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Reducing Artisanal Fishery Impact on Marine Community: New Data from Comparison of Innovative and Traditional Gear

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Abstract: Fishery resources overexploitation, together with bycatch and discards, have an impact on marine ecosystems. The adoption of technologically innovative gears is a possible solution to reduce the discard and to enhance the sustainability of fishery, mainly in artisanal fisheries that represent about 80% of the EU Mediterranean fleet. In the perspective of fishery sustainability, it is necessary to study and test alternative gears to the traditional ones, also with collaboration of fishers. In the present study, results of experimental fishing activities carried out in two Mediterranean areas with traditional and innovative gears of small-scale fishing are reported. Thirty-four hauls were carried out to compare the catch of two types of trammel nets: a traditional one and experimental guarding net. Additionally, 12 hauls were carried out to compare collapsible pots and traditional pots. No significant differences were recorded between trammel nets in terms of commercial catch and discard. However, interesting differences in discard composition were recorded, with higher Elasmobranchs presence in trammel nets, including species assessed as critically endangered and vulnerable. The use of trapula pots in place of traditional ones showed a lower discard of specific resources and an advantage for fishers in terms of space occupied on board.

Keywords: discard; experimental gears; trammel nets; pots; small-scale fishery

Key Contribution: The results on the use of innovative fishing gears, such as experimental guarding nets and collapsible pots, in place of the traditional ones highlighted the potential reduction in fishing discards and support to artisanal Mediterranean fisheries sustainability.

1. Introduction

The reduction in bycatch and discard in fishing, with active and passive gears, is a key issue in fisheries management and marine ecosystems conservation [1,2]. In the Mediterranean Sea, for example, discard rates in fisheries with trammel nets range from 10% to 43%, depending on target species [3]. Considering that the small-scale fleet accounts for 80% of fishing vessels in the EU Mediterranean region, this phenomenon is significant but still poorly understood [4,5]. Few studies aimed at evaluating the catches and discard of invertebrate or habitat-forming organisms have been carried out, while much research has focused on vertebrate species [6]. Discarded species, such as crabs, hermit crabs, starfishes, sea urchins, sea cucumbers, and elasmobranchs, not only damage nets but their harvesting also poses a threat to marine biodiversity and ecosystem sustainability [7,8].

The excessive fishing discard can lead to a decline in fish populations, resulting in negative impacts on coastal ecosystems [9,10]. Additionally, discard imposes an additional burden on fishers, since they must dedicate time and energy to remove these organisms from the nets.

Improving the selectivity of gears, like traditional trammel nets, is challenging due to the various capture modes and target species [11]. Some proposed solutions include changes in mesh size, addition of extra non-fishing net panels, and use of visual or acoustic signals to repel unwanted catch [12]. However, the effects of these interventions on species, such as benthic communities and elasmobranchs, have not been adequately evaluated [13].

The impact of fishing discard extends beyond fish species and can also affect marine mammals, seabirds, and habitats [14]. Therefore, it is essential to explore alternative and innovative gear to reduce the discard and to improve their selectivity also in small-scale fisheries.

The development and adoption of new technologies, methodologies, and strategies that increase the sustainability and efficiency of the fishing sector are at the base of fisheries' innovation. According to the International Council for the Exploration of the Sea (ICES), innovations in fisheries regard the improvement of the current state with enhancement of traditional gears [15].

Among selective passive traditional gears of artisanal fishery are the pots, whose use is common in some Italian areas and dropped out in others. They are characterized by a capture efficiency comparable to traditional fixed nets. Pots are intriguing for their lower environmental impacts and production costs; moreover, they are designed to be selective for specific prey, minimizing bycatch and discard [16–18]. On the Mediterranean scale, pots are widely used, with relatively low discard rates [17,19]. However, a significant issue associated with traditional pots is their bulky volume [20].

Considering recent EU and General Fisheries Commission for the Mediterranean (GFCM) fisheries management indications that give priorities to the coexistence of good marine environmental status with local stakeholders' socio-economic wellness, preventing the incidental catches of species becomes urgent and crucial; this is needed both for the protection of biodiversity and the reduction in negative effects for the fishers in terms of losing time and economic damage [21].

Few recent studies have highlighted the importance of using technologically innovative gears and of proper management in the reduction of fishery impacts [22], and, therefore, it is necessary to continue investigation and testing of alternative gears also with active collaboration of fishers in the perspective of fishery sustainability.

In the present study, we report the results of experimental fishing carried out with traditional and innovative gears of small-scale fishing (trammel nets and pots), aimed at evaluating the differences in terms of catches and discard, and, therefore, identifying and proposing alternative gears with lower impact on fisheries resources and, likewise, that are cost-effective for fishers.

2. Materials and Methods

2.1. Study Area

All fishing activities were carried out in two Italian marine areas: around Porto Pino (southwestern Sardinia) and Favignana Island (western Sicily) (Figure 1).

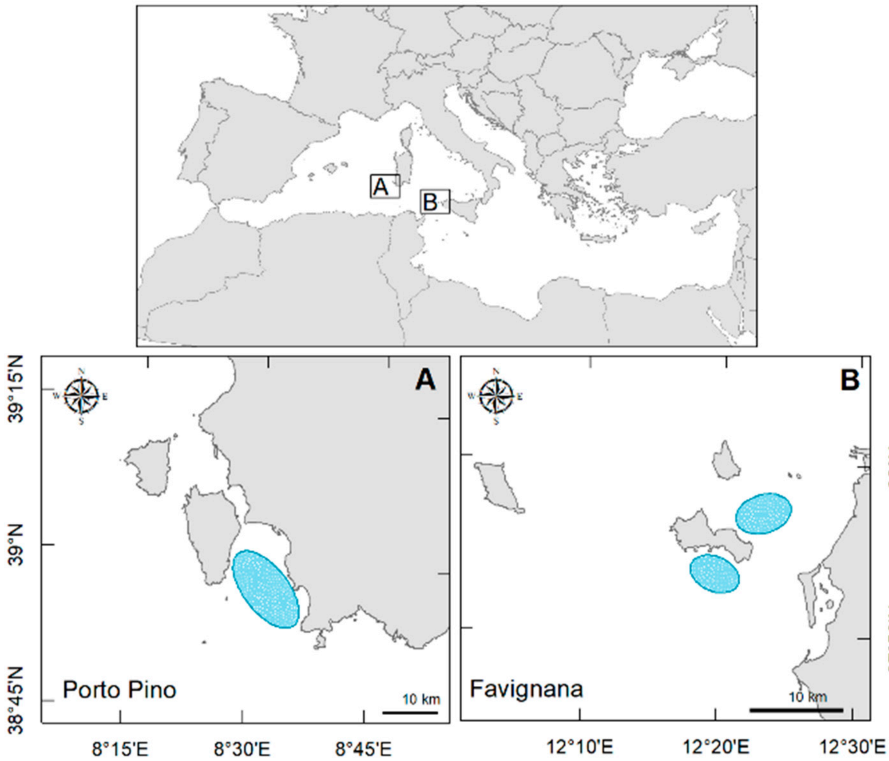

Figure 1. Porto Pino (**A**) and Favignana (**B**) with indication of experimental fishing areas (light blue elliptic shapes).

Favignana is the main island of the Egadi Islands, a Marine Protected Area (MPA) in the northwestern coast of Sicily. The MPA has specific hydrodynamic conditions that make it a landing point of many marine species carried by Atlantic currents from the Strait of Gibraltar, which affect temperature and salinity, as well as planktonic distribution and composition and ichthyofauna [23]. Unlike other MPAs with three different protection levels, in Egadi Island MPA, there are four different ones (A, B, C, and D). The experimental fishing hauls were carried out in the C zone, where small commercial fishing is allowed with prior authorization.

Porto Pino is in front of the southern continental shelf of western Sardinia; this site is characterized by high wave energy and frequent sea storms, with wave height up to 3 m [24]. The 5 km long beach hosts a complex dune system bordered to the north by marsh and lagoonal deposits and naturally protected by Carloforte and Sant'Antioco islands to the northeast and by Cape Teulada to the southeast [24]. This land area falls in a Site of Community Importance (SCI) "Promontorio, dune e zona umida di Porto Pino" (ITB040025) belonging to the Natura 2000 network. Lastly, the second largest Italian military area is in Teulada peninsula, where 30 km of its coastline are off-limits to navigation.

2.2. Fishing Gear Characteristics

In Favignana and Porto Pino the fishing trials were carried out with two types of trammel nets: the traditional trammel net (CN) and an experimental trammel net, namely a guarding net (GN). Two types of pots, a traditional and an experimental one, named "trapula pot", were also deployed in Porto Pino.

2.2.1. Trammel Nets

The traditional trammel net was constituted by a panel 1000 m long, commonly used by local fishers; it consists of an inner panel 210/3 with 31.25 mm mesh (mesh size 9), reinforced with an outer panel 210/12, with 180 mm mesh (5 × 500 mg) with a height of 1.8 m. Unlike a traditional trammel net, a guarding net is equipped at the base with a narrow net named "*greca*", characterized by a 35 cm 210/6 monofilament of 50 mm mesh (mesh size 6) fixed between the webbing and the net. The floats used are the lm −20 type, the 4 mm colored polyester braid, the 26 = 1 kg barrel type sinkers, the 210/1/8 white twisted yarn and 3 mm white braid (Figure 2).

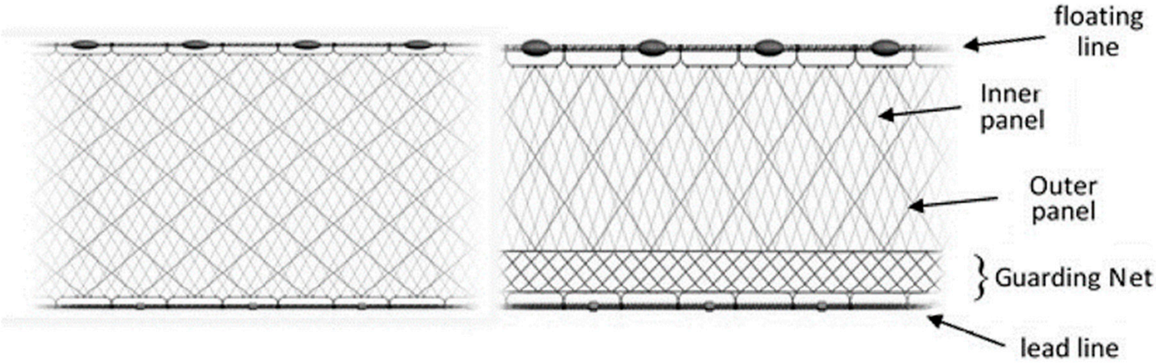

Figure 2. Scheme of traditional trammel nets (CN) and guarding nets (GN) modified from [25].

2.2.2. Pots

The traditional pots used by local fishers of Porto Pino are cylindrical in shape with a height of about 60 cm and a diameter of 30 cm, made with a metal frame covered with a nylon net of 10 mm mesh (Figure 3). This pot is mostly employed for catching octopus, during the spring–summer months, on mixed seabed at a depth between 40 and 60 m, using mainly crabs and, secondarily, sardines and discarded fish as bait [26].

Figure 3. Traditional pot used in Porto Pino (Sardinia).

The experimental gear used was the "*trapula* pot", a single chamber pot consisting of a pentagonal-shaped frame with a single oval entrance. The structure is made up of stainless-steel bars (2 mm in diameter) linked by a propylene rope (5 mm in diameter), externally reinforced with a nylon net (32 mm square mesh) (Figure 4A). The measures of the pot are reported in Figure 4A. This design makes the pot fully collapsible (Figure 4B), allowing it to occupy a space 50 times less than a traditional pot when closed. The pot locking is operated using 3/4 steel rings applied to the upper and lateral "closing hinge".

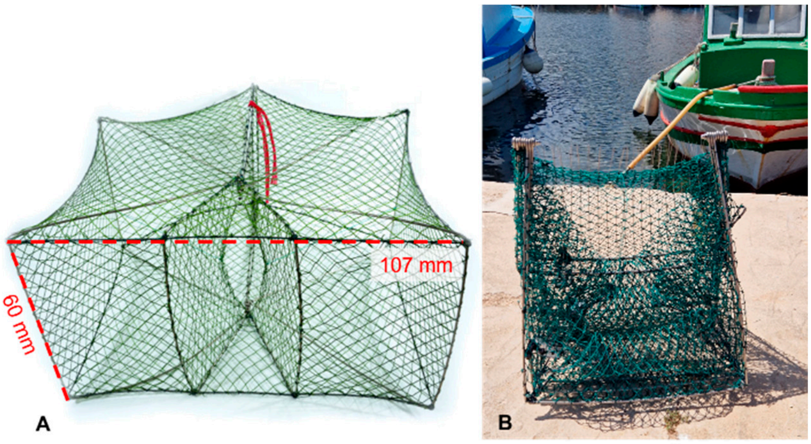

Figure 4. "Trapula pot": opened (**A**) and closed (**B**).

2.3. Experimental Fishing Setup

2.3.1. Trammel Nets

Local vessels between 5.5 and 6.5 m in total length were selected in Favignana and Porto Pino. A total of 18 experimental fishing activities were carried out in June (period 1) and October 2023 (period 2) in Favignana and 16 in July (period 1) and September 2023 (period 2) in Porto Pino in order to test the two types of trammel nets.

In each experiment, a fishing guarding net (GN) and trammel net as control (CN) were simultaneously placed by the same vessel in similar marine areas with depths ranging from 15 to 60 m in order to compare catch data. The gears were set in the afternoon (about 05:00 p.m.) and hauled the following morning at sunrise (about 6:00 a.m.). Fish removal and net cleaning were carried out by the fishers either at sea, in most cases, or shortly after returning to the fishing harbor, contingent upon weather conditions and catch volume.

2.3.2. Pots

The fishing activities with pots were carried out in Porto Pino on board a small local fishing vessel (total length: 8.6 m) in three days of July (period 1) and of September 2023 (period 2). On each day, three rows of 9 pots (set 15 m apart) spaced about 100 m from each other were placed at similar depths. This setup was used both with "trapula" and traditional pots that were deployed at the same time and in similar substrates. A total of 12 fishing trials were carried out in the two periods.

The pots were generally left in seawater for 48 h, according to the fishers' experience, except on days with adverse weather conditions (in the period 2), when they were sailed after 1 or 3 days. During period 1, sardines were mainly used as bait. In period 2, the pots were always baited with frozen sardines.

2.4. Data Collection and Analysis

For each haul, individuals found in the gears were identified to the lowest possible taxonomic level, merged in main taxonomic groups (i.e., Crustaceans, Molluscs, Osteichthyes, Elasmobranchs, Echinoderms, Seagrasses, Macroalgae, and Coralligenous) and divided into catches of commercial value and discard (without commercial value, undersized or in poor condition organisms). Catches were brought ashore and every individual weighed (to the nearest 0.1 g). Mean CPUE was calculated for each taxonomic group as mean biomass ± standard deviation per day (g/day) for the entire sampling period in order to compare the commercial catches and discard between types of gears. In the case of pots, from this calculation, the organisms found accidentally (e.g., macroalgae collected from interaction of the pot with the seafloor) were excluded.

Permutational univariate analysis of variance (PERANOVA) [27] based on a Bray Curtis resemblance matrix with square root transformed data was performed on commercial and discard data. Permutational ANOVA was designed for multivariate analysis on distance matrices; it can be used for univariate ANOVA and the resulting sums of squares and F-ratios are exactly the same as Fisher's univariate F-statistic in traditional parametric ANOVA. The advantage of nonparametric PERANOVA is that it allows the use of unbalanced data (different numbers of replications within the factors) and that the procedure does not require tests of homogeneity of variance but the software suggests data transformation when important variations in the used variables are present. For data of trammel nets, based on the null hypothesis that there are no differences between the factors Gear (with two levels, CN and GN), Periods (with two levels, Period 1: June–July and Period 2: September–October) and Location (with two levels: Favignana and Porto Pino) for each variable, a PERANOVA was performed. In the analysis, each single haul represented the sampling unit and, therefore, a replication within the Gear, Period and Location factors. In the case of pots, PERANOVA were used to compare trapula and traditional ones, with two factors: Gear (with two levels, trapula pot and traditional pot) and Period (with two levels, Period 1: July and Period 2: September). All the statistical analyses were performed with PRIMER 6 and PERMANOVA plus [27].

3. Results

3.1. Experimental Fishing with Trammel Nets

A total of 180.74 kg and 110.47 kg of catch were recorded in Favignana with a traditional trammel net and guarding net, respectively; a total of 82.71 kg and 69.42 kg of catch were recorded in Porto Pino area with a traditional trammel net and guarding net, respectively.

Osteichthyes were the most abundant group of organisms caught with both trammel nets in both study areas. In Favignana, this group accounted for 49.53% of total biomass with trammel net and 67.37% with guarding net; in Porto Pino, 79.14% and 73.57% of Osteichthyes were recorded with traditional trammel and guarding nets, respectively (Figure 5A,B).

Elasmobranchs was the second group more abundantly caught in Favignana with a traditional trammel net, with 32.19% of total biomass and mainly constituted by batoids, except on *Mustelus mustelus* and *Mustelus punctulatus*. *Dasyatis pastinaca* and *Myliobatis aquila* were the most abundant species, followed by *Raja radula*. In Favignana, the group of elasmobranchs was the third most abundant (12.23%), preceded by Molluscs (14.81%) (Figure 5B).

Regarding guarding nets in Porto Pino, the elasmobranchs accounted for 1.92% of the total biomass, with similar species caught; meanwhile, traditional trammel nets captured 0.64% of this group. In Porto Pino, the second most abundant taxonomic group was Molluscs, with percent values of 11.31% and 10.11% caught with trammel nets and guarding nets, respectively (Figure 5C,D).

In Figure 6, some species of elasmobranchs caught during the experimental surveys are reported.

The list of species caught with trammel nets in Favignana and Porto Pino, divided into commercial and discard, is reported in Tables 1 and 2, respectively. Many commercial species are reported also in discard fraction because they were caught undersized or in poor condition.

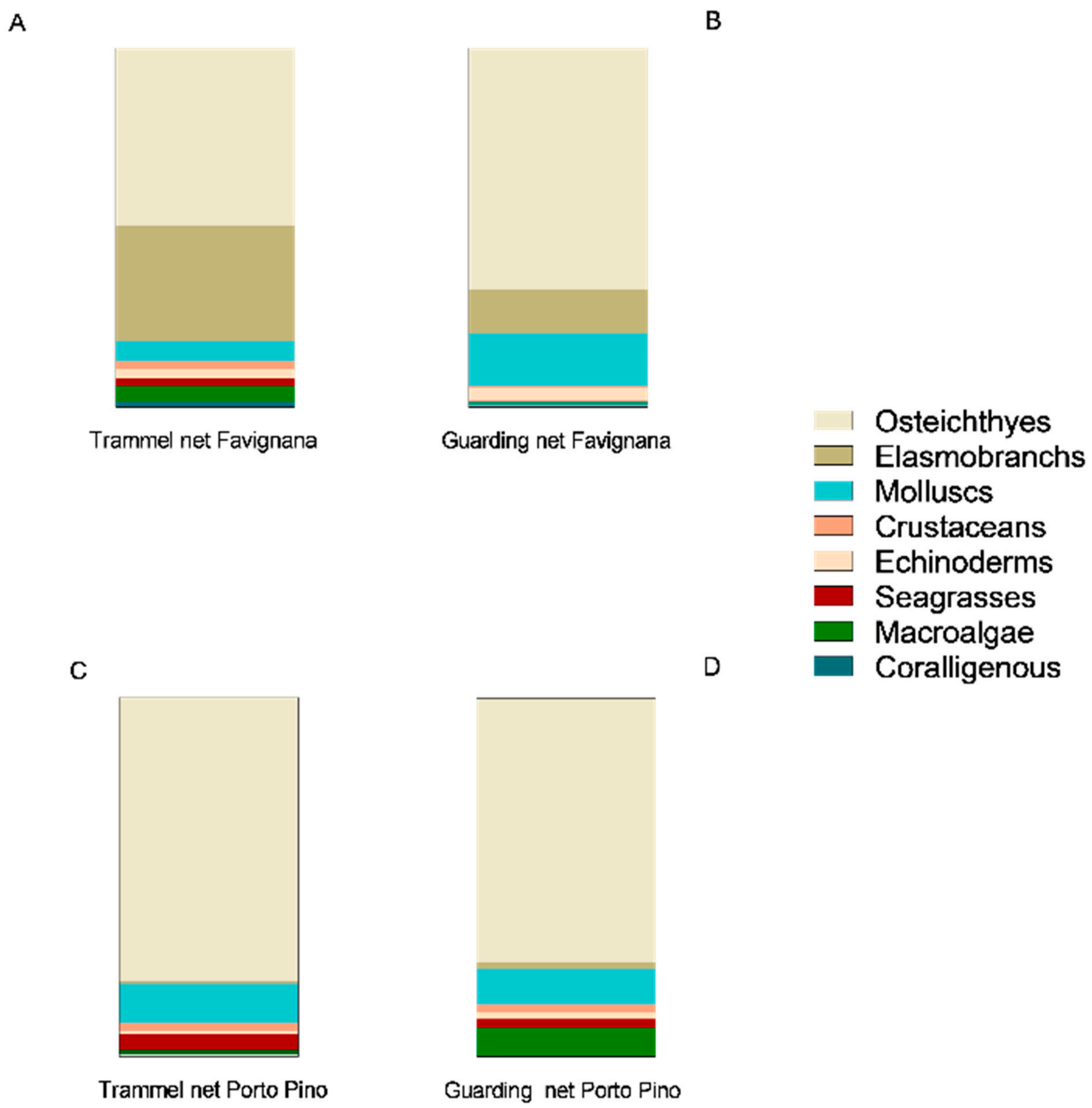

Figure 5. Percent distribution (total biomass) of taxonomic groups caught with the two gears in the two areas. Traditional trammel net in Favignana (**A**); guarding net in Favignana (**B**); traditional trammel net in Porto Pino (**C**); guarding net in Porto Pino (**D**).

In Favignana, a total of 130.54 kg of commercial species have been caught with traditional trammel nets, of which 61.19% consists of Osteichthyes (mean CPUE = 4456 ± 3625.12 g/day). Elasmobranchs were the second most abundant taxonomic group, accounting for 30.26% (mean CPUE = 2203 ± 4702.87 g/day). In the case of the guarding nets in Favignana, a total of 80.195 kg of commercial catches were recorded, of which 75.53% constituted Osteichthyes, with a mean CPUE of 3336 ± 2771.13 g/day, followed by Molluscs, with 18.77% of total biomass and mean CPUE of 836.61 ± 1234.89 g/day, and Elasmobranchs (5.27% of total commercial biomass and mean CPUE of 234.77 ± 592.13 g/day) (Figures 7A,B and 8).

Table 1. List of taxa found in traditional trammel net and guarding net, divided into commercial and discard, in Favignana.

Guarding Net			
Commercial		**Discard**	
Osteichthyes	*Serranus cabrilla*	**Osteichthyes**	**Elasmobranchs**
Boops boops	*Serranus scriba*	*Apogon imberbis*	*Myliobatis aquila*
Chelidonichthys lucerna	*Sparisoma cretense*	*Boops boops*	**Molluscs**
Dentex dentex	*Sparus aurata*	*Dactylopterus volitans*	*Sepia officinalis*
Diplodus annularis	*Spondyliosoma cantharus*	*Dentex dentex*	*Hexaplex trunculus*
Diplodus puntazzo	*Symphodus ocellatus*	*Diplodus annularis*	**Crustaceans**
Diplodus sargus	*Symphodus tinca*	*Diplodus vulgaris*	*Liocarcinus corrugatus*
Diplodus vulgaris	*Trachurus trachurus*	*Labrus viridis*	*Pagurus bernhardus*
Labrus bergylta	*Trigla lyra*	*Mullus surmuletus*	**Echinoderms**
Labrus merula	*Uranoscopus scaber*	*Muraena helena*	*Astrospartus mediterraneus*
Labrus viridis	*Zeus faber*	*Pagellus acarne*	*Marthasterias glacialis*
Lithognathus mormyrus	**Elasmobranchs**	*Phycis phycis*	**Seagrasses**
Mullus barbatus	*Mustelus punctulatus*	*Sarpa salpa*	*Posidonia oceanica*
Mullus surmuletus	*Mustelus mustelus*	*Scorpaena porcus*	**Macroalgae**
Muraena helena	*Torpedo marmorata*	*Scorpaena scrofa*	*Codium bursa*
Pagellus acarne	*Torpedo torpedo*	*Seriola dumerili*	Coralligenous
Pagellus erythrinus	**Molluscs**	*Serranus scriba*	*Eunicella singularis*
Pagrus pagrus	*Loligo vulgaris*	*Spondyliosoma cantharus*	
Sarpa salpa	*Octopus vulgaris*	*Symphodus tinca*	
Sciaena umbra	*Sepia officinalis*	*Trachurus mediterraneus*	
Scorpaena maderensis	**Crustaceans**	*Zeus faber*	
Scorpaena notata	*Palinurus elephas*		
Scorpaena porcus			
Scorpaena scrofa			
Trammel Net			
Commercial		**Discard**	
Osteichthyes	*Serranus cabrilla*	**Osteichthyes**	*Mustelus punctulatus*
Auxis rochei	*Serranus scriba*	*Apogon imberbis*	*Raja miraletus*
Bothus podas	*Spondyliosoma cantharus*	*Bothus podas*	*Raja radula*
Conger conger	*Symphodus tinca*	*Dactylopterus volitans*	*Torpedo marmorata*
Diplodus annularis	*Trachurus trachurus*	*Diplodus annularis*	*Torpedo torpedo*
Diplodus vulgaris	*Trigla lyra*	*Diplodus vulgaris*	**Molluscs**
Echiichthys vipera	*Uranoscopus scaber*	*Labrus viridis*	*Hexaplex trunculus*
Labrus merula	*Zeus faber*	*Mullus surmuletus*	*Sepia officinalis*
Mullus barbatus	**Elasmobranchs**	*Pagellus acarne*	**Crustaceans**
Mullus surmuletus	*Mustelus punctulatus*	*Sarpa salpa*	*Calappa granulata*
Pagellus acarne	*Mustelus mustelus*	*Scorpaena notata*	*Liocarcinus corrugatus*
Pagellus erythrinus	*Raja miraletus*	*Scorpaena porcus*	*Pagurus bernhardus*
Pagrus pagrus	*Raja radula*	*Scorpaena scrofa*	*Dardanus arrosor*
Sarpa salpa	*Torpedo torpedo*	*Serranus scriba*	**Echinoderms**
Scorpaena maderensis	**Molluscs**	*Spondyliosoma cantharus*	*Marthasterias glacialis*
Scorpaena notata	*Bolinus brandaris*	*Symphodus tinca*	*Spatangus purpureus*
Scorpaena porcus	*Callistoctopus macropus*	*Synodus saurus*	*Sphaerechinus granularis*
Scorpaena scrofa	*Octopus vulgaris*	*Trachinus draco*	**Seagrasses**
	Sepia officinalis	*Zeus faber*	*Posidonia oceanica*
	Crustaceans	**Elasmobranchs**	**Macroalgae**
	Palinurus elephas	*Dasyatis pastinaca*	*Botryocladia botryoides*
		Myliobatis aquila	Coralligenous
			Eunicella singularis

Figure 6. Some species caught during the experimental surveys: *Raja radula* caught in Favignana (**A**); *Myliobatis aquila* caught in Favignana (**B**); two specimens of *Mustelus punctulatus* caught with the guarding net (**C**).

Table 2. List of taxa found in traditional trammel net and guarding net, divided into commercial and discard, in Porto Pino.

Guarding Net			
Commercial		**Discard**	
Osteichthyes	*Serranus scriba*	**Osteichthyes**	*Trachinus araneus*
Diplodus annularis	*Solea solea*	*Boops boops*	*Trachinus draco*
Bothus podas	*Sparus aurata*	*Bothus podas*	*Trachinus radiatus*
Chelidonichthys lastoviza	*Spondyliosoma cantharus*	*Conger conger*	*Uranoscopus scaber*
Conger conger	*Symphodus tinca*	*Dentex dentex*	*Zeus faber*
Dentex dentex	*Synodus saurus*	*Diplodus annularis*	**Elasmobranchs**
Diplodus puntazzo	*Trachinus araneus*	*Diplodus vulgaris*	*Raja miraletus*
Diplodus vulgaris	*Trachinus draco*	*Labrus viridis*	*Torpedo torpedo*
Labrus viridis	*Trachinus radiatus*	*Lithognathus mormyrus*	**Molluscs**
Microchirus ocellatus	*Uranoscopus scaber*	*Mullus surmuletus*	*Bolinus brandaris*
Mullus surmuletus	*Xyrichtys novacula*	*Pagellus bogaraveo*	*Hexaplex trunculus*
Pagellus erythrinus	*Zeus faber*	*Pagellus erythrinus*	*Sepia officinalis*
Sarpa salpa	**Molluscs**	*Phycis phycis*	**Crustaceans**
Sciaena umbra	*Sepia officinalis*	*Sarpa salpa*	*Dardanus arrosor*
Scorpaena maderensis	*Octopus vulgaris*	*Sciaena umbra*	*Pagurus bernhardus*
Scorpaena notata	*Bolinus brandaris*	*Scorpaena notata*	*Palinurus elephas*
Scorpaena porcus	**Crustaceans**	*Scorpaena porcus*	**Echinoderms**
Scorpaena scrofa	*Panaeus kerathurus*	*Scorpaena scrofa*	*Sphaerechinus granularis*
	Liocarcinus corrugatus	*Serranus scriba*	*Spatangus purpureus*
	Maja squinado	*Solea solea*	**Seagrasses**
		Spondyliosoma cantharus	*Posidonia oceanica*
		Symphodus tinca	**Macroalgae**
		Synodus saurus	*Botryocladia botryoides*
			Codium bursa
Trammel net			
Commercial		**Discard**	
Osteichthyes	*Serranus scriba*	**Osteichthyes**	*Spondyliosoma cantharus*
Bothus podas	*Solea solea*	*Apogon imberbis*	*Symphodus tinca*
Coris julis	*Sparus aurata*	*Boops boops*	*Synodus saurus*
Dactylopterus volitans	*Spicara maena*	*Bothus podas*	*Trachinus draco*
Dentex dentex	*Spondyliosoma cantharus*	*Conger conger*	*Trachinus radiatus*
Diplodus annularis	*Symphodus tinca*	*Dentex dentex*	*Trachurus mediterraneus*
Diplodus puntazzo	*Synodus saurus*	*Diplodus annularis*	*Uranoscopus scaber*
Diplodus vulgaris	*Trachinus araneus*	*Diplodus sargus*	*Zeus faber*
Helicolenus dactylopterus	*Trachinus draco*	*Diplodus vulgaris*	**Molluscs**
Labrus merula	*Trachinus radiatus*	*Helicolenus dactylopterus*	*Bolinus brandaris*
Labrus viridis	*Trachurus mediterraneus*	*Labrus bergylta*	*Sepia officinalis*
Lithognathus mormyrus	*Uranoscopus scaber*	*Mullus surmuletus*	**Crustaceans**
Mullus surmuletus	*Zeus faber*	*Phycis phycis*	*Liocarcinus corrugatus*
Pagellus bogaraveo	**Molluscs**	*Sarpa salpa*	*Maja squinado*
Pagellus erythrinus	*Galeodea echinophora*	*Sciaena umbra*	*Pagurus bernhardus*
Pegusa lascaris	*Hexaplex trunculus*	*Scorpaena maderensis*	*Palinurus elephas*
Sarpa salpa	*Loligo vulgaris*	*Scorpaena notata*	**Echinoderms**
Sciaena umbra	*Octopus vulgaris*	*Scorpaena porcus*	*Spatangus purpureus*
Scorpaena maderensis	*Sepia officinalis*	*Scorpaena scrofa*	*Sphaerechinus granularis*
Scorpaena notata	**Crustaceans**	*Serranus cabrilla*	**Seagrasses**
Scorpaena porcus	*Liocarcinus corrugatus*	*Serranus scriba*	*Posidonia oceanica*
Scorpaena scrofa		*Solea solea*	**Macroalgae**
		Spicara maena	*Codium bursa*

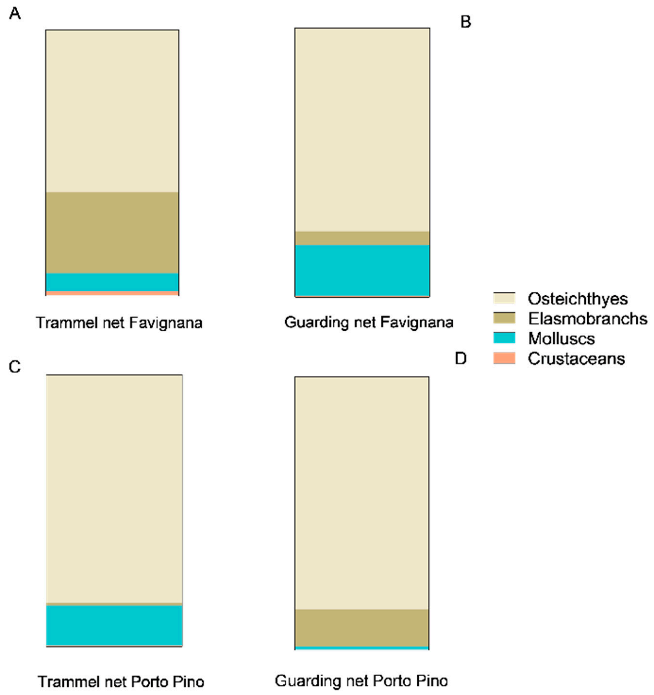

Figure 7. Percent distribution of commercial taxonomic group biomass caught with the two gears in the two areas: traditional trammel net in Favignana (**A**); guarding net in Favignana (**B**); traditional trammel net in Porto Pino (**C**); guarding net in Porto Pino (**D**).

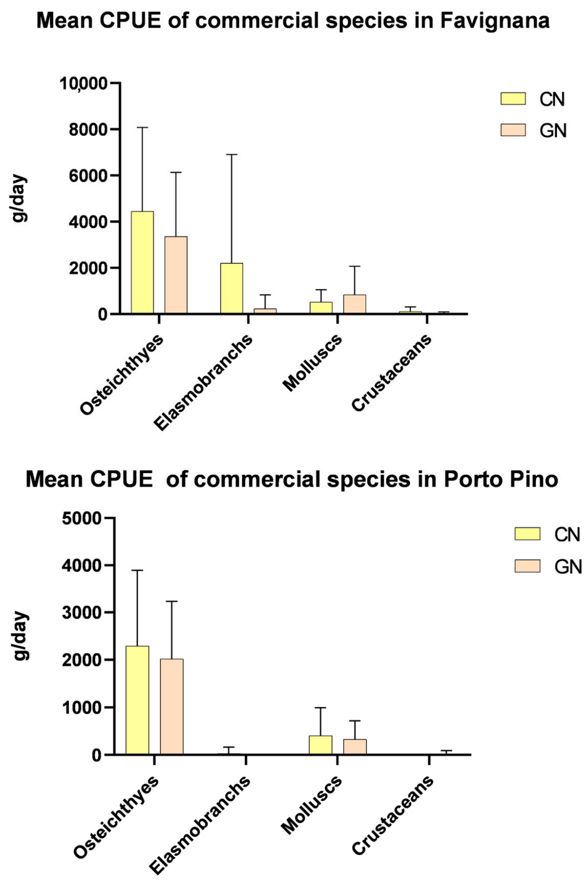

Figure 8. Mean CPUEs of commercial fraction (±standard deviation) with traditional trammel net (CN) and guarding net (GN).

In Porto Pino, 49.23 kg of commercial species were captured with the traditional trammel net, with the highest percentage of Osteichthyes (83.90%) with mean CPUE of 2581 ± 1603. 71 g/day. The second most important taxonomic group was that of Molluscs, with 14.92% of total commercial biomass and mean CPUE of 459.18 ± 585.33 g/day. Next, 1.08% was constituted by Elasmobranchs, whose mean CPUE was 33.25 ± 133 g/day. In Porto Pino, 42.72 kg of commercial species were caught with guarding nets, of which 85.13% consisted of Osteichthyes that have recorded a mean CPUE of 2272 ± 1212.36 g/day, followed by Molluscs (13.77% and mean CPUE of 368.12 ± 390.14 g/day) (Figures 7C,D and 8).

The mean CPUEs of commercial catch with the two types of trammel nets in the two study areas are reported in Figure 8.

PERANOVA aimed to compare the CPUEs of four commercial categories caught from CN and GN did not show significant differences between two gears (pseudo-F comprised between 0.8 and 2.1; $p > 0.05$). Even if PERANOVA showed significant differences in the interactions between "Location" and "Period", this result is far from the hypothesized difference between the two gears (Table S1).

In Favignana, 49.54 kg of discard (27.4% of total biomass) was caught with traditional trammel nets and 30.27 kg with guarding nets (27.38% of total biomass). In Porto Pino 33.48 kg (40.5% of total biomass) were discarded, while for the guarding net 26.69 kg of discard was recorded (38.4% of total biomass).

In Favignana, with the traditional trammel net, the most discarded taxonomic group was Elasmobranchs, with a percentage of 37.35% and a mean CPUE of 1156 ± 1871.51 g/day. The second most discarded group is Osteichthyes (18.69%), with a mean CPUE of 578.37 ± 716.51 g/day, followed by macroalgae (mean CPUE = 516 ± 722.52 g/day) and Echinoderms (mean CPUE = 302 ± 157.99 g/day). For the guarding net, the most discarded taxonomic group was Osteichthyes (45.69%), which have recorded a mean CPUE of 846.90 ± 1286.68 g/day, followed by Elasmobranchs (mean CPUE = 580.7 ± 1496.23 g/day) and macroalgae (mean CPUE = 39.15 ± 83.37 g/day) (Figures 9A,B and 10).

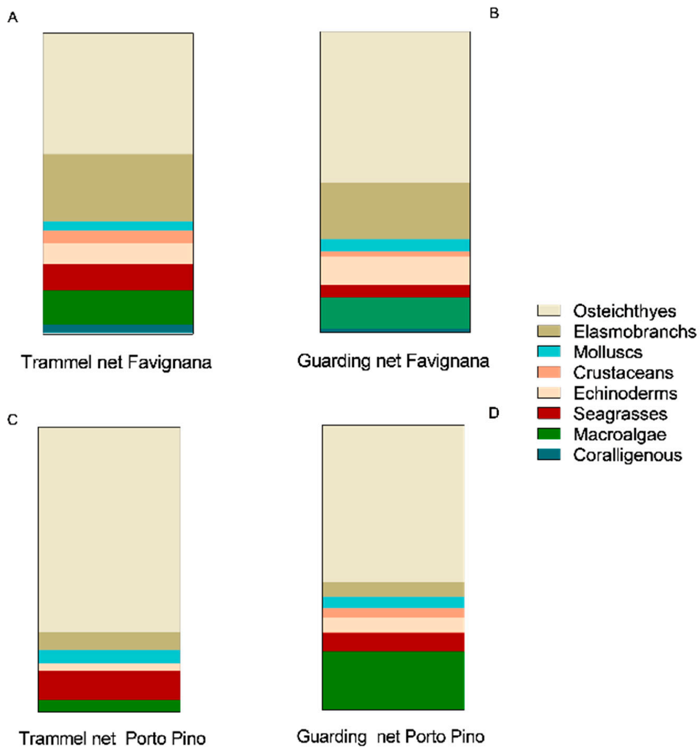

Figure 9. Percent distribution of discarded taxonomic group biomass caught with the two gears in the two areas: traditional trammel net in Favignana (**A**); guarding net in Favignana (**B**); traditional trammel net in Porto Pino (**C**); guarding net in Porto Pino (**D**).

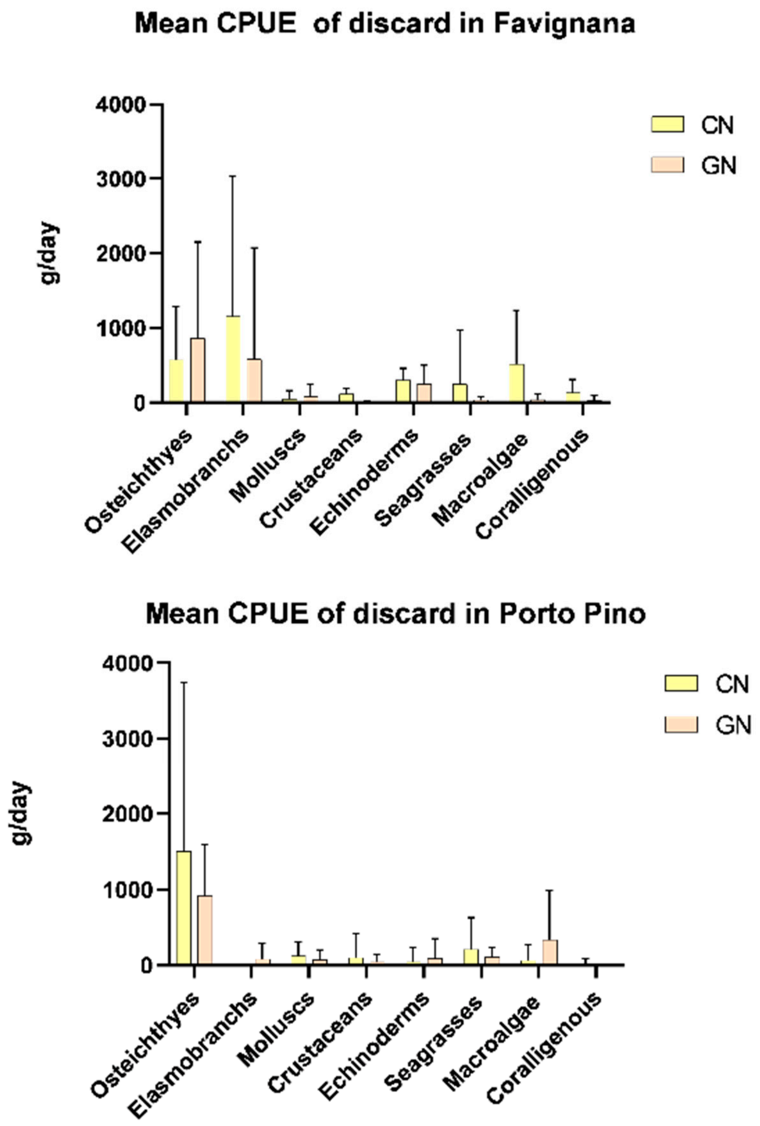

Figure 10. Mean CPUEs of discard (±standard deviation) with trammel net (CN) and guarding net (GN).

In Porto Pino, the most discarded taxonomic groups with the traditional trammel net were Osteichthyes, with a percentage of 72.06% of total discard and mean CPUE of 1508 ± 2236.95 g/day), and macroalgae, with mean CPUE of 206 ± 213.66 g/day. The most discarded taxonomic group with the guarding net is Osteichthyes, with 55.24% of total discard and a mean CPUE of 921.9 ± 674.48 g/day, followed by macroalgae (20.17% and mean CPUE = 336.81 ± 657.30 g/day) (Figures 9C,D and 10).

Discard analyzed by PERANOVA showed a high variation over the factors "Gear", "Location" and "Period" but no significant differences were recorded between two gears (Pseudo-F comprised between 0.03 and 0.5; $p > 0.05$). The only significant difference was found for macroalgae caught by GN, with higher biomass at Porto Pino than Favignana (Pseudo-F = 13.07; $p < 0.01$) (Table S2).

3.2. Experimental Fishing with Pots

The list of taxa found inside "trapula" and traditional pots in Porto Pino divided into commercial and discard is reported in Table 3.

Table 3. List of taxa found in trammel net and guarding net, divided into commercial and discard, in Porto Pino.

Trapula Pots		Traditional Pots	
Commercial	**Discard**	**Commercial**	**Discard**
Osteichthyes *Conger conger* *Diplodus* sp. *Diplodus vulgaris* *Labrus viridis* *Microchirus ocellatus* *Mullus surmuletus* *Pagellus erythrinus* *Scorpaena* sp. *Spondyliosoma cantharus* *Trachinus radiatus* **Molluscs** *Hexaplex trunculus* *Octopus vulgaris*	**Crustaceans** *Dardanus arrosor* *Dromia personata* Brachyura (remains) *Inachus thoracicus* Paguridea **Molluscs** *Squid eggs* **Echinoderms** *Spatangus purpureus* Asteroidea **Macroalgae**	**Osteichthyes** *Arnoglossus laterna* *Coris julis* *Gobius cruentatus* *Muraena helena* *Scorpaena porcus* *Serranus cabrilla* *Serranus scriba* *Spondyliosoma cantharus* *Symphodus mediterraneus* *Symphodus* sp. **Molluscs** *Bolinus brandaris* *Hexaplex trunculus* Muricidae *Octopus vulgaris* **Crustaceans** *Liocarcinus corrugatus*	**Osteichthyes** *Blennius ocellaris* *Chromis chromis* *Parablennius gattorugine* *Serranus hepatus* *Serranus* sp. **Molluscs** Gasteropode (cf. *Natica stercusmuscarum*) Mollusca (Pleurobranchaea) *Empty shells* **Crustaceans** *Dardanus arrosor* *Pagurus bernhardus* Brachyura Paguridea Crustacea (remains) **Echinoderms** Ophiuroidea *Sphaerechinus granularis* Asteroidea

The discard fraction was lower than the commercial one in both pots for Osteichthyes and Molluscs, while it was higher for Crustaceans, with mean CPUEs of 128.3 ± 112.6 g/day vs. 64.3 ± 150.8 g/day with traditional pots and 22.66 ± 24.11 g/day vs. 0 g/day with "trapula pots". For Echinoderms, only discard was recorded with both pots but with very low values (<3.3 ± 4 g/day with traditional pots).

Comparing two types of pots, the mean CPUE of the commercial fraction was higher with "trapula pots" (1807.5 ± 2865.4 g/day) than traditional pots (501 ± 515.9 g/day) only for Osteichthyes; for the other target groups, the mean CPUEs were higher with traditional pots than trapula ones. However, no difference in commercial catches was statistically significant (Figure 11; Table S3). Fishing discard with "trapula pots" was generally lower than that with traditional pots for all taxonomic groups, but the differences statistically significant were recorded only for Crustaceans (Pseudo-F = 5.9643; $p < 0.05$), with values of 22.6 ± 24.1 g/day versus 128.3 ± 112.6 g/day, and Molluscs (Pseudo-F = 16.051; $p < 0.01$), with values of 1.6 ± 2.5 g/day versus 28.3 ± 22 g/day, respectively (Figure 11; Table S4).

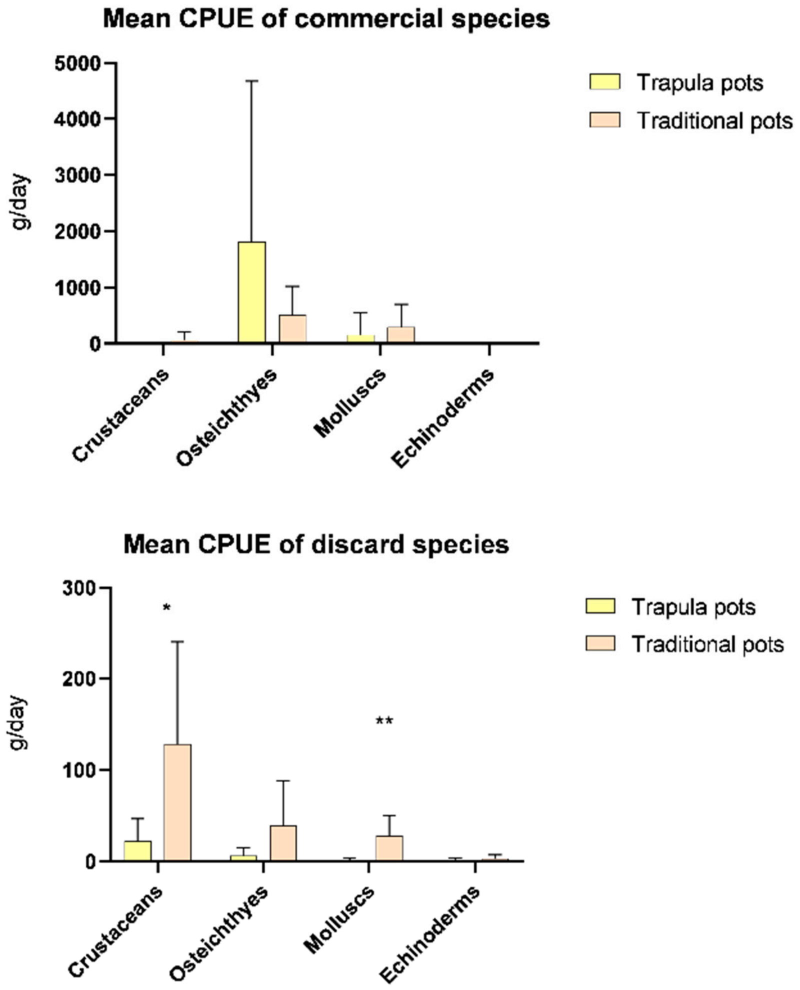

Figure 11. Mean CPUE (±standard deviation) with pots; * $p < 0.5$ and ** $p < 0.01$.

4. Discussion

The present study focused on the effectiveness of alternative artisanal gears to traditional ones, such as guarding nets and "trapula pots", in terms of reduction in discard, especially when it is constituted by vulnerable species, and, thus, improvement of the traditional gears' selectivity.

The authors recognized some limitations with the experimental design related to the use of different gears (guarding and traditional trammel nets) in different areas. However, in order to reduce these limitations, chosen fishing grounds were similar in terms of habitats, as confirmed by fishers involved in the activities.

Nevertheless, an interesting result obtained with guarding nets was relative to the difference in terms of discard composition compared with that of the trammel net, mainly for the elasmobranchs. Species such as *Myliobatis aquila* and *Dasyatis Pastinaca,* assessed as critically endangered and vulnerable in the IUCN European Red List, were more abundant in discard of trammel nets. This could be related to the size of the specimens, which may be more likely to be retained by the trammel net but pass through the guarding net [28].

The high abundance of batoids recorded in our study with a trammel net is in accord with the results recorded with the same gear targeting common cuttlefish in southern Sicily, where specimens belonging to *Torpedo*, *Raja* and *Dasyatis* genus were prevalent in discard [29].

Because of their venomous spines, individuals like *Dasyatis* spp. and *M. aquila* found in the nets by fishers are stripped of their spines and, if still alive, discarded at sea; therefore, these species have low chances of survival once released.

Although the guarding net seemed improve the selectivity for elasmobranchs, this result could adversely affect fishers' perception on the effectiveness of this net in sites such as Favignana, where some cartilaginous fish have a good commercial value [30,31]. Indeed, in Favignana, species such as *M. mustelus*, *M. punctulatus* and some species of *Raja* and *Torpedo*, are usually sold and are targets of fishing with trammel net; however, in the present study, these species were included in the commercial fraction in this area.

On the other hand, no difference recorded between gears was statistically significant in terms of overall catch, also considering the benthic organisms. Although our results are in accordance with [28], they are in contrast with those reported in Mersin Bay [32], where the use of a guarding net on the lead line of shrimp trammel nets reduced the discard, and in Favignana, where [30] a gear composed of a trammel net panel alternated by a guarding net panel was tested. Moreover, except for some studies where the use of guarding net reduced discard without affecting the catch [13,33], it also reduced the commercial catch [30,31].

Our results highlight that the efficiency of the guarding net is strictly correlated to the geographic area and the local catch profiles. In order to reduce discard in artisanal fishery and propose tailored gear modification, indeed, it is necessary to thoroughly investigate the catch composition and abundance, distinguishing between commercial fraction and discard, as also suggested by [28]; in this case, considering the high catch of Elasmobranchs in Favignana, appropriate modifications to the traditional gears should be adopted to reduce these catches; instead, in Porto Pino, the attention could be focused on benthic organisms that were caught in higher quantities.

Given that benthic organisms and some Elasmobranchs are caught by trammel net, the impact of this type of net on these resources will depend on the fishing effort and the composition of the community [34]. Further research is therefore needed to study the effectiveness of alternative trammel nets in terms of impact on fishery resources and fishers' profitability.

As regards our results on pots, the use of trapula in place of traditional ones in Porto Pino did not seem to determine significant differences in terms of catches, but it showed a low impact on Crustaceans and Molluscs, considering the minor discard recorded.

Although CPUEs obtained from the "trapula pots" were not very high, they are, however, mainly attributable to commercially appreciated species, such as *Diplodus vulgaris*, *Spondyliosoma cantharus*, *Mullus surmuletus* and *Octopus vulgaris*; therefore, these preliminary results offer interesting points of reflection which deserve to be studied further in-depth. Additional experimental fishing trials aimed at comparison between the two types of pots should be carried out in other periods, such as when the small-scale fisheries targeting the common octopus (*O. vulgaris*) are conducted by local fishers with traditional pots (especially in spring and summer months). Moreover, the potential efficiency of "trapula pots" should be also tested, diversifying the baits or even not using them, given the results obtained in the Adriatic Sea with similar gears [20].

However, fishing with "trapula pots" has proven to be more advantageous for fishers in terms of space occupied by the gear on board vessels and it allowed the reduction in discard, mainly for specific resources.

Traditionally, pots mainly targeting *Palinurus elephas* were used also in Favignana, but lower yields compared with those of other artisanal gears, such as trammel nets, and the operational difficulties have caused their gradual disuse. Considering the results obtained with trapula pots in Porto Pino, mainly for the advantages in operational terms, it would be interesting to test these alternative pots also in Favignana and just in the suitable period for spiny lobsters (spring–summer).

Although all pots have recorded low values of CPUE compared with those of trammel nets, their use should be encouraged anyway, considering the high selectivity of these passive gears and the low impact on ecosystems. This could be implemented by proposing the use of alternative pots, like "trapula" ones, that are easily manageable also in small vessels in specific fishing periods targeting resources of high local commercial value.

5. Conclusions

This study provides interesting insights to promote the sustainability of fishing practices. Understanding the composition of catches in each study area in terms of commercial and discard fractions is needed to develop modifications of traditional gears aimed at reducing discard and limiting the negative effects on marine ecosystems. These actions should, at the same time, ensure good yields to be accepted by fishers.

Therefore, their active collaboration in the identification of technical adjustments on traditional gears should be thus encouraged.

Supplementary Materials: The following supporting information can be downloaded at: https://www.mdpi.com/article/10.3390/fishes9050171/s1, Table S1. PERANOVA (Permutational Analysis of Variance) performed for each commercial taxonomic group with trammel net and guarding net, on the factors: Gear (Ge), Location (Lo) and Period (Pe); ns = not significant, * = significant for $p < 0.05$, ** = significant for $p < 0.01$. Table S2. PERANOVA (Permutational Analysis of Variance) performed for discarded taxonomic groups with trammel net and guarding net, on the factors: Gear (Ge), Location (Lo) and Period (Pe); ns = not significant, * = significant for $p < 0.05$, ** = significant for $p < 0.01$. Table S3. PERANOVA (Permutational Analysis of Variance) performed for each commercial taxonomic group caught with trapula and traditional pots, on the factors: Pots and Period (Pe); ns = not significant, * = significant for $p < 0.05$, ** = significant for $p < 0.01$. Table S4. PERANOVA (Permutational Analysis of Variance) performed for each discarded taxonomic group caught with trapula and traditional pots, on the factors: Pots and Period (Pe); ns = not significant, * = significant for $p < 0.05$, ** = significant for $p < 0.01$.

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Data Availability Statement: The data that support the findings of this study are available on request from the corresponding author: M.M.

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Conflicts of Interest: The authors declare no conflicts of interest.

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