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Local knowledge and official landing data point to decades of fishery stock decline in West Africa

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ABSTRACT

Small-scale fisheries play a pivotal role in providing food and livelihoods for millions worldwide, particularly in low-income countries in Africa. However, a common challenge in these fisheries is the relative scarcity of statistical data on the composition, abundance, and distribution of fisheries resources, which is crucial for effective management. In data-poor regions, like West Africa, local ecological knowledge has been advocated as a valid source of information for assessing stock conditions and historical performance in relation to distinct drivers of change. This approach, however, needs to be used with caution due to changes in human perceptions related, for example, to the natural state of marine environments, which is known as Shifting Baseline Syndrome (SBS). Hence, this study combines 50 years of users' perceptions and landing data from Maio island, Cabo Verde, where fishing communities dependent on fish stocks are becoming increasingly vulnerable. Our aims were i) to investigate changes in small-scale fisheries catches over the past five decades, and ii) to understand and refine the use of these data as alternative or complementary sources in local-regional fisheries management. Our results highlight the impact of SBS on users' perceptions, which is influenced by local socio-ecological context. Significantly, our results point to a staggering decline in local stocks that may exacerbate the vulnerability of West African coastal fisheries.

1. Introduction

Small-scale fisheries (SSF) are crucial for the food security of over 200 million people in Africa, representing nearly half of the continent's fisheries catches and landed value (www.seaaroundus.org). The West African SSF contributes to the highest proportion of the fishery sector, providing employment and livelihoods for about 16 % of the coastal population (4.8 million people) [5]. Overexploitation and climate change, however, are escalating the decline of marine fisheries, leading to socio-ecological impacts mainly on coastal populations [26]. The expansion of industrial fishing and the adoption of unsustainable harvesting practices have also contributed to stock depletion of at least 15 species in the Canary Current region since the late 1990s [4]. The lack of systematic and long-term scientific data on fisheries resources is still a major challenge for most African coastal countries. This deficiency poses a threat to the food security of coastal fishing communities, which are especially vulnerable due to their socioeconomic dependence on SSF

[38].

In Africa, local ecological knowledge (LEK) is one of the few available sources of information on past fisheries status and environmental baselines needed for management and policy design [17]. Fisheries managers, however, still tend to dismiss LEK due to changes in human perceptions of biological systems over generations, a phenomenon known as 'Shifting baseline syndrome' (SBS) [29]. The SBS concept refers to the gradual change in people's perceptions of what is considered a healthy or natural environment due to the loss of experience about past conditions [29,30]. Several studies have assessed perceptions of fishers from different age and experience generations to test SBS occurrence and to report changes in fisheries and in marine biodiversity through time [1,25,34,6,8].

According to Papworth et al. [28], one of the biggest challenges in assessing the implications of SBS is the absence of concrete empirical evidence proving its occurrence. To identify SBS in a socio-ecological system, firstly "a biological change must be present in the system" and

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secondly, “any perceived changes must be consistent with the biological data” [28]. In addition, most studies on SBS in marine socio-ecological systems have not considered the spatial dynamics of fishing and gender roles in local knowledge. It is crucial to recognize the pivotal role that women play in fishing communities, particularly within the processing and selling stages of the fish value chain, for a more comprehensive understanding of the dynamics of coastal systems [18,7].

The Cabo Verde archipelago is a Small Island Developing State (SIDS), located in the Eastern Central Atlantic Ocean, where SSF play an important role in the country’s economy and food security. Artisanal fisheries constitute around 64 % of the country’s fishing activity, both in terms of catches and employment (Government of Cape Verde, 2004); however, the sector has been threatened by overcapacity and overfishing due to increasing pressure from the international market, tourism, climate change, and fishers’ migration [2,15,16,24]. International fishery agreements with the European Union, Senegal, Japan and China have been criticized for the lack of transparency and inefficiency in guaranteeing sustainable large-scale fisheries [2]. According to the Sea Around Us project, there is a great discrepancy between the reported data by FAO and the National Fisheries Development Institute (INDP). Since 2005, FAO has reported twice as many catches as the INDP, with a peak of increase in catches in 2013 [12]. Additionally, official artisanal

landing data covers mainly commercial species, excluding important top predators already depleted or less abundant, such as sharks and large demersal fish (i.g. *Epinephelidae*). Ecological changes related to population structure and fish community dynamics are also unlikely to be assessed due to limited landing data, which leads to failed strategies to protect marine biodiversity and ensure the sustainability of marine resources.

In this study, we aimed to assess baselines and the main changes in artisanal fisheries by combining users’ perceptions and landing data from Maio island, one of Cabo Verde’s most vulnerable islands, where population subsistence mainly relies on SSF. Our key questions were: 1) How have artisanal catches changed over the last five decades? and 2) Are users’ perceptions and landing data alternative or complementary sources for assessing these changes? To address these questions, we interviewed over one hundred people on Maio island, and assessed whether there were differences in perceptions between genders (considered in this paper as men and women) and geographical areas. We then tested whether shifting baseline syndrome is occurring among participants of three age groups by comparing data from local knowledge with artisanal landing data. Despite social-ecological contexts greatly varying among the Cabo Verde islands, our results provide a relevant model study for local and national management decisions, and

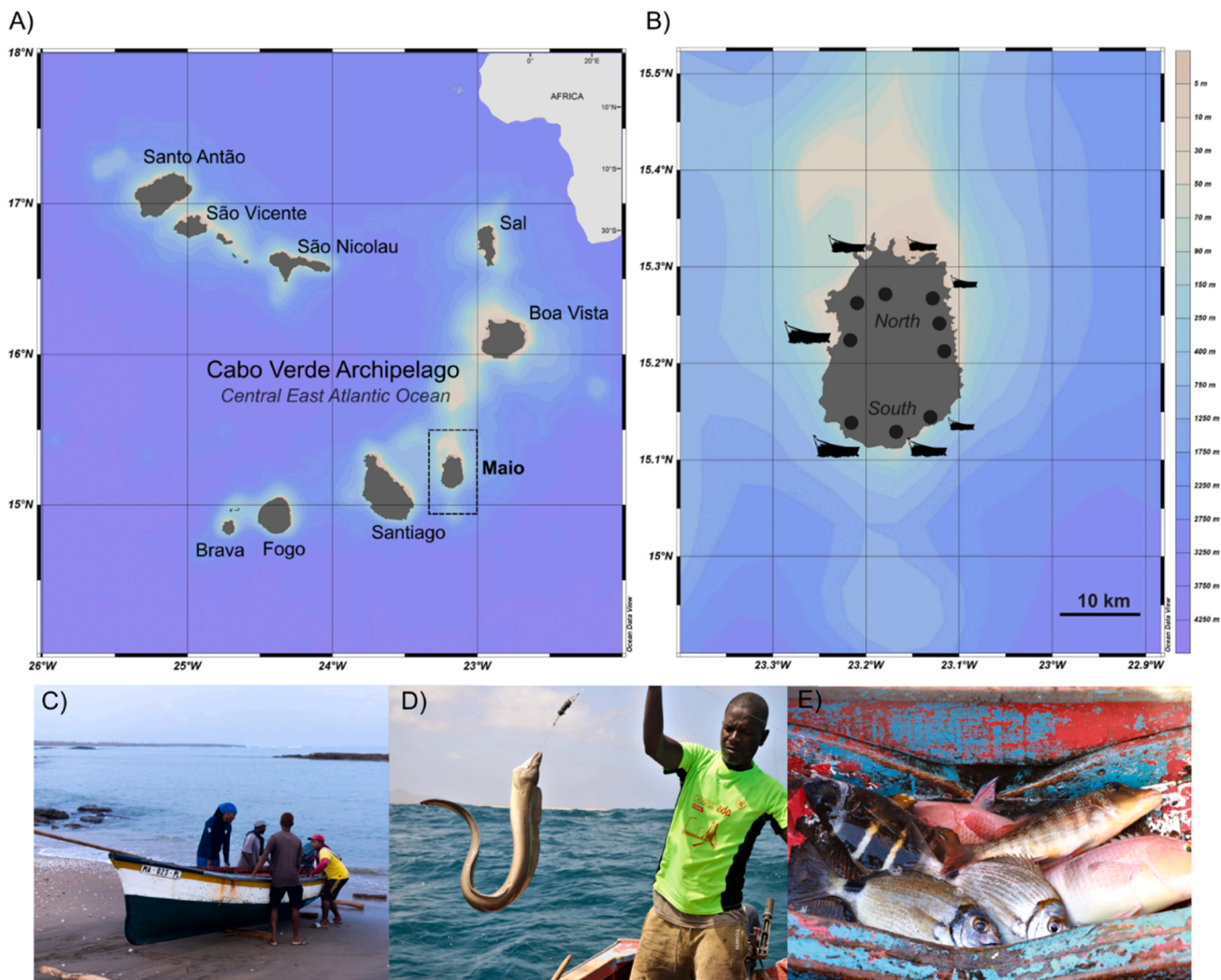


Fig. 1. A) Bathymetric map of the Cabo Verde archipelago and Maio island in the Central East Atlantic Ocean, with detail of the African coast in the top right. B) Map of Maio island with black dots representing the local communities grouped in North and South zones where interviews were conducted. C) Typical artisanal fishing boat. D) Moray eel caught by handline. E) Commonly caught species in reef-associated fishing.

serve as a case study that should be applied to the other islands.

2. Methods

2.1. Study region

The Cabo Verde archipelago (Fig. 1), which consists of 10 islands (9 inhabited) and over 15 islets, is situated in the Eastern Central Atlantic Ocean, approximately 570 km off the coast of Senegal [16]. The tropical climate is characterized by warm temperatures and distinct dry (November to July) and wet (August to October) seasons, however, the influence of the trade winds contribute to the overall aridity of the region. A former Portuguese colony until 1975, the country had been historically exploited for salt, cattle, whales, and as site for slave trade. Presently, Cabo Verde's economy is predominantly centered around the tertiary sector, particularly tourism. It is classified as a Small Island Developing State (SIDS) due to its extensive coastal and marine area (Economic Exclusive Zone of 796,555 km²) relative to its land surface (4000 km²), which leads to a high environmental, social, and economic vulnerability, especially in islands still reliant on local resources for livelihoods.

Maio (15.1350° N, 23.2257° W; 275 km²), situated only 23 km from Santiago island, has an annual precipitation of less than 150 mm and it has been marked by droughts and crises linked to climate change [10]. The vegetation cover consists mainly of the invasive species *Prosopis juliflora*, which decreases water availability in the soil, hindering agriculture and cattle production (Direção Geral dos Recursos Marinhos and PRAO-CV 2016). Maio's insular shelf extends about 3560 km and it is home to about 75 % of the Cabo Verde's fish diversity (Stromme et al., 1982). The island is influenced by Mauritania's upwelling, the Canary Current, depth currents, and more locally by island effect, enhancing phytoplankton and marine biodiversity [10]. With a population of 6330 people, Maio is one of the islands with the lowest GDP per capita of the archipelago [21]. Its population subsistence and economy rely on small-scale fisheries, in which abundant marine resources and affordable prices contribute to the island's food security.

In Cabo Verde, artisanal fishing is defined by the use of handlines for tunas and demersal species, purse seine and gillnet for small-pelagic species (usually baitfish), and creels and spearfishing (apnea) for lobsters, mollusks, and other fish in 3–8 m boats with outboard motors. Semi-industrial vessels of 8–20 m target mainly large and small pelagic fishes using pole and line and purse-seine, respectively [32]. About 90 % of the Maio's artisanal fleet catch demersal and pelagic species using handlines. The last census from 2021 recorded 58 active artisanal boats (from a total of 75 boats), 113 fishers, 58 fish sellers, 74 “armadores” (boat owner or manager) [19]. The act of fishing is exclusively practiced by men, while processing (evisceration, fileting, drying) and selling is performed mostly by women (96.6 %). Spearfishing is also a commercial fishing practice in Maio, conducted either by free divers or fishers using scuba gear, although the latter is restricted to harvesting whelks under relevant licenses. Maio has the second highest percentage of artisanal boats used for diving (12 %) only behind Boa Vista (17.3 %) due to the extensive shallow shelf around these islands.

2.2. Data collection

2.2.1. Quantitative interview data

We interviewed fishers (only men) and fishmongers (only women) from 9 fishing communities in Maio from March to August 2023 using a structured questionnaire (SI1) following Sáenz-Arroyo et al. [34], Bunce et al. [8], Ainsworth et al. [11], and Maia et al. [25]. The questionnaire included questions about the users' profile (e.g. age, gender, village of residence, age when they started fishing/selling), fishing effort, species most caught at the present and in the past, target species size, weight and price, and the occurrence, onset and causes of fish decline, to quantify local ecological knowledge about stocks and environmental changes.

For this study, we only interviewed fishers that use handline as primary or secondary fishing gear.

The interviews were carried out in Creole language by a team of 2–3 trained interviewers, including at least one fluent local language speaker, at locations convenient to the interviewees, mainly near the landing sites or at their residences. Prior to each interview, we informed the participants about the study's objectives and asked for their written consent to take part in the research and to record audio of the interview using our mobile phone. We used Epicollect 5 to design a structured questionnaire and to record the data from the interviews. For the questions related to the largest individual ever caught (cm), the interviewees used a measuring tape to show the fish sizes. We also used a fish identification guide with 72 commercial species from Cabo Verde to help interviewees identify the most caught species in the past and present, as well as the most depleted species. Sharks were not included since they are not considered main targets for artisanal fishers. Typically, one interviewer, often the first author, assumed the lead role by guiding the interview process (asking the questions and completing the questionnaire in the Epicollect application), while the other team member helped with measurement tasks, handling the fish identification guide, and with language translation when it was needed. Ethics approval was obtained from the Ethics Committee of the Universitat Autònoma de Barcelona (CEEAH 6345).

2.2.2. Landing data

Official artisanal fishery data from Maio, comprising catches of pelagic and demersal species using handlines, were provided by the Instituto do Mar (IMar) of the Cabo Verde Government (<https://imar.cv/>). The data was shared in the format of annual technical reports and Excel spreadsheets, and then organized into a single database. Landing data from 1995 to 2019 (data from 2002 and 2016 were not available) consisted of landings per month (kg) of commercial species (or group of species), total number of trips per month, and number of surveyed artisanal vessels. In Maio, the only landing site surveyed by an IMar officer was the beach of Cidade do Porto Inglês (“Bitxi Rotxa”). In some cases, the fish names in the data were only in Creole language and referring to more than one species (e.g. “Esmoregal” is the Creole name used for different *Seriola* species), which made it difficult to assess stock trends for single species. Whenever possible fish local common names were converted to names used in the official landing report (SI2).

2.3. Data analysis

Subtle geographic differences in targeted species are noticeable in Maio. Fisheries in the northern region predominantly target demersal species, whereas in the southern region, the focus is on pelagic stocks. Based on this distinction, we have classified communities into North and South zones (Fig. 1), which also determines their fishing strategies and targets. For example, although reef-associated fishing is common in both zones, there is a preference for targeting pelagic taxa such as tuna, wahoo and dolphinfish in the south due to environmental conditions that favor their presence nearshore. Within each zone, interviewees were classified in three age groups following Bunce et al. [8]: young = 18–29 years old; middle-aged = 30–49 years old; and old = 50–80 years old. We then tested for differences in the perception between genders within the same age and zone groups by using an ANOVA with interaction (\sim age*zone*gender), after checking the data was normally distributed. Since there was no significant difference between genders ($p < 0.05$) for all response variables analyzed, we performed the ANOVA test with interaction between age group and zone followed by post-hoc Tukey's Honest Significant Difference (Tukey's HSD) for pairwise comparisons. To check whether the models fit the assumption of homoscedasticity, we plotted the residuals vs fitted and the Normal Q-Q plot. The analyses were performed using the functions `aov()` and `TukeyHSD()` in the R package ‘stats’ version 4.3.0.

2.4. Research positionality statement

The authors TM, PZ and ACC recognise their position as outsiders to the study region and the local communities sampled, including their historical, cultural, and political contexts. As researchers from an academic institution with a background in natural sciences and qualitative research, we understand that the interpretation of the collected data can be influenced by certain biases. The first author of this study, TM, lives on Maio island and has been working in collaboration with the local NGO Fundação Maio Biodiversidade (FMB) since 2022. During this time, TM has engaged with members of the fishing communities and built a respectful and collaborative relationship with them. BV is a Cape Verdean conservationist who works in the FMB's Marine and Sustainable Fisheries Program and was a key element in conducting the interviews. The authors also acknowledged the importance of incorporating gender-specific fishery data and urge future studies to recognize women's ecological knowledge and their role in the fish value chain, especially in African countries. In addition, authors are committed to sharing the findings of this study with the fishing communities of Maio through a transparent and open dialogue, in a context of increased need for community-based management.

3. Results

A total of 155 interviews with fishers (only men) and fishmongers (only women) from three age groups were conducted in 9 fishing communities around Maio island between March and August 2023. The largest communities were Cidade do Porto Inglês, located in the South zone, with 2976 residents and Calheta, in the North, with 1081 residents [20], where the number of interviews represented 39.4 % and 34.9 % of the total sample, respectively.

We interviewed 50 fishers and 24 fishmongers from South communities, and 47 fishers and 34 fishmongers from North communities. The middle-aged group (30–49 years) was the largest sample representing 47.7 % ($n = 74$), followed by the old group (≥ 50 years) with 38.7 % ($n = 60$), and the young group (18–29 years) with 14.2 % ($n = 21$) (Table 1). The oldest interviewee was a 77-year-old retired fisher, and half of the interviewees started working in the SSF between the ages of 12 and 18. The lower proportion of young people working in SSF in Maio is probably related to a high level of emigration to other islands of the archipelago (Santiago and Sal) and Europe (Portugal). Our records offer snapshots of approximately 50 years of local perceptions on the status of fisheries, with a more robust record spanning the last 30 years.

Most of the interviewees (94.2 %) from all age groups reported that fish have been declining. Within each age group, however, 23.5 % of the participants of the young group reported that fish have not been declining, compared to 1.7 % and 5.7 % of the old and middle-aged groups, respectively. Significantly though, the old group recalled catching larger total catches in terms of weight (median = 200 kg; avg = 194 kg; sd = 143; se = 19.1) in their best fishing days compared to both the middle-aged (median = 75 kg; avg = 140 kg; sd = 155; se = 18.8) and young (median = 52 kg; avg = 135 kg; sd = 168; se = 36.8) groups. In addition, larger total catches were reported in the South compared to the North among all age groups. Within each zone, the best day's catch (BDC) distribution gets wider from the old to the young group in the

South, while young and middle-aged groups showed a narrower distribution than the old group in the North (Fig. 2). There was no difference in BDC between genders within the same age and zone groups. BDCs were higher in the past in both zones, although there was a greater variability of BDCs in recent years, from 2010 onwards, due to the larger sample size (Fig. 3). These results indicate that more drastic changes in SSF in Maio may have occurred in the last 20 years, when young and part of the middle-aged group started fishing.

Yellowfin tuna, *Thunnus albacares* (Bonnaterre, 1788) and African hind, *Cephalopholis taeniopsis* (Valenciennes, 1828), also called blue-spotted seabass, were selected as indicator species to assess changes in maximum size and price of highly targeted pelagic and demersal species, respectively. The interviewees were asked about the weight of the largest individual they ever caught, and the species price/kg when they started fishing. For the yellowfin tuna, the old group recalled having caught or sold larger fish (maximum 129 kg, 210 cm) than the middle-aged (maximum 120 kg, 210 cm) and young groups (maximum 70 kg, 185 cm). Larger tunas were also caught more often in the South than the North. The tuna price followed the same difference pattern among the age groups but with increased prices being reported by the young and middle-aged groups compared to the old group. In fact, species targeted by multi-level market scales (local, national and international), such as tunas, might have greater volatility in price than species targeted mostly for the local market. Differences in weight and length of the largest African hind were not significant among age and zone groups. The maximum values varied from 4 kg (young and old) to 5 kg (middle), and from 54 cm (young) to 75 cm (middle), while the minimum values were 0.5 kg, 1 kg and 1.5 kg, and 25 cm, 24 cm, 30 cm for young, middle and old groups, respectively. The African hind price/kg were also much lower when older fishers and fishmongers started working around 30–50 years ago compared to the young and middle-aged (Fig. 3). There was no difference between perceptions among fishers and fishmongers within the same age and zone groups ($p > 0.05$).

The species reported most frequently as depleted were the dusky grouper, *Epinephelus marginatus* (Lowe, 1834) (Creole: Merato, EMAR), island grouper, *Mycteroperca fusca* (Lowe, 1838) (Creole: Badejo, MFUS), African hind (Creole: Garoupa, CTAE) from the Epinephelidae family, and small-pelagic species mackerel scad, *Decapterus macarellus* (Cuvier, 1833) (Creole: Cavala, DMAC) and bigeye scad, *Selar crumenophthalmus* (Bloch, 1793) (Creole: Chicharro, SCRE) from the Carangidae family (Fig. 4A and C). In the North, EMAR and MFUS were most frequently reported as depleted by interviewees (Fig. 4A), while DMAC and SCRE were the most frequently reported as depleted in the south (Fig. 4C). Interestingly, tuna species, including the yellowfin tuna (Creole: Albacora, TALB) and albacore tuna (*Thunnus alalunga* (TALA)) were frequently reported as depleted by the South and North groups, which suggests that these pelagic species were also common in the north of Maio in the past. The lobster species *Panulirus echinatus* (PECH), *P. regius* (PREG) and *Scyllarides latus* (SLAT) were only mentioned as depleted in the North where they have been overexploited mainly by spearfishing divers from Maio and Boa Vista to supply the islands with greater tourism economy (Santiago, Sal and Boa Vista). On the other hand, pelagic species such as *Sphyrna viridensis* (SVIR), *Euthynnus alletteratus* (EALL), and *Coryphaena hippurus* (CHIP), were reported mostly in the South.

Based on the target species shifting index (n° of mentions as most caught in the present - n° of mentions as most caught in the past, when an individual started fishing, for each species) (Fig. 4B and D), we found that the main target species in the past were recognized as depleted and have been replaced by reef-associated species from the Carangidae family, such as amberjacks, *Seriola dumerili* (Risso, 1810) and *S. carpanteri* (Mather, 1971) (Creole: Esmoregal, SDUM and SCAR), the rainbow runner, *Elagatis bipinnulata* (Quoy & Gaimard, 1825) (Creole: Salmon, EBIP) and blue runner, *Caranx crysus* (Mitchill, 1815) (Creole: Bonito, CCRY), especially in the south of Maio. In the north, the African hind appeared as one of the main target species in the present, despite

Table 1
Sample distribution by zone, age group and gender.

Zone	Age group	Man	Woman	Man%	Woman%	Total
North	Young	9	5	64	36	14
	Middle-aged	20	17	54	46	37
	Old	18	12	60	40	30
South	Young	5	2	71	29	7
	Middle-aged	28	9	76	24	37
	Old	17	13	57	43	30
Total						155

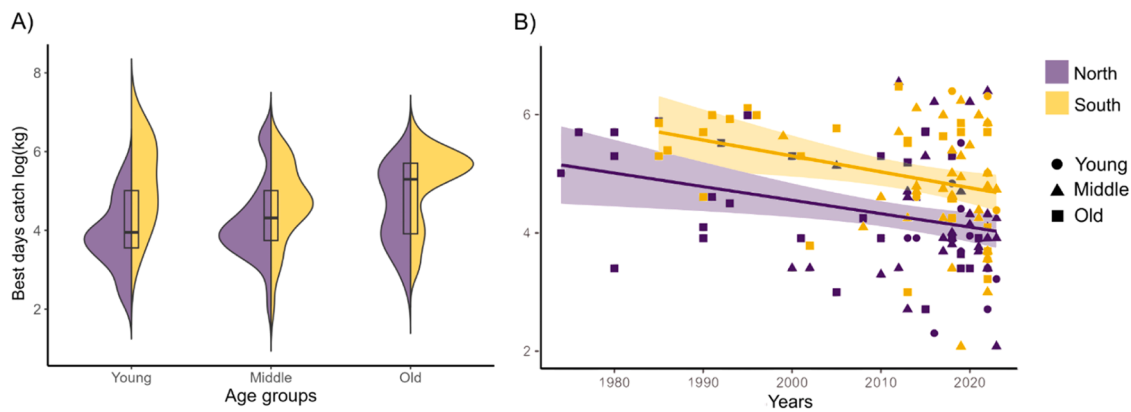


Fig. 2. A) Best day's catch (kg) per age and zone groups (violin plots represent the data distribution for each zone and boxes show median, 25 and 50 percentiles for each age group). B) Linear regression and 95 % confidence interval of the best day's catch as a function of the year for each zone.

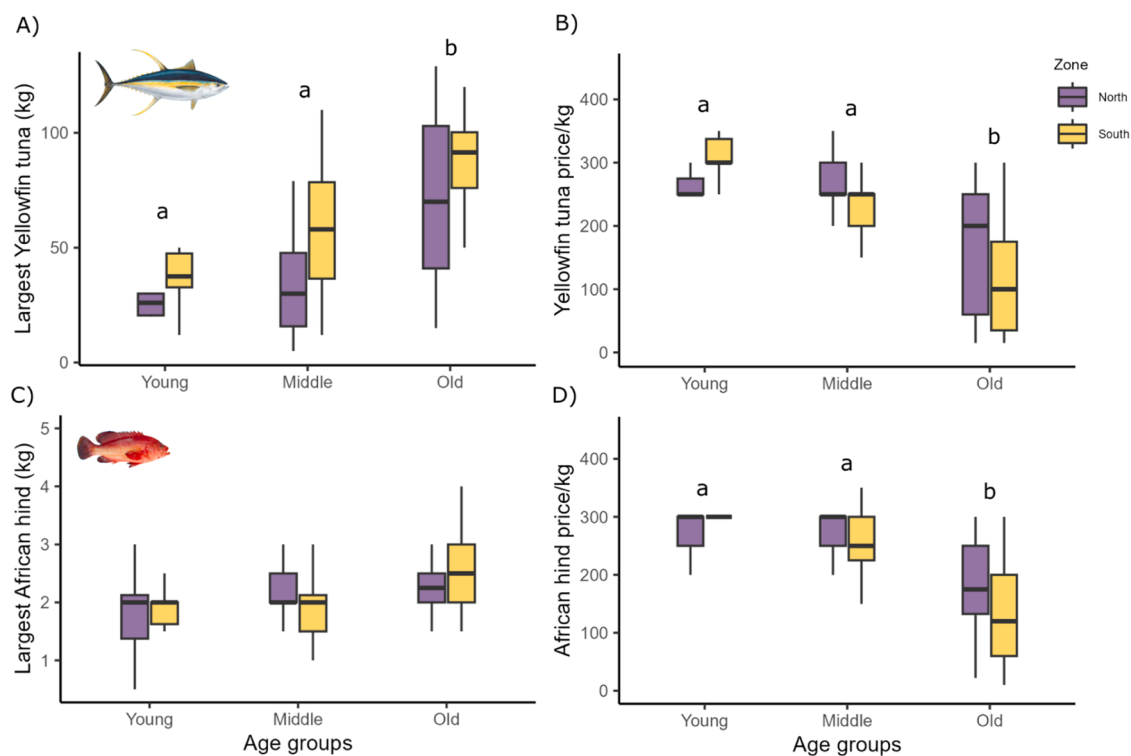


Fig. 3. Largest individual ever caught (kg) and past price/kg (CVE) for yellowfin tuna (A and B) and African hind (C and D) mentioned by interviewees of each age group in each zone. Past price/kg is the price interviewees recalled when they started fishing or selling fish. The currency conversion at the time of writing is 100 CVE = 0,99 USD.

being the fifth most frequently reported depleted species in Maio. This result suggests the species was more abundant in the past, but maybe less fished, since high-valued species such as the dusky and island groupers were still available. Moray eels have also become more targeted nowadays, being a typical dish in Maio, especially in Calheta village where every year a gastronomic festival ("Festival da Moreia") promotes the local seafood gastronomy.

The landing data analysis showed a similar pattern of users' perceptions. Catches per trip of Epinephelidae decreased over time, (Fig. 5A), while it increased for Carangidae, mainly represented by amberjacks, jacks and runners (*Seriola* and *Caranx* spp.) (Fig. 5B). Unfortunately, landing data of *Epinephelus* sp. ('Meros') were recorded only from 1995 to 2000, with catches only in 1995, suggesting the species were already in decline when the landing surveys started in Maio. Data from INDP-IMar reveals a negative correlation between the annual

number of trips and the total volume of catch per trip (Fig. 5C), and an overall annual increasing trend in fishing efforts from 1995, except for 2013, 2017 and 2018 (Fig. 5D). This negative correlation indicates that most local stocks were exploited to their maximum capacity, a down-trend initiated in the late 1990's and early 2000's, $\geq 10,000$ trips/year.

Semi-industrial fishing and spearfishing with scuba gear were reported as the main causes of local fish decline by 55.6 % and 45.7 % of the respondents in the North, and 78.8 % and 28.4 % in the South, respectively. Other drivers of local fish decline included pollution, climate change and industrial fishing (Fig. 6A). Regarding the semi-industrial fishing, interviewees mentioned the vessels come from other islands, mainly Santiago, and use purse seines and night lights to catch small-pelagic fish. They also reported that these vessels are often fishing within the 3 nautical miles that is exclusively for artisanal fishing. More than 50 % of the young and middle-aged groups pointed out that fish

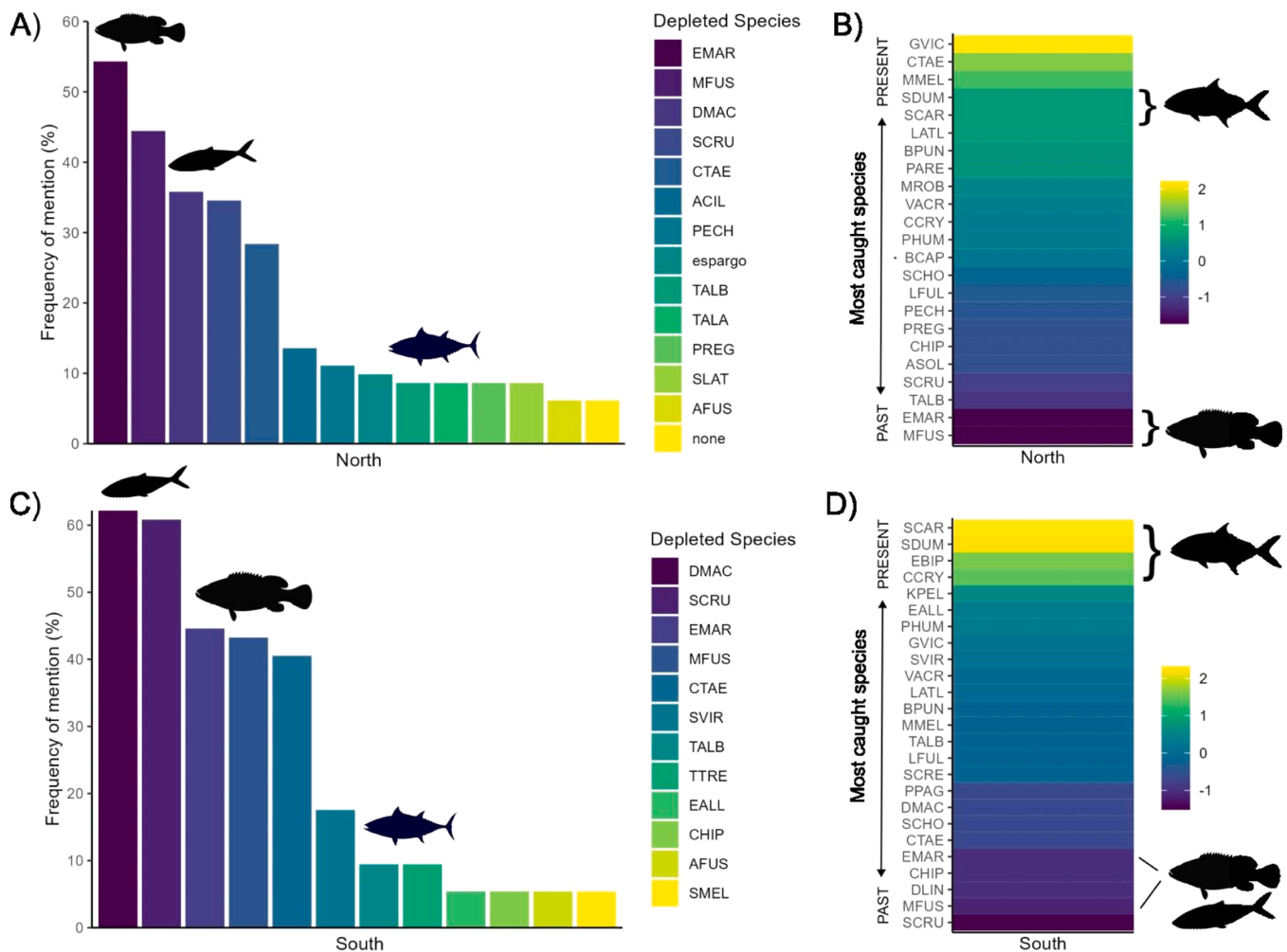


Fig. 4. Fish species most frequently reported as depleted and the shift between the most caught species in the past and present, reported by respondents from the North (A and B) and South (C and D). In B and D, light colors represent species that were less fished in the past and highly fished in the present; dark colors represent species that were highly fished in the past and less fished in the present. See S14 for the corresponding common and scientific names of the abbreviations.

decline began between 5 and 10 years ago, while the largest proportion of the old group believe fish decline began up to 15 years ago. The perceptions were very similar between the North and South zones, although in the North, a larger proportion of young users believe fish decline began up to 5 years ago and a larger proportion of the old group believe fish decline began up to 30 years ago (Fig. 6B).

4. Discussion

4.1. Changes in artisanal catches over the last five decades

Both LEK and official landing data showed declines of commercial large pelagic Scombridae species (e.g. *Thunnus* spp.) and long-lived demersal Epinephelidae species (e.g. *Mycteroperca* and *Cephalopholis* spp.), as well as an increase in catches of reef-associated Carangidae species (e.g. *Seriola* and *Caranx* spp.). Besides these common trends, LEK particularly indicates that small-pelagic Carangidae species (e.g. *Decapterus*, *Selar* and *Trachurus* spp.), usually captured for use as live bait in artisanal fishing or captured by semi-industrial purse-seine fishing, are already depleted. The dusky grouper and lobster species were also considered depleted, but poorly recorded in the landing data of Maio. Differences in perceptions on the current and past state of fisheries among age groups suggest a significant reduction in size of yellowfin tuna and increased prices for both yellowfin tuna and the African hind. These indicators may be driven by increased demand on the local market

due to increased tourism on other islands and the export of pelagic species to the international market [16,21,33]. Increased prices can also be due to increasing boat fuel prices [10].

The perceptions of the young and middle-aged groups were significantly different from those of the older group, suggesting that more pronounced changes may have occurred around 30 years ago. This same pattern has been observed among small-scale fishing communities in the Eastern Pacific (*Baja California*: Saenz-Arroyo et al., 2005), Western Atlantic (*Brazil*: [6,13]), Eastern Atlantic [25] and Indian Ocean (*Tanzania*: Katikiro, 2014 and *Rodrigues island*: [8]). In African oceanic systems, Bunce et al. [8] also found that large predators, such as groupers, were most cited as depleted by older fishers, while Maia et al. [25] showed that the oldest generation of fishers (>40 years of experience) from São Tomé and Príncipe recalled catching larger individuals compared to less experienced generations.

LEK was also shaped by the ecological contexts where fishers and fishmongers have worked most of their lives, especially concerning perceptions of the shifts in the most caught species, depleted species, and the causes of fish decline. Differences between the north and south can be attributed to environmental conditions that favor pelagic fishing in the deep waters of the south, while the shallow shelf that extends north between Maio and Boa Vista favors fishing demersal species. According to older fishers from the north, they used to catch greater amounts of large groupers which are now depleted mainly due to spearfishing with scuba gear. On the other side, both small and large

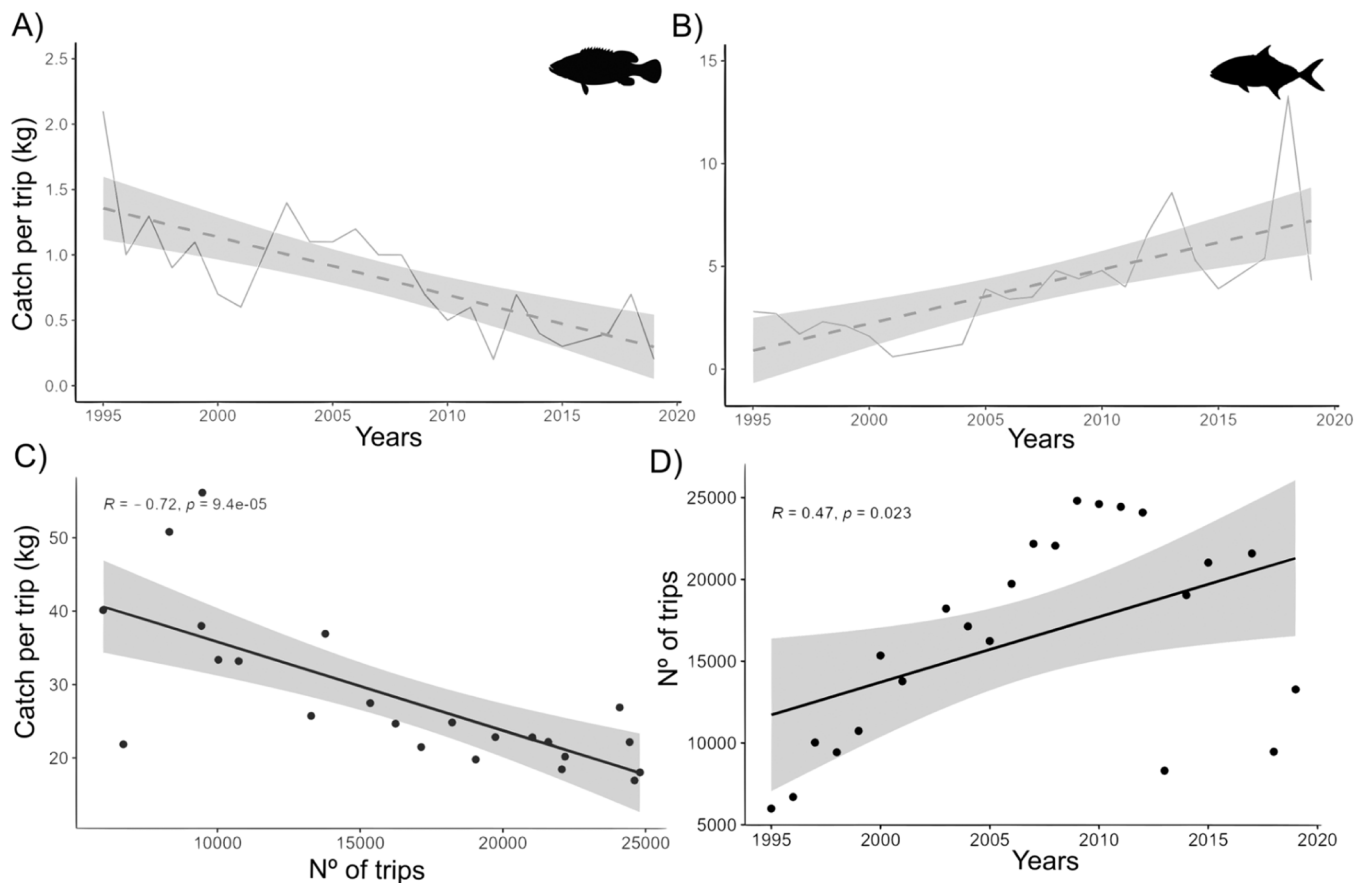


Fig. 5. A) Linear regression of catch per trip (kg) of Epinephelidae and B) Carangidae, and C) total catch per trip and number of trips, and D) correlation between fishing effort (number of trips) and year. Gray areas indicate 95 % confidence interval. Data source: INDP-IMar.

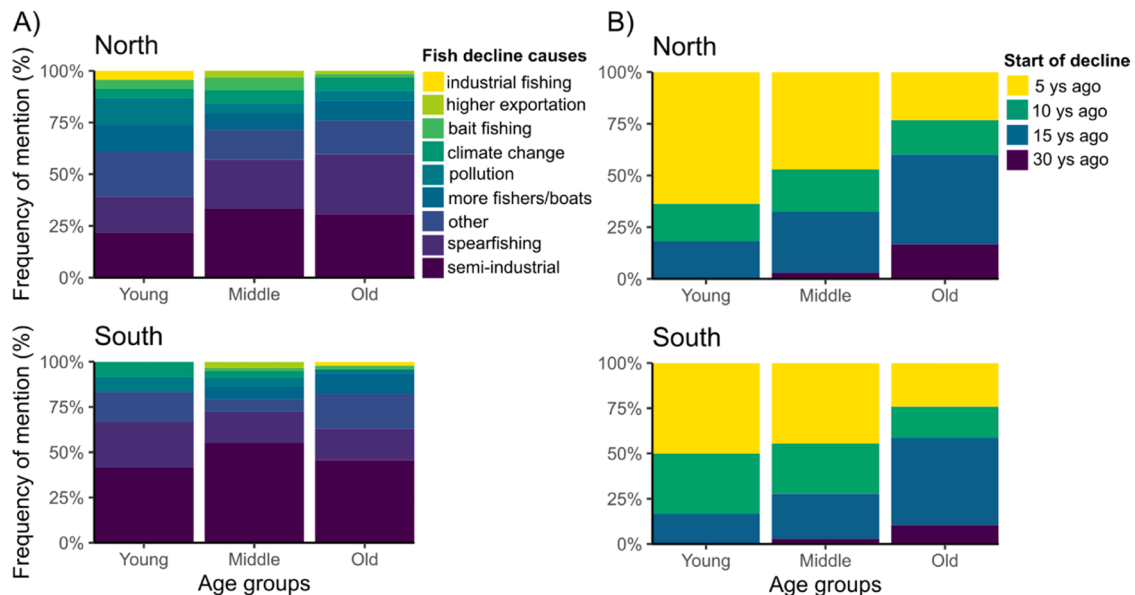


Fig. 6. A) Frequency of mention (%) of the drivers perceived as main causes of fish decline and B) when local fish decline began in Maio by age group in each zone.

pelagic species were mentioned as the most depleted species in the south, where semi-industrial fishing (mainly from Santiago island) was considered as the main cause of fish decline. According to local fishers, these vessels even operate within three nautical miles, and in marine protected areas with restricted use for artisanal fishing.

Our results essentially mirror the overall declining trend of global marine catches since the late 1990s driven by population growth, market demand, more efficient technologies and increasing fishing effort [31]. Domestic purse seine vessels have been catching great amounts of small-pelagic fish since 1992, coinciding with a decrease in tuna

landings, reduced to about 40 % by 1998 [14]. Although industrial fishing was not prominently cited as one of the main causes contributing to fish decline by interviewees, this perception may stem from the fact that the fishing areas normally used by artisanal and industrial vessels do not overlap. Tuna species, such as the yellowfin, bigeye and skipjack tunas, are highly targeted by the industrial sector in Cabo Verde for a global market [37] that adds little value at the national level. Since the 2000s, the capacity of industrial fishing in Cabo Verde, Gabon, and Mauritania has increased [3] under international fishery agreements that lack transparency and risk the sustainability of tuna stocks [2]. Thus, it is crucial to recognize that industrial fishing has a significant impact on stocks of large migratory species, preventing them from reaching coastal waters.

4.2. LEK and landing data as complementary sources in SSF

Combining LEK and landing data was essential to recover the past fisheries status of Maio island, which is one of the most economically vulnerable islands of Cabo Verde. Significantly, local users' perceptions revealed species decline trends that were not adequately represented in landing data. Additionally, they uncovered significantly larger size distributions than those currently reported for species facing over-exploitation. Overall, LEK was consistent with landing data, providing empirical evidence of SBS. This is crucial to validate the use of human perceptions to inform fisheries decision-making and to encourage investment in activities that facilitate inter-generational transfer of experience to tackle SBS in small-scale fisheries [28].

From a gender perspective, LEK did not significantly differ between men and women of the same age group and zone, probably due to the conjugal relationships often coinciding with a collaborative involvement between fishmongers and fishers in Maio's fish value chain. Yet, women were able to recall fish prices more easily, whereas men tended to better remember the size of the largest individual they ever caught and their best day's catch. Women's knowledge of marine ecosystems is still often overlooked in biological or social sciences despite their important roles in the production, processing and trade stages of the fish value chain, especially in African countries [23]. Acknowledging and accounting women's knowledge in SSF and actively involving them in management has led to improvement in understanding social-ecological systems and in resource management [11,9].

Landing monitoring programs are still limited to a few sites across the Cabo Verde archipelago and do not represent fishing catches on a local scale. This has clearly emerged from our study, which revealed that landing data from Maio, collected only at the Cidade do Porto Inglês in the south, cannot be generalized to the whole island due to fundamental differences in targeted species. For example, catches of the dusky and island groupers, both classified as vulnerable (IUCN Red list), were probably underestimated as they were heavily exploited in the north of Maio. Moreover, multi-species landing data usually do not provide species-specific information, such as size metrics, price, and reproductive state, important for fisheries management. Our study therefore reinforces the emerging consensus that in resource-limited contexts, especially in SIDS where local government is unable to cover a representative area, alternative approaches such as community-based monitoring and management approaches should be adopted [22,27,35].

Cabo Verde is a Small Island Developing State that until 50 years ago was a Portuguese colony already exploited by Europeans. Although there have been considerable improvements in fisheries agreements and management over the recent years, the sustainability of marine resources depends on a data-limited management with poor scientific foundations. Our results show that local fishing knowledge accumulated and passed through generations effectively tracks changes in fisheries resources and offers information otherwise unavailable in official landing statistics. LEK among fishing communities in Cabo Verde should be regarded as a highly valuable cultural and ecological asset in fisheries management and conservation.

5. Conclusions

Declining catch trends in parallel with absent or data-poor management have been threatening the food security of numerous populations, especially in African Small Island Developing States, where SSF are fundamental for subsistence and livelihood. In Cabo Verde, landing monitoring is recent, limited to a few sites across the archipelago and with many data gaps (e.g. lack of species-specific data). Here, we highlighted that LEK and landing data were complementary sources to assess fishery baselines and trends in a small island with geographical and environmental particularities, where tunas (Scombridae) and groupers (Epinephelidae) have been overexploited by multi-scale fisheries over the past five decades. Our findings also provide evidence of shifting baseline syndrome across generations indicated by a higher proportion of the young interviewees (23.5 %) reporting that fish stocks have not declined over time compared to the older groups (5.7 % of middle-aged and 1.7 % of old group). We have also documented interviewees' perceptions of changes in their total catches and in the maximum size of fish, which is further confirmed by declining trends in catch per trip based on landing data. Although these indicators do not necessarily prove SBS, they do point to environmental changes and increased fishing pressure which, combined with a lack of data, can lead to SBS [36]. While groupers, small-pelagic fishes and lobsters are poorly accounted for in Maio's artisanal landing data, LEK suggests they should be considered the most vulnerable groups and thus deserve special attention from fishery managers and decision-makers. Spearfishing and semi-industrial purse-seine fishing, including illegal activities, were the most mentioned causes of fish decline in Maio, which suggests that large-scale drivers, such as industrial fishing and climate change are less correlated to local fish decline by the fishing communities.

Contributors

TM, PZ and ACC conceived and designed the study, TM and BV acquired data, analyzed and interpreted the data; TM, PZ and ACC drafted the article; TM, PZ, BV, ACC revised it critically for important intellectual content; all authors approved the final version to be submitted.

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CRediT authorship contribution statement

André Colonese: Writing – review & editing, Writing – original draft, Supervision, Funding acquisition, Conceptualization. **Thais Macedo:** Writing – review & editing, Writing – original draft, Formal analysis, Data curation, Conceptualization. **Benalsy Varela:** Writing – review & editing, Data curation. **Patrizia Ziveri:** Writing – review & editing, Writing – original draft, Supervision, Funding acquisition, Conceptualization.

Declaration of Competing Interest

The authors 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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Appendix A. Supporting information

Supplementary data associated with this article can be found in the online version at [doi:10.1016/j.marpol.2024.106447](https://doi.org/10.1016/j.marpol.2024.106447).

Data availability

I have shared the link to my data at the Attach files
Macedo et al., 2024_interview and landing data (Mendeley Data)

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