



OPEN ACCESS

EDITED BY

Jie Cao,
North Carolina State University, United States

REVIEWED BY

Alba Jurado-Ruzafa,
Centro Oceanográfico de Canarias (CN IEO,
CSIC), Spain
Mišo Pavičić,
Institute of Oceanography and Fisheries
(IZOR), Croatia

*CORRESPONDENCE

Marta Pujol-Baucells
✉ baucells@icm.csic.es

RECEIVED 29 July 2025

ACCEPTED 03 October 2025

PUBLISHED 27 October 2025

CITATION

Pujol-Baucells M, Mateu-Pinilla C, Blanco M,
Carreton M, Recasens L, Company JB and
Galimany E (2025) Baseline data of the
marine recreational fisheries in the
NW Mediterranean Sea: finding the
variable that drives the catch.
Front. Mar. Sci. 12:1675575.
doi: 10.3389/fmars.2025.1675575

COPYRIGHT

© 2025 Pujol-Baucells, Mateu-Pinilla, Blanco,
Carreton, Recasens, Company and Galimany.
This is an open-access article distributed under
the terms of the [Creative Commons Attribution
License \(CC BY\)](https://creativecommons.org/licenses/by/4.0/). The use, distribution or
reproduction in other forums is permitted,
provided the original author(s) and the
copyright owner(s) are credited and that the
original publication in this journal is cited, in
accordance with accepted academic
practice. No use, distribution or reproduction
is permitted which does not comply with
these terms.

Baseline data of the marine recreational fisheries in the NW Mediterranean Sea: finding the variable that drives the catch

Marta Pujol-Baucells^{1,2*}, Carlota Mateu-Pinilla^{1,2},
Marta Blanco^{1,2}, Marta Carreton^{1,2}, Laura Recasens^{1,2},
Joan B. Company^{1,2} and Eve Galimany^{1,2}

¹Institut Català de Recerca per a la Governança del Mar (ICATMAR), Barcelona, Catalonia, Spain,

²Department of Marine Renewable Resources, Institut de Ciències del Mar (ICM-CSIC), Barcelona, Catalonia, Spain

Recreational fishing is an increasingly popular leisure activity on a global scale, with catches that may surpass those of commercial fisheries. However, the lack of comprehensive and standardized data hinders accurate assessment of its ecological impact. This study investigates the species composition across three variables including fishing modalities (shore angling, boat angling, and spearfishing), zone and season along the NW Mediterranean coast. Species identification and number of individuals caught data were obtained through onsite surveys conducted between 2020 and 2023. The results reveal significant differences in catch composition among modalities, as well as across spatial and seasonal scales. However, modality exhibited the greatest differentiation in catch composition compared to the other two variables. Then, regarding modality, boat angling and spearfishing yield the highest catch rates but boat angling had the greatest number of species (i.e., 69). However, species composition characterized the catches of each modality. Specifically, *Dicentrarchus labrax* was more frequently fished by shore anglers, *Loligo vulgaris* by boat anglers, and *Mullus surmuletus* by spearfishers. Currently, there is a need to develop and reinforce marine recreational fisheries sustainable management practices at a regional scale. In the study area, our findings suggest that fishing modality is the main driver to consider when developing sustainable management strategies and the conservation of coastal marine biodiversity.

KEYWORDS

shore angling, boat angling, spearfishing, species composition, Catalan coast, Fisheries Management

1 Introduction

The exploitation of marine resources has become a global conservation concern, traditionally focused on the impacts of commercial fishing (Ben Lamine et al., 2018; Cooke and Cowx, 2006). However, the potential ecological and socioeconomic significance of marine recreational fisheries (MRF) has often been overlooked (Solomon et al., 2020). Globally, the MRF engage an estimated 220 million people, in some cases exceeding commercial catches in volume (Arlinghaus et al., 2019). In 2018, in Europe, approximately 8.7 million people participated in MRF, with 2.8 million located in the Mediterranean Sea (Hyder et al., 2018).

Recent literature increasingly recognizes the need to include MRF in comprehensive fisheries management frameworks that integrate scientific data, stakeholder involvement, and adaptive governance strategies (Lewin et al., 2019; Pawson et al., 2008). This integration is vital to support ecosystem health, maintain biodiversity, and ensure long-term sustainability while preserving the economic and social benefits derived from recreational fishing (Arlinghaus and Cooke, 2005; Soldo et al., 2018). Across Europe, annual expenditures associated with MRF are estimated at €5.89 billion, including €920 million within the Mediterranean basin alone (Hyder et al., 2018). In Catalonia, an autonomic region located in the northwestern Mediterranean Sea, MRF is a key contributor to the blue economy, generating approximately €90 million in indirect income annually, one-third of which directly benefits local coastal economies (Gómez, 2022).

Effective MRF management depends on accurate and systematic data collection for better evaluating managing and comprehending the dimensions of these fisheries (Brownscombe et al., 2019). Long-term datasets are crucial to assess the impacts of MRF and to inform policy. Data are typically gathered through off-site methods (e.g., recall surveys by phone or mail surveys) and/or on-site approaches (i.e., face-to-face interviews at key access points or creel surveys). While both approaches have inherent limitations, online surveys are primarily used for short-term memory issues, whereas onsite surveys are particularly well suited to obtain detailed catch data, including species identification, quantification, and size composition (Taylor et al., 2021).

Similar studies across the Mediterranean regions have explored the biological, ecological, and environmental implications of MRF, such as the Balearic Islands, where Morales-Nin et al. (2005) described the activity from a perspective for best management advise, understanding fishers and their behavior, and describing the fishing activity. In the Northern Adriatic Sea, Pranovi et al. (2016) exposed the magnitude of MRF comparing it with commercial fishing and its impacts in the ecosystems, emphasizing the need to consider recreational fishing catches in management strategies and the introduction of new systems to monitor the activity (Ben Lamine et al., 2018). Further examples can be found across the Mediterranean; for instance, shore-based sport fishing competitions have been systematically recorded along the Maltese coast (Agius Darmanin and Vella, 2018), while recreational

shore and boat angling have been assessed along the Adriatic Sea (Soldo, 2022), including spearfishing activities along the eastern Adriatic (Jelić Mrčelić et al., 2023).

The first two statewide assessments were conducted by Dedeu et al. (2019) and Gordo et al. (2019). These studies provide nationwide data for Spain as a whole. In Catalonia, research by Font and Lloret (2014) has drawn attention to the environmental risks associated with MRF, including the use of exotic baits, gear loss, the capture of vulnerable species, and the frequent landing of individuals below size at first maturity, thereby threatening reproductive potential. Additional studies conducted in northern Catalonia (Cape of Creus) further explored the socioeconomic relevance of MRF, particularly in tourism-driven hotspots where foreign recreational fishers represent a substantial share of effort and expenditure (Font and Lloret, 2011, 2014; Lloret et al., 2008b, 2018). In these areas, the majority of fishers interviewed were foreigners and their expenditures were associated to the activity (Vitale et al., 2021).

The regulation of MRF in the wider Mediterranean Sea context (including both European and North African countries) is fragmented and varies significantly between countries (Franquesa et al., 2004). In fact, it is acknowledged that the EU regulation on MRF is insufficient and lacks data and stakeholder engagement (Grati et al., 2025). The understanding and managing of MRF is key to develop sustainable fisheries practices, especially when they can be of the same magnitude as commercial fisheries (Michailidis et al., 2020). In Spain, management responsibilities are devolved to regional governments, which issue fishing licenses and implement localized measures such as daily bag limits, species and size restrictions, and gear regulations (BOE-A-2011-6099, 2011). This decentralization has led to heterogeneous regulatory frameworks across coastal regions (Gordo et al., 2019). Catalonia, one of Spain's most economically dynamic regions (Brenner et al., 2006), features 699 km of diverse coastline, including 270 km of beaches, ranging from rocky cliffs in the north to deltaic estuaries in the south (Brenner et al., 2010; Aranda et al., 2013). Current MRF regulation in Catalonia is based on a law issued in 1995 (DOGC-2040-DECRET 109/1995, 1995), which defines three different modalities: shore angling and boat angling, both defined as surface fishing, and spearfishing defined as underwater fishing, and concerns gear, fishing time, and catch limits. However, this regulation seems obsolete and calls have been made to reform MRF legislation to better align it with the extractive potential of the activity, comparable in some cases to small-scale commercial fisheries (Gómez, 2022). In response, a recent resolution (RESOLUCIÓ ARP/3253, 2024) has been issued to improve the management of this activity in northern Catalonia, as a pilot model to begin managing the resources as well as promoting good practices in the sector.

The hypothesis of this study is that fishing modality is the main driver for the MRF catch composition in NW Mediterranean Sea. To test this hypothesis, we studied the species caught by the fishers in the Catalan Coast, a coastline of 580km. For a more comprehensive study, other variables were also considered, such

as season and geographic zone, to better approach the complexity of MRF. The results of this study will provide scientific data to support the development of best management strategies along the Catalan coast and, in extension, to the NW Mediterranean Sea.

2 Materials and methods

2.1 Sampling area

The study covers the entire Catalan Coast (Northeast Iberian Peninsula), as shown in Figure 1. The coastline exhibits significant geological and biological diversity, characterized by its rocky coast, cliffs, sandy beaches, estuaries and river deltas. The Catalan coast is divided in to 21 subzones to ease sampling protocols but for management goals, the sampling subzones are grouped into three distinct zones based on management administrative units: north (province of Girona), center (province of Barcelona) and south (province of Tarragona).

2.2 Data collection

The data used in this study was obtained from ICATMAR's MRF continuous and ongoing monitoring program conducted between 2020 and 2023 (ICATMAR (Institut Català per a la Governança del Mar), 2024). The onsite surveys (face-to-face) were gathered by three different means: at port, on foot or by boat, which were performed by MRF experts able to visually identify all the species caught in the zone. The fishers were asked information on their trip journey, fishing modality, and catch composition. During face-to-face interviews, fishers were also asked to specify fishing techniques and hook that used. For the purposes of this study, however, all rod-and-line practices from the shore line were grouped under shore angling, and from vessels were grouped under the general category of boat angling modality. The surveys design ensured a minimum of 88 field sampling days per year, with additional sampling efforts compensating for surveys with low or no responses (Table 1). Sampling days were assigned randomly within zones and seasons, maintaining a distribution of

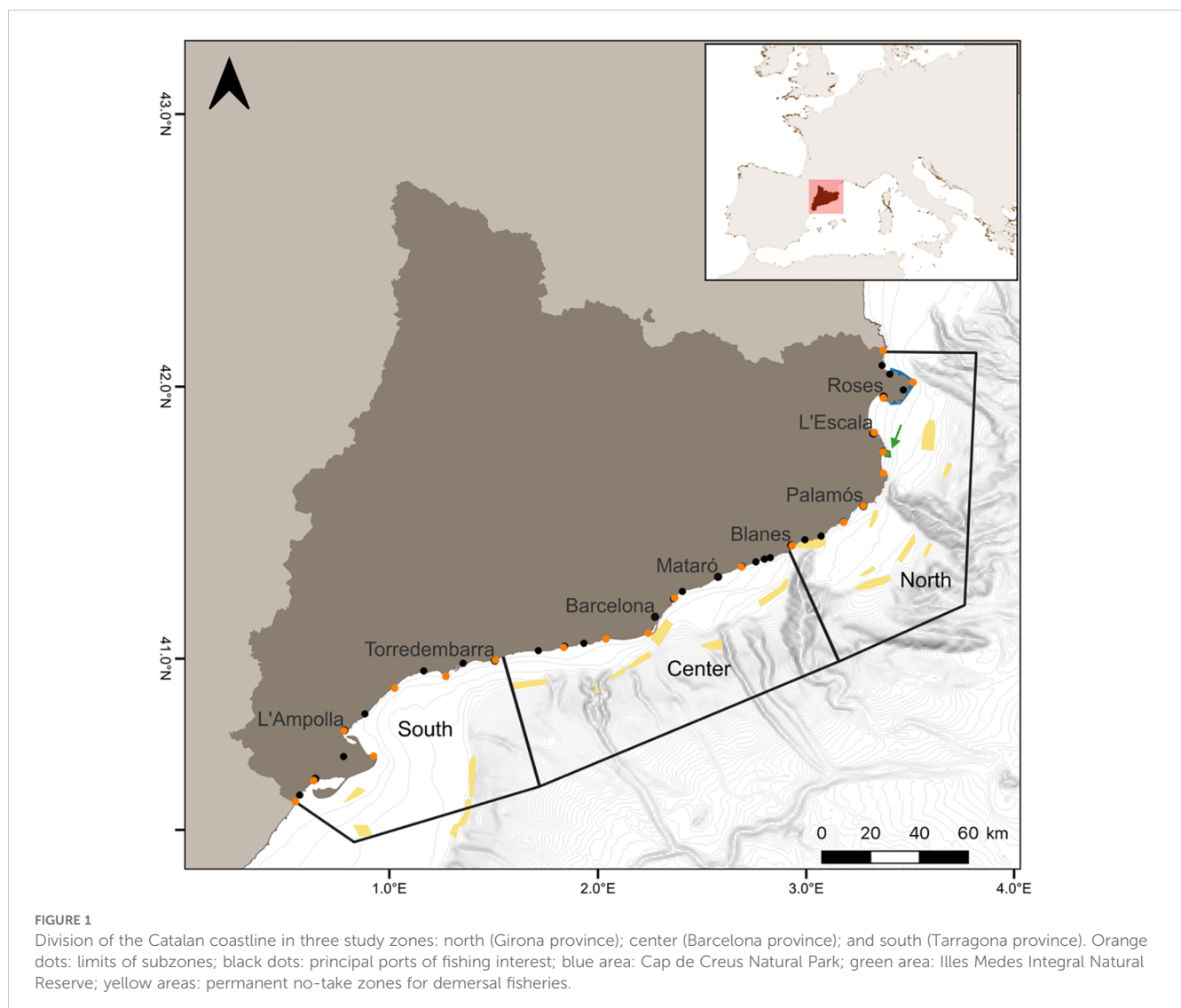


TABLE 1 Summary of sampling data including sampling days, surveys and quantified individuals between 2020 and 2023 detailed by zone.

Sampling zones	Sampling days (N)			Surveys (N)			Number of individuals (N)		
	Sampling days per zone	Sampling days per zone and season		Surveys per zone	Survey per zone and sampling type		Individuals per zone	Individuals per zone and fishing modality	
North	185	Winter	40	2355	On foot	713	6165	Shore angling	1602
		Spring	34		By boat	475		Boat angling	3923
		Summer	53		At port	1167		Spearfishing	640
		Fall	58						
Center	156	Winter	30	2409	On foot	1071	3060	Shore angling	574
		Spring	24		By boat	264		Boat angling	1939
		Summer	48		At port	1074		Spearfishing	547
		Fall	54						
South	80	Winter	15	1013	On foot	457	1347	Shore angling	338
		Spring	12		By boat	87		Boat angling	904
		Summer	27		At port	469		Spearfishing	105
		Fall	26						
Total	421			5777			10572		

40% on weekdays and 60% on weekends and public holidays, to accurately represent the fishing effort distribution in Catalonia (ICATMAR (Institut Català per a la Governança del Mar), 2024).

In this study, shore angling refers to rod-and-line fishing from land-based platforms such as harbors, jetties, beaches, and rocks. Boat angling refers exclusively to MRF with rod and line conducted from a vessel, as this is the only legal modality from boats in Catalonia. Spearfishing refers to underwater fishing conducted by apnea divers, either accessed from shore or by boat.

Port surveys, a total of 2710, targeted boat anglers and spearfishers initiating their activities from boats. These fishers were surveyed upon entering the port, regardless of angling from the boat or using it to access spearfishing. Surveys were conducted at the busiest ports within each zone. On foot surveys targeted shore anglers fishing from harbors, jetties, beaches and rocks, as well as spearfishers returning to land after fishing. Surveyors walked to the popular sites in each region, interviewing every fisher encountered, a total of 2241. Finally, 826 surveys by boat were conducted from a speedboat cruising along the coast, surveying shore anglers on rocks and breakwaters and spearfishers in the water. The selection of these two methods (on foot and by boat surveys), depended on the accessibility of primary fishing locations and the presence or absence of underwater reefs in the sampling zone.

Each sampling trip lasted six hours and the survey timing was aligned with peak fishing activity with the objective to survey fishers at the end of their journey: midday for port surveys, sunset for on foot surveys, and sunrise to midday for on port surveys. This scheduling ensured that the data collected represented the peak effort periods for each fishing mode, as well as interviewing as many fishers as possible. A summary of sampling data can be found in Table 1.

2.3 Data analyses

All data collected through the onsite surveys was organized by sampling days, each containing multiple unique surveys. Data normality and homogeneity of variances were assessed using the Shapiro–Wilk and Levene’s tests, respectively. As both assumptions were violated, non-parametric methods were applied.

To examine the species composition of catches by zone, fishing modality and season, standardized abundance per fishing hour (n/h^{-1}) by species was calculated based on the different variables (i.e. zone, fishing modalities, and season). Multivariate analyses (NMDS, ANOSIM, SIMPER) were performed using the package *vegan* in R software (R Core Team, 2025), and surveys conducted on the same day, within the same subzone, and fishing modality, were combined into a single NMDS data point. Species abundance was used to calculate the Bray-Curtis distance matrix with similarity index between single points. The similarities in species composition were explored by a non-metric multidimensional scaling analysis (NMDS). Differences in the species composition were analyzed through an ANOSIM test, a non – parametric method based on the rank distances among sample units that produces the statistic R (scaled between -1 to +1) and a p-value, lowest R values indicates less differences between groups than within them and higher R values indicates the opposite. Pairwise comparisons between zone, fishing modality and season were also tested using ANOSIM to examine the differences between levels for each factor. A similarity percentage analysis (SIMPER) was used to detect the species accounting for differences between zone and season per fishing modalities.

3 Results

The number of surveys conducted over 421 sampling days were 5777, categorized by the type of trip: 2241 surveys were carried out on foot, 826 by boat, and 2710 at port. However, categorized by season the total number of surveys were; 671 in winter, 1079 in spring, 2441 in summer, and 1586 in autumn. Over the study period, 10572 fish catch individuals were sampled. Of the total catches, 58% (6165 individuals) were recorded in the north, followed by 28% (3060) from the center, and 12% (1347) in the south zone. Regarding fishing modalities, boat angling accounted for the largest share with 6766 specimens caught (64%), followed by shore angling with 2514 (24% of the catches), and spearfishing with 1292 (12%; [Table 1](#)). Seasonally, the highest number of catches occurred in summer (45%), followed by fall (28%), spring (19%), and winter (8%).

A total of 86 species were documented in the surveys. The northern zone exhibited the highest species number, with 79 species recorded, followed by the central zone with 61 species, and the southern zone with 46 species. Regarding fishing modalities, the greatest number of species was sampled from boat angling, with 69 species, followed by shore angling with 58 species, and spearfishing with 37 species. Seasonal variation also influenced the number of species with the highest number of species observed in summer (i.e., 74 species), followed by spring and fall, with 65 species in each season, and winter displaying the lowest number of species, with 51 species.

A detailed table with the total number of individuals caught per species throughout the sampling period can be found in [Supplementary Table S1](#). Overall, the species most frequently caught was *Serranus cabrilla*, with 1408 individuals, corresponding to 13.26% of the analyzed catch. The cephalopod *Loligo vulgaris* was the second most commonly caught species, with 660 individuals (6.21%), and *Diplodus sargus* was the third, with 632 individuals (5.99%; [Supplementary Table S1](#)).

3.1 Drivers of the catch composition

The ANOSIM test, based on a matrix of species abundances (number of individuals), highlighted significant differences in the species' catch composition among all fishing modalities ($p < 0.01$; [Table 2](#)) as shown in the NMDS plot ([Figure 2A](#)). The top species accounting for the highest differences in fishing modalities were as follows: (1) between boat and shore angling, the species *S. cabrilla*, *L. vulgaris*, *Sepia officinalis*, *Euthynnus alletteratus*, and *Scomber scombrus*, were more abundant in boat angling, and *Sparus aurata* and *D. sargus*, were more abundant in the shore angling modality, accounting for 52% of the total difference; (2) between boat angling and spearfishing the species obtained in boat angling were the same species than for boat and shore angling with the addition of *Seriola dumerili*; while *D. sargus* and *Mullus surmuletus* were more abundant for the spearfishing modality, accounting for 58% of the total differences; (3) between spearfishing and shore angling modalities, *D. sargus*, *M. surmuletus*, *Octopus vulgaris* and *S. dumerili*, were more abundant for spearfishing, and, *S. aurata*, *Dicentrarchus labrax*, *S. cabrilla* and *Lithognathus mormyrus*, were more abundant for shore angling, accounting for 54% of the total differences ([Table 2](#)).

Z one and seasons also revealed significant differences among them. No differences were found between center and south ($R_{\text{Anosim}} = 0.01$; $p = 0.19$; [Figure 2B](#)), but there were significant differences at all other levels, as described in [Supplementary Table S2A](#). Regarding seasons ([Figure 2C](#)), there were significant differences between all levels except between for fall and spring ($R_{\text{Anosim}} = 0.03$; $p < 0.06$; [Supplementary Table S2B](#)).

3.2 Multivariate analyses

Based on the analysis of similarity performed for the three variables (i.e., fishing modality, zone and seasonality), fishing

TABLE 2 List of species contributing to the difference in the catch composition of the marine recreational fisheries among different fishing modalities.

Fishing modalities compared		Species accounting for differences		Statistical results		
Modality 1	Modality 2	Spp assamblage 1	Spp assamblage 2	% Difference	R_{anosim} value	p-value
Boat angling	Shore angling	<i>Serranus cabrilla</i> <i>Loligo vulgaris</i> <i>Sepia officinalis</i> <i>Euthynnus alletteratus</i> <i>Scomber scombrus</i>	<i>Sparus aurata</i> <i>Diplodus sargus</i>	52%	0.25	<0.01
Boat angling	Spearfishing	<i>Serranus cabrilla</i> <i>Loligo vulgaris</i> <i>Sepia officinalis</i> <i>Euthynnus alletteratus</i> <i>Seriola dumerili</i> <i>Scomber scombrus</i>	<i>Diplodus sargus</i> <i>Mullus surmuletus</i>	58%	0.36	<0.01
Spearfishing	Shore angling	<i>Diplodus sargus</i> <i>Mullus surmuletus</i> <i>Octopus vulgaris</i> <i>Seriola dumerili</i>	<i>Sparus aurata</i> <i>Dicentrarchus labrax</i> <i>Serranus cabrilla</i> <i>Sepia officinalis</i> <i>Lithognathus mormyrus</i>	54%	0.12	<0.01

The difference that these species account for is represented in the % Difference. R_{anosim} and p-value are statistic values.

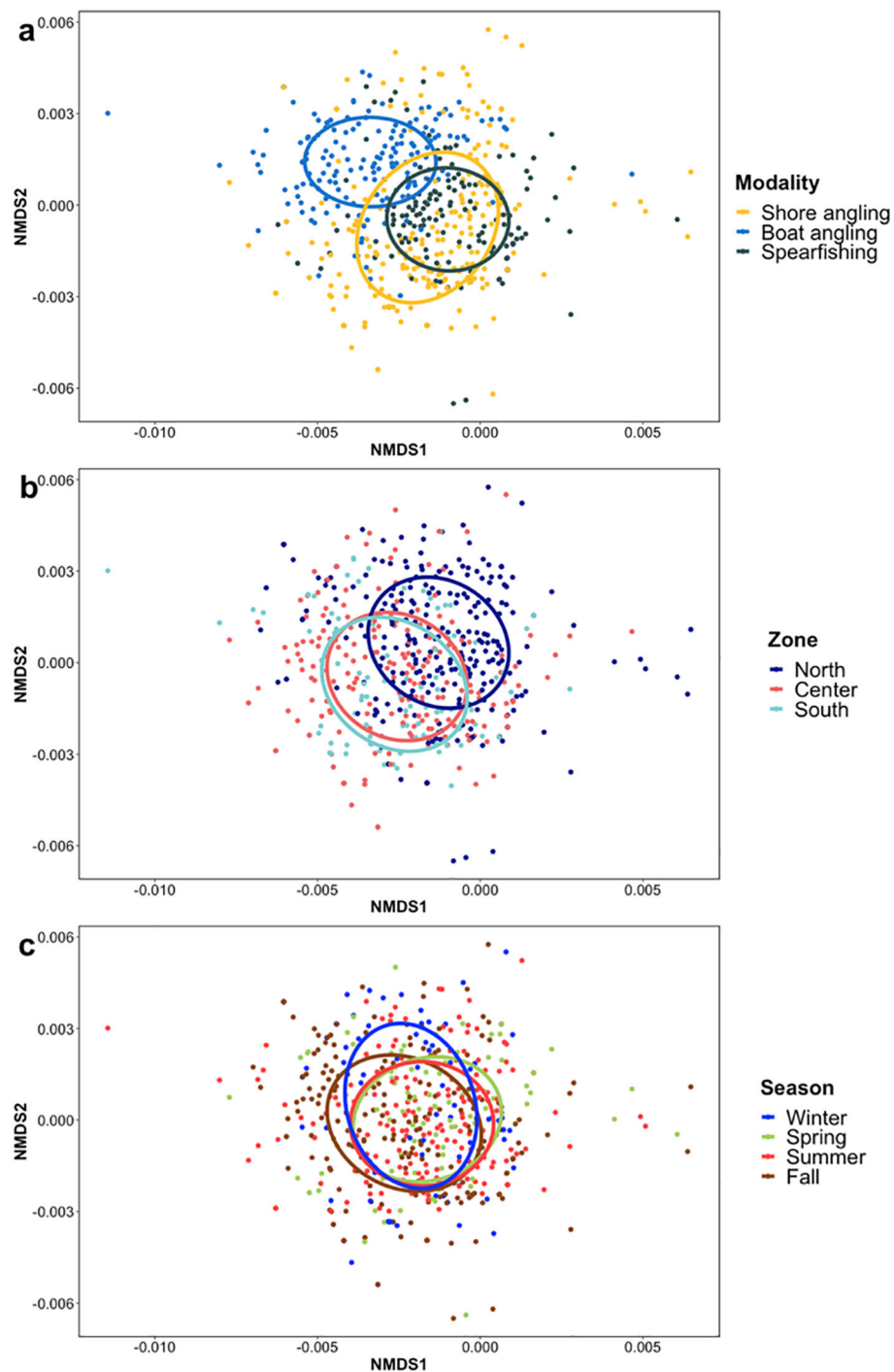


FIGURE 2

Non-metric Multidimensional Scaling ordination plot (NMDS) of the single group of surveys with abundance (n/h⁻¹) according to (A) fishing modality (shore angling, boat angling and spearfishing), (B) zone (north, center and south), and (C) season (winter, spring, summer and fall).

modality exhibited the greatest differentiation in catch composition compared to the other two variables. In detail, despite $p < 0.01$ in all cases, the R_{ANOSIM} values were 0.23, 0.06 and 0.07 for fishing modality, zone and seasonality, respectively. Consequently, further analyses were conducted to evaluate the effect of zone and season in each fishing modality.

3.2.1 Shore angling

For shore angling, the ANOSIM test revealed that the species composition had significant differences between the north zone and the center and south zones (p value < 0.01 ; Figure 3A, Table 3A). The test also revealed significant differences among some seasons, i.e., winter vs. summer and summer vs. fall ($p < 0.001$ in both cases;

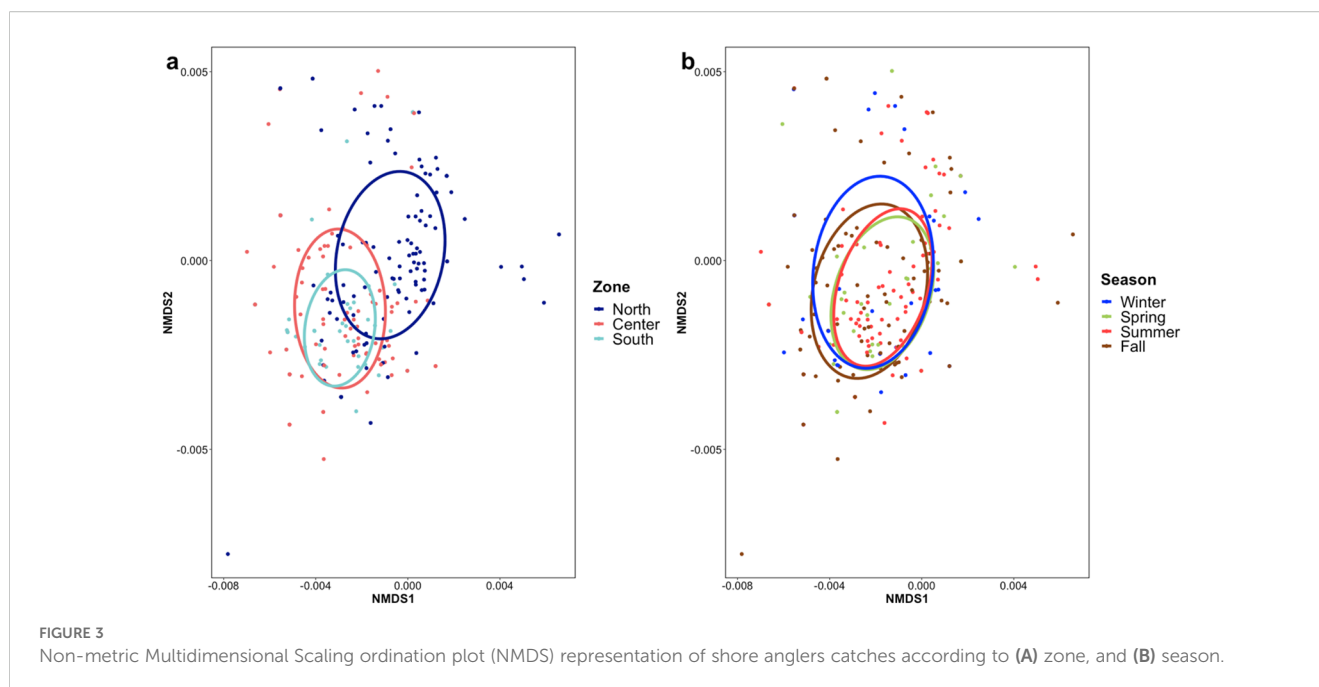


Figure 3B, Table 3B). No significant differences were observed between the center and south zones, nor among the other seasons of the year, with respect to shore fishing activity.

Concerning the species composition *S. cabrilla*, *Boops boops*, and *Oblada melanurus*, were more abundant in the catches in northern zone, while *D. sargus*, *D. labrax* and *Diplodus annularis*, were more prevalent in the central zone (Table 3A). Similarly, comparisons between the northern and southern zones revealed that *S. cabrilla*, and *B. boops*, were more abundant in the north, and *S. aurata*, *D. labrax*, and *D. sargus*, were more abundant in the south zone (Table 3A). Regarding seasonal variability in shore angling, *Spicara maena* was the most abundant species in winter, while *O. vulgaris* was more common during the fall. The summer season showed the greatest species diversity, highlighting *S. aurata*, *D. sargus*, *S. cabrilla*, and *D. labrax* (Table 3B).

3.2.2 Boat angling

For boat anglers, an ANOSIM test determined significant differences for the catch composition among the three zones ($p < 0.001$; Figure 4A, Table 4A). Significant differences were also observed among most seasons ($p < 0.001$), with the exception of winter vs. spring (Table 4B, Figure 4B).

Species such as *E. alletteratus*, and *S. officinalis* were more abundant on the central than in the north zones, whereas *S. cabrilla*, and *Pagellus erythrinus* were more prevalent in the north than in the center. Similarly, comparisons between the south and north zones revealed similar patterns, with the addition of *S. aurata* in the south zone. Lastly, *S. officinalis*, *L. vulgaris* and *S. aurata* dominated the southern catches, while *E. alletteratus*, and *S. dumerili* were more prevalent in the central zone (Table 4A). Regarding seasonal variability in boat angling, *L. vulgaris* was the most abundant in winter. In spring, catches of *P. erythrinus*, and *Trachurus trachurus*

were more abundant, while in summer, catches of *E. alletteratus* and *S. cabrilla* (Table 4B).

3.2.3 Spearfishing

For spearfishing, the ANOSIM test revealed significant differences in the catch composition between the north and center zones ($p < 0.001$; Table 5A, Figure 5A), but no significant differences were found between south and the other two zones ($p > 0.05$). Seasons also showed significant differences in species composition ($p < 0.001$; Table 5B, Figure 5B). However, no significant differences were detected between winter and spring or between winter and fall ($p > 0.05$).

The top species accounting for the differences between the north and center zones were *M. surmuletus* and *O. vulgaris*, both more abundant in the north zone (Table 5A). The primary species contributing to seasonal variability in spearfishing differed significantly between winter and summer, with *O. vulgaris*, and *D. labrax* being more abundant in winter, and *D. sargus*, *M. surmuletus*, and *S. aurata*, in summer. As for the comparison between spring and fall, catches of *O. vulgaris*, and *Diplodus puntazzo* stood out in spring, whereas in the fall, catches of *Diplodus* sp., *S. dumerili*, *M. surmuletus* highlighted (Table 5B).

4 Discussion

Several variables, including fishing modality, zone, and seasonality can help predict how MRF evolve over time, which is key to ensuring its local sustainability. The results of this study confirm the hypothesis that fishing modality is the main driver for the differences observed in the species composition of MRF catches along the NW Mediterranean Sea, emphasizing the need for fine-

TABLE 3 List of species contributing to the difference in the catch composition of shore angling among (A) sampling zones and (B) seasons.

A)						
Shore angling & zones compared		Species accounting for differences		Statistical results		
Zone 1	Zone 2	Spp assemblage 1	Spp assemblage 2	% Difference	R _{anosim} value	p-value
North	Center	<i>Sparus aurata</i> <i>Serranus cabrilla</i> <i>Boops boops</i> <i>Lithognathus mormyrus</i> <i>Oblada melanurus</i>	<i>Diplodus sargus</i> <i>Dicentrarchus labrax</i> <i>Diplodus annularis</i>	55%	0.12	< 0.01
North	South	<i>Serranus cabrilla</i> <i>Boops boops</i> <i>Oblada melanurus</i> <i>Diplodus vulgaris</i>	<i>Sparus aurata</i> <i>Dicentrarchus labrax</i> <i>Diplodus sargus</i> <i>Lithognathus mormyrus</i> <i>Diplodus annularis</i>	63%	0.13	< 0.01

B)						
Shore angling & seasons compared		Species accounting for differences		Statistical results		
Season 1	Season 2	Spp assemblage 1	Spp assemblage 2	% Difference	R _{anosim} value	p-value
Winter	Summer	<i>Spicara maena</i>	<i>Sparus aurata</i> <i>Diplodus sargus</i> <i>Serranus cabrilla</i> <i>Dicentrarchus labrax</i> <i>Diplodus annularis</i> <i>Lithognathus mormyrus</i> <i>Boops boops</i>	60%	0.17	< 0.01
Summer	Fall	<i>Sparus aurata</i> <i>Diplodus sargus</i> <i>Serranus cabrilla</i> <i>Dicentrarchus labrax</i> <i>Boops boops</i> <i>Diplodus annularis</i> <i>Oblada melanurus</i> <i>Lithognathus mormyrus</i>	<i>Octopus vulgaris</i>	59%	0.03	< 0.01

Only comparisons with significant differences are shown. The difference that these species account for is represented in the % Difference. R_{anosim} and p-value are statistic values.

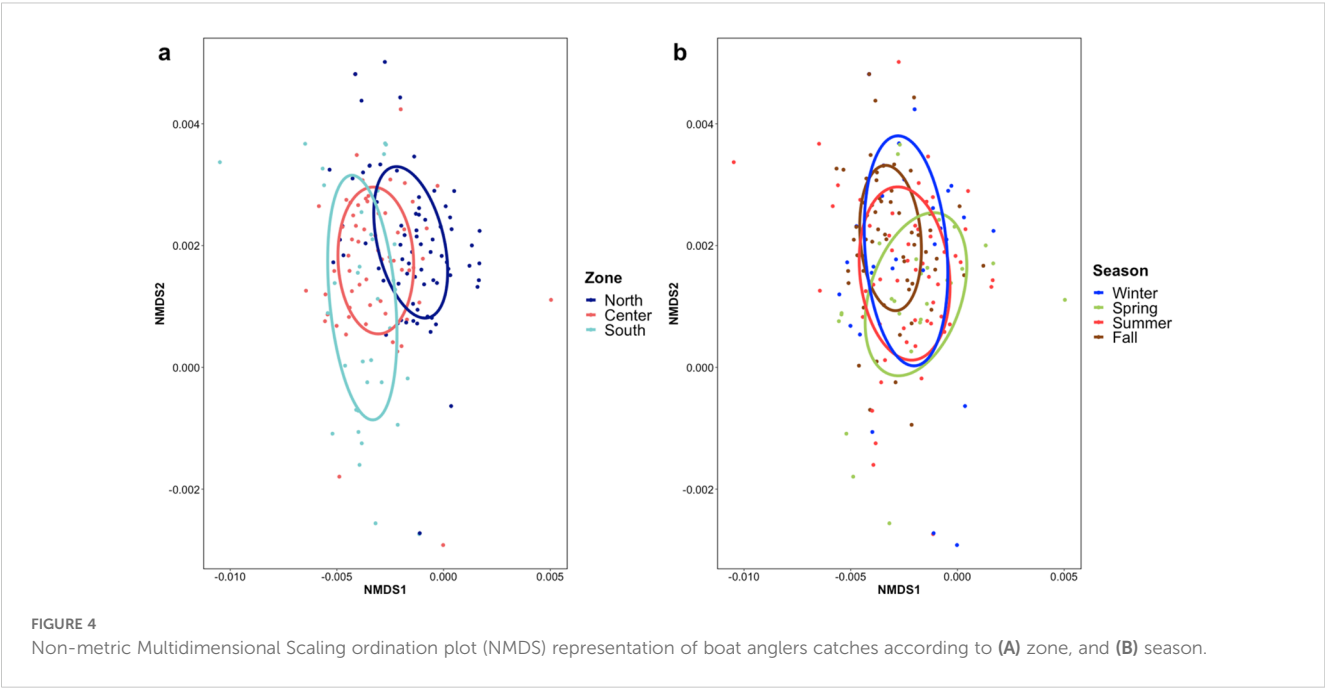


TABLE 4 List of species contributing to the difference in the catch composition of boat angling among (A) sampling zones and (B) seasons.

A)						
Boat angling & zones compared		Species accounting for differences		Statistical results		
Zone 1	Zone 2	Spp assemblage 1	Spp assemblage 2	% Difference	R _{anosim} value	p-value
Center	North	<i>Euthynnus alletteratus</i> <i>Sepia officinalis</i> <i>Seriola dumerili</i>	<i>Serranus cabrilla</i> <i>Loligo vulgaris</i> <i>Scomber scombrus</i> <i>Pagellus erythrinus</i>	64%	0.21	< 0.01
South	North	<i>Sepia officinalis</i> <i>Euthynnus alletteratus</i> <i>Sparus aurata</i>	<i>Serranus cabrilla</i> <i>Loligo vulgaris</i> <i>Pagellus erythrinus</i>	63%	0.33	< 0.01
South	Center	<i>Sepia officinalis</i> <i>Loligo vulgaris</i> <i>Sparus aurata</i>	<i>Euthynnus alletteratus</i> <i>Scomber scombrus</i> <i>Seriola dumerili</i>	61%	0.15	< 0.01
B)						
Boat angling & seasons compared		Species accounting for differences		Statistical results		
Season 1	Season 2	Spp assemblage 1	Spp assemblage 2	% Difference	R _{anosim} value	p-value
Winter	Summer	<i>Loligo vulgaris</i>	<i>Serranus cabrilla</i> <i>Euthynnus alletteratus</i> <i>Scomber scombrus</i> <i>Trachurus trachurus</i> <i>Pagellus erythrinus</i>	51%	0.28	< 0.01
Winter	Fall	<i>Serranus cabrilla</i>	<i>Loligo vulgaris</i> <i>Sepia officinalis</i> <i>Euthynnus alletteratus</i> <i>Seriola dumerili</i>	69%	0.14	< 0.01
Summer	Fall	<i>Serranus cabrilla</i> <i>Euthynnus alletteratus</i> <i>Scomber scombrus</i>	<i>Loligo vulgaris</i> <i>Sepia officinalis</i> <i>Seriola dumerili</i>	57%	0.21	< 0.01
Summer	Spring	<i>Serranus cabrilla</i> <i>Euthynnus alletteratus</i> <i>Scomber scombrus</i>	<i>Sepia officinalis</i> <i>Pagellus erythrinus</i> <i>Loligo vulgaris</i> <i>Trachurus trachurus</i>	57%	0.15	< 0.01
Fall	Spring	<i>Sepia officinalis</i> <i>Loligo vulgaris</i> <i>Euthynnus alletteratus</i> <i>Seriola dumerili</i>	<i>Serranus cabrilla</i> <i>Pagellus erythrinus</i>	66%	0.17	< 0.01

Only comparisons with significant differences are shown. The difference that these species account for is represented in the % Difference. R_{anosim} and p-value are statistic values.

scale, modality-specific management, and a multifaceted activity influenced by a variety of ecological, social, and methodological factors (Font and Lloret, 2014; Lloret et al., 2008). There is scarce bibliography on MRF in the same studied area but a global list of the species of interest caught by the MRF fishers had not been previously reported (Dedeu et al., 2019; Gordoa et al., 2019). With 86 recorded species, our findings underscore the diverse and regional particularities of MRF (mirroring marine communities' characteristics) in the area, since other studies reported much lower values, i.e. 51 species in Turkey (Unal et al., 2010) or 38 species in Israel (Frid et al., 2023). Incorporating the diversity of fishing modalities, the difference in fishers' habits, and the vast spatial extension of MRF introduce significant complexity to the studies in this field, which may explain why MRF remains less well understood than commercial fisheries (ICES, 2020). However,

understanding this variability has been proved here as essential for developing science-based and regionally adapted management strategies (Frid et al., 2023).

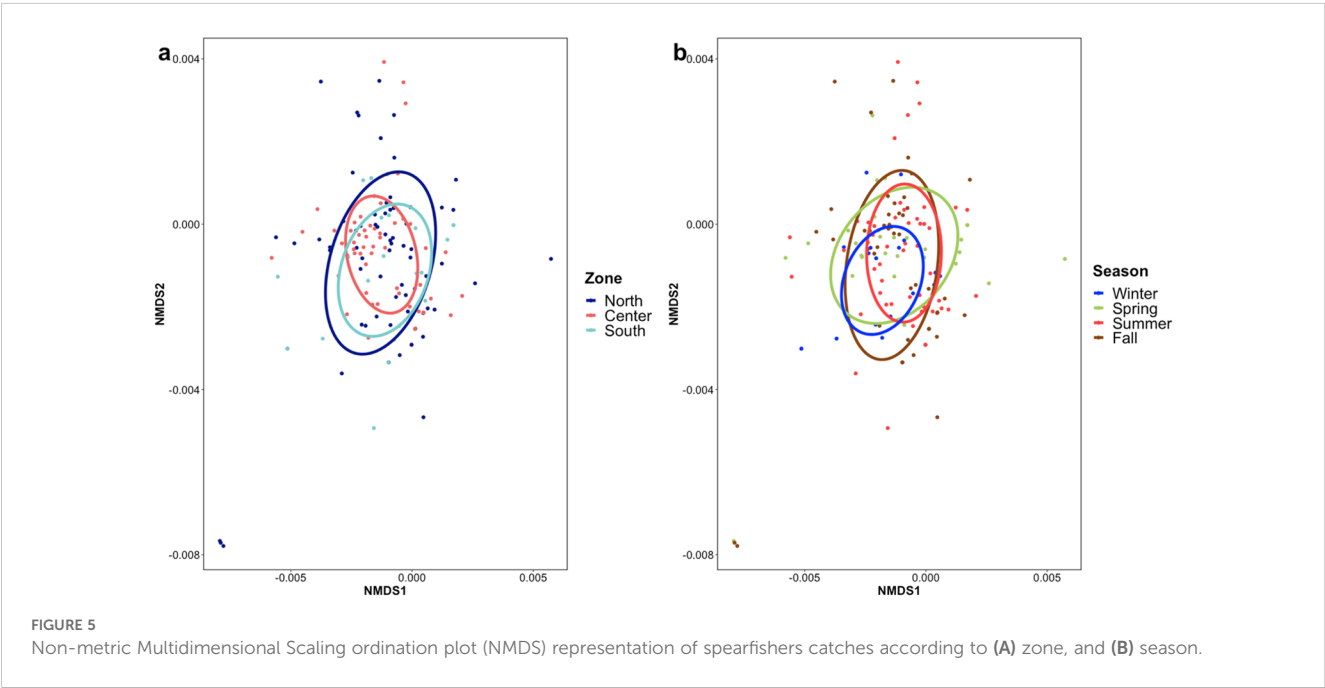
Among the three modalities, boat angling catches exhibited the highest number of species, as found in similar studies (e.g. 54 species in Mallorca (Morales-Nin et al., 2005); 42 species in Turkey (Unal et al., 2010)). Boat anglers' catches diversity could be explained by a combination of factors and characteristics. For instance, they may use various fishing techniques such as bottom fishing, a variety of jigging types, trolling with live, dead or artificial baits, bottom longlining and deep dropping, among others (Michailidis et al., 2020). Within boat angling, seasonality seems to play an important role in the catch composition, as reported by Frid et al., 2023; Unal et al., 2010, where seasonal peaks in the catch abundance may be related to the biology of the species. For example, the temporal

TABLE 5 List of species contributing to the difference in the catch composition of spearfishing among (A) different sampling zones and (B) different seasons.

A)						
Spearfishing & zones compared		Species accounting for differences		Statistical results		
Zone 1	Zone 2	Spp assemblage 1	Spp assemblage 2	% Difference	R _{anosim} value	p-value
North	Center	<i>Mullus surmuletus</i> <i>Octopus vulgaris</i>	<i>Diplodus sargus</i> <i>Seriola dumerili</i> <i>Sepia officinalis</i> <i>Sparus aurata</i>	54%	0.04	0.01

B)						
Spearfishing & seasons compared		Species accounting for differences		Statistical results		
Season 1	Season 2	Spp assemblage 1	Spp assemblage 2	% Difference	R _{anosim} value	p-value
Winter	Summer	<i>Octopus vulgaris</i> <i>Dicentrarchus labrax</i> <i>Sepia officinalis</i>	<i>Diplodus sargus</i> <i>Mullus surmuletus</i> <i>Sparus aurata</i>	61%	0.15	0.01
Spring	Summer	<i>Sepia officinalis</i> <i>Octopus vulgaris</i> <i>Diplodus puntazzo</i>	<i>Diplodus sargus</i> <i>Mullus surmuletus</i> <i>Sparus aurata</i> <i>Dentex dentex</i> <i>Epinephelus marginatus</i>	64%	0.12	<0.01
Summer	Fall	<i>Sparus aurata</i> <i>Dentex dentex</i>	<i>Diplodus sargus</i> <i>Mullus surmuletus</i> <i>Seriola dumerili</i> <i>Octopus vulgaris</i>	56%	0.08	<0.01
Spring	Fall	<i>Sepia officinalis</i> <i>Octopus vulgaris</i>	<i>Diplodus sargus</i> <i>Seriola dumerili</i> <i>Mullus surmuletus</i> <i>Diplodus puntazzo</i>	59%	0.12	<0.01

Only comparisons with significant differences are shown. The difference that these species account for is represented in the % Difference. R_{anosim} and p-value are statistic values.



abundance variations described for *S. officinalis* aligns with the peak observed in the fall, associated with the recruitment of small individuals. Meanwhile, in the spring months, larger individuals migrate to shallow waters for reproduction, becoming easier to catch (Duysak et al., 2014; Rico et al., 2023). Similarly, *E. alletteratus* feeds on a variety of preys, including squids (Falautano et al., 2007), which are more abundant in the same zones where *E. alletteratus* is mostly caught, i.e., waters shallower than 100 m and rather low salinity (Sanchez et al., 2008). These seasonal behaviors and habitat preferences likely contribute to the higher number of catches during the warmer seasons (Morales-Nin et al., 2005; Dedeu et al., 2019). Likewise, *L. vulgaris*, appeared amongst the caught species in fall and winter, coinciding with its spawning aggregations near the coast (Cabanelas-Reboredo et al., 2012; Moreno et al., 2002). Similarly, *S. officinalis* and *P. erythrinus* are easier to catch during the spawning season, between spring and summer (Somarakis and Machias, 2002) because they approach shallower areas (Guerra et al., 2016; Somarakis and Machias, 2002).

Spearfishing has been reported as the most selective modality thus, with fewer catches (Dedeu et al., 2019) but catching valued species such as *D. sargus*, *O. vulgaris* and *S. dumerili* which are commonly targeted species in other areas in the Mediterranean (Font and Lloret, 2011; Lloret et al., 2008b; Jiménez-Alvarado et al., 2020; Terlizzi et al., 2022). Studies from western Mediterranean marine protected areas (i.e. Cap de Creus and the Balearic Islands), demonstrate that spearfishing affects at least of 35 species which fishing pressure concentrated in some species that also appear in our study area (e.g. *D. sargus*, *Mullus surmuletus* and *O. vulgaris* (Riera-Batle and M. Grau, 2022; Rocklin et al., 2011). Seasonality also influenced spearfishers' catch composition as they may shift their effort toward seasonally species, such as *S. officinalis* during spring or *E. marginatus* during summer, when the adults aggregate near coastal rocky habitats in spawning grounds (Sbragaglia et al., 2021). The seasonal pattern observed suggests that spearfishers may maintain a relatively stable catch rate year-round.

Shore angling is considered to be the most popular modality in Spain, probably because it requires minimal logistical support, is cost-effective, and is less influenced by sea conditions (Gordoa et al., 2019; Pita et al., 2017). This modality in the Mediterranean commonly targets species from the Sparidae family, which have been estimated to represent, globally, 12% of the MRF catch (Freire et al., 2020). Within this family, *S. aurata* is one of the most frequently caught species in the Mediterranean Sea (Dedeu et al., 2019), as observed in this present study. In addition, species like *S. aurata* and *O. melanurus* are related to summer, consistent with their seasonal inshore migrations during reproduction (Daban et al., 2020; March et al., 2010; Marques et al., 2024).

In general, the Mediterranean Sea is characterized by a strong seasonal pattern (Poulos, 2020), that influences the biology of marine species and, hence, fishing patterns. In our study, seasonal differences in catches seems linked with the life cycle of some species. In addition to the biological traits of the species, the differences found among seasons may also be defined by a social component of the fishers. For example, summer was the season with the greatest number of catches and species biodiversity, as

previously reported in different areas of the Mediterranean, where the fishing effort is biased towards the hottest months of the year (Lloret et al., 2008a; Michailidis et al., 2020; Morales-Nin et al., 2005; Pranovi et al., 2016) matching with vacation months and tourism increases in coastal areas, as noted by Lloret et al. (2008a), who observed that almost 35% of the fishers interviewed in 2020–2023 in northern Catalonia were foreigners.

The spatial variability observed seems to be closely related to the geomorphological heterogeneity of the NW Mediterranean, including the Catalan coast. Northern zones, with seagrass (*Posidonia oceanica*) meadows, and deep, rocky substrates, may favor species such as *S. cabrilla* and *B. boops*, caught by shore anglers, *L. vulgaris* and *P. erythrinus* fished by boat anglers, and *M. surmuletus* and *O. vulgaris* caught by spearfishers (Dulc et al., 1998; Ordines et al., 2014). In the deltaic zones, species such as *D. labrax* were mainly fished around the Llobregat and Ebre Deltas, a species adapted to euryhaline condition (Cardona, 2000). The central and southern zones, characterized by sandy bottoms, supported species like *S. officinalis* (Sardo et al., 2023). As commented, in some cases, prey-predator dynamics, such as the diet of *E. alletteratus*, further explain spatial patterns of abundance (Falautano et al., 2007). On a social scale, the behavior of fishers are probably influenced by the existence of marine protected areas, and they may choose these destinations as their fishing spots (Franceschini et al., 2024; Gómez et al., 2021). These areas (see Figure 1), may function as “fishing hot spots” where fishers take advantage of the ecosystem benefits that the areas offer (Lloret et al., 2008; Marcos et al., 2021).

Previous studies have emphasized the need to focus on particular species at small spatial scales to implement effective management measures (Hyder et al., 2020; Lewin et al., 2006; Morales-Nin et al., 2005). Marine species targeted by MRF requires integrated, science-based information to support decision-making (Pita et al., 2020) and should be evaluated along with commercial fisheries as they also contribute to the potential decline of commercial species at a global scale (Cooke and Cowx, 2006). Although southern European countries such as Spain and Portugal have made progress in developing legal frameworks for MRF (Pita et al., 2018), gaps remain. Current regulations are often unclear to fishers (Pita et al., 2017) and might not be effective in protecting the marine resources. Therefore, studies such as the one presented here aim to provide valuable data to improve the existing regulation and ensure the sustainability of the marine resources. As a result of the information gathered, in September 2024 a new regulation was approved for interior waters of the northern region of Catalonia (Girona province) which encompasses 42 species and establishes measures such as minimum legal size (based on the size at first maturity), daily species bag limits, and biological closures for certain species (RESOLUCIÓ ARP/3253, 2024).

Further progress will be required co-management approaches that combine scientific knowledge with the practical experience of the recreational fishing sector. Such participatory models will help ensure that regulations are ecologically sound, socially acceptable, and effectively enforced. While most recreational fishers are anglers (Arlinghaus et al., 2019), our results highlight the importance of managing each modality separately due to their distinct target

species. However, spatial and seasonal variables act as important complementary influences, whose observed relationships with the species composition of the catches are consistent with previous studies conducted along the Catalan coast (Soliva, 2006; Lloret et al., 2008; Font and Lloret, 2011; Font and Lloret, 2014; Dedeu et al., 2019), and in other parts of the Mediterranean Sea (Morales-Nin et al., 2005). A key insight from this work is the importance of developing differentiated management strategies that account for the specific characteristics and impacts of each modality. Although progress has been made in recent years, existing regulations still fall short in addressing the ecological and social dimensions of MRF. Overall, our results offer valuable insights to support the design and implementation of evidence-based management measures for marine recreational fisheries at the administrative and policy levels.

Data availability statement

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

Ethics statement

Ethical review and approval was not required for the study on human participants in accordance with the local legislation and institutional requirements. Written informed consent from the participants was not required to participate in this study in accordance with the national legislation and the institutional requirements.

Author contributions

MP: Conceptualization, Data curation, Formal Analysis, Investigation, Methodology, Visualization, Writing – original draft, Writing – review & editing. CM: Data curation, Formal Analysis, Visualization, Writing – review & editing. MB: Conceptualization, Formal Analysis, Supervision, Validation, Writing – review & editing. MC: Conceptualization, Methodology, Supervision, Validation, Writing – review & editing. LR: Investigation, Project administration, Resources, Supervision, Writing – review & editing. JC: Funding acquisition, Investigation, Project administration, Resources, Supervision, Writing – review & editing. EG: Investigation, Project administration, Resources, Supervision, Validation, Writing – review & editing.

Funding

The author(s) declare that financial support was received for the research and/or publication of this article. This study was financed by the European Maritime and Fisheries Fund (EMFF) through the Spanish Fishery Secretary and the *Direcció General de Política Marítima i Pesca Sostenible* from *Generalitat de Catalunya* with projects PESCAT (ARP029/18/00003) and CGCAT (ARP140/20/

000006). We acknowledge support of the publication fee by the CSIC Open Access Publication Support Initiative (PROA) through its Unit of Information Resources for Research (URICI).

Acknowledgments

This work acknowledges the “Severo Ochoa Centre of Excellence” accreditation (CEX2019-000928-S). We are thankful to all the recreational fishers who participated in the surveys and generously shared their information on fishing trips, catches, and social aspects. We thank Llibori Martinez, Albert Martinez, Joan Carles Fluixà and Carla Fluixà for carrying out the sampling trips in the framework of the MRF data collection that ICATMAR coordinates since 2019. Our sincere appreciation goes to the ICATMAR personnel and colleagues for their support throughout the data collection. Any information provided by local fishers was collected in accordance with ethical considerations prevailing in the country, and we maintained confidentiality of names and locations upon request.

Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

Generative AI statement

The author(s) declare that no Generative AI was used in the creation of this manuscript.

Any alternative text (alt text) provided alongside figures in this article has been generated by Frontiers with the support of artificial intelligence and reasonable efforts have been made to ensure accuracy, including review by the authors wherever possible. If you identify any issues, please contact us.

Publisher's note

All claims expressed in this article are solely those of the authors and do not necessarily represent those of their affiliated organizations, or those of the publisher, the editors and the reviewers. Any product that may be evaluated in this article, or claim that may be made by its manufacturer, is not guaranteed or endorsed by the publisher.

Supplementary material

The Supplementary Material for this article can be found online at: <https://www.frontiersin.org/articles/10.3389/fmars.2025.1675575/full#supplementary-material>.

References

- Agius Darmanin, S., and Vella, A. (2018). An assessment of catches of shore sport fishing competitions along the coast of the Maltese Islands: Implications for conservation and management. *Fisheries Manage. Ecol.* 25, 127–135. doi: 10.1111/fme.12271
- Aranda, G., Abascal, F. J., Varela, J. L., and Medina, A. (2013). Spawning behavior and post-spawning migration patterns of Atlantic Bluefin Tuna (*Thunnus thynnus*) ascertained from satellite archival tags. *PloS One* 8, e76445. doi: 10.1371/journal.pone.0076445
- Arlinghaus, R., Abbott, J. K., Fenichel, E. P., Carpenter, S. R., Hunt, L. M., Alós, J., et al. (2019). Governing the recreational dimension of global fisheries. *Proc. Natl. Acad. Sci.* 116, 5209–5213. doi: 10.1073/pnas.1902796116
- Arlinghaus, R., and Cooke, S. J. (2005). Global impact of recreational fisheries. *Science* 307, 1561–1563. doi: 10.1126/science.307.5715.1560b
- Ben Lamine, E., Di Franco, A., Romdhane, M. S., and Francour, P. (2018). Comparing commercial, recreational and illegal coastal fishery catches and their economic values: A survey from the southern Mediterranean Sea. *Fisheries Manage. Ecol.* 25, 456–463. doi: 10.1111/fme.12321
- BOE-A-2011-6099 (2011). *Decreto, R. (347/2011) de 11 de marzo, por el que se regula la pesca marítima de recreo en aguas exteriores*. Madrid (Spain): Ministerio de Medio Ambiente, y Medio Rural y Marino.
- Brenner, J., Jimenez, J. A., and Sardá, R. (2006). Definition of homogeneous environmental management units for the Catalan Coast. *Environ. Manage.* 38, 993–1005. doi: 10.1007/s00267-005-0210-6
- Brenner, J., Jiménez, J. A., Sardá, R., and Garola, A. (2010). An assessment of the non-market value of the ecosystem services provided by the Catalan coastal zone, Spain. *Ocean Coast. Manage.* 53, 27–38. doi: 10.1016/j.ocecoaman.2009.10.008
- Brownscombe, J. W., Adams, A. J., Young, N., Griffin, L. P., Holder, P. E., Hunt, J., et al. (2019). Bridging the knowledge-action gap: A case of research rapidly impacting recreational fisheries policy. *Mar. Policy* 104, 210–215. doi: 10.1016/j.marpol.2019.02.021
- Cabanelas-Reboredo, M., Alós, J., Palmer, M., March, D., and O'Dor, R. (2012). Movement patterns of the European squid *Loligo vulgaris* during the inshore spawning season. *Mar. Ecol. Prog. Ser.* 466, 133–144. doi: 10.3354/meps09925
- Cardona, L. (2000). Effects of salinity on the habitat selection and growth performance of Mediterranean flathead Grey mullet *Mugil cephalus* (Osteichthyes, Mugilidae). *Estuarine Coast. Shelf Sci.* 50, 727–737. doi: 10.1006/ecss.1999.0594
- Cooke, S. J., and Cowx, I. G. (2006). Contrasting recreational and commercial fishing: Searching for common issues to promote unified conservation of fisheries resources and aquatic environments. *Biol. Conserv.* 128, 93–108. doi: 10.1016/j.biocon.2005.09.019
- Daban, I. B., Ismen, A., Ihsanoglu, M. A., and Cabbar, K. (2020). Age, growth and reproductive biology of the saddled seabream (*Oblada melanura*) in the North Aegean Sea, Eastern Mediterranean. *Oceanological Hydrobiological Stud.* 49, 14. doi: 10.1515/ohs-2020-0002
- Dedeu, A. L., Boada, J., and Gordoa, A. (2019). The first estimates of species compositions of Spanish marine recreational fishing reveal the activity's inner and geographical variability. *Fisheries Res.* 216, 65–73. doi: 10.1016/j.fishres.2019.03.025
- DOGC-2040-DECRET 109/1995 (1995). *Regulació de la pesca marítima recreativa* (Gneralitat de Catalunya). DOGC-2040-DECRET 109/1995.
- Dulic, J., Skakelja, N., Kraljevic, M., and Cetinic, P. (1998). On the fecundity of the Black Sea bream, *Spondyliotoma cantharus*, from the Adriatic Sea (Croatian coast). *Scientia Marina*, 62(3), 289–294. doi: 10.3989/scimar.1998.62n3289
- Duysak, Ö., Özcan, G., Çek, Ş., and Türeli, C. (2014). Reproductive biology of the common cuttlefish (*Sepia officinalis* Linnaeus 1758) in iskenderun bay (Northeastern mediterranean sea). *Ind. J. Geo-Mar. Sci.* 43, 1689–1694.
- Falautano, M., Castriota, L., Finoia, M. G., and Andaloro, F. (2007). Feeding ecology of little tunny *Euthynnus alletteratus* in the central Mediterranean Sea. *J. Mar. Biol. Assoc. United Kingdom* 87, 999–1005. doi: 10.1017/S0025315407055798
- Font, T., and Lloret, J. (2011). Biological implications of recreational shore angling and harvest in a marine reserve: The case of Cape Creus. *Aquat. Conservation: Mar. Freshw. Ecosyst.* 21, 210–217. doi: 10.1002/aqc.1167
- Font, T., and Lloret, J. (2014). Biological and ecological impacts derived from recreational fishing in Mediterranean Coastal areas. *Rev. Fisheries Sci. Aquaculture* 22, 73–85. doi: 10.1080/10641262.2013.823907
- Franceschini, S., Lynham, J., and Madin, E. M. P. (2024). Ecologia global test of MPA spillover benefits to recreational fisheries. *Sci. Adv.* 10, 8. doi: 10.1126/sciadv.ado9783
- Franquesa, R., Gordoa, A., Mina, T., and Nuss, S. (2004). The recreational fishing in the Central and Western European Mediterranean frame. *Report of the 16th Annual Conference of the European Association of Fisheries Economists. Gabinete de Economía del Mar, Universidad de Barcelona*. 16.
- Freire, K. M. F., Belhabib, D., Espedido, J. C., Hood, L., Kleisner, K. M., Lam, V. W. L., et al. (2020). Estimating global catches of marine recreational fisheries. *Front. Mar. Sci.* 7. doi: 10.3389/fmars.2020.00012
- Frid, O., Gavriel, T., Ben-Ari, Y., Weinberger, A., Yancovich-Shalom, H., and Belmaker, J. (2023). Catch estimates and species composition of recreational fishing in Israel. *Fishes* 8, 69. doi: 10.3390/fishes8020069
- Gómez, S. (2022). The moral and ethical baseline of marine socio-ecological values: the case of recreational and artisanal fishing in NW mediterranean coastal waters (Catalonia, Spain). *Hum. Ecol.* 50, 895–910. doi: 10.1007/s10745-022-00354-0
- Gómez, S., Carreño, A., and Lloret, J. (2021). Cultural heritage and environmental ethical values in governance models: Conflicts between recreational fisheries and other maritime activities in Mediterranean marine protected areas. *Mar. Policy* 129, 104529. doi: 10.1016/j.marpol.2021.104529
- Gordoa, A., Dedeu, A. L., and Boada, J. (2019). Recreational fishing in Spain: First national estimates of fisher population size, fishing activity and fisher social profile. *Fisheries Res.* 211, 1–12. doi: 10.1016/j.fishres.2018.10.026
- Grati, F., Hyder, K., Mugerza, E., Arlinghaus, R., Baudrier, J., Bell, B., et al. (2025). Effective governance of marine recreational fisheries in Europe is needed to maximize the societal benefits of its fisheries. *ICES J. Mar. Sci.* 82, fsae169. doi: 10.1093/icesjms/fsae169
- Guerra, Á., Hernández-Urcera, J., Garci, M. E., Sestelo, M., Regueira, M., Gilcoto, M., et al. (2016). Spawning habitat selection by the common cuttlefish *Sepia officinalis* in the Cies Islands (Northwest Spain). *Fisheries Res.* 183, 44–54. doi: 10.1016/j.fishres.2016.04.023
- Hyder, K., Maravelias, C. D., Kraan, M., Radford, Z., and Prellezo, R. (2020). Marine recreational fisheries—Current state and future opportunities. *ICES J. Mar. Sci.* 77, 2171–2180. doi: 10.1093/icesjms/fsaa147
- Hyder, K., Weltersbach, M. S., Armstrong, M., Ferter, K., Townhill, B., Ahvonen, A., et al. (2018). Recreational sea fishing in Europe in a global context—Participation rates, fishing effort, expenditure, and implications for monitoring and assessment. *Fish Fisheries* 19, 225–243. doi: 10.1111/faf.12251
- ICATMAR (Institut Català per a la Governança del Mar) (2024). *State of marine recreational fisheries in catalonia* (Barcelona (Spain): ICATMAR), 79. doi: 10.20350/digitalC-SIC/16409
- ICES (2020). Working group on recreational fisheries surveys (WGRFS). *ICES Scientific Reports*, 2:102. doi: 10.17895/ICES.PUB.7563
- Jelić Mrčelić, G., Slišković, M., and Soldo, A. (2023). An assessment of spearfishing catches along the Eastern Adriatic Coast. *Fishes* 8, 346. doi: 10.3390/fishes8070346
- Jiménez-Alvarado, D., Guerra-Marrero, A., Sarmiento-Lezcano, A., Meyers, E. K. M., and Castro, J. J. (2020). First assessment of the spearfishing impact in the Canary Islands. *Regional Stud. Mar. Sci.* 38, 101385. doi: 10.1016/j.rsma.2020.101385
- Lewin, W.-C., Arlinghaus, R., and Mehner, T. (2006). Documented and potential biological impacts of recreational fishing: Insights for management and conservation. *Rev. Fisheries Sci.* 14, 305–367. doi: 10.1080/10641260600886455
- Lewin, W.-C., Weltersbach, M. S., Ferter, K., Hyder, K., Mugerza, E., Prellezo, R., et al. (2019). Potential environmental impacts of recreational fishing on marine fish stocks and ecosystems. *Rev. Fisheries Sci. Aquaculture* 27, 287–330. doi: 10.1080/23308249.2019.1586829
- Lloret, J., Cowx, I. G., Cabral, H., Castro, M., Font, T., Gonçalves, J. M. S., et al. (2018). Small-scale coastal fisheries in European Seas are not what they were: Ecological, social and economic changes. *Mar. Policy* 98, 176–186. doi: 10.1016/j.marpol.2016.11.007
- Lloret, J., Zaragoza, N., Caballero, D., Font, T., Casadevall, M., and Riera, V. (2008). Spearfishing pressure on fish communities in rocky coastal habitats in a Mediterranean marine protected area. *Fisheries Res.* 94, 84–91. doi: 10.1016/j.fishres.2008.07.002
- Lloret, J., Zaragoza, N., Caballero, D., and Riera, V. (2008a). Biological and socioeconomic implications of recreational boat fishing for the management of fishery resources in the marine reserve of Cap de Creus (NW Mediterranean). *Fisheries Res.* 91, 252–259. doi: 10.1016/j.fishres.2007.12.002
- Lloret, J., Zaragoza, N., Caballero, D., and Riera, V. (2008b). Impacts of recreational boating on the marine environment of Cap de Creus (Mediterranean Sea). *Ocean Coast. Manage.* 51, 749–754. doi: 10.1016/j.ocecoaman.2008.07.001
- March, D., Palmer, M., Alós, J., Grau, A., and Cardona, L. (2010). Short-term residence, home range size and diel patterns of the painted comber *Serranus scriba* in a temperate marine reserve. *Mar. Ecol. Prog. Ser.* 400, 195–206. doi: 10.3354/meps08410
- Marcos, C., Díaz, D., Fietz, K., Forcada, A., Ford, A., García-Charton, J. A., et al. (2021). Reviewing the ecosystem services, societal goods, and benefits of marine protected areas. *Frontiers Media S.A.* 8, 37. doi: 10.3389/fmars.2021.613819
- Marques, R., Brazo, A., Aspillaga, E., Zimmermann, M., Hereu, B., Saragoni, G., et al. (2024). Movements and spatial distribution of an endangered fish (*Sciæna umbra*) within a marine protected area. *Sci. Rep.* 14, 3103. doi: 10.1038/s41598-023-50194-1
- Michailidis, N., Katsanevakis, S., and Chartosia, N. (2020). Recreational fisheries can be of the same magnitude as commercial fisheries: The case of Cyprus. *Fisheries Res.* 231, 105711. doi: 10.1016/j.fishres.2020.105711
- Morales-Nin, B., Moranta, J., García, C., Tugores, M. P., Grau, A. M., Riera, F., et al. (2005). The recreational fishery off Majorca Island (western Mediterranean): Some

implications for coastal resource management. *ICES J. Mar. Sci.* 62, 727–739. doi: 10.1016/j.icesjms.2005.01.022

Moreno, A., Pereira, J., Arvanitidis, C., Perales-Raya, C., Cunha, M. M., Balguerías, E., et al. (2002). Biological variation of *Loligo vulgaris* (cephalopoda: *Loliginidae*) in the eastern atlantic and mediterranean. *Bull. Mar. Sci.* 71, 515–534.

Ordines, F., Farriols, M. T., Leonart, J., Guijarro, B., Quetglas, A., and Massuti, E. (2014). Biology and population dynamics of by-catch fish species of the bottom trawl fishery in the western Mediterranean. *Mediterr. Mar. Sci.* 15, 613. doi: 10.12681/mms.812

Pawson, M. G., Glenn, H., and Padda, G. (2008). The definition of marine recreational fishing in Europe. *Mar. Policy* 32, 339–350. doi: 10.1016/j.marpol.2007.07.001

Pita, P., Alós, J., Antelo, M., Artetxe, I., Biton-Porsmoguer, S., Carreño, A., et al. (2020). Assessing knowledge gaps and management needs to cope with barriers for environmental, economic, and social sustainability of marine recreational fisheries: The Case of Spain. *Front. Mar. Sci.* 7, doi: 10.3389/fmars.2020.00023

Pita, P., Artetxe, I., Diogo, H., Gomes, P., Gordo, A., Hyder, K., et al. (2017). Research and management priorities for Atlantic marine recreational fisheries in Southern Europe. *Mar. Policy* 86, 1–8. doi: 10.1016/j.marpol.2017.08.030

Pita, P., Villasante, S., Arlinghaus, R., Gomes, P., Strehlow, H. V., Veiga, P., et al. (2018). A matter of scales: Does the management of marine recreational fisheries follow the ecosystem approach to fisheries in Europe? *Mar. Policy* 97, 61–71. doi: 10.1016/j.marpol.2018.08.039

Poulos, S. E. (2020). The Mediterranean and Black Sea Marine System: An overview of its physico-geographic and oceanographic characteristics. *Earth-Science Rev.* 200, 103004. doi: 10.1016/j.earscirev.2019.103004

Pranovi, F., Anelli Monti, M., Caccin, A., Colla, S., and Zucchetto, M. (2016). Recreational fishing on the West coast of the Northern Adriatic Sea (Western Mediterranean) and its possible ecological implications. *Regional Stud. Mar. Sci.* 3, 273–278. doi: 10.1016/j.rsma.2015.11.013

R Core Team (2025). *R: A language and environment for statistical computing*. (Vienna, Austria: R Foundation for Statistical Computing). Available online at: <https://www.R-project.org/> (Accessed September 11, 2025).

RESOLUCIÓ ARP/3253 (2024). *per la qual es fixen les talles mínimes de captura, quotes i vedes d'aplicació a la pesca marítima recreativa a les aigües interiors del litoral de les comarques de Girona per al període 2024-2026* (Generalitat de Catalunya).

Rico, A., Fernandez-Arcaya, U., Quetglas, T., and Valls, M. (2023). Reproductive traits and feeding activity of the commercially exploited common cuttlefish *Sepia officinalis* L. (Mollusca: Cephalopoda) in the Balearic Islands. *Mar. Biol.* 170, 69. doi: 10.1007/s00227-023-04213-4

Riera-Batlle, I., and M. Grau, A. (2022). Spearfishing in the Balearic Islands (western Mediterranean): Affected species and yield. *Boll. Soc. Hist. Nat. Balears*, 65, 185205.

Rocklin, D., Tomasini, J.-A., Culioli, J.-M., Pelletier, D., and Mouillot, D. (2011). Spearfishing Regulation benefits artisanal fisheries: The ReGS indicator and its

application to a Multiple-Use Mediterranean marine protected area. *PLoS One* 6, e23820. doi: 10.1371/journal.pone.0023820

Sanchez, P., Demestre, M., Recasens, L., Maynou, F., and Martin, P. (2008). Combining GIS and GAMs to identify potential habitats of squid *Loligo vulgaris* in the Northwestern Mediterranean. *Hydrobiologia* 612, 91–98. doi: 10.1007/s10750-008-9487-9

Sardo, G., Geraci, M. L., Falsone, F., Gancitano, S., Gancitano, V., Massi, D., et al. (2023). First records with biological notes of *Umbrina ronchus*, Valenciennes 1843 (Osteichthyes, *sciaenidae*) in the strait of sicily (Central mediterranean sea). *Fishes* 8, 434. doi: 10.3390/fishes8090434

Sbragaglia, V., Coco, S., Correia, R. A., Coll, M., and Arlinghaus, R. (2021). Analyzing publicly available videos about recreational fishing reveals key ecological and social insights: A case study about groupers in the Mediterranean Sea. *Sci. Total Environ.* 765, 142672. doi: 10.1016/j.scitotenv.2020.142672

Soldo, A. (2022). An assessment of catches of shore and boat recreational angling along the coast of the Adriatic Sea. *J. Mar. Sci. Eng.* 10, 1999. doi: 10.3390/jmse10121999

Soldo, A., Fredotović, M., Šaran, A., Šlišković, M., Mihanović, V., and Mrčelić, G. J. (2018). Economic and social impact of marine sport and recreational fisheries in Croatia. *Croatian J. Fisheries* 76, 154–163. doi: 10.2478/cjf-2018-0019

Soliva, A. M. (2006). *La Pesca Marítima Recreativa en Cataluña: aspectos biológicos, sociales y económicos*. (Universitat de Barcelona).

Solomon, C. T., Dassow, C. J., Iwicky, C. M., Jensen, O. P., Jones, S. E., Sass, G. G., et al. (2020). Frontiers in modelling social–ecological dynamics of recreational fisheries: A review and synthesis. *Fish Fisheries* 21, 973–991. doi: 10.1111/faf.12482

Somarakis, S., and Machias, A. (2002). Age, growth and bathymetric distribution of red pandora (*Pagellus erythrinus*) on the Cretan shelf (eastern Mediterranean). *J. Mar. Biol. Assoc. United Kingdom* 82, 149–160. doi: 10.1017/S002531540200526X

Taylor, S. M., Smallwood, C. B., Desfosses, C. J., Ryan, K. L., and Jackson, G. (2021). Corroborating catch estimates to inform monitoring of a small-scale marine recreational fishery in a World Heritage property. *ICES J. Mar. Sci.* 78, 1887–1899. doi: 10.1093/icesjms/fsab095

Terlizzi, A., Tarantino, G., and Sbragaglia, V. (2022). Ecological, social and economic aspects of Italian marine spearfishing tournaments, (2009–2020). *Front. Mar. Sci.* 9, doi: 10.3389/fmars.2022.891246

Unal, V., Acarli, D., and Gordo, A. (2010). Characteristics of marine recreational fishing in the anakkale Strait (Turkey). *Mediterr. Mar. Sci.* 11, 315. doi: 10.12681/mms.79

Vitale, G., Dedeu, A. L., Pujol, M., and Sbragaglia, V. (2021). Characterizing the profile of recreational fishers who share their catches on social media. *Front. Mar. Sci.* 8, doi: 10.3389/fmars.2021.768047