Boka Kotorska Bay and in front of Budva (Fig. 10).

Red mullet, *M. barbatus* (Fig. 11), is considered one of the three most important species in large-scale commercial fisheries (namely bottom trawl fisheries) in Montenegro, with annual catches of around 40 t. Its impact on gillnet fisheries is not as significant. It was found in 15 samplings, with catch weight ranging from 0.04 to 3.2 kg (average 1.01 ± 1.08 kg). The average CPUE for red mullet was 0.41 kg/100 m (Table 3), and ranged from 0.01 kg/100 m to 1.40 kg/100 m, with the highest value recorded in the area in front of Budva (Fig. 12).

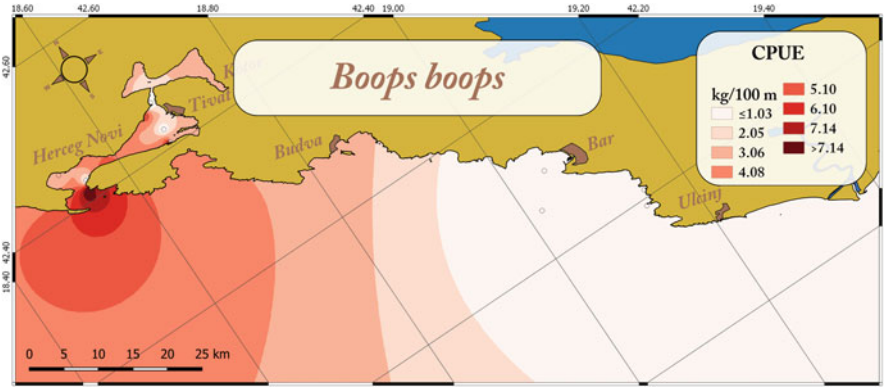

Fig. 8 CPUE spatial distribution of gillnet catches of *B. boops*, circles mark individual samplings (DCRF data 2017–2020)

Fig. 9 Golden grey mullet (*Chelon auratus*). (Photo by Diego Delso, CC BY 4.0)

Like red mullet, European hake (*M. merluccius*) (Fig. 13) is one of the most important species in Montenegrin bottom trawl fisheries. In gillnet monitoring, it was present in 13 samplings with weights from 0.3 to 5.4 kg, and a mean of 1.48 ± 1.66 kg. The highest CPUE, 1.48 kg/100 m, was recorded just in front of Bar, while the lowest value was found in front of Utjeha (Fig. 14).

Gilthead sea bream (*S. aurata*) (Fig. 15) is a very sought-after species on the market. Farmed variety is commonly available, but the wild specimens reach much

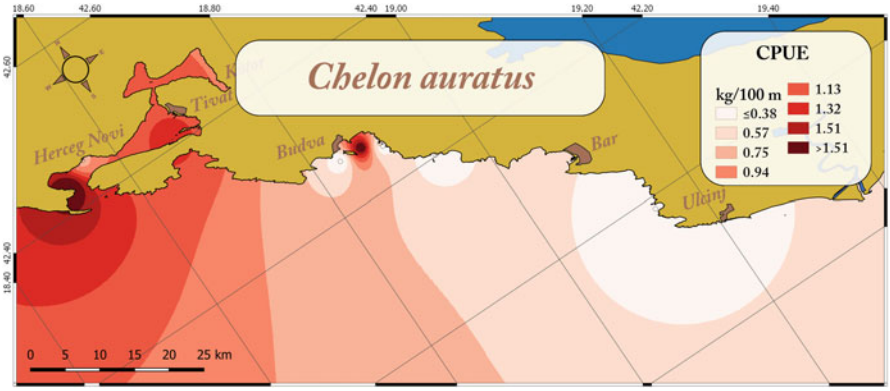

Fig. 10 CPUE spatial distribution of gillnet catches of *C. auratus*, circles mark individual samplings (DCRF data 2017–2020)

Fig. 11 Red mullet (*Mullus barbatus*). (Photo by Milica Peković)

higher prices on the market. It was found in 22 samplings. Catch weights in samples were in the 0.16–6.21 kg range, with an average of 0.87 ± 1.35 kg. Higher CPUE values were concentrated in the Boka Kotorska Bay (0.65 kg/100 m), Trašte Bay (0.61 kg/100 m) and in front of Rafailovići (0.62 kg/100 m), near Budva. The lowest CPUE value (0.02 kg/100 m) was estimated very close to the last position, between Rafailovići and Sveti Nikola Island in front of Budva (Fig. 16).

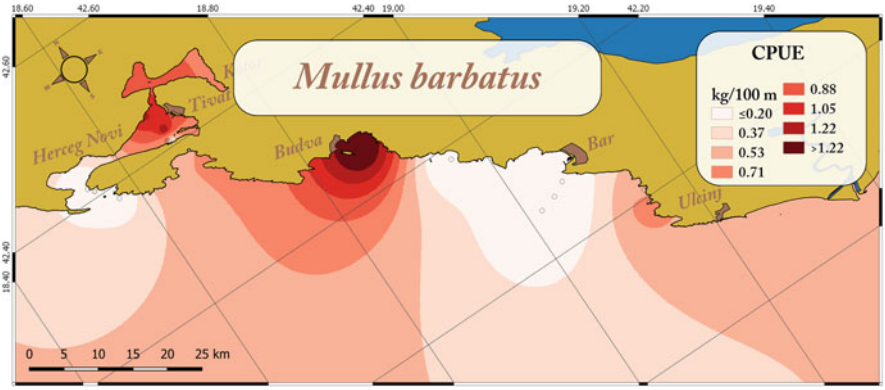

Fig. 12 CPUE spatial distribution of gillnet catches of *M. barbatus*, circles mark individual samplings (DCRF data 2017–2020)

Fig. 13 European hake (*Merluccius merluccius*). (Photo by Igor Isajlović)

3.2 Trammel Nets

The total catch recoded in trammel nets from April 2017 to June 2020 was 483.77 kg. The individual catches ranged from 0.02 to 33.46 kg, with a mean value of 5.56 ± 8.25 kg. As much as 83.05% of all sampled catches were below 11 kg total catch weight (Table 4), and only 3.45% were above 50 kg.

The CPUE ranged from 0.02 kg/100 m to 4.14 kg/100 m (Fig. 17), with an average of 0.30 ± 0.58 kg/100 m of net. The highest value of CPUE is a result of Pink dentex catches (see below for details), and represents an outlying value in an otherwise more unified value range (0.02–1.91 kg/100 m).

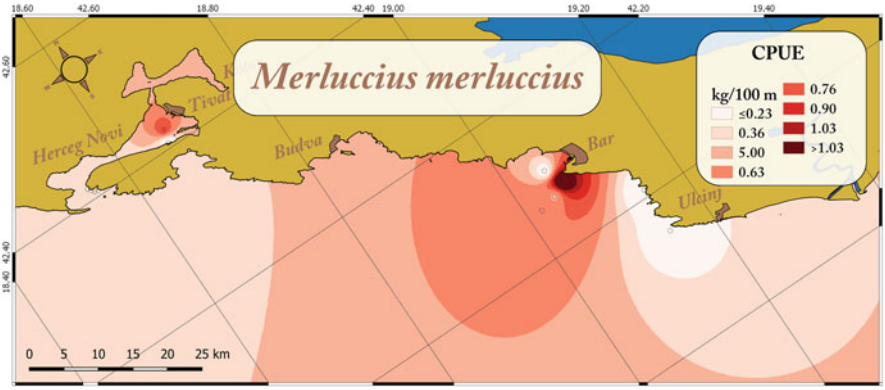

Fig. 14 CPUE spatial distribution of gillnet catches of *M. merluccius*, circles mark individual samplings (DCRF data 2017–2020)

Fig. 15 Gilthead sea bream (*Sparus aurata*). (Photo by Dario Vrdoljak)

CPUE of species caught in trammel nets is given in Table 5 below.

Pink dentex (*D. gibbosus*) (Fig. 18) had the highest CPUE of all species caught in trammel nets, 4.38 kg/100 m of net (Table 5). This is, however, the result of a single large catch (31.68 kg) in a net 250 m in length. The other two catches of *D. gibbosus* weighed less than 1 kg, in nets 250–300 m in length, with CPUEs of 0.21 and 0.25 kg/100 m (the mean catch of the species was 10.99 ± 17.92 kg). Such large catches are not uncommon for this species, as individuals aggregate in large shoals during spawning. This large catch of Pink dentex has weighted the CPUE distribution heavily to that sampling site (Fig. 19).

Striped red mullet or surmullet (*M. surmuletus*) (Fig. 20) is a species closely related to *M. barbatus*, which is much more prevalent in fisheries, being a species targeted by bottom trawlers. *M. surmuletus* can reach higher market prices, however,

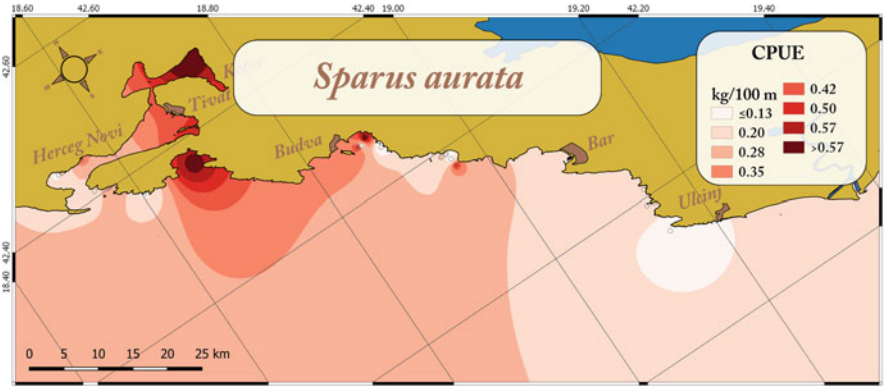

Fig. 16 CPUE spatial distribution of gillnet catches of *S. aurata*, circles mark individual samplings (DCRF data 2017–2020)

Table 4 Percentage proportions of trammel net catch by weight (DCRF, 2017–2020)

Catch weight [kg]	Percentage [%]
>51	3.39
31–51	1.69
11–31	11.86
6–11	15.25
1–6	54.24
<1	13.56

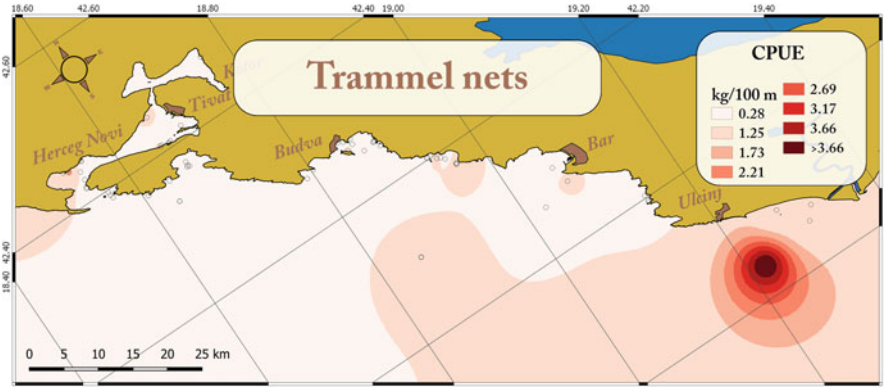

Fig. 17 Spatial distribution of average CPUE (kg/100 m of net) of trammel nets (DCRF 2017–2020)

and is more valued as food than *M. barbatus*. It was recorded in 25 samplings, with catch weights between 0.04 kg and 6.7 kg (average of 1.29 ± 1.60 kg) (Fig. 21). It CPUE values ranged from 0.01 kg/100 m (just in front of Budva) to 1.30 kg/100 m (mid-point between Lastavica (Mamula) Island and Cape Arza at the entrance to the

Table 5 List of species in trammel net catches, with total catch per species (kg), number of samples the species was present in, average CPUE (kg per 100 m of net used), and percentage of the CPUE per species

Species	Total catch (kg)	No. of samples	Average CPUE	Percent of CPUE (%)
Dentex gibbosus	32.97	3	4.38	18.81
Homarus gammarus	4.70	1	1.88	8.07
Raja asterias	22.76	3	1.45	6.22
Raja clavata	33.46	3	1.33	5.73
Pagrus pagrus	24.43	7	1.33	5.71
Lophius budegassa	20.86	3	1.20	5.14
Scyliorhinus canicula	16.64	5	0.71	3.05
Chelon auratus	10.79	7	0.63	2.73
Chelon ramada	19.84	11	0.49	2.11
Octopus vulgaris	5.49	5	0.49	2.09
Sparus aurata	21.43	10	0.47	2.02
Alosa fallax	8.36	4	0.47	2.00
Lophius piscatorius	15.88	4	0.46	1.99
Euthynnus alletteratus	11.56	3	0.40	1.74
Penaeus kerathurus	9.06	7	0.34	1.44
Mullus surmuletus	32.30	25	0.32	1.39
Myliobatis aquila	3.66	3	0.31	1.34
Squalus blainvillei	1.55	1	0.31	1.33
Merluccius merluccius	20.47	11	0.28	1.19
Sepia officinalis	23.71	27	0.27	1.17
Solea solea	9.51	8	0.26	1.11
Pagurus prideaux	1.38	2	0.24	1.05
Epinephelus marginatus	1.18	3	0.24	1.02
Scophthalmus rhombus	0.67	1	0.22	0.96
Mullus barbatus	10.23	15	0.21	0.91
Mustelus mustelus	2.62	2	0.20	0.87
Conger conger	1.85	3	0.17	0.75
Dicentrarchus labrax	0.52	1	0.17	0.74
Raja miraletus	8.60	8	0.16	0.69
Scorpaena scrofa	7.48	13	0.16	0.68
Trigla lyra	16.60	10	0.15	0.66
Dentex dentex	1.63	3	0.15	0.64
Trachurus trachurus	2.88	3	0.14	0.62
Muraena helena	2.82	3	0.14	0.59
Symphodus roissali	1.61	5	0.14	0.58
Phycis phycis	6.66	15	0.13	0.56
Scorpaena porcus	7.50	16	0.12	0.52
Torpedo torpedo	1.01	2	0.12	0.50
Sciaena umbra	1.27	4	0.11	0.49

(continued)

Table 5 (continued)

Species	Total catch (kg)	No. of samples	Average CPUE	Percent of CPUE (%)
Palinurus elephas	1.63	4	0.11	0.46
Diplodus annularis	6.04	19	0.11	0.45
Symphodus tinca	3.27	10	0.10	0.42
Sarpa salpa	0.82	2	0.09	0.39
Serranus cabrilla	1.37	9	0.09	0.39
Lithognathus mormyrus	3.85	7	0.09	0.37
Trachinus draco	2.72	5	0.08	0.36
Scorpaena notata	1.64	9	0.08	0.36
Zeus faber	4.17	7	0.08	0.36
Torpedo marmorata	1.51	4	0.08	0.35
Pagellus erythrinus	5.46	21	0.08	0.33
Spicara flexuosa	2.10	6	0.07	0.32
Sphyraena sphyraena	0.59	2	0.07	0.32
Synodus saurus	2.46	8	0.07	0.31
Uranoscopus scaber	3.00	15	0.07	0.31
Platichthys flesus	0.70	2	0.07	0.31
Pagellus acarne	3.60	11	0.07	0.31
Eledone moschata	0.30	1	0.07	0.29
Monachirus hispidus	0.47	3	0.06	0.27
Spondylosoma cantharus	1.60	8	0.06	0.27
Lichia amia	0.24	1	0.06	0.26
Loligo vulgaris	0.66	3	0.06	0.26
Seriola dumerili	0.32	1	0.05	0.23
Maja squinado	0.40	2	0.05	0.22
Diplodus sargus	0.58	3	0.05	0.22
Scomber colias	0.35	1	0.05	0.21
Labrus merula	0.81	4	0.05	0.20
Citharus linguatula	1.13	8	0.05	0.19
Labrus viridis	0.27	1	0.05	0.19
Oblada melanura	0.34	2	0.04	0.18
Scomber scombrus	0.31	2	0.04	0.18
Diplodus vulgaris	1.87	14	0.04	0.17
Boops boops	0.51	3	0.04	0.16
Dactylopterus volitans	0.21	1	0.04	0.15
Diplodus puntazzo	0.28	2	0.03	0.14
Serranus scriba	0.63	5	0.03	0.14
Microchirus ocellatus	0.51	6	0.03	0.11
Chelidonichthys lucerna	0.41	3	0.03	0.11
Spicara maena	0.12	1	0.02	0.10

(continued)

Table 5 (continued)

Species	Total catch (kg)	No. of samples	Average CPUE	Percent of CPUE (%)
Epinephelus aeneus	0.12	1	0.02	0.09
Gobius sp.	0.02	1	0.02	0.06
Xyrichtys novacula	0.08	1	0.01	0.06
Callinectes sapidus	0.05	1	0.01	0.05
Chelidonichthys lastoviza	0.05	1	0.01	0.05
Squilla mantis	0.14	5	0.01	0.04
Sardinella aurita	0.09	1	0.01	0.04
Sardina pilchardus	0.04	2	0.00	0.01
Spicara smaris	0.02	1	0.00	0.01
Total	**483.77**	**87**		**100.00**

The bold value in the third column represents the number of species sampled per fishing gear (gill- or trammel nets). The bold value in the second column gives the total value of caught fish of all listed species in kilograms, and the value is correct. The fourth column does not have a final value in the last row, as this parameter cannot be summed or averaged. The final column is the sum of all the percentages given per species, and should equal 100 (%)

Fig. 18 Pink dentex (*Dentex gibbosus*). (Photo by Dario Vrdoljak)

Boka Kotorska Bay) and 1.34 kg/100 m (Trašte Bay), with an average of 0.32 kg/100 m (Table 5).

European hake (*M.merluccius*) (Fig. 13) had highest CPUE values near Buljarica (0.63 kg/100 m) and Utjeha (0.56 kg/100 m), while the lowest values were recorded outside of Cape Arza (entrance to the Boka Kotorska Bay) and at a site

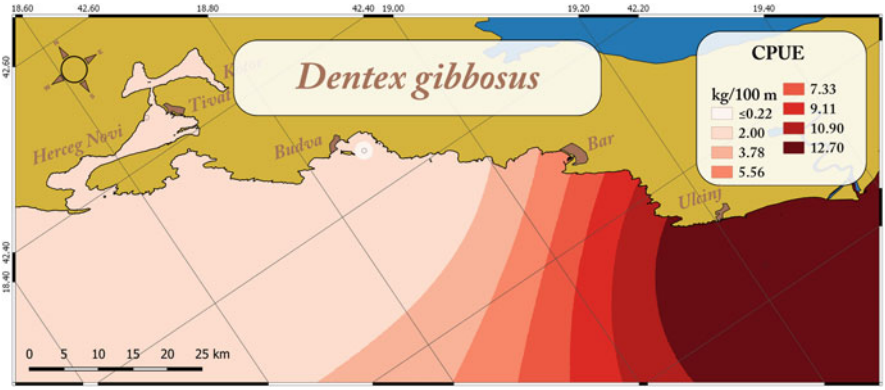

Fig. 19 CPUE spatial distribution of trammel net catches of *D. gibbosus*, circles mark individual samplings (DCRF data 2017–2020)

Fig. 20 Striped red mullet or surmullet (*Mullus surmuletus*). (Photo by Dario Vrdoljak)

approximately 1.5 NM outside the Dobra Luka Cove (Luštica peninsula), 0.03 kg/100 m for both sites (Fig. 22). There are two samplings at about 8.2 NM off the coast of Petrovac, with very different CPUE values, 0.06 kg/100 m and 0.53 kg/100 m. On Fig. 22, they can be observed as a small round area of 0.23 kg/100 m range surrounded by 0.29 kg/100 m field. The total catch of European hake in trammel net samplings was 20.47 kg, while the average catch was 1.86 ± 2.20 kg (0.12–7.36 kg).

Thinlip grey mullet (*C. ramada*) was present in 11 of 3 samplings, with a total catch of 19.84 kg. The catch value ranged from 0.14 to 5.10 kg, with an average of 1.80 ± 1.91 kg. Mean CPUE value was 0.49 kg/100 km (Table 5), with a range from

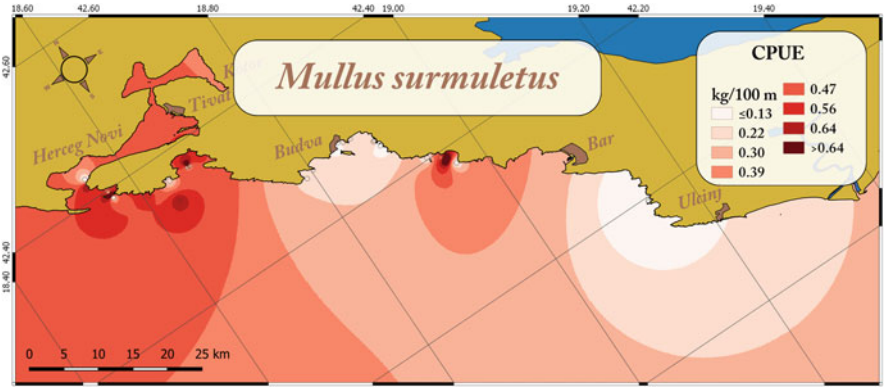

Fig. 21 CPUE spatial distribution of trammel net catches of *M. surmuletus*, circles mark individual samplings (DCRF data 2017–2020)

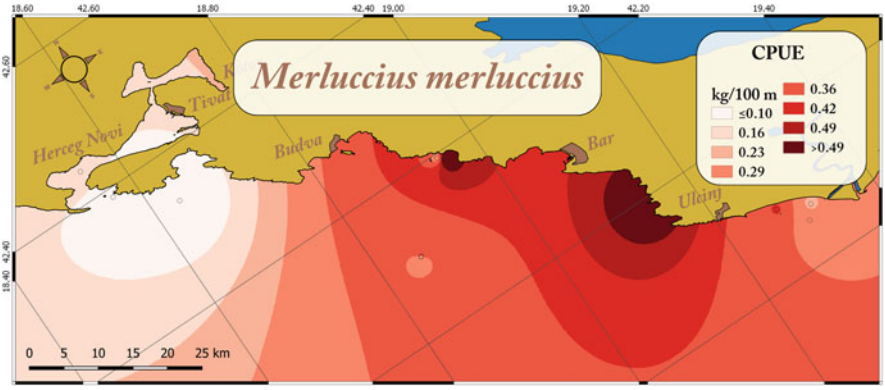

Fig. 22 CPUE spatial distribution of trammel net catches of *M. merluccius*, circles mark individual samplings (DCRF data 2017–2020)

0.03 kg/100 km (in front of Buljarica beach, Budva Municipality) to 1.70 kg/100 km (Bijela in Boka Kotorska Bay) (Figs. 23 and 24).

Whereas the gillnet CPUE of Gilthead sea bream (Fig. 15) was highest around the Boka Kotorska Bay (Fig. 16), the values in trammel net CPUE were highest near the other end of Montenegrin coastline, in front of the Velika plaža and Bojana River estuary area of the Ulcinj Municipality. The lowest value was 0.03 kg/100 m, found in front of Cape Arza and in the Velika plaža area, while the highest value, 3.30 kg/100 m was in the Velika plaža area, about 5 km from the site of the lowest CPUE. Average CPUE was 0.47 kg/100 m (Table 5, Fig. 25).

Common cuttlefish, (*Sepia officinalis*) (Fig. 26), the only cephalopod species with sizeable catches, 23.71 kg (0.06–5.3 kg; average of 0.88 ± 1.05 kg), was found in 27 samples all along the Montenegrin coast. The highest CPUE values were recorded inside the Boka Kotorska Bay (in front of Krašići, Tivat, 0.95 kg/100 m,

Fig. 23 Thinlip grey mullet (*Chelon ramada*). (Photo by Massimiliano Marcelli – Etrusko25, CC BY-SA 3.0)

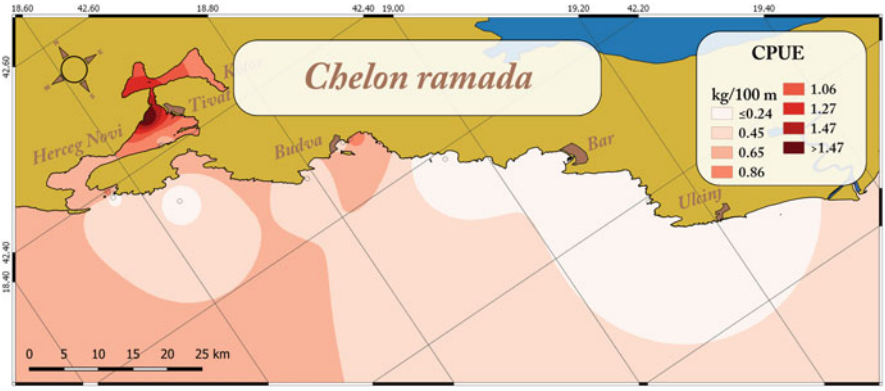

Fig. 24 CPUE spatial distribution of trammel net catches of *C. ramada*, circles mark individual samplings (DCRF data 2017–2020)

and 0.80 in Ljuta, Kotor) (Fig. 27). The minimum was 0.02 kg/100 m, and was recorded at two sites, at a point midway between the Lastavica (Mamula) Island and Cape Arza, and inside the Trašte Bay. Average CPUE was 0.27 kg/100 m (Table 5).

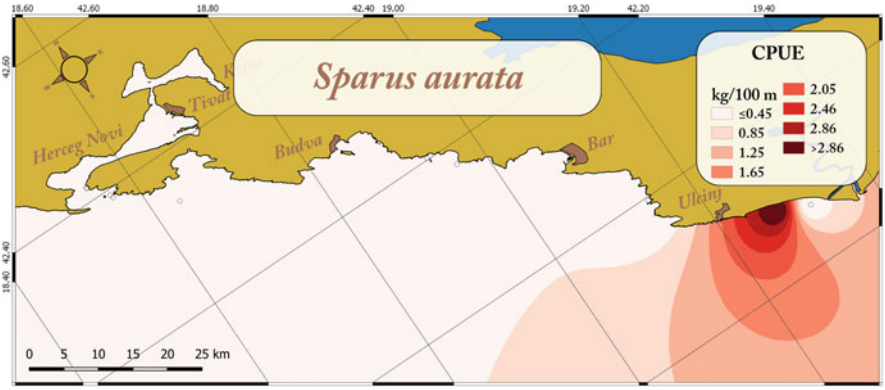

Fig. 25 CPUE spatial distribution of trammel net catches of *S. aurata*, circles mark individual samplings (DCRF data 2017–2020)

Fig. 26 Common cuttlefish (*Sepia officinalis*). (Photo by Ivana Orlović Kranjc)

4 The "Ghost Fishing" Problem and Fixed Nets

While marine litter presents a global threat in the world [11], "ghost fishing" and derelict fishing gear is a problem intrinsically tied to small-scale fisheries. "Ghost fishing" is defined as the capacity of a fishing gear to continue fishing after it has been lost and/or the fisher has lost control of it [12]. It has been confirmed for various gear used in small-scale fisheries, such as gillnets, trammel nets, long-lines, and traps, but also for gear used in large-scale fisheries (trawl nets, small purse seines)

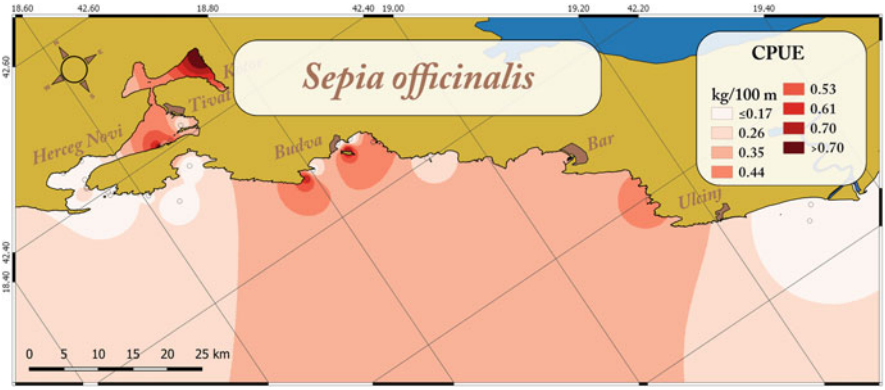

Fig. 27 CPUE spatial distribution of trammel net catches of *S. officinalis*, circles mark individual samplings (DCRF data 2017–2020)

Fig. 28 Derelict fishing gear retrieved from the sea during marine litter collection, mostly pots and fixed nets (Photos by Milica Mandić)

[13]. Gillnets and trammel nets can continue to fish for years after they have been lost or abandoned, although the sea bottom composition plays a role in how long such nets remain operational, with nets on rocky bottoms lasting longer than those on soft sediments [12]. However, it is not only the continued fishing operation of

such nets that presents a problem, the degradation of synthetic materials used in production of modern nets can lead to pollution and appearance of microplastics [14] (Fig. 28).

Tutman et al. [13] collected over 1.1 t of derelict fishing gear in Croatia, of which 37% was estimated to have been in the sea for longer than a year. Most of the collected derelict gear (77%) was found on underwater rocky reefs, with 21% on sand or boulder seafloor habitat, and 2% stranded on shorelines. There are currently no comparable data published in Montenegro, but the results could be similar to those in Croatia, albeit with a smaller total weight of derelict gear retrieved, as both the number of fishing vessels and the length of the shoreline are much lower in Montenegro.

5 Discussion

Small-scale fisheries, which include fixed nets such as gillnets and trammel nets, are generally highly selective and have a low impact on seabed [12, 15]. General Fisheries Commission for the Mediterranean (GFCM) highlights that small-scale fisheries promote sustainable use of resources though exploitation of living marine resources in a way that minimises environmental degradation, while emphasising economic and social benefits [16].

Contribution of small-scale fisheries in the total fisheries sector is 71% in both Croatia and Montenegro [16].

Catch composition of gillnet and trammel nets varies across the Adriatic region. In Croatia, gillnet landings are dominated by European hake (77%), followed by Chub mackerel (*Scomber colias*; 11%). In Italian northern coast area (GSA 17), the species were represented over 10% in catches, Common cuttlefish, Common sole and the Spottail shrimp, while in GSA 18 (south Adriatic) Spottail mantis shrimp (20%) and Common cuttlefish (15%) were the main species. In Slovenia, Gilthead sea bream made up 20% of the landings, followed by common sole (6%) and Mackerel (6%) [17]. Even the catches reported for Montenegro differ from those presented in this study, with Atlantic bonito (38%), Common pandora (11%), and Greater amberjack (8%). The presence of Atlantic bonito and Greater amberjack is due to a few large catches, as the species are known to gather in large shoals [18], similar to how Little tunny is (over-)represented in current findings. Common dentex remains one of the most important species in gillnet fisheries, although it is slightly less represented. Gillnet catches are difficult to compare, as the gear is highly selective, and wide range of mesh sizes is in use. In Montenegro, for example, the minimum mesh size for various gillnets allowed ranges from 20 mm (gillnet for sand smelt, *gavunara*) all the way to 80 mm (gillnet for bonito, *polandara*).

The most common species caught by trammel in Croatian rocky bottom areas were Gilthead sea bream (19%), Common cuttlefish (14%), Common octopus (13%), and Salema (10%), while on the soft bottom areas in Istria, Common sole was the dominant species (83%). Slovenian trammel net catches were also

dominated by the Common sole (36%). In Italy, the most common species were Common cuttlefish (18%), Common octopus (12%), Black scorpionfish (9%), and Mugilidae species (6%). These are all species found in samples in this study, only the ratios differ, and this probably has to do with the local environmental conditions.

Dulčić et al. [19] report values of 0.689 to 4.609 kg/100 m of net, with an average of 2.860 kg/100 m for trammel nets around islands of Zadar Archipelago (Croatia). These values are higher than the ones presented in this study, but the channels between Croatian islands are likely richer fishing grounds than the relatively narrow Montenegrin shelf, directly exposed to the influence of the open sea.

6 Conclusion

Fixed nets (gillnets and trammel nets) are highly selective, low-impact fishing gears, generally targeting species with higher economic value. On the other hand, their CPUE varies significantly, and is generally low. They are a representation of tradition and a way of life spreading all over the Mediterranean, and are now being given a new focus as the relatively environmentally friendly practice within the society that is continuously becoming more aware of the ecological problems faced by the modern society.

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