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SHORT COMMUNICATION

Using citizen science to understand the recreational fishing impact on elasmobranchs along the Italian Northern Adriatic coast

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Abstract: Marine recreational fishing has significantly increased in recent years, especially in the Northern Adriatic Sea, where it accounts for equivalent up to 45% of artisanal fishery catches. Despite its relevance, few studies have investigated the potential impact of recreational fishing, particularly on vulnerable elasmobranch species, some of which are commercially targeted but face significant conservation problems. In this study, through online questionnaires administered to recreational fishers, we collected information on recreational fishing activities and their interaction with the most common demersal elasmobranchs along the western coast of the Northern Adriatic Sea. The responses revealed an intense fishing effort throughout the coastal area, especially around port entrances. The target species resulted primarily in those with high commercial value, while elasmobranchs are mostly bycatch, particularly *Mustelus* spp. Although 83% of fishers claimed to release them alive, the lack of studies on post-release survival rates makes it difficult to assess the impact of this fishing activity on elasmobranch populations.
Keywords: Mediterranean Sea; coastal area; demersal elasmobranchs; hook and line; questionnaires

Sažetak: KORIŠTENJE GRAĐANSKE ZNANOSTI U RAZUMIJEVANJU UTJECAJA REKREACIJSKOG RIBOLOVA NA HRSKAVIČNJAČE DUŽ TALIJANSKE OBALE SJEVERNOG JADRANA. Rekreacijski ribolov na moru u značajnom je porastu posljednjih godina, naročito u sjevernom Jadranu, gdje čini ekvivalent od gotovo 45 % ulova priobalnog ribolova. Unatoč njegovoj važnosti, malo je studija istraživalo potencijalni utjecaj rekreacijskog ribolova, osobito na ranjive vrste hrskavičnjača, od kojih su neke komercijalno značajne, a suočavaju se s problemom očuvanja populacija. U ovom smo istraživanju, putem internetskih upitnika za rekreacijske ribolovce, prikupili informacije o aktivnostima rekreacijskog ribolova i njihovoj interakciji s najčešćim pridnenim vrstama hrskavičnjača duž zapadne obale sjevernog Jadrana. Odgovori su ukazali na intenzivan ribolov u cijelom obalnom području, posebno u blizini ulaza u luke. Ciljane vrste prvenstveno su bile one s visokom komercijalnom vrijednošću, dok su hrskavičnjače uglavnom slučajni ulov, naročito *Mustelus* spp. Iako je 83 % ribolovaca tvrdilo da ih pušta žive, nedostatak studija o stopama preživljavanja nakon puštanja otežava procjenu utjecaja ove ribolovne aktivnosti na populacije hrskavičnjača.
Ključne riječi: Sredozemno more; obalno područje; pridnene hrskavičnjače; udičarski alati; upitnici

INTRODUCTION

Marine recreational fishing is a highly heterogeneous practice in terms of fishing gears and methods employed, with angling by hook and line being the main one (FAO, 2012). Globally, participation in this practice is estimated at about 10.6% of the population, corresponding to approximately 120 million recreational fishers across North America, Oceania, and Europe (Arlinghaus *et al*., 2021). In Europe, the number of recreational sea fishers has been estimated at around 8.7 million, including 2.8 million in the Mediterranean region. Participation rates vary across countries, ranging from 2.7% in Greece to 0.61% in Spain (Hyder *et al*., 2018). Specifically, in Italy, approximately 1.24 million individuals engage in this activity (Bolognini *et al*., 2022). In the Adriatic Sea marine recreational fishing accounts for 30 to 45% of artisanal fishery catches, as reported by Pranovi *et al*. (2016), in an area that also hosts intense pelagic and demersal commercial fisheries.

Despite being often size-selective (Cooke and Cowx, 2004), recreational fishing is commonly concentrated in coastal and estuarine areas, which frequently serve as nursery habitats for many species, thereby increasing the potential for impacting vulnerable life stages (McPhee *et al*., 2002), especially for those species that are relatively large at birth, such as elasmobranchs. Due to the difficulty of monitoring catches from recreational fishing there is often a lack of quantitative data on its impact (Shephard *et al*., 2021). As a consequence,

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citizen science and the local ecological knowledge can provide useful information about the catch per unit effort (CPUE), seasonality, abundance and estimated mortality at capture of threatened species, such as elasmobranchs, across various recreational fishing practices (Dicken *et al*., 2006).

Elasmobranchs can represent both bycatch (Crowder and Murawski, 1998) and target species in recreational fisheries (Gallagher *et al*., 2017), but few studies have investigated this interaction in the Mediterranean Sea. Most of the available studies focused only on the large pelagic shark species (Babcock, 2008; Panayiotou *et al*., 2020), while there are no evaluations on the interaction with demersal elasmobranch species in the area nowadays. In the Mediterranean Sea, the commercial and recreational fishing of elasmobranch species is regulated through national and international legislative frameworks, that include both binding and non-binding measures developed at different scales (e.g., United Nations, European Union, Mediterranean; see for review Giovos *et al*., 2024). For what concerns recreational fishery, some additional measures apply, and in particular the limit of 5 kg of total landing *per* person per day or one individual if this exceeds this weight (Guardia Costiera, 2024). In addition, recreational fishery is regulated through ICCAT (International Commission for the Conservation of Atlantic Tunas), with the prohibition of targeting and landing of several pelagic highly migratory species, as well as prohibiting the use of longlines for their catch (European Commission, 2023).

This study aimed to estimate the interactions between recreational fishing practices and demersal elasmobranch species along the western coasts of the North Adriatic Sea through questionnaires administered to local fishers.

MATERIALS AND METHODS

The Adriatic Sea is a semi-enclosed basin in the Mediterranean Sea, characterized by a north-to-south gradient in depth and productivity. The northern part of the Adriatic Sea is the shallowest and most productive sub-basin and is strongly influenced by riverine inputs and seasonal variations. The Venetian Lagoon is located on the western side of the Northern Adriatic Sea and is connected to the sea through three large (400-900 m) and deep (15-50 m) port entrances (Artioli *et al*., 2008).

Data were collected using an anonymous questionnaire administered *via* Google Forms, distributed through Facebook on several recreational fishing groups engaging fishers from the Venice lagoon and Venetian coast. The project was publicised through official Facebook and Instagram profiles of the Department of Biology of the University of Padova, between December 2022 and October 2023. The questionnaire targeted recreational fishers using hook and line techniques operating in the North-Western Adriatic Sea (in particular of the Veneto region) and included open-ended short answer questions (n=13) and multiple-choice questions (n=17) regarding target catches and bycatches of elasmobranchs (see Supplementary Material S1 for details), with a particular focus on species such as smoothhound sharks *Mustelus* spp., spiny dogfish *Squalus acanthias*, and several batoid species (e.g., common eagle ray *Myliobatis aquila*, bull ray *Aetomylaeus bovinus*, pelagic stingray *Pteroplatytrygon violacea*, common stingray *Dasyatis pastinaca* and skates *Raja* spp.) commonly present in Adriatic Sea. To avoid misidentification of elasmobranch species, the questions were accompanied by corresponding images or scientific illustrations. To obtain the most accurate possible indication of the coastal areas frequented by the fishers, the questionnaire included a map showing all relevant localities.

The data obtained from the questionnaires were then analysed using the statistical software R version 4.2.1. Descriptive statistics (mean ± standard deviation) were used to summarize the data. Based on the responses regarding the areas frequented by the fishers and the zones where the catches of the different elasmobranch species were reported, a map was created using QGIS software (3.32.1). The map represents a heatmap of fishing activity intensity, measured as the percentage of responses for each specific area and the exact locations where fishers reported catching elasmobranchs.

RESULTS AND DISCUSSION

A total of 132 questionnaires were collected from recreational anglers operating along the western coast of the Northern Adriatic Sea, particularly around the Venice area. Respondents ranged in age from 20 to 78 years (mean 40.5 ± 14.2 years), with fishing experience ranging from less than one year to a maximum of 70 years (mean 25.1 ± 16.5 years). Nearly half of them (49%) reported fishing from both shore and boat, 29% fished only from a boat, while the remaining 22% fished only from shore. The majority (74%) of the anglers used two to three rods and spent, on average, 5.8 ± 2.8 hours per day.

Fishing habits showed a strong seasonal pattern, with most anglers engaging in the activity once a week, especially during the summer season (Fig. 1). Almost half of the anglers (48%) preferred to fish during tidal changes, while the others did so during rising (17%) or falling (9%) tides. Additionally, 62% reported fishing both during the day and at night, 24% fished only during daylight hours, and the remainder only at night. Recreational fishers reported fishing mainly in areas in the vicinity of the port entrances (Fig. 2). These findings reveal a widespread and regular fishing effort across different times and conditions, involving both lagoon and coastal environments, and reflect a substantial level of exploitation by the recreational fishing sector, comparable to patterns observed in other Mediterranean regions, such as Cyprus, where the impact of recreational fisheries has, in some cases, surpassed that of commercial

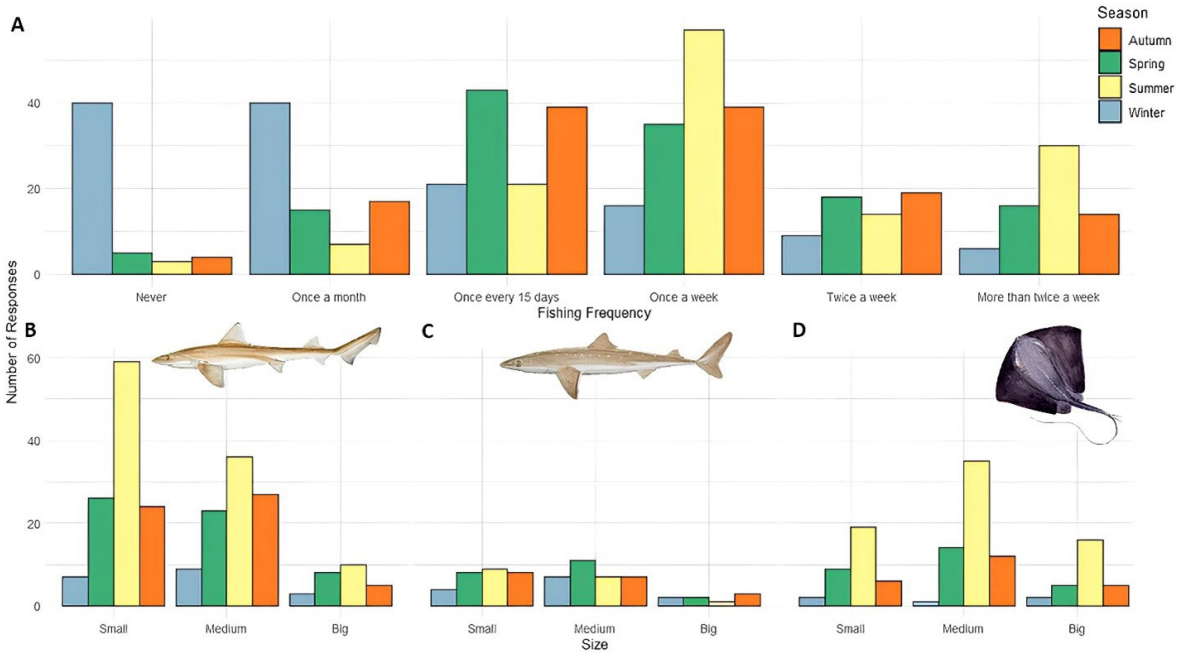

Fig. 1. Number of responses from anglers: frequency of fishing trips by season **(A)**; seasonal catch rates of *Mustelus* spp. of different sizes **(B)**; seasonal catch rates of *S. acanthias* of different sizes **(C)**; seasonal catch rates of batoids of different sizes **(D)**. Sizes are defined as: small: 30-50 cm total length (TL); medium: 50-100 cm TL; big: more than 100 cm TL.

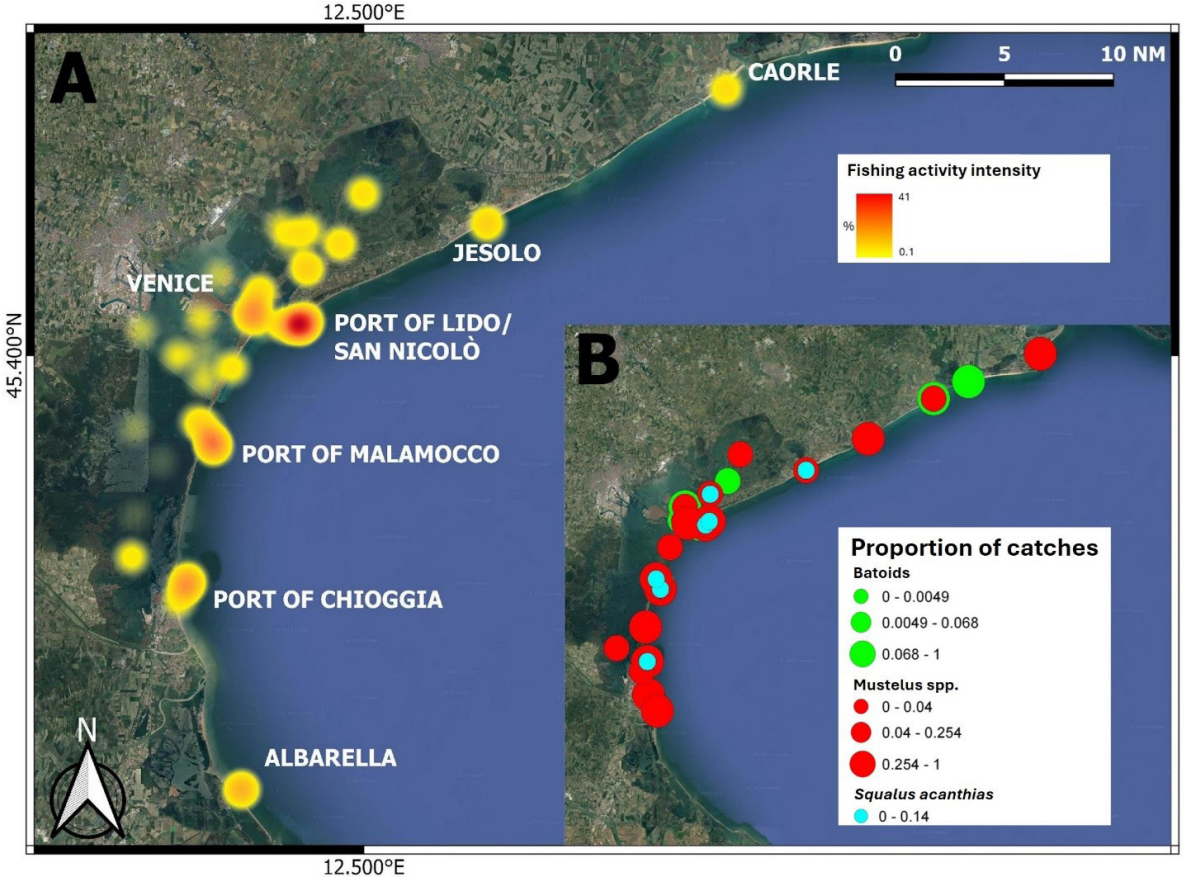

Fig. 2. Map of the distribution of fishing activities and elasmobranch catches according to information provided by recreational fishers. Heatmap of fishing activity intensity, measured as the percentage of answers on each specific area. The points with the highest frequency are in red **(A)**. Map of elasmobranch catches. The size of the points is proportional to the number of fishers reporting catching batoids (in green), *Mustelus* spp. (in red) and *S. acanthias* (in light blue) in the respective areas (Google Maps) **(B)**.

ones in terms of catch magnitude and species targeted (Michailidis *et al*., 2020).

Mustelus spp. were the most reported elasmobranch catch, generally found throughout the coast adjacent to the Venice Lagoon (Fig. 2). The majority of fishers (77%) reported having caught smoothhounds (*Mustelus* spp.) more than once, while the remaining only once or never in their lives. More than half of the anglers (58%) stated that they catch at least one smoothhound *per* fishing day, whereas the rest considered such catches rare. The catches mainly involved small individuals (30-50 cm total length (TL)), particularly in the summer season, while medium-sized individuals, over 50 cm TL, were caught with comparable frequency during spring, summer, and autumn (Fig. 1). The catches occurred similarly during day and night, and the most commonly used baits were polychaete worms (46%) and sardines (18%).

These results reflect the frequent occurrence of *Mustelus* spp. in the Northern Adriatic Sea (Barausse *et al*., 2014; Barbato *et al*., 2021), as also evidenced by the landings data from the Chioggia fleet, the most important in the Adriatic Sea, which recorded a total of 81.7 tonnes of these species in 2023 (Clodia database, 2025). Moreover, this study confirms their distribution along the coast adjacent to the Venice Lagoon, at least during the summer season, when the highest fishing effort is observed. This may have influenced the higher catch rates of small individuals during the summer, since this period aligns with the reproductive season of this species (Riginella *et al*., 2020), and coastal areas can serve as nursery grounds for juveniles, making them particularly vulnerable to capture.

Squalus acanthias showed rare occurrences, particularly in the most intensively fished areas (Fig. 2). The majority of anglers (77%) reported never having caught *S. acanthias*, and 4% reported having caught one only once in their lives. Among the 19% who reported catching them, 65% stated that they catch at least one *per* fishing day. The catches were reported to primarily occur in the spring for medium-sized individuals (50-100 cm TL) and in the summer for small individuals (30-50 cm TL; Fig. 1). Anglers reported catching them mostly during the day, and the most commonly used baits for catching them were sardines (50%) and polychaete worms (18%).

The less frequent catch of *S. acanthias*, a species occurring in the area (Barausse *et al.*, 2014), and regularly landed by the Chioggia fleet, with a total of 4.6 tonnes reported in 2023 (Clodia database, 2025), suggests a low overlap between recreational fishing activities and species distribution, likely limited to the port entrances where catches were reported. As observed for *Mustelus* spp., the main season of recreational fishing also overlaps with the reproductive season of *S. acanthias* (Bargione *et al*., 2019). Indeed, more small sized individuals are caught in this period, further highlighting the possible impact of recreational fishing on vulnerable life stages.

The distribution of the catches of batoids were primarily reported in the northern area (Fig. 2), which suggests that these fish may utilize specific habitats that require further investigation. A total of 41% of fishers reported catching batoids more than once in their life, while the rest had caught them only once or never. Additionally, 53% of those who had caught batoids stated that they catch at least one per fishing day, whereas the rest considered such catches rare. The catches were reported to mainly occur in the summer season and involve medium-sized individuals (50-100 cm TL; Fig.1). Anglers reported catching batoids mostly during the day, and the most commonly used baits for catching them were sardines (47%) and polychaete worms (15%).

These data indicate that batoid species are an important component of bycatch in local recreational fishing, with almost half of the fishers reporting their catch. Most of the catches occur predominantly during the summer and involve medium-sized individuals. This could be attributed to increased fishing effort during this period or may suggest the presence of seasonal dynamics influencing the occurrence of batoids. Further species-specific studies focused on batoids are needed to investigate these aspects.

The most frequently declared targeted species were the gilt-head bream (*Sparus aurata*), European sea bass (*Dicentrarchus labrax*), shi drum (*Umbrina cirrosa*) and sand steenbras (*Lithognathus mormyrus*), which together accounted for almost 50% of the total responses regarding target species (Table 1). Elasmobranchs were indicated as target species in about 8% of the responses. Among the anglers who reported regularly fishing for sharks, the majority (83%) stated that they release them, while 17% reported retaining them.

These results reflect a tendency to target species of high commercial value, as also noted by Stocco *et al*. (2024). In contrast, the relatively low percentage of anglers targeting elasmobranchs suggest that these species are not the main attraction for recreational fishing in the area but rather incidental catches. The high release rate may be associated with low consumption or, possibly reflect awareness of their vulnerability. As emerged from the review of marine recreational fisheries by Tarantino *et al*. (2025), recreational fishing activities seem to impact primarily higher trophic levels. In an area where elasmobranch populations are under high fishing pressure (Barausse *et al*., 2014), and with the expectation that recreational fishing activities may increase (Tarantino *et al*., 2025), it would be essential to investigate the impact of recreational fishing on the survival of these species once released (Lynch *et al*., 2010). The most abundant catches of elasmobranchs consist of small to medium-sized individuals, which are generally more vulnerable to capture (Ellis *et al*., 2017). Releasing individuals in poor condition or already dead can have the same impact as harvesting them, with severe repercussions on the population (Lynch *et al*., 2010). Given the current lack of a minimum landing size for these species

Table 1. Number of anglers who reported targeting each species (or taxonomic group), the percentage of total responses received (each angler could list multiple target species), and the proportion of anglers (out of the total 132) who target each species. Elasmobranch species are indicated in bold.

Common name	Scientific name	Number of responses	Percentage of total responses (%)	Percentage of anglers targeting each species (%)
Gilt-head bream	*Sparus aurata*	117	15.83	88.64
European sea bass	*Dicentrarchus labrax*	102	13.8	77.27
Shi drum	*Umbrina cirrosa*	75	10.15	56.82
Sand steenbras	*Lithognathus mormyrus*	69	9.34	52.27
Bluefish	*Pomatomus saltatrix*	52	7.04	39.39
Horse mackerels	*Trachurus* spp.	43	5.82	32.58
Atlantic mackerel	*Scomber scombrus*	39	5.28	29.55
Smoothhound	***Mustelus* spp.**	**35**	**4.74**	**26.52**
Leerfish	*Lichia amia*	30	4.06	22.73
Brown meagre	*Sciaena umbra*	29	3.92	21.97
Mullets	Mugilidae	27	3.65	20.45
Turbots	*Scophthalmus* spp.	22	2.98	16.67
Cuttlefish	*Sepia officinalis*	20	2.71	15.15
Batoids	**Batoidea**	**14**	**1.89**	**10.61**
Soles	*Solea* spp.	14	1.89	10.61
Atlantic bluefin tuna	*Thunnus thynnus*	8	1.08	6.06
Squid	*Loligo vulgaris*	7	0.95	5.3
Piked dogfish	***Squalus acanthias***	**7**	**0.95**	**5.3**
Little tunny	*Euthynnus alletteratus*	4	0.54	3.03
European eel	*Anguilla anguilla*	4	0.54	3.03
Conger eel	*Conger conger*	4	0.54	3.03
Gobies	Gobiidae	3	0.41	2.27
Dolphin fish	*Coryphaena hippurus*	3	0.41	2.27
Cephalopods	Cephalopoda	2	0.27	1.52
Scorpionfish	*Scorpaena* spp.	2	0.27	1.52
Weevers	*Trachinus* spp.	2	0.27	1.52
Blue crab	*Callinectes sapidus*	1	0.14	0.76
Saddled seabream	*Oblada melanura*	1	0.14	0.76
Atlantic bonito	*Sarda sarda*	1	0.14	0.76
Green wrasse	*Labrus viridis*	1	0.14	0.76
Blue shark	***Prionace glauca***	**1**	**0.14**	**0.76**

in Italy, raising awareness among fishers and promoting the adoption of best practices of release could limit the potential impacts of this practice.

This study provides essential insights into the patterns of recreational fishing along the western coast of the Northern Adriatic Sea, emphasizing the need for sustainable management of local fishery resources, particularly for vulnerable species such as elasmobranchs. Despite the relatively low targeting of these species, the high levels of incidental catches and the potential impact of recreational fishing on the survival of released individuals highlight the necessity for further investigation into the effects of this activity. It is crucial to develop initiatives that promote awareness and best practices among local fishers to minimize the negative consequences of recreational fishing on marine biodiversity and ensure the sustainability of this practice. Finally, this study underscores how citizen science can be a valuable tool for gathering information, thus guiding future research efforts.

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