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Compiling fishers' local ecological knowledge for the conservation of threatened shark species in the Galapagos Islands

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ABSTRACT

Eng: This study examines the role of local ecological knowledge among fishers in the Galápagos Islands as a participatory approach to advancing the conservation of threatened shark species. Through the collection of qualitative and quantitative data using the open-source platform ONA, the research captures fishers' insights on shark abundance, distribution patterns, habitat use, and their practices and perceptions regarding shark conservation. These data were integrated with participatory mapping, using fisher's drawings and processing them in QGIS, enabling the spatial identification of key areas occupied by adult and juvenile sharks. The findings provide the first baseline assessment of the conservation status of threatened shark species since the implementation of protective measures. Results indicate population recovery in certain shark species following the cessation of shark fishing in the archipelago. Additionally, previously unidentified nursery areas were mapped, and fishers' interest in shark conservation was documented. This study underscores the importance of collaborative knowledge generation, emphasizing the value of integrating fishers' ecological expertise into conservation strategies.

Keywords: local ecological knowledge, fishers, Galapagos Islands, sharks, conservation.

Esp: Este estudio examina el papel del conocimiento ecológico local de pescadores de las Islas Galápagos como un acercamiento participativo para avanzar en la conservación de especies amenazadas de tiburones. A través de la recopilación de datos cualitativos y cuantitativos utilizando la plataforma ONA, la investigación recoge las perspectivas de los pescadores sobre la abundancia, los patrones de distribución, el uso del hábitat de los tiburones, así como sus prácticas y percepciones respecto a su conservación. Estos datos se integraron con mapeo participativo, utilizando dibujos realizados por los pescadores y procesándolos en QGIS, lo que permitió la identificación espacial de áreas clave ocupadas por tiburones adultos y juveniles. Los hallazgos proporcionan la primera línea base sobre el estado de conservación de los tiburones desde la implementación de medidas de protección. Los resultados indican una recuperación poblacional en ciertas especies de tiburones tras el cese de la pesca de tiburones en el archipiélago. Además, se mapearon nuevas áreas de crianza previamente no identificadas y se documentó el interés de los pescadores en la conservación de tiburones. Este estudio destaca la importancia de la generación colaborativa de conocimiento, enfatizando el valor de integrar la experiencia ecológica de los pescadores en las estrategias de conservación.

Compiling fishers' local ecological knowledge for the conservation of threatened shark species in the Galapagos Islands

1. INTRODUCTION

1.1. Historical Context and the Traditional Conservation Paradigm

The global perception and management of the Galápagos Islands have been heavily influenced by the forces of globalization and the Modern World-System. This system connects regions across continents through networks that facilitate the movement of goods, capital, people, culture, and biological resources. As globalization opens regions of economic or strategic value, powerful actors such as states, international organizations, and corporations exert transformative influence (Christophe Grenier, 2010). In the case of the Galápagos, these global forces have framed the archipelago as an archetype for evolutionary studies and conservation initiatives (Hennessy, 2018).

Since the early history of the Galápagos Islands, narratives shaped by explorers (late 16th century), British pirates (late 17th to early 18th century), American whalers (19th century), and later Western scientists (late 19th to early 20th century) influenced the world's perception of the islands. These narratives, inspired by the revolutionary acceptance of natural selection as a driver of evolution—a theory conceived in the archipelago—helped the Galápagos earn the title of a "natural laboratory" and inspired iconic imagery of a pristine, untouched environment from a Western perspective. Meanwhile, in the 19th century, the Galápagos became further integrated into the modern world system with the onset of colonization by mainland Ecuadorians. From the outset, small-scale fisheries (SSF) were essential for the nutritional and financial security of the archipelago's communities (Arianna Huff et al., 2023; Hennessy, 2018; Quiroga, 2009, 2013).

Species on the Galápagos Islands, believed to exist largely untouched by human influence, garnered international attention and fueled a drive for their protection. In 1959, a century after the publication of The Origin of Species, the Charles Darwin Research Station (CDRS), headquartered in Belgium, was established. That same year, the Ecuadorian government created the Galápagos National Park (GNP). In 1964 the CDRS was inaugurated in Santa Cruz Island and the Ecuadorian government signed an agreement making it the official advisor of the GNP. While some Ecuadorians were involved, the creation of the GNP was primarily driven by European and North

American scientists, united by a global perspective on the scientific significance of the Galápagos, with little, if any, participation of the local community (Hennessy, 2018; Quiroga, 2009).

In the 1980s and 1990s, as fisheries and marine tourism grew in economic importance, management practices initially developed for terrestrial areas were extended to marine and coastal ecosystems. In 1986, the Galápagos Marine Resource Reserve (GMRR) was created, although it had not yet achieved national protected area status. By 1992, a management plan for the GMRR was approved, implementing a zoning scheme for 15 square nautical miles and recommending special protection for adjacent areas up to 80 nautical miles away. The Galápagos Marine Reserve (GMR) was officially established with the passage of the 40-nautical-mile law in 1998, and its first management plan was finalized in 1999 (Quiroga, 2009). This plan established the Participatory Management Board (PMB) and the Inter-institutional Management Authority (IMA) (Quiroga, 2009).

However, fishermen believe that the PMB is biased toward conservationists, tour operators, and the CDRS, allowing these groups to dominate decision-making. Fishermen feel marginalized, asserting that they understand the marine environment better than scientists, who often fail to recognize their needs. They argue that, despite contributing to the creation of the GMR, they do not benefit from it and instead face restrictions on fishing as well as barriers to transitioning to other economic activities (Quiroga, 2009, 2013).

This dynamic created a polarized perspective, where traditional activities, such as fishing, were criminalized as a threat to biodiversity (Quiroga, 2013) because they didn't align with the conservation paradigm. As fishing grew, tensions rose between fishermen, the GNP, and the CDRS, leading to protests and strikes. This polarization was further exacerbated by an increase in conservation funds flowing to the GNP and various NGOs, from which the local community perceived little or no benefit at all (Quiroga, 2009).

This global framing has reinforced the narrative of the Galápagos as an untouched wilderness, valuable primarily for its natural heritage, while simultaneously commodifying its biodiversity for the purposes of conservation tourism and international scientific research. As a result, local residents often find themselves marginalized, as their traditional practices and livelihoods, such as fishing, are labeled harmful to the conservation agenda, while the influx of global capital, tourism, and external scientific interventions shapes the islands' future more than local perspectives. Thus, the Galápagos represent a microcosm of the broader tensions within the Modern World-System, where global environmental governance and capitalist interests intersect, often at the expense of local autonomy and socio-ecological justice (Hennessy, 2018).

Hence, nowadays, as a product of green colonialism, locals who are not part of the economic sectors benefiting from the conservation agenda mistrust conservationists, who blame them for the destruction of natural capital. Meanwhile, locals in the fishing sector feel left behind in the project of creating a sustainable territory and have even expressed anger toward emblematic animals like sharks, which are seen as both competitors for resources and symbols of conservationist priorities (Quiroga, 2013; Zimmerhackel et al., 2015). These tensions highlight the significant gap between local utilitarian perspectives and the conservationist views derived from the Modern World-System and the conservation paradigm.

1.2. The fishing sector and food security

SSF in the Galápagos provides the community with access to fresh fish products, serving as the primary source of protein consumed on the islands and ensuring food security. This role was especially significant during the COVID-19 pandemic, as it allowed the community continued access to fresh products, (Arianna Huff et al., 2023; Ramírez-González et al., 2022). Additionally, SSF reduces the need to import goods from the mainland, thereby lowering the risk of introducing non-native species and illnesses into the archipelago.

Nevertheless, the fishing sector is at risk as young people are choosing to leave their family businesses, ending the inheritance of the PARMA permit that allows fishers to legally operate in the reserve (Reglamento Para Actividad Pesquera En Reserva Marina de Galápagos, 2013), to pursue higher education or more lucrative career opportunities. If this trend continues, labor gaps will inevitably lead to instability in food security (Arianna Huff et al., 2023).

1.3. Environmental Justice and Post-Development Alternatives

Over time, protests from the fishing sector have prompted the conservation sector to implement new strategies, as it became clear that the conservation model could no longer overlook the local population. Western experts introduced new strategies and discourses that sought to address local needs and concerns through empowerment, community participation, and gender equality (Quiroga, 2009).

With a post-development perspective beginning to reshape the conservation paradigm worldwide, fostering local responsibility and community-based management of common resources within the GMR seems to require promoting non-hierarchical human cooperation based on solidarity, equity, and mutual support. This approach empowers locals, such as fishers, to actively participate in the governance of their shared resources. It involves processes of collective production and value-based cultural practices that are participatory and democratic, with a clear commitment to the equal welfare of both the community and the environment (De Angelis, 2019; McMichael, 2019).

1.4. Shifting Towards Inclusive Conservation

In the 1990s, the Charles Darwin Foundation (CDF) began incorporating aspects of the local social reality into its discourse, involving the local population in the planning and execution of various conservation programs. Educational and public awareness campaigns were launched to bridge the gap between global environmental discourses and local realities, though significant portions of the local population, especially in rural areas and among fishermen, continued to adhere to traditional frameworks. This shift marked a departure from the traditional conservation discourse, which often disregarded the role of local people (Quiroga, 2013). The new conservationist model recognized the presence of a local population that could no longer be ignored, framing conservation as a social issue that required social science expertise and active local involvement.

The traditional approach to conservation often imposed a form of control over nature that prioritized investor rights and commodified natural resources as "ecosystem services," leading to the externalization of nature (McMichael, 2019). In the Galápagos, the shift from cruise-oriented tourism to land-based tourism by the end of the century created opportunities for locals to become more integrated into the dynamics and benefits of conservation-oriented tourism. Tensions between fishermen and conservationists began to decrease due to several factors, such as the reduced importance of fishing to the Galápagos economy, the growing interest in tourism among many permanent residents, including fishermen, and a shift in conservationist discourses and practices toward a greater awareness of the need to include local people in their strategies (Quiroga, 2013).

1.5. Bridging the Gap Between Conservationists and Local Communities

Since the beginning of the 21st century, a more participatory approach has been adopted by researchers and conservation organizations such as the CDF. Even decision-makers have recognized the importance of involving fishers in the management of the GMR (Burbano & Meredith, 2020; Quiroga, 2013). However, the development and implementation of more participatory methods are still needed to foster cooperation between researchers and small-scale fisheries for the conservation of threatened marine species in the GMR and the well-being of the fisheries economy (Doménica Montaño, 2023; Ramírez-González et al., 2022).

Moreover, both objectives must be connected if food security, biodiversity conservation, and sustainable living are to be achieved while facing climate change adaptation in the islands. Fisheries have the potential to contribute to all these goals, but the integration of the sector into the development of a strategic plan (Galapagos Government Council, n.d.) is essential throughout the entire process. To do this, we must rethink the production and consumption systems, not only of goods but also of information and knowledge.

Based on this, our study will explore the extent to which the compilation of local ecological knowledge can serve as a bridge between academia and the local community for conservation purposes. The aim of this study is to integrate local knowledge into scientific research to gain insights into the ecology of some of the most iconic threatened shark species, including key locations for adult and juvenile shark gatherings, their presence across different marine ecosystems and habitats, historical changes in abundance, and perceptions of their conservation status.

1.6. Participatory Approaches and Local Ecological Knowledge

Participatory methods have been shown to enhance the effectiveness of conservation projects by involving local communities directly. These methods bring an intimate knowledge of local conditions, which foreign technicians and bureaucrats often lack, fostering networks of cooperation and relations on the ground. Despite potential biases and contradictions, integrating local and scientific ecological knowledge can lead to more comprehensive and effective conservation strategies (Rahnema, 2019).

The inclusion of participatory methods as essential dimensions of development ensures greater effectiveness in projects. Participatory processes bring close knowledge of the 'field reality', creating networks of cooperation on the local scene among actors capable of carrying out developmental activities (Rahnema, 2019). Those activities must be adjusted to a post-development view, where the final objective is to achieve regenerative acts. For the fishing sector and the conservation of threatened shark species, this could be translated into learning more about the ecological interactions carried out in the GMR to ensure food security, diversity conservation and sustainable living, while strengthening the fishing sector security.

1.7. Status of threatened shark species protection in the Galápagos Islands

Marine ecosystems worldwide are being threatened by anthropogenic activities and their consequences, such as overexploitation of resources, habitat loss, invasive species, climate change, and pollution. Human activities have greatly impacted the world's oceans, raising concerns about the potential extinction of marine species (Dulvy et al., 2003).

About 16% of the 465 species of sharks are threatened with extinction (Giovos et al., 2019). The Galápagos Islands are considered one of the locations with the highest congregations of sharks in the world, providing a home to 33 shark species, some of which are listed as threatened by the IUCN Red List (De León et al., 2016; Hearn et al., 2014; IUCN, 2024; Schiller et al., 2015). Recognizing the importance of protecting both the endemic animals of the Galápagos and those that occupy the archipelago during their migratory routes, local leaders and scientists worked together to establish the special regime, applying the Organic Law on the Special Regime for the Conservation and Sustainable Development of Galápagos (LOREG) since 1997. Following this, in 1998, the Galápagos Marine Reserve (GMR) was created to strengthen conservation efforts (Galapagos Government Council, n.d.).

Since 1972, various policy instruments such as agreements, agendas, reports, and conventions have been established to protect and conserve marine environments worldwide. These efforts led to the creation of Sustainable Development Goal #14 (SDG #14): "Conserve and sustainably use the oceans, seas, and marine resources for sustainable development," as well as the UN Decade of Ocean Research for Sustainable Development (Ocean Decade) (Huck, 2022). These instruments aim to guide the development of innovative solutions that enhance science-based policies and strengthen connections between science and policy at global, regional, national, and local levels. Their goals include protecting and restoring ecosystems, achieving sustainable fishing, increasing the economic benefits from the sustainable use of marine resources, advancing scientific knowledge and research for ocean health, and supporting small-scale fisheries, among other targets (Guan et al., 2023; UN General Assembly, 2015).

Aligned with these common goals, Galápagos leaders recognize the imperative to transition toward more sustainable practices in the archipelago, involving the community in the conservation of the islands' natural heritage, and preserving and enhancing both the intrinsic and economic value of the island ecosystems. Two of the proposed initiatives include promoting the development, implementation, and dissemination of projects that encourage the organization and participation of the community in the conservation of the natural and historical heritage of Galápagos, and creating and implementing a program to promote research and knowledge management processes in the field of culture. This program aims to contribute to the development of a sustainable, intercultural, and inclusive lifestyle that highlights identity based on diversity, historical memory, and the connection between human beings, the community, and the unique natural environment of the Galápagos (Galapagos Government Council, n.d.).

Despite these initiatives, the prevailing belief remains that locals' interactions with threatened iconic marine species in the islands, such as elasmobranchs, are limited to tourism and fishing. While sharks are protected within the boundaries of the GMR, there is still a risk of their capture. This can occur through legal operations by industrial fishers outside the GMR boundaries or through illicit incursions into the protected waters. Additionally, local fishers may inadvertently catch sharks as bycatch in hook-and-line and gillnet fisheries, or sharks may become targets in illegal fisheries specifically for shark fins (Hearn et al., 2014).

Anecdotal evidence suggests that sharks have been fished in the Galápagos since the 1950s, but it was during the late 1990s, following the collapse of the cucumber fishery, that Galápagos fishers turned to shark fishing (Jacquet et al., 2008; Schiller et al., 2015). Due to the nature of the fishing activity, which became illegal after the creation of the GMR, there is a lack of data on the number of sharks fished. As a result, only estimates have been made in an effort to understand the impact of this activity on shark populations in the islands (Jacquet et al., 2008; Schiller et al., 2015).

As has been recognized, there are no numerical or anecdotal indications that shark fishing ever declined or stopped in the Galápagos (Schiller et al., 2015). However, it should be noted that sanctions, monitoring, and various efforts from the conservation sector to educate locals about the importance of sharks in the food chain and their ecosystemic role—along with the decline of the fishing sector due to the shift toward tourism-related jobs—should have had an effect on the recovery of shark populations.

Even though the Galápagos Islands boast a rich diversity of shark species, uncertainties persist regarding their distribution throughout various life stages and their interactions with the ecosystems across the archipelago (De León et al., 2016; Goodman et al., 2020a; Hearn et al., 2014). Recent studies have highlighted the crucial role of mangroves as nurseries for certain shark species, such as *Sphyrna lewini* and *Carcharhinus limbatus* (Chiriboga-Paredes et al., 2022; Goodman et al., 2020b; Páez-Rosas et al., 2021), as well as the risks of bycatch they face in this ecosystem (Acuña-Marrero, Smith, et al., 2018; Goodman et al., 2020a; Llerena et al., 2015; Páez-Rosas et al., 2021; Pontón-Cevallos, 2023).

Bycatch of shark species in nursery areas remains inadequately addressed (Acuña-Marrero et al., 2018; Acuña-Marrero et al., 2018; Páez-Rosas et al., 2021). The specific ecosystems acting as nurseries in the archipelago and the shark species composition within them remain unclear, so more research is needed to understand the threats different species face throughout their life cycles and migratory routes in order to develop better conservation tools.

Bridging this knowledge gap is crucial for devising conservation strategies that prevent the bycatch of juvenile sharks in the Galápagos' marine ecosystems, while ensuring that fishers can actively contribute to managing their commons and securing the economic stability of the sector. The viability of economic endeavors, such as artisanal fishing in the islands, is entirely reliant on the health of native ecosystems and the ecological services they provide. Conversely, the enduring preservation of Galápagos' distinctive biodiversity and ecosystems significantly depends on locals, who bear the ultimate responsibility for upholding sustainable economic and social practices (Castrejón et al., 2014; González et al., 2008).

Because of this social-ecological system, involving local fishers in research, as well as in the management and monitoring of the GMR, while enhancing ecological knowledge of threatened species, should be an integral part of a conservation strategy and territorial development plan. This would increase the resilience of marine ecosystems and promote sustainability in the islands.

1.8. Local Ecological Knowledge

To better understand shark ecology, several scientific studies have been carried out throughout the islands, enhancing knowledge about which species rely on the Galápagos ecosystems, their abundance, distribution, and behaviors in different areas of the archipelago. Special attention has been given to studies focused on their migratory pathways to protect them from illegal fishing

(Acuña-Marrero et al., 2018; Bessudo et al., 2011; De León et al., 2016; Hearn et al., 2014; Páez-Rosas et al., 2021). From a more sociological perspective, some conservation programs have explored local fisher perceptions of sharks (Acuña-Marrero et al., 2018).

Artisanal fishing, as practiced in the Galápagos under LOREG, allows fishers to maintain a close connection with the ocean, providing them with unique and valuable life histories filled with testimonies, adventures, and observations. This practice is further enriched by the fact that shark fishing was historically conducted in the archipelago, meaning that some generations of fishers may have had more frequent and closer encounters with sharks, enabling them to more easily identify shark species. Collecting these diverse narratives could help create a clearer picture of shark population trends over the past decades, offering new insights into the success of conservation efforts and other factors influencing their abundance over time.

Fishers' narratives have the potential to fill knowledge gaps about marine ecosystems and their biodiversity to science. Nevertheless, despite historical efforts in shark conservation, scientific studies have generally failed to actively involve fishers or incorporate their knowledge into the scientific process (Cavole et al., 2020; González et al., 2008).

Locals can contribute to and support scientific studies with their knowledge on topics where traditional data is lacking, such as species abundance fluctuations over time, the presence and use of different habitats, migratory processes, and monitoring. This knowledge also encompasses a collection of data, preferences, perspectives, and values regarding their relationship with the living environment (Almojil, 2021; Bakiu et al., 2023; Barbato et al., 2021; Colloca et al., 2020; Custodio Nascimento et al., 2023; Giovos et al., 2019; Leduc et al., 2021; Rasalato et al., 2010).

Incorporating the perceptions and feedback of local communities into research processes significantly enhances the likelihood of developing management plans tailored to the specific realities of the socio-ecological context (de Sousa et al., 2022). This participatory approach empowers marine scientists and resource managers by equipping them with critical insights and tools necessary for effective conservation efforts and policy formulation. Integrating fishers' perspectives facilitates a bottom-up management framework, which has been shown to be more effective and sustainable compared to top-down approaches (Barbato et al., 2021; Giovos et al., 2019; González et al., 2008).

Local Ecological Knowledge (LEK) emerges as a valuable tool for incorporating fishers' insights, creating a bridge between academic research and citizen science (Bessesen & González-Suárez, 2021). Recognizing the importance of taking action to safeguard biodiversity and promote sustainability, the Galapagos Islands Strategic Plan, in connection with the participatory management system of the GMR, encourages the use of knowledge as a resource for transitioning to a diversified economic system and a bottom-up management approach among various stakeholders (Galapagos Government Council, n.d.; González et al., 2008). This necessitates a reconsideration of how knowledge is produced and opens the door to incorporating more participatory science when developing research and strategic plans for marine conservation, actively involving Galapagos inhabitants in the pursuit of sustainable territory management that benefits all living beings in the territory.

1.9. Reshaping narratives for environmental justice and knowledge production in the Galapagos Islands

Historically, conservation efforts in the Galapagos, often spearheaded by international scientists and organizations, have focused on protecting biodiversity and ecosystems, sometimes at the expense of local communities' livelihoods, knowledge systems, and rights. Fishermen and other residents have frequently been marginalized in decision-making processes, leading to tensions and conflicts as their traditional practices and economic needs have been overlooked or criminalized under strict conservation policies.

As Hennessy (2018) points out, the governance of the Galapagos as a 'natural laboratory' has led to a biopolitical control of human populations, benefiting certain groups (scientists, conservationists, tourists) while marginalizing others, particularly locals and fishers, whose access to nature is restricted. This dynamic has the potential to shift with the introduction of a new instrument for biopolitical control: the creation of the Galapagos Life Fund (GLF)[1] in 2023.

According to its official webpage, the GLF manages conservation grants, funding projects focused on, among others, the management of the New Hermandad Marine Reserve and Sustainable Fisheries Initiatives. This research aims to demonstrate the potential of involving fishers in the control and monitoring of the New Hermandad Marine Reserve, particularly in monitoring non-commercial species like sharks. Such an initiative could mark the beginning of a project that

[1] Galapagos Life Fund webpage: https://galapagoslifefund.org.ec/about-us/

positively impacts local livelihoods and their relationship with the environment, fostering new conservation narratives where fishers play a central role in ensuring both socio-economic and socio-ecological sustainability.

1.10. Aims and Objectives

By highlighting LEK, conservation efforts can advocate for a more inclusive approach that respects and incorporates the experiences and insights of the Galapagos fishing sector. This study aims to align with the principles of environmental justice by ensuring that local communities, who are directly affected by conservation policies, have a voice in shaping those policies. It addresses the power imbalance between global conservation interests and local needs, working towards a more equitable conservation model that benefits both the environment and the people who depend on it (de Sousa et al., 2022; Haklay & Francis, 2018; Rasalato et al., 2010).

In this context, the objective of this research is to explore the extent to which compiling fishers' LEK about threatened shark species in the Galapagos Islands contributes to knowledge building. In specific, it seeks to provide insights into the conservation status of these species, while integrating perceptions from the fishing sector regarding shark conservation. The final goal is to translate these insights into actionable steps that foster intersectoral synergies, guided by a post-development point of view, promoting food security, diversity conservation and sustainable living, while strengthening the fishing sector security.

2. METHODOLOGY

2.1. Study Area

The Galapagos Islands are in the Eastern Tropical Pacific Ocean, approximately 970 km away from Ecuador’s continental coast. The oceanographic conditions around the archipelago can be divided into two seasons: a cold season with temperatures between 18–20˚C (from June to November), and a warm season with temperatures > 25˚C (from December to May) (Chinacalle-Martínez et al., 2024). General features of the three main fishing ports of the Galapagos Islands including a summary of the fishery information based on Castrejón & Charles (2020) can be found in the table below.

Table 1: General features of the three main fishing ports of the Galapagos Islands

	San Cristobal	Santa Cruz	Isabela	Total
Fishing port	Baquerizo Moreno	Ayora	Villamil	3
Main landing sites	1	2	1	4
Population	7945	15393	2256	25144
Coastline (km^2)	~ 156	~ 170	~ 617	~ 944
License holders (active/registered)	174/552	136/293	100/239	410/1084
Cooperatives	2	2	1	5

A study in 2007 found that for every 100 people employed in the Galapagos 8 work in agriculture and the fishing sector, and concerning tourism, 42.78% of people working on the island perform activities associated with it (Epler, 2007). One of the focal problems for the Galapagos Fishing Community is the low profitability that fisherfolk receives, with about 70% of fisherfolk reporting they must supplement their revenues with other activities. The most profitable fisheries, sea cucumber and lobster fisheries, only operate from July to December (Castro, 2005). Fisherfolk reports that these months are not the best for fishing activities due to very bad weather conditions (Castro, 2005; Ramírez-González et al., 2022).

2.2. Survey design and implementation

2.2.1. **Defining the approach:** To compilate fishers' LEK a literature review on the topic was conducted, to understand the type of questions and approaches already tested in other parts of the world to study fishers' LEK about sharks. Considering the approaches, it was defined to develop an interview guided by questions to characterize LEK of sharks, including three sections: a) sociodemographic characteristics, including questions to understand the person's experience and trajectory in the field (e.g. age, main occupation, education level, years of trajectory); b) general knowledge about shark's ecology (e.g. adults and juveniles sightings, adult's size, marine ecosystems it occupies, changes in abundance); c) perspective about shark conservation (e.g. experience fishing sharks, opinion on the conservation of sharks and the current restrictions for shark fishing). Therefore, the questionnaire was defined based on literature review and the local context. The full questionnaire is presented in Supplementary Material 1.

To decide which species to include, firstly it was considered to ask questions about all threatened shark species present in the Galapagos, but after testing how much the interview would last, it was defined to work only with eight species. To select the species to include in the questionnaire, priority was given to the ones that have been most reported as product of shark fin commerce and are considered understudied (Bonaccorso et al., 2021; Carr et al., 2013; Fundación Charles Darwin (FCD) & WWF-Ecuador, 2018; Hearn et al., 2014; Jacquet et al., 2008; Matsunaga & Yokawa, 2013). The final questionnaire included: *Alopias pelagicus, Alopias superciliosus, Prionace glauca, Isurus oxyrinchus, Sphyrna zygaena, Sphyrna lewini, Carcharhinus falciformis* and *Galeocerdo cuvier.* Local names for species were extracted from Charles Darwin Foundation´s dataZone webpage.

In this research, data collection was conducted using ONA, a mobile data collection platform that leverages the capabilities of ODK Collect. ONA is particularly effective for field research due to its capacity to operate offline, making it ideal for use in the Galápagos Islands, where internet access can be limited or unavailable. The platform was selected for its ability to handle various question types, such as multiple-choice, numeric, open-ended, and geospatial data, enabling the integration of complex datasets, including fishermen's ecological knowledge.

2.2.2. **Survey Design:** Since one goal of this research is to promote free and easy access to information on biodiversity and ecosystems, it was decided to use only free and open-source software, that any person or entity can use regardless of their location or financial constraints. The forms for the interviews were created using ONA's interface, which supports structured questionnaires. These forms were tailored to capture both quantitative and qualitative data, focusing on fishermen's trajectory, their perceptions of sharks' ecology, and opinion about shark conservation.

The questionnaire was reviewed and approved by shark researcher in the Galapagos, Alex Hearn, and it was tested before going to the field with people involved in academic research and non-academics. On the field, it was first tested with a fishermen from the Galapagos, Manolo Yepez, who is involved in research as well and works with Alex, who helped to improve the approach on the field (i.e. reformulate the way a questions is asked or explain it differently). He also explained the dynamics in the different types of fishing in the archipelago so the author could understand better fishers' context.

Additionally, the ability to incorporate geolocation in the forms allowed the collection of spatial data regarding shark sightings, so initially the questionnaire included questions to map on a digital map the points where fishers had seen shark aggregations of adults and juveniles, as well as places where there is an absence of them now (compared to the time when they started fishing). But when testing this method, it became clear that it took a lot of time to answer the questions, and digital mapping might not be so easy to get familiarized with, so it was decided to make a participatory mapping activity using boards printed with the main islands and the whole archipelago to make fishers draw on them with board markers (Supplementary Material 1).

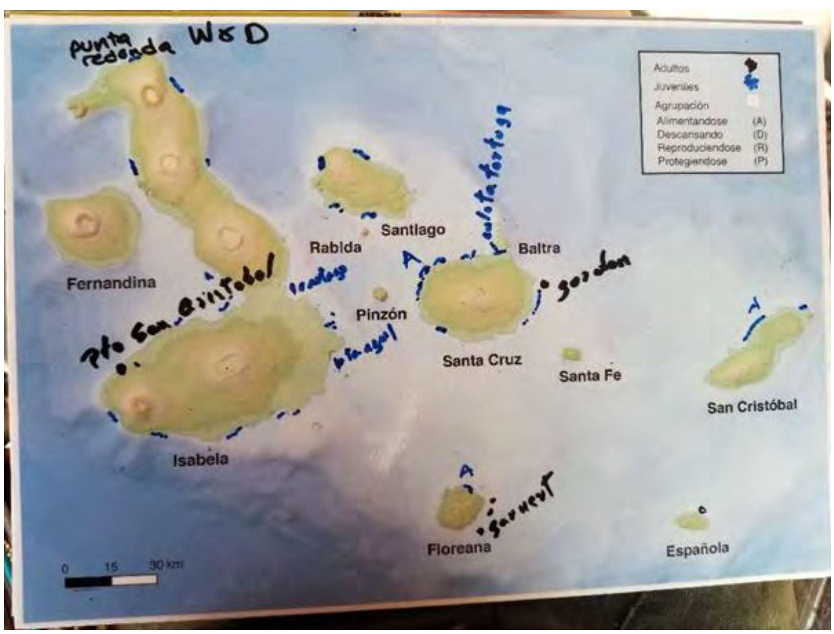


Figure 1: Photography of a participatory mapping activity using the printed boards. As the participant had fished in all the archipelago, a board with the entire printed archipelago was used with him. The fisher marked the places where he saw a species (Sphyrna sp.), adults in black and juveniles in blue marker, indicating with an 'A' in this case the places where he saw them eating. Local names of specific locations were given as well for reference.

Visual material used along the interview as reference was printed as well, including a representation of the Galapagos seascapes following Pontón-Cevallos (2023) representation, along with photographs of the shark species studied (Supplementary Material 1). The use of these materials required for the interview to be performed in person.

2.2.3. **Data Collection Process:** Data collection was performed in the three main Galapagos islands where artisanal fishing is allowed: San Cristobal, Santa Cruz and Isabela, spending one month on each one from 1st of July to the 27th of September 2024. On each island, participant observations were initially performed, to understand the island's dynamics, and the author talked with key local actors who could help her to start getting to know the fishing sector, to prompt multi-stakeholder engagement (e.g. fishing cooperatives, research institutions, local government, conservation organizations).

The universe of participants targeted consisted of fishers from any gender and age, time of experience, both active or retired, with or without fishing permit, but resident of the islands. In order to triangulate fishers' LEK, especially spatial patterns, interviews to other users of the marine reserve (OUMR) were conducted, including field and marine guides, scientists and tourism agents, considering on-ground knowledge, experience in research, monitoring, tourism or management activities; following Pontón-Cevallos (2023) approach in the Galápagos doing LEK research with fishers, but related to mangroves.

For San Cristobal Island the 'Instituto de Ecología Aplicada ECOLAP' from USFQ facilitated a list of active fishers with their phone number, which facilitated the process of contacting them via cellphone call to arrange a meeting. The list of active fishers from Santa Cruz and Isabela couldn't be obtained, requiring more time to recruit contacts.

During fieldwork, local fishers were contacted to tell them about the research and arrange a meeting, in a one-to-one approach. This was important as the author learnt that there is a strong repulsion from the fishing sector towards conservationists and scientists, so giving them an explanation about the research objectives and the author's affiliations, and allowing them to mark a time for our meeting, respecting their working time and free time, was something that in the end allowed the author to have the interviews and, most importantly, gain their trust.

After informing them about the research, before starting the interview, an informed consent document was signed. Once the interview started, their responses were recorded anonymously directly into the ONA app, by my person, using a mobile device. This method facilitated real-time data entry, reducing the risk of errors associated with manual transcription. The app's offline functionality was crucial in remote areas of the islands, where internet connection is unreliable. Respondents could skip questions or finish the interview whenever they wanted.

At the end of each survey, the author would ask the interviewee to suggest her other fishers contacts, or people who have had experience in the fishing sector, applying a snow-ball methodology to obtain more possible interviewees, which has proved to be effective in this type of researches (Almojil, 2021; Peñaherrera-Palma et al., 2018; Pontón-Cevallos, 2023; Seidu et al., 2022; Shaff et al., 2023). It was necessary to create a lot of contacts to have as much interviews as possible, working collaboratively with actors from different sectors, such as the Galapagos Science Center (which has previously worked in San Cristobal with some fishermen), Fishing Cooperatives, the National Park Service, and the general community of the islands.

2.3. Data analysis

2.3.1. **Qualitative and quantitative data:** Data was exported from ONA into Excel, where the raw data was first cleaned to prepare it for processing into separate sheets or documents. For the open-ended question responses, data was categorized using an inductive approach, identifying emergent themes (Pissarra et al., 2024). For the question about the reasons for supporting or opposing shark conservation, qualitative data was exported as a CSV file into Voyant Tools, a free tool for text analysis. Voyant detected frequent words and generated graphs and detailed language use analysis. By visualizing word clouds using the 'Cirrus' and 'Links' tools, it was possible to visually identify the most common words used by each group when answering specific questions.

Descriptive summaries and proportions were used to analyze categoric data in Microsoft Excel, and when necessary (Pissarra et al., 2024), visually presenting it in figures using 'Dynamic graphs' tool to create the graphs. For answers that didn't require an analysis categorized by groups, graphs generated by ONA using 'Charts' section were used.

2.3.2. **Participatory mapping data:** Free and open-source software QGIS 3.28.5 was used to perform territorial analysis from the participatory mapping responses. It was necessary to acquire local names, asking locals to locate them in the board map and later using available online touristic maps of the Galapagos to compare the accuracy, as well as getting help from fishers, to help locate sea mounts (which are important areas for their fishing activity) and key areas for shark sighting directly in QGIS. Shapefiles and raster data used from other sources for visualization purposes are listed in Anex 1.

To integrate the mapping drawings from each interview, the drawings were converted into polygons in shapefiles within QGIS. Each shapefile represented an interviewee's response, enabling the identification of patterns and areas of interest. The categories ‘species,’ ‘ecosystem,’ and ‘life_stage’ were incorporated into the shapefiles. The interviews were then ‘Merged’ using the Vector geoprocessing tool, and a ‘value’ category with a value of ‘1’ was added to all items to facilitate cell statistics processing, with each layer representing a single sighting. The layer was reprojected to WGS 84/UTM zone 15 to ensure all layers shared the same coordinate system for analysis. Finally, spatial objects were selected using the ‘Select by Expression’ tool and ‘field and values’ expressions to select by species, creating a new layer for each species.

The layers were then split into separate layers by name using the ‘Split Vector Layer’ tool. These layers were subsequently transformed into rasters using the ‘Rasterize’ tool. Afterward, Map Algebra was performed with the ‘Cell Statistics’ tool, using the ‘sum’ function to add the overlapping layers, summing the ‘1’ value in each layer to determine the total number of people who reported sightings in each area. The results were visualized using a color palette with unique values to symbolize the summed raster layers.

3. RESULTS

3.1. **On the approach to obtain interviews:** Trying to start a project that involves intersectoral participation requires exploring which approach is the best for each group. Particularly, when working with fishers, literature, past experiences narrated by colleagues, and even locals from Galapagos recommend approaching fishers at the dock, or in the places where they gather to talk to each other. During the research the author realized that a connection one-to-one is mostly more effective, and even if it can result in difficulty, trying to arrange meetings previously by phone, respecting their availability.

The reason is because at the dock one can find them when returning, tired, from work, getting ready to leave, or repairing their boats. When gathered in groups, it is enough that one of them answers that they don’t give interviews for the entire group to refuse to do one. On some occasions some of them do agree to give an interview, but the others then refuse as it is perceived that the researcher has already obtained enough information. There is a lot of group pressure as, in some cases, as members of a cooperative they have already agreed not to give interviews or collaborate with researchers, as one of the fishers in Isabela told the author when refusing to help her.

3.2. Sociodemographic characteristics

3.2.1. Interviewee's experience and trajectory in the field

Regarding the composition of respondents, a total of 60 fishers were interviewed (74% of total interviews): 31 from San Cristobal, 14 from Santa Cruz and 15 from Isabela. OUMR integrated 21 interviewees (26% of total interviews): 11 guides, 7 researchers and 3 tourism agents, most of them from Santa Cruz Island (Figure 2).

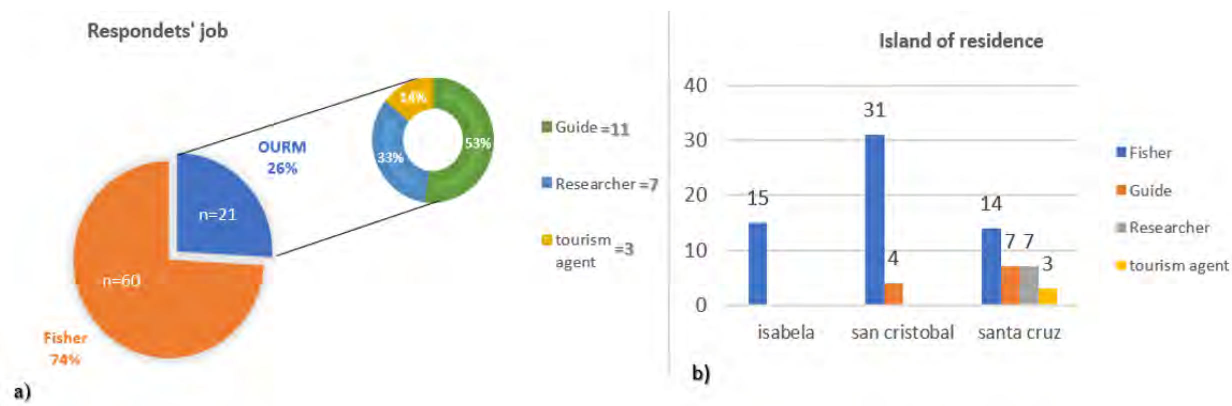


Figure 2: a) Respondent's main job, left pie showcasing percentage of fishers and OUMR interviewed, and right wheel pie OUMR percentage break down into guides, researchers and tourist agents; b) respondent's island of residence classified by job.

When asked if they had another job apart from their main one, only fishers answered positively. From the group of people who practice fishing, 20% dedicate only to this profession, while from the 80% who keep an alternative job 24% have a job related to tourism, 9% dedicate to agriculture, 5% to research, %5 are tourism guides and 3% dedicate to maritime transport. The remaining 34% have another job not related to any of the above-mentioned (Figure 3).

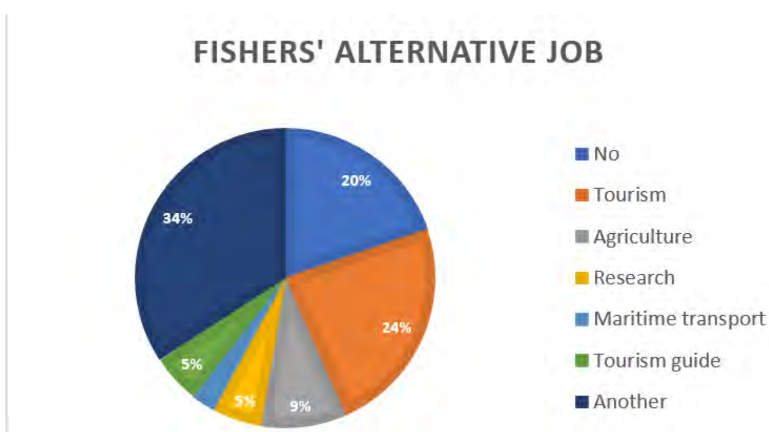


Figure 3: Fishers' report percentage about having an alternative job.

It was desired to obtain interviews from a wide age range, resembling different amounts of experience and perspectives. The average age of all respondents was 46, but especially for fishers, age varied a lot, including individuals who were from 18 to 84 years old and a mean of 48,5. The average age for OUMR was: guides = 43; tourism agents = 27; and researchers = 33 (Figure 4).

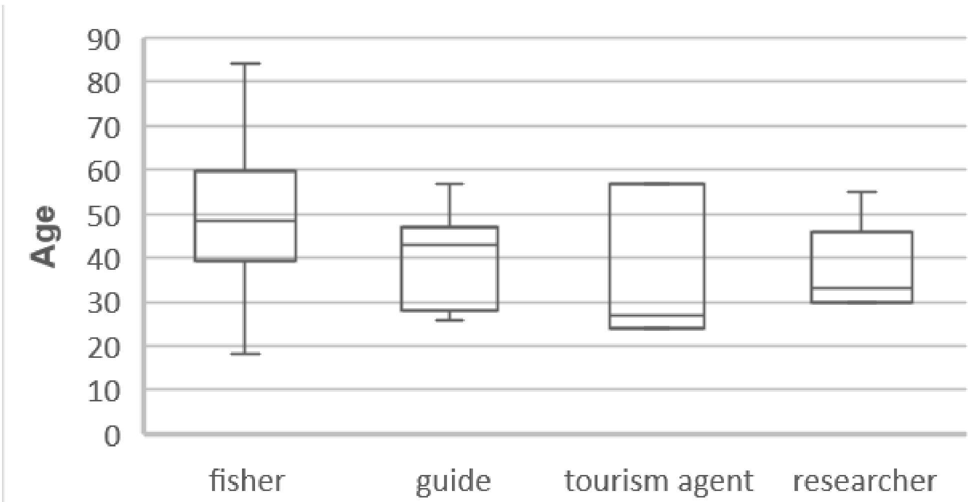


Figure 4: Respondent's age by job category

Respondent's gender included mostly men for fishers' category, and even though less interviews were held with OUMR, by experience gathered living in the islands and getting immersed in the reality of each one of them, the same could be said for guides. Researchers and tourism agents seem to have more gender equality in their field, and this was somehow resembled in the number of interviews obtained per gender (Figure 5).

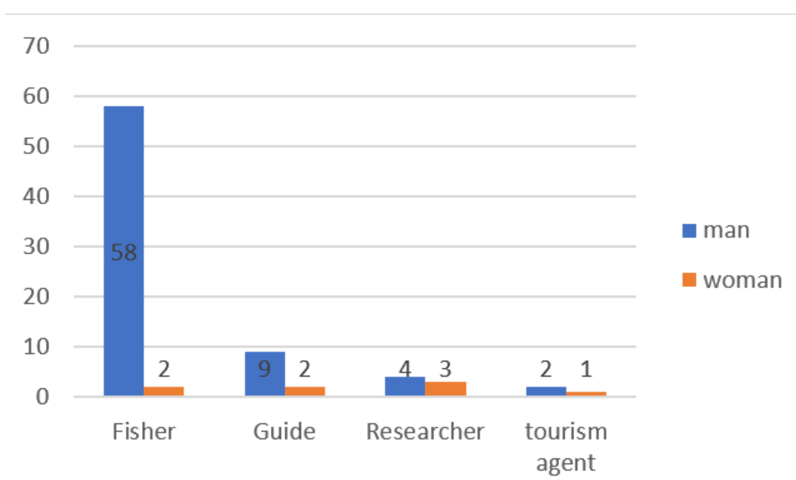


Figure 5: respondent's gender by job category

Education level was dependent on job category as well, with most fishers holding a high school degree, while most of OUMR hold a university degree. Researchers had a higher-level degree (master's, PhD or post-doctoral degree), but were included in the university category as well (Figure 6).

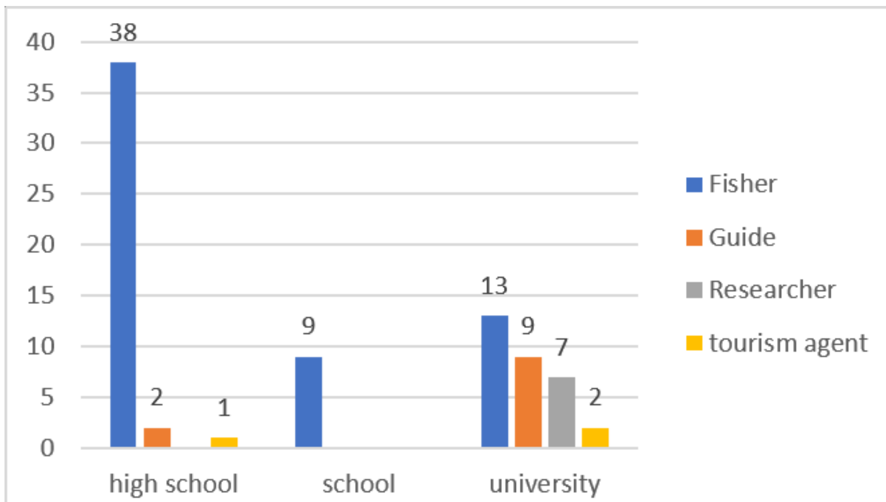
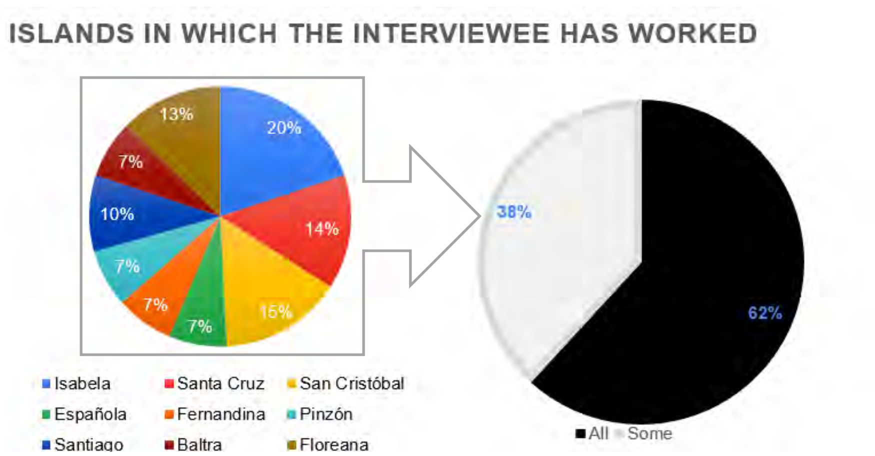


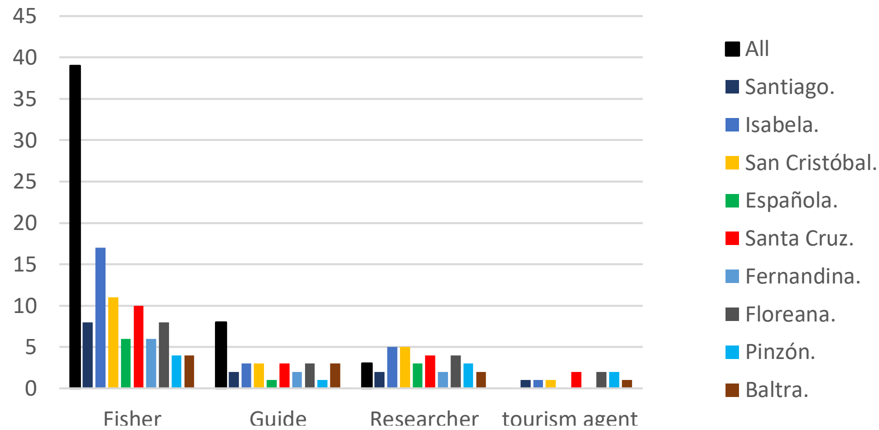
Figure 6: respondent's education level per job category.

Most of the respondents have visited all the archipelago as part of their job (62%), while the rest have mainly visited the inhabited islands (Isabela 20%, Santa Cruz 14%, San Cristóbal 15% and Floreana 13%) (Figure 7a).

Most fishers (39 out of 60) and guides (8 out of 11) have worked in all the islands, while researchers and tourism agents have worked and visited just some of them. Fishers' most visited island is Isabela (17) even though it's the furthest one, followed by San Cristobal (11) and then Santa Cruz (10) (Figure 7b).



a)



b)

Figure 7: a) Percentage of visited islands, 60% of respondents have visited all the archipelago, while 38% have visited some of the islands (percentages showcased in colourful wheel) b) respondent's visited islands classified by job category.

Experience gained is related to the year in which the respondent started working. Most fishers started working before the creation of the GMR, while most of OUMR started working after the creation of it (Figure 8). For fishers, the number of years of experience was analyzed. In average, fishers have 29 years of experience, with a minimum of 3 years and a maximum of 64 years. In total, 70% keep actively fishing, while the remaining group have changed their profession or are retired (Figure 9).

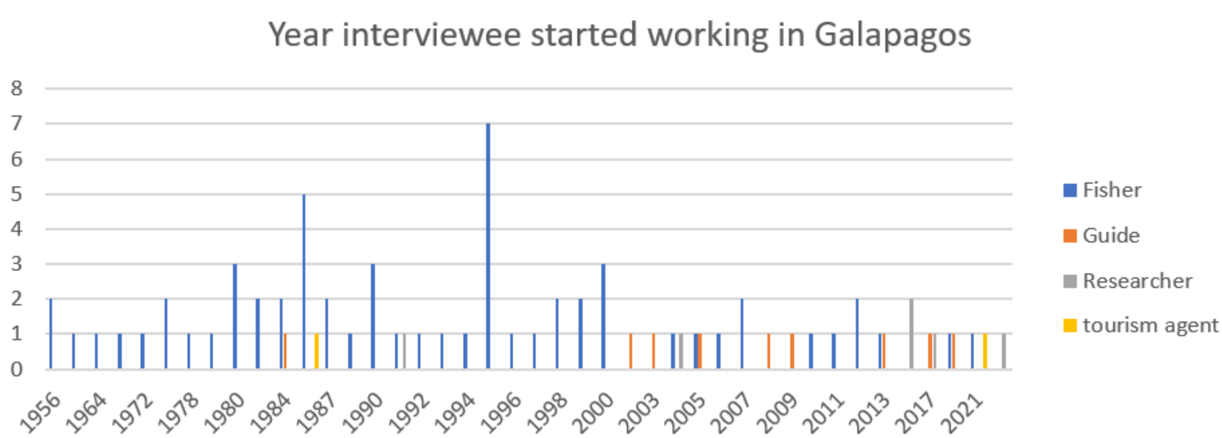


Figure 8: Year the respondent started working in the Galapagos, per job category.

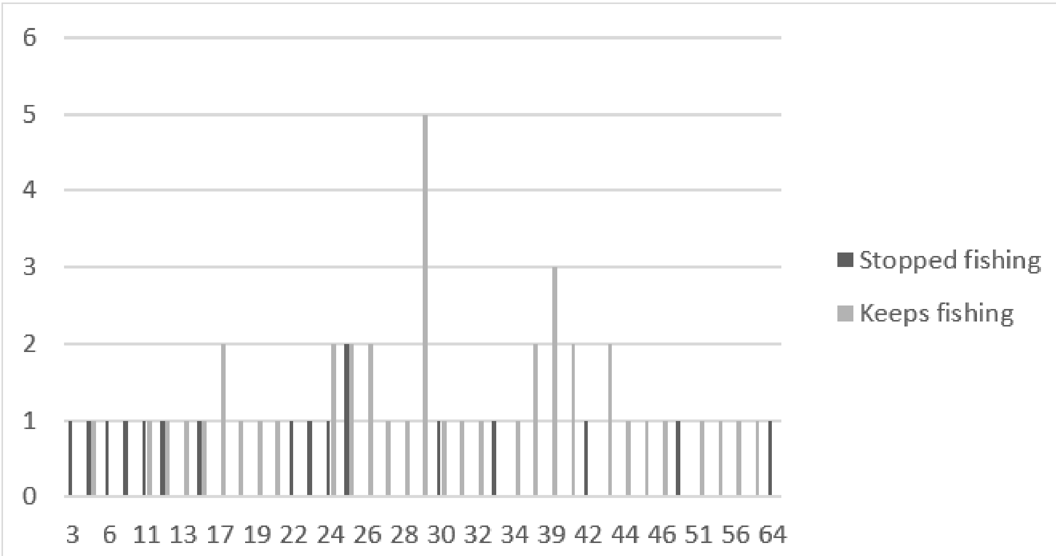


Figure 9: Fisher's years of experience. The legend distinguishes between fishers who stopped fishing and who keep doing it actively.

When asked about the frequency of fishing days/week, fishers' answers varied a lot (Figure 10). 27% answered that it depends on the target and for them the working days are not structured. For example, when they fish for lobster (when making the interviews lobster fishing was open) it depends on the time it takes them to obtain the amount expected, taking long journeys which can go from 7 to 14 days in a row. Whereas when lobster or sea cucumber fishing is closed, they can go for daily journeys, depending on the weather.

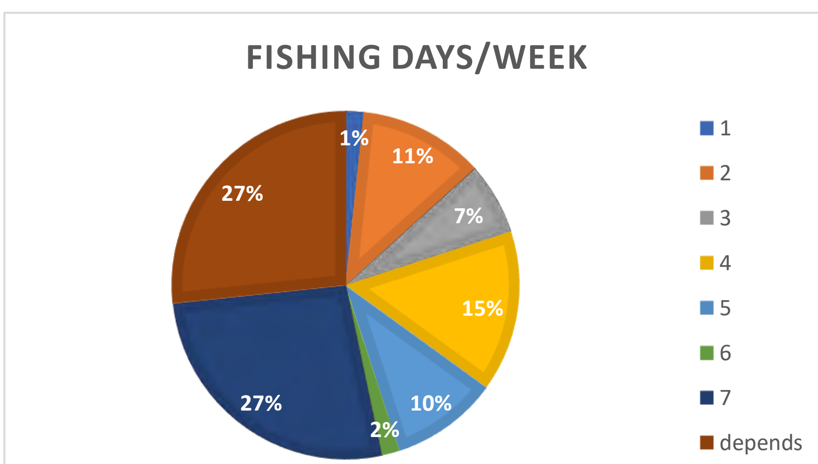


Figure 10: fishing days/week. The legend represents the number of days.

Other fishers (27%) answered that they always go fishing, adapting to the fishing target but working the entire week. The rest answered they go fishing for just a few days of the week, connecting this to the fact that they have another job apart from fishing. Nevertheless, the majority

(58%) of fishers answered that they practice fishing during the entire year, while 19% mentioned they do it just for half of the year (Figure 11). This last percentage is connected to lobster or sea cucumber fishing periods.

When asked about the marine ecosystems they most frequently visit/ed and hence, they are more familiarized with, most of them mentioned that it depends on the fishing target. For example, some mentioned that mangroves are visited while fishing for bait, specifically the Galapagos mullet (common name 'Lisa', scientific name *Mugil cephalus*), using fishnet (malla). They narrate that sometimes juvenile sharks tend to fall (hammerheads) in the net and are freed by catching them by the tail and throwing them outside of it, without apparent harm.

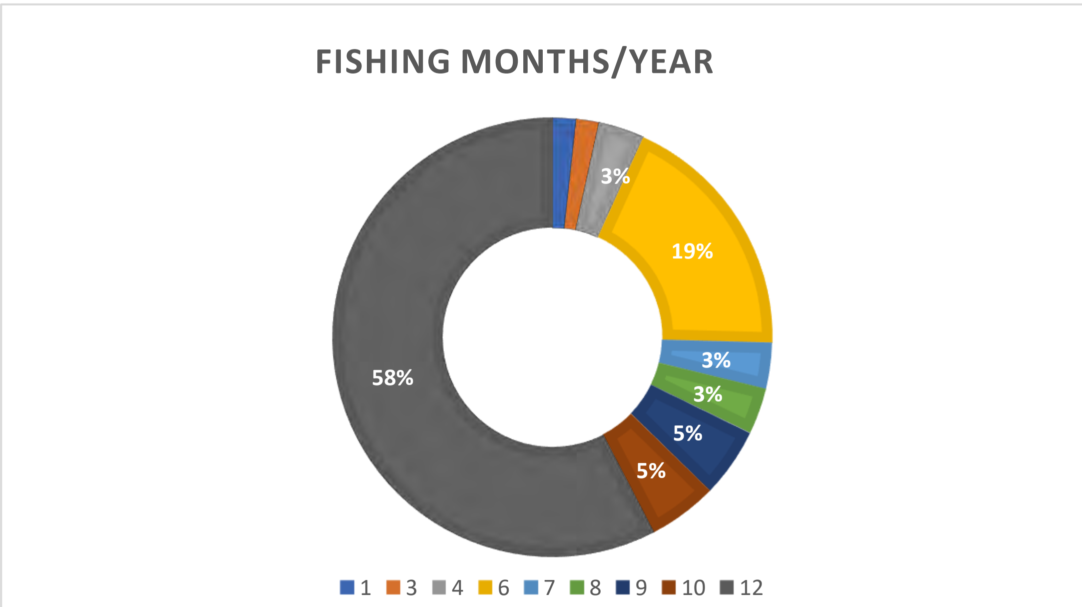


Figure 113: fishing months/year. The legend represents the number of months.

In shallow reefs they fish for octopus, lobster and sea cucumber at a maximum of 35m. deep, but cautious fishers recommend doing it at a maximum of 15m. deep. In vertical walls they can also find lobster and sea cucumber. Along the coast in bays with sandy bottoms, from 1 to 6m. deep, they fish for long-fin tuna (Albacora', *Thunnus alalunga*), and wahoo ('Guaho', *Acanthocybium solandri*). In open waters, from 100 to 200m. deep, they fish for yellow-fin tuna ('Atún', *Thunnus albacares*), sword fish ('Pez espada', Xiphias gladius), long-fin tuna, Almaco jack ('Palometa', *Seriola rivoliana*), wahoo, and the Galapagos grouper ('Bacalao', *Mycteroperca olfax*). Sea mounts lowest parts can range from 80m to 300m., and they fish for the misty grouper ('Mero', *Hyporthodus mystacinus*) and scorpionfish ('Brujo', *Pontinus clemensi*) there.

Some mentioned they recognize seasons for fishing, depending on the target. They recognize the season of the ‘seco salado’, in which they fish for the Galapagos grouper, and then there are the seasons to fish for lobster, slipper lobster (‘langostino’, *Scyllarides astori*), chief rocksnail (‘churo’, *Hexaplex princeps*), sea cucumber, and ‘canchalagua’ (*Chiton magnificus*) (Find more information regarding fishing types classification and used fishing arts allowed for each one in Anex 2, according to Ramírez-González et al., 2022). They mention that only old people who don’t go diving dedicates to ‘seco salado’ fishing. At the beginning this used to be a lucrative practice as they exported the Galapagos grouper for ‘Semana Santa’ to mainland and received good remuneration for it. Nowadays, the new generation specializes in diving for lobster or sea-cucumber, which is now more lucrative. Nevertheless, there are risks associated with diving, including cerebral embolism, which they fear as many fishers have died or ended up paralytic because of it.

In general, fisherfolk are familiar with all the marine ecosystems of the Galapagos as they visit them according to their fishing target throughout the year, but according to the generation, fishers can have more or less experience in some ecosystems. As some fishers of the oldest generation recognize, the new and younger generation of fishers tend to specialize in sea cucumber and lobster fishing, showing more experience along the coast near shore, while fishers over 30 years old do all types of fishing and are equally familiar with all the ecosystems. As well, fishers mention that now they need to go further to capture enough fish compared to when they started fishing. Back then, they could find enough fish in the vicinity of their island of residence. For this reason, many of them go fishing in Isabela now.

3.3. Interviewee’s knowledge about shark species’ ecology

When the interviewees were asked about the type of reproduction sharks have, depending on the job category, they referred to different types of reproduction in general terms to avoid confusion, including ‘gives birth’ (ovoviviparous and viviparous) and ‘lays eggs’ (oviparous); and gave more or less specifications depending on how much they knew about the topic. For example, most fishers described a viviparous/ovoviviparous type of reproduction, based on their empiric knowledge. Many of them narrated their experience during fishing trips, when they have caught big sharks (they mostly named hammerheads or the Galapagos’ shark) and wondered why its stomach was so big. Guided by curiosity, they sometimes opened their stomachs, and discovered completely formed babies, which they then freed in the ocean. Some narrate that even now when they catch a shark by accident and it's dead, if they recognize it's pregnant, they open it to free the babies. Just a few have seen hammerhead sharks giving birth naturally, all of them in mangrove areas.

Interestingly, some fishers and tourism agents associated the fact that the baby sharks grew inside of their mother to mammals, and said that sharks are mammals (meaning viviparous, another in Figure 11 legend). This happened mostly with respondents over 50 years old. Fishers who described an oviparous reproduction named the Galapagos bullhead shark (*Heterodontus quoyi*). Guides and researchers named almost equally ovoviviparous/viviparous and oviparous type of reproduction, clarifying that it depends on the species.

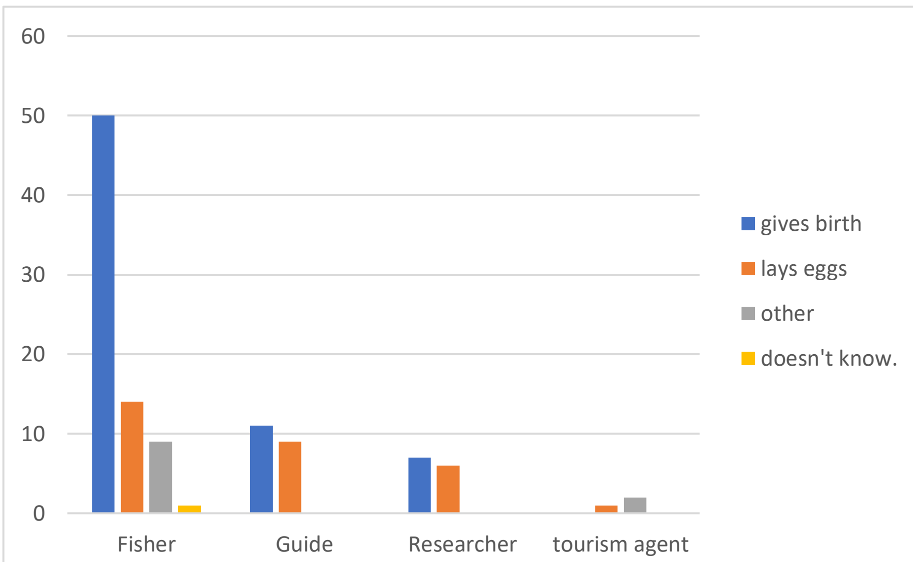


Figure 124: Respondent's knowledge about shark reproduction types per job category

Some fishers described the mating process, which many narrate they have witnessed (mostly with more common sighted sharks, like hammerheads, the Galapagos' shark, blacktip and white tip shark). They narrate male sharks biting the females, and the female ending up all bitten, with marks. They associate those marks with females who are giving birth when they see them near the shores, and with places where sharks reproduce in open waters, like in Genovesa Island, Cartago Bay, and Tortuga (Brater).

When the interviewees were asked if they had seen each of the eight studied species, it depended on the species if they had seen them or not. When asking them if they recognized the species and could tell if it was a juvenile or an adult, people who had sighted the species could also identify it, and it was clear for them if it was an adult or a juvenile. When unsure, they mentioned it was difficult because there was not another reference in the picture to tell how big the shark was, but in the end, they could recognize the life stage anyways. Knowing the local names for each species was important in this part of the interview, as in some islands different names could be used for the same species, and people who had a background fishing at the continent also knew them by different names sometimes.

In detail, *Alopias pelagicus* was only seen by fishers and guides, with most fishers (72%) reporting sighting it. *A. superciliosus* seemed to be difficult to see, with only one third of fishers (33%) reporting sighting it. *Prionace glauca* was sighted by fishers, guides and researchers, with almost

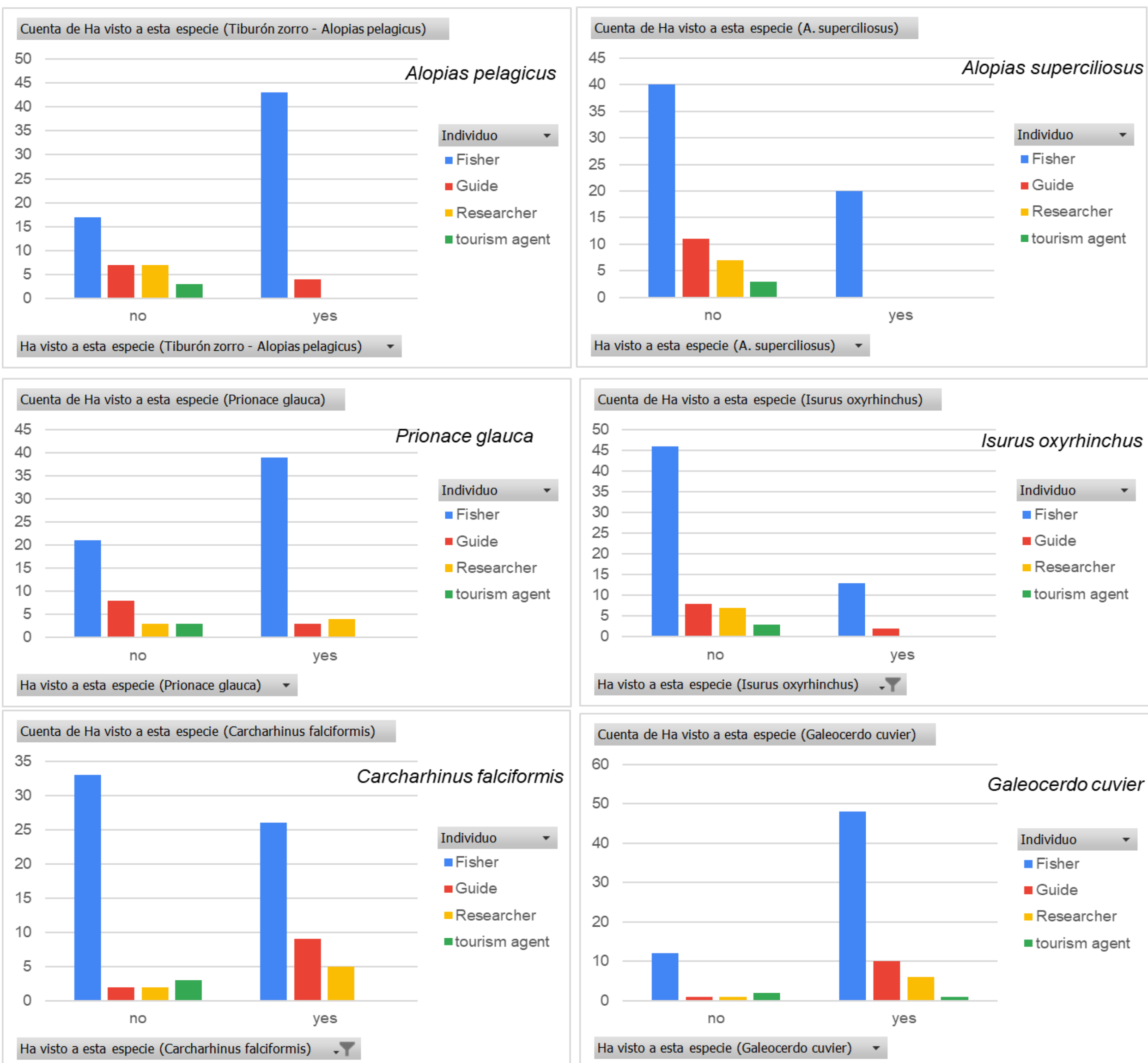


Figure 135: Sighted species per job category. It is indicated if the interviewee has seen the species (yes) or not (no).

two thirds of fishers (65%) reporting sighting it. For *Isurus oxyrinchus* the majority of interviewees didn't report sightings, with only a few fishers (22%) and guides reporting seeing it. For *Carcharhinus falciformis* almost half of fishers (44%) reported sighting it and most of OUMR, while the rest have not seen it. For *Galeocerdo cuvier* most of the interviewees and fishers (80%) reported seeing it.

For hammerhead sharks it was important to distinguish between people who had sighted a hammerhead shark and people who could identify the species, as one (*Sphyrna zygaena*) is often mistaken for the other (*S. lewini*).

Most fishers (82%) and tourism agents can't differentiate between the two hammerhead species, while most of the guides and researchers can (Figure 14). Absolutely all the respondents reported sighting a hammerhead so, for the purpose of this study, in this question it was assumed all of them had sighted *S. lewini* as it is the most frequently sighted and reported hammerhead shark species in the Galapagos, because it has a big population and can be found near seaports, whereas *S. zygaena* is rare to sight.

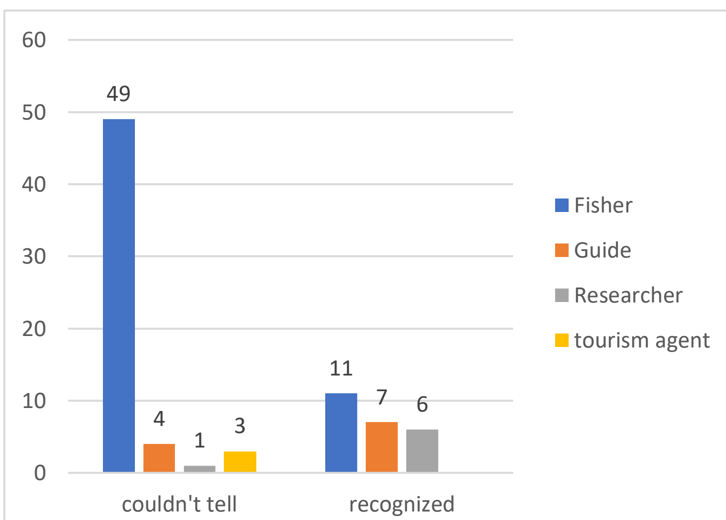


Figure 64: Groups that differentiate between hammerhead shark species by job category.

Even though most fishers didn't differentiate the species by their name and call both species simply 'hammerhead', some could tell that there is a difference between them by comparing head shape and coloration when adults. They recognize that *S. zygaena* is less common to sight, compared to *S. lewini*. This ability to recognize that there is more than one hammerhead species is remarkable, as even shark researchers admit finding it difficult to recognize them sometimes. Nevertheless, it is important to mention that, from the group of fishers that could recognize both species, most of them have had experience doing research, collaborating in field research with these species. This reveals an outcome of involving fishers into the scientific field, which is to enrich their own perspective of what they see in their waters, giving them the ability to understand the environments they occupy differently from their counterparts.

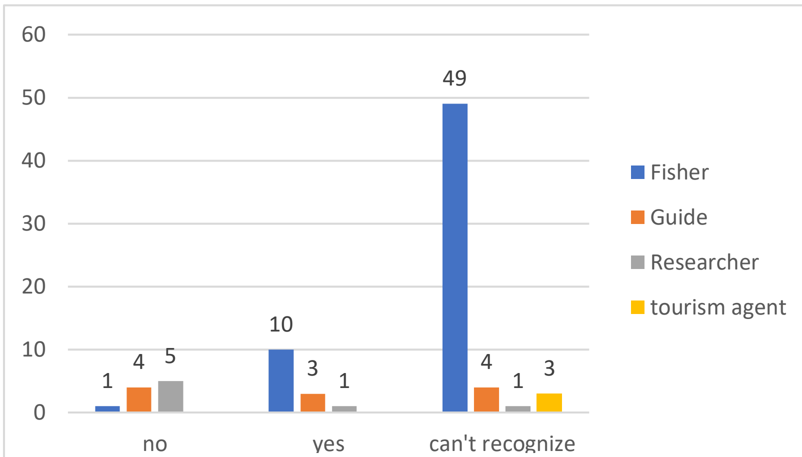


Figure 15: Respondents who have sighted S. zygaena per job category

Of the ones who could differentiate between hammerhead species, only a few had sighted *S. zygaena*, including fishers, guides and researchers. Even though most guides and researchers can differentiate them, not all of them have had the chance to see them in person (Figure 15).

The rest of the questions were asked depending on if the respondent had sighted the species; if not, the questions were omitted.

Interviewees were asked how much a shark should measure as minimum to be considered an adult. Shark's measurements (Figure 16) were estimated based on total length (TL), from the tip of the snout to the tip of the caudal fin, as most interviewees are more familiar with this way of measuring sharks. If a range was given as an answer, the lowest size was registered.

During the interviews it was mentioned that water alters the size at which we perceive things, magnifying them a little bit, but answers could still be biased by the respondent's space perception. Measurements for *S. lewini* and *S. zygaena* are represented by the Hammerhead column graphic, as everyone reported the same measurements for both species. Most mentioned sizes were 2 m. for *A. pelagicus, A. superciliosus, P. glauca, I. oxyrinchus*, and both Hammerheads; 1,5 m. for *C. falciformis;* and 3 m. for *G. cuvier*.

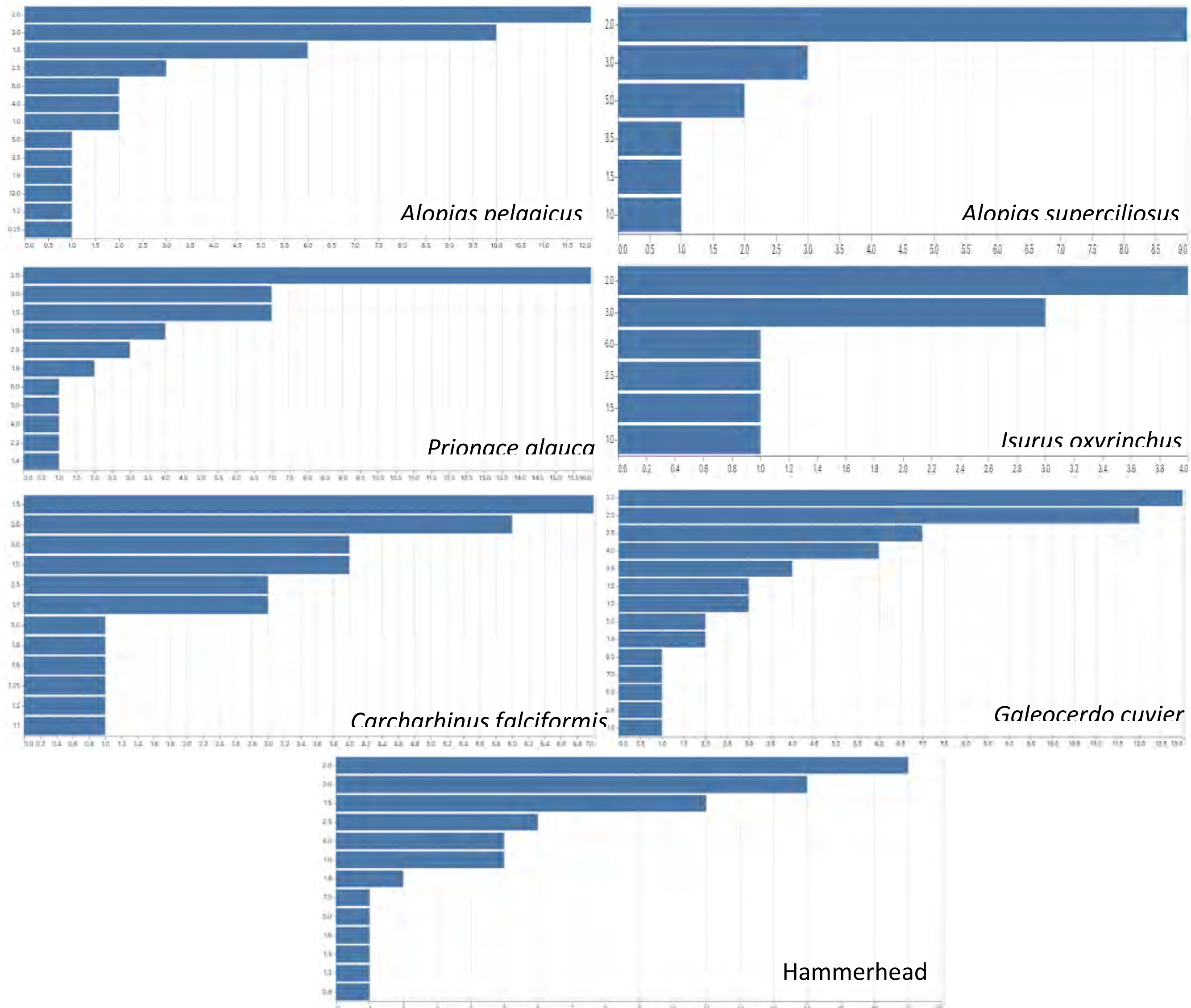


Figure 16: adult sharks estimated minimum size. X axe represents the number of respondents while Y axe represents size in meters.

Regarding the main marine ecosystems where each species can be found in, it needs to be considered that sharks are migratory species, and they can occupy a mix of ecosystems depending on the activity they are performing and their life stage. Many times, fishers mentioned two main ecosystems for each species. For the adults (Figure 17), for *A. pelagicus, A. superciliosus* and *P. glauca* respondents mentioned open waters and deep ocean; for *I. oxyrinchus* sea mounts and open waters; for both hammerheads vertical walls and shallow reefs; for *C. falciformis* open waters and shallow reefs; and for *G. cuvier* shallow reefs and bays with sandy bottoms. Let's consider that the species sighted in open waters, deep ocean and sea mounts are the ones sighted mostly by fishers, but just a few OUMR respondents.

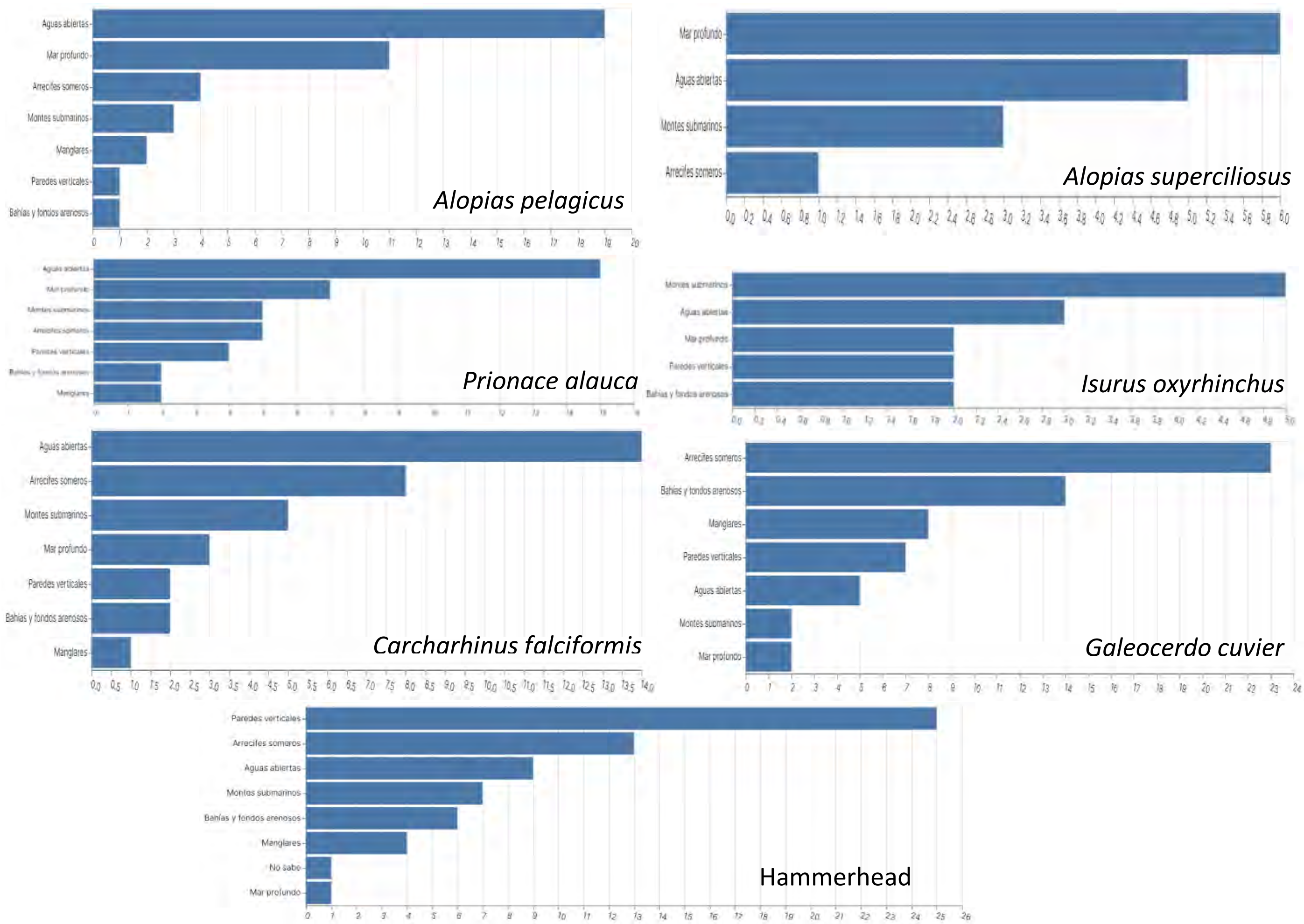


Figure 17: Adult sharks' main habitat perception by species.

For the juveniles (Figure 18), as just a few of the respondents had sighted them, less answers were gathered. *A. pelagicus* juveniles (4) were mostly seen in open waters; *A. superciliosus* (2), *P. glauca (5)*, and *I. oxyrinchus* (2) in sea mounts; *C. falciformis* (6) and Hammerheads (34) in mangroves; and *G. cuvier* (7) in bays with sandy bottoms.

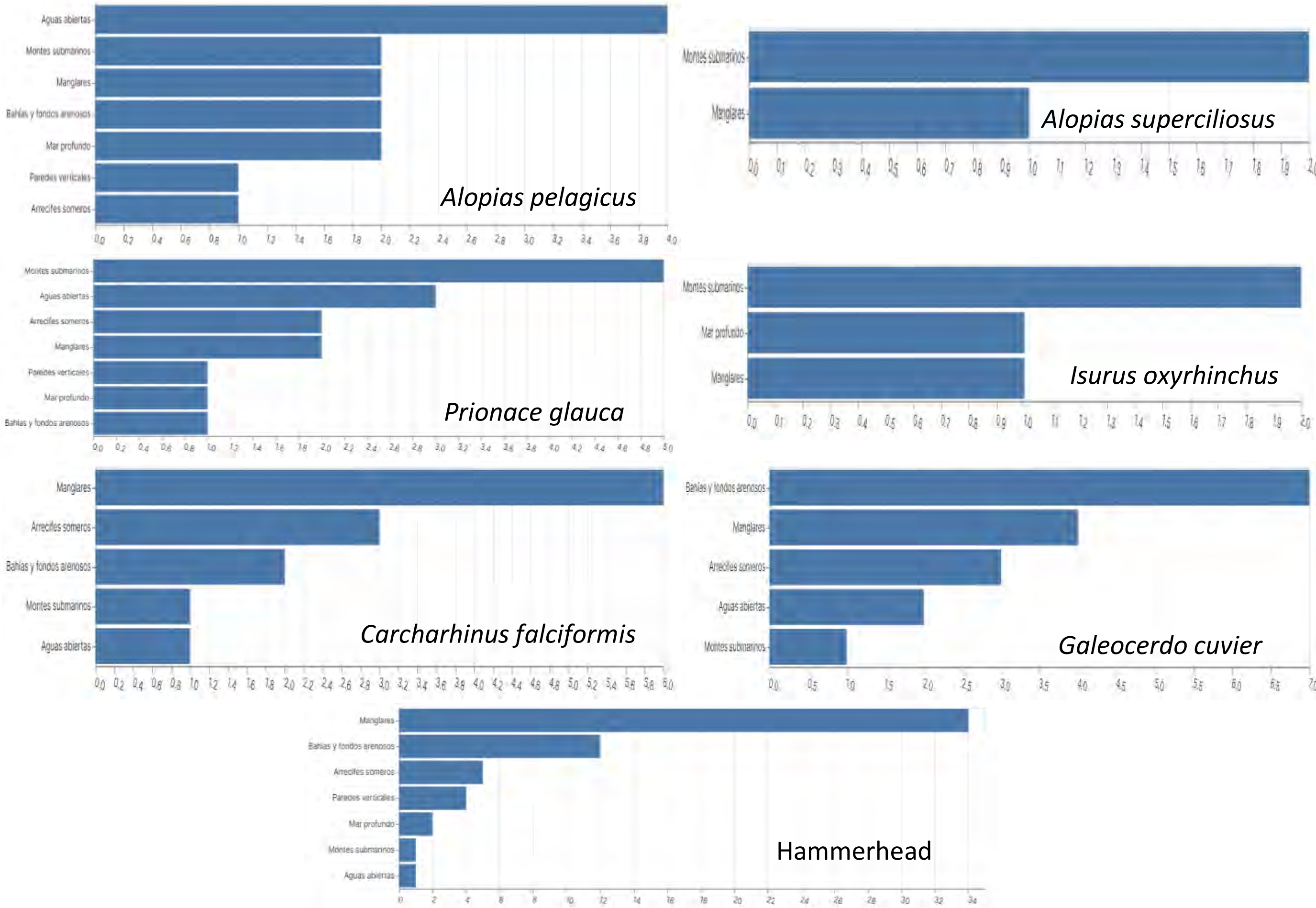


Figure 18: Juvenile sharks' main habitat perception by species.

Perceptions about changes in species' population abundance throughout the years, comparing today's abundance to the year when respondents started working in the islands, reveals that there exists a connection between job category and the mentioned perception (Figure 19). For fishers, there is a tendency to perceive the same amount as before (*A. pelagicus*, *A. superciliosus, P. glauca*, *I. oxyrinchus*, *S. lewini*) and in some species even more now (*Hammerheads*, *C. falciformis*, *G. cuvier*); while OUMR report less abundance for some (*A. pelagicus, P. glauca, Hammerheads* in general, and *S. lewini*) with divided perceptions between more and less for others (*C. falciformis and G. cuvier*). Of the respondents who recognize S. zygaena nobody could make a statement on their perception, as the species has just a few sightings and it would be biased to give an opinion.

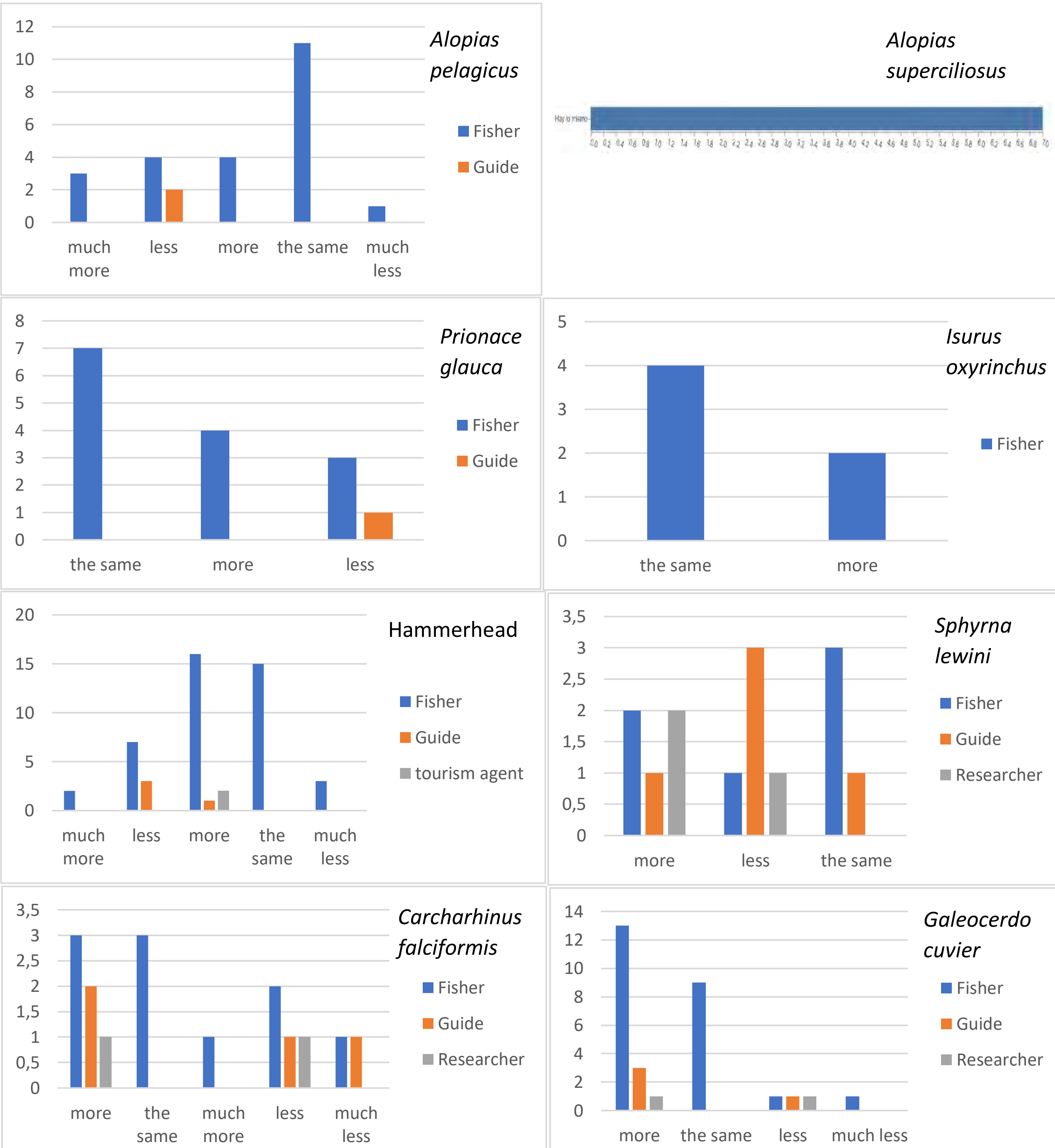


Figure 19: Abundance changes perception by job category.

('palangre') and industrial fishing outside of the marine reserve, from China and Manta floats. As the species migrate, they get fished outside of the GMR. Perceived causes for an increase in the populations include the restrictions for fishing sharks and the abundant food availability for them inside of the GMR. In particular, *P. glauca* population increase was related to the number of babies they can have. It was also mentioned that before they used to fish close to the island of residence, but now there is a lack of fish close to Santa Cruz for example and fishers from there must go further, sighting *P. glauca* more now.

For hammerheads in general there were more opinions. Respondents who perceive a reduction attribute it to climate change, past and present (illegal) shark fishing from locals and Chinese floats, landscape changes (bays' structure), knowledge lagoons about their ecology to create conservation strategies, and human population grown which involves more pollution.

Respondents who perceive an increase for shark populations mention it is because they reproduce and they are protected now so they are not fished anymore, neither by locals nor Manta fishers. As perceived by one respondent, after the pandemic some species approximated to the bays in Santa Cruz so they can be more easily sighted now.

Some fishers report that sharks take their catch, cutting the fishing line and causing them to lose part of their gear, which has become a problem. They perceive there are now too many sharks, with some feeling they are competing for resources. In particular, fishers note that *G. cuvier* are more frequently sighted, attributing this to an increase in available prey, such as turtles, compared to the years when sharks were still fished. A researcher suggested that this increase could also be due to knowledge transfer, as new migration routes to the Galapagos are passed down across shark generations, allowing them to benefit from the abundant food supply.

Some OUMR note that sightings of *S. lewini* are now more common in the bays. They suggest that this may be linked to rising water temperatures, as seen in El Niño years, and speculate that these bays could be new nursery areas. However, they caution that these increased sightings do not necessarily indicate a growing population. They acknowledge that human-generated pollution has negatively impacted these sharks, and, despite signs of recovery, populations are still far below historic levels—one researcher recalls far greater numbers in 1991. One respondent also highlights an ecological imbalance, attributing it to fishing pressures outside the Galapagos Marine Reserve (GMR) by foreign and local fishing fleets, particularly from China and Manta. They warn that overexploited, sensitive species face the greatest risk of disappearing, while more resilient species, like *C. falciformis*, are likely to increase.

3.4. Participatory mapping

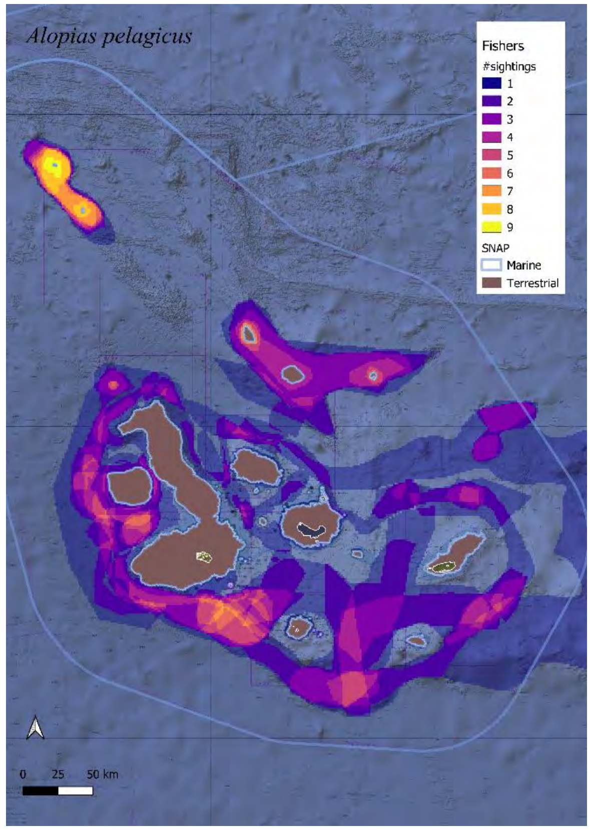
In the participatory mapping questions, a notable difference emerged in how Marine Reserve users oriented themselves on the maps. Fishers, who regularly use GPS devices (currently Navionics) for navigation and to locate fishing spots, demonstrated ease in identifying the locations of shark sightings and the specific marine ecosystems in each area. Their familiarity with geographic tools and spatial awareness helped them accurately pinpoint sites. Conversely, it was more challenging for OUMR, who are less accustomed to using maps for orientation, to accurately locate shark sighting spots.

For presentation purposes, a composition for each shark species is included in this section. To facilitate better visualization, some maps are individually displayed in a larger format in the Anex section.

Alopias pelagicus (Fig. 21) had been sighted by fishers and guides. Sighting's locations are mainly in open waters and deep ocean areas, reinforcing ecosystems occupation answer. The areas with the highest reports are Darwin and Wolf, followed by the platform's drop area south to Isabela Island and outside of Elizabeth Bay, surrounding Fernandina Island. From 5 to 1 sighting were recorded along the channels between islands and surrounding the islands. Guides' reported areas intersect or are close to fishers' reported areas, except for the ones in San Cristobal, which don't overlap.

A. superciliosus (Fig. 22 - Anex 3) had only fisher sightings, and reported areas, even though it has been less sighted, coincide with some of the locations presented for *A. pelagicus,* in open waters and deep oceans. It has been more sighted in the platform's drop area south to Isabela Island and outside of Elizabeth Bay.

Prionace glauca (Fig. 23 – Anex 3) was sighted by fishers, guides and researchers. Reported sightings are located in open waters and deep oceans, in accordance with the ecosystem occupation responses. In this case, most reports are located surrounding the archipelago, but not so much along the channels between islands. The areas with the highest reports are the platform's drop area south to Isabela Island; outside of Elizabeth Bay, surrounding Fernandina Island; and in the northern islands including Darwin and Wolf, Pinta, Genovesa and Marchena. OUMR's reported locations mostly coincide or are close to fisher's ones.



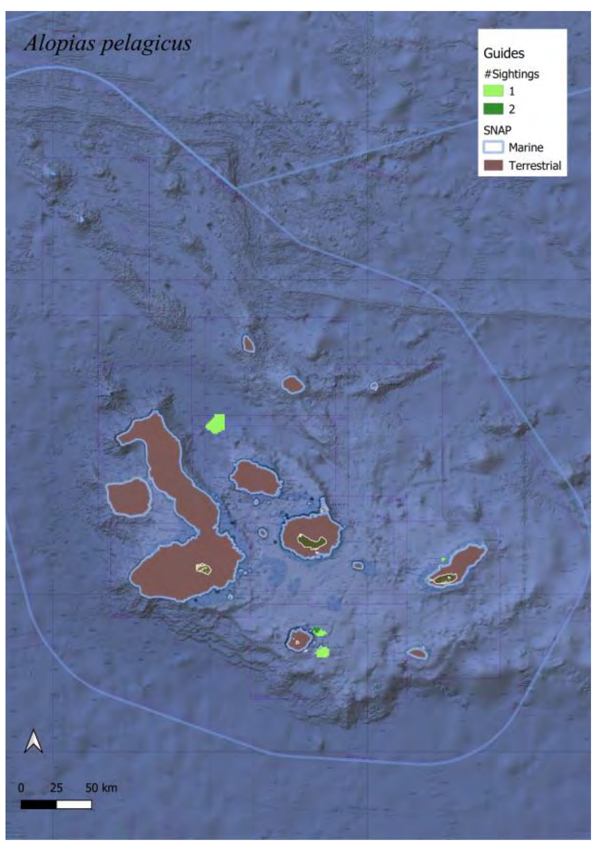
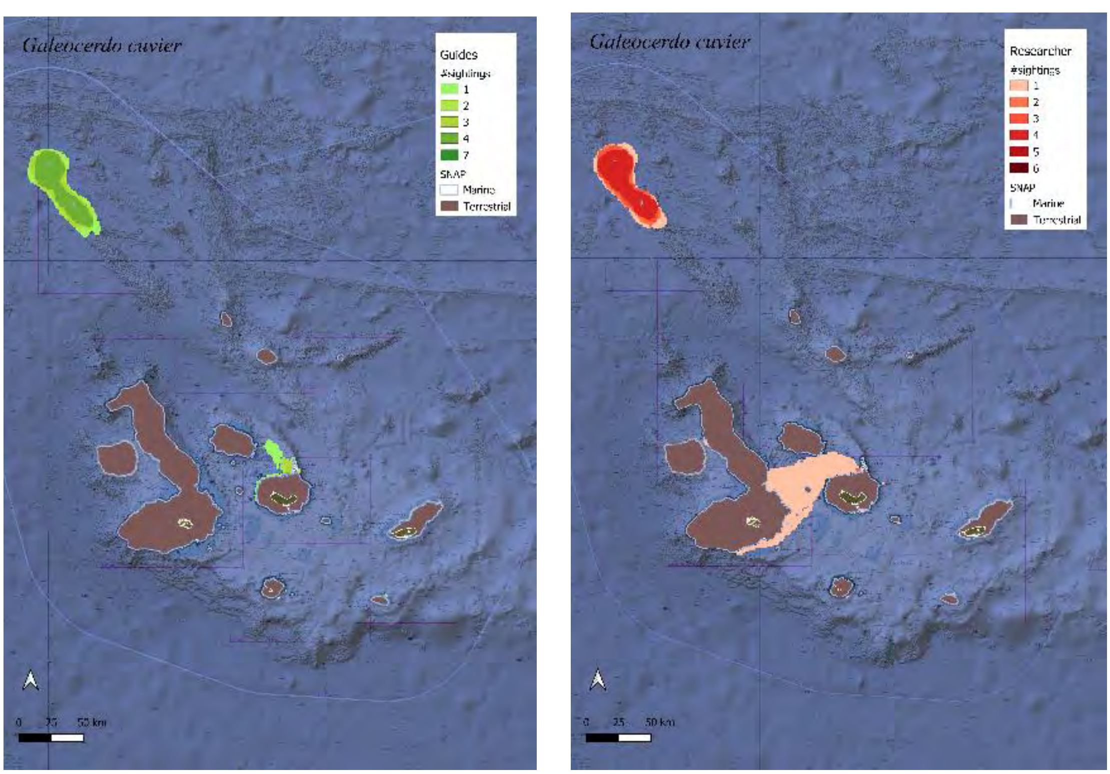


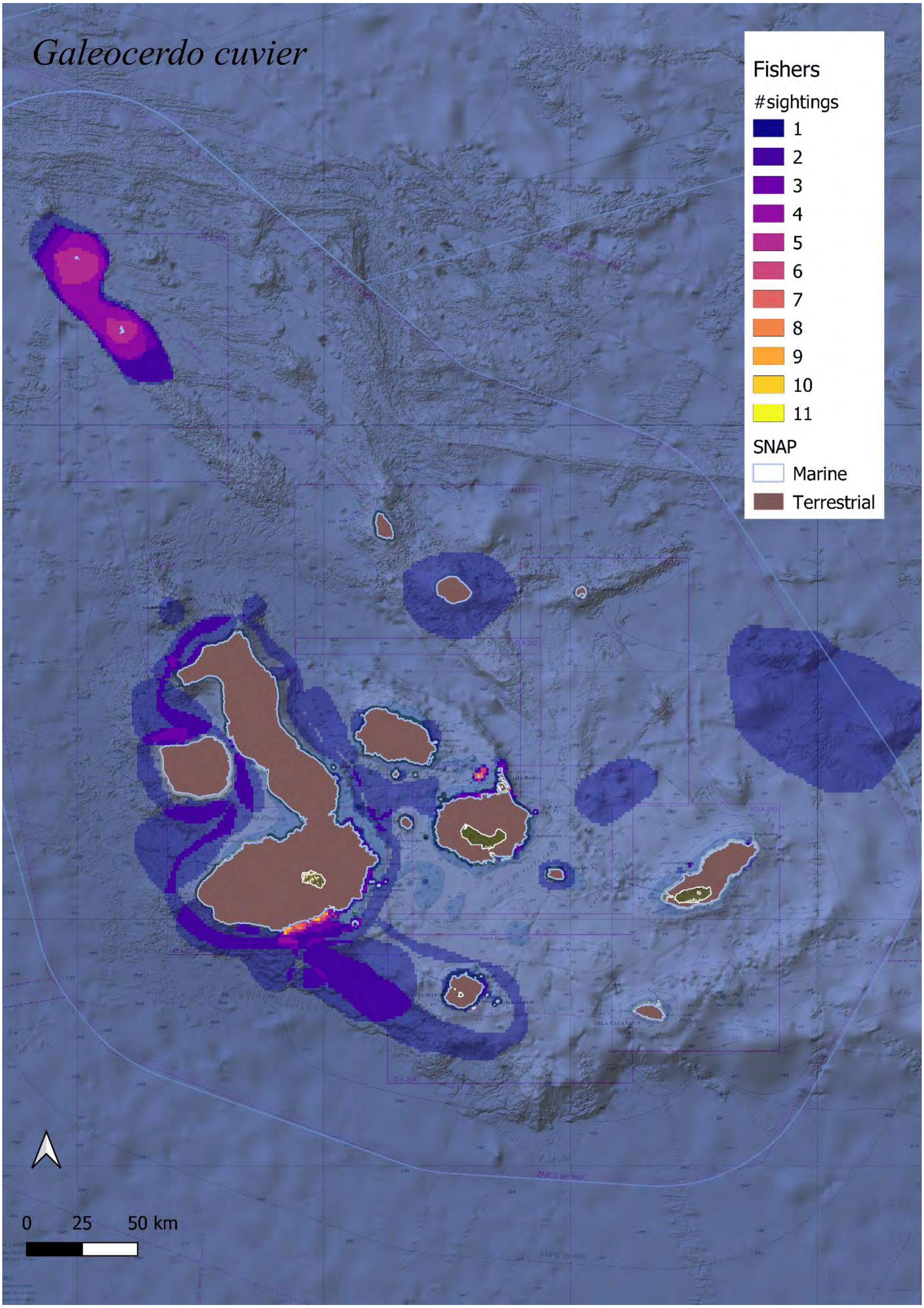
Figure 7: Alopias pelagicus sightings according to participatory mapping

Isurus oxyrinchus (Fig. 24 – Anex 3) was reported by fishers and guides, but most sightings weren't located specifically in sea mounts as was expected from the ecosystem occupation responses, still, they were reported even once in Vermales, Tres Focos, Bajo 30 and Bajo 89 sea mounts. Most sightings correspond to Genovesa, and the platform's drop area south to Isabela and San Cristobal Island. Guides' sighting didn't coincide with the ones reported by fishers.

Carcharhinus falciformis (Fig. 25 – Anex 3) was reported in open waters and shallow reefs, as mentioned the ecosystem of Darwin and Wolf are like, the islands with most sightings. It also had some sightings (4) in the North and East of Santa Cruz, south of Isabela and north of Floreana. OUMR's reports coincided with fisher's ones.

Galeocerdo cuvier (Fig. 26) reported sightings areas are located mostly in shallow reefs and bays with sandy bottoms, like in the south of Isabela from Bahía Villamil to Cabo Rosa, and in the North of Santa Cruz in the Itabaca channel. This species seems to be more concentrated on the western side of the archipelago. OUMR reports are consistent to fishers' ones, only with a difference that they report more sightings for Darwin and Wolf, while fishers report more for the South of Isabela.




Galeocerdo cuvier
Fishers
#sightings
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2
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7
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10
11
SNAP
Marine
Terrestrial
0 25 50 km

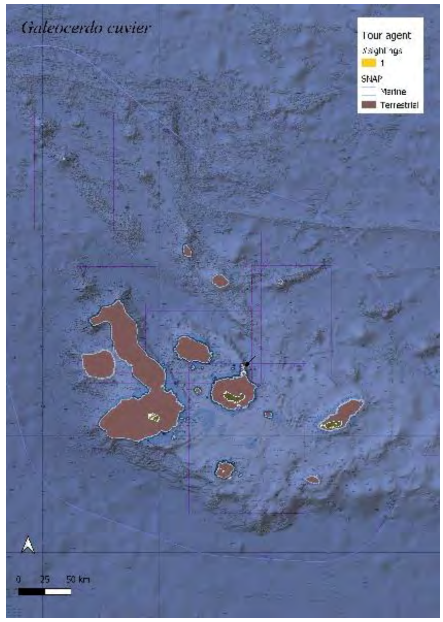
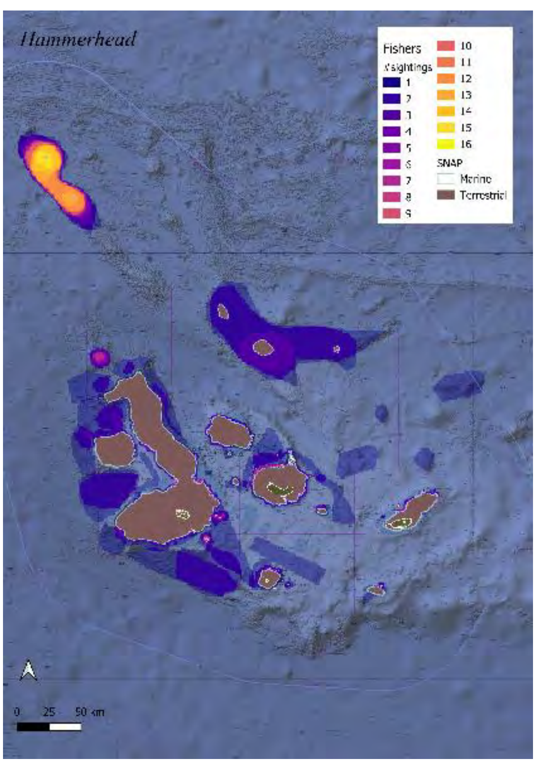
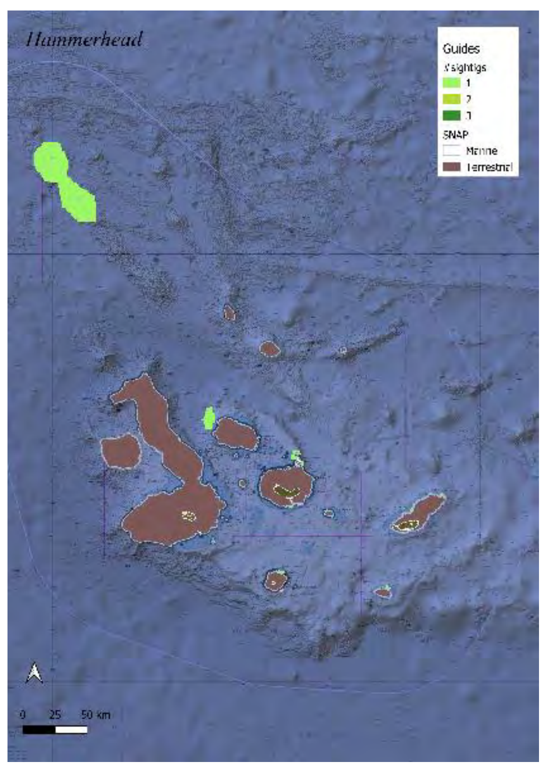


Figure 8: Galeocerdo cuvier sightings according to participatory mapping

Hammerheads in general (Fig. 27), from the ones who couldn't identify *Sphyrna lewini* and *S. zygaena* (including fishers, guides and tourism agents), revealed more sights near vertical walls and shallow reefs, like in Leon Dormido and Darwin and Wolf, with less reports in sea mounts and open waters. OUMR sightings coincide with the fishers' ones. Sightings along the coast correspond to juveniles which will be analyzed below.





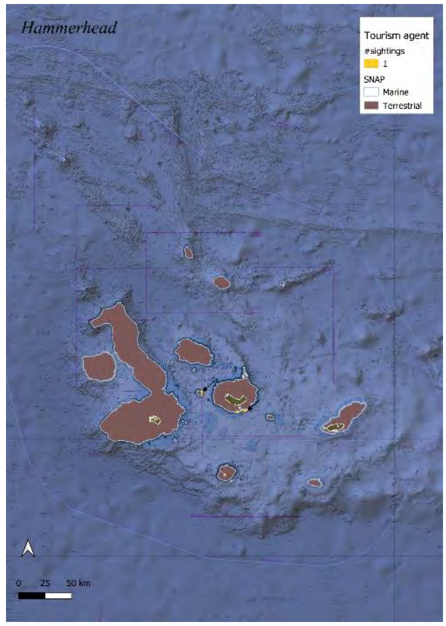


Figure 9: hammerheads sightings according to participatory mapping.

People who could differentiate between the two species reported their sightings separately, including fishers, guides and researchers. For *S. lewini* (Fig 28 – Anex 3) fishers reported areas with vertical walls, shallow reefs and sea mounts, coinciding with OUMR reports. These areas are dispersed along the archipelago. People who had seen *S. zygaena* (Fig. 29 – Anex 3), including fishers, guides and researchers reported it in the same but also in different places from the ones reported for *S. lewini*. Sightings are in sea mounts, shallow reefs and vertical walls as well. Just some sightings between OUMR and fishers coincide.

For juveniles (Fig. 30 – Anex 3), as few sightings were reported per species, only one map was generated for each one, overlapping the different actors' sightings. Most of them were reported in the same ecosystemic areas with high number of sightings for their adult counterparts (*A. pelagicus, A. superciliosus, C. falciformis, I. oxyrinchus, P. glauca).*

Hammerhead juvenile sightings (Fig. 30 – Anex 3) corresponded to the reports along mangrove areas, particularly in Cartago Bay (Isabela), Borrero Bay (Santa Cruz), and Puerto Grande (San Cristobal). *S. lewini* is mostly reported in Cartago by fishers and researchers, while guides place them in mangrove areas as well but also in vertical walls. *S. zygaena* is mostly reported in Cartago by fishers as well, with another area in Canal Bolivar (Isabela) overlapping with researchers' report, and different ones in Santa Cruz reported by guides. *G. cuvier* was reported at the south of Isabela by fishers, contrasting with OUMR reports.

3.5. Perspective about shark conservation

When fishers were asked if they have fished accidentally or intentionally for sharks, almost all the respondents (52 fishers = 87%) said yes, and only 7 said no. During the interviews, voluntarily some fishers mentioned they used to fish intentionally for sharks, in the years when it was common (Fig. 31). When asked to give a range of how many sharks they fish/ed in a month, some (24 respondents) mentioned more than 10 per month, while almost the same number (22 respondents) mentioned withing 1 to 3.

As a question asking specifically if they fished intentionally or it was just accidentally wasn't included (thinking it would be too delicate for them to specify it), the number of sharks can not be linked to this question (Fig 32); but by the narrations compiled it can be said that the ones who mentioned fishing more than 10 were the ones who used to fish for sharks and were referring mostly to those past years, and where doing it intentionally. It must be mentioned that fishers narrated having accidental catches nowadays using the artisanal fishing arts allowed by the GNP, but they mention it is rare for it to happen, accidentally catching one shark per month approximately.

Nevertheless, it needs to be clarified that answers could be very biased as fishing arts could not be the ones really used, as some are prohibited on the island and by no means would fishers like outsiders to know if they are using them illegally (like longline). For the fishing arts mentioned in this study it wasn't specified if they keep using them or if they have stopped totally their use.

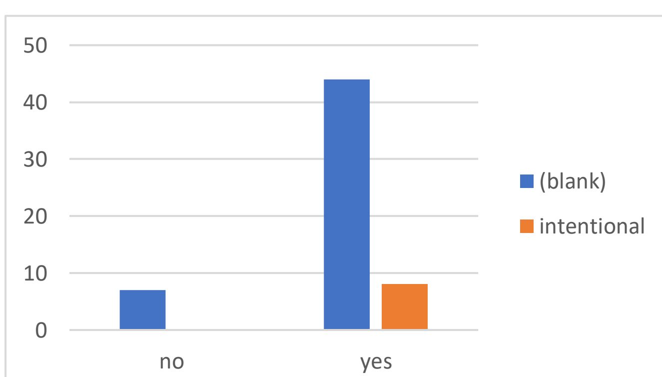


Figure 10: Fishers who have accidentally of intentionally fished sharks. In red it is indicated the number of fishers who voluntarily narrated they used to fish intentionally for them; in blue didn't specify.

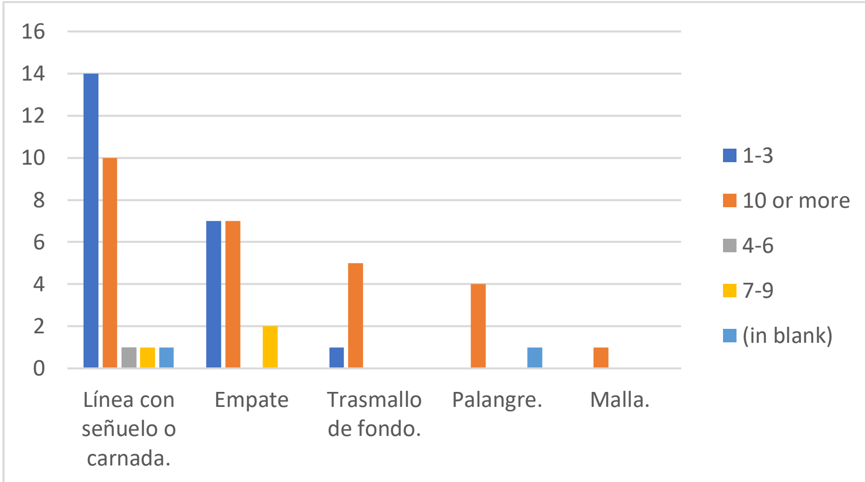


Figure 11: Fishing arts and monthly incidence of shark fishing. The range of fished sharks is signaled in the legend. 'Línea con señuelo o carnada' is equivalent to trolling; 'Empate' is a modified longline; 'trasmallo de fondo' are like bottom-set trammel nets; 'Palangre' are longlines; and 'Malla' are fishing nets.

The allowed fishing methods, such as "Línea con señuelo o caranda" and "Empate," show varied levels of incidence, ranging from very high (over 10 instances) to very low (1 to 3 instances). In contrast, banned fishing methods, including "Trasmallo de fondo," "palangre," and "malla," predominantly demonstrate high incidence rates. It is worth noting that when fishing for bait species like "lisa" in mangrove areas, incidental capture of baby or juvenile sharks may occur, though these are typically released. The specifics of the use of "Empate" (a modified longline) and "palangre" (standard longline) will be further analyzed in the following sections.

When asked about strategies to avoid catching sharks, more than half of the respondents (54%) reported that they had found ways to mitigate shark bycatch. Their techniques focused on freeing sharks once they were hooked rather than preventing bites altogether. For example, many fishers have transitioned to using nylon lines, moving away from "reinal" or "gualla" (metallic lines), which are still permitted by the Galapagos National Park. Nylon allows sharks to bite through the line and free themselves, or fishers can cut the line to release them. Some also mentioned using circular or curved hooks, which are more selective and reduce bycatch of sharks and turtles, or switching to biodegradable hooks, which decompose within three months if lost.

Promoting scientific research on these practices could further inform fishers about which strategies are most effective and encourage sustainable techniques within the fishing community (Doménica Montaño, 2023). Integrating research findings into local fishing practices would help validate and enhance these conservation efforts. One interviewee mentioned that it is not the fishing art but the fisher who determines shark bycatch incidence, with a similar thought mentioned by another one, complementing this idea by saying that it is necessary to learn how to read the ocean to avoid catching sharks.

Some fishers shared proactive strategies to avoid catching sharks from the outset. For instance, they mentioned steering clear of areas where sharks are known to aggregate and leaving the area if a shark bites, as more are likely to follow. Others suggested replacing organic bait with artificial lures like "rapala," which better target specific fish and are less attractive to sharks.

Fishing at specific hours, such as from 11:00 p.m. to 3:00 a.m., was also mentioned, as sharks are less active during these hours, potentially reducing bycatch. Additionally, fishers emphasized the importance of watching the movement of floaters to identify what has been hooked: sharks tend to move in circles when caught, while other fish pull downward. Supervising fishing gear closely was another strategy, enabling fishers to quickly bring in targeted species to prevent sharks from being drawn to the catch or, if necessary, release untargeted species before sharks arrive.

These techniques illustrate a practical knowledge that could complement scientific insights, further supporting sustainable practices that benefit both fishers and marine conservation efforts.

When interviewees were asked about the importance of shark conservation (see Fig. 33), the majority expressed a positive view, affirming its significance. However, 10 fishers responded negatively, indicating a nuanced perspective within this group. While they acknowledged the importance of shark conservation, they felt it should be managed differently, suggesting that current strategies might not align with their views or practical needs. This division highlights potential areas for dialogue between conservationists and local fishers to address specific concerns and find common ground in conservation practices.

In general, people who answered 'yes' mentioned in their reasons that sharks are important because they keep ecosystems in balance, healthy and in equilibrium, controlling the food chains by regulating marine ecosystems for their predator roll, cleaning the ocean. By other side, it was mentioned that they help tourism as tourists come to the Galapagos just to see it, making it more valuable alive than dead (Fig. 34).

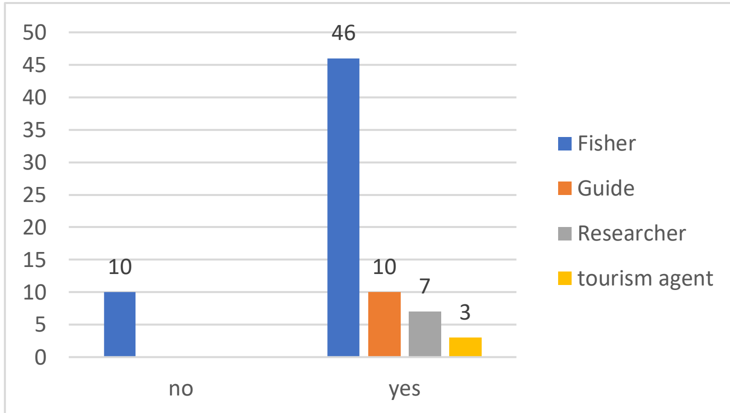


Figure 12: number of respondents who consider that shark conservation is important or not, classified by job category.

By job category, some fishers mention that for them it doesn't have any economic value (one mentioned there are not studies estimating sharks' value for the fishing sector, but there are for the touristic sector); meanwhile guides recognized that it is economically important for them because of tourism; and researchers were the only ones who mentioned shark conservation is important because populations are declining worldwide, they suffer overfishing, and are exposed to the consequences of climate change.

Figure 13: visualization of most used terms for the reasons why shark conservation is important, using Voyant-tools.

On the other hand, fishers who don't fully agree with shark conservation mentioned it benefits tourism but not the fishing sector. It was mentioned that inside of the GMR there are too many sharks which steal their fishing art; and that corruption and politics affect them and shark conservation as even though sharks are protected inside of the archipelago, as they are migratory creatures, they are fished outside of the GMR, benefiting others.

Figure 14: visualization of most used terms for the reasons why shark conservation is not important, using Voyant-tools.

When asked about the current restrictions for shark fishing in the GMR, everyone answered it is prohibited. Some added there are economic sanctions, PARMA permit and boat removal, and jail condemnation. Almost the same number of people who mentioned to be in favor of shark conservation also agreed with the restrictions, with only 14 fishers disagreeing with them (Fig. 36).

Fishers who answered against it included justifications like the lack of alternatives for the fishing sector; some suggested that there are too many sharks and there should be a regulating agent to control their populations, allowing them to fish them sometimes. It was also mentioned that the sanctions are too aggressive with the fishing sector.

Regarding the appreciation of possible harms towards shark populations coming from the different users of the GMR, and what the authorities should do about it, generally the fishing sector mentioned impacts from the touristic sector and industrial fishing from outside of the GMR; meanwhile some respondents from the touristic sector and researchers gave a more holistic analysis including all users as possible agents of impact. From all respondents, 76% mentioned there are impacts and harms towards sharks, while 24% said there are not apparent impacts or harms because they are protected.

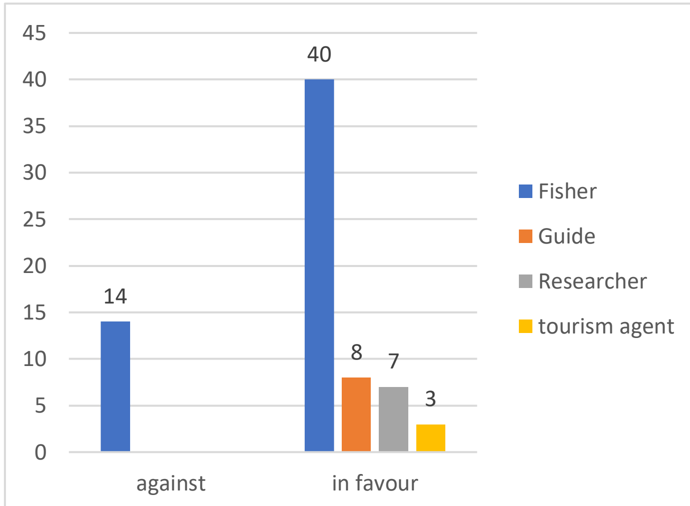


Figure 15: Respondents against and in favor of the current restrictions for shark fishing.

In detail, as possible agents of impact (Fig. 37) the fishing sector was mentioned when talking about the industrial fishing activities outside of the GMR, including Chinese and mainland fleets (40% of respondents who referred to the fishing sector blamed industrial fleets). Regarding fishers inside of the GMR (60% of respondents talking about the fishery impact referred to the SSF), they are blamed for the illegal use of 'palangre' and illegal shark fishing, particularly in Isabela. Accidental fishing was also mentioned as sharks can die in the process or end up with affections for the remaining hook when freed. It was mentioned that even though longline is forbidden, there is a lack of research for other fishing arts and their impact, for example the use of nets, for 'Pesca Blanca' (coastal fishery) (Ramírez-González et al., 2022) and its influence over baby and juvenile sharks.

The touristic sector was mentioned as an agent of impact because of the presence of lots of tourists, who can scare sharks, making them go away. It is said there exists an excess of pressure for the sites assigned for touristic activities related to shark sighting, particularly for Darwin and Wolf where in certain seasons there is an overcharge, and there should be more control and regulations over this. In addition, one person mentioned that during experiential fishing tours there also occurs accidental and intentional shark fishing; or the boats throw their organic waste to intentionally attract sharks (to receive more tips).

For both, the touristic and the fishing sector, it was mentioned that sometimes they throw their organic waste into the ocean, attracting sharks and altering their natural behavior, even attracting them to the shores unintentionally, which could lead to accidents (sharks biting tourists). In Isabela, after listening about this problem, the author encountered in the port a man who was waiting for the boats to arrive with a big barrel, who told the author he collects the food waste to give it to his farm animals in the highlands. He is one example of how this problem could be solved.

Also, for both sectors it was mentioned the use of engines inside of nursery areas without any regulation. Vessels generate acoustic and chemical pollution caused by their engines, which must affect not only sharks, but other marine animals too. As well, anchors are used in the bays, causing harm to corals and the seabed, harming the ecosystem's physical structure.

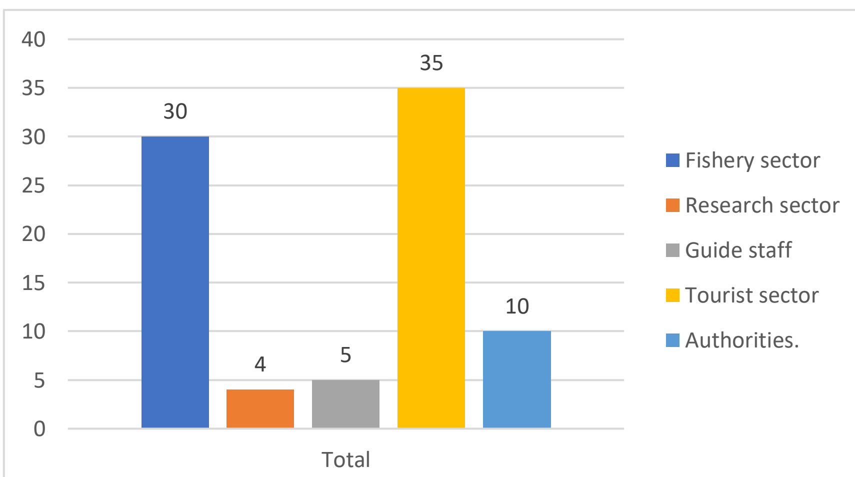


Figure 16: Users of the GMR perceived as agents of possible impact for shark conservation.

About researchers, it was mentioned that shark manipulation must generate stress and make them go away. One person said that tagging must be performed only by experts (not volunteers) and they should be clearly identified with the organization they belong to by using a T-shirt, as sometimes tourists see them and can't tell what is happening. It was commented that there should be an effort to communicate to locals the research projects developed in the islands. In general, it was mentioned that there is a lack of cooperation between the tourist sector and conservation. As one interviewee mentioned "There should be a purpose for it all, in which tourists and guides are educated on good practices and how to take care of the species while interacting with them. There should be a coalition, a project for good practices focused on education, with a dialogue between researchers, conservationists and guides". It was mentioned that ecological tourism is confused with tourism in the islands.

About the impacts generated by the authorities, it was said that there is a lack of regulation of the fishing arts. For example, tuna is the most fished fish inside of the reserve and fishers use 'palangre' to fish for it, but it is not regulated and there are legal holes in its use and vigilance in open waters. There are not enough vessels to monitor in open water what the fishing and touristic sector are doing. As a solution to the impacts mentioned above, it was mostly said there should be more control and regulation from the authorities.

As extra comments, some locals mentioned they would be interested in getting involved in shark conservation projects, in particular people from the fishing sector, as now sharks don't have an economic value for them, and they don't fish for it anymore; they would like to have more options. They would like to know what they can do to protect it, receive more education on the research that is conducted in the archipelago. Particularly one fisher mentioned that even though there are sanctions in case of shark capture, they haven't received workshops on how to free them properly if caught. They would like to be informed about possible alternatives they can have to make their fishing activities more sustainable while receiving socioeconomic benefits as well.

International cooperation was also mentioned as a key component for species conservation, developing monitoring controls along the reserve to protect the biodiversity but also the fishery sector. This control must be led by teams that have the proper equipment to protect the reserve. This includes control for the use of 'palangre'; there should exist a plan for the use of it, not only just a ban, because it is still in use but there doesn't exist a monitoring of it. By banning it and making it illegal, fishers throw it in the ocean to not get the sanctions, and this material transforms into ghost fishing, which affects the marine species in a way that is not even known yet for the lack of information.

4. DISCUSSION

4.1. **On the approach:** Doing participatory and intersectoral research, gathering local ecological knowledge for the conservation of species for which there is a knowledge lagoon regarding their ecology, proved to be a good approach in the context of the Galapagos islands. By collecting fishers' knowledge about threatened shark species, some of which are usually difficult to see according to the narrations (especially the ones that occupy open waters and deep ocean ecosystems), it was possible to have an insight into their current conservation status, map their most occupied areas and ecosystems, gather information about the location of unreported nursery areas and comprehend locals' perspectives on shark conservation.

As comments for the methodology, performance in the field could have been influenced by many factors. For example, even though performing the interviews alone as a female lead to uncomfortable situations, it was perceived by myself and other researchers who have worked doing interviews with fishermen, that they feel more comfortable talking and giving information to female researchers. This might have influenced the number of interviews conducted (Fig. 2), and the quality of the information received. As well, when the field research started, lobsters fishing had just opened, so arranging meeting with fishers to perform the interview was sometimes impossible as they traveled for long journeys (one week to 15 days) which could have influenced the number of respondents in each island, but at the same time the one-to-one approach must have allowed to have more participants than approaching them in public places like the fishing ports. More details regarding each island's context, which could have influenced the number of respondents, and the quality of answers will be discussed in the following section.

4.2. Sociodemographic characteristics

4.2.1. Interviewee's experience and trajectory in the field

The sociodemographic characteristics aligned to the ones expected for the targeted group of fishers in the aspects of having another job (Fig. 4), age (Fig. 5), gender proportion (Fig. 6), education level (Fig. 7), and years of experience (Fig. 10) (Castro, 2005; Ramírez-González et al., 2022). It is important to mention that the sociodemographic context was different for each island, affecting their perspectives about shark species and shark conservation.

For example, the relationship fisherfolks have with research and researchers varies depending on each island. In San Cristobal, it is notorious that there has been more work with the community regarding environmental education, as more fishers agreed to collaborate in this research and were open to help with the snowball methodology to contact more participants. The presence of The Galapagos Science Center might be an agent that is highly influencing the perspective of fishers towards conservation efforts, as it develops lots of projects with locals. In general, the author could perceive a better integration between the research sector and the community. This doesn't exclude the fact that there were fishers who didn't agree to participate in the research because they don't trust in how the information will be used.

In Santa Cruz, fishers were notably more hesitant to participate in interviews, possibly due to the proximity of primary regulatory institutions like the CDF and the GNP. Many fishers initially inquired if the author was affiliated with these institutions before deciding whether or not to assist with the interview. This cautiousness suggests a degree of mistrust or concern about how their shared information might be used. Additionally, it was apparent that they have been frequently approached for research collaboration, to the point where some seemed weary of these repeated requests. This pattern indicates potential "research fatigue," where overexposure to studies might be affecting their willingness to engage.

In Isabela the situation is different, maybe for being the most distant island and receiving less attention from conservation projects, fishers have another approach towards researchers and go to their own rhythm, prioritizing their working activities and postponing the interviews most of the time. More than anything it seems to be a lack of integration with the community and the research sector as they don't necessarily refuse to give the information, but they are not eager to help either.

Comparing the different users of the marine reserve, based on the demographic characteristics of the participants in this research it would be thought to exist inequality regarding gender participation in the fishing sector compared to OUMR (Fig. 6). In other studies, it has been discussed that it is because women are invisibilised by not being considered in their role in the pre-capture and post-capture activities (Arianna Huff et al., 2023; Ramírez-González et al., 2022). In this study it was desired to collect women's ecological knowledge about shark species, but as few of them go on fishing journeys, most of them haven't sighted other sharks rather than the ones in the bays (hammerheads and Galapagos' shark). Moreover, there were few women known by the community for going fishing with their husbands, and some of them didn't agree to participate in the research for lack of trust in how the data would be used. In general, there is a lack of involvement of fisherwomen in research studies, so there doesn't exist reports related to their knowledge and perspectives in the Galapagos. For future research it would be valuable for the expansion and appreciation of the arts to collect women's narratives, integrating them also into conservation efforts (Ramírez-González et al., 2022).

Most fishers have received high school education while OUMR have attended university or even higher education levels, in the case of Researchers. Fisherfolks recognize that the new generations of sons/daughters are not interested in working as fishers, as jobs related to tourism are more attractive, and try to pursue higher education levels. It has already been mentioned how this could affect food security, so encouraging young people into fishing practices while allowing them to access higher education levels and ensuring economic security for the sector will be crucial for its survival (Arianna Huff et al., 2023).

It is vital to reinforce the connection locals have towards scientific knowledge (Ramírez-González et al., 2022). The youngest fisher interviewed was a woman, who is admired and respected by her counterpart fishermen colleagues. Talking with the group, it was easy to perceive the love and connection they have for ocean life, but also the lack of appreciation and respect for the academic, research and conservation sectors. What is the destiny of a sector which has closed its doors to the academy in a place considered an archetype of conservation, meant to be shaped by science and knowledge? What are the goals and opportunities young people in this sector can aspire to?.

In Santa Cruz a fisherman narrated that her daughter is bullied in school because his father is a fisherman. When the author attended the annual symposium organized by the Galapagos Science Center, which is meant to reach the local community and inform them about the results of research projects, two exponents mentioned fisherfolks as part of the threats towards marine species conservation, because of bycatch and overexploitation. For the metamorphosis of the conservation paradigm in the Galapagos, it will be indispensable to question the current narratives that the academic, the research and the conservation sector create for young generations, reflecting about the failures of the Modern Worl-System rather than blaming a specific productive sector. The goal must be to create a coalition in which the fishing sector is seen also as an agent who has its role in the protection of the GMR, rather than keeping the simplistic conservation paradigm where the sector is portrayed as a threat.

Fisherfolk’s experience along the archipelago saves hidden potential for knowledge expansion in Galapagos’ biodiversity studies. The islands they have visited (Fig. 8), the years of experience (Fig.10), and the time spent in the ocean doing their job (Fig. 11-12) are greater compared to OUMR’s, simply because of the sector’s trajectory in the archipelago’s colonization history (Arianna Huff et al., 2023; Hennessy, 2018; Quiroga, 2009, 2013)and the profession's intrinsic relationship with the sea. They have experienced firsthand the historical fluctuations of marine populations, such as sharks, by acting as agents of change: firstly, fishing for them; then experiencing the pressure of conservation efforts since the creation of the GMR and new legislations; and finally transitioning to what is said to be the end of intentional shark fishing inside of the reserve.

Considering that a baseline over which it can be possible to understand the impacts of the GMR and legislations creation doesn’t exist, compiling fishers’ LEK, actively involving them in the monitoring process of conservation efforts, could help to fill this knowledge gap over marine biodiversity abundance changes, and the success scale of those conservation efforts. Based on the interviews, it is of fisherfolk’s as of the authorities’ interest to know more on this topic, to safeguard the marine ecosystemic balance. It is of all users’ interest to have a healthy ocean.

As the results show, and based on informal conversations with fishers, the new fisherfolk generations are losing in some degree their connection with marine ecosystems offshore, as they focus on more lucrative fishing targets such as lobster and sea cucumber, fishing just for half of the year and dedicating the rest of it to another job (Fig. 12). This reflects the pressing need for fishers to find secure economic options, often through activities that lead them away from traditional fishing sites that the sector has relied on for generations.

This can be summed to the topic of the new sonification system of the Galapagos (Ramírez-González et al., 2022), in which the 2016 version intended to close some of the historically used fishing zones in the name of sustainable conservation, without the fishing sector consent. This was seen as a betrayal for the fishing sector and was part of the reasons why they lost their trust for conservationists, academics and authorities in general (Quiroga, 2009, 2013). In order to keep the sector’s valuable connections with the different marine ecosystems, while opening new alternatives which consider socioeconomic security, and involving them in decision making over the GMR, the promotion of the use and value of fisher's LEK for the monitoring of the GMR's biodiversity should be considered.

By valuing fishers' perspectives and empowering them it can be possible to trace new transformative ocean science solutions for sustainable development, connecting people and our ocean as other studies collecting fishers' LEK have proved (Almojil, 2021; Colloca et al., 2020; Custodio Nascimento et al., 2023; Peñaherrera-Palma et al., 2018; Pissarra et al., 2024; Seidu et al., 2022) . This is the Ocean decade mission, and Galapagos authorities and conservationists are working towards it; but to come up with transformative solutions new actors who have been historically left aside need to be integrated into the conservation efforts.

4.3. Interviewee's knowledge about shark species' ecology

Empirical knowledge acquired while working in the sea has allowed fishers to collect sometimes different knowledge from the one OUMR have access to. Their knowledge is highly connected to what they have witnesses, for example, when we talk about sharks' reproduction. Some fishers recalled watching sharks give birth to baby sharks, completely formed. A few mentioned bullhead sharks lay eggs. Some, in the years when shark fishing was common, dissected big sharks and found baby sharks connected by an umbilical cord to their mother, and thought they were mammals. Maybe because of OUMR education level and connection to tourism and science have reached more theoretical knowledge and don't associate this with mammals but rather know that some sharks are viviparous.

Nevertheless, fisherfolks have learnt to identify different ecological trends. For some species they have sighted and learnt about: their life-stages; sings of reproduction in females as bite marks association with reproductive or birthing sites; and marine ecosystems use, but in general, sightings were greater for difficult-to-see species in the Galapagos, compared to OUMR's (Fig. 14), including pelagic species such as *A. pelagicus, A. superciliosus,* and *P. glauca.* This is an expected result as collecting fishers' LEK is in fact used as a tool to expand and fulfill knowledge gaps that couldn't be obtained in another way (Bessesen & González-Suárez, 2021; Custodio Nascimento et al., 2023).

By listening to their narratives, it could be appreciated that the generation of fishers who were involved in shark fishing can identify species easier and better compared to the older and new generations and have sighted more of them. This must be related to the fact that the older and new generation didn't/don't have sharks as a main target, and focus/ed in other species such as 'bacalao' back then and in lobster and sea cucumber nowadays.

Fishers' perceptions will be discussed by question, analyzing results for: minimum adult size, presence in marine ecosystems for adults and juveniles, population trends and abundance, by contrasting it with The IUCN Red List description for Habitat and Ecology for each species (IUCN, 2024). Finally participatory mapping will be discussed.

Fishers' perceptions of minimum adult shark species' size (Fig. 17) are crucial for conservation because they help identify size thresholds at which sharks are most likely to be caught, allowing for targeted strategies to avoid the bycatch of juvenile sharks that are vital for population growth. By aligning fishers' knowledge with scientific data, conservation efforts can more effectively regulate fishing practices to protect younger, more vulnerable individuals and support sustainable shark populations.

There is no universally fixed size to determine when sharks reach adulthood, as sexual maturity varies by species, sex, and age range. However, fishers estimate sexual maturity by size, prompting questions in this study about the minimum size they associate with an adult shark of each species.

Table 2: Sharks' mature size according to fishers' perception and reported scientific literature.

Species	Fishers perceived minimum adult size (TL in m.)	Mature size for males (TL in m.) (Scientific Literature)	Mature size for females (TL in m.) (Scientific Literature)	Adult's maximum size (TL in m.) (Scientific Literature)
Alopias pelagicus	2 *	2,50–3,00	2,50–3,00	3,65
Alopias superciliosus	2*	2,45-3,00	2,82-3,55	4,84
Prionace glauca	2	1,83-2,18	1,83-2,21	3,80
Isurus oxyrinchus	2	1,66-2,04	2,65-3,12	4,45
Carcharhinus falciformis	1,5*	1,80-2,30	1,80-2,46	2,29-3,71
Galeocerdo cuvier	3	2,50-3,05	2,74-3,45	5,00-7,40
Sphyrna lewini	2	1,40-1,98	2,00-2,50	3,70-4,20
Sphyrna zygaena	2*	2,50-2,60	2,46-2,65	3,70-4,00

** -Fishers perceived adult minimum size is not inside of the mature size range for either males or females according to scientific literature.*

Mature and adult's maximum size was taken from IUCN (2024)

For half of the species studied the perceived minimum measurement for adult sharks, according to fishers', does not fit into the mature size range for either males or females according to scientific literature. There is an underestimation of mature sizes for *A. pelagicus, A. superciliosus, C. falciformis and S. zygaena.* This reflects there exists a misappreciation between juveniles and adults for these species. Education and scientific dissemination are needed to inform the community about sharks' mature sizes and its importance for the protection of juveniles to promote sharks' population growth in the GMR. This could also help us to better understand if there exists a correlation between bycatch and life stage.

By aligning fishers' knowledge with scientific data, conservation efforts can more effectively regulate fishing practices to protect younger, more vulnerable individuals and support sustainable shark populations. In this research, fishers' LEK can complement scientific data by identifying specific locations where sharks are consistently sighted, adding a spatial component to population distribution models (Bakiu et al., 2023; Custodio Nascimento et al., 2023; Rasalato et al., 2010).

Species and life stage association with marine ecosystems patterns provide clues on how sharks use different marine ecosystems at various life stages, which is essential for conservation (Hearn et al., 2014; Pontón-Cevallos, 2023). Knowing the ecosystems each shark species frequents helps shape ecosystem-specific conservation policies. Since fishers report specific depths for each ecosystem and scientific literature reports sharks' habitat, with further research, sightings for each species can tailor conservation efforts to local ecosystems, ensuring that measures like fishing restrictions or bycatch reduction methods are not only effective but also enforceable and ecologically relevant.

Species for which adults and juveniles were sighted in different marine ecosystems (*A. superciliosus, P. glauca, C. falciformis*, both Hammerheads, Fig 18-19) suggest an ontogenetic shift, where juveniles may inhabit safer, resource-rich environments until they develop the capacity to venture deeper. For instance, recognizing such habitat use enables conservationists to focus protection efforts on areas essential for juveniles, like sea mounts and mangroves, to ensure their survival until maturity (Bakiu et al., 2023; Barbato et al., 2021; Custodio Nascimento et al., 2023).

In the same line, ecosystemic protection needs to be paired with sharks' abundance monitoring, to align conservation measurements with current population stability. Fishers' perceptions of shark populations over time offer an initial indication of population trends, especially in regions where long-term scientific monitoring data may be limited such as the Galapagos (Almojil, 2021; Colloca et al., 2020; Peñaherrera-Palma et al., 2018; Seidu et al., 2022). According to fishers' answers, species' population abundance is nowadays 'the same' or 'greater' as when most of them started working in the Galapagos (Fig. 9), which could be attributed to many factors that need further research.

Fishers' observations can serve as real-time indicators of population recovery or decline, offering immediate feedback on conservation measures' effectiveness. Fishers attributed an increase in abundance to shark fishing restrictions and the abundant food availability for them inside of the GMR; while a decrease was attributed to the use of longline and industrial fishing outside of the marine reserve. Indicators must be developed in order to track the degree in which the creation of marine reserves and legislations; the beginning and end of shark fishing; and bycatch have balanced with species' reproductive cycles and litter sizes, to better understand sharks' abundance tendencies.

LEK acts as a supplementary data source, revealing trends that might align with, or diverge from, scientific findings (Colloca et al., 2020; Seidu et al., 2022). For example, if fishers report steady sightings of *A. pelagicus*, this might suggest local stability, but when combined with low reproductive rates reported in literature, it also highlights the species' vulnerability to overfishing, indicating a need for closer monitoring.

Reports of population stability from fishers could help signal unmonitored pressures, such as illegal, unregulated, and unreported (IUU) fishing. For instance, if fishers report stable numbers of *P. glauca* despite illegal fishing reports (Bonaccorso et al., 2021; Carr et al., 2013; Jacquet et al., 2008; Schiller et al., 2015), it suggests the need to investigate possible conservation blind spots, where IUU fishing might be impacting populations without immediate detection. Perceived abundance could also resemble the species' resilience over IUU; an increase in population growth rate; or a change in migratory patterns with shark populations changing their migratory routes towards the Galapagos, influenced by food availability or climate change. More research is needed to understand shark abundance patterns and changes in the Galapagos.

4.4. Participatory mapping

The heatmaps generated from fishers' sightings reveal spatial patterns that illustrate how different shark life stages and species use the Galápagos marine ecosystems. Adult sharks may be concentrated in deeper or open-water regions, sea mounts or bays with sandy bottoms, while juvenile sightings are clustered near coastal or sea-mount areas. Discussing these habitat preferences helps identify critical nursery grounds and adult habitats, allowing conservation efforts to target specific areas crucial to different life stages (Acuña-Marrero, Smith, et al., 2018).

Participatory mapping directly incorporates fishers' localized knowledge, making conservation strategies more accurate and potentially more accepted by local stakeholders (Custodio Nascimento et al., 2023). By visually representing where fishers report shark sightings, the maps generated in this research validate LEK and provide a collaborative framework for conservation planning. This must be integrated into available scientific literature and reports on shark sightings by OUMR such as the ones uploaded into Shark Count app, in which divers register their sightings for elasmobranchs in the Galapagos.

Using fishers' LEK, it can be possible to detect areas with high shark congregation, boosting the opportunity to recognize priority areas for conservation (Acuña-Marrero, Smith, et al., 2018). For example, fishers' heatmaps reveal Darwin and Wolf as an area with high number of shark sightings; this is knowledge they've had because of years of experience, but it was only in 2016 that scientists published the first report of the largest global shark biomass for this area (Acuña-Marrero, Smith, et al., 2018; De León et al., 2016), and a marine sanctuary was stablished for their protection. Working in coalition with the different users of the marine reserve, like fisherfolks, for monitoring and decision making can allow for better advance in conservation strategies, particularly in zones recognized as high-activity regions for sharks.

Further research could direct attention to the regions with high-sighting reports, like the platform's drop area south to Isabela Island and in front of Elizabeth Bay for adult pelagic-shark species. Fishers mentioned this area concentrates shark aggregations because of the influence of the marine currents, which fill the waters with nutrients. For juvenile sharks, these participatory maps can inform about putative nursery areas.

By complementing these reports with scientific research key areas for juvenile shark protection can be characterized easier, reducing costs and effort. For example, some fishers' marked areas with high number of sightings for juvenile Hammerheads coincide with what has been reported by scientists for *S. lewini* just in the last years (Chiriboga-Paredes et al., 2022; Senior et al., 2024). In this respect, working collaboratively has the potential to fill scientific data gaps, particularly for elusive or less-studied species and juvenile sharks that are hard to monitor through traditional survey methods. This could help to refine scientific research priorities, allocate monetary resources effectively, and improve species distribution models (Bessesen & González-Suárez, 2021).

Moreover, participatory mapping empowers fishers by acknowledging their role as key informants for threatened species conservation. Involving them in the mapping process could foster a sense of ownership and partnership in protecting shark habitats. With this collaborative approach, conservation gains credibility and sustainability through the involvement of the local community, who are more likely to support protective measures in areas they have identified as significant (Almojil, 2021; Bessesen & González-Suárez, 2021); which is much needed considering the antagonization the fishing sector still has towards conservation and vice-versa (Burbano & Meredith, 2020).

Furthermore, participatory mapping allows for the creation of adaptive management frameworks that are informed by local observations, making policies more flexible to changes in shark populations and distributions, which could be valuable feedback for managing the reserve and establishing the new sonification(Ramírez-González et al., 2022). With continuous updates to heatmaps based on ongoing fisher sightings, conservation strategies can evolve responsively, shifting focus to areas of increasing juvenile activity, emerging adult habitats, or distribution changes caused by climate change or IUU/industrial-fishing effects.

4.5. Perspectives about shark conservation

Fishers in the Galápagos present a range of perspectives on shark conservation, heavily influenced by both practical and economic considerations. Even though intentional and directed shark fishing is considered over because there is not a market for this anymore and sanctions are high if they are discovered fishing for them or transporting any body part of the animal, among the 87% that reported catching sharks attributed it to unintentional bycatch rather than targeted fishing. Longline fishing—'empate', a method prohibited within the Galápagos Marine Reserve (GMR)—was often mentioned, indicating that enforcement gaps exist (Castrejón & Defeo, 2023, 2024; Doménica Montaño, 2023). Despite this, many fishers shared strategies for releasing sharks safely (as the law indicates) or avoiding them altogether, suggesting a developing awareness of conservation needs. These practices hint at a shift from active shark fishing toward a more cautious approach, reflecting a willingness to adapt if their livelihoods are supported.

The primary reason fishers cite for their reduced interest in shark fishing is economic. Tuna is now one of the primary targets, valued for both local consumption and export (Ramírez-González et al., 2022), while shark bycatch is seen as an obstacle rather than an asset. Although a majority of fishers support shark conservation, many feel that conservation efforts disproportionately benefit tourism over fisheries. Fishers recognize the ecological role of sharks, particularly in maintaining ecosystem balance, yet express concern over limited tangible benefits for their sector. Their observations on illegal longline practices (Doménica Montaño, 2023) further highlight the disconnect between conservation goals and practical challenges faced by local fishing communities (Castrejón & Defeo, 2023, 2024).

Regarding sectoral impacts, large industrial fleets—primarily from China and mainland Ecuador—are perceived as the most significant threat to shark populations, due to intensive fishing outside the GMR. However, small-scale, local fishing practices, despite being less extensive, still contribute to the issue through illegal use of longlines and inadvertent shark captures (Doménica Montaño, 2023). This juxtaposition highlights the need for a more nuanced regulatory approach that recognizes both the global and local pressures on shark populations, with clear, enforceable guidelines for sustainable practices across all fishing sectors (Castrejón & Defeo, 2024; Ramírez-González et al., 2022).

Participants noted that regulations on fishing gear, specifically longline use, are insufficiently enforced, allowing for loopholes that permit continued illegal fishing practices. Other studies (Castrejón & Defeo, 2023, 2024; Doménica Montaño, 2023) highlight similar challenges, showing the complexities of enforcing rules within the GMR and pointing to a need for additional monitoring resources. Addressing these enforcement gaps is crucial to reducing bycatch and ensuring that regulations effectively contribute to the resilience of threatened shark species populations in the region while ensuring socioeconomic prosperity for the fishing sector (Ramírez-González et al., 2022).

The study also revealed tourism as a potential disturbance to shark populations due to the high influx of tourists at specific shark-watching sites. This disturbance could disrupt sharks' natural behavior, especially in congregation areas. Improved management and clear goals for the purpose of tourism in the archipelago could mitigate these conflicts, supporting both conservation and the sustainable coexistence of tourism and fishing within the GMR.

Different users of the GMR report that the disposal of organic waste at sea by both tourism and fishing vessels attracts sharks to coastal areas, altering their natural behavior and potentially increasing the risk of shark-human interactions. Such reports underscore the need for better waste management practices among vessels, such as the one registered in this study that occurs in Isabela, connecting fishing and touristic vessels with the productive are in the highlands; as well as community education to mitigate these unintended effects.

Finally, many fishers and guides expressed a desire for improved collaboration and communication among scientists, conservationists, and local stakeholders. The lack of inclusion of fishers' perspectives in conservation strategies can limit the effectiveness of these initiatives, and better engagement could foster strategies that integrate local knowledge, ultimately leading to more adaptive and responsive management practices (Bessesen & González-Suárez, 2021; Custodio Nascimento et al., 2023; Ramírez-González et al., 2022).

Transversal research and training for the improvement of the fishing sector is of great importance to know about the conservation state of marine biologic populations (Ramírez-González et al., 2022). To solve this, it is necessary to reshape narratives for conservation, climate justice and scientific knowledge building, to trace new transformative ocean science solutions for sustainable development, connecting people and our ocean.

5. CONCLUSION

Reshaping narratives for conservation in the Galápagos require a holistic approach, and by integrating local ecological knowledge (LEK) it can be possible to fosters post-development alternatives which allow for the creation of a new conservation paradigm. By involving and empowering local communities in conservation efforts, valuing their knowledge and perspectives, we can create more sustainable and equitable conservation strategies that benefit both biodiversity and the people who depend on these ecosystems.

This study is the first effort to integrate fishers' LEK, offering invaluable insights that complement scientific research, thanks to fishers' extensive, hands-on experience in the ocean. It has given a first hint into the current state of shark populations after the creation of the GMR and implementation of legislation to conserve them; perceived congregation areas for each species, revealing putative new strategic areas for shark conservation and ecological studies; and perceptions about shark conservation considering different sectors' point of view. In this research, fishers' observations of marine species and ecosystems go beyond the reach of occasional field studies conducted by researchers and guides, offering unique perspectives that enhance data collection efforts. By incorporating these observations into studies to guide decision making conservation efforts in the Galapagos could gain depth, with a more nuanced approach that considers the different users of the marine reserve knowledge and interests.

Bridging the gap between science and the fishing sector is essential. Connecting fishers with conservation goals through education and new opportunities could redefine the role of younger generations within this sector. Integrating fishers' experiences and insights is part of environmental justice and should be considered in the shaping of new biopolitical control instruments, such as the GLF. This integration can empower them with sustainable fishing goals, aligning their practices with unharmful fishing gear, ultimately contributing to marine ecosystem health. Moreover, creating new opportunities for youth in sustainable fishing promotes environmental stewardship, giving them a renewed sense of purpose and innovation in their field.

Integrating Galapagos fishers' LEK has the potential to significantly expand ecological knowledge and boost its expansion. This shared knowledge can address information gaps, especially for elusive species and in understudied habitats, promoting conservation approaches informed by real-world ecosystem interactions. Such expanded ecological insights pave the way for more effective conservation strategies that respect and utilize the wisdom of those most familiar with these ecosystems.

Participatory mapping is a powerful tool in this endeavor. By creating detailed, spatially precise maps based on fishers' observations, stakeholders can develop targeted protection measures for key habitats. The collaborative nature of this mapping not only strengthens community engagement in conservation efforts but also builds a shared sense of responsibility for protecting marine resources. Integrating fishers' spatial insights creates a robust foundation for sustainable management that supports both marine biodiversity and local livelihoods.

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7. ANNEXES:

Anex 1: Shapefiles and raster data used from other sources for the Geographical Spatial Analysis developed using participatory mapping information.

Document name	Type of document	Description	Source
CN_GEO_IOA20_3ED_15052018_ACT2022	tiff.	Galapagos islands Nautical Charts (IOA20)	Servicio Hidrográfico y Oceanográfico Insular de la Armada
Batimetria	tiff.	Galapagos islands Bathymetry. (DEM Global Mosaic Hillshade, cell size: 3 arc-seconds (~90m)).	NOAA. National Centers for Environmental Information (NCEI) Bathymetric Data Viewer
Galapagos_Mangrove_Distribution_2014_Moityetal	shp.	Mangrove cover (ha) in the Galapagos	In: Moity, N., Delgado, B., & Salinas-de-León, P. (2019). Mangroves in the Galapagos islands: Distribution and dynamics. *PloS one*, *14*(1), e0209313.
SNAP	shp.	Protected Areas in the Galapagos according to the Sistema Nacional de Areas Protegidas	Protected Planet https://www.protectedplanet.net/191

Anex 2: Fisheries present in the Galapagos Marine Reserve, their main target species and permitted fishing gear according to Ramírez-González et al. (2022)

Fishery	Main targeted species	Allowed fishing arts	Types of authorized vessels	Use and commercialization
Large pelagic fish or deep-sea fisheries (13 species)	Atún aleta amarilla *Thunnus albacares* Pez espada *Xiphias gladius* Guajo *Acanthocybium solandri*	Rod with reel. Trawl line with lure or bait (trolling). 'Empate' (vertical drifting longline). Horizontal longline only under research permit or authorisation after technical survey.	Fishing boats. Small craft type 'B' (from 9.6 to 12.5 metres in length).	~58% local sale fresh, whole, fillet or sliced. ~42% export to USA and mainland Ecuador fresh or frozen whole without head and guts.
Coastal and demersal fish or 'pesca blanca' (43 species)	Bacalao de Galápagos *Mycteroperca olfax* Brujo *Pontinus clemensi* Mero de profundidad *Hyporthodus mystacinus* Camotillo *Paralabrax albomaculatus*	'Empate' or línea de mano. Red lisera.	Fishing boats. Small craft type 'A' (up to 9.5 mts. in length) and 'B'.	~40% local sale fresh, whole or fillet. Also vacuum packed fillet. ~60% export to mainland Ecuador fresh or frozen whole or fillet.
Spiny lobster	Langosta roja *Panulirus penicillatus* Langosta verde o langosta azul *Panulirus gracilis*	Catch by hand or Hawaiian pole, hookah diving or free diving.	Fishing boats. Small craft type 'A'.	31% local sales primarily fresh whole. 69% export to USA and mainland Ecuador fresh or frozen whole or without tail
Langostino or Chinese lobster	*Scyllarides astori*	atch by hand or Hawaiian pole, hookah diving or free diving.	Fishing boats. Small craft type 'A'.	100% local sale primarily fresh whole (export for commercial purposes is prohibited; in 2022 export of 6 tonnes for commercial purposes allowed).
Sea cucumber	*Isostichopus fuscus*	Hand catch with hookah diving.	Fishing boats. Small craft type 'A'.	100% export to Asian markets cooked in brine.
Minor resources	Pulpo *Octopus sp.* Churos o caracoles *Hexaplex princeps* y *Pleuroploca princeps* Canchalagua o *quitones Chiton goodalli* y *Chiton sulcatus*	Catch by hand with hookah diving, free diving or on foot in the intertidal zone.	Small craft type 'A'.	100% sold locally fresh whole and without shells in the case of churos and canchalagua (export for commercial purposes is prohibited).
Bait	Pelágicos menores *Anchoa sp. Opisthonema sp. Sardinops sagax.* Lisa rabo amarillo *Mugil galapagensis* Lisa rabo negro *Xenomugil thoburni*	'Atarraya' o 'red de mano'. 'Chinchorro de playa'.' Red lisera'.	Small craft type 'A'.	Bait for deep sea fishing and 'pesca blanca'.

Anex 3: Participatory mapping

Figure 17: Alopias superciliosus sightings according to participatory mapping

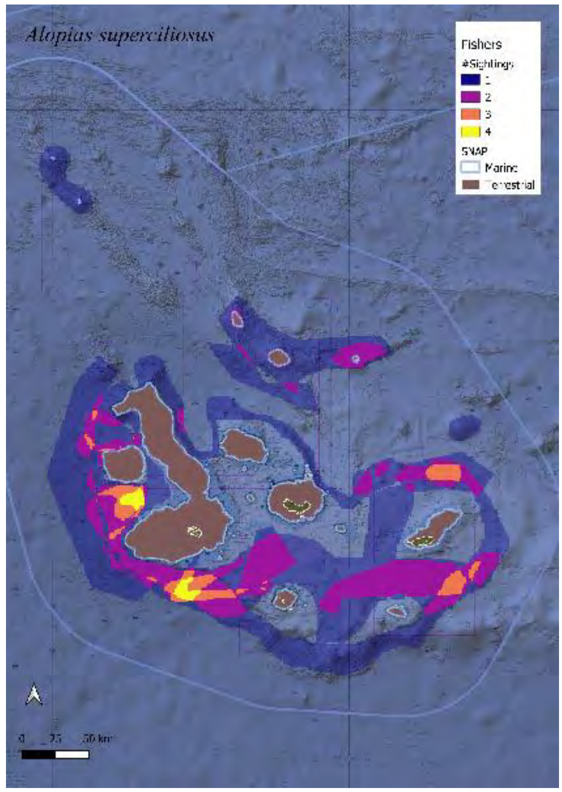
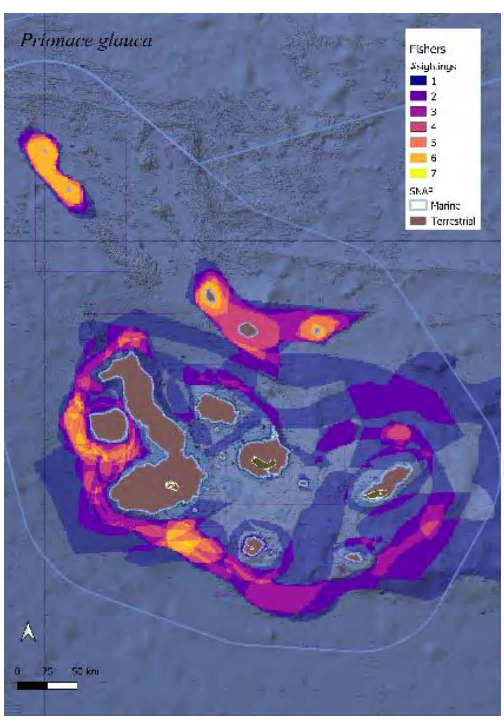
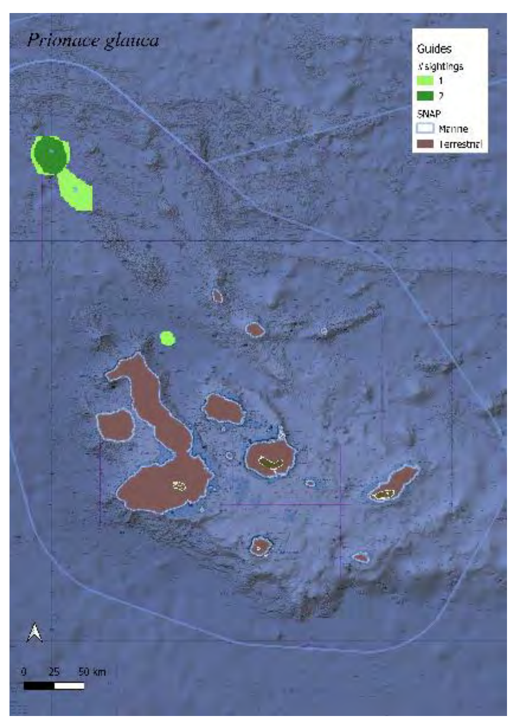


Figure 18: Prionace glauca reported sightings according to participatory mapping.





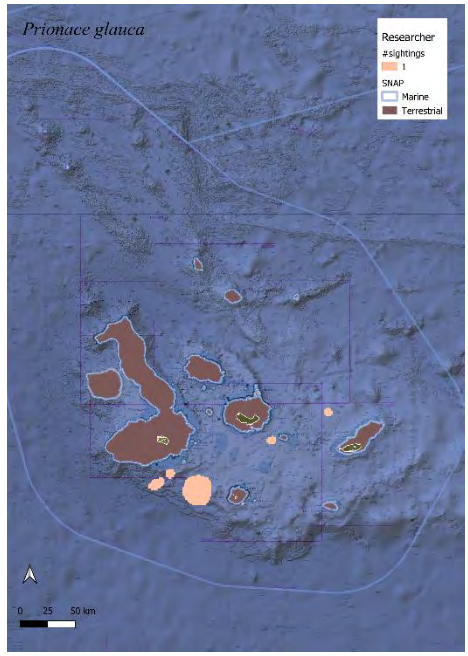
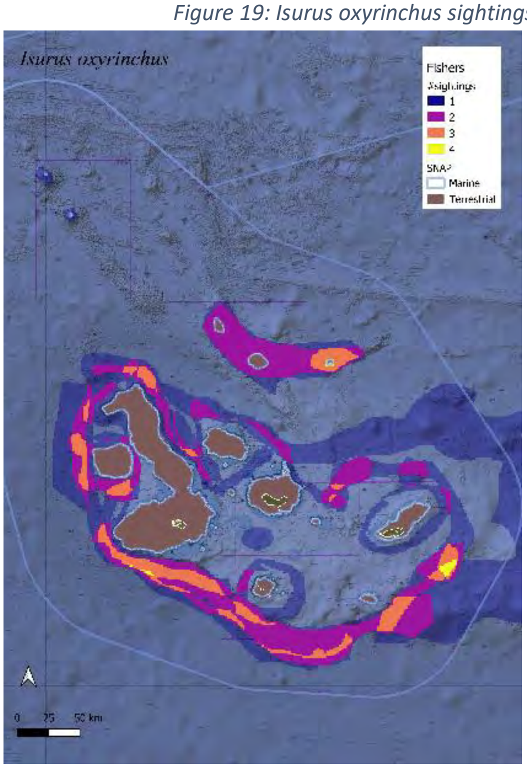


Figure 19: Isurus oxyrinchus sightings according to participatory mapping.



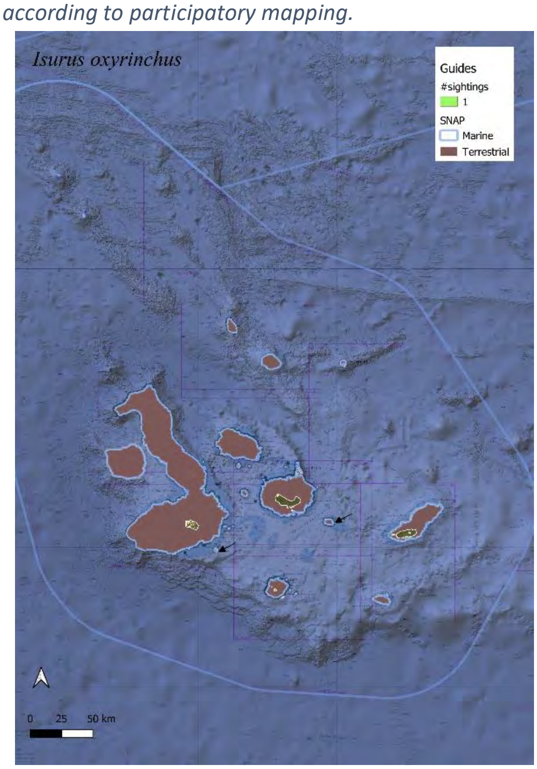


Figure 20: Carcharhinus falciformis sightings according to participatory mapping.

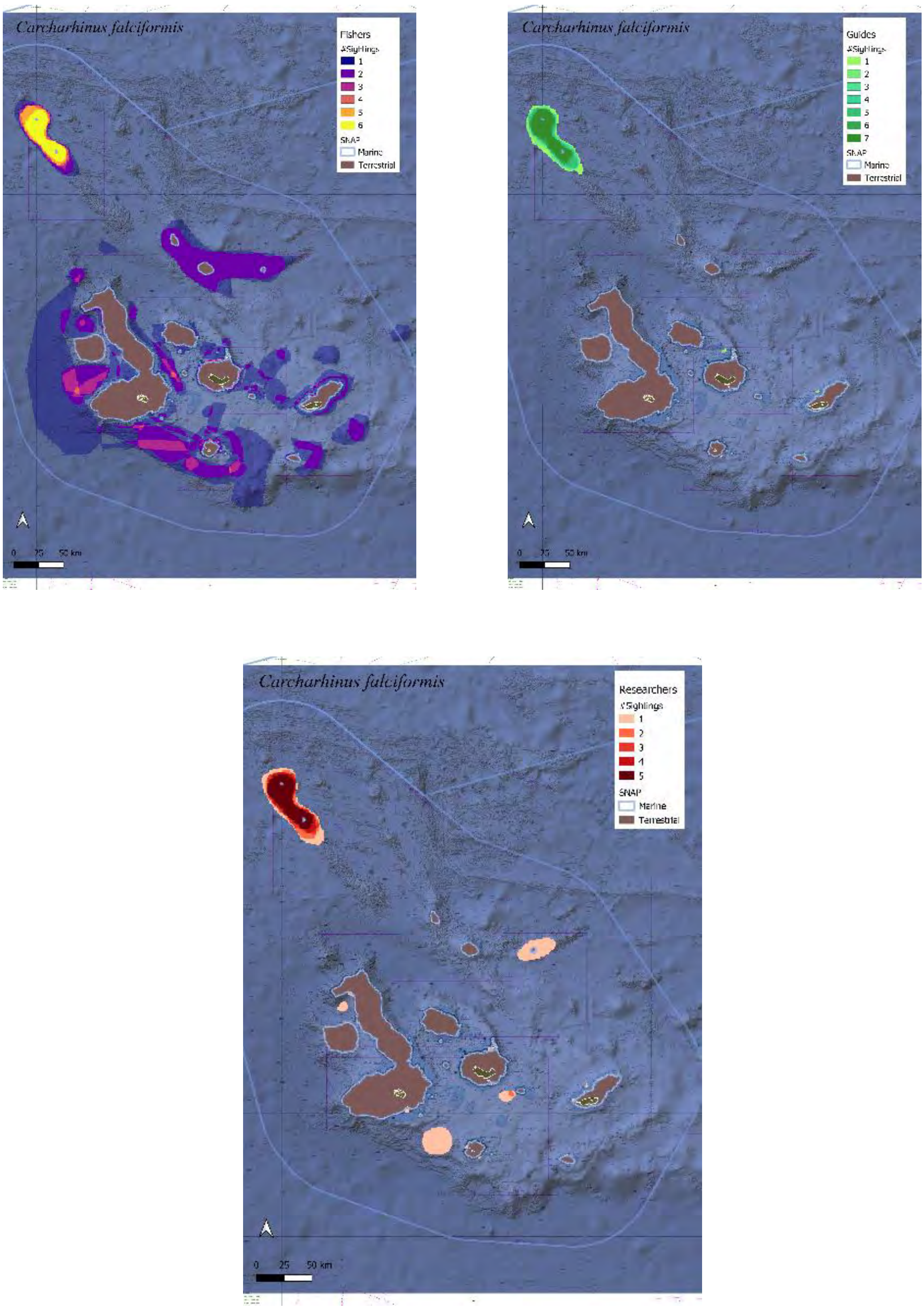


Figure 21: Sphyrna lewini sightings according to participatory mapping.

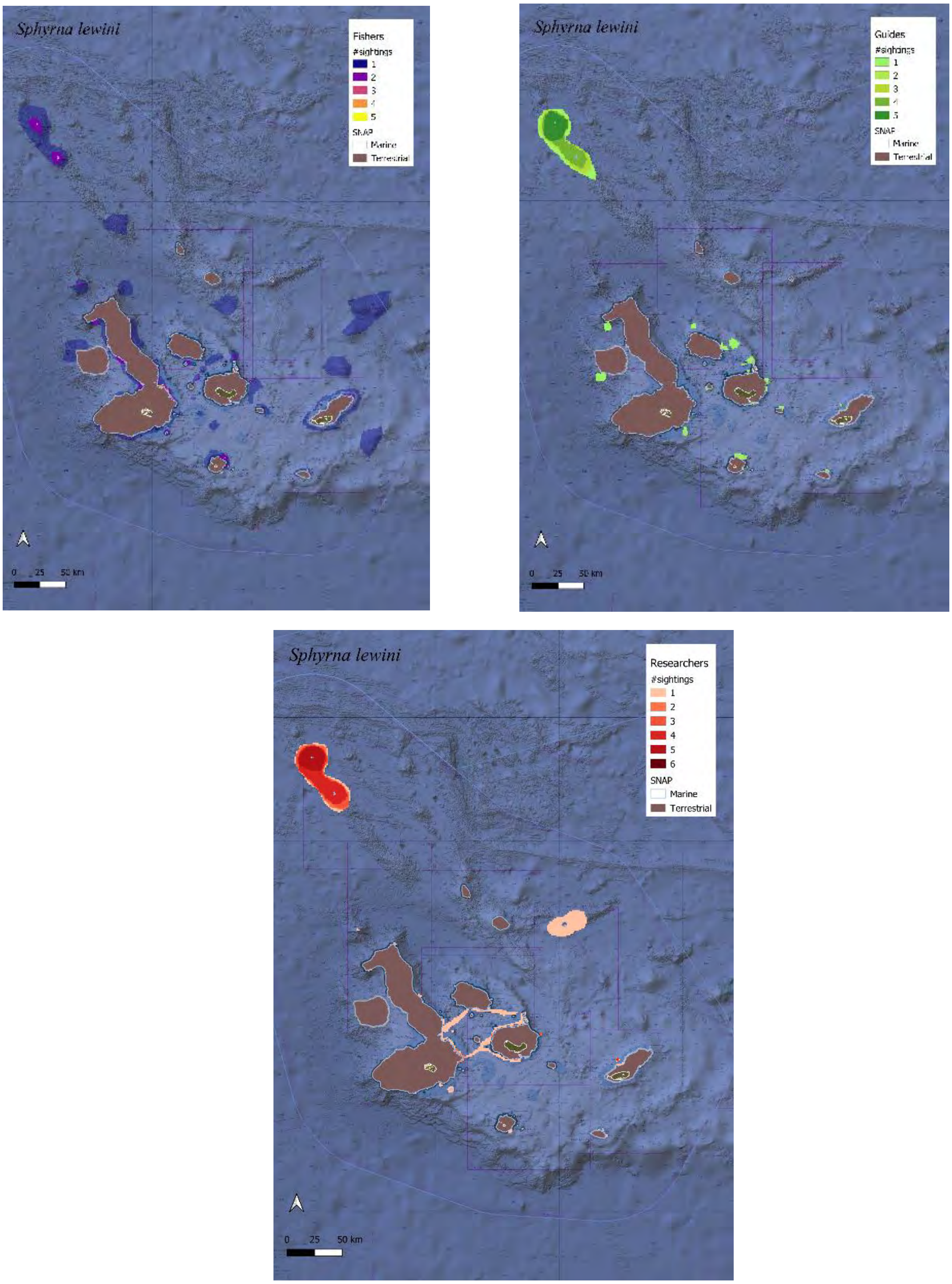


Figure 22: Sphyrna zygaena sightings according to participatory mapping.

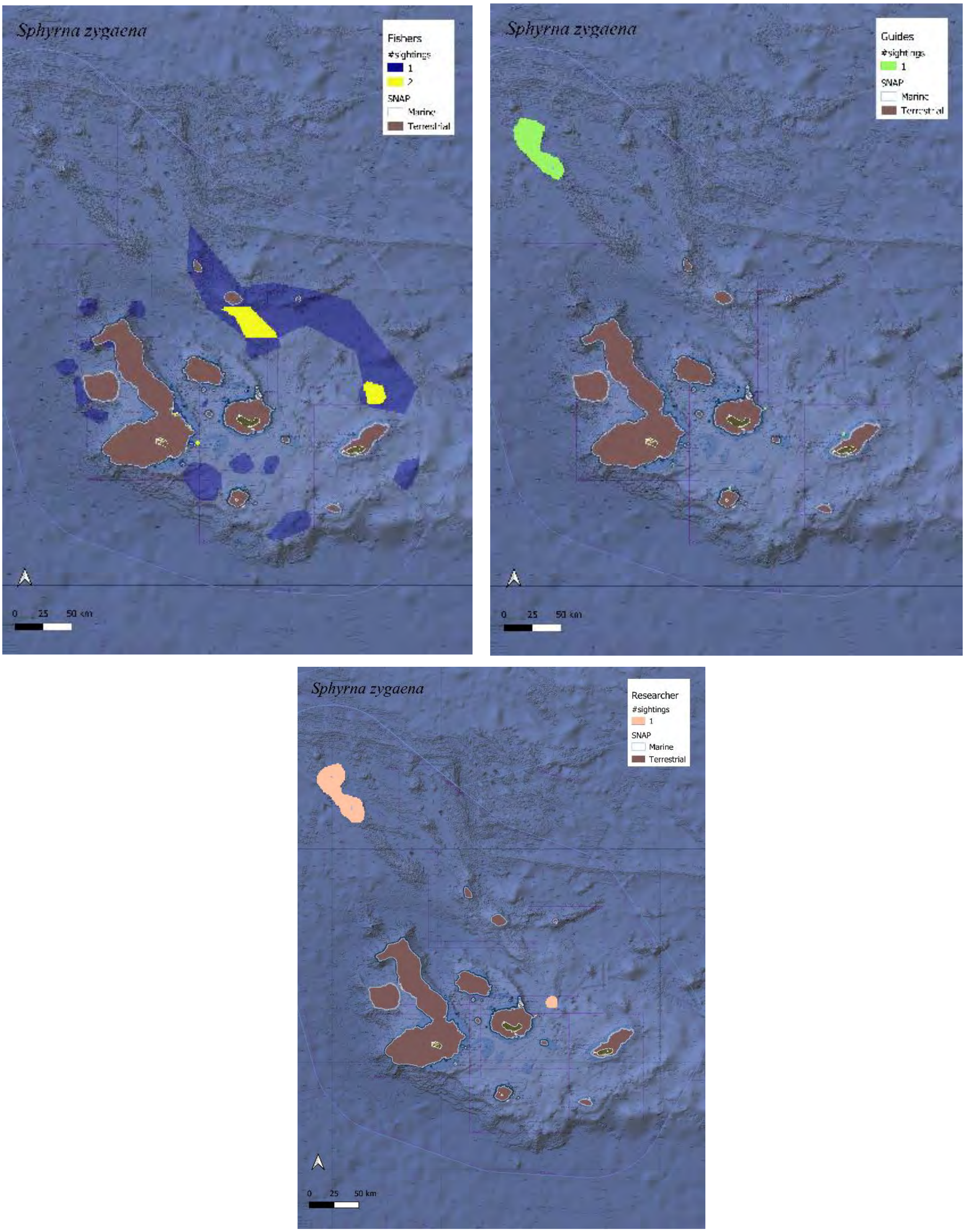
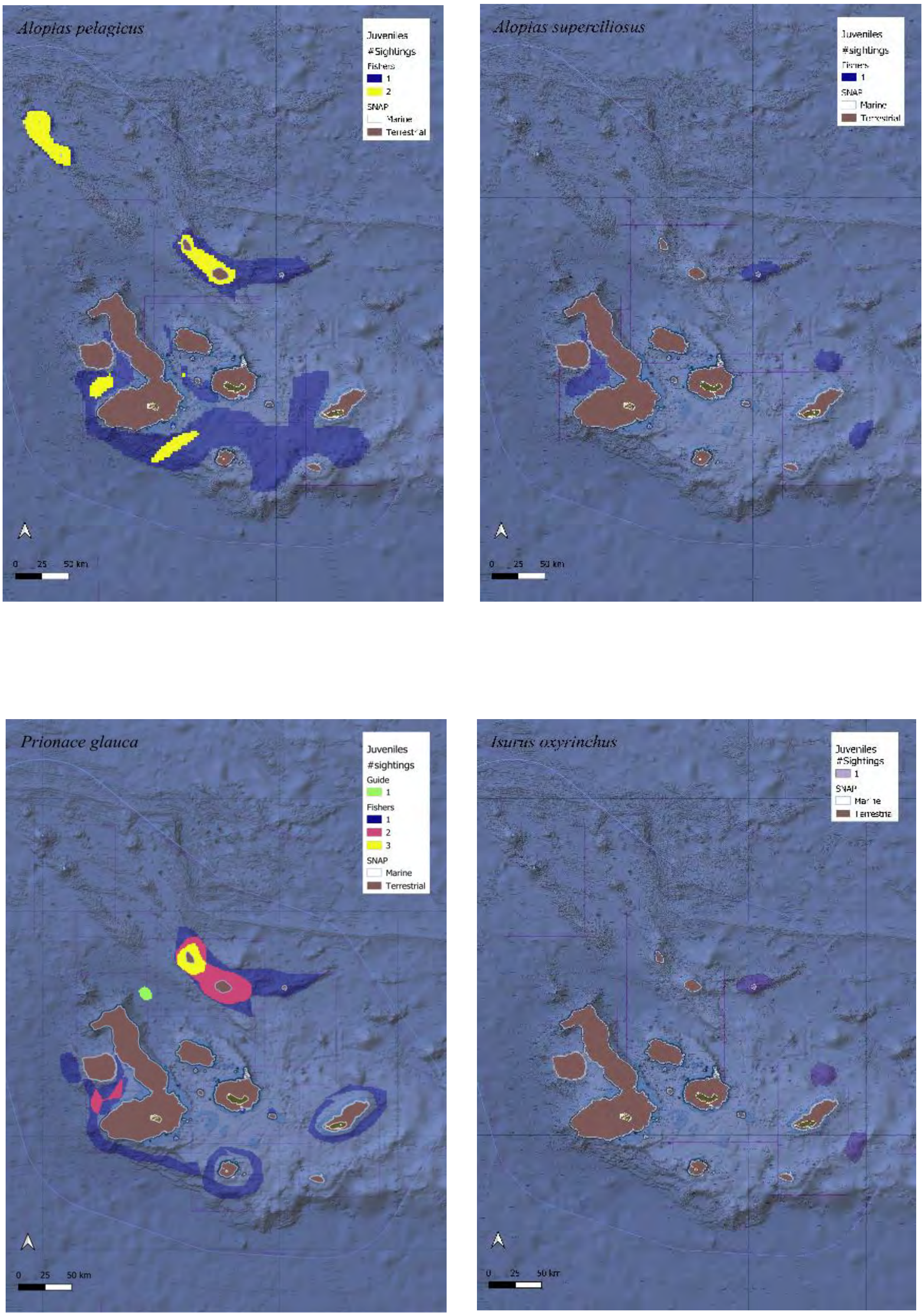
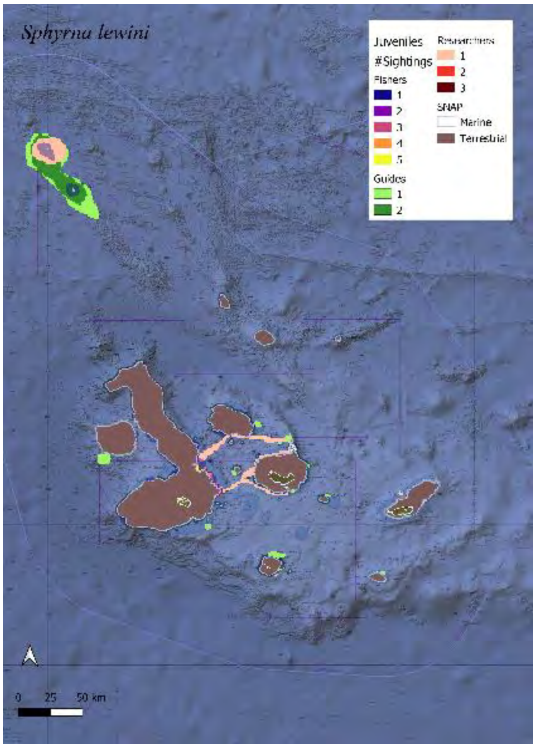


Figure 23: juvenile's sightings according to participatory mapping.




Sphyrna lewini
Juveniles
#Sightings
Fishers
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5
Guides
1
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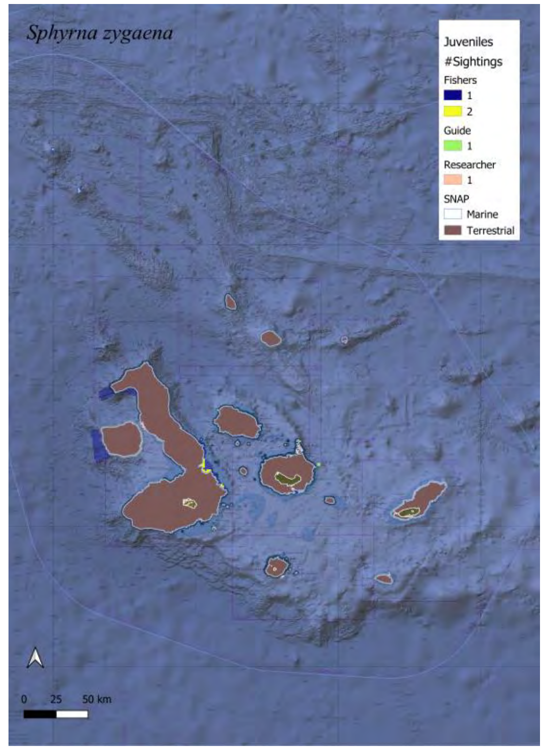
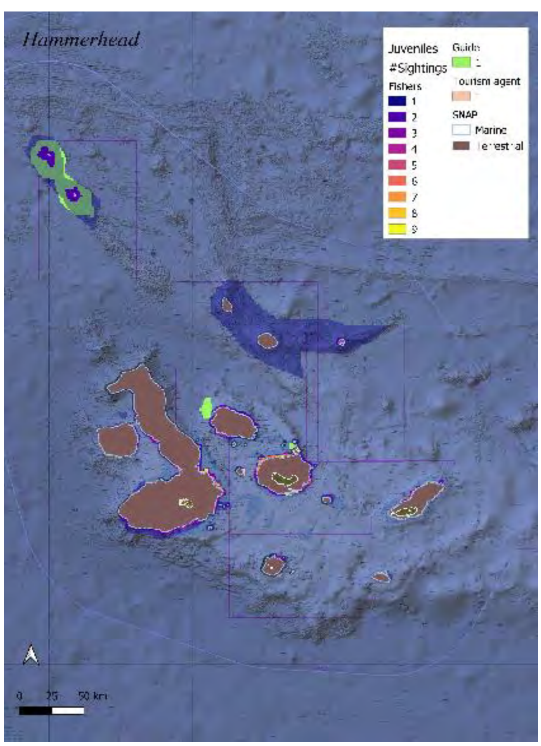
Researchers
1
2
3
SNAP
Marine
Terrestrial
0 25 50 km


Sphyrna zygaena
Juveniles
#Sightings
Fishers
1
2
Guide
1
Researcher
1
SNAP
Marine
Terrestrial
0 25 50 km


Hammerhead
Juveniles
#Sightings
Fishers
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6
7
8
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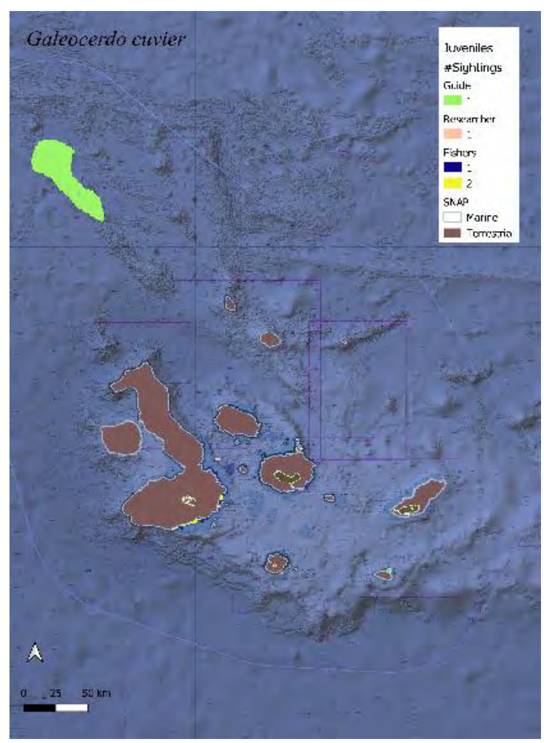
Guide
SNAP
Marine
0 25 50 km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Juveniles
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Researcher
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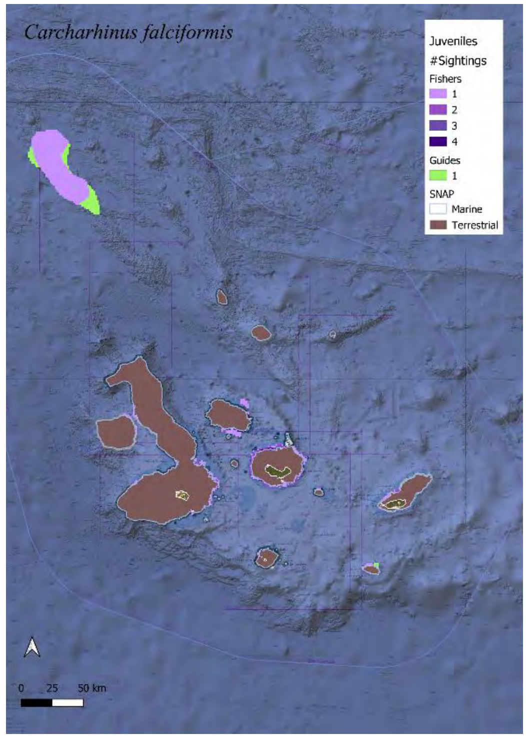
Carcharhinus falciformis
Juveniles
#Sightings
Fishers
1
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Guides
1
SNAP
Marine
Terrestrial
0 25 50 km