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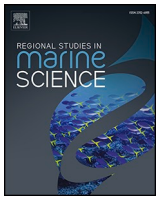

Insights into conservation success: Analysing shore angling before implementing a marine protected area

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ABSTRACT

In January 2024, the "Natural Marine Park of the Algarve Reef – *Pedra do Valado*" (NMPAR-PV; southern Portugal), a community-based Marine Protected Area (MPA) was formally classified, setting the scene for a new paradigm for co-creating Portuguese MPAs. While complying with the best practices for MPA establishment, this area also contributes to national and international conservation targets. Measuring the success of MPAs relies on the availability of the best scientific information, including baseline data on biodiversity, habitat and human activities characterization. Marine recreational fishing is a significantly important human activity within this recently designated MPA. Hence, the systematic collection of quantitative data on this activity is critical for determining its impacts and ensuring the preservation and protection of fisheries resource. This study aims to collect and analyze socioeconomic and ecological data on shore angling fisheries at NMPAR-PV, implementing surveys and instantaneous counting. Data from 325 questionnaires and 27 counting surveys conducted between February 2022 and February 2023 highlighted the importance of shore angling. The activity is primarily conducted by local Portuguese men, over 50, employed and with low formal education. Most recreational fishers supported the MPA's implementation, suggesting community care for conservation efforts. The annual fishing effort was estimated at 52 198 ± 6 631 angling hours, with peaks in Autumn. Annual catches, dominated by Scombridae and Sparidae species, were estimated at 10.41 ± 1.96 tonnes of fish. This study provides valuable insights into the evolution of recreational fishing activity within the MPA, addressing important information to assess its effectiveness.

1. Introduction

Marine Protected Areas (MPAs) are an effective tool for enhancing resilience and protecting marine ecosystems from threats (Roberts et al., 2017). In response to the current global crisis that is leading to ecosystem degradation and loss of biodiversity and habitats, there has been a notable increase in the number and size of protected areas worldwide over the past two decades (Maestro et al., 2019). Recently, the EU has set a target for achieving 30 % coverage of EU waters by MPAs by 2030, aligning with the United Nations (UN) Sustainable Development Goal 14 and the CBD target 3 from the Global Biodiversity Framework (adopted in late 2022) (European Commission, 2020; Convention on Biological Diversity, 2022; United Nations, 2015). At present, 4.2 % of Portuguese territorial waters are covered by MPAs according to (Horta e Costa et al., 2019). However, not all MPAs are the same, and their socio-ecological effectiveness depends on their design (size, zoning, level of protection; Claudet et al., 2008; Zupan et al., 2018; Ban et al., 2019), management and enforcement (Edgar et al., 2014; Gill et al., 2017), and stakeholders' engagement since the early stages of MPA design and implementation (Di Franco et al., 2016; Fidler et al., 2022).

In January 2024, the MPA "Natural Marine Park of the Algarve Reef – *Pedra do Valado*" (NMPAR-PV) was officially classified in the Algarve region, southern Portugal (*Resolution of the Council of Ministers n.º 1/2024*), aligning with national and international conservation goals. This MPA was established based on robust scientific information dating back

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to the 2000s and involved a ~3-year participatory process with 89 institutions contributing to the co-design of the area (Horta e Costa et al., 2022; Guimarães et al., 2023;). The NMPAR-PV, is a hotspot of species biodiversity and abundance, and is also important for multiple human activities, including commercial and recreational fishing, as well as marine tourism (Sales Henriques et al., 2018; Ressurreição et al., 2020).

The multi-use setting of the area highlights the significance of integrating all stakeholders into the MPA design since the early stages of its planning, to ensure its effectiveness as a conservation and management tool (Horta e Costa et al., 2022). The next challenge in implementing this MPA is the establishment of a co-management setting and the development of a management plan and. The plan will define the rules and regulations for the different users (most already agreed under the collaborative process), the socio-ecological monitoring and the future assessment of this MPA effectiveness. Informing MPA design and management with the best available information and conducting systematic and regular monitoring to assess and improve MPA effectiveness are central for MPA success (Christie and White, 2006; Claudet et al., 2008; Giakoumi et al., 2017; Gaines et al., 2010; Grorud-Colvert et al., 2021; Horta e Costa et al., 2022). Despite rare, collecting baseline socio-ecological data is key to disentangle other spatial-temporal effects independent from protection measures and to better understand MPA effectiveness - through a BACI (before-after-control-impact) monitoring design (Osenberg et al., 2011).

Marine Recreational Fishing (MRF) stands out as a significant human activity within the proposed MPA area as it has an intense and regular presence in the area, which was made evident in the preliminary census and in the participatory process (Ressurreição et al., 2020). In Portugal, MRF enjoys widespread popularity, with the participation of approximately 170–200 thousand individuals annually according to official licensing statistics (Hyder et al., 2018; DGRM, 2024). Numerous documented examples underscore the socioeconomic importance of recreational fishing worldwide, creating associated employment opportunities and generating substantial revenue for local regions (Rangel and Erzini, 2007; Hyder et al., 2018; Diogo et al., 2020; Pita et al., 2020). Further, it is increasingly evident, that MRF are responsible for an important part of fish removals and, in some documented cases, recreational exceed commercial catches (Allen et al., 2013; Coleman et al., 2004). Despite this evidence, several EU countries, including Portugal, lack a consistent national data collection program to gather information on target species, catches, effort, and socioeconomic aspects related to various fishing methods and regions within the country (Diogo et al., 2020). The systematic collection of quantitative data on MRF would play a crucial role in adapting current legislation to the activity, that should contribute to the preservation and protection of fisheries resources and their respective habitats (Rangel and Erzini, 2007).

In Portugal, three modes of MRF are regulated and require specific fishing licenses, which national citizens with Portuguese identification cards can require at any ATM: shore angling, boat angling and spearfishing (DGRM, 2022). Only in 2023, individual licenses for shore angling represented 56 % of the total issued licenses for recreational fishing in mainland Portugal, exceeding licenses for boat fishing, spearfishing, and general fishing (including the three modes of MRF; DGRM, 2022).

This study aimed at collecting social and ecological baseline data on shore angling fisheries in the NMPAR-PV before its implementation to assess its current status, and contribute to the future monitoring plan. The collected data provided and assessment of fishing effort, catch rates, total catches and overall related expenditures, as well the analysis of local fishers' perceptions and knowledge about the MPA.

2. Materials and methods

2.1. Study area

This study was conducted in the recently designated Natural Marine Park of the Algarve Reef - *Pedra do Valado* (NMPAR-PV), a Marine Protected Area (MPA) located in the Algarve region, southern Portugal (Fig. 1). The area extends along the coastline between the marina of Albufeira and the Alfanzina lighthouse, covering 156.4 km^2 of sea area. Of this, 63.7 km^2 are composed of rocky bottom or mixed sediments, while 92.7 km^2 consist of unconsolidated sediment (Horta e Costa et al., 2022). The marine biodiversity of this area has been thoroughly studied following several research projects since 2003, revealing exceptional natural heritage (Gonçalves et al., 2008, 2015). Overall, a total of 889 marine species have been reported, representing 70 % of all marine species recorded in the entire region of southern Portugal, and including species with conservation status, such as seahorses (Sales Henriques et al., 2018). According to the same authors, the area is also a multi-use hotspot, featuring small-scale commercial (gillnet, trammel net, longline, purse seine, and octopus's traps and pots) and recreational fishing, and marine tourism activities such as dolphin watching and cave sightseeing.

2.2. Sampling strategy

The characterization of shore angling activity was conducted using two distinct methods: 1) face-to-face questionnaire surveys employed to gather socioeconomic and fishing trip-related data (e.g., retained and discarded catches, time spent fishing, gear used, travelled distance to reach the fishing site, etc), as opinions and perceptions regarding the MPA design and implementation; and 2) instantaneous counts of anglers to assess fishing effort. The sampling effort lasted one year, from February 2022 to February 2023.

2.3. Face-to-face questionnaires surveys

The 'roving creel survey' method was used for developing onsite face-to-face questionnaire surveys, involving pre-establishing a randomly selected route where anglers were approached and interviewed while actively fishing (Pollock et al., 1995). Five transects of 5 km were defined to cover the entire coastal line of the MPA, and as many transects as possible were covered each day (Fig. 1). Two four-hour daily periods (morning and afternoon) were designated for the onsite surveys. During the interviews, fish retained by anglers was counted, weighed, measured, and identified, whenever possible to the species level. The questionnaires were divided into different sections, including demographic and socioeconomic data, general characterization of the activity, fishing trip data and personal opinions and perceptions towards the NMPAR-PV. Since the same fisher could be approached and surveyed multiple times, questions regarding demographic and socioeconomic information or opinions and perceptions were only asked the first time the angler was approached.

2.4. Instantaneous counting

Angling effort, measured in fishing hours, was estimated using instantaneous counts of shore anglers (following Malvestuto, 1996; Brouwer et al., 1997; Soupir et al., 2006; Veiga et al., 2010). Anglers were counted in the two daily periods (morning and afternoon) each sampling day, using a research vessel and following predefined nearshore transects to cover the entire coastal area from 200 m off the shore (Fig. 1). Since each survey, accounting for an individual counting event, lasted approximately 60 min, counting was assumed to be instantaneous, avoiding duplicating counts (Veiga et al., 2010). Stratification was applied to the season, the daily period (morning; afternoon), and the typology of day (weekend/holiday; weekday), following Veiga et al. (2010). Between February 2022 and February 2023 (one-year period), 54 surveys were conducted (27 sampling days), with a minimum of two per month, covering both typologies of the day.

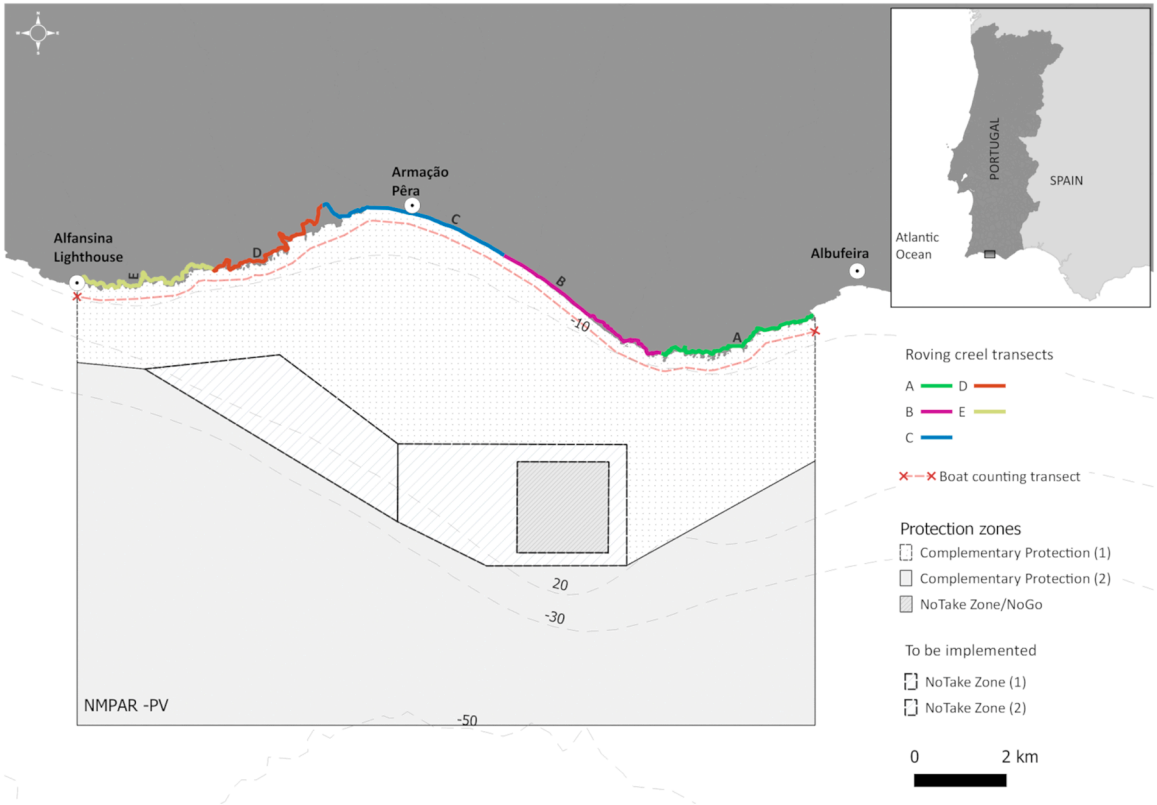

Fig. 1. Map of the study area (Natural Marine Park of the Algarve Reef - *Pedra do Valado* - NMPAR-PV) showing the zones with different protection levels and the respective shore-based transects (for questionnaire surveys) and vessel-based transects (instantaneous counting).

2.5. Data analyses

Catch and effort calculations followed the procedures of Lockwood et al. (1999). Catch rates (R) measured in both the quantity and weight of fish captured per fishing hour (CPUE: in number - Nh^{-1}; and in weight - Wh^{-1}), were derived from aggregated data collected during face-to-face questionnaires surveys, employing the "multiple day estimates" method. This approach is particularly suitable when multiple fisheries data are available per sampling day, as was the case in this study. The dataset encompassed both total catches (including discards) and harvested catches (excluding discards). To estimate the catch rates R, as suggested by Pollock et al. (1995), Lockwood et al. (1999), and Erzini et al. (2008), we employed the mean of ratios estimator:

$$\overline{R}_{ws} = \frac{1}{n}\sum_{i=1}^{n}\frac{c_{wsi}}{h_{wsi}},$$

where 'w' is the typology of day, 's' the season, 'c' the total catch in number or weight by fisher 'i', 'h' the number of fishing hours of fisher 'i', and 'n' the total number of fishers interviewed. The sampled variance of the catch rate is denoted by V_R.

To estimate the fishing effort (E_{ws}), expressed in hours, we first obtained the mean and the variance of the daily counts, which are used to calculate the mean daily number of fishers observed in each season and typology of day $\overline{N}_{ws}$ and its variance $V_{N_{ws}}$. Considering the daylight fishing hours and the number of fishing days, the fishing effort was then estimated as follows:

$$E_{ws} = H_s \quad D_{ws}\overline{N}_{ws}$$

where, H_s is the number of daylight fishing hours in season 's', and D_{ws} the number of fishable fishing days (days with atmospheric conditions suitable for practicing the activity, following (Veiga et al., 2010) in season 's' and day typology 'w'. The days of winds exceeding 18 knots were excluded based on historical data from the Windguru meteorological site (Windguru, 2023). The variance of the fishing effort was estimated as follows:

$$V_{E_{ws}} = (H_s D_{ws})^2 V_{N_{ws}}$$

Since the estimated of the fishing effort by season and day typology are independent, their sum was used to obtain the total catch for each season or day typology. The estimation of the total annual fishing effort for the 12-month survey period was obtained by summing the fishing effort for each season and day typology.

The estimation of the mean catch for each season and typology of day was obtained by multiplying the CPUE (in weight or number) by the fishing effort. The estimate of the yearly total catch was also obtained by summing the total catch for each season and day typology.

An unbiased estimator of the variance of the total catch (Goodman, 1960) was given by:

$$V_{C_{ws}} = E_{ws}^2 V_R + \overline{R}_{ws} V_{E_{Ws}} - V_R V_{E_{ws}}$$

To estimate the hourly expenditures 'HC' we also used the means of ratios estimator. In this case, the ratio calculated was between the total expenditure of the fishing trip (bait, food and beverages, fuel, equipment, other items, and total) and the predicted number of hours of that fishing trip. The estimation was obtained by season 's'. The estimation of the annual expenditures by season, was then obtained by multiplying the daylight fishing hours and the number of fishing days, by the hourly expenditures:

$$AC_s = H_s D_s HC_s$$

The annual expenditure was obtained by summing the total expenditures by season. Using the sample variance of the hourly expenditure V_{HC}, the estimated variance of the annual expenditures was given by:

$V_{AC} = (H_s D_s)^2 V_{HC}$

All statistical analyses were conducted using the R Project, version 4.2.2 (R Core Team, 2022). The level of significance used was 0.05. Shapiro-Wilk test, the analysis of the skewness and the kurtosis coefficients were used to evaluate the normality assumption of the number of anglers observed during the instantaneous counting, the CPUE and annual expenditures. The homogeneity of variances was evaluated with the Levene test. Two-way ANOVA test was performed to compare the number of anglers observed during the instantaneous count survey by season, where a square root transformation on data was done to guarantee the normality and homogeneity of variances assumptions. Due to the lack of these assumptions, nonparametric one-way ANOVA (Kruskal-Wallis test) was used to test the differences in CPUE and annual expenditures between season. Dunn's test was used for post hoc comparisons with Bonferroni correction. The Mann-Whitney-Wilcoxon test was used to compare the number of anglers observed during the instantaneous count, CPUE and annual expenditures by day type.

Study limitations

Several limitations were faced during this study. Firstly, due to safety concerns, surveys could not be conducted at night, which affected the estimations of nocturnal fishing activity. According to several interviewees during informal conversations, night fishing is more popular in the summer to avoid intense daytime heat and the high number of tourists. In terms of catches, Diogo and Pereira (2016) also found differences in catches composition, fish sizes between daytime and night-time in shore angling fishery in the mid-Atlantic. Secondly, the experience level of individual anglers was not factored into our estimations, potentially affecting the accuracy of our findings. Lastly, it would have been important to consider the description of all recreational fishing modes occurring in the area. However, due to logistical and budget constraints, this was not feasible. Therefore, we opted to focus exclusively on shore angling, as it is the most representative recreational fishing mode in Portugal (DGRM, 2022) and in the area (Ressurreição et al., 2020). Despite these limitations, our study employs complementary methods and approaches to understand the dynamics of this very important fishery in the region. The estimates obtained suggest an important contribution of shore angling catches to the area. Our findings provide a baseline for monitoring and comparing future changes in catches, fishing effort, and CPUE in the shore-based recreational fishing activity.

3. Results

3.1. Face-to-face questionnaires

During face-to-face questionnaire surveys, 402 anglers were observed and 228 were interviewed, accounting for 325 fishing episodes registered (81 % response rate). Fifty-three anglers were interviewed on multiple occasions. Of the interviews conducted for the study, 60 % were carried out on the cliffs, while the rest were conducted on the beach (20 % from the sand and 20 % from rocky outcrops).

3.1.1. Socioeconomics, demographics and expenditures

Most of the interviewed anglers were Portuguese (90 %), male (96 %), aged over 50 years (50 %), married (50 %), residing in the nearby localities of study area (69 %), and 73 % reported having a family of 2–4 members (Table 1). The last completed formal educational level of 38 %of the anglers was the first cycle of basic education, and only 7 % had completed university studies. Regarding the working status, 68 % of the fishers declared being actively employed, while 22 % stated that they were retired. The monthly income of 32 % of the interviewees ranged between €751 and €1 250, and 22 % declared incomes below the minimum legal wage (705€ at the time of the survey; Pordata, 2023). In terms of direct expenditures, the average spent per fishing trip was €10.2 ± €11.3 (± SD), divided by: €4.7 ± €7.6 in bait, €3.5 ± €4.2 in fuel for transport, €1.2 ± €3.5 in food and beverages, €0.6 ± €2.4 in fishing equipment and €0.1 ± €0.9 in other items. No significant differences were found among seasons and between weekends and weekdays for total expenditures ($X^2_{(3)}$= 0.45371, p = 0.9289 and W= 9344, p = 0.1887, respectively).

Table 1
Demographic characterization of the anglers interviewed during the questionnaire surveys carried out in the NMPAR-PV between February 2022 and February 2023. [a]Education level: 1st cycle of basic education: 4 years of schooling, complete basic education: 9 years of schooling, secondary: 12 years of schooling, higher education: university degree. [b]No info: Unanswered, not applicable, or lack of response. [c]Residents of the Municipalities of Lagoa, Albufeira and Silves (municipalities of the NMPAR-PV area).

Demographic characteristics	Category	Number	Percentage (%)
Age	≤ 20	8	3.5
	21–30	24	10.5
	31–40	32	14.0
	41–50	44	19.3
	51–60	52	22.8
	> 60	63	27.6
	No info[b]	5	2.2
Civil status	Married	114	50.0
	Single	76	33.3
	Divorced	20	8.8
	Widowed	2	0.9
	De facto union	12	5.3
	No info[b]	4	1.8
Gender	Female	9	3.9
	Male	219	96.1
Family aggregate	1	33	14.5
	2–4	166	72.8
	> 5	15	6.6
	No info[b]	14	6.1
Education level[a]	1st cycle of basic education	86	37.7
	Complete basic education	58	25.4
	Secondary education	58	25.4
	Higher education	16	7.0
	No info[b]	10	4.4
Professional situation	Employed	155	68.0
	Unemployed	13	5.7
	Student	5	2.2
	Retired	50	21.9
	No info[b]	5	2.2
Monthly income	€0	1	0.4
	€1 - €250	3	1.3
	€251 - €500	13	5.7
	€501 - €750	33	14.5
	€751 - €1000	46	20.2
	€1001 - €1250	27	11.8
	€1251 - €1500	10	4.4
	€1501 - €1750	8	3.5
	€1751 - €2000	6	2.6
	€2001 - €2500	3	1.3
	> €2500	15	6.6
	No info[b]	63	27.6
Nationality	Portuguese	204	89.5
	Other	24	10.5
Residence	Nearby NMPAR-PV area[c]	158	69.3
	Algarve excluding NMPAR-PV area	33	14.5
	Other	37	16.2

3.1.2. Shore angling patterns

During onsite surveys, half of the interviewees (50 %) declared that shore angling was their only and most important leisure activity, while 37 % included it among other relevant hobbies. In order to measure and weight catches, 25 % and 21 % declared using rulers and scales, respectively. Half of the anglers (50 %) reported being accompanied by friends and/or family members, while the other half indicated that they were fishing alone. The average number of rods and hooks used during the interviews was 1.4 (± 0.6) and 1.6 (± 1.0), respectively. The most used fishing techniques were buoy [surface] fishing (55 %) and bottom

fishing (38 %), while the rest was divided among different methods such as surfcasting (4 %), spinning (2 %), or others (1 %).

3.1.3. Compliance with legislation

Overall, 2.4 % of the retained catches were below the respective minimum landing size limits. No angler declared exceeding exceeded the 10 kg daily bag limit. The majority of catches were intended for personal consumption (78 %), while 19 % of caught fish were released back into the sea (of which 93 % were undersized and 7 % were non-target species). Only 2 % of the interviewed anglers declared offering their catches to others, and catch-and-release, as a principle, was occasional. Approximately 96 % of the surveyed anglers reported having a fishing license.

3.1.4. 3.1.4 Attitudes and perceptions towards the Marine Protected Area NMPAR-PV

Anglers were asked about their opinions on several aspects of the NMPAR-PV (Fig. 2). The majority of the interviewed reported not having sufficient information about the MPA (64 %), while 22 % had heard something about it, and only 9 % claimed to be fully informed. After being briefly informed about the process and content of the NMPAR-PV proposal (Horta e Costa et al., 2022; Guimarães et al., 2023), 65 % evaluated the establishment of the marine park as positive or very positive, with only 8 % assigned a negative evaluation ('unsatisfied'). Most interviewees (62 %) noticed a decrease in fish stocks in the area over the past five years, with the majority agreeing that the decline was significant. The perceived primary causes cited for this decline included commercial fishing (28 %), marine pollution (23 %), illegal fishing (13 %), and other factors (9 %). Among the other causes mentioned, marine tourism companies (i.e., dolphin-watching tour operators) were highlighted. Regarding the potential perceived impacts of the marine park, most of the interviewed fishers expressed optimism believing that the impact in the marine ecosystem and the local economy would be positive or very positive (74 % and 37 %, respectively). When asked about the impact of the NMPAR-PV in their fishing activity 46 % expected a positive or very positive impact, while 26 % were neutral. Only 8 % anticipated a negative effect. The same trend was showed when the question referred to the impact on their catches (40 % positive, 15 % neutral and 5 % negative). It should be noted that throughout the survey, some respondents stated they lacked enough information to form an opinion or choose not to respond (No answer/Don't know). This was evident among the 82 % of anglers who opted not to express an opinion regarding the participatory process that led to the NPMAR-PV, and the 74 % who did not comment on the zoning proposal. However, in these specific questions, the proportion of 'negative' responses was notably low, being less than 1 % and 2 %, respectively.

3.1.5. Catch characterization

During the surveys, 85 % of the participants reported catching at least one fish. More than 80 % of the interviewees declared having a target species, and over 50 % more than one. The Sparidae family was the group most targeted (White seabream, *Diplodus sargus* 29 %, Gilthead seabream, *Sparus aurata* 19 %, Two-banded seabream, *Diplodus vulgaris* 5 %), while other mentioned species were Chub mackerel, *Scomber colias* (16 %), European seabass, *Dicentrarchus labrax* (12 %) and Horse mackerel, *Trachurus trachurus* (11 %). A total of 804 individuals (153.7 kg) of at least 27 species were caught or reported, most belonging to the Scombridae and Sparidae families, accounting for 43 % and 42 % of the total catch by number, respectively (Table 2). More than half of the recorded species have commercial interest, according to the National Institute of Statistics (INE, 2023). Catches in number and mass were dominated by *S. colias* (number: 39 %, mass: 39 %), *D. sargus* (number: 22 %, mass: 23 %), and *D. vulgaris* (number: 14 %, mass: 9 %). *Scomber colias* was the most frequently caught species during Spring

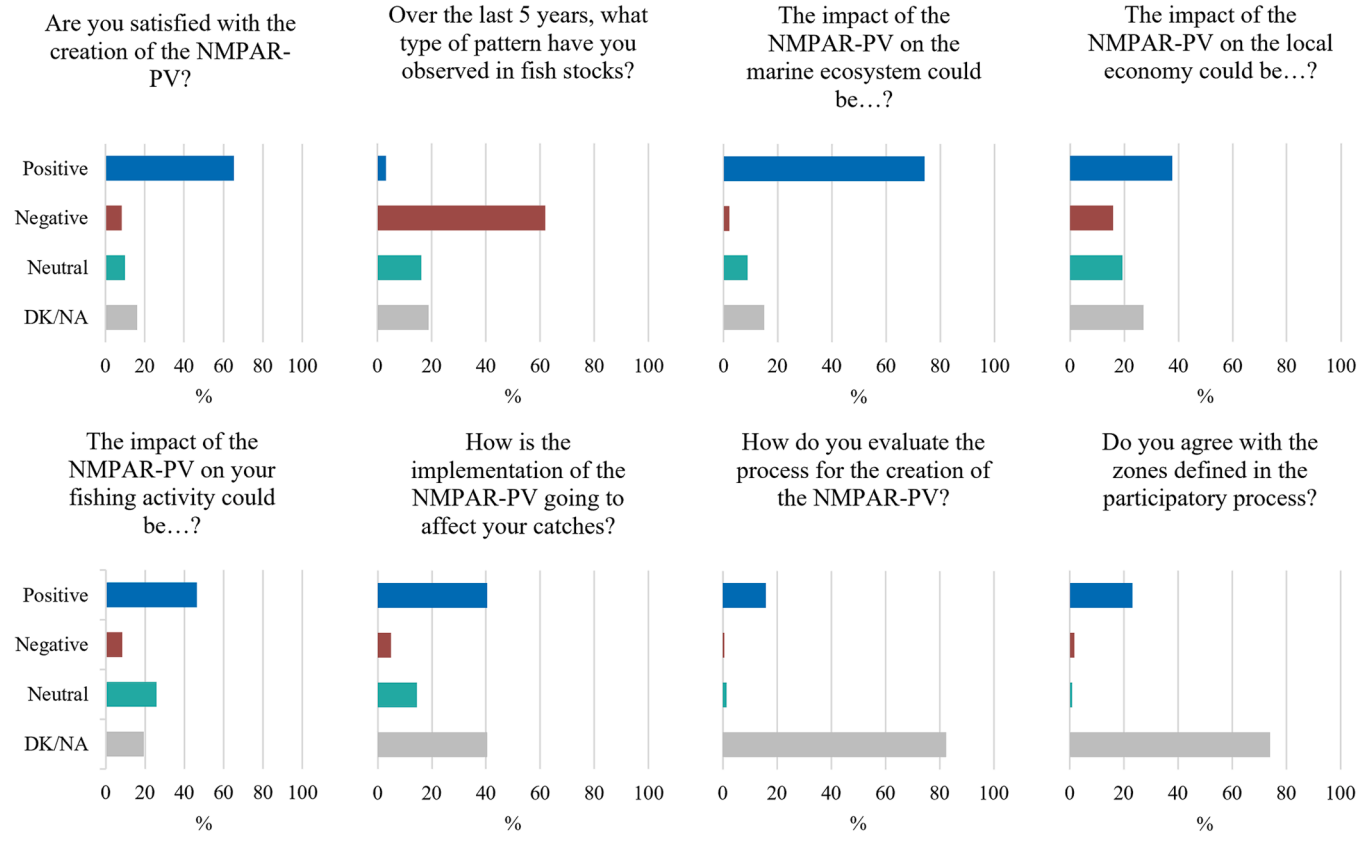

Fig. 2. Opinions of marine recreational anglers recorded in the questionnaire surveys carried out in the NMPAR-PV between February 2022 and February 2023. DK/NA= No answer/Don't know.

Table 2
Catch composition of the fishing events accompanied during the questionnaire surveys conducted between February 2022 and February 2023 (one-year period). Species, number, average mass (± SD), average length (± SD), estimated catch (± SD), CPUE: Catch Per Unit of Effort (± SD), percentage of species discarded, main discard reason, percentage of target species reported, and commercial interest species are shown. *Including commercially traded species in the mandatory Docapesca first auction place, according to the National Institute of Statistics 2002 and those with a minimum landing size defined by the European legislation (Regulamento (UE) 2019/1241).

	Number (N)	Average weight (Kg ± S.D)	Average length (cm ± S.D)	Estimated catch (Kg ± S.D)	CPUE (Kg*angler^{-1}*hr^{-1} ± S.D)	Discarded (%)	Main discard reason	Target species (%)	Commercial interest*
Balistidae									
Balistes capriscus	2	1.33 ± 0.39	46.3 ± 4.6	175.3 ± 124.5	0.003 ± 0.04	0.0		< 1.0	
Belonidae									
Belone belone	27	0.13 ± 0.56	47.8 ± 6.8	330.4 ± 168.8	0.005 ± 0.03	0.1	Undesired		
Carangidae									
Trachurus trachurus	21	0.13 ± 0.04	24.3 ± 2.3	189.9 ± 77.5	0.006 ± 0.04	0.0		10.7	Yes
Trachinotus ovatus	2	0.35 ± 0.07	34.9 ± 1.6	41.7 ± 30.0	0.002 ± 0.02	0.0			
Engraulidae									
Engraulis encrasicolus	1	0.02	13.8	1.3	< 0.001	0.0			Yes
Gobiidae									
Gobius spp.	2	0.03 ± 0.02	12.5 ± 3.5	17.2 ± 17.2	0.002 ± 0.02	0.0		< 1.0	
Labridae									
Coris julis	13	0.05 ± 0.03	16.2 ± 3.0	36.3 ± 14.0	0.001 ± 0.00	0.4	Undersize		
Symphodus melops	24	0.05 ± 0.02	15.8 ± 2.0	38.2 ± 14.9	0.001 ± 0.01	79.2	Undersize	< 1.0	
Labrus bergylta	1	0.08	16.5	8.9	< 0.001	0.0			
Loliginidae									
Loligo vulgaris	2	0.55 ± 0.45	27.3 ± 10.3	82.0 ± 70.5	0.002 ± 0.001	0.0		1.0	Yes
Moronidae									
Dicentrarchus labrax	2	0.77 ± 0.72	40.5 ± 14.8	40.0 ± 32.5	0.001 ± 0.003	0.5	Undersize	12.3	Yes
Dicentrarchus puntactus	3	0.60 ± 0.09	39.0 ± 1.3	112.0 ± 101.3	0.003 ± 0.003	0.0		1.4	
Mugilidae									
Chelon labrosus	15	0.30 ± 0.20	28.5 ± 9.7	388.6 ± 175.0	0.006 ± 0.05	0.2	Undersize	1.4	Yes
Scombridae									
Sarda sarda	1	0.10	20.0	4.1	< 0.001	100.0	Undersize		Yes
Scomber colias	310	0.19 ± 0.04	27.6 ± 2.4	3 796.5 ± 1066.2	0.107 ± 0.47	3.9	Undesired	15.8	Yes
Scomber scombrus	32	0.18 ± 0.04	28.2 ± 1.5	333.1 ± 191.1	0.011 ± 0.12	0.0			Yes
Scorpaenidae									
Scorpaena porcus	1	0.30	26.5	60.3	< 0.001	0.0			
Scorpaena spp.	3	0.13 ± 0.02	18.8 ± 1.3	13.3 ± 9.4	< 0.001	100.0	Undesired		
Sepiidae									
Sepia officinalis	2	0.61 ± 0.41	25.0 ± 4.2	159.7 ± 159.7	< 0.001	0.0		< 1.0	Yes
Sparidae									
Boops boops	2	0.17 ± 0.05	26.5 ± 3.0	59.8 ± 47.9	< 0.001	50.0	Undesired		Yes
Diplodus bellottii	3	0.06 ± 0.00	15.1 ± 0.1	22.4 ± 17.4	< 0.001	33.3	Undersize		
Diplodus cervinus	2	0.27 ± 0.13	27.2 ± 8.5	20.9 ± 16.2	< 0.001	0.0			Yes
Diplodus sargus	175	0.20 ± 0.18	20.8 ± 6.2	2 699.2 ± 812.1	0.046 ± 0.15	34.9	Undersize	29.2	Yes
Diplodus vulgaris	114	0.13 ± 0.09	18.8 ± 4.3	773.3 ± 179.2	0.019 ± 0.07	29.8	Undersize	4.7	Yes
Diplodus spp.	5	0.05 ± 0.01	14.0 ± 1.4	22.8 ± 17.6	< 0.001	100.0	Undersize		
Oblada melanura	1	0.01	16.4	0.5	< 0.001	0.0			
Pagellus erythrinus	2	0.03 ± 0.00	13.0	12.6 ± 12.6	< 0.001	100.0	Undersize		Yes
Pagrus pagrus	3	0.75 ± 0.43	35.0 ± 9.2	397.6 ± 327.2	0.004 ± 0.003	0.0		< 1.0	Yes
Sparus aurata	17	0.58 ± 0.32	33.4 ± 5.5	573.6 ± 189.5	0.011 ± 0.05	0.0		19.3	Yes
Spondyliosoma cantharus	15	0.12 ± 0.05	20.1 ± 4.0	116.7 ± 45.5	0.002 ± 0.01	6.7	Undersize		Yes
Trachinidae									
Trachinus draco	1	0.19	31.0	14.7	< 0.001	0.0			

(61 % of the recorded fishing events) and Summer (49 %), while *D. sargus* was the dominant species in Autumn (25 %) and Winter (71 %). The overall catch rate (including harvested and discarded catches) was 0.24 kg angler^{-1} h^{-1} and 1.3 fish angler^{-1} h^{-1}. Generally, the mean CPUE was different between seasons ($X^2_{(3)}$= 20.58, $p < 0.001$ for kg of and $p = 0.02$ for number of fish), and Summer CPUE was significantly higher than in Winter and Autumn CPUE ($p < 0.001$). The harvest rate was 0.23 kg angler^{-1} h^{-1}. The catch rates in weight of each of the three dominant species exhibited differences among seasons (Fig. 3) ($X^2_{(3)}$= 19.18, $p < 0.001$ for *D. vulgaris*, $X^2_{(3)}$= 10.62, $p = 0.04$ for *D. sargus*, and $X^2_{(3)}$= 35.82 $p < 0.001$ for *S. colias*). For *D. sargus* and *D. vulgaris*, the catch rates were significantly higher in Summer than in Winter ($p = 0.024$ and $p < 0.001$, respectively). For *S. colias*, the catch rates were significantly higher in Summer and Spring compared to the Winter season ($p < 0.001$ in both cases), and in the summer season, they were significantly higher than in the Autumn season ($p < 0.001$).

3.2. Instantaneous counting

3.2.1. Fishing effort

Overall, 887 shore anglers were recorded during the 27 instantaneous counting events undertaken in the NMPAR-PV, with significant differences between the average of the number of anglers registered per day on weekdays (11.5 ± 2.7 SD) and weekends (21.1 ± 2.0) (two-way ANOVA, $F_{(1,46)}$= 13.96, $P < 0.001$) (Fig. 4) and a significantly higher mean of the number of anglers registered daily for Autumn (24.0 ± 5.6) when compared to Summer (8.9 ± 1.4) (two-way ANOVA, $F_{(3,46)}$= 3.53, $P = 0.02$). The total annual fishing effort for the 12-month survey period

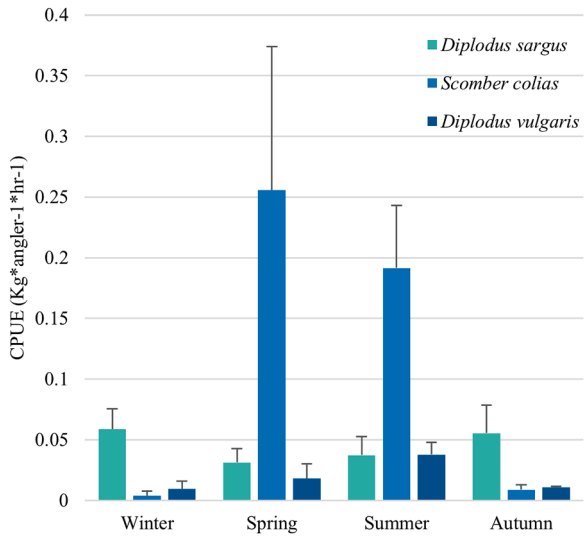

Fig. 3. Estimated catch rates (CPUE in number - Nh^{-1}; and in weight - Wh^{-1}) by season for the three most caught species (*Scomber colias, Diplodus sargus* and *D. vulgaris*) registered in the questionnaire surveys conducted in the NMPAR-PV between February 2022 and February 2023 (one-year period).

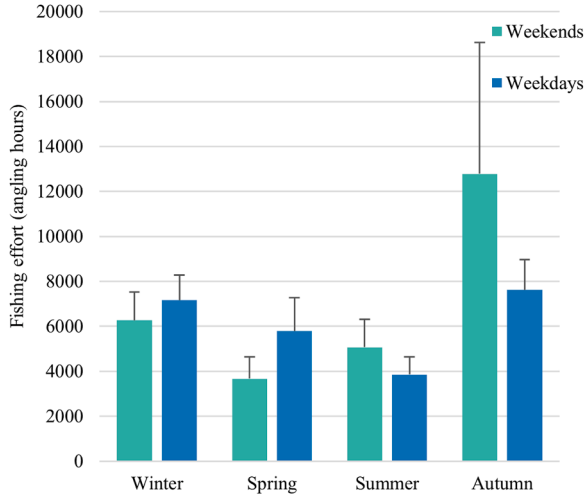

Fig. 4. Estimated fishing effort (angling hours) for shore angling in the NMPAR-PV by season and during weekdays and weekends between February 2022 and February 2023 (one-year period).

was estimated in 52 198 ± 6 631 angling hours. Autumn was the season with the highest estimated fishing effort (20 398 ± 5 991 hours), while in the remaining seasons it ranged from 8 920 ± 1 467 fishing hours (Summer) to 13 423 ± 1 685 fishing hours (Winter) (Fig. 5).

Anglers were distributed along the entire area, but the highest density of anglers was observed in two different sections of the area (Fig. 5): (1) the Albandeira fishing spot (Albandeira Arch and Algar de Albandeira), which coincided with the most densely represented fishing zone in the questionnaire surveys, and (2) the eastern side of the Evaristo beach. Cliffs (61 %) were the preferred fishing locations, followed by sandy beaches (23 %).

3.2.2. Annual estimated catches and fishing-associated expenditure

Approximately 10.4 ± 2.0 tonnes of fish and 54 189 ± 9 464 individuals were estimated to be caught by shore anglers during the study period. Of these, 10.1 ± 1.9 tonnes of fish and 49 048 ± 8 763 individuals were estimated to be retained. The estimated harvest in Winter (1 092 ± 288 kg; 5 044 ± 1 206 individuals) was lower than in the other seasons (Table 3). *Scomber colias*, *D. sargus* and *D. vulgaris* were the most caught and retained species, representing 60 % and 70 % of the total harvest by number and weight, respectively. Seasonally, the highest harvest estimates for *D. sargus* were observed during the cold seasons (Autumn: 1 236 kg and 4 572 individuals; Winter: 781 kg and 3 114 individuals), while the opposite trend was noted for *S. colias* (Spring: 1 811 kg and 9 057 individuals; Summer: 1 623 kg and 8 642 individuals). *Diplodus vulgaris* exhibited relatively consistent values throughout all seasons, with the lowest numbers recorded during Winter (75 kg and 467 individuals).

Based on the average daily direct expenditure on the items considered and the angling effort obtained from the instantaneous counts, anglers spent an estimated total amount of €185 643 spent between February 2022 and February 2023. There were no significant differences of costs between seasons ($X^2_{(3)}$= 1.22, p = 0.748). The total estimated costs are divided in the following items: bait (€78 342) accounted for most of the estimated direct expenses, followed by fuel (€71 918), food and beverages (€24 081), equipment (€12 492), and other items (€2 473) (Table 4).

4. Discussion

MPAs are designated zones where human activities are limited to protect and preserve marine life and ecosystems. By allowing recreational fishing, MPAs can balance the need for conservation with the desire for public engagement and enjoyment. This study shows that the Natural Marine Park of the Algarve Reef – *Pedra do Valado* (NMPAR-PV), is an important area for recreational shore angling in terms of effort, catches and local associated economies, justifying the need for a regular monitoring of this fishery. It also suggests fishers are aware of catch declines in the recent years and that they are supportive, and expect, ecological and social benefits from this recently designated MPA. This work represents an invaluable baseline characterization of this activity that will contribute to improve the quality of future socio-ecological assessments and inform decisions towards an effective MPA.

We assessed the social component by conducting face-to-face questionnaires, allowing to characterize the angler sociodemographic profile and the fisheries dynamics. Shore angling in this area is conducted mainly by resident Portuguese males employed, married, aged over 50, and with a low formal education level. The angler profile identified in this study is similar to those described in other Portuguese regions and seems to have remained relatively unchanged over time, aligning with studies on MRF conducted in Portugal over the past decades (Rangel and Erzini, 2007; Veiga et al., 2010; Ressurreição et al., 2020; DGRM, 2022). However, the average monthly income of most anglers of this region indicates an increase if compared to the income reported in previous studies (€501-€1000 in Erzini et al. 2008 and in Veiga et al. 2010; €750-€1250 in the current study). This could be due to an overall increase of the minimum wage at the national level, which grew from €497 in 2008 to €705 in 2022 (Pordata, 2023). In other countries where fisher's sociodemographic profiles were studied, anglers are also predominantly men aged between 40 and 50 years, but they often have a higher level of formal education, usually exceeding secondary education (Morales-Nin et al., 2005; Pita et al., 2018; Tunca et al., 2016). Although the employment status of most anglers is consistent with other countries, in Spain, the unemployment rate among anglers is significantly higher than the one observed in this study (Gordoa et al., 2019). These differences at the sociodemographic level may reflect variations in economic conditions, cultural values, and access to recreational opportunities across countries. Therefore, it is important to consider regional socio-economic dynamics when designing management strategies to balance conservation goals with the needs and desires of the fishing community.

Despite the Algarve being a highly touristic destination, only 10 % of the interviewees were foreign, and just 16 % referred inhabiting outside the Algarve region. As this area is predominantly used by local anglers that revealed an overall support of the MPA, a reasonable

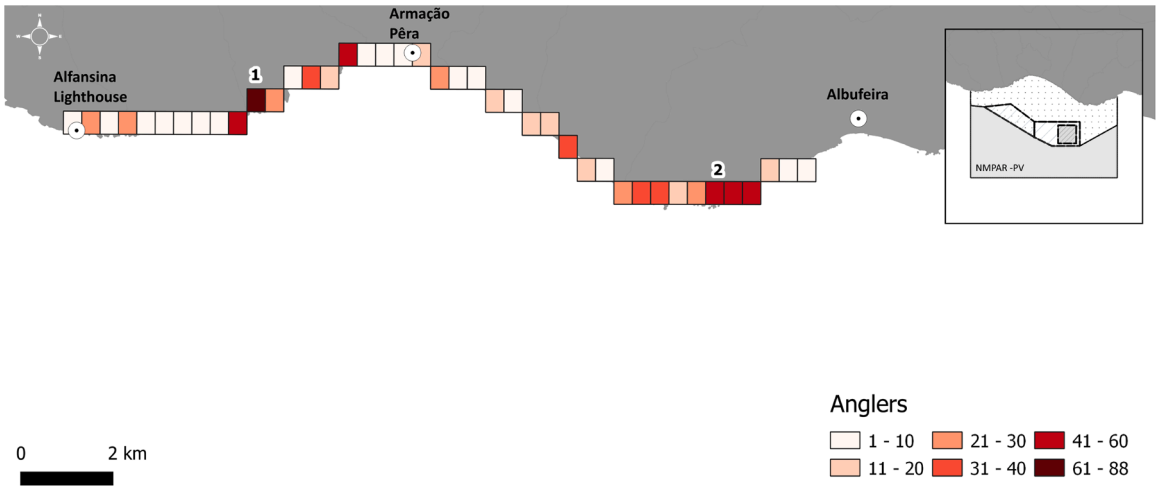

Fig. 5. Map of the study area (NMPAR-PV) showing the total number of recorded anglers during the instantaneous counts. 1: Albandeira arch; 2: Evaristo beach.

Table 3
Total catch estimates (harvest only) by weight (kg) and number for all species and for the three most frequently captured species (*Scomber colias, Diplodus sargus* and *D. vulgaris*) by season in marine shore angling at the NMPAR-PV between February 2022 and February 2023 (one-year period).

	Scomber colias		*Diplodus sargus*		*Diplodus vulgaris*		Total harvest	
Season	Weight (Kg ± SD)	Number ± SD	Weight (Kg ± SD)	Number ± SD	Weight (Kg ± SD)	Number ± SD	Weight (Kg ± SD)	Number ± SD
Winter	35 ± 35	124 ± 124	781 ± 243	3 114 ± 866	75 ± 55	467 ± 319	1 092 ± 288	5 044 ± 1 206
Spring	1 811 ± 898	9 057 ± 4 375	207 ± 86	780 ± 290	124 ± 83	1 105 ± 842	2 605 ± 1 035	11 954 ± 4 737
Summer	1 811 ± 898	8 642 ± 2 922	309 ± 137	1 091 ± 459	272 ± 87	1 469 ± 435	3 079 ± 728	16 363 ± 3 931
Autumn	203 ± 118	1 051 ± 619	1236 ± 729	4 572 ± 2 623	121 ± 71	896 ± 515	3 040 ± 1 386	11 791 ± 5 448
Total	1 623 ± 549	18 847 ± 5 299	2 532 ± 785	9 558 ± 2 815	592 ± 150	3 936 ± 1 125	9 815 ± 1 898	45 141 ± 8 307

Table 4
Estimated direct expenses (bait, fuel, food and beverages, equipment, other items; €) by season incurred between February 2022 and February 2023 (one-year period) based on the information collected in the questionnaire surveys and the angling effort obtained from the instantaneous counts.

Season	Bait (€ ± SD)	Fuel (€ ± SD)	Food and beverages (€ ± SD)	Equipment (€ ± SD)	Others ítems (€ ± SD)	Total (€ ± SD)
Winter	23 607 ± 13 028	22 294 ± 12 690	10 691 ± 8 760	3 137 ± 4 629	417 ± 1670	60 444 ± 21 727
Spring	13 203 ± 8 336	6 696 ± 5 872	1 811 ± 3 051	1 991 ± 3 126	2 056 ± 3 454	25 756 ± 12 226
Summer	15 496 ± 9 153	13 821 ± 8 204	5 275 ± 4 950	1 040 ± 2 038	0 000 ± 0 000	35 632 ± 14 233
Autumn	26 036 ± 17 941	29 108 ± 20 486	6 305 ± 8 307	6 324 ± 9 154	0 000 ± 0 000	63 811 ± 32 820
Total	78 342 ± 25 395	71 918 ± 26 125	24 081 ± 13 400	12 492 ± 10 915	2 473 ± 3837	185 643 ± 43 603

understanding, acceptance, and compliance with the MPA rules may be expected. According to (Morales-Nin et al., 2015), higher proportions of tourists involved in fishing activities are usually associated with challenges related to a lack of awareness and understanding about fishing regulations and local sustainable fishing practices. Moreover, only 2.4 % of the recorded retained fish by number were undersized (i.e., below the legal minimum landing size). Finally, we verified that none of the anglers exceeded the regulated 10 kg daily bag limit, and almost all shore anglers reported having the mandatory fishing license. These results not only provide an optimistic outlook for the implementation of the MPA, in terms of a potential acceptance of regulations, but also suggest that the shore-based angling community supports responsible and sustainable practices. The fact that rules and regulations for the NMPAR-PV were co-designed with stakeholders, including recreational fishers, which were included in the co-creation of the MPA since the beginning (Horta e Costa et al., 2022) also enhances the potential for compliance, as referred by Read et al. (2011).

Local Ecological knowledge (LEK) is being increasingly recognized as a valuable complementary information to empirical scientific studies (Boubekri et al., 2022; Murray et al., 2005; Sbragaglia et al., 2020), hence fishers' perceptions have been progressively used to assess the social and ecological dynamics of fisheries (Berkström et al., 2019; McClanahan et al., 2005). In general, anglers' opinions and perceptions towards the implementation of the NMPAR-PV were positive. Conversely, their perception about the current state of the resources were predominantly negative. Most anglers perceived a decline in fish stocks over the past five years, attributing this primarily to commercial fishing and marine pollution. These perception align with findings from previous studies conducted in the region, where a significant number of anglers also reported similar perceptions (Pita et al., 2020; Veiga et al., 2010; Pontes, 2019). Furthermore, it aligns with the global perspective on declining fish stocks, a widespread concern worldwide, supporting the need for developing measures such as MPAs, to protect marine habitats and fish populations (Brewer, 2013; Márquez et al., 2024). However, it is important to note that these perceptions can change over time. Stakeholders who initially supported the MPA may gradually lose confidence in it and withdraw their support over time (Chuenpagdee et al., 2013), highlighting the importance of continuously engaging

stakeholders at all stages of MPA design, implementation and management (Horta e Costa et al., 2022). In the particular case of the NMPAR-PV, it was co-designed following a transparent ~3-year participatory process where all relevant stakeholders were included, from recreational fishers' representatives, and 20 years of scientific research were integrated in the discussions (Horta e Costa et al., 2022). Combining fishers' perceptions with scientific data is essential to identify mismatches, improve mutual understanding, and ensure that both sources of information are important for the effective evaluation, monitoring, and governance of MPAs (Leleu et al., 2012). Stakeholder input can also help in identifying eventual deficiencies in monitoring data, definition of MPA zoning, or enforcement strategies (Huang et al., 2024). Efforts to keep stakeholders engaged, as well as periodical socio-ecological monitoring, are recommended for a successful assessment (Pita et al., 2020).

For the ecological component, the *in situ* catch composition indicated a total of 29 species from 14 different families. This finding can be compared to the previous study developed by Veiga et al. (2010) in south and south-west Portugal, in which 36 species were recorded in the same region but across a much larger area (approximately 250 km of shoreline), highlighting the variety of species targeted and captured by recreational shore fishing in this smaller area. Both studies revealed that shore angling in this region is predominantly focused on species belonging to the Sparidae family, with *D. sargus* (White seabream) being one of the most targeted and captured species, (22 % in number and 23 % in mass; present study and 44 % number and 48 % in mass, Veiga et al., 2010). Moreover, fish from the Sparidae family are the most targeted and caught by shore anglers in Southern Europe (Spain: Morales-Nin et al., 2005; Pita et al., 2018; France: Font et al., 2012; Greece: Papadopoulos et al., 2022). Similar results were obtained in other shore angling surveys conducted in mainland Portugal and the Azores, consistently identifying species from the Sparidae family as among the most targeted and frequently caught (Rangel and Erzini, 2007; Diogo et al., 2020). Nonetheless, despite their notable presence in MRF catches in Southern European countries, species from the Sparidae family are not covered by the Data Collection Framework (DCF) (EU, 2017). In the ICES expert group on Recreational Fisheries Surveys (WGRFS), this question has been extensively discussed and a vitality matrix score was developed to the main MRF targeted species in the countries represented in the group to assess their vulnerability and prioritize data collection and management efforts at a regional level (WGRFS, 2023). The absence of mandatory data collection for recreational catches of Sparidae species highlights an important gap in monitoring and managing the impact of shore angling in European marine waters.

Despite not being highly commercial, the Atlantic chub mackerel (*S. colias*) was the most caught species and rank the third position of the target species, after the White seabream, *D. sargus* and the Gilthead seabream, *Sparus aurata*. Previous research undertaken at the Algarve suggest that the White seabream and the European seabass (*Dicentrarchus labrax*) are the primary targets and caught species in shore angling (Veiga et al., 2010) and spearfishing (Assis et al., 2018). The sea, topographic and environmental conditions in this area might favour the catch of the Atlantic chub mackerel, leading fishers also target a species that might not be so desired but has (more) easily available for catching. This may result in higher catches of more available species, such as the case of White Seabream during spring and summer. The high catch rates of this specie, identified as the primary target species of the local anglers, coincides with their onshore spawning migration, as noted by Veiga et al. (2010). Anglers seem to adjust their fishing habits (e.g., in terms of locations and seasons) according to the seasonal changes in the abundance of target species. This strategy could also be related angler's consumptive orientation, as they capture not only the most abundant species during that period but also those with commercial and gastronomic value (e.g., White seabream, Chub mackerel, Two-banded seabream, European seabass) (INE, 2023). Additionally, most of the fishers declared the main fishing purpose was consumption, which is consistent with the high percentage of reported retained catches and low incidence of catch-and-release practices. Further research is crucial to better understand motivations and attitudes that drive anglers to fish in this area and how these motivations are affected.

A higher density of anglers was observed during winter and autumn, resulting in more estimated angling hours, as observed by Veiga et al. (2010). Conversely, the Summer months registered the lowest numbers of observed anglers. This could be attributed to the intense temperature and the lack of shades at the fishing locations. Further, during the day in the bathing season ("balnear" period) most beaches in the region are crowded, and it is forbidden to fish in concession beaches (with mandatory presence of lifeguards), reducing possible locations to fish (Article 14º of Decree Law no. 101/2013, 25th of July). During weekends a higher number of anglers was registered, likely because the interviewees (which are mostly residents) are probably working during weekdays and took advantage of their free time on weekends to engage in this leisure activity. These results are in line with previous studies, which also found that fishing effort is higher on weekends and holidays (Jensen et al., 2022; Morales-Nin et al., 2005; Schmid et al., 2024; Stocco et al., 2024). Understanding these dynamics is crucial for deeper insights into the fishing practices within the region, enabling the development of adequate management measures to maximize resource sustainability while minimizing potential conflicts between resource users (Cabanellas-Reboredo et al., 2014).

The distribution and quantity of fishing effort observed in this study will be useful to compare with future studies and to assess the development of impacts on fishing resources as the effects of being MPA become evident. Although regulations do not directly affect shore angling, it is crucial to acknowledge how the regulations on other fisheries will indirectly influence it. We have previously demonstrated how anglers can easily shift their targets to other species, in periods that the usual target species are less available and in a study by (Lynch, 2014), after 8 years of the implementation of a zoning plan in the Jervis Marine Park on the southeastern coast of Australia, there was a significant decrease in fishing effort, exceeding 88 %. However, the author did not find this variation reflected on the fishing licenses obtained during this period which suggests that the change was not due to a general decline in recreational fishing but rather a redistribution of effort from the park to other areas. According to the literature, a consequence of closing an area to fishing is the redirection of fishing effort elsewhere, which can lead to several undesirable outcomes (Rijnsdorp et al., 2001; Hilborn et al., 2004). Therefore, it is imperative to continue monitoring the distribution and intensity of fishing effort in the context of this MPA and management.

The €185 643 estimated for annual expenditures of shore fishing in this area reflect the economic importance and impact of recreational angling for the local economy, highlighting its important contribution to the communities' wellbeing. In fact, anglers' expenditures make a significant contribution to the local economy through purchases of fishing gear, equipment, and services, supporting local businesses and employment (Pita et al., 2018). Furthermore, recreational fishing also provides significant physiological, psychological, and social benefits (Pita et al., 2022; Hughes, 2014).

Our study stresses the significant contribution of shore angling to the fishing mortality in the area. The estimated harvest by shore anglers at the park during one year (10.1 tonnes in 25 km of coastline) is notably above what has been reported for shore fishing in two MPAs along the Mediterranean with similar coastline lengths. Particularly, the annual biomass extracted in the park exceeds that reported in Côte Bleue, France (4 tonnes; 20 km coastline) Cap de Creus, Spain (3 tonnes; 40 km coastline) (Font et al., 2012), indicating a substantial impact on the marine ecosystem. This trend is particularly concerning given the relatively stable catch rates (harvest only) over time observed in the south of Portugal, as documented in previous studies (0.23 kg/hr in this study; 0.19 kg/h by Erzini et al. (2008) and 0.25 kg/h by Ressurreição et al.

(2020). Moreover, in 2007/08, estimated shore angling catches for south/southwest Portugal were relatively small when compared with to commercial landings, (<1 % in Veiga et al., 2010). However, when comparing specific species groups such as seabreams, the same study found that recreational catches can be comparable to those from commercial fishing. The findings from the current study and those by Veiga et al. (2010) reinforce the theory that, for particular species and areas (e.g., closer to the shore), the competition between these two fisheries segments can be relevant, both in terms overall catches (e.g.; Schroeder and Love, 2002; Coleman et al., 2004; Font et al., 2012). For example, in this study 16 out of the 29 species recorded to have been captured have commercial interest. In this context, these findings provide valuable information for developing and implementing conservation measures that protect the marine environment while supporting the sustainability of fishing activities.

Catch and effort estimates, as well as information on the human dimensions of shore angling fishing in an area transitioning into a marine protected area are fundamental for effective monitoring to support marine conservation planning and management. As some examples, these key indicators provide essential data on the dynamics of resource utilization, fishing pressure, and socioeconomic aspects, which will allow determining the effectiveness of existing conservation measures, and socioeconomic aspects. Effective monitoring of an MPA, requires not only the ecological assessment but also consideration of social dimensions including the stakeholders involvement. Regular monitoring enables a better understanding of the potential ecological impacts of the marine recreational fisheries and provides critical data for evaluating and adapting management strategies over time. This study highlights the importance of integrating social and biological insights pre-implementation of the MPA, offering a baseline for understanding changes in fishing activity and its impacts. Management recommendations include continuous monitoring of all fishing modalities, implementing a specific recreational fishing license for the area to quantify fishing effort, and developing a data collection application for fishers to self-report their activity. Adaptive restrictions based on monitoring results and consistent involvement of recreational fishers in decision-making would also be essential to ensure the effectiveness and acceptance of these measures.

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Jacinto Gonçalo: Writing – review & editing, Supervision, Software, Formal analysis, Data curation, Conceptualization. **Veiga Pedro:** Writing – review & editing, Data curation, Conceptualization. **nuñez velazquez samira:** Writing – review & editing, Writing – original draft, Visualization, Software, Methodology, Formal analysis, Data curation, Conceptualization. **Pontes João:** Writing – review & editing, Methodology. **Costa e Horta Barbara:** Writing – review & editing, Resources, Project administration, Funding acquisition. **Rangel Mafalda:** Writing – review & editing, Supervision, Resources, Project administration, Funding acquisition, Conceptualization. **Guerreiro Pedro:** Writing – review & editing, Supervision. **Monteiro Pedro:** Writing – review & editing, Visualization. **Fonseca Tereza:** Writing – review & editing, Methodology. **Gonçalves Jorge:** Writing – review & editing, Resources, Project administration, Funding acquisition. **Erzini Karim:** Writing – review & editing, Resources, Project administration, Funding acquisition.

Declaration of Competing Interest

The authors declare the following financial interests/personal relationships which may be considered as potential competing interests: Samira Nunez Velazquez reports financial support was provided by Foundation for Science and Technology. If there are other authors, they declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Data Availability

Data will be made available on request.

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