Biological Conservation 311 (2025) 111452

Contents lists available at ScienceDirect

Biological Conservation

journal homepage: www.elsevier.com/locate/biocon

Revealing the unseen: Shark finning in the Galapagos Marine Reserve through illegal fishers' eyes and a situational crime prevention approach

Mauricio Castrejón [a]

[a] *Grupo de Investigación en Biodiversidad, Medio Ambiente y Salud, Universidad de Las Américas, UDLA Park, redondel del ciclista s/n, Quito, Ecuador*

A R T I C L E I N F O

Keywords:
Illegal fishing
Shark finning
Situational crime prevention
Galapagos
Marine protected area
Eastern Tropical Central Pacific

A B S T R A C T

Illegal, unreported, and unregulated (IUU) fishing presents a major threat to shark conservation in marine protected areas (MPAs). This study explores the history and evolution of illegal shark fishing in the Galapagos Marine Reserve through the perspectives of former poachers, utilizing a situational crime prevention approach. In depth interviews were conducted to understand the motivations, methods, and socio economic factors that drove illegal shark finning within the GMR. Using these insights, the scale and economic impact of illegal shark finning were quantified for the first time. From the 1980s to 2005, socioeconomic challenges and market demands incentivized local fishers to engage in shark fishing, with weak surveillance and corruption within regulatory bodies exacerbating IUU fishing. However, advancements in surveillance technology, reduction of shark fins price on the black market— likely caused by Decree 486 — and the availability of more stable economic alternatives, such as small-scale tuna fishing significantly reduced the incentives for illegal shark finning. Despite this success, illegal activities shifted to other forms, such as longlining and fuel trafficking, revealing the adaptability of illegal enterprises. To effectively combat IUU fishing, resilient socio-economic conditions, robust legal frameworks, and transparent institutions are required. This study also highlights the role of market dynamics in driving illegal activities, emphasizing the need to adopt a SCP approach to reduce opportunities for illegal fishing. The findings offer valuable lessons for developing effective, adaptive management policies to discourage illegal shark fishing in other multiple-use MPAs.

1. Introduction

Illegal, unreported, and unregulated (IUU) fishing poses a significant threat to global marine biodiversity, undermining the ecological and management objectives of marine protected areas (MPAs) (Petrossian, 2019; Weekers et al., 2021). By targeting both commercially valuable and ecologically important species, IUU fishing erodes biodiversity, disrupts food webs, and weakens the effectiveness of conservation and fisheries management efforts (Pascoe et al., 2008; Riskas et al., 2018). Among the most vulnerable taxa are sharks, whose slow life histories and ecological role as apex predators make them especially susceptible to overexploitation (Dulvy et al., 2021, 2014; Pacoureau et al., 2021). In some regions, sharks are especially targeted by IUU fishers due to the high market value of their fins, primarily driven by demand in Asian markets. MPAs are often exploited for shark finning, the practice of catching sharks, removing their fins, and discarding the bodies, because they harbor relatively abundant populations and often lack adequate surveillance and enforcement capacity (Carr et al., 2013; González-Andrés et al., 2020; López-Garro et al., 2016; Petrossian, 2019). The ecological consequences of shark finning are potentially severe and unpredictable, given sharks' role in maintaining the structure and function of marine food webs (Dulvy et al., 2021, 2014; Field et al., 2009; Pacoureau et al., 2021).

Despite global concern, the clandestine nature of IUU fishing complicates the estimation of its magnitude, severely limiting the assessment of its ecological and socioeconomic impact (Petrossian, 2019). Most existing methods rely on indirect estimates, such as trade data analysis or satellite-based vessel tracking, that often suffer from limited coverage, questionable accuracy, non-transparent assumptions, and high uncertainty (FAO, 2023, 2023b; Giovos et al., 2020; Macfadyen et al., 2016).

Fishing communities possess invaluable, yet largely ignored or unexplored, knowledge about the prevalence and practices of IUU fishing (Blank and Gavin, 2009; Chapsos et al., 2019; Luomba et al., 2016). Their insights, accessible through participatory methods like interviews and surveys, can illuminate the motivations and methods behind illegal activities (Donlan et al., 2020; Luomba et al., 2016; Seminara et al., 2023). However, reluctance to share sensitive information, often rooted

E-mail address: hugo.castrejon@udla.edu.ec.

https://doi.org/10.1016/j.biocon.2025.111452
Received 29 December 2024; Received in revised form 7 August 2025; Accepted 17 August 2025
Available online 28 August 2025

in fear of repercussions and mistrust toward authorities and scientists, poses a major challenge (Burbano et al., 2020; Ebel et al., 2018; Silver and Campbell, 2005; Solomon et al., 2007). Building trust, ensuring confidentiality, and adapting research to local contexts, following ethical standards, are essential for enabling honest dialogue and effective knowledge exchange (Calderwood et al., 2023; Ebel et al., 2018; Kaplan and McCay, 2004; Satizábal et al., 2021; Silver and Campbell, 2005).

The Galapagos Marine Reserve (GMR) represents a paradigmatic case. Globally renowned for its exceptional shark diversity and biomass (Salinas de León et al., 2016), the GMR is a multiple-use MPA that was historically impacted by illegal shark finning, especially during the late 1990s and early 2000s (Carr et al., 2013; Castrejón et al., 2021; Jacquet et al., 2008; Reyes and Murillo, 2007; Schiller et al., 2014). Although regulatory and institutional frameworks have strengthened over time (Castrejón and Charles, 2013), little is known about the historical dynamics and magnitude of illegal shark fishing in the reserve—who participated, how it operated, how much was caught, and why it eventually declined. This knowledge gap hinders our ability to evaluate past management actions and inform future interventions aimed at protecting sharks and other endangered, threatened, and protected (ETP) species, within and beyond GMR's boundaries.

This study reconstructs the history, evolution and social-ecological impacts of illegal shark finning in the GMR through in-depth interviews with former local fishers who directly participated in these activities. The interviews were designed to address the following research questions: (1) What were the primary drivers and motivations behind the rise of illegal shark fishing in the GMR?; (2) How was the illegal shark finning organized and executed by local fishers?; (3) What was the scale and profitability of illegal shark finning in the GMR?; (4) What institutional, regulatory, or socio-economic factors contributed to its eventual decline?; and (5) How did fishers respond to this change, and what were the social-ecological consequences of their adaptive responses?

A Situational Crime Prevention (SCP) framework was adopted during the analysis phase to interpret the conditions that ultimately discouraged continued participation in illegal shark fishing within the GMR. SCP, developed in the field of environmental criminology, shifts focus from offender motivations to the situational and environmental contexts that enable crime, seeking to make illegal acts more difficult, risky, or less rewarding through targeted interventions (Petrossian, 2015, 2019; Weekers et al., 2021). While SCP is not a criminological theory *per se*, it offers a practical set of response strategies grouped under five categories: increasing effort, increasing risks, reducing rewards, reducing provocations, and removing excuses (Clarke, 1980). These strategies are grounded in three foundational criminological theories: Routine Activity Theory (Cohen and Felson, 1979), which emphasizes the convergence of motivated offenders, suitable targets, and a lack of capable guardians; Rational Choice Theory (Cornish and Clarke, 1986), which views offending as a calculated decision based on expected costs and benefits; and Crime Pattern Theory (Brantingham and Brantingham, 1993), which highlights how environmental and spatial factors shape opportunities for crime.

Unlike traditional criminological theories that seek to explain why offenders commit crimes, or deterrence-based theories that emphasize punitive measures to discourage criminal behavior, the SCP focuses on reducing opportunities for crime by modifying the immediate conditions in which offenses occur (Petrossian, 2015). This includes measures such as enhancing surveillance, increasing the effort required to offend, and reducing potential rewards, thereby making criminal behavior less attractive and more difficult to carry out. This makes SCP particularly effective for addressing opportunistic and economically motivated offenses like illegal fishing, which often exploit weak enforcement, high profit margins, and regulatory loopholes (Petrossian, 2019; Weekers et al., 2021).

In this study, SCP is applied not as a theoretical lens, but as a practical framework informed by these theories, to retrospectively examine how institutional and socioeconomic changes in the GMR reshaped opportunity structures and influenced fishers' decision-making. By applying SCP retrospectively, this study identified key regulatory, institutional, and socio-economic changes that collectively diminished the attractiveness, accessibility, and perceived rewards of shark finning within the GMR. The contributions of this study are twofold. First, the SCP framework applies to a marine biodiversity context, offering rare insights into how crime prevention theory can inform conservation enforcement in multiple-use MPAs. Second, it draws directly from the testimonies of former illegal fishers—voices seldom captured in academic literature—to uncover the local and systemic drivers of IUU fishing and highlight practical leverage points for deterring illegal shark finning in other multiple-use MPAs. In doing so, the study contributes to building more sustainable and resilient marine ecosystems.

2. Methods

2.1. Study area

Shark fishing in the Galapagos began in the 1950s, escalating significantly by the late 1980s as demand for shark fins in Asian markets grew (Carr et al., 2013; Jacquet et al., 2008; Schiller et al., 2014). Increasing public concern over the potential impacts on the archipelago's marine biodiversity led to banning shark fishing and trade through Ministerial Decree 151 in 1989 (Castrejón and Defeo, 2024). Nevertheless, the ban proved difficult to enforce due to the vast marine area and the lucrative nature of the shark fin trade, resulting in rampant illegal fishing by local, national, and international fleets during the late 1980s and early 1990s (Jacquet et al., 2008; Schiller et al., 2014).

In March 1998, the Galapagos Islands and their adjacent waters were established as a multiple-use MPA (Fig. 1), covering 146,599 km^2 of marine and terrestrial area (DPNG, 2014). The GMR represents the most emblematic MPA in the Eastern Tropical Central Pacific, which includes the Economic Exclusive Zones (EEZs) of Costa Rica, Panama, Colombia, and Ecuador. Following its designation, large-scale fishing was prohibited within the GMR, while exclusive fishing rights were granted to local small-scale fishers (Castrejón and Charles, 2013). Several precautionary measures have been implemented to conserve ETP species, particularly sharks (Table 1) (Castrejón, 2020a; Castrejón and Defeo, 2024). In 2000, longlining was banned within the GMR as a precautionary measure to prevent illegal fishing and bycatch of sharks (Castrejón and Defeo, 2024, 2023a). That same year, an agreement was reached to establish a marine zoning scheme, leading to the creation of a network of no-take zones designed to protect critical habitats and ETP species (Castrejón and Charles, 2013; Heylings and Bravo, 2007). Currently, these no-take zones cover approximately 32 % of the GMR's total area (45,380.02 km^2) (Fig. 2). The largest of these, called "Marine Sanctuary", encompasses 38,546.49 km^2, or 27 % of the total area of the GMR (Fig. 2), specifically to protect regions rich in shark populations (Burbano et al., 2020; Castrejón et al., 2024a).

Additionally, the Interinstitutional Authority for the Management of the Galápagos Marine Reserve implemented Resolution No. 011-2000 on November 15, 2000, which banned the capture, landing, and commercialization of sharks within the Galapagos. In 2001, the Ecuadorian Ministry of the Environment extended these restrictions to prohibit the landing and trading of incidentally caught sharks at the national level. In 2007, the enactment of Decree 486 by the Ecuadorian government aimed to manage incidental shark catches more effectively and regulate their trade. This decree strengthened the nationwide prohibition against targeted shark fishing, explicitly outlawing practices such as shark finning and the use of longlines for catching sharks (Castrejón, 2020a,b). While the decree permitted the commercialization of incidentally caught sharks, it specifically excluded the Galapagos Islands from this provision. Despite these regulatory efforts, illegal shark

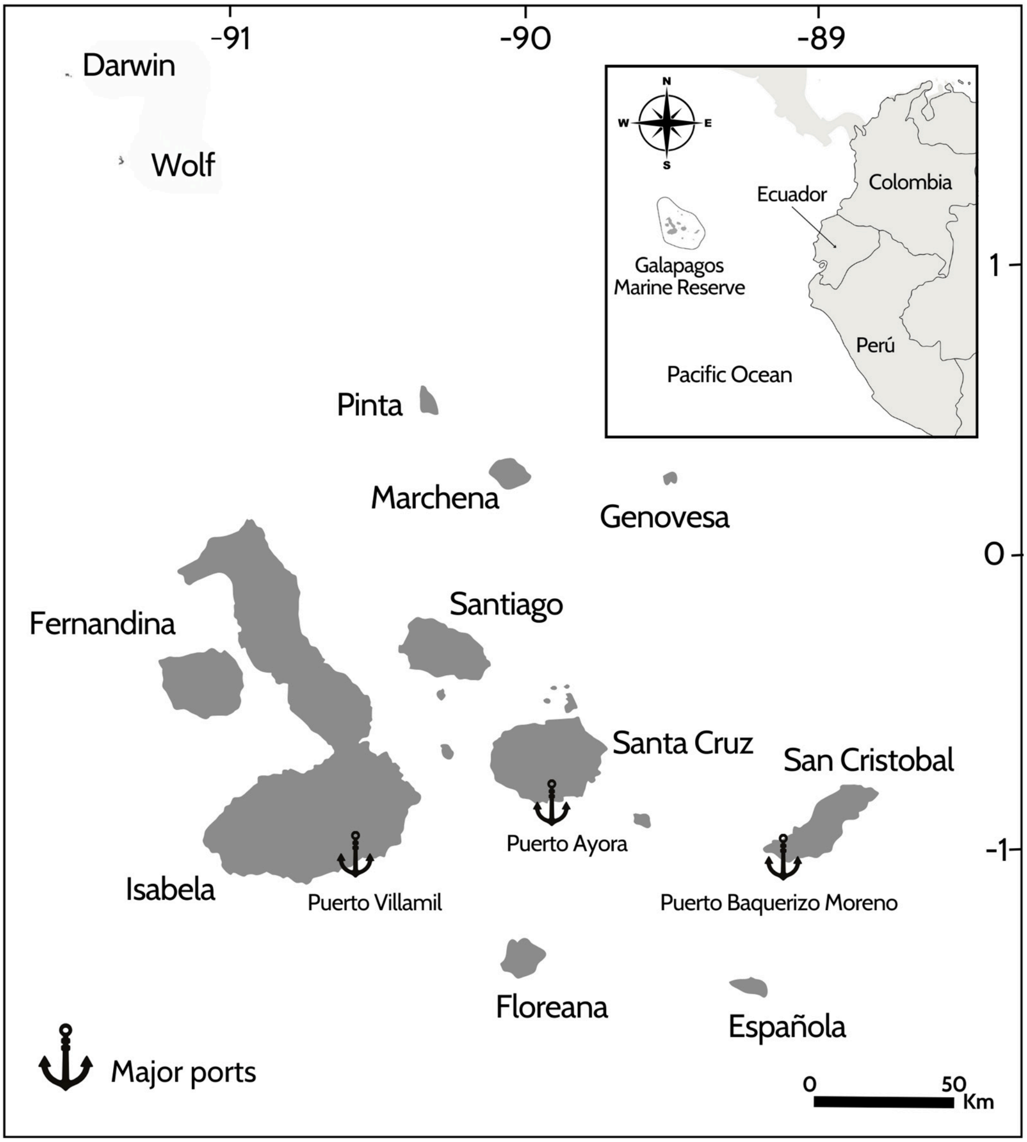

Fig. 1. Main islands and ports of the Galapagos Marine Reserve, Ecuador. Adapted from Castrejón et al. (2024c).

Table 1
Mean weight per shark for various species caught illegally within the Galapagos Marine Reserve (GMR) by the longline fishing vessel "Fer Mary I" from Manta, apprehended on July 19, 2011. "N/A" indicates data not available or not applicable.

Species	Total (#)	Total biomass (tons)	Mean weight per shark (kg)
Alopias superciliosus (bigeye thresher)	303	14.96	49.4
Carcharhinus falciformis (silky shark)	42	2.3	54.8
Prionace glauca (blue shark)	24	3.95	164.6
Sphyrna zygaena (smooth hammerhead)	5	0.3	60.0
Galeocerdo cuvier (tiger shark)	2	0.39	195.0
Carcharhinus galapagensis (Galápagos shark)	2	0.13	65.0
Isurus oxyrinchus (shortfin mako shark)	1	N/A	NA
Unidentified shark	1	N/A	NA
Total	**380**	**22.03**	**58.0**
Total (without blue sharks)	**356**	**18.08**	**50.8**

Source: Car et al. (2007).

fishing continued among local small-scale fishers, driven by the lucrative black market for shark fins (Castrejón et al., 2021).

The small-scale fishing sector plays a crucial role in supporting the economy and food security of nearly 30,000 residents and over 329,000 visitors annually in the Galapagos (Castrejón et al., 2024b; DPNG, 2024; Ramírez-González et al., 2022; Rodríguez-Jácome et al., 2023). Within the GMR, there are approximately 336 full-time and part-time fishers, operating 139 fishing vessels across the three main islands: Santa Cruz, San Cristóbal, and Isabela (Fig. 1) (Ramírez-González et al., 2022). Approximately, 97 % of these vessels are smaller than 12 m in length and are constructed from fiberglass or wood. The remaining 3 % are larger wooden boats, ranging from 12 to 18 m long, equipped with inboard engines (DPNG, 2021).

In terms of volume and economic value, the most significant fisheries include: (1) the tuna and tuna-like small-scale fishery, locally known as "pesca de altura", whose main target species are the yellowfin tuna (*Thunnus albacares*) and swordfish (*Xiphias gladius*); (2) the whitefish fishery, locally known as "pesca blanca," which primarily targets demersal finfish species such as the sailfin grouper (*Mycteroperca olfax*), whitespotted sandbass (*Paralabrax albomaculatus*), mottled scorpionfish (*Pontinus clemensi*), and misty grouper (*Hyporthodon mystacinus*); and (3) marine invertebrates fisheries, being the most relevant the spiny lobsters

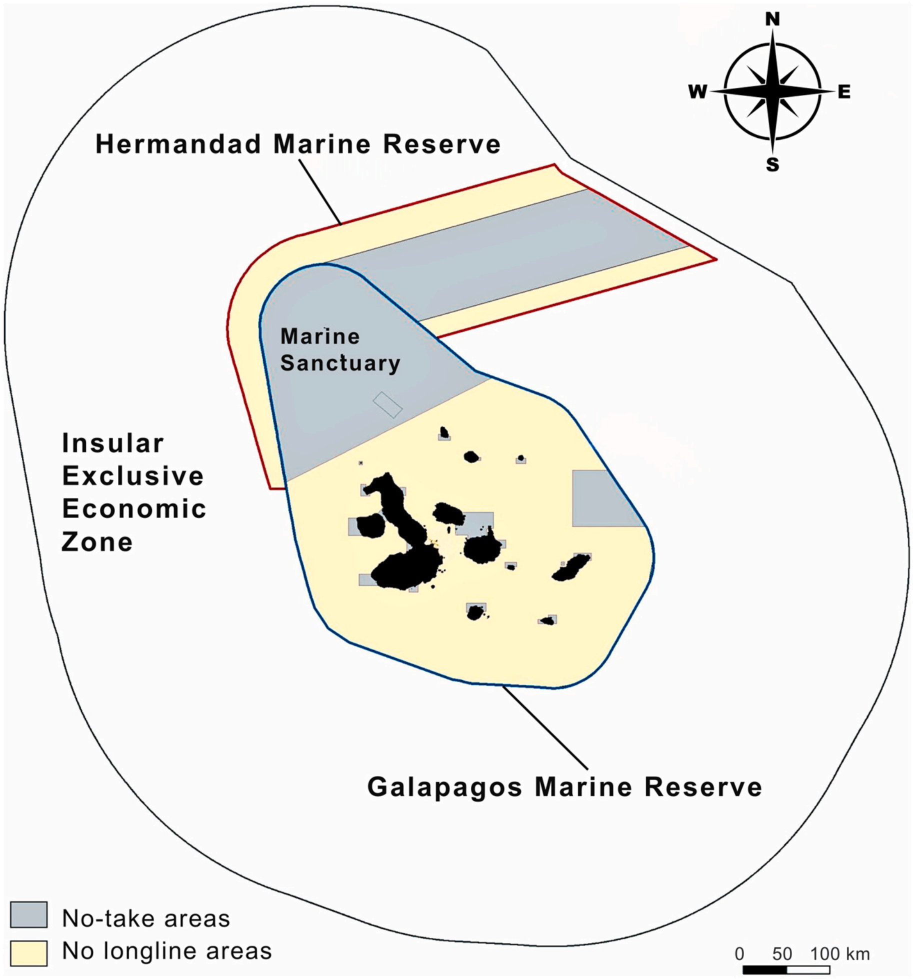

Fig. 2. Galapagos Marine Reserve (blue line) and Hermandad Marine Reserve (red line) within the Insular Exclusive Economic Zone of Ecuador. Adapted from Castrejón and Defeo (2024). (For interpretation of the references to color in this figure legend, the reader is referred to the web version of this article.)

(*Panulirus penicillatus* and *P. gracilis*), and the brown sea cucumbers (*Isostichopus fuscus*) (Castrejón et al., 2024b; Ramírez-González et al., 2022; Zimmerhackel et al., 2015). The stocks of the sailfin grouper, whitespotted sandbass, and brown sea cucumber are overexploited (Ramírez-González et al., 2020; Usseglio et al., 2016), and they are listed as endangered by the IUCN Red List of Threatened Species (IUCN, 2024).

The authorized fishing gears for tuna in the GMR include handlines, pole and line, trolling, and rods. However, illegal longlining remains an ongoing threat, driven by a combination of legal, institutional, and socioeconomic challenges that have hindered effective enforcement of the ban (Ben-Yami, 2001; Castrejón and Defeo, 2024, 2023b).

2.2. Data collection

This research was approved by the Ethics Committee for Research Involving Human Subjects of Universidad de Las Américas on July 9, 2024, with the assigned code 2024-OBS-018. A qualitative methodology was employed, using in-depth interviews with former fishers who had firsthand knowledge of illegal shark fishing practices in the GMR. This approach enabled a deep exploration of participants' experiences, motivations, and perceptions, while allowing flexibility to capture emergent themes and contextual details that may not have been anticipated a priori.

The target population consisted of former Galapagos fishers who were directly involved in illegal shark finning activities up to the mid-2000s. The author used purposive and snowball sampling techniques to identify participants, leveraging over two decades of professional engagement with fishing communities in Santa Cruz, San Cristóbal, and Isabela. Trust-based relationships developed over time facilitated access to sensitive information and helped foster candid conversations on a topic often associated with legal and social stigma.

The interviews were conducted in private settings between September and October 2024. Each interview lasted between 60 and 90 min and was recorded with the informed consent of the participants. No identifying personal data were collected, and strict confidentiality protocols were followed. To protect participant anonymity, the specific number of interviews and locations are not disclosed. However, the sample represents approximately 15 % of the estimated number of vessel owners historically involved in illegal shark fishing in the GMR.

The interview guide (see Supplementary Material) was organized around three core themes: (1) background and historical context, including fishers' motivations and the rise of shark finning in the GMR; (2) operational knowledge, including fishing methods, practices, and networks; and (3) evolution and impacts, including adaptive responses to policy changes and perceived social and ecological outcomes. An open-ended format allowed participants to narrate their personal histories and perspectives in their own terms, without being constrained by predefined theoretical frameworks or terminology. Particular attention was given to minimizing social desirability bias by using neutral language and emphasizing the retrospective and non-judgmental nature of the research.

2.3. Data analysis

Interview recordings were transcribed and analyzed using thematic analysis. Emergent patterns were grouped into recurrent themes aligned with the research questions. Although the interview guide was not grounded in a specific theory, the Situational Crime Prevention (SCP) approach was applied retrospectively to interpret how regulatory, institutional, and socioeconomic changes reshaped opportunity structures and influenced the perceived risks and rewards of illegal shark fishing in the GMR.

A range-based approach was used to estimate the annual number of sharks illegally caught by local fishers. Key input values, including the number of vessels involved, frequency and duration of fishing trips, sharks caught per day, average fin price, bribes, and operational costs (e.g., fuel and food), were extracted from interviews. For each variable, the minimum and maximum values reported across all interviews were identified and used to calculate the lower and upper bounds of the estimates. The number of sharks was estimated as:

$$\begin{aligned} \textit{Annual catch of sharks} = & \textit{ Number of vessels} \\ & \times (\textit{Effective fishing days per vessel per year} \\ & \times \textit{sharks per effective fishing day}) \end{aligned} \tag{1}$$

Biomass estimates were derived using an average weight of 50.8 kg per shark, based on species-specific data from Carr et al. (2013) (Table 1). Blue sharks (*Prionace glauca*) were excluded, as they held no market value and were typically discarded, according to interviewees.

To estimate profitability, gross and net income per fishing day were calculated using the following formulas:

$$\begin{aligned} \textit{Gross income per effective fishing day} = & \textit{ Fins sets per effective fishing day} \\ & \times \textit{Average price per fin set} \end{aligned} \tag{2}$$

$$\begin{aligned} \textit{Variable cost per effective fishing day} = & \textit{ Bribe per bundle of fins} \\ & + \textit{fuel} + \textit{food} \end{aligned} \tag{3}$$

$$\begin{aligned} \textit{Net income per effective fishing day} = & \textit{ Gross income per effective fishing day} \\ & - \textit{Variable cost per effective fishing day} \end{aligned} \tag{4}$$

Annual net income per vessel was estimated to be assuming a seven-month fishing season, as reported by interviewees. Total annual net income was estimated based on the range of vessels involved in illegal shark fishing within the GMR during the mid-2000s. The following formulas were used:

$$\begin{aligned} \textit{Annual net income per vessel} = & \textit{ Net income per effective fishing day} \\ & \times \textit{Effective fishing days per vessel per year} \end{aligned} \tag{5}$$

$$\textit{Total annual net income} = \textit{Net income per vessel} \times \textit{Number of vessels} \tag{6}$$

Finally, to assess the potential ecological consequences of shark exploitation, the conservation status of shark species most frequently landed in Ecuador in 2007 (Jacquet et al., 2008), and their most recent conservation status according to the IUCN Red List published in 2024. Each species was classified under the following IUCN categories: not evaluated, data deficient, least concern, near threatened, vulnerable, endangered, and critically endangered. This classification enabled a comparison of the conservation status of key shark species over time and helped highlight those most at risk in the context of changing exploitation patterns.

3. Results

The following subsections describe the history and evolution of illegal shark fishing from the perspectives of poachers, focusing on key drivers, motivations, fishing methods, operational modes, adaptive responses and socio-ecological impacts.

3.1. Drivers and motivations behind illegal shark fishing

According to interviewees, illegal shark fishing in the GMR began in the late 1980s and escalated in 2000, declining after 2005 (Fig. 3). Several interrelated drivers motivated fishers to engage in this illicit activity. A key factor was the abrupt shift in regulatory status. Before 1989, shark fishing was legal and commonly associated with the production of salted meat. However, the national ban on shark fishing and commercialization enacted that year created a regulatory vacuum. As one fisher recalled, "*Shark fishing was already happening before 1993… sharks were caught year-round, but they were salted.*" When regulatory controls increased, fishers began hiding fins instead of meat due to ease of transport: "*It was too bulky to transport the meat, so it couldn't be hidden. So we started hiding the fins instead because they were easier to move.*" These fins were then sold to intermediaries from mainland Ecuador, who primarily distributed them throughout mainland Ecuador, especially in Manta, Guayaquil, Quito, and Ambato.

Economic marginalization also played a central role. During the 1980s and 1990s, Galapagos fishers had few viable alternatives. The local seafood market was underdeveloped because of a small resident population and a nascent tourism sector, while export options were constrained by high logistical costs and poor bargaining power. Interviewees emphasized that shark fishing filled a crucial gap in household income. "*Illegal shark fishing happened because there were no other fishing alternatives. Aside from lobster, shark fishing was the only source of income—there was nothing else to do.*" Fins, unlike meat, could be sold easily and at high prices. Additionally, until the mid-2000s, there was minimal demand for tuna in the Galapagos, with a strong local preference for sailfin grouper, commonly known as "Galapagos cod". One interviewee stated: "It was cod or nothing, nobody ate tuna here." This preference rendered tuna fishing an economically unattractive alternative.

Shark fishing was not only a matter of opportunity, but it was also a survival strategy. Economic insecurity made fishers vulnerable to shocks such as illness, debts, or equipment failure. "*One of my sons had a brain tumor. I made more money fishing sharks than doing anything else… thanks to shark fishing, my son is alive.*" Others highlighted the lack of support and investment from authorities: "*As a fisher, I went through very hard times, not feeling any support in the sale of what I produced. This happened between 1990 and 1995, until the creation of the reserve in 1998.*"

Weak enforcement and low perceived risks further encouraged participation. Before the expansion of surveillance infrastructure and patrol coverage, many fishers viewed illegal shark fishing as a low-risk activity. "*Back then, the sanctions weren't the same. The penalties were ridiculous, treated like petty cash.*" Enforcement was sporadic, and bribes were commonplace. One interviewee stated, "*As a trader and boat owner, I was in charge of bribing whoever needed to be bribed,*" while another added, "*Ten percent* [*of the profits*] *went just to bribes.*" The devaluation of the Ecuadorian Sucre prior to dollarization in 2000 also diminished the deterrent effect of financial penalties (Fig. 3). Collectively, these drivers and motivations created a powerful incentive structure: high profits, low legal risk, few viable alternatives, and weak institutional enforcement.

3.2. Organization and operational modes of illegal shark fishing

Illegal shark fishing within the GMR followed a seasonal and strategic pattern. Most activities occurred during the warm season, when sea conditions were calmer and shark presence was more predictable. "*Shark fishing occurred during the warm season, which ran from November*

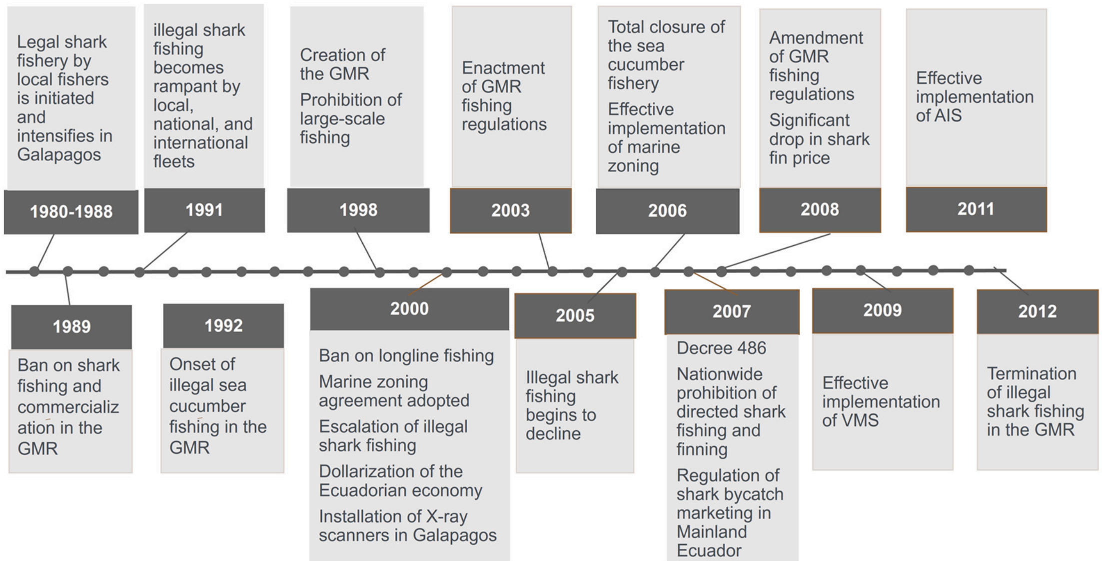

Fig. 3. Timeline of shark fishing regulations and conservation measures in the Galápagos Marine Reserve (GMR), 1980–2012. VMS: Vessel Monitoring System; AIS: Automatic Identification System.

to May," one fisher explained.

Fishing operations centered around remote seamounts, locally known as "bajos", especially around Darwin, Wolf, Pinta, Marchena, Genovesa, Santiago, and the southwestern coast of Isabela Island (Fig. 1). These sites were chosen for their high shark abundance and relative distance from patrolling authorities.

Poachers strategically avoided detection by minimizing overlap with other fishing vessels and timing their trips to coincide with moonless nights. "*We would go out when the moon was down, on dark nights*," explained one fisher. Another noted, "We *fished on dark nights so the sharks wouldn't see the nets*," highlighting the importance of lunar cycles in maximizing catch efficiency. The operations typically used 8 to 10 meter-long fiberglass vessels (fibras), organized in groups of 6 to 10 per island. "*There were 6 or 7 boats in Santa Cruz, also in Isabela, and about 10 boats in San Cristóbal*," reported a participant. Another estimated that "*roughly 80% of the fleet*" was involved in shark fishing at its peak.

Fishing trips lasted one to five days, with each vessel conducting 10 to 12 effective shark-fishing days per month, although one participant reported up to 16. Trammel nets measuring 300 m in length, 15 m in depth, and with an 8-inch mesh size were the primary gear used in illegal shark fishing. These nets were typically replaced each month due to wear and tear. As one fisher explained, "*A quintal of net cost about 600 dollars back then, and with shipping and setup, the gear cost you around 2,000 dollars. If the fishing was good, in one month the net had already paid for itself.*" Although some fishers used longlines, nets were generally preferred for their efficiency. "*The net was the most common gear used because it was quicker for capturing adult sharks*," noted one interviewee. Another added, "*Longlines catch one shark per hook, even if you deploy 150 hooks, it's not the same as a net… a net drags with the currents and sweeps up whatever it finds.*" Sea lions were also reportedly used as bait: "*Many fishers used sea lions as bait*," confirmed another participant.

Daily catches per vessel usually ranged from 40 to 150 sharks, according to most participants. "*I made three trips per month, with three effective days of fishing per trip. The lowest catch was 40 sharks; the most I ever caught was about 220*," said one participant. Most species were retained. Blacktip sharks (*Carcharhinus limbatus*) were the most common, while scalloped hammerhead (*Sphyrna lewini*) fins were the most valued. "*Those fins were heavier, thicker—they paid better.*" Fins sold for $20–$35 per set, with hammerhead fins fetching $70 per pound. Galapagos sharks (*C. galapagensis*) were also in demand, while blue sharks (*Prionace glauca*) were discarded. Fins needed to be at least 20 cm to have market value. With an average of 100 sharks per trip, gross income could reach $3000 per night, according to one interviewee.

Shark fin trafficking operated through a complex and coordinated system involving at-sea transshipment. In the early stages, fins were typically handed over to motherships originating from Manta, a major mainland port city in Ecuador, while still at sea. "*We'd go fishing in two to four small boats… We passed the fins to the boat from Manta, which was outside the reserve, although it also came in before there was so much surveillance.*" Bribes were routine: "*We had to pay $500 per bundle* [*of fins*] *just to get it on the ship.*" A bundle had 100 fin sets (four fins per shark), and fishers delivered around 10 bundles per trip. "*Each fisher earned about $1,500 per trip from shark fin trafficking.*"

Later, some fishers began renting motherships from Manta directly, aiming to bypass intermediaries and maximize profits. "*We brought the ship ourselves, and others paid us to take their fins… it was a business*," recalled one interviewee. These vessels charged $400 per bundle to transport shark fins to Manta or Guayaquil, generating an additional source of income. Some fishers opted to sell their catch directly to motherships from Manta. "*Four vessels each delivered about 40 sharks to the captain*," explained one participant. The motherships transported the fins outside the GMR, while retaining the shark bodies, which were sold in Manta for US$40 each. This at-sea transshipment strategy reduced detection risk by avoiding Galapagos ports, where surveillance by the Galapagos National Park Directorate (GNPD) and Ecuadorian Navy was strongest. Instead, fins were transferred offshore, beyond regular patrol zones. Fishers then traveled by air to the mainland to meet the mothership offshore to retrieve their fins, minimizing inspection and concealing the fins' origin, thereby evading detection and prosecution.

Air trafficking also emerged. Fins were smuggled out via Baltra and San Cristobal airports, with bribes ranging from $600 to $800 per quintal (roughly 100–120 sets of fins, equivalent to 100 kg). The bribe payment was made in cash to a specific contact, usually the intermediary, who was responsible for distributing the bribe among the corrupt public officials who were involved in the operation. According to one interviewee, "*We paid the park ranger so the fins could go through on the plane. Everyone shared the bribe: the police, the park ranger, the aviation guard—they were all involved.*" This operation depended on insider knowledge, coordination, and systemic corruption. As one fisher concluded, "*If you haven't done illegal fishing in Galapagos, you haven't been a fisher, we all went through that phase.*"

Table 2
Estimated annual number of sharks illegally caught by local fishers within the Galapagos Marine Reserve between 2000 and 2005. The first column presents calculations per individual vessel, followed by aggregated estimates per island and across the three main inhabited islands (Santa Cruz, San Cristóbal, and Isabela), based on the range of values reported by interviewees.

Parameter	Estimate per vessel	Estimate per island	Total (three islands)
Number of vessels	1	6–10	18–30
Effective fishing days per month	10–12	60–120	180–360
Sharks caught per effective fishing day per vessel	40–150	40–150	40–150
Sharks caught per month	400–1800	2400–18,000	7200–54,000
Number of sharks caught annually (November–May)	3500–13,500	21,000–135,000	63,000–405,000
Biomass of sharks caught annually (November–May)	178–686 tons	1067–6858 tons	3200–20,574 tons

3.3. Scale and profitability of illegal shark fishing within the GMR

The scale and profitability of illegal shark finning within the GMR between 2000 and 2005 was substantial. Based on the quantitative data gathered during interviews, it was assumed that between 18 and 30 vessels operated from Santa Cruz, San Cristóbal, and Isabela during the seven-month fishing season (November to May) (Table 2). Each vessel was estimated to fish between 10 and 12 days per month, with daily catches ranging from 40 to 150 sharks. Based on these assumptions, the total number of sharks illegally caught annually ranged from approximately 63,000 to 405,000 individuals (Table 2).

To estimate total biomass, an average weight of 50.8 kg per shark was applied (Table 1), excluding blue sharks, which, according to interviewees, were reportedly discarded due to their lack of commercial value. Based on these assumptions, the estimated annual biomass of sharks illegally landed within the GMR ranged from 3200 to 20,574 metric tons (Table 2).

Net income per vessel per effective fishing day ranged from US$450 to US$3750 (Table 3). Assuming 70 to 84 effective fishing days per year, annual net income per vessel ranged from US$31,500 to US$315,000 (Table 4). When scaled to a fleet of 18 to 30 vessels, the total annual net income from illegal shark finning was estimated at US$567,000 to US $9.45 million (Table 4).

3.4. Drivers, adaptive responses, and impacts of shark finning decline in the GMR

According to interviewees, illegal shark fishing in the GMR began to decline after 2005 (Fig. 3). This transformation was driven by a combination of institutional, regulatory, market, and socioeconomic shifts that gradually reduced the profitability and viability of shark finning while increasing the perceived risks associated with it.

Table 3
Estimated net income per effective fishing day per vessel engaged in illegal shark finning within the Galapagos Marine Reserve between 2000 and 2005.

Parameter	Value
Average price per set of fins	US$30
Sharks caught per effective fishing day	40–150
Number of fins per effective fishing day	160–600
Set of fins per effective fishing day (four fins per shark)	40–150
Gross income per effective fishing day	US$ 1200–4500
Average bribe per bundle of fins (100 sets of fins)	US$500
Average fuel and food cost per effective fishing day	US$ 250
Net income per effective fishing day	US$ 450–3750

Table 4
Estimated total annual income generated from illegal shark finning within the Galapagos Marine Reserve between 2000 and 2005.

Parameter	Value
Net income per effective fishing day	US$ 450–3750
Effective fishing days per vessel per month	10–12
Effective fishing days per vessel per year (seven months)	70–84
Annual net income per vessel	US$ 31,500–315,000
Number of vessels	18–30
Total annual net income	US$ 567,000–9,450,000

Technological advances and regulatory reforms played a deterrent role. The installation of X-ray scanners at the Baltra and San Cristóbal airports in the early 2000s improved the detection of concealed fins (Fig. 3). In 2007, the national maritime authority mandated the installation of Satellite Monitoring Devices (Dispositivo de Monitoreo Satelital, DMS) on all vessels operating within Ecuador's jurisdiction, including those navigating in the GMR, through Resolution DIGMER No. 054-07. Subsequently, between 2009 and 2011, the Galápagos National Park Directorate (GNPD) and the Ecuadorian Navy implemented satellite-based Vessel Monitoring Systems (VMS) and the Automatic Identification System (AIS) to further enhance maritime surveillance (Hockings et al., 2012) (Fig. 3). In parallel, the 2008 amendment of the GMR Fishing Regulations introduced stricter penalties for environmental crimes, including shark fishing (Fig. 3). However, the deterrent effect of these interventions remained limited due to weak governance. "*Sometimes authorities prefer to look the other way rather than impose sanctions. The government often turns a blind eye*," said one interviewee. "*The tools are available, and with minimal investment, much more could be done—but it takes genuine commitment from institutions and their officials for effective enforcement to finally happen. Otherwise, if you leave the bank open and I'm broke, I'll go in*."

A turning point came with the implementation of Decree 486 in 2007, which mandated that sharks landed as bycatch in mainland Ecuador be brought in whole (Fig. 3). This measure obstructed fin trafficking, as it required a match between fins and bodies at landing sites in mainland Ecuador. "*Shortly after 2005, the market price began to fall because national policies started to regulate shark fishing*," explained one fisher. "*You could no longer cut the fins and sell the bodies to the boat captain*." Another added, "*The captain from Manta could no longer land more fins than he had bodies, because you're not going to find a shark with two sets of fins or a body without them*." One interviewee also mentioned a speculative explanation for the price collapse, attributing it to a virus affecting shark fins exported to China: "*The price of fins dropped because an NGO introduced some kind of virus into the fins, which caused an epidemic. Then China stopped buying them*."

Nevertheless, most participants agreed that the sharp decline in black-market shark fin prices following the enactment of Decree 486 was the primary factor that discouraged finning in the GMR. "*Between 2008 and 2012, we saw the black-market price of shark fins drop to $10 per set. Meanwhile, outside Galapagos, people were selling the meat, which became more profitable than fins*," explained one respondent. Another noted, "*On the black market, when you ban something, the price goes up. When it's allowed, the price crashes*."

At the same time, tuna fishing gained momentum as a viable and more stable economic and legal alternative. This shift was driven by growing tourism demand and the expansion of export markets. "*Nowadays, a 20-pound tuna is more profitable than a four- or five-meter shark*," said one interviewee. Another added, "*Tuna, the 'red gold,' started gaining value, and we realized we could market a different species that gave us better returns. We no longer had to risk our boats or our families facing administrative sanctions*." A third summarized, "*If you catch a 10-pound tuna and sell it for $2 per pound, that's $20. Why kill a shark if it doesn't pay off?*"

In response to these institutional, regulatory, and socioeconomic shifts, fishers adopted diverse adaptive responses. Most transitioned into small-scale tuna fishery, often using banned longlines arguing that authorized fishing gears were ineffective for catching adult tuna of premium quality, raising new enforcement and bycatch concerns. Other abandoned fishing altogether, relocating to mainland Ecuador or pursuing alternative livelihoods within or adjacent to the marine sector. As one interviewee noted, "*Some fishers switched to experiential tourism fishing, others to dive fishing; some became park rangers, and others are now working for NGOs.*" A fraction turned to other illicit activities. Some engaged in illegal sea cucumber harvesting, while others participated in fuel trafficking, a dangerous yet lucrative venture involving clandestine fuel transfers to national or foreign vessels involved in drug trafficking.

Together, these regulatory, technological, regulatory and socioeconomic factors gradually dismantled the conditions that had enabled illegal shark fishing. Although the process took time, by 2012, shark finning had lost much of its economic attractiveness (Fig. 3). As one interviewee recalled, "*I left in 2005, but there were still people fishing sharks illegally in Galapagos until 2012.*" Another one stated, "*Maybe someone still buys shark fins, but nobody here does that activity anymore.*"

The cessation of illegal shark fishing within the GMR had mixed socio-ecological impacts. Economically, the profits rarely translated into long-term financial stability. While a few individuals invested in homes or small businesses, this was the exception. "*I saw my colleagues wasting their money, and it made me feel sorry*," one interviewee recalled. "*Some used it to pay off debts or on entertainment. Only a few made something out of it.*" Another added, "*This is the result of a culture of not knowing how to manage your money and resources… You never have enough money when you don't have a culture of saving.*"

Ecologically, the cessation of shark finning by local fishers reduced direct pressure on shark populations within the GMR. Most interviewees observed a noticeable rebound in shark numbers. One reflected, "*There's now an overabundance of sharks, we're seeing more blacktip, more hammerhead, more bull sharks. Even white sharks are closer to shore and in larger numbers across most areas.*" However, this perceived local recovery contrasts with global trends. From 2007 to 2024, 67 % of shark species assessed by the IUCN Red List have declined in status (Table 5). Iconic species like the scalloped hammerhead (*Sphyrna lewini*) and oceanic whitetip (*Carcharhinus longimanus*), remain endangered, only the Galapagos (*C. galapagensis*) and crocodile sharks (*Pseudocarcharias kamoharai*), have shown signs of recovery (Table 5). This overall trend suggests that regional and global pressures continue to hinder shark recovery, even as localized threats within the GMR have diminished.

Table 5
Conservation status of shark species landed in mainland Ecuador between 2007 and 2024, according to IUCN Red List Status. NE: Not Evaluated, DD: Data Deficient, LC: Least Concern, NT: Near Threatened, VU: Vulnerable, EN: Endangered, CR: Critically Endangered.

Common name	Scientific name	IUCN Red List Status		Trend
		2007	2024	
Scalloped hammerhead shark	*Sphyrna lewini*	EN	CR	Decreasing
Pelagic thresher	*Alopias pelagicus*	VU	EN	Decreasing
Bigeye thresher	*Alopias superciliosus*	VU	VU	Stable
Oceanic whitetip shark	*Carcharhinus longimanus*	VU	CR	Decreasing
Shortfin mako	*Isurus oxyrinchus*	VU	EN	Decreasing
Longfin mako	*Isurus paucus*	VU	EN	Decreasing
Galapagos shark	*Carcharhinus galapagensis*	NT	LC	Increasing
Blue shark	*Prionace glauca*	NT	NT	Stable
Silky shark	*Carcharhinus falciformis*	NT	VU	Decreasing
Blacktip shark	*Carcharhinus limbatus*	NT	VU	Decreasing
Bull shark	*Carcharhinus leucas*	NT	VU	Decreasing
Dusky shark	*Carcharhinus obscurus*	NT	EN	Decreasing
Tiger shark	*Galeocerdo cuvier*	NT	NT	Stable
Lemon shark	*Negaprion brevirostris*	NT	VU	Decreasing
Crocodile shark	*Pseudocarcharias kamoharai*	NT	LC	Increasing
Pacific angel shark	*Squatina californica*	NT	NT	Stable
Bonnethead shark	*Sphyrna tiburo*	NT	EN	Decreasing
Smooth hammerhead shark	*Sphyrna zygaena*	NT	VU	Decreasing
Smalltail shark	*Carcharhinus porosus*	DD	CR	Decreasing
Nurse shark	*Ginglymostoma cirratum*	DD	VU	Decreasing
Mexican hornshark	*Heterodontus mexicanus*	DD	LC	Stable
Sharptooth smoothhound	*Mustelus dorsalis*	DD	VU	Decreasing
Scoophead hammerhead shark	*Sphyrna media*	DD	CR	Decreasing
Brown smoothhound	*Mustelus henlei*	NE	LC	Unknown
Sicklefin smoothhound	*Mustelus lunulatus*	NE	LC	Unknown
Whitenose shark	*Nasolamia velox*	NE	EN	Decreasing
Pacific sharpnose shark	*Rhizoprionodon longurio*	NE	VU	Decreasing

Sources: Jacquet et al. (2008) and IUCN (IUCN, 2024).

4. Discussion

The findings of this study reveal the origin, nature and magnitude of illegal shark fishing within the GMR, whose evolution was influenced by a complex interplay of institutional, technological, regulatory, and socioeconomic factors. From the perspective of interviewees, the decline of this widespread wildlife crime was not the result of a single intervention, but rather the convergence of multiple changes that gradually dismantled the opportunity structures sustaining it. Notably, many of these changes were unintended outcomes of broader governance reforms and shifting market dynamics, rather than the product of a targeted, comprehensive strategy to eliminate shark finning in the GMR.

4.1. Illegal shark fishing from a Situational Crime Prevention perspective

From a SCP perspective, the decline of illegal shark fishing in the GMR can be understood as a shift in the conditions that once made shark finning a low-risk, high-reward activity in the GMR. SCP framework emphasizes altering the environment in which crimes tend to occur by increasing the effort required to offend, raising the risks of detection, reducing rewards, minimizing situational provocations, and removing excuses (Petrossian, 2019; Petrossian, 2015; Weekers et al., 2021). These dimensions are examined below in the context of the GMR, based on insights from former illegal fishers and the scientific information available about the institutional, regulatory, and market transformations that progressively disrupted the opportunity structures enabling this form of wildlife crime.

In the early years of shark finning in the GMR, the effort to engage in this activity was minimal. Sharks were abundant, especially in poorly surveilled areas like Darwin and Wolf (Salinas de León et al., 2016), enforcement capacity was weak, and penalties were either light or inconsistently applied (Castrejón et al., 2021). As a result, fishers could operate with relative impunity. Over time, however, several changes raised the perceived risks and reduced the attractiveness of illegal shark fishing. The installation of airport X-ray scanners, the implementation of satellite-based monitoring, and the expansion of patrol efforts made concealment more difficult. Regulatory amendments, such as the 2008 revision of GMR Fishing Regulations and the enactment of Decree 486 in 2007, increased legal clarity and introduced stricter sanctions, while the expansion of marine no-take zones restricted access to shark habitats (Castrejón and Charles, 2013; Heylings et al., 2002).

Despite institutional and technological advancements, enforcement gaps and systemic corruption continued to enable poachers to operate with relative impunity, as noted in several studies (Carr et al., 2013; Jacquet et al., 2008; Reyes and Murillo, 2007; Schiller et al., 2014). However, declining economic returns proved to be a decisive factor in reducing illegal shark fishing. After 2007, according to interviewees, black-market fin prices dropped sharply, diminishing the expected rewards. Simultaneously, the tourism boom and growing demand for tuna provided viable legal and economic alternatives (Castrejón and Defeo, 2024; Epler, 2007). Tuna became not only the most consumed seafood in the archipelago (Castrejón et al., 2024b), but also the economic backbone for many former illegal shark fishers, generating more than $1 million annually in gross income (Anastacio-Solis and Velasco-Plaza, 2023). Following the collapse of the sea cucumber fishery in 2006 and the decline of demersal species such as sailfin grouper (Ramírez-González et al., 2020; Usseglio et al., 2016), fishers increasingly adopted tuna fishing as their primary adaptive strategy, offering a more stable and lower-risk livelihood. The emergence of this legal and financially attractive opportunity gradually reduced situational provocations, such as income gaps due to seasonal closures, medical emergencies, and personal debt, that had previously increased vulnerability to illegal shark fishing. In this context, illegal activity became less necessary and less appealing.

Although not explicitly mentioned by interviewees, the gradual erosion of excuses for illegal shark fishing may have played a complementary role in its decline. Prior to the creation of the GMR in 1998, many fishers likely did not perceive shark finning as environmentally harmful. Weak enforcement and limited conservation awareness may have contributed to permissive social norms that tolerated this illegal practice. Following the creation of the GMR, several education and awareness campaigns, such as "The Year of the shark" and "Play fair with sharks", sponsored by NGOs, sought to inform local communities about the ecological importance of sharks and the need for their protection (WWF-USAID, 2006). Over time, these initiatives likely promoted a gradual shift in social attitudes toward greater support for shark conservation. However, the actual impact of these efforts has not been systematically evaluated, and their role in shaping behavioral change remains largely speculative. Further research is needed to assess whether, and to what extent, changes in values, awareness, and social norms influenced the observed decline in illegal shark fishing.

The decline of illegal shark fishing in the GMR did not eliminate all forms of non-compliance; rather, it marked a shift in how some fishers adapted their strategies and livelihoods in response to evolving regulatory, technological, and market conditions. While many transitioned into the growing small-scale tuna fishery, others redirected their efforts toward alternative illegal activities, such as fuel trafficking and the illegal harvest of brown sea cucumbers. Although these practices may pose a lower direct threat to shark populations, they highlight the continued presence of situational incentives to circumvent regulations. Ongoing challenges in the GMR, such as weak governance and enforcement capacity, economic precarity, and limited opportunities for livelihood diversification (Castrejón et al., 2024a, 2021; Castrejón and Defeo, 2024; Falcones, 2019; Ramírez-González et al., 2022), continue to influence fishers' behavior in a context of persistent uncertainty.

The challenges faced in the GMR to address IUU fishing are not unique. Similar patterns are observed in other multiple-use MPAs, such as the Great Barrier Reef in Australia and the Territorial Use Rights for Fishing (TURF) system in Chile, where illegal activity tends to cluster where perceived rewards outweigh risks and enforcement is weak or misaligned with local contexts (Vallejos et al., 2024; Weekers et al., 2021). Both cases explicitly applied the SCP framework to examine the opportunity structures that facilitate non-compliance. In Australia, SCP was used to analyze the conditions enabling illegal recreational fishing in no-take zones, leading to recommendations for enforcement strategies aimed at reducing opportunities for poaching (Weekers et al., 2021). In Chile, SCP helped identify how environmental, socio-economic, and institutional factors create poaching opportunities within TURFs, guiding the development of a comprehensive deterrence strategy (Vallejos et al., 2024). These examples illustrate how SCP can guide the identification of intervention points by suggesting strategies to reshape incentives, increase the perceived risk of detection, and reduce justifications for offending. Drawing on such experiences can help MPA managers, including those in the GMR, design context-sensitive approaches to curb IUU fishing and promote long-term ecological and socio-economic sustainability.

4.2. Scale, profitability, and ecological consequences of illegal shark fishing in the GMR

Estimating the scale and profitability of illegal shark fishing in the GMR is inherently difficult due to its covert nature and the lack of systematic monitoring during peak finning periods. Existing reconstructions of shark catches in Ecuador's Exclusive Economic Zones (EEZs) offer partial insights. For example, Jacquet et al. (2008) estimated that shark landings in the continental EEZ averaged 7000 tons per year between 1979 and 2004, roughly 500,000 sharks annually. However, these authors estimated that 44 % of Ecuadorian shark exports went unreported, likely originating from illegal sources, such as the GMR. Similarly, Schiller et al. (2014) estimated over 105,000 metric tons of sharks harvested from the insular EEZ between 1950 and 2010, although unreported catches by foreign and domestic fleets were likely excluded.

This study provides the first range-based estimates of illegal shark catches in the GMR based on direct accounts from former shark fishers. According to their testimonies, between 63,000 and 405,000 sharks were illegally caught each year, representing an estimated biomass of 3200 to 20,574 metric tons. These figures suggest far greater fishing intensity than previously acknowledged. Notably, the upper bound is nearly three times greater than Jacquet et al.'s (2008) estimate for Ecuador's entire EEZ. These estimates are plausible considering the operational simplicity of shark finning and the spatial concentration of fishing effort around productive areas like Darwin and Wolf Islands. For comparison, in neighboring Peru—where shark fishing is legal—the small-scale fishery, involving 202 full-time and 738 part-time vessels operating along a vast coastline, landed approximately 16,007 metric tons in 2018, with historical averages of 8352 metric tons and peaks exceeding 14,000 metric tons between 2006 and 2017 (Grillo-Núñez and Gozzer-Wuest, 2019).

In contrast, the GMR's estimated illegal shark catches highlight a disproportionately intense level of extraction occurring within a multiple-use MPA that hosts the highest known shark biomass in the world (Salinas de León et al., 2016). Although only small-scale fishing is legally permitted in the GMR, an undetermined number of both small-scale and potentially large-scale vessels, primarily from mainland Ecuador, also participated in this illegal activity (Bucaram et al., 2018; Carr et al., 2013; Reyes and Murillo, 2007). This comparison suggests that illegal shark fishing in the GMR was not a matter of small-scale opportunism, but rather a case of large-scale, systematic exploitation within one of the planet's most ecologically significant MPAs. It underscores the severity of past enforcement gaps and illustrates how even well-established MPAs can become hotspots of IUU fishing when governance is weak and incentives are misaligned.

The ecological impacts of sustained high-volume shark removals in the GMR remain difficult to quantify due to several important limitations. Long-term, species-specific monitoring data are scarce, and most available information relies on diver observations (Peñaherrera-Palma et al., 2018) or sporadic visual censuses (Salinas de León et al., 2016), which are limited in spatial and temporal scope. These methodological constraints hinder the establishment of robust ecological baselines and the ability to assess long-term population trends (Peñaherrera-Palma et al., 2018). Although some studies have documented declines, such as a 50 % reduction in hammerhead sharks and a 30 % decline in whitetip reef sharks (Peñaherrera-Palma et al., 2018), these findings are based on short-term data and do not provide comprehensive or continuous records across the archipelago.

External pressures further complicate the attribute of observed trends. Ongoing illegal fishing by foreign fleets operating just outside the boundaries of the GMR (Alava and Paladines, 2017; Bonaccorso et al., 2021; Hearn et al., 2021), combined with environmental variability driven by climate change (Cerutti-Pereyra et al., 2024), likely influence shark abundance and distribution independently of local management actions. Additionally, the ecological resilience of shark species varies considerably. Blacktip and Galapagos sharks, for example, appear to have stabilized or even recovered in certain areas (Peñaherrera-Palma et al., 2018), suggesting a capacity for localized recovery. In contrast, highly migratory and slow-reproducing species such as scalloped hammerheads remain vulnerable and continue to face significant regional and global threats (IUCN, 2024).

These complexities make it difficult to isolate and assess the long-term ecological consequences of the cessation of illegal shark fishing within the GMR. To improve understanding, enhanced ecological monitoring is needed, particularly through standardized methodologies, species-specific indicators, and longitudinal data collection. Such efforts are critical for distinguishing the relative influence of local conservation measures from broader oceanographic and geopolitical dynamics that affect shark populations across their migratory ranges.

To address transboundary threats, Ecuador established the 60,000 km^2 Reserva Hermandad in 2022, expanding protection into key migratory corridors and prohibiting longlining within this new MPA. However, the effectiveness of this initiative depends not only on national enforcement capacity but also on stronger regional cooperation and international governance. In particular, the consolidation of the Eastern Tropical Pacific Marine Corridor (CMAR, for its initials in Spanish) as a functional platform for coordinated surveillance, data sharing, and joint enforcement among Ecuador, Colombia, Costa Rica and Panama is critical (Enright et al., 2021). Equally important is the broader implementation of global frameworks such as the United Nations Agreement on the Conservation and Sustainable Use of Marine Biological Diversity of Areas Beyond National Jurisdiction (BBNJ Agreement), which can help close legal gaps to curb illegal activities beyond national waters (Tiller et al., 2019). Effective enforcement of CMAR and the BBNJ Agreement is essential to ensure that conservation gains made within the GMR are not undermined by IUU fishing in adjacent jurisdictions or the high seas.

4.3. Limitations and further research

This study provides rare insights into the drivers, organization, and scale of illegal shark fishing in the GMR, but it is not without limitations. These arise primarily from the retrospective and qualitative nature of the data and the inherent difficulties in quantifying historical illegal activity.

A key limitation stems from reliance on self-reported accounts by individuals involved in illegal shark fishing, sometimes recalling events from two decades prior. Memory bias, both unintentional and influenced by prevailing norms, may have led participants to misestimate quantities, misremember details, or frame narratives to minimize their own involvement. The sensitivity of the topic may also have prompted some to shift blame or omit incriminating information. To mitigate these risks, interviews were designed to be open-ended and non-judgmental, with an emphasis on confidentiality and historical reconstruction rather than attribution of guilt. Prompts were anchored to specific regulatory or ecological milestones (e.g., Decree 486) to help contextualize responses and reduce ambiguity. Still, memory degradation and social desirability bias cannot be fully eliminated.

Limitations also apply to the estimates of shark catches and profits. While ranges were used instead of average values to reflect variability across participants, important fluctuations in fishing effort, fin prices, and vessel involvement may still be underrepresented. These figures offer only contextual approximation, not precise metrics, and should be interpreted cautiously. Despite these limitations, triangulation with secondary sources, such as shark landing statistics and export records reported by Jacquet et al. (2008), helped validate the plausibility of interview findings. Still, quantitative results should be viewed as indicative, not definitive.

Moving forward, research on IUU fishing in the GMR would benefit from methodological approaches that integrate interviews with remote sensing (e.g., AIS/VMS), customs records, and port inspections. Comparative analyses across other multiple-use MPAs could further clarify the generalizability of findings, while long-term monitoring of fishers' responses to regulatory and market shifts remains essential for designing adaptive conservation strategies.

5. Conclusion

This study provides a retrospective account of the origin, evolution, and eventual decline of illegal shark fishing in the GMR. It reveals how a dynamic interplay of governance reforms, technological improvements, market fluctuations, and shifting livelihood opportunities progressively dismantled the enabling conditions for shark finning. Rather than resulting from a single targeted intervention, this decline emerged through the gradual transformation of the opportunity structures that had once sustained this pervasive wildlife crime.

During the early 2000s, high global demand for shark fins, weak enforcement, institutional corruption, and limited legal fishing opportunities created fertile ground for illegal shark fishing to flourish. Over time, however, the combined effects of enhanced surveillance technologies, stricter penalties, regulatory reforms such as Decree 486, and expanding market alternative, including a growing domestic demand for tuna, gradually increased the effort and risks of offending while reducing expected rewards.

From a SCP perspective, this transformation reflects a shift in the structural conditions that once made shark finning a low-risk, high-reward activity. As enforcement became more effective and fin markets collapsed, many fishers turned to legal and economically viable alternatives. The expansion of tourism and the decline of competing fisheries (e.g., sea cucumber and demersal finfish species) accelerated this transition, steering effort toward small-scale tuna fishing as a more stable and socially accepted livelihood.

However, the disappearance of illegal shark fishing did not eliminate all forms of non-compliance in the GMR. Some fishers redirected their activities toward other illicit practices, such as illegal longlining, brown sea cucumber and fuel trafficking, demonstrating that as long as enforcement capacity remains limited and economic insecurity persists, incentives to bypass regulations will endure. These adaptive responses revealed an important lesson for other multiple-use MPAs: curbing IUU fishing and other environmental crimes require more than punitive enforcement. It demands structural interventions that realign economic incentives, strengthen institutional capacity, and address community needs.

The GMR experience highlights that conservation success depends not only on increasing the costs of illegal activity but also on enabling legal, profitable, and socially acceptable alternatives. Transparent institutions, reliable enforcement, diversified livelihoods, and participatory governance are essential to ensure that conservation outcomes are sustained over time. Just as importantly, anticipating how systems of illegality might evolve in response to changing conditions is key to avoiding unintended consequences and policy backfire.

Ultimately, the decline of illegal shark fishing in the GMR shows that lasting conservation gains are not achieved by force, but by transforming the systems of opportunity, incentive, and governance that shape human behavior.

CRediT authorship contribution statement

Mauricio Castrejón: Writing – review & editing, Writing – original draft, Methodology, Investigation, Funding acquisition, Formal analysis, Conceptualization.

Declaration of Generative AI and AI-assisted technologies in the writing process

During the preparation of this work, the author used ChatGPT to improve the readability and language of the manuscript. After using this tool/service, the author reviewed and edited the content as needed, and he takes full responsibility for the content of the published article.

Funding sources

This work was supported by the Universidad de las Américas-Ecuador (Grant code: 519.B.XV.24).

Declaration of competing interest

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

Acknowledgments

I would like to express my deepest gratitude to those fishers from Galapagos who generously shared their experiences and knowledge, providing invaluable insights into the history and evolution of illegal shark fishing in the Galapagos Marine Reserve. Their contributions have been central to the success of this study. I also extend my sincere thanks to Universidad de las Américas-Ecuador for their financial support to conduct and publish this research (Grant code: 519.B.XV.24).

Data availability

The data that has been used is confidential.

References

Alava, J.J., Paladines, F., 2017. Illegal fishing on the Galápagos high seas. Science 357, 1362. https://doi.org/10.1126/science.aap7832.

Anastacio-Solis, J., Velasco-Plaza, M., 2023. Estudio de mercado de la pesquería responsable de atún de aleta amarilla (*Thunnus albacares*) de Galápagos para identificar mercados con preferencia por un producto pesquero de calidad, legal y sostenible que contribuyan a la mejora de ingresos de los pescadores artesanales de la RMG. In: Producto 2. Galápagos, WildAid, Puerto Ayora.

Ben-Yami, M., 2001. Managing Artisanal Fisheries of Galapagos. Charles Darwin Foundation, Galapagos, Ecuador.

Blank, S.G., Gavin, M.C., 2009. The randomized response technique as a tool for estimating non-compliance rates in fisheries: a case study of illegal red abalone (*Haliotis rufescens*) fishing in Northern California. Environ. Conserv. 36, 112–119. https://doi.org/10.1017/S037689290999004X.

Bonaccorso, E., Ordóñez-Garza, N., Pazmiño, D.A., Hearn, A., Páez-Rosas, D., Cruz, S., Muñoz-Pérez, J.P., Espinoza, E., Suárez, J., Muñoz-Rosado, L.D., Vizuete, A., Chaves, J.A., Torres, M. de L., Bustos, W., Rueda, D., Hirschfeld, M., Guayasamin, J. M., 2021. International fisheries threaten globally endangered sharks in the Eastern Tropical Pacific Ocean: the case of the Fu Yuan Yu Leng 999 reefer vessel seized within the Galápagos Marine Reserve. Sci. Rep. 11, 14959. https://doi.org/10.1038/s41598-021-94126-3.

Brantingham, P.L., Brantingham, P.J., 1993. Environment, routine and situation: toward a pattern theory of crime. Adv. Criminol. Theory 5, 259–294.

Bucaram, S.J., Hearn, A., Trujillo, A.M., Rentería, W., Bustamante, R.H., Morán, G., Reck, G., García, J., 2018. Assessing fishing effects inside and outside an MPA: the impact of the Galapagos Marine Reserve on the Industrial pelagic tuna fisheries during the first decade of operation. Mar. Policy 87, 212–225.

Burbano, D.V., Meredith, T.C., Mulrennan, M.E., 2020. Exclusionary decision-making processes in marine governance: the rezoning plan for the protected areas of the 'iconic' Galapagos Islands, Ecuador. Ocean Coast Manag 185, 105066. https://doi.org/10.1016/j.ocecoaman.2019.105066.

Calderwood, J., Pedreschi, D., Ó Cuaig, M., Reid, D.G., 2023. Reflecting on the importance of open communication and social capital for the co-creation of knowledge in Irish fisheries. Front. Mar. Sci. 9, 1081616. https://doi.org/10.3389/fmars.2022.1081616.

Carr, L.a., Stier, A.C., Fietz, K., Montero, I., Gallagher, A.J., Bruno, J.F., 2013. Illegal shark fishing in the Galápagos Marine Reserve. Mar. Policy 39, 317–321. https://doi.org/10.1016/j.marpol.2012.12.005.

Castrejón, M., 2020a. The Ecuadorian Tuna and Mahi-Mahi Fisheries: Characterization, Trends, and Management Strategies. Island Conservation and Pew Bertarelli Ocean Legacy Project, Puerto Ayora, Galapagos, Ecuador.

Castrejón, Mauricio, 2020b. La pesca ilegal, no declarada y no reglamentada (INDNR) en el Pacífico Este Tropical: caracterización, causas, soluciones y prioridades de inversión. World Wildlife Fund and Fundación PACÍFICO, Galápagos, Ecuador.

Castrejón, M., Charles, A., 2013. Improving fisheries co-management through ecosystem-based spatial management: the Galapagos Marine Reserve. Mar. Policy 38, 235–245. https://doi.org/10.1016/j.marpol.2012.05.040.

Castrejón, M., Defeo, O., 2023a. Perceptions and attitudes of residents toward small-scale longline tuna fishing in the Galapagos Marine Reserve: conservation and management implications. Front. Mar. Sci. 10, 1235926. https://doi.org/10.3389/fmars.2023.1235926.

Castrejón, M., Defeo, O., 2023b. Reconsidering the longline ban in the Galapagos Marine Reserve. Mar. Policy 151, 105589. https://doi.org/10.1016/j.marpol.2023.105589.

Castrejón, M., Defeo, O., 2024. Addressing illegal longlining and ghost fishing in the Galapagos Marine Reserve: an overview of challenges and potential solutions. Front. Mar. Sci. 11, 1400737. https://doi.org/10.3389/fmars.2024.1400737.

Castrejón, M., Astrálaga, J., Montoya, G., Villegas, T., 2021. Delitos contra la vida silvestre en Galápagos: caracterización, causas, y potenciales soluciones. World Wildlife Fund, Puerto Ayora, Galápagos.

Castrejón, M., Moity, N., Charles, A., 2024a. The bumpy road to conservation: challenges and opportunities in updating the Galapagos zoning system. Mar. Policy 163, 106146. https://doi.org/10.1016/j.marpol.2024.106146.

Castrejón, M., Pittman, J., Miño, C., Ramírez-González, J., Viteri, C., Moity, N., Andrade-Vera, S., Caceres, R., Tanner, M.K., Rodríguez, G., Barragán-Paladines, M.J., 2024b. The impact of the COVID-19 pandemic on the Galapagos Islands' seafood system from consumers' perspectives. Sci. Rep. 14, 1690. https://doi.org/10.1038/s41598-024-52247-5.

Castrejón, M., Pittman, J., Ramírez-González, J., Defeo, O., 2024c. An overview of social-ecological impacts of the El Niño-Southern Oscillation and climate change on Galapagos small-scale fisheries. Ocean Coast. Manag. 259, 107436. https://doi.org/10.1016/j.ocecoaman.2024.107436.

Cerutti-Pereyra, F., Drenkard, E.J., Espinoza, M., Finucci, B., Galván-Magaña, F., Hacohen-Domené, A., Hearn, A., Hoyos-Padilla, M.E., Ketchum, J.T., Mejía-Falla, P. A., Moya-Serrano, A.V., Navia, A.F., Pazmiño, D.A., Ramírez-Macías, D., Rummer, J. L., Salinas-de-León, P., Sosa-Nishizaki, O., Stock, C., Chin, A., 2024. Vulnerability of Eastern Tropical Pacific chondrichthyan fish to climate change. Glob. Chang. Biol. 30, e17373. https://doi.org/10.1111/gcb.17373.

Chapsos, I., Koning, J., Noortmann, M., 2019. Involving local fishing communities in policy making: addressing illegal fishing in Indonesia. Mar. Policy 109, 103708. https://doi.org/10.1016/j.marpol.2019.103708.

Clarke, R.V.G., 1980. "Situational" crime prevention: theory and practice. Br. J. Criminol. 20, 136–147. https://doi.org/10.1093/oxfordjournals.bjc.a047153.

Cohen, L., Felson, M., 1979. Social change and crime rate trends: a routine activity approach. Am. Sociol. Rev. 44, 588–608.

Cornish, D.B., Clarke, R.V. (Eds.), 1986. The Reasoning Criminal: Rational Choice Perspectives on Offending. Springer-Verlag, New York.

Donlan, C.J., Wilcox, C., Luque, G.M., Gelcich, S., 2020. Estimating illegal fishing from enforcement officers. Sci. Rep. 10, 12478. https://doi.org/10.1038/s41598-020-69311-5.

DPNG, 2014. Plan de manejo de las áreas protegidas de Galápagos para el buen vivir. Dirección del Parque Nacional Galápagos, Puerto Ayora, Ecuador..

DPNG, 2021. Boletín oficial de resultados del censo pesquero de Galápagos. Dirección del Parque Nacional Galápagos, Puerto Ayora, Galápagos.

DPNG, 2024. Informe anual 2023. Ingreso de visitantes a las áreas protegidas de Galápagos. Dirección del Parque Nacional Galápagos, Galápagos, Ecuador.

Dulvy, N.K., Fowler, S.L., Musick, J.A., Cavanagh, R.D., Kyne, P.M., Harrison, L.R., Carlson, J.K., Davidson, L.N., Fordham, S.V., Francis, M.P., Pollock, C.M., Simpfendorfer, C.A., Burgess, G.H., Carpenter, K.E., Compagno, L.J., Ebert, D.A., Gibson, C., Heupel, M.R., Livingstone, S.R., Sanciangco, J.C., Stevens, J.D., Valenti, S., White, W.T., 2014. Extinction risk and conservation of the world's sharks and rays. Elife 3. https://doi.org/10.7554/eLife.00590.

Dulvy, N.K., Pacoureau, N., Rigby, C.L., Pollom, R.A., Jabado, R.W., Ebert, D.A., Finucci, B., Pollock, C.M., Cheok, J., Derrick, D.H., Herman, K.B., Sherman, C.S., VanderWright, W.J., Lawson, J.M., Walls, R.H.L., Carlson, J.K., Charvet, P., Bineesh, K.K., Fernando, D., Ralph, G.M., Matsushiba, J.H., Hilton-Taylor, C., Fordham, S.V., Simpfendorfer, C.A., 2021. Overfishing drives over one-third of all sharks and rays toward a global extinction crisis. Curr. Biol. 31, 4773–4787 e8. https://doi.org/10.1016/j.cub.2021.08.062.

Ebel, S.A., Beitl, C.M., Runnebaum, J., Alden, R., Johnson, T.R., 2018. The power of participation: challenges and opportunities for facilitating trust in cooperative fisheries research in the Maine lobster fishery. Mar. Policy 90, 47–54. https://doi.org/10.1016/j.marpol.2018.01.007.

Enright, S.R., Meneses-Orellana, R., Keith, I., 2021. The Eastern Tropical Pacific Marine Corridor (CMAR): the emergence of a voluntary regional cooperation mechanism for the conservation and sustainable use of marine biodiversity within a fragmented regional ocean governance landscape. Front. Mar. Sci. 8, 674825. https://doi.org/10.3389/fmars.2021.674825.

Epler, B., 2007. Tourism, Economy, Population Growth, and Conservation in Galapagos. Charles Darwin Foundation, Galapagos.

Falcones, E., 2019. Diagnóstico y censo de la flota pesquera artesanal de Galápagos 2019. Dirección del Parque Nacional Galápagos, Galapagos.

FAO, 2023. Implementation of the International Plan of Action to Prevent, Deter and Eliminate Illegal, Unreported and Unregulated Fishing – 1. Methodologies and indicators for the estimation of the magnitude and impact of illegal, unreported and unregulated fishing: 1.3 A catalogue of examples. Rome. https://doi.org/10.4060/cc9054en.

FAO, 2023b. Implementation of the International Plan of Action to Prevent, Deter and Eliminate Illegal, Unreported and Unregulated Fishing – 1. Methodologies and indicators for the estimation of the magnitude and impact of illegal, unreported and unregulated fishing: 1.1 Principles and approaches. FAO Technical Guidelines for Responsible Fisheries, No. 9, Suppl. 1, Vol. 1., Rome. https://doi.org/10.4060/cc6434en.

Field, I.C., Meekan, M.G., Buckworth, R.C., Bradshaw, C.J.A., 2009. Chapter 4 susceptibility of sharks, rays and chimaeras to global extinction. In: Advances in Marine Biology. Academic Press, pp. 275–363. https://doi.org/10.1016/S0065-2881(09)56004-X.

Giovos, I., Arculeo, M., Doumpas, N., Katsada, D., Maximiadi, M., Mitsou, E., Paravas, V., Naasan Aga-Spyridopoulou, R., Stoilas, V.-O., Tiralongo, F., Tsamadias, I.E., Vecchioni, L., Moutopoulos, D.K., 2020. Assessing multiple sources of data to detect illegal fishing, trade and mislabelling of elasmobranchs in Greek markets. Mar. Policy 112, 103730. https://doi.org/10.1016/j.marpol.2019.103730.

González-Andrés, C., Sánchez-Lizaso, J.L., Cortés, J., Pennino, M.G., 2020. Illegal fishing in Isla del Coco National Park: spatial-temporal distribution and the economic trade-offs. Mar. Policy 119, 104023. https://doi.org/10.1016/j.marpol.2020.104023.

Grillo-Núñez, J., Gozzer-Wuest, R., 2019. La cadena de valor de la pesquería de tiburones en el Perú. OCEANA, Perú.

Hearn, A., Cárdenas, S., Allen, H., Castrejón, M., Cruz, S., Espinoza, E., Forryan, A., Gabela, M.V., Kelley, D., Naveira-Garabato, A., O'Leary, B., Pazmiño, D., Peñaherrera-Palma, C., Picho, J., Reck, G., Reyes, H., Smith, F., Tudhope, S., Vera, A., Vinueza, D., Wilson, M., Zurita, L., 2021. Propuesta de ordenamiento espacial de la Zona Económica Exclusiva Insular de Ecuador. Universidad San Francisco de Quito, Quito, Ecuador.

Heylings, P., Bravo, M., 2007. Evaluating governance: a process for understanding how co-management is functioning, and why, in the Galapagos Marine Reserve. Ocean Coast. Manag. 50, 174–208. https://doi.org/10.1016/j.ocecoaman.2006.09.003.

Heylings, P., Bensted-Smith, R., Altamirano, M., 2002. Zonificación e historia de la Reserva Marina de Galápagos. In: Danulat, E., Edgar, G.J. (Eds.), Reserva Marina de Galápagos, Línea Base de La Biodiversidad. Fundación Charles Darwin and Servicio Parque Nacional Galápagos, Quito, Ecuador, pp. 10–21.

Hockings, M., Valenzuela, S., Calvopiña, M., Chamorro, S., León, P., Bucaram, S., Villalta, M., 2012. Galapagos Marine Reserve Management Effectiveness Assessment. Dirección Parque Nacional Galápagos, World Wildlife Fund, Galapagos.

IUCN, 2024. The International Union for Conservation of Nature's Red List of Threatened Species [WWW Document]. International Union for Conservation of Nature.

Jacquet, J., Alava, J.J., Pramod, G., Henderson, S., Zeller, D., 2008. In hot soup: sharks captured in Ecuador's waters. Environ. Sci. 5, 269–283. https://doi.org/10.1080/15693430802466325.

Kaplan, I., McCay, B., 2004. Cooperative research, co-management and the social dimension of fisheries science and management. Mar. Policy 28, 257–258. https://doi.org/10.1016/j.marpol.2003.08.003.

López-Garro, A., Zanella, I., Martínez, F., Golfín-Duarte, G., Pérez-Montero, M., 2016. La pesca ilegal en el Parque Nacional Isla del Coco, Costa Rica. Rev. Biol. Trop. 64, S249–S261. https://doi.org/10.15517/rbt.v64i1.23412.

Luomba, J., Chuenpagdee, R., Song, A., 2016. A bottom-up understanding of illegal, unreported, and unregulated fishing in Lake Victoria. Sustainability 8, 1062. https://doi.org/10.3390/su8101062.

Macfadyen, G., Caillart, B., Agnew, D., 2016. Review of Studies Estimating Levels of IUU Fishing and the Methodologies Utilized. Poseidon Aquatic Resource Management Ltd., Lymington, England.

Pacoureau, N., Rigby, C.L., Kyne, P.M., Sherley, R.B., Winker, H., Carlson, J.K., Fordham, S.V., Barreto, R., Fernando, D., Francis, M.P., Jabado, R.W., Herman, K.B., Liu, K.-M., Marshall, A.D., Pollom, R.A., Romanov, E.V., Simpfendorfer, C.A., Yin, J. S., Kindsvater, H.K., Dulvy, N.K., 2021. Half a century of global decline in oceanic sharks and rays. Nature 589, 567–571. https://doi.org/10.1038/s41586-020-03173-9.

Pascoe, S., Okey, T.A., Griffiths, S., 2008. Economic and ecosystem impacts of illegal, unregulated and unreported (IUU) fishing in Northern Australia. Aust. J. Agric. Resour. Econ. 52, 433–452.

Peñaherrera-Palma, C., van Putten, I., Karpievitch, Y.V., Frusher, S., Llerena-Martillo, Y., Hearn, A.R., Semmens, J.M., 2018. Evaluating abundance trends of iconic species using local ecological knowledge. Biol. Conserv. 225, 197–207. https://doi.org/10.1016/j.biocon.2018.07.004.

Petrossian, G.A., 2015. Preventing illegal, unreported and unregulated (IUU) fishing: A situational approach. Biol. Conserv. 189, 39–48. https://doi.org/10.1016/j.biocon.2014.09.005.

Petrossian, G., 2019. The Last Fish Swimming: The Global Crime of Illegal Fishing. ABC-CLIO, LLC, Santa Barbara, California.

Ramírez-González, J., Moity, N., Andrade-Vera, S., Reyes, H., 2020. Overexploitation and more than a decade of failed management leads to no recovery of the Galápagos sea cucumber fishery. Front. Mar. Sci. 7, 554314. https://doi.org/10.3389/fmars.2020.554314.

Ramírez-González, J., Andrade-Vera, S., Moreno, J., Moity, N., Viteri, C., Viz, M., Rodríguez-Jacome, G., Obregón, P., 2022. Evaluación de las pesquerías de pequeña escala de Galápagos mediante indicadores de desempeño pesquero. Fundación Charles Darwin, Puerto Ayora, Galápagos.

Reyes, H., Murillo, J.C., 2007. Efforts to control illegal fishing activities in the Marine Reserve. In: Stimson, J., Cárdenas, S., Marín, A. (Eds.), Galapagos Report 2006–2007. Charles Darwin Foundation, Galapagos National Park and Galapagos National Institute, Quito, Ecuador, pp. 23–30.

Riskas, K.A., Tobin, R.C., Fuentes, M.M.P.B., Hamann, M., 2018. Evaluating the threat of IUU fishing to sea turtles in the Indian Ocean and Southeast Asia using expert elicitation. Biol. Conserv. 217, 232–239. https://doi.org/10.1016/j.biocon.2017.10.011.

Rodríguez-Jácome, G., Estes, O., Barragán-Paladines, M.J., Viteri, C., 2023. Contribución de las pesquerías artesanales a la seguridad alimentaria y nutrición de las islas Galápagos. Fundación Charles Darwin, Galápagos, Ecuador.

Salinas de León, P., Acuña-Marrero, D., Rastoin, E., Friedlander, A.M., Donovan, M.K., Sala, E., 2016. Largest global shark biomass found in the northern Galápagos Islands of Darwin and Wolf. PeerJ 4, e1911. https://doi.org/10.7717/peerj.1911.

Satizábal, P., Le Billon, P., Belhabib, D., Saavedra-Díaz, L.M., Figueroa, I., Noriega, G., Bennett, N.J., 2021. Ethical considerations for research on small-scale fisheries and blue crimes. Fish Fish. 22, 1160–1166. https://doi.org/10.1111/faf.12590.

Schiller, L., Alava, J.J., Grove, J., Reck, G., Pauly, D., 2014. The demise of Darwin's fishes: evidence of fishing down and illegal shark finning in the Galápagos Islands. Aquat. Conserv. 25, 431–446. https://doi.org/10.1002/aqc.2458.

Seminara, C.I., Barbosa-Filho, M.L.V., Hauser-Davis, R.A., Souza, G.B.G., Alvarenga, M., Profice, C.C., Siciliano, S., 2023. Artisanal fisher knowledge on the impacts of destructive and illegal practices on the Southern Coast of Bahia, Brazil. Mar. Policy 158, 105862. https://doi.org/10.1016/j.marpol.2023.105862.

Silver, J.J., Campbell, L.M., 2005. Fisher participation in research: dilemmas with the use of fisher knowledge. Ocean Coast. Manag. 48, 721–741. https://doi.org/10.1016/j.ocecoaman.2005.06.003.

Solomon, J., Jacobson, S.K., Wald, K.D., Gavin, M., 2007. Estimating illegal resource use at a Ugandan park with the randomized response technique. Hum. Dimens. Wildl. 12, 75–88. https://doi.org/10.1080/10871200701195365.

Tiller, R., De Santo, E., Mendenhall, E., Nyman, E., 2019. The once and future treaty: towards a new regime for biodiversity in areas beyond national jurisdiction. Mar. Policy 99, 239–242. https://doi.org/10.1016/j.marpol.2018.10.046.

Usseglio, P., Friedlander, A.M., Koike, H., Zimmerhackel, J., Schuhbauer, A., Eddy, T., Salinas-de-León, P., 2016. So long and thanks for all the fish: overexploitation of the regionally endemic Galapagos grouper Mycteroperca olfax (Jenyns, 1840). PLoS One 11, 1–20. https://doi.org/10.1371/journal.pone.0165167.

Vallejos, T., Nahuelhual, L., Gelcich, S., Oyanedel, R., 2024. Situational crime analysis of poaching within Territorial Use Rights Fisheries (TURFs). Front. Mar. Sci. 11, 1419800. https://doi.org/10.3389/fmars.2024.1419800.

Weekers, D., Petrossian, G., Thiault, L., 2021. Illegal fishing and compliance management in marine protected areas: a situational approach. Crime Sci. 10, 1–14. https://doi.org/10.1186/s40163-021-00145-w.

WWF-USAID, 2006. Pasos hacia la sustentabilidad de la Reserva Marina de Galápagos. Proyecto Conservación de la Reserva Marina de Galápagos. World Wildlife Fund and USAID, Galápagos, Ecuador.

Zimmerhackel, J.S., Schuhbauer, A.C., Usseglio, P., Heel, L.C., Salinas-de-León, P., 2015. Catch, bycatch and discards of the Galapagos Marine Reserve small-scale handline fishery. PeerJ 3, e995. https://doi.org/10.7717/peerj.995.