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IDENTIFICATION OF AVAILABLE SHARK FISHERY DATA SOURCES (METADATA)

Improving data collection for shark fisheries in the coastal states of the eastern Pacific Ocean: An update to the IATTC ABNJ-Tuna II project

An IATTC project in support of the FAO-GEF project "Sustainable management of tuna fisheries and biodiversity conservation in the areas beyond national jurisdiction"

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SUMMARY

The artisanal fishing fleets of the coastal states of the eastern Pacific Ocean (EPO) catch chondrichthyans either as target or bycatch. For many coastal communities, this is a traditional resource and low-cost source of protein-rich food. However, the lack of reliable statistics makes it difficult to accurately assess the stocks of different species of chondrichthyans in the region.

In view of this, the IATTC is responsible for implementing management strategies for species of chondrichthyans associated with tuna fisheries in the EPO, mainly sharks and rays. This is largely dependent on reliable data and an accurate understanding of these stocks. As part of these efforts, the second part of the FAO-GEF Common Oceans Program (ABNJ-Tuna II project) got underway in 2023, in which the IATTC received further support to improve the monitoring and assessment of shark and ray stocks in the EPO. This funding allows for the expansion of the work initially conducted in Central America (ABNJ-Tuna I) to other IATTC CPCs, including Ecuador, Mexico, and Peru. It will also support the development and implementation of a regional sampling program for these fisheries, providing the necessary data for stock assessments, including ecological, genetic, and conventional approaches.

As the activities planned for 2023 were being carried out, sources of information (metadata) were identified in Ecuador, Mexico, and Peru. With the aim of compiling as much online literature as possible relating to shark studies, various search engines were used, employing keywords in Spanish and English. Subsequently, the bibliographic references in each study were carefully reviewed and the selection of documents was expanded through author profiles on ResearchGate, Google Scholar, and others. In parallel to this research, meetings were held with government agencies, academic institutions, and civil society organizations to compile documents, databases, and information on relevant shark and ray landing sites in the region studied.

A total of 1,167 documents were compiled, including unpublished studies such as undergraduate and graduate theses (termed “gray literature”), scientific articles published in indexed journals, fisheries management documents, handbooks, and technical reports. A database was also created in Microsoft Access to organize documents according to different criteria, such as type of document, focus of research, taxonomic group, author, year of publication, and institutional affiliation, which included government agencies, academic institutions, research institutes, and non-governmental organizations (NGOs). Scientific articles made up the largest share of the compiled documents (47%), followed by theses (28%), technical reports (20%), fisheries management documents (4%), and handbooks (1%). It is important to note that the relative weights of these categories of documents may vary by country. In addition, a wide diversity of species of elasmobranchs was observed, although this varied considerably depending on the state or province assessed in the project. Ecuador recorded 149 species of elasmobranchs, while Mexico reported 156 species and Peru documented 140 species.

I. Introduction

Sharks[1] are captured in large part, either as target species or bycatch, by multi-species artisanal fisheries using different types of fishing gear in the coastal states of the eastern Pacific Ocean (EPO). Despite this, the fisheries lack reliable statistics, such as the catch, effort, and species composition data necessary for accurate stock assessments. This lack of information poses a significant challenge for stock assessment and sustainable management.

Under the Antigua Convention, the Inter-American Tropical Tuna Commission (IATTC) is responsible for implementing management measures for shark species associated with tuna fisheries in the EPO. However, the efficacy of these measures depends crucially on the availability of reliable data and an accurate understanding of shark stocks. The lack of reliable fisheries statistics for the artisanal fisheries of the coastal states of the EPO makes it difficult to accurately assess these stocks.

To address this issue, the IATTC staff has been conducting extensive research since 2014 to develop a robust sampling methodology aimed at improving data collection in the shark fisheries[2] of Central America. At SAC-14, two research papers were presented that summarize the results of recent work in this region. The first paper presents revised estimates for the catch of silky and hammerhead sharks by Central American artisanal fisheries (SAC-14 INF-L). The second paper is a staff proposal for a long-term shark sampling program for artisanal fisheries, which is available for consideration by IATTC Members (SAC-14 INF-P). This program is part of the "Shark Research Work Plan" in the new proposed IATTC Strategic Science Plan (2025-2029; SAC-14-01a).

Despite recent advances in shark data collection in Central America, there is a need for similar improvements in other coastal states in the EPO, where shark fisheries are well developed. As part of the second stage of the FAO-GEF Common Oceans Program (ABNJ-Tuna II project), the IATTC has received additional financial support to improve the monitoring and assessment of shark stocks in the EPO. This funding will allow for the expansion of the work initially conducted in Central America to other IATTC CPCs, including Ecuador, Mexico, and Peru.

The planned activities and early results of the project that started in 2023 will ultimately contribute to the development and implementation of a regional shark fishery sampling program in the EPO. This will generate data for various types of shark stock assessments at the IATTC, including 1) the Ecological Assessment of the Sustainable Impacts of Fisheries (EASI-Fish) approach (Griffiths *et al*. 2019; SAC-13-11; SAC-14-12), 2) Close-kin mark recapture (CKMR, SAC-12-14) stock assessments for data-limited shark species (for example, the silky shark *Carcharhinus falciformis* and scalloped hammerhead shark *Sphyrna lewini*), and 3) conventional stock assessments.

Initial results have included a comprehensive compilation of documents, including both unpublished work at the international level (termed "gray literature") and scientific articles published in indexed journals. In total, 1,167 documents were compiled and organized in a database using the Microsoft Access program. These documents have been classified according to different criteria, such as type of document, main focus of research, and possible subfocuses, in addition to the taxonomic group, target species, author, year of publication, and institutional affiliation, including governmental and private institutions and NGOs, among other relevant information.

[1] In this document, the term "sharks" is used to refer to all chondrichthyans (sharks, rays, and chimaeras).

[2] In the context of this proposal, "shark fishery" means any fishery that catches sharks, whether as target species or bycatch. It is acknowledged that these are multi-species fisheries that interact with various species or groups of large pelagic fish (for example, tunas, billfish, dorado). While the proposed program will focus mostly on sharks, it is expected to expand to include other species in order to fulfill various mandates under the Antigua Convention.

Presented below are the technical and scientific advances made from studies on chondrichthyans in the countries participating in the ABNJ-Tuna II project (Ecuador, Mexico, and Peru). Each country section was written by the local coordinator responsible for managing and undertaking the activities established in the project.

II. Shark fisheries

Ecuador

In most countries with production in coastal areas, the fisheries sector is an essential part of economic development (Choez and Vásquez 2020). In Ecuador, artisanal fishing is a key source of employment and livelihood (Banchón *et al.* 2020). Indeed, the State of World Fisheries and Aquaculture report found that in 2014 Ecuador was among the top 25 fish producers by marine capture (663,000 tons) (FAO 2016), while in 2020 the country was among the ten leading exporters of fishery products (FAO 2022).

According to the 2013 Ecuadorian artisanal fisheries census, which covers the five continental coastal provinces (Esmeraldas, Manabí, Santa Elena, Guayas, and El Oro), there are 45,793 fishing vessels (fiberglass and wooden) operating in Ecuador and providing employment for 57,158 fishers (VAP 2014). Information shared by the Undersecretariat of Fisheries Resources (SRP, for its acronym in Spanish) shows that in 2023 there were 7,859 vessels registered with a fishing permit (artisanal and industrial fleet). Additionally, it was estimated that in 2012 the domestic market for fish and seafood from artisanal fishing was worth approximately 200 million US dollars a year (Martínez *et al.* 2015).

Although traditionally catches of elasmobranchs were discarded in fishing operations, growing demand in the foreign market has raised their economic value and the retention rate (Camhi *et al.* 2008; Carr *et al.* 2013). In the case of Ecuador, targeting of sharks has been prohibited since 2007, and only shark bycatch may be sold (Executive Decree No. 486). In some cases, this leads to exports of shark meat, whereas the fins are exported in their entirety as they are not consumed locally. In 2008, total artisanal catch in Ecuador was estimated at 32,150.37 t, of which 67.4% were species of large pelagic fish, 20.2% were sharks, and 12.4% were species of demersal fish and rays. The ports with the highest incidence of these landings were Manta, Santa Rosa, Anconcito, Puerto Bolívar, Esmeraldas, Puerto López, and Muisne (Peralta 2009). According to data on volumes of shark landings reported by the SRP,[3] a total of 84,849.29 tons was recorded during the 2013-2022 period, a large share of which originated from fisheries targeting species of large pelagic fish.

IATTC records of landings by the longline fleet indicate that the SRP reported a total of 12,221.77 t of sharks landed in the 2019-2022 period. Shark exports amounted to a total of 3,784.75 t of shark meat (body with/without fins and fillets) and 641.26 t of fins. The main markets were Spain, Peru, Portugal, Colombia, and Hong Kong. Exports to Hong Kong were only recorded in 2020, according to data by the SRP.[4]

About 64 shark species have been recorded in the Ecuadorian Pacific (Calle-Morán and Béarez 2020). The most commonly caught are the pelagic thresher shark (*Alopias pelagicus*; 36%), blue shark (*Prionace glauca*; 24%), and silky shark (*Carcharhinus falciformis*; 15%). Catches also regularly include species like the smooth hammerhead (*Sphyrna zygaena*; 11%), the scalloped hammerhead shark (*Sphyrna lewini*; 5%), the bigeye thresher shark (*Alopias superciliosus*; 3%), and the shortfin mako shark (*Isurus oxyrinchus*; 1%); demersal species include the sicklefin smooth-hound shark (*Mustelus lunulatus*; 2%) and the Pacific angelshark (*Squatina californica*; 1%) (Martínez-Ortiz *et al.* 2007; Diaz and Elías 2019). In recent years, an increase in landings of blue

[3] The data come from the statistical databases of the SRP, Ref.: 0446-545, 2023, Solicitud a la Autoridad de Pesca [Request to Fisheries Authority].

[4] Letter No. MPCEIP-SRP-2022-0768-O.

shark has been observed, in contrast to the pelagic thresher shark, the relative abundance of which has fallen to 15.7%, according to reports by Briones-Mendoza *et al.* (2022).

Beginning in 2006, Ecuador implemented the National Shark Action Plan for the conservation, management and recovery of chondrichthyan populations (PAT-Ec) (Aguilar *et al.* 2005). Currently, the new PAT-Ec 2020-2024 is being implemented throughout the country and incorporates previous objectives and updated recommendations.

Mexico

In Mexico, elasmobranchs have been exploited since pre-Hispanic times, their meat being used primarily for human consumption (Applegate *et al.* 1993). Globally, Mexico is among the top ten shark-catching countries, and nationally, the shark fishery ranks 7th by volume and 11th by economic value. During the 2012-2021 period, Mexico reported average shark production of 36,455 t, with maximum production of 47,873 t in 2018 and a mean annual growth rate of 3.62% (DOF 2023a).

The states that reported the greatest volumes of shark landings (which includes rays) in 2021 were Baja California Sur (19%), Sinaloa (19%), Nayarit (13%), Tamaulipas (9%), and Chiapas (9%). These figures indicate that Mexico's Pacific coast accounts for most of the country's shark production, totaling 78%, compared to the Gulf of Mexico and Caribbean Sea, which together represent 22% (CONAPESCA 2021).

In the Mexican Pacific, commercial elasmobranch catch consists of 28 species of sharks and eight species of rays. The most common families of shark species, in descending order of frequency, are Carcharhinidae, Lamnidae, Alopidae, Sphyrnidae, and Triakidae. The most common families of ray species, in descending order of frequency, are Dasyatidae, Gymnuridae, Myliobatidae, and Rhinopteridae. It is important to note that the official classification of elasmobranchs (CONAPESCA) is basic, grouping all species as *tiburón* (> 1.5 m TL), *cazón* (< 1.5 m TL) or ray; this classification is applied all along the Mexican coast. However, for quantitative assessment purposes, in recent years this classification has been extended to include the blue shark, shortfin mako shark, and thresher shark (*Alopias vulpinus*) species (DOF 2007; DOF 2023a).

Peru

The chondrichthyan fishery in Peru is characterized by the fact it is essentially artisanal and makes full use of this resource. It constitutes an important socioeconomic activity for the country as it is considered a traditional source of low-cost sustenance and employment that brings in foreign currency through international trade of derived products. Thus, according to González-Pestana *et al.* (2016), Peru ranks among the top 12 exporters of shark fins to the Hong Kong market. Shark bycatch has been reported by the industrial trawling and purse-seine fleets (which target hake and tunas, respectively) (Roman-Verdesoto 2014; Grillo and Gozzer 2019).

In total, 68 species of sharks have been identified in fishing records, of which 12 are landed by the artisanal fle*et al*ong the coast (Romero Camarena 2019) and six account for approximately 94% of landings: the blue shark, shortfin mako shark, hammerhead shark, thresher shark, humpback smooth-hound shark (*Mustelus whitneyi*), and Pacific angelshark (González-Pestana *et al.* 2016). Meanwhile, among the 25 species of batoids caught off the coast of Peru (Zavalaga *et al.* 2021a), the most frequently landed taxonomic groups are *Myliobatis* spp. (i.e., the Chilean eagle ray *M. chilensis* and the Peruvian eagle ray *M. peruvianus*; 45%), *Mobula* spp. (primarily the spinetail devil ray *M. mobular*, and secondarily, the smoothtail devil ray *M. thurstoni*, Munk's devil ray *M. munkiana*, and Chilean devil ray *M. tarapacana*; 28%), the Pacific guitarfish (*Pseudobatos planiceps*; 6%), and the diamond stingray (*Hypanus dipterurus*; 6%) (González-Pestana *et al.* 2022).

Landings originate mainly from the artisanal fishing fleet (bycatch or target), from *bote* and *lancha* vessels, which are described below. In general, they use fishing gear like surface mainlines (*espinel*) and curtain nets, which vary in design and mode of operation depending on the season of the year and target. The fleet targeting these resources is distributed across various landing sites along the Peruvian coast and may have high navigational autonomy, with fishing trips that may exceed a week in duration (Guevara-Carrasco and Bertrand 2017).

At the time of landing, most shark catches have been gutted and their head and dorsal, pectoral, and caudal fins removed ("trunks") (Pérez-Huaripata *et al.* 2021). It should be noted that in some landing sites on the Peruvian coast, sharks may be landed whole and gutted (with or without the head). Depending on the species and landing site, batoids may be landed whole, without the tail or spine, gutted (with or without the head), in pieces, or split in half (headless and gutted). This depends on the size of the captured individual and proximity of the fishing area.

Notable conservation and management measures implemented in Peru to ensure the sustainable exploitation of chondrichthyans include i) minimum catch lengths for the blue shark, shortfin mako shark, sharks of the genus *Carcharhinus*, various species of smooth-hounds (*Triakis maculata, M. whitneyi*, and *M. mento*); ii) the National Action Plan for the Conservation and Management of Sharks, Rays, and Related Species in Peru (PAN Tiburón-Perú); iii) management measures for sharks; iv) establishing a fishing season and catch limits for the scalloped hammerhead shark; and v) prohibiting extraction of the giant devil ray (*Manta birostris*), whale shark (*Rhincodon typus*), and largetooth sawfish (*Pristis pristis*) in marine waters of Peruvian jurisdiction.

III. Classification of fishing fleets

Ecuador

Fishing activity in Ecuador includes industrial fishing and artisanal fishing and is regulated by the Undersecretariat of Fisheries Resources (SRP, for its acronym in Spanish), which has jurisdiction and the responsibility to implement the Organic Law for the Development of Aquaculture and Fisheries (LODAP)[5] and its Regulations,[6] by enforcing secondary regulations and procedures to regulate fishing activities. Pursuant to Article 152 of the Regulations of the LODAP, the industrial fishing fleet is divided into three categories by vessel size (NRT: net register tonnage): small scale, $\leq$ 100; medium scale, > 100 to $\leq$ 500; and large scale > 500. This group of vessels is made up of the tuna purse-seine fleet, coastal purse-seine fleet for small pelagic fish, multi-purpose fleet (hake – shallow-water shrimp), hake fleet, shrimp trawling fleet or titi shrimp fleet (*flota pomadera*), eel fleet, and longline fleet (Table 1; Figure 1).

Article 183 of the Regulations of the LODAP defines artisanal vessels as those below 18 meters in length (LOA), with or without a full deck and with no technologically enhanced or mechanized gear, and divides them into three classes: a) Class I (< 8 m LOA); b) Class II (< 12 m LOA and < 15 t of fish per trip); and c) Class III (< 18 m LOA and < 30 t of fish per trip). These vessels operate beyond 8 nautical miles from the baseline and may use mother vessels.

Support vessels are considered part of the fishing unit and must be registered and associated with the mother vessel. Article 153 of the Regulations also states that for all legal effects, all vessels operating as longline mother vessels, whether to support industrial or artisanal fishing, shall be subject to the same legal framework as industrial vessels.

[5] Published in Official Registry No. 187 dated April 21st, 2020.
[6] Published in Official Registry No. 19 dated March 11th, 2022.

The mother vessel system was developed in 1994 and involves mother vessels that tow smaller fiberglass boats to the fishing area and back to the port of landing. The catch is kept in ice chests and very few boats have a refrigeration system on board. The mother vessels are 20-30 m in length, with an autonomy of approximately 30-40 days. In general, these vessels are capable of towing up to six (6) fiberglass vessels, targeting fish species considered large pelagics, in what is commonly known as the "big" fishing season (tunas, billfish, and escolar, with bycatch of sharks). Fishing areas may reach the Galapagos Islands region, outside the marine protected area. During the "slim" dorado fishing season,[7] trip durations range from 15 to 25 days and as many as ten fiberglass vessels may be towed (Table 1; Figure 1).

Small artisanal vessels (GN/LL/PS/HAR/LP /LHP/OTR)

Small-scale mother artisanal (LL-1) and mother industrial (LL-2) vessels (longline)

Medium-scale industrial vessels (longline and tuna purse-seiner)

[7] Special longline for the capture of dorado (mahi-mahi).

Figure 1. Types of fishing vessels as classified by Ecuador. Source: Undersecretariat of Fisheries Resources (SRP), Vice-Ministry of Aquaculture and Fisheries (VAP), Ministry of Production, Foreign Trade, Investment, and Fisheries (MPCEIP), 2023. Gillnet (GN); longline (LL); purse-seine (PS); handline (LHP); pole-and-line (LP); harpoon (HAR); other (OTR).

Data provided by the SRP indicate a combined total of 7,859 vessels with valid fishing permits in the artisanal and industrial fleets. About 92% (7,250) are artisanal outboard fiberglass skiffs (*fibras*), while 8% (609) constitute the small, medium, and large-scale industrial fleet. It is important to note that most artisanal vessels use longline (LL) and gillnet (GN) fishing gear (Table 1).

Table 1. Number and classification of vessels in Ecuador, following the provisions of Article 152 of the Regulations of the LODAP, by category, fishing gear, target (T) or bycatch (ByC); length overall (LOA); net register tonnage (NRT); gillnet (GN); longline (LL); purse-seine (PS); handline (LHP); pole-and-line (LP); harpoon (HAR); other (OTR). Source: Registry of artisanal and industrial vessel permits, reported by the Undersecretariat of Fisheries Resources (SRP), 2023.

Category	Definition	Number	Gear	Date	T/ByC
Small artisanal	Fiberglass ≤ 14 m LOA	7,250	GN/LL/PS/HAR/LP /LHP/OTR	2023	ByC
Mother artisanal	Longline boat ≤ 18 m LOA	86	LL	2023	ByC
Small-scale industrial	Vessel NRT ≤ 100	397	134 LL/15 PS (tuna purse-seiners) /248 PS (small pelagic purse-seiners)	2023	ByC
Medium-scale industrial	Vessel NRT > 100 to ≤ 500	112	9 LL/95 PS (tuna purse-seiners) /8 PS (small pelagic purse-seiners)	2023	ByC
Large-scale industrial	Vessel NRT > 500	14	14 PS (tuna purse-seiners)	2023	ByC

The artisanal fishery is made up of smaller vessels that are able to make their fishing trips independently. These vessels are made of fiberglass or wood or are of mixed construction. They generally have no deck and near the

stern they have a hold that functions as a livewell, without insulation for storage of catch. However, during the dorado (*Coryphaena hippurus*) fishing season, the livewell near the stern is used for temporary storage and preservation of fish. In addition, near the bow there is a compartment to hold fishing gear and storage areas for the fishers' personal items. These vessels have a total length ranging from 4-14 m. Their displacement capacity depends on their engine power, which may be 45 hp, 75 hp or 110 hp, the most common being 75 hp. The most commonly used types of fishing gear, both for coastal and large pelagic fish and for shrimp and demersal species, include longline, gillnets, handline, and squid jigging[8] (for handline). Depending on the target catch, the gear may be deployed on the surface, in midwater or on the bottom.

Artisanal fishing operations tend to last from one to five days. The vessels lack refrigeration systems but ice blocks (also known as *marquetas*) are used to preserve the catch. They have neither the capacity nor safety conditions onboard for longer fishing trips. This is due to the lack of navigational autonomy, which includes provisions, fish preservation facilities, and safety equipment (Table 1; Figure 1).

The other fleet operating in Ecuadorian maritime territory is found in the Galapagos Islands region, where, according to the Galapagos National Park[9] (PNG), there are currently around 350 registered vessels, 60% of which are made of fiberglass. The other vessels generally have greater autonomy and are no more than 18 m in length. All these vessels fish for large pelagic species. Landings of shark bycatch are prohibited due to exclusive Galapagos regulations. The main ports of landing in the Galapagos Islands region are Baltra, Baquerizo Moreno, Ayora, and Villamil.

Mexico

Under the General Law of Sustainable Fisheries and Aquaculture (LGPAS) and Official Mexican Standard NOM-029-PESC-2006, sharks and rays in Mexico must be exploited using vessels classed as small (*menor*) or coastal (*ribereño*), offshore (*de mediana altura*), or oceangoing (*de altura*) (Figure 2; DOF 2023a; DOF 2007). "Small" vessels are (mostly) made of fiberglass, have an outboard motor and do not exceed 10.5 m in length. These vessels are permitted to use drifting longlines, bottom longlines known as *cimbras*,[10] or gillnets. Despite established permissible fishing gear types and characteristics, the fishing equipment used by small vessels varies widely in design, size, and construction materials (CONAPESCA 2004). Offshore vessels (*de mediana altura*) have a steel and fiberglass hull and are 10-27 m in length, with a stationary engine and one deck. Lastly, and although they are currently no longer in operation, shark-targeting oceangoing vessels (*de altura*) have a steel hull, are 27-44 m in length, and have one or more decks and one or more stationary engines. Both offshore and oceangoing vessels are permitted to use drifting longlines (Table 2).

Table 2. Classification of vessels authorized to catch sharks and rays in the Mexican Pacific, under NOM-029-PESC-2006; LOA: length overall; Number: number of authorized vessels; Gear: registered fishing gear, GN: gillnet, LL: drifting longline or bottom longline; Year: year for which information was verified; T: target/ByC: bycatch.

Category	Definition	Number	Gear	Year	T/ByC
Small (*Menor*)	Fiberglass hull, 10.5 m LOA; 115 hp outboard motor; autonomy of 3 days; carrying capacity of 3 t; operate approximately 18 km from shore.	2,188	GN/LL	2022	T/ByC

[8] Targeting jumbo squid, used primarily as bait.

[9] Galapagos National Park, personal communication, 6 December 2023.

[10] Longlines that use small hooks, both straight and circular, and are placed at the bottom and anchored to prevent displacement due to the effect of currents. They are commonly used to catch rays.

Offshore (*Mediana altura*)	Steel hull, 10-27 m LOA; inboard motor; autonomy > 20 days; mechanical cooling system; mechanized fishing gear; fishfinder system; operate approximately 27-37 km from shore.	132	Drifting LL	2022	T/ByC
Oceangoing (*Altura*)	Steel hull, > 27 m LOA; one or more stationary engines; mechanized fishing gear; refrigeration systems; fishfinder systems; autonomy > 20 days; operate approximately 92 km from shore.	6	Drifting LL	2021	T

Figure 2. Types of vessels used in catching sharks and rays in the Mexican Pacific; vessels classed by size, material, type of engine, and autonomy: A) small vessel (*menor*) (< 10.5 m LOA), made of fiberglass with an outboard motor; B) offshore vessel (*de mediana altura*) (< 27 m LOA), with a steel and fiberglass hull, one stationary engine, and one deck; C) oceangoing vessel (*de altura*) (> 27 m LOA), with a steel hull, two or more stationary engines, and two or more decks. Mexico, 2023.

Based on the type of vessel and coastline, the shark fisheries in the Mexican Pacific are managed and classed as artisanal fisheries in the Gulf of California, the Central Pacific, and the Gulf of Tehuantepec. There are also the offshore and oceangoing fisheries of the west coast of Baja California and the oceangoing fishery of the Pacific Ocean (DOF 2007). Unofficially, there have been cases where fishers in certain areas have made adaptations to small vessels to increase their capacity and autonomy. For example, one variation found in artisanal and offshore vessels used by the longline fleet of the port of Manzanillo, Colima, to target various species of pelagic sharks consists of vessels 9-14 m in length that have an autonomy of 7-10 days and use stationary engines (Cruz *et al.* 2011; Saldaña-Ruiz *et al.* 2017).

The authorized fishing effort for the exploitation of sharks comprises a national total of 2,317 permits for small vessels, 182 for offshore vessels, and 6 for oceangoing vessels. Based on information shared with this project, in the Mexican Pacific valid registrations currently exist for 2,188 small vessels and 132 offshore vessels (CONAPESCA 2023a).

In addition to targeted fishing effort, bycatch of sharks and rays is recorded in artisanal fishing of finfish and offshore fishing of swordfish (*Xyphias gladius*), and in tuna purse-seining (Román-Verdesoto 2014), tuna longlining, shrimp trawling, finfish trawling, and recreational fishing (CONAPESCA 2004).

Peru

Under the General Fisheries Law (LGP), fishing activity in Peru is divided into i) artisanal or small-scale fishing, and ii) large-scale fishing. However, Article 30 of the Regulations of the LGP (Supreme Decree No. 012-2001-PE) defines three categories of vessel type: artisanal, small-scale, and large-scale, as described in Table 3. Currently,

information is only available on the number of valid fishing permits to catch sharks and rays (149 permits). There is no official information available on the total number of vessels with chondrichthyans as target or bycatch species.

Table 3. Number and classification of vessels with valid fishing permits to catch sharks and rays in Peru, by category and gear. T/ByC: target/bycatch; WC: well capacity; LOA: length overall; LL: longline; PS: purse-seine; TX: trawl; AG: all fishing gear and equipment. As defined by the Regulations of the General Fisheries Law. Peru, 2023.

Category	Definition	Number	Gear	Date[11]	T/ByC
Artisanal	≤ 32.6 m^3 WC and ≤ 15 m LOA, predominantly manual labor.	52	PS/AG	2001	ByC
Small-scale	≤ 32.6 m^3 WC, with modern equipment and fishing systems, and fishing activity not considered artisanal.	89	LL/PS/TX /AG	2001	ByC
Large-scale	> 32.6 m^3 WC.	8	LL/PS/TX	2001	ByC

It is worth noting that Law 31749 was passed in May 2023, giving recognition to ancestral and artisanal traditional fishing and promoting its preservation within five nautical miles of Peru, which is unregulated. It divides commercial fishing into i) artisanal fishing, performed using predominantly manual labor to recover fishing gear or equipment, with or without small vessels; ii) small-scale fishing, performed with small vessels using mechanized fishing equipment and systems to recover fishing gear or equipment, and labor that is not predominantly manual; and iii) large-scale fishing, performed with larger fishing vessels.

Meanwhile, in its Atlas of Artisanal Fishing (Guevara-Carrasco and Bertrand 2017), the Peruvian Institute of the Sea (IMARPE) describes the main types of artisanal vessels[12] (Figure 3). This classification is used for scientific purposes (it is not regulated). With the aim of gaining up-to-date knowledge on artisanal fishing in Peru, IMARPE carries out structural surveys and found around 17,848 vessels in 2015, counting *zapato*, *chalana*, *bote*, and *lancha* vessels (Castillo *et al.* 2018). This number includes vessels that catch chondrichthyans and other species as target or bycatch (Table 4).

[11] Determined by the year in which the three categories were established (Supreme Decree No. 012-2001-PE)
[12] Included here are types of vessels that may catch chondrichthyans as target or bycatch species.

Figure 3. Classification of artisanal fishing vessels in Peru. The figure shows vessel types: A) *zapato*; B) *chalana*, from Castillo *et al.* (2018); C) *bote*; D) *lancha*, from Guevara-Carrasco and Bertrand (2017).

Table 4. Number and classification of artisanal fishing vessels in Peru, as classified by IMARPE, with or without shark or ray catch, by category and main gear. T/ByC: target/bycatch; WC: well capacity; GN: gillnet; HX: handline; LL: longline; PS: purse-seine; TX: trawl. Peru, 2023.

Category	Definition	Number[13]	Gear	Date[14]	T/ByC
Zapato	Wooden boats with no deck. They have a pronounced bow and square sloping stern, with no keel. WC between 0.2 and 1.0 t, most commonly 0.5 t. Essentially rowboats.	699	GN/HX	2017	ByC
Chalana	Wooden boats with no deck, small in size, up to 6 m in length, with WC of 0.2 to 2.0 t, but mostly between 0.5 and 1.0 t. The stern is square and the bow pointed. They are powered by a mid-engine or outboard motor; some are propelled by oar.	2,670	GN/HX	2017	ByC
Bote	Boats made primarily of wood but also fiberglass. They are variable in size and may have a full or partial deck, with WC between 1.0 and 8.0 t, most commonly in the range of 2.0 to 5.0 t. They are powered by a mid-engine or outboard motor, although in the Piura region some are propelled by sails or a combination of both.	8,852	GN/LL/ HX	2017	T/ByC
Lancha	Vessels mostly made of wood, or in smaller numbers, metal, fiberglass and ferrocement. They have a full or partial deck and a bridge deck. They are powered by a mid-engine or outboard motor, with WC between 5 and 32 t, most commonly in the range of 6 to 20 t. The engine varies in design and placement depending on the gear used.	5,627	PS/TX/ LL/HX	2017	T/ByC

IV. Management

Ecuador

The foundations for fisheries management in Ecuador are established by the LODAP and its Regulations, which takes an ecosystem approach consistent with the United Nations Convention on the Law of the Sea (UNCLOS), a leading international agreement to which the country acceded in 2012. Ecuador has also implemented international management measures for elasmobranchs, as adopted by the IATTC (Antigua Convention in 2004).

Similarly, Ecuador has complied with other agreements and measures enacted by international or regional organizations and instruments, such as the Permanent Commission for the South Pacific (CPPS), since 1967; the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES), which it joined in 1975; the Convention on the Conservation of Migratory Species of Wild Animals (CMS), since 2004; and the Southern Pacific Regional Fisheries Management Organization (SPRFMO), which it joined in 2015 (Figure 4).

[13] Third Structural Survey of the Artisanal Fishery on the Peruvian Coast (Castillo *et al.* 2018). This is the number of artisanal fishing vessels that catch chondrichthyans and other species as target or bycatch.

[14] Determined by the year in which the categories were published (Guevara-Carrasco and Bertrand 2017).

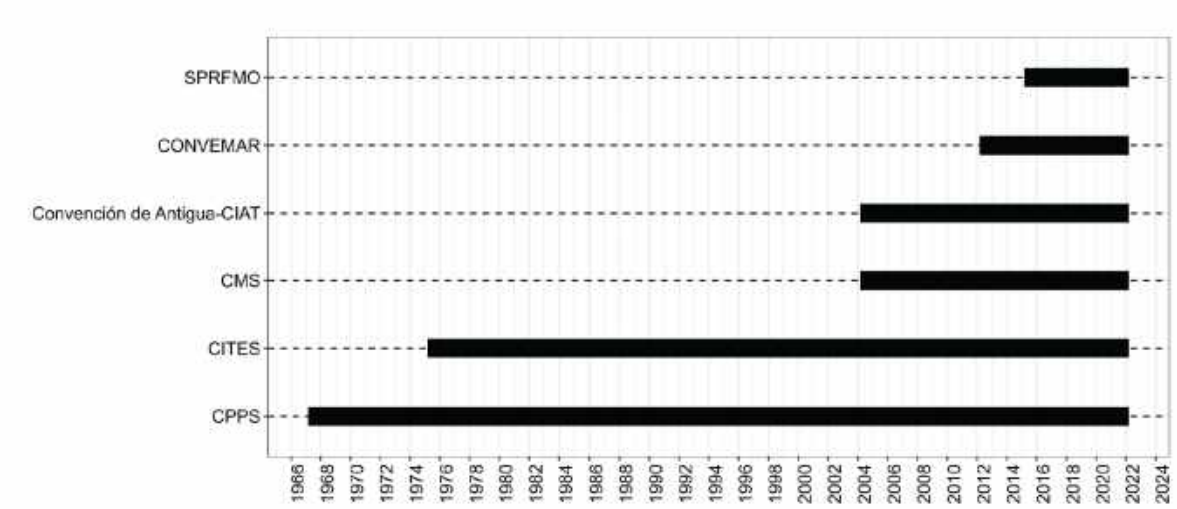

Figure 4. International standards for shark fishery management, Ecuador, 1967-2022. CPPS: Permanent Commission for the South Pacific; CITES: Convention on International Trade in Endangered Species of Wild Fauna and Flora; CMS: Convention on the Conservation of Migratory Species of Wild Animals; SPRFMO: Southern Pacific Regional Fisheries Management Organization.

The national regulatory framework for shark management began in 2006 with the creation of the National Action Plan for the Conservation and Management of Sharks in Ecuador (PAT-Ec). An evaluation was then conducted for PAT-Ec 2013-2018, which highlighted advances in data collection, the creation of an analysis team, and a traceability system. Regulations were also issued for the appropriate use of shark and ray resources, in addition to recommendations for stock assessment and research into key habitats.

In 2007, by way of Executive Decree No. 486 and its subsequent reform in Executive Decree No. 902 of 2008, the conservation and management of sharks was established as a policy of the Ecuadorian state, through the implementation of PAT-Ec and other instruments issued by the SRP to that end. Thus, a ban on targeted shark fishing was introduced throughout the country, along with a ban on fishing gear and systems used specifically to catch sharks, prohibiting species like the whale shark, basking shark (*Cetorhinus maximus*), great white shark (*Carcharodon carcharias*), and sawfish (*Pristis* spp.), while also issuing regulations prohibiting finning and regulating the sale of shark bycatch.

Additionally, the fisheries authority has signed ministerial resolutions to prohibit the capture, possession, storage, transportation, sale or export of the following shark species in any form: the oceanic whitetip shark (*Carcharhinus longimanus*), silky shark,[15] scoophead shark (*Sphyrna media*), great hammerhead (*Sphyrna mokarran*), smooth hammerhead, and scalloped hammerhead shark. Also covered are species of rays and manta rays: the giant devil ray, devil rays (*M. thurstoni*, *M. mobular*, and *M. tarapacana*), Munk's devil ray, Pacific eagle ray (*Aetobatus laticeps*), and longnose eagle ray (*Myliobatis longirostris*). Measures have also been put in place for landings, including having fins attached to the body of sharks; the percentage of silky shark catch permitted; bycatch authorization fees; and a ban on the use of steel wire known as "*huaya*" on the end of branchlines (Figure 5).

In 2020, PAT-Ec was updated for a period of five years, from 2020 to 2024, with the aim of achieving responsible management through compliance with applicable regulations, such as the prohibition of finning and the use of

[15] Prohibited for tuna purse-seiners, regulated for artisanal and industrial longline mother vessels.

steel wire in longline branchlines and the implementation of a traceability system for sharks. Also included is the collection of biological information, together with efficacy tests for bycatch reduction devices (Rosero and Rosero 2020) (Figure 5).

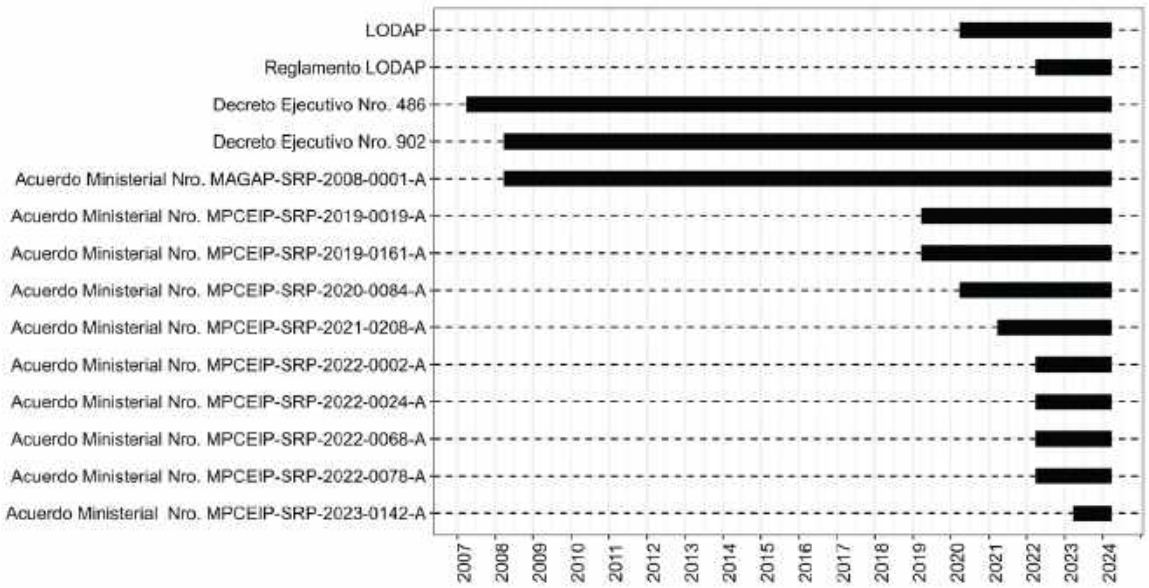

Figure 5. National standards for shark management, SRP, Ecuador, 2007-2023. LODAP: Organic Law for the Development of Aquaculture and Fisheries; MAGAP: Ministry of Agriculture, Livestock, Aquaculture, and Fisheries; MPCEIP: Ministry of Production, Foreign Trade, Investment, and Fisheries.

Mexico

In Mexico, there are a number of management instruments aimed, directly or indirectly, at sharks and rays. These include official standards, general laws, and management programs (Table 5; Figure 6). The most frequently used is the National Fisheries Charter (CNP), developed and updated by the Mexican Research Institute for Sustainable Fisheries and Aquaculture (IMIPAS) in collaboration with other federal, state, and academic institutions, which was first approved and published in 2000 (DOF 2000). Compliance with the charter, which sets forth the conservation and regulation strategies that must be observed in extracting and exploiting fisheries resources, is mandatory. The charter also includes a comprehensive assessment of each Mexican fishery, presented graphically and summarized. It also presents the indicators employed by the fisheries authority in implementing fisheries control measures and deciding applications for fishing permits and concessions (DOF 2007).

The CNP was last updated in 2023 and the data sheet on Pacific sharks lists shark species targeted by fisheries and associated species of rays and bony fish. Also presented is a time series from 1976-2018 showing trends in the capture of sharks (classed as *tiburón* or *cazón*) and rays landed in the Mexican Pacific, along with information on the effects of climate change and environmental abnormalities recorded in the capture of sharks and rays in the region, the status of the shark fishery in Mexico, and stock assessments of the blue shark, shortfin mako shark, and thresher shark (ISC 2021; DOF 2023a).

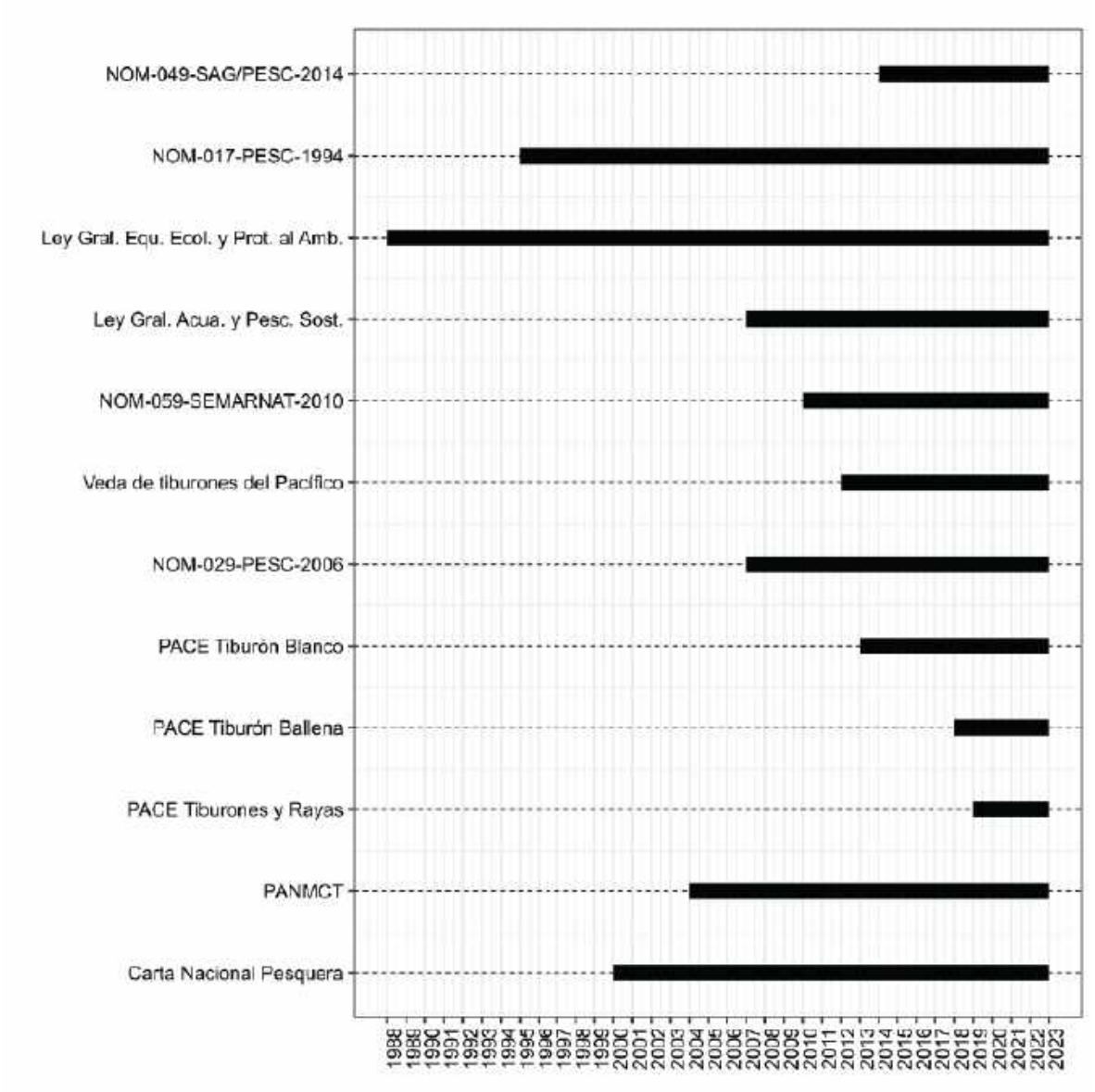

Figure 6. Main national shark and ray management instruments in Mexico; the chart shows the period during which each management instrument has been in force ('x' axis) and lists the main management instruments ('y' axis). NOM: Official Mexican Standard; SAG/PESC: Secretariat of Agriculture, Livestock and Fisheries; Ley Gral. Equ. Ecol. y Prot. al Amb.: General Law of Ecological Balance and Environmental Protection; Ley Gral. Acua. y Pesc. Sost.: General Law of Sustainable Fisheries and Aquaculture; PACE: Species Conservation Action Program; PANMCT= National Action Plan for the Management and Conservation of Sharks, Rays, and Related Species in Mexico.

Table 5. Conservation instruments for shark and ray species in the Mexican Pacific by government and international institutions.[16] Mexico, 2023.

Conservation instrument	Institution	Description	Effective
National Fisheries Charter (CNP)	IMIPAS	Assessment of fisheries; mandatory compliance in the implementation of fisheries control and authorization of permits	2000-2023
PANMCT	CONAPESCA/ IMIPAS	Permanent strategies for the management and sustainable exploitation of sharks and rays	2004-2023
PACE Sharks and rays	CONANP	Acknowledgment of the importance of species within protected natural areas	2019-2023
PACE Whale shark	CONANP	Species conservation strategies	2018-2023
PACE Great white shark	CONANP	Species conservation strategies	2013-2023
NOM-029-PESC-2006	SAGARPA	Promotes responsible shark and ray fishing	2007-2023
Shark fishery closure in the Pacific	CONAPESCA	Establishes closed seasons for sharks and rays in the Mexican Pacific	2012-2023
NOM-059-SEMARNAT-2010	SEMARNAT	Lists and classifies species of flora and fauna based on conservation status	2010-2023
LGPAS	CONAPESCA	Regulates sport and recreational fishing activities, limiting the capture of vulnerable species	2007-2023
LGEEPA	SEMARNAT	Regulates sport and recreational fishing activities, limiting the capture of vulnerable species	1988-2023
NOM-017-PESC-1994	SEMARNAT	Regulates sport and recreational fishing activities, limiting the capture of vulnerable species	1995-2023
NOM-049-SAG/PESC-2014	SAGARPA	Establishes fishing refuge zones	2014-2023
IATTC recommendations	IATTC	Recommendations and management from scientific research	2003-2023
ISC recommendations	ISC	Management recommendations from scientific research	1995-2023
CITES agreements	CITES	International agreements on trade in flora and fauna that does not threaten species	1991-2023

[16] PANMCT: National Action Plan for the Management and Conservation of Sharks, Rays, and Related Species in Mexico; PACE: Species Conservation Action Program; NOM: Official Mexican Standard; IMIPAS: Mexican Research Institute for Sustainable Fisheries and Aquaculture; CONAPESCA: National Commission for Aquaculture and Fisheries; SAGARPA: Secretariat of Agriculture, Livestock, Rural Development, Fisheries, and Food (now SADER); SEMARNAT: Secretariat of the Environment and Natural Resources; LGPAS: General Law of Sustainable Fisheries and Aquaculture; LGEEPA: General Law of Ecological Balance and Environmental Protection; IATTC: Inter-American Tropical Tuna Commission; ISC: International Science Council; CITES: Convention on International Trade in Endangered Species of Wild Fauna and Flora.

One important management instrument is the National Action Plan for the Management and Conservation of Sharks, Rays, and Related Species in Mexico (PANMCT), created in 2004 by IMIPAS and CONAPESCA through the General Directorate of Fisheries and Aquaculture Management. The PANMCT is a set of permanent strategies and programs aimed at the management and sustainable exploitation of this group of fish species within Mexican territorial seas (CONAPESCA-INP 2004). In parallel, the National Commission of Protected Natural Areas (CONANP) published a Species Conservation Action Program (PACE) for sharks and rays that inhabit Mexico's protected natural areas (SEMARNAT 2018). The primary purpose of this program is to acknowledge the importance of different species of sharks and rays within the marine ecosystems of protected natural areas and generate directives for their management and conservation. In addition, specific PACEs exist for the whale shark and great white shark, which provide a strategic conservation plan for these species in the short, medium, and long term (SEMARNAT 2020a; SEMARNAT 2020b).

Another management instrument currently in effect is standard NOM-029-PESC-2006, which is grounded in a series of studies conducted by IMIPAS that reported that many species of chondrichthyans were being improperly exploited, with immature individuals accounting for over 50% of production. Consequently, this standard promotes the responsible fishing of sharks and rays, establishing fishing specifications such as permitted fishing gear and tools based on vessel size, and areas where harvesting this group of fish is prohibited or limited, based on the characteristics of the area (DOF 2007).

In addition, this standard prohibits the capture of the following species of chondrichthyans: the whale shark, basking shark, great white shark, sawfish (*Pristiphorus shroederi*, *Pristis pectinata*, *P. perotteti*, and *P. microdon*), and various species of rays (the giant devil ray, spinetail devil ray *Mobula japonica*, devil fish *M. mobular*, Munk's devil ray, Atlantic pygmy devil ray *M. hypostoma*, and Chilean devil ray).

One regulation that has been highly impactful for the sustainable exploitation of sharks and rays, and which originates from NOM-029-PESC-2006, is the resolution establishing closed seasons for sharks and rays in the Pacific Ocean and sharks in the Gulf of Mexico, published in the Official Gazette of the Federation (DOF) in 2012 (DOF 2012). This resolution arose out of biological research and assessments by IMIPAS reporting a sustained decline of various species of sharks and rays. The resolution established a closure for all species of chondrichthyans in the Pacific Ocean, effective upon publication, from May 1st to July 31st, and from May 1st to August 31st for the coastal area of the Gulf of Mexico (DOF 2012). The main objective of the closure is to ensure the reproduction and development of the various species of sharks and rays subject to fishing pressure.

Another regulatory standard is NOM-059-SEMARNAT-2010, the main objective of which is to identify important components of biodiversity for conservation or sustainable exploitation. For animal species, the following classification was employed: endangered (P), threatened (A), subject to special protection (Pr), and probably extinct in the wild (E). Following these criteria, the great white shark, basking shark, and sawfish *P. pristis* and *P. pectinata* are listed in this standard as threatened non-endemic species (DOF 2010). Other regulatory instruments and official standards contribute indirectly to chondrichthyan conservation, such as the General Law of Sustainable Fisheries and Aquaculture (LGPAS); the General Law of Ecological Balance and Environmental Protection (LGEEPA) (DOF 2023b, DOF 2023d); NOM-017-PESC-1994, which regulates sport and recreational fishing activities and limits the capture of vulnerable species (including chondrichthyans); and NOM-049-SAG/PESC-2014, which orders the establishment of fishing refuge zones in Mexican waters under federal jurisdiction (DOF 1995; DOF 2014).

Mexico is also guided by various international organizations working towards the sustainable exploitation of resources and species conservation (Figure 7). One such framework is that of the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES), which Mexico joined in 1991. The country observes

CITES resolutions. Mexico's management authority is the Secretariat of the Environment and Natural Resources (SEMARNAT), its scientific authority the National Commission for the Knowledge and Use of Biodiversity (CONABIO), and its enforcement authority the Federal Environmental Protection Agency (PROFEPA). Mexico reports exports of CITES-listed species annually to the Convention. According to the CITES trade database, over the 2014-2022 period, Mexico reported the exportation of sharks (12 species) and subproducts (fins, skin, cartilage, etc.) to eight (8) countries (United States, China, Hong Kong, Chile, United Kingdom, Australia, Denmark, Guatemala), averaging 435 t per year. Reported exports of species of rays (4 species) are minimal, at an average of 157 kg over the same period. These records indicated that all individuals were obtained from the wild and exported for personal, scientific, and commercial purposes.

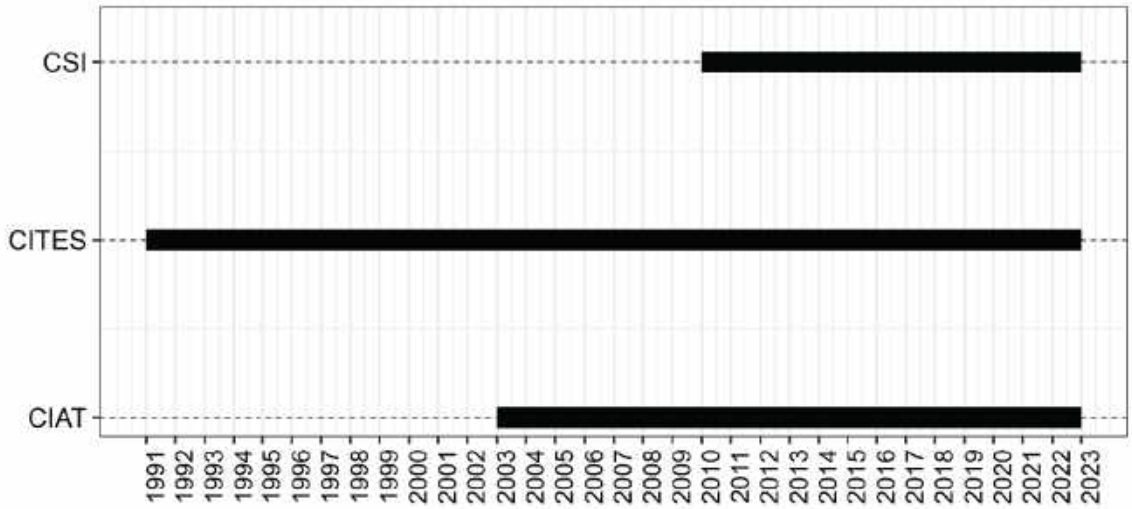

Figure 7. International institutions with which Mexico observes agreements and collaborates with the necessary information and data for the sustainable exploitation and conservation of fisheries resources, including sharks; the chart shows the length of collaboration ('x' axis) and international institutions ('y' axis). ISC: International Science Council; CITES: Convention on International Trade in Endangered Species of Wild Fauna and Flora; IATTC (CIAT): Inter-American Tropical Tuna Commission.

In Mexico, sawfish are listed in CITES Appendix I, while Appendix II includes the common thresher shark, bigeye thresher shark, pelagic thresher shark, great white shark, oceanic whitetip shark, silky shark, sharks in the Carcharhinidae family (*C. acronotus, C. albimarginatus, C. brachyurus, C. brevipinna, C. cerdale, C. galapagensis, C. isodon, C. leucas, C. limbatus, C. obscurus, C. perezii, C. plumbeus, C. porosus, C. signatus, Rhizoprionodon longurio, R. terranovae, R. porosus, Galeocerdo cuvier, Nasolamia velox, Negaprion brevirostris*, *Prionace glauca*, *Isurus oxyrinchus*, and *Isurus paucus*), whale shark, basking shark, species of hammerhead shark (*S. lewini*, *S. corona*, *S. gilberti*, *S. media*, *S. mokarran*, *S. tiburo*, *S. vespertina*, and *S. zygaena*), and ray species: the giant devil ray, Atlantic pygmy devil ray (*M. hypostoma*), Munk's devil ray, Chilean devil ray, the devil ray species *M. thurstoni* and *M. mobular*, and the various species of guitarfish (*Pseudobatos buthi, P. glaucostigma*, *P. lentiginosus*, *P. leucorhynchus*, *P. percellens*, *P. planiceps*, *P. prahli*, and *P. productus*).

Another guiding institution is the Inter-American Tropical Tuna Commission (IATTC), which is devoted to fisheries management and the conservation of tunas and associated species in the eastern Pacific Ocean, and of which Mexico has been a member since 2003. Over the 2001-2023 period, the IATTC issued numerous resolutions, ten of which aimed at the conservation of different shark species. Following these recommendations, Mexico has adopted various conservation strategies, implemented in the fishing activities of larger purse-seine vessels

targeting tuna species (DOF 2023a). These measures provide general protection to all shark and ray species caught as bycatch (C-01-04; C-23-07) and direct protection to the oceanic whitetip shark (C-11-10), silky shark (C-16-05; C-16-06; C-19-05; C-21-06; C-23-08), whale shark (C-19-06), hammerhead shark (C-16-05), scalloped hammerhead shark (C-16-05), and great hammerhead shark (C-16-05), and to the Mobulidae family (C-15-04), including the various species of manta rays (Table 6).

Lastly, the International Science Council (ISC), an intergovernmental body devoted to fisheries science, focuses its research on tuna and related species in the northern Pacific Ocean. Mexico is currently a member of the ISC and has participated in the Shark Working Group since its creation in 2010. A number of population studies have since been conducted, mainly for the blue shark and shortfin mako shark, for which all member countries contribute biological and fishing effort data (Table 24). Importantly, the Mexican researchers participating in the ISC are specialists on sharks in Mexico and as such belong to IMIPAS, and sometimes academia by official invitation. The results of the ISC studies are taken into account by the Mexican government through the National Fisheries Charter (CNP) (DOF 2023a) and other regulatory instruments like sustainable export volumes (VES, for its acronym in Spanish), used by CITES authorities to make non-detriment findings (NDFs) necessary to issue export permits. Other shark species reviewed by the ISC in its monitoring and research efforts are the bigeye thresher shark, pelagic thresher shark, oceanic whitetip shark, silky shark, the different species of hammerhead shark, longfin mako shark (*Isurus paucus*), salmon shark (*Lamna ditropis*), and crocodile shark (*Pseudocarcharias kamoharai*).

Table 6. Inter-American Tropical Tuna Commission (IATTC) resolutions relating to the conservation of different shark species, issued over the 2001-2023 period.

Year	Code	Resolution	Protected species
2001	C-01-04	Resolution on bycatch	Species of sharks caught as bycatch
2011	C-11-10	Resolution on the conservation of oceanic whitetip sharks in association with fisheries in the Antigua Convention Area	*Carcharhinus longimanus*
2015	C-15-04	Resolution on the conservation of Mobulid rays caught in association with fisheries in the IATTC Convention Area	Mobulidae, *Manta birostris*, *Mobula thurstoni*, and *M. munkiana*
2016	C-16-05	Resolution on the management of shark species	*Carcharhinus falciformis, Sphyrna lewini*, *S. zygaena*, and *S. mokarran*
2016	C-16-06	Conservation measures for shark species, with special emphasis on the silky shark (*Carcharhinus falciformis*), for the years 2017, 2018, and 2019	*Carcharhinus falciformis*
2019	C-19-06	Conservation of whale sharks	*Rhincodon typus*
2019	C-19-05	Conservation measures for shark species, with special emphasis on the silky shark (*Carcharhinus falciformis*), for the years 2020 and 2021	*Carcharhinus falciformis*
2021	C-21-06	Conservation measures for shark species, with special emphasis on the silky shark (*Carcharhinus falciformis*), for the years 2022 and 2023	*Carcharhinus falciformis*

2023	C-23-07	Conservation measures for the protection and sustainable management of sharks	Species of sharks caught as bycatch
2023	C-23-08	Conservation measures for shark species, with special emphasis on the silky shark (*Carcharhinus falciformis*), for the years 2024 and 2025	*Carcharhinus falciformis*

Peru

The first regulation concerning the conservation and management of chondrichythans was enshrined into Peruvian national law (Figure 8) in 2001,[17] setting a minimum catch size and maximum tolerance of juveniles for six shark species (blue shark and shortfin mako shark; various species of the genus *Carcharhinus*; and smooth-hound sharks *T. maculata*, *M. whitneyi*, and *M. mento*). This regulation also establishes a mesh size (200 to 330 mm) for the harvesting of sharks and rays along the Peruvian coast with curtain nets (gillnets). In the same year,[18] the Regulation for the Management of Fishing of the Patagonian Toothfish and Related Species was approved, which includes species like the chimaeras of the genus *Hydrolagus* spp., skates of the genus *Bathyraja* spp., and the Pacific sleeper shark (*Somniosus pacificus*).

[17] Ministerial Resolution No. 209-2001-PE
[18] Ministerial Resolution No. 236-2001-PE

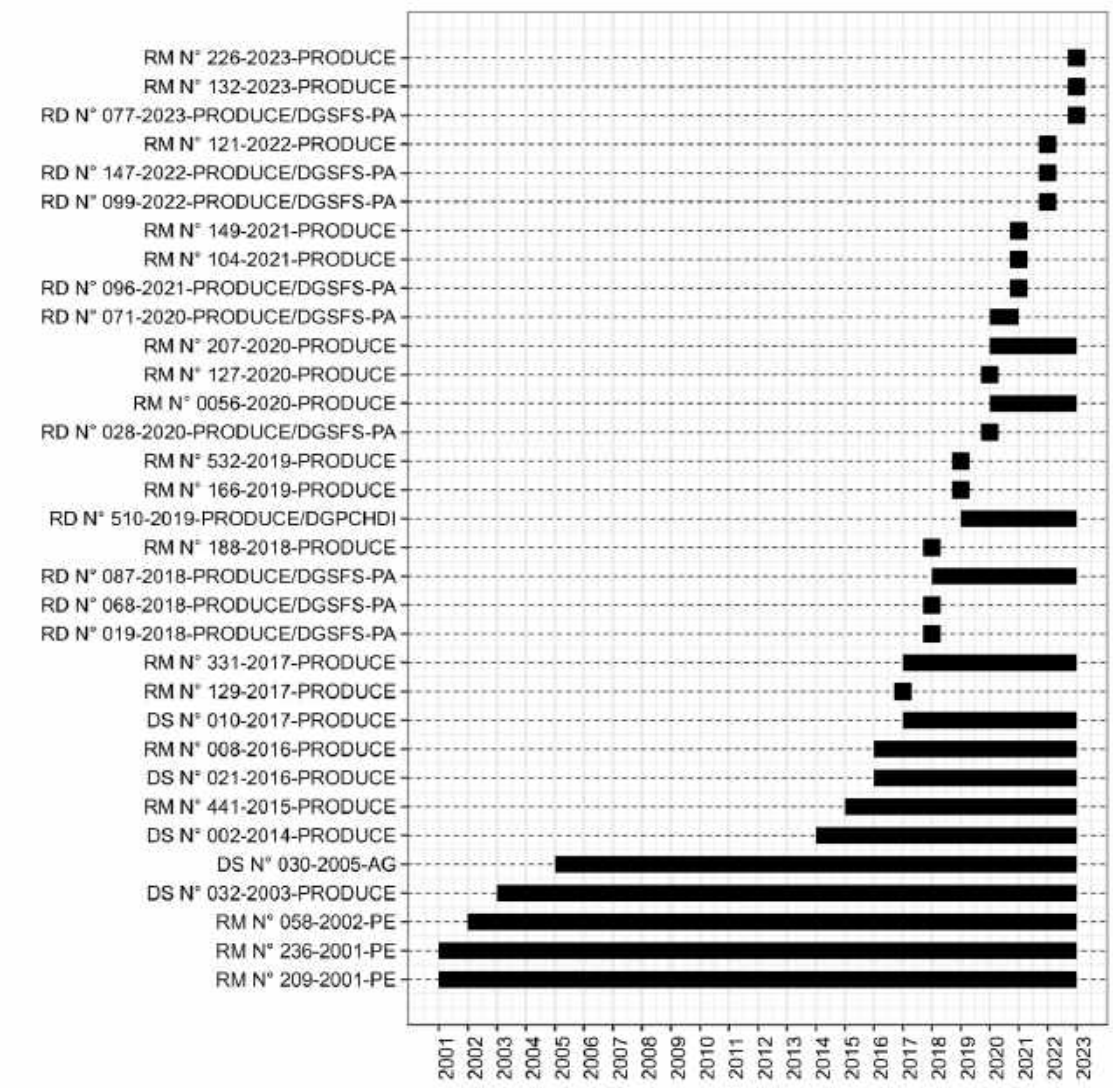

Figure 8. Timeline of national regulations concerning chondrichthyan fishing, 2001-2023, Ministry of Production (PRODUCE), Peru.

In 2002,[19] a list was established of highly migratory and intermittent marine biological resources in Peruvian maritime territory, including 10 species of shark (silky shark, Galapagos shark *C. galapagensis*, blacktip shark *C. limbatus*, oceanic whitetip shark, blue shark, shortfin mako shark, smooth hammerhead shark, Galapagos bullhead shark *Heterodontus quoyi*, thresher shark, and tope shark *Galeorhinus galeus*). In 2003,[20] the Regulation for the Management of Fishing of Tunas and Related Species was approved, which included the ten shark species listed above. In 2005,[21] the CITES Convention was implemented in Peru to strengthen management and conservation actions for the species of wild fauna and flora included in the appendices to the Convention.

[19] Ministerial Resolution No. 058-2002-PE
[20] Supreme Decree No. 032-2003-PRODUCE
[21] Supreme Decree No. 030-2005-AG

In 2014,[22] the National Action Plan for the Conservation and Management of Sharks, Rays, and Related Species in Peru (PAN TIBURÓN – PERÚ) was established, along with management measures for the shark fishery in 2016[23] and an amendment in 2017.[24] This management measure requires the landing of sharks with all their fins totally or partially naturally attached to the body, thus prohibiting the landing or transshipment of loose fins and/or finless trunks of any species of shark along the Peruvian coast; it prohibits "animal harpoons" (*arpón animalero*) and mandates that the landing and unloading of sharks take place only at landing sites authorized by PRODUCE. It should be noted that the list of authorized shark landing sites is regularly updated[25] and shark landing forms were established in 2018[26] and updated in 2020.[27]

Peru established a fishing season and catch limit for the smooth hammerhead shark in 2016.[28] This is updated every year[29] and the fishery is closed when the assigned catch limit is reached.[30] The country has also banned the harvesting, landing, transportation, retention, transformation, and sale of the giant devil ray since 2015,[31] the whale shark since 2017,[32] and the sawfish species *P. pristis* since 2020[33] in marine waters under Peruvian jurisdiction. Importantly, in 2019[34] PRODUCE established guidelines to process applications relating to the issuance of export, import or re-export permits or certificates for marine biological species listed in the appendices to the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) and in 2020,[35] it established conservation measures to be applied in the tuna fishery in compliance with Inter-American Tropical Tuna Commission (IATTC) resolutions.

Peru also observes agreements and measures adopted by international or regional organizations and instruments, such as the Permanent Commission for the South Pacific (CPPS), of which it has been part since 1952; the Inter-American Tropical Tuna Commission (IATTC), of which it has been a full member since 2003; the Southern Pacific Regional Fisheries Management Organization (SPRFMO), of which it has been a full member since 2016; and the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES), since 1974 (Figure 9).

[22] Supreme Decree No. 002-2014-PRODUCE
[23] Supreme Decree No. 021-2016-PRODUCE
[24] Supreme Decree No. 010-2017-PRODUCE
[25] Directorial Resolution No. 019-2018-PRODUCE/DGSFS-PA; Directorial Resolution No. 068-2018-PRODUCE/DGSFS-PA; Directorial Resolution No. 071-2020-PRODUCE/DGSFS-PA; Directorial Resolution No. 096-2021-PRODUCE/DGSFS-PA; Directorial Resolution No. 099-2022-PRODUCE/DGSFS-PA; Directorial Resolution No. 147-2022-PRODUCE/DGSFS-PA; Directorial Resolution No. 077-2023-PRODUCE/DGSFS-PA
[26] Directorial Resolution No. 087-2018-PRODUCE/DGSFS-PA
[27] Directorial Resolution No. 028-2020-PRODUCE/DGSFS-PA
[28] Ministerial Resolution No. 008-2016-PRODUCE
[29] Ministerial Resolution No. 129-2017-PRODUCE; Ministerial Resolution No. 188-2018-PRODUCE; Ministerial Resolution No. 166-2019-PRODUCE; Ministerial Resolution No. 127-2020-PRODUCE; Ministerial Resolution No. 104-2021-PRODUCE; Ministerial Resolution No. 121-2022-PRODUCE; Ministerial Resolution No. 132-2023-PRODUCE
[30] Ministerial Resolution No. 532-2019-PRODUCE; Ministerial Resolution No. 149-2021-PRODUCE; Ministerial Resolution No. 226-2023-PRODUCE
[31] Ministerial Resolution No. 441-2015-PRODUCE
[32] Ministerial Resolution No. 331-2017-PRODUCE
[33] Ministerial Resolution No. 0056-2020-PRODUCE
[34] Directorial Resolution No. 510-2019-PRODUCE/DGPCHDI
[35] Ministerial Resolution No. 207-2020-PRODUCE

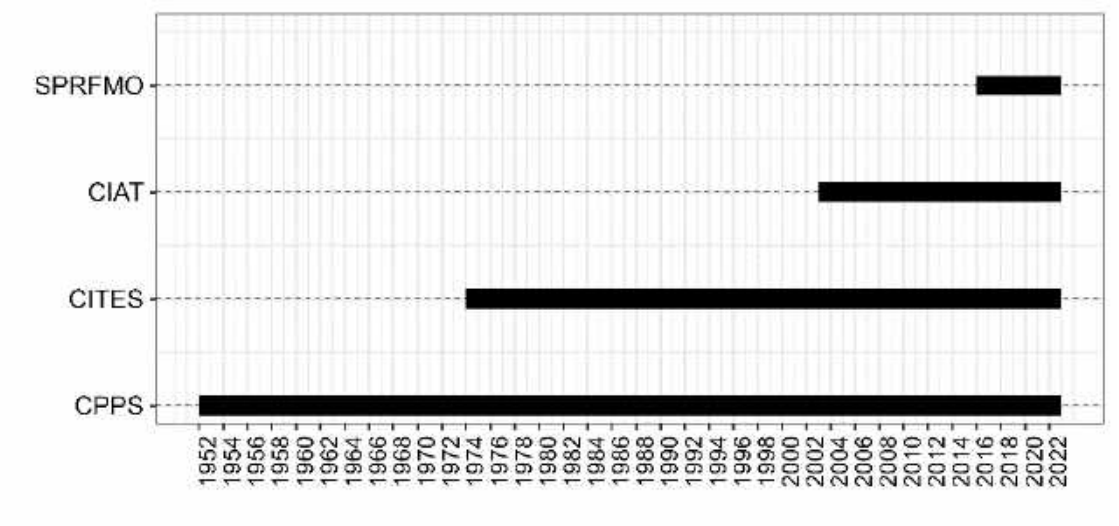

Figure 9. Timeline (1952-2022) of agreements with international or regional organizations and instruments for the management and conservation of chondrichthyans, Peru. SPRFMO: Southern Pacific Regional Fisheries Management Organization; IATTC (CIAT): Inter-American Tropical Tuna Commission; CITES: Convention on International Trade in Endangered Species of Wild Fauna and Flora; CPPS: Permanent Commission for the South Pacific.

V. Identification and description of data sources – Metadata

Methodology

In 2023, sources of information (metadata) were identified in Ecuador, Mexico, and Peru. To achieve this, in-person and virtual meetings were held with various entities that generate biological and fisheries information, including government institutions, research institutes, universities (state and private), foundations, and non-governmental organizations (NGOs). The purpose of these meetings was to present the project and provide information about the project's background, objectives, and planned activities. This built trust and facilitated the sharing of information that may or may not have been available online, including but not limited to monitoring programs, institutional document formats, forms, research, reports, identification manuals, and biological resource handling/release guides. In addition, the first capacity building workshop was conducted for local coordinators, with the aim of standardizing work methodologies and developing detailed planning for the various tasks and activities to be undertaken in the first year of the project (Appendix I).

Official documents were obtained from the relevant fisheries, research, and environmental authorities, academia, and NGOs through formal processes (by letter) and document management systems or transparency websites ("Quipux" in Ecuador and "Datos Abiertos" in Peru). It should be stressed that, during this phase, trips were made to the head offices of fisheries and scientific authorities in the region, such as the Undersecretariat of Fisheries Resources (SRP), the Mexican Research Institute for Sustainable Fisheries and Aquaculture (IMIPAS), and the Peruvian Institute of the Sea (IMARPE), in order to visit the main landing sites for chondrichthyans in each jurisdiction. The aim was to evaluate logistical support and understand the landing dynamics at key sites identified by the scientific authorities. Appendix II includes a summary of the meetings held with various public institutions, NGOs, foundations, and universities, and the reports that resulted from the visits to fisheries inspection offices.

Various databases and search engines were used to locate chondrichthyan research material, such as Google, Google Scholar, ResearchGate, SciElo, and Connected Papers, together with digital repositories hosted by

relevant institutions (SRP, IPIAP, CONAPESCA, IMIPAS, IMARPE, ALICIA-CONCYTEC) and those of public and private universities. To locate documents in search portals, keywords were used in both Spanish and English, such as “sharks,” “rays,” “batoids,” “shark fishery + [country name],” “ray fishery + [country name],” “batoid fishery + [country name],” and “chondrichthyan fishery + [country name].”

Once some initial documents had been identified from different sources, an extensive review was conducted of the bibliography in each study and the ResearchGate and Google Scholar profiles of authors who made significant contributions were also used to conduct a thorough search to broaden the selection of documents and mitigate any bias from previous searches.

For scientific works not available online, physical libraries were searched or direct contact made with main authors, who kindly shared any available scientific articles or theses. Studies on chondrichthyans outside of each country were also considered, provided they included relevant information relating to the country in question (Ecuador, Mexico, or Peru). It is important to note that for Mexico, most of these studies were led by experts in chondrichthyans who were nationally recognized by the National System of Researchers (SNI) of Mexico’s National Council of Humanities, Science, and Technology (CONAHYCT), indicating that the research is highly reliable.

The following sections describe the findings from the various data sources identified in the three countries covered by the ABNJ-Tuna II project.

Ecuador

1. Fisheries authority: Management and scientific authority

Fisheries and aquaculture management has been the responsibility of the Ministry of Production, Foreign Trade, Investment, and Fisheries (MPCEIP) since 2019 and is carried out by the Vice-Ministry of Aquaculture and Fisheries (VAP). This ministry includes the Directorate of Fisheries and Aquaculture Policy (DPPA), the Undersecretariat of Fisheries Resources (SRP), their respective administrative units to exercise their powers in fisheries matters, the Undersecretariat of Aquaculture (SA), and the Undersecretariat of Quality and Food Safety (SCI) (Table 7).

The SRP is the competent authority for fisheries management in Ecuador, created by way of Executive Decree No. 669 dated July 24th, 1972,[36] as part of the Ministry of Natural Resources and Tourism. The Public Institute for Aquaculture and Fisheries Research (IPIAP) is the scientific authority, formerly named “National Fisheries Institute” and created on December 5th, 1960, by way of Executive Decree No. 1321 dated October 18th, 1966. The IPIAP is attached to the MPCEIP and generates scientific and technological information and knowledge for the rational exploitation of Ecuador’s marine biological resources (Table 7).

Table 7. Institutional mapping and scope of responsibility in fisheries management, according to the Organic By-Laws of Management by Processes of the MPCEIP,[37] Ecuador, 2023.

Institution		Role
Ministry of Produc...	**Vice-Ministry of Aquaculture and Fisheries (VAP)**	Issue strategic directives and guidelines for the regulation, promotion, and use of fisheries and aquaculture activities by applying policies, strategies, plans, programs, and projects.

[36] Published in Official Registry No. 113 dated August 1st, 1972.

[37] Approved in Ministerial Resolution No. 21- 001, published in Official Registry Second Supplement No. 367 dated January 11th, 2021.

	Directorate of Fisheries and Aquaculture Policy (DPPA)	Propose and evaluate management regulations (develop public policy) and national and international cooperation agreements, based on technical and scientific instruments that enable the regulation and promotion of activities in the fisheries and aquaculture sector.
	Undersecretariat of Quality and Food Safety (SCI)	Strategically manage regulation, control, and certification processes inherent to the health of aquaculture farms and the quality and safety of bioaquatic products. Ensure the health, quality, and safety of the aquaculture and fisheries production chain for export and aquaculture inputs in Ecuador.
	Undersecretariat of Fisheries Resources (SRP)	Implement and enforce the Organic Law for the Development of Aquaculture and Fisheries (LODAP) for the development, strengthening, promotion, and control of all stages of fisheries activity.
	Directorate of Artisanal Fisheries (DPA)	Regulate and formalize artisanal vessels and fishers and provide technical assistance to strengthen the value chain of artisanal fishing.
	Directorate of Industrial Fisheries (DPI)	Regulate industrial fishing activity through the generation of permits, technical information, and the legalization of catch and the source of fish, ensuring the traceability of fisheries products and compliance with regulations for internal and external trade.
	Directorate of Fisheries Control (DCP)	Control fishing activity by implementing monitoring, surveillance, and inspection processes to ensure the protection, conservation, and sustainable exploitation of bioaquatic resources.
Attached to the MPCEIP	**Public Institute for Aquaculture and Fisheries Research (IPIAP)**	Provide scientific advice for management decisions to the authorities that regulate these sectors. Issue a binding technical report for decision making.

For national monitoring, surveillance, and inspection of fishing activity, the Directorate of Fisheries Control (DCP) has 29 fisheries inspection offices, with resources to cover 255 fishing coves (*caletas*) or landing control posts. With the help of 262 fisheries inspectors, the DCP operates 24 hours a day, all year round, in rotating 8-hour daily work shifts, thus providing continuous monitoring of fishing activity at all stages of production.

Based on information provided by the SRP, in the five coastal provinces (Esmeraldas, Manabí, Santa Elena, Guayas, and El Oro), around 16 fisheries inspection offices were found to report landings of shark bycatch, primarily from the artisanal fishery (Table 8).

Table 8. Number of fishing coves or landing control posts recording landings of shark bycatch, SRP, 2023.

Province	**Fisheries inspection offices**	**Number of sites by landing type**		
		Artisanal	**Industrial**	**Industrial/Artisanal**
El Oro	Huaquillas	2		1
Esmeraldas	Esmeraldas	4		
	Muisne	18		
	Rocafuerte	2		
	Tonchigue	3		
Guayas	Playas	1		
Manabí	Bahía de Caráquez	17		
	Crucita	6		
	Jaramijó	1		1

	Manta	7	4	2
	Puerto López	4		1
	Zona Norte Manabí	5		1
Santa Elena	Chanduy	2		
	Santa Rosa	3		3
	Zona Norte Santa Elena	3		1
	Anconcito	0		3
TOTAL		**78**	**4**	**13**

SRP records of landing volumes for large pelagic species, including shark bycatch (2013-2022), indicate that the main fishing localities used by artisanal and industrial vessels, from north to south, are Esmeraldas, Muisne, Cojimíes, El Matal, Crucita, Jaramijó, Manta (Playita Mía and the artisanal pier, *Muelle Artesanal*), Puerto López, Santa Rosa, Anconcito, Chanduy, and Puerto Bolívar. Also of note is the fact that landings reported in the ports of Manta, Anconcito, and Jaramijó came mostly from the longline mother fleet. Many other locations feature predominantly small-scale artisanal fisheries that target pelagic and demersal species, resulting in a low volume of shark landings (Figure 10).

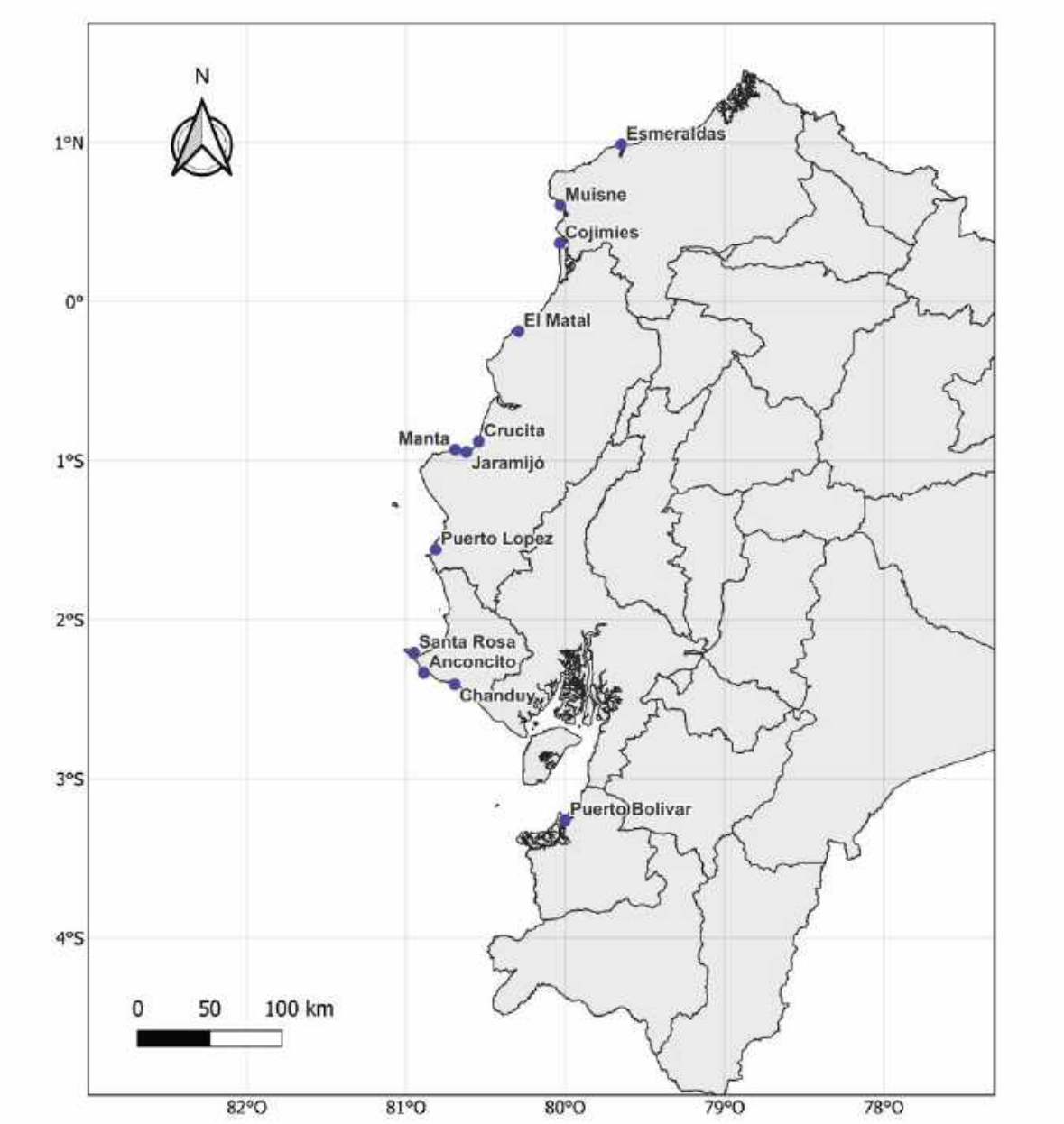

Figure 10. Main fishing localities, based on landing volumes reported by the SRP, from 2013 to 2022.

Governmental institutions (SRP and IPIAP) collect information on catch and effort, spatial distribution, and species composition in the various monitoring and landing control systems and programs and in the fishery observer program. The following section details the data collection systems used by each institution (Table 9).

Table 9. Summary of information available from public institutions, Ecuador, 2023.

Institution	Data available	Inspection (I) Sampling (S) Observer (OB)	Coverage (Year)
LANDINGS			
SRP	Vessel data; fishing effort; target and bycatch species; number of individuals and catch volumes.	I	Since 2007
IPIAP	Landing data; fishing effort for fish species classed as pelagics, small pelagics, demersals, and sharks.	S	Since 1998
DISTRIBUTION, ABUNDANCE (CPUE), AND COMPOSITION BY LENGTH, SEX, AND MATURITY STAGE			
SRP	Identification of species and sex, fishing gear, sizes and maturity stage.	S	Since 2009
IPIAP	Morphometric data for sharks and rays.	S	Since 2006
SRP	Georeferenced data on catch and effort of the longline fleet; species composition by length, sex, and identification of pregnant females; length (TL) of embryos.	OB	Since 2008
EXPORTS			
SRP[38]	"Authorization for the Export of Restricted Fishery Products: Sharks" service by means of the Single Ecuadorian Processing Counter (*Ventanilla Única Ecuatoriana*).		Since 2008
MAATE	Issuance of export permits for CITES-listed species.		
SENAE	Sole Authorization from Prior Verification (AUCP) for shark exports.		

2. Data collection system

The Undersecretariat of Fisheries Resources (SRP) has a National Control Plan implemented by the Directorate of Fisheries Control (DCP), which is aligned with the traceability system referred to as the Integrated Aquaculture and Fisheries System (SIAP). One of its main functions is to record stakeholders, resources, and products, in addition to other fisheries monitoring, control, and surveillance actions.

There are four types of information collection, described below:

1) **Landing monitoring and control**: Performed by fisheries inspectors since 2007, through monitoring and control as vessels arrive at authorized ports or fisheries facilities, and on small breakwater docks or in spaces on beaches used for landings by smaller artisanal boats (i.e., "*fibras*"). For all vessels, the inspector verifies the reliability of catch composition data recorded in the captain's logbook for catch from *fibra* boats, and sometimes confirms the source of the catch with the merchant (Figure 11).

   The inspector proceeds to issue both a physical and digital copy of the Fisheries Landing Monitoring and Control Certificate (CMCDP), which is linked to the SIAP.[39] The certificate records information about the

[38] Exports are coordinated with other government institutions, like the Ministry of Environment, Water, and Ecological Transition (MAATE) and the National Customs Service of Ecuador (SENAE).

[39] The first version of SIAP Móvil has been in use since September 2023.

vessel's fishing permit, including the satellite monitoring device, fishing gear, date of departure, area of catch (FAO), start and end of catch, date of arrival, and composition of target catch and bycatch (species, number of individuals, and weight in kilograms). A Bill of Lading for Fisheries Products (GMPP, for its acronym in Spanish) is also issued with details of the vessel, merchant, consignee, means of shipment, and the species, number of individuals, and weight. Also issued is a Bill of Lading for Shark Bycatch (GMPIT, for its acronym in Spanish),[40] which contains a section detailing the CMCDPs supporting the issuance of the bills of lading. The Bill of Lading for Shark Bycatch records shark bodies and fins separately (species, number of individuals, and weight in kilograms).

2) **Fishery observer program:** This program, known as the Single Longline Fleet Observer Program of Ecuador, began in 2008 and was officially established in 2011 by way of Ministerial Resolution No. SRP-2011-204. Its main objective is to provide a random monitoring system and real-time data collection for at least 10% of trips by this fleet. This initiative is in compliance with IATTC Resolution C-19-08 and applies specifically to longline vessels over 20 meters in length overall.

   In 2021, Ministerial Resolution No. SRP-2011-204 was repealed and replaced with Resolution No. MPCEIP-SRP-2021-0208-A. This new regulation mandates a progressive increase in on-board observer coverage for the fleet of mother vessels, setting a required coverage level of 10% for 2022, to be raised to 15% and 20% for 2023 and 2024, respectively. The resolution also expands the scope of this regulation to include foreign vessels that use drifting longlines and sail under the flag of Ecuador.

   The information collected through this program includes data on fishing effort, length composition of the catch of target species, and bycatch like sharks, rays, turtles, and seabirds, consistent with IATTC Resolution C-19-08. Various forms are used to collect data, including descriptions of the vessel and fishing gear, set forms, and individual specimen and turtle records (Appendix III).

3) **PAT-Ec biological monitoring:** This has been in place since 2009 and is carried out during shark landings, when samplers collect biological data including the species and main length measurements of sharks (total length [TL], precaudal length, interdorsal length, and fork length); for rays, samplers record disc width and disc length. In both sharks and rays, clasper length, sex, maturity characteristics, and TL of embryos are recorded. If a female has many pups, 2-4 embryos are measured, and a maturity scale is used; weights are recorded and a photographic record is made. Counts are also reported by species and sex for whole specimens, and shark trunks are reported by species (Appendix III). It is important to note that there are only five samplers at present, three of whom cover Playita Mía in Manta and two cover Santa Rosa in Salinas (Figure 11).

4) **Export records**: In 2008, the SRP began to issue documentation for shark exports, and in 2015 implemented the Single Ecuadorian Processing Counter (*Ventanilla Única Ecuatoriana*) system, where initially only exports of dried shark fins were recorded. However, these records progressively began to include other information, such as frozen bodies with or without fins and frozen and refrigerated fillets without fins, by species. This is managed jointly by the DCP and the DPPA, together with other operational and financial units (Figure 11).

The SRP shared information based on collected data relating to shark landings from both the artisanal and industrial fleets (Table 9). There is also information prior to 2013 that has not yet been validated. According to

[40] The forms, bills, and logbook used by the SRP in fisheries monitoring and control were shared confidentially and therefore have not been appended to this report.

its technical report presented in November 2023, IPIAP began the Permanent Artisanal Landing Monitoring Program in 1990 in a number of ports, including Manta, San Mateo, Santa Rosa, Anconcito, Engabao, Playas, and Puerto Bolívar. Information from these sites was used for the "Estimation of total fish landings by the artisanal fleet and fishing effort exerted on large pelagic fish, demersals, and sharks." Equally, biological information was collected on the main species captured, like the dorado, Pacific bearded brotula (*Brotula clarkae*), and others.

The report also notes that there has been an increase in efforts to generate biological and fisheries data on sharks since 2004. This is a result of the application of the Code of Conduct for Responsible Fisheries, which establishes fisheries sustainability as a priority. In addition, priority has been given to the implementation of national and international action plans for the conservation and fisheries management of sharks. Similarly, it is worth recalling the commitments undertaken at various international forums, including the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) and the World Summit on Sustainable Development.

The Large Pelagic Fish Program was established in 2006, which includes sharks and rays and has enabled collection of relevant biological and fisheries data on these species. However, the program was suspended from 2012 to 2017 due to funding constraints that limited the ability to continue implementation. Collection of shark data continued from 2018 to 2020, and in 2021, the Large Pelagic Fish Program was incorporated into the Vulnerable Species Program, which currently has a group of five experts who perform monthly monitoring in the ports of Manta, Santa Rosa, Puerto Bolívar, and Esmeraldas. In addition, IPIAP is working on issues related to the release of shark bycatch as part of capacity building (IPIAP 2023),[41] while also collecting complementary information through the SRP's fisheries observer program. This program issues staff with additional forms to record information on catch, fishing effort, and discards, and report sightings and longline interactions for seabirds, turtles, and marine mammals (Appendix III; Figure 11).

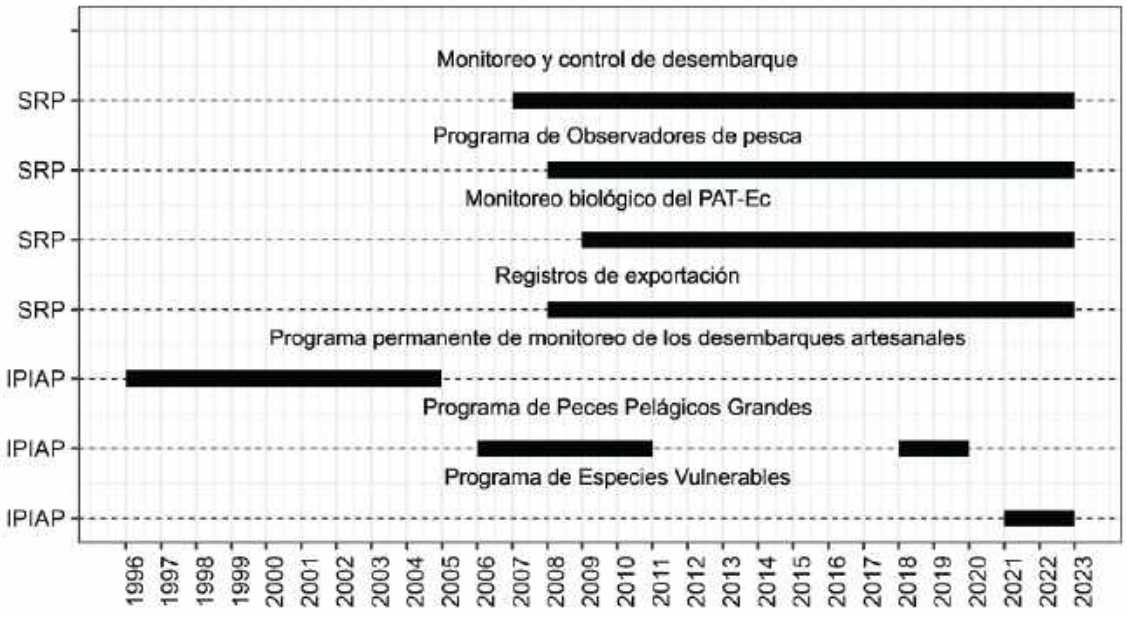

Figure 11. Timeline of sources of shark fisheries data available in Ecuador, from the SRP and IPIAP, 1996-2023.

[41] To date, the information has been sent as a report, but the biological fisheries data has not yet been shared.

2. Research

a. Fisheries authority: Management

The scientific technical documentation prepared by the SRP includes, notably, important papers like the technical report on biological and fisheries aspects of the silky shark (Martínez *et al.* 2012), compliance reports on Resolution C-11-10 on the conservation of oceanic whitetip sharks from 2020 to 2023, and reports on relevance for decision making in fisheries management.

In addition, the SRP has carried out fisheries research including campaigns aboard the Spanish oceanographic vessel "Miguel Oliver," conducted between 2008 and 2010 with the primary objective of studying the demersal fauna inhabiting the Ecuadorian continental slope, between the 500 and 1500-meter isobaths.

In 2013, the PAT-Ec group developed the Field Guide to the Chondrichythans of Ecuador: Chimaeras, Sharks and Rays (*Guía de Campo de Condrictios del Ecuador: Quimeras, Tiburones y Rayas*). This document has been widely used by the SRP's monitoring programs.

Collaborations with other organizations have resulted in notable publications including "Pesquería artesanal ecuatoriana de grandes pelágicos: composición de especies y dinámica espacio-temporal [The Ecuadorian artisanal large pelagic fishery: Species composition and spatiotemporal dynamics]" by Martínez *et al.* (2015) and the recently published first 2023 edition of the "Identification Guide to the teeth, trunks, and fins of sharks associated with the fisheries of Ecuador – PAT-Ec,"[42] developed by the PAT-Ec group with technical support from the scientific organization for migratory species research in the eastern Pacific Ocean MIGRAMAR and the World Wildlife Fund (WWF), and funding from the United States Agency for International Development (USAID).

In addition, the SRP has contributed to academia, sharing information on shark landings for research, mostly bachelor's and doctoral theses.

b. Scientific authority

The research on sharks initiated by the IPIAP dates back to 1998 and has resulted in a remarkable scientific production that has been disseminated through its scientific and technical bulletins, as well as in various specialized journals. The following publications are worth highlighting: an analysis of the artisanal landings of sharks and rays in the main fishing ports of Ecuador (Ruiz, 2007), and a study on target and bycatch of foreign longline vessels, carried out between August 2008 and March 2009 (Pacheco, 2010).

In 2010, scientific papers were published on the disappearance of the smalltooth sawfish, and records of the presence of the pelagic thresher shark and the sharpnose stingray *Dasyatis acutirostra* (Aguilar, 2010). In addition, during this same period, studies have highlighted the bycatch of sharks, rays, birds, turtles and marine mammals in the artisanal surface gillnet fishery in the fishing cove of Santa Rosa (Coello *et al.,* 2010).

In 2021, studies were carried out on the size distribution of sharks caught by the artisanal fleet of longline mother vessels between April and July 2021 (Herrera, 2021). In addition, an analysis of the length-weight relationship of 26 species of fish from the artisanal fishery in Ecuador, including shark species, was carried out (Coello *et al*., 2021).

Conversely, other studies have been conducted on deep-sea chondrichthyan species, including the analysis of the length-weight relationship of chimaera species of the genus *Hydrolagus* spp*.,* the short-spined shark species *Centroscymnus owstonii* and *C. squamosus.* These species were caught by the Patagonian toothfish experimental fishery (*Dissostichus eleginoides*) (Sepa *et al*., 2021). In addition, an analysis of the modal and empirical lengths

[42] The guide can be downloaded here: https://wwflac.awsassets.panda.org/downloads/guia-tiburones-final-confirmada.pdf

of sexual maturity in six species of bottom feeders and elasmobranchs caught incidentally by the Patagonian toothfish experimental fishery is still in the process of publication (Zambrano *et al*., 2023).

In collaboration with academic institutions, the IPIAP is working on projects for undergraduate and graduate degrees, focusing on topics related to fisheries and trophic ecology of the chimaera species *Hydrolagus melanophasma* in the Ecuadorian Pacific in 2019-2020 (Avila *et al*., 2022), as well as size structure, sex ratio and weight of this species (Tenelema *et al*., 2022). It is important to note that for the same species, three studies on reproduction, feeding, and spatial and temporal distribution are under revision.

It is important to highlight that in 2013, the IPIAP joined the Working Group of the Scientific Council of the Convention on Migratory Species (CMS), focusing on crucial issues such as bycatch, conservation of sharks, sea turtles and marine fish monitoring. It has also been designated as the CITES scientific authority for Ecuador, resulting in the issuance of five non-detriment findings (NDFs) for the pelagic thresher shark, bigeye thresher shark, silky shark, shortfin mako shark and blue shark. In addition to regional and international information, data provided by the SRP are used to develop assessments. It should be noted that the competent authority for the respective CITES permits is the Ministry of Environment, Water and Ecological Transition (MAATE).

c. Universities

Academia contributes to the development of research on chondrichthyans, both in the continental and insular areas of Ecuador. Among the most important universities are: Universidad de San Francisco de Quito (USFQ); Universidad Laica Eloy Alfaro de Manabí (ULEAM); Universidad de Guayaquil; Universidad de Santa Elena (UPSE). In addition, there are external or foreign academic institutions such as the Mexican Interdisciplinary Center of Marine Sciences (CICIMAR) and the University of California (USA), which collaborate with shark research projects in the country. On the other hand, some academic research, mainly from USFQ, has had collaborations with other scientific groups such as the Charles Darwin Foundation (CDF) and the Galapagos National Park (PNG), with funding from external sources such as international universities and non-governmental organizations, among others.

ULEAM, for its part, has carried out various studies in collaboration with CICIMAR and other research groups, highlighting studies on reproductive aspects of pelagic and bigeye thresher sharks (Briones *et al*., 2021). In addition, studies have been carried out on the biology of the blue shark (Briones *et al*., 2016) and the sicklefin smooth-hound, *M. lunulatus* (Briones *et al*., 2018).

In addition, through self-management, they have managed to create the "ShaREP" groups of the Pacific Sharks and Rays Project, which started in 2013, and the Life History Research Group, which started in 2019. As part of the work carried out, they have conducted biological monitoring in Manta, specifically in Playita Mía and Los Esteros, where morphometric data have been collected on both sharks and rays, as well as information on sexual maturity and sample collection, all for life history analysis (the form used can be found in Appendix III). Among the results obtained, two studies stand out: one on the diversity of biological aspects of batoids, which is in the final stage of development, and another on the reproduction, age and growth of blue sharks and silky sharks. In the case of the shortfin mako shark, the study focused exclusively on age and growth (Interview, Director of the Biology degree, ULEAM 2023). These contributions are of great importance for a better understanding of the ecology and biology of these species and will contribute to the management and conservation of sharks at national and regional level.

d. Non-Governmental Organizations (NGOs)

Currently, there are shark projects and study programs for the conservation of chondrichthyans in Ecuador, mainly carried out by the following organizations:

WWF Ecuador has played an active and significant role in shark conservation, contributing through research, education, conservation policies, collaborations and comprehensive strategies to ensure the survival of elasmobranchs in the Ecuadorian marine territory. In addition, as mentioned above, it has supported the VAP and the SRP, focusing its efforts on issues related to the impact on sharks and oceanic rays, among others, which are considered in its 2017-2025Strategic Plan.

CDF, in partnership with WWF, launched project “Habla Tiburón” in July 2023, funded by USAID for $11.9 million to be implemented over the next 5 years. The project aims to promote markets through conservation incentives to reduce shark and ray fishing mortality and strengthen participatory governance with a gender focus for large pelagic fisheries in the EEZ. It also aims to strengthen the capacity of fisheries authorities and organizations for monitoring, control and compliance to combat IUU fishing in continental and insular fishing communities, but with a greater focus on continental Ecuador. The scientific objectives include: (i) analysis of shark ecology, where possible using available official data on landing statistics to increase the accuracy of the information; (ii) relative abundance; (iii) species movement using fishing fleet distribution data; (iv) strengthening best fishing practices; (v) shark survival; and (vi) tagging of blue shark, shortfin mako shark, silky shark, and shark species of the Alopidae family (thresher sharks) and identification of other species for tagging, all within the Galapagos Reserve.

MIGRAMAR provided scientific evidence for the creation of the new marine reserve called "Hermandad", which adds 60,000 km² to the Galapagos marine protected area. Fifty percent will be a strict no-fishing zone where no extractive activities will be allowed. The remaining 50% will allow fishing, with the exception of longline fishing. The government of Ecuador has financed the monitoring and control of this reserve with international cooperation through a debt-for-nature swap. In addition, it is supporting the "Project for the Creation of the First 8 Nautical Miles", which covers the entire continental coastal zone, specifically with the characterization phase for the socio-fisheries study, leaving out the province of Esmeraldas due to security concerns in this area (Interview, MIGRAMAR 2023).

Conservation International (CI) in Ecuador focuses on developing and implementing sustainable management strategies, promoting marine protected areas, and conducting scientific research to better understand the ecology of shark stocks in Ecuadorian waters. They have also worked closely with local communities, government agencies and other organizations to promote the conservation of endangered species and encourage responsible fishing practices. One of the highlights of this work is the publication on the criminal prosecution of illegal shark fishing in the Galapagos Marine Reserve (Echeverría, 2017), which systematizes the lessons learned on this matter.

The Marine Megafauna Foundation of Ecuador (FMME) initiated the Mantas Ecuador Project in 2008, during which 15 satellite tags and 30 acoustic tags were placed on manta rays. These tools have been used to determine the habits and movement patterns of manta rays in Ecuadorian waters. This research spanned more than 14 years and provided a valuable contribution to the knowledge of the demography and dynamics of the giant ray species along the Ecuadorian coast (Harty *et al.*, 2022). It is important to note that this study was supported by the "Giants of the Pacific" project, funded by the German Federal Ministry for Economic Cooperation and Development (BMZ) and carried out in collaboration with WWF Ecuador. In addition, in 2014 the FMME collaborated with the IATTC to train tuna vessel captains on manta ray interactions and shared tissue samples to support the "Population genetics of mobulid species in the EPO" project. Samples were analyzed by the Conservation Action Lab at the University of California, Santa Cruz and results are pending publication.

Currently, there is an agreement with the Center for the Restoration of Endangered Marine Species (CREMA) to conduct comparative genetic analyses with data from Costa Rica, Galapagos and mainland Ecuador. The Mantas

Ecuador Project has an exclusive network of researchers dedicated to the study of manta ray species (Interview with the Director of the Mantas Ecuador Project - FMME, 2023).

The Equilibrio Azul Foundation has been involved in marine research projects since its inception in 2004, focusing primarily on the Isla de la Plata, located within the Machalilla National Park in Ecuador. One of their most outstanding projects is the shark study, in which they have carried out a comprehensive monitoring of artisanal fisheries in the fishing locality of Puerto López. The main actions of this project are the collection of biological fishery data, the collection of genetic samples, underwater monitoring with remote cameras (BRUVS), the search for breeding areas, the monitoring of marine protected areas and the tagging of sharks with acoustic and satellite devices to study their migrations. In addition to its research work, the Foundation works closely with academic institutions to support the development of undergraduate and graduate research theses.

Another important contribution is the collaboration between TUNACONS and the IATTC in the development of a study to provide quantitative estimates of post-capture shark survival. This work is an experiment that explores good handling and release practices beyond those established in IATTC resolutions, including silky and oceanic whitetip sharks, as well as manta rays. It is also intended to promote the immediate release of other shark species wherever possible.

3. Summary of studies on total shark catch estimates

Estimates of total shark catches have not been made in Ecuador. However, the IPIAP has estimated total landings by analyzing statistical data provided by the SRP and assessing catch distribution.

Mexico

1. Fisheries authorities: Management and scientific authority

National Commission of Aquaculture and Fisheries (CONAPESCA)

CONAPESCA is the federal fisheries authority responsible for the administration and management of Mexico's fisheries and aquaculture resources. It was created by a presidential decree in 2001 and has its headquarters in the city of Mazatlán, Sinaloa. However, since 1976 there has been a fisheries department responsible for managing the country's fisheries resources (www.conapesca.gob.mx). Currently, CONAPESCA is the official source of catch data for all fisheries resources, including sharks and rays.

Regarding national statistics on shark and ray production, CONAPESCA has a time series that covers the period 2006-2022 and is updated every year. This time series includes the federal entity (state), type of vessel, landed weight, live weight and estimated economic value. This information is public and can be requested through the Information Access Request System of the National Transparency Platform.

Mexican Research Institute for Sustainable Fisheries and Aquaculture (IMIPAS)

IMIPAS is recognized as the main scientific authority for fisheries in Mexico. Formerly known as the National Institute of Fisheries and Aquaculture (INAPESCA), its official name was changed to IMIPAS in December 2023 (DOF, 2023c). This institution plays a crucial role in coordinating scientific research in fisheries and aquaculture at the national level. Through this role, it provides basic technical assessments for the management and conservation of marine and inland water resources (DOF, 2023b). This institution is more than 60 years old, having its origins in the Secretariat of the Navy in 1955 as the Technical Office of the General Directorate of Fisheries (INAPESCA, 2012). IMIPAS currently has 14 Regional Centers for Aquaculture and Fisheries Research (CRIAPs), 8 of which are distributed throughout the Mexican Pacific (Figure 12). These regional centers also

handle requests for resource assessments and technical opinions, which are required for the authorization and renewal of fishing permits and concessions.

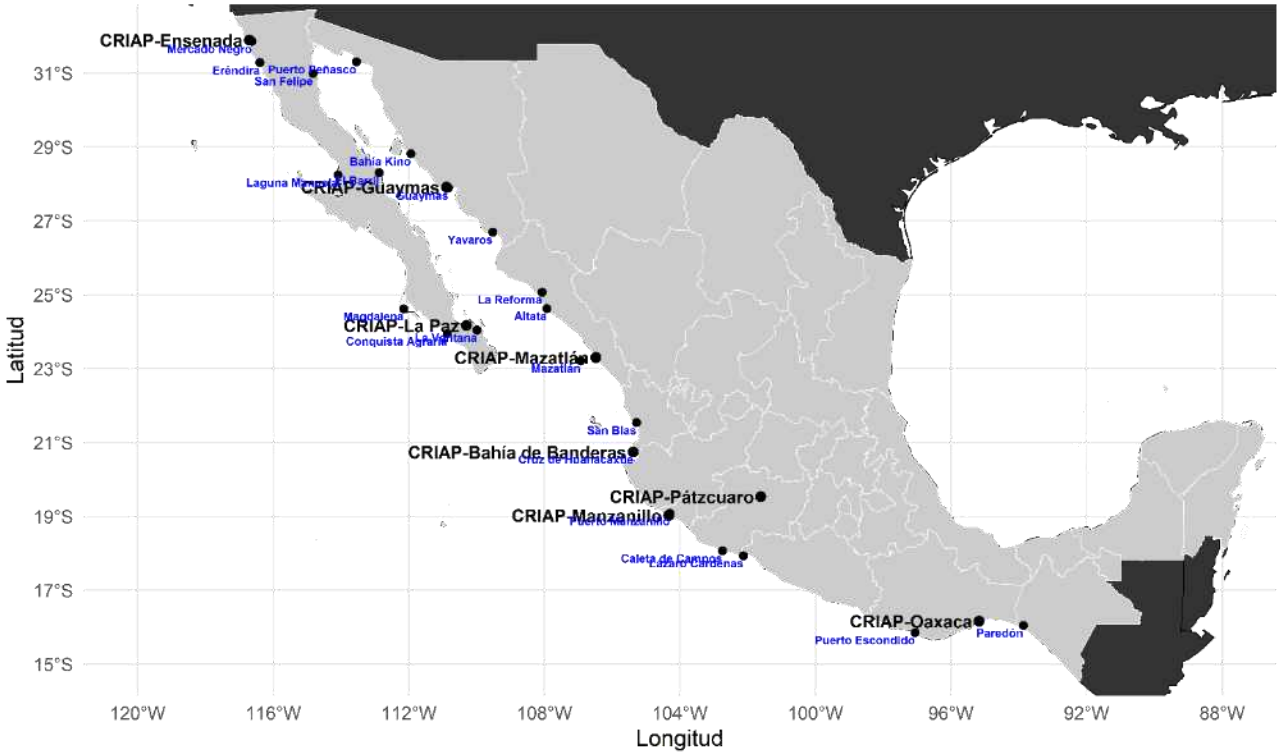

Figure 12. Distribution map of Regional Centers for Aquaculture and Fisheries Research (CRIAPs) and major shark landing sites in the Mexican Pacific. CRIAPs are shown in black and landing sites are shown in blue according to the researchers responsible for shark resources or fisheries.

1. Data collection system

The basis of the data collection system that maintains the national statistics are the arrival notices that fishermen use to report to the fisheries authority (CONAPESCA) the catch volume of each fishing trip they make (Appendix IV). It is the responsibility of the holder of each fishing permit to submit these notices periodically, which can be done electronically or physically at 60 offices distributed throughout the Mexican Pacific (www.conapesca.gob.mx). This landing registration system is mandatory and has national coverage, both for marine resources and inland waters.

Another official data collection system is the IMIPAS field work (landing, biological, effort sampling) and data analysis, which is carried out according to the needs of the fisheries sector in each state. Based on the results of these analyses, technical opinions are issued to assist the fisheries authority (CONAPESCA and state fisheries offices) in the management and conservation of fisheries resources (DOF, 2023b). Currently, the only shark research programs in the Mexican Pacific are at the Regional Centers for Aquaculture and Fisheries Research (CRIAPs) in Ensenada, Mazatlán, Bahía de Banderas, Manzanillo and Pátzcuaro, where shark landings and biological data are collected periodically at the main ports in these regions. However, although these CRIAPs collect shark landings and biological data in their respective regions, the system and forms they use are not standardized. In the aforementioned CRIAPs, there are Shark Program specialists in their respective regions who will participate in the data collection during the monitoring program planned within the activities of this project.

2. Research

a. Fisheries authority

CONAPESCA is the institution responsible for managing the statistics of all fisheries resources exploited by Mexico along its coasts (Table 10; Figure 13). As a result of a cooperation agreement with the IATTC, this institution shared a database of licenses or permits for the exploitation of sharks in the Mexican Pacific, which includes important information for the project, such as state, area of operation, home port, number of vessels covered, validity, and authorized fishing gear (CONAPESCA, 2023a). Similarly, a time series covering the period 2015-2022 was shared, which includes the landed weight by small and large vessels, reported by state and month of the year (CONAPESCA, 2023b).

Regarding the volumes of shark landings in 2022 reported by the states that make up the Mexican Pacific, it is worth noting that large vessels contribute the largest volumes with 74% (12,966 t), while small vessels contribute only 26% (4,541 t). In terms of effort by state, in Baja California the fleet of small vessels contributed the most effort with just over 2,077 t, followed by Sinaloa with 1,700 tons. Similarly, Baja California Sur and Chiapas have the highest volume of shark landings reported by large vessels, with 3,189 and 4,053 t, respectively (Table 11).

An ally of CONAPESCA in research related to tuna and tuna-like species is the National Chamber of Fishing Industry (CANAIPESCA), which has created a trust called FIDEMAR. This trust has an on-board observer program for tuna purse-seine vessels operating in the eastern Pacific Ocean (PNAAPD), which complies with IATTC regulations (Table 10; Figure 13). This program has an average annual coverage of 105 trips (3% of the total), during which information relating to sharks is generated and shared with the IATTC.

Table 10. Shark fisheries and landing monitoring programs in the Mexican Pacific; CONAPESCA = National Commission of Aquaculture and Fisheries; FIDEMAR= Trust for the Development of the National Program for the Use of Tuna and Protection of Dolphins.

Institution	Period	Description	Region
CONAPESCA	2006-2023	Recording of landings (volume of catch, live weight, landed weight and economic value) of sharks through arrival notices reported to the regional fisheries offices.	Mexican Pacific
IMIPAS	2018-2023	Biological/reproductive sampling of pelagic sharks caught by the offshore (*de mediana altura*) fleet based in Ensenada, Baja California.	Baja California
IMIPAS	2014-2019	Record of catch and landing sites of sharks caught by artisanal vessels.	Michoacán and Guerrero
IMIPAS	2016-2019	Record of biological data and fishing effort of sharks and rays caught by artisanal vessels.	Oaxaca and Chiapas
FIDEMAR	1991-2023	Monitoring of shark catches through the on-board observer program on offshore (*de mediana altura*) vessels.	Mexican Pacific

Table 11. National production by fleet of small and large vessels, reported in kg by Mexican Pacific coast states; BC= Baja California, BCS= Baja California Sur, Chia= Chiapas, Col= Colima, Gue= Guerrero, Jal= Jalisco, Mich= Michoacán, Nay= Nayarit, Oax= Oaxaca, Sin= Sinaloa, Son= Sonora.

States with coastline on the Pacific Ocean													
Vessel type	**BC**	**BCS**	**Chia**	**Col**	**Gue**	**Jal**	**Mich**	**Nay**	**Oax**	**Sin**	**Son**	**Total per fleet**	**%**
Small	2,077,394	115,165	4,150	402,373	0	0	0	26,453	0	1,777,294	138,781	4,541,610	26
Large	536,438	3,189,127	4,053,087	153,946	171,648	3,545	38,861	592,082	768,124	2,249,444	1,209,934	12,966,236	74
Total	2,613,832	3,304,292	4,057,237	556,319	171,648	3,545	38,861	618,535	768,124	4,026,738	1,348,715	17,507,846	100

Figure 13. Monitoring programs of shark and ray catches and landings in different areas of the Pacific, carried out by different Mexican institutions, 1991-2023; the period of the program ('x' axis) and the responsible institutions ('y' axis) are indicated; IMIPAS= Mexican Research Institute for Sustainable Fisheries and Aquaculture; CONAPESCA= National Commission of Aquaculture and Fisheries; FIDEMAR= Trust for the Development of the National Program for the Use of Tuna and Protection of Dolphins.

b. Scientific authority

To obtain shark landings and biological data generated by IMIPAS specialist researchers, the eight (8) CRIAPs distributed along the Mexican Pacific coast were visited between September and December of this year (Figure 12). During these visits, the ABNJ 2 project was presented to the heads of the centers, researchers in charge of the shark resource and related fisheries such as finfish and large pelagics. As a result, nine (9) specialized researchers distributed in the CRIAPs of Ensenada, Bahía de Banderas, Manzanillo, Mazatlán, Pátzcuaro and Oaxaca, responsible for the Shark Program, were registered and will participate in the monitoring planned in the ABNJ 2 project activities. Based on their experience, these researchers provided information from 24 landing sites considered the most important for shark landings, distributed along the Mexican Pacific coast (Figure 12).

In addition, the validity of a program to monitor and record biological information (reproductive information) of pelagic shark species caught by offshore vessels (*de mediana altura*), coordinated by IMIPAS, through CRIAP-Ensenada, during 2018-2023, was verified. A shark catch and landing monitoring program for the coast of Michoacán, carried out by CRIAP-Pátzcuaro during 2014-2019, was also verified, as well as a shark landing and biological monitoring program on the coast of Oaxaca and Chiapas, carried out by CRIAP-Salina Cruz during 2016-2019 (Table 10; Figure 13). It is important to mention that the objectives of these investigations were based on the needs of each region, so no standardized forms or collection methods were used. The information collected in this monitoring may be shared with the ABNJ 2 project, if established in the interinstitutional agreement.

Finally, during the visit to each CRIAP, we had the opportunity to talk with researchers who have conducted research on sharks or large pelagic species and who provided valuable information on important active sites for shark and ray landings. These researchers also shared the field forms they use in their regions to collect biological and landing data for sharks and rays (Appendix III; Mexico section).

c. Universities

Research on sharks and rays carried out by universities and academic institutions is mainly represented by undergraduate and graduate theses, which have already been included in the documents and make up an important percentage of the metadata (see Section VI). All the thesis documents were downloaded directly from the electronic library of the different universities and, in specific cases, the document was requested directly from the thesis director or the student.

One of the institutions that contributed the largest number of theses related to sharks and rays was the Mexican Interdisciplinary Center of Marine Sciences (CICIMAR) of the National Polytechnic Institute (IPN), located in La Paz, Baja California Sur (B.C.S.). Within this institution, Dr. Felipe Galván, a specialist in elasmobranchs, was contacted and shared a web page with a history of the theses he has produced throughout his career at the institution. This laboratory currently has ongoing projects called "Biology of chondrichthyans in the coasts of Baja California Sur (2023-2025)" and "Trophic habits of chondrichthyans in the coasts of Baja California Sur". The second institution that contributed a significant number of scientific theses was the Center for Scientific Research and Higher Education of Ensenada (CICESE), in Baja California. The vast majority of these theses came from the Fisheries Ecology Laboratory, headed by Dr. Oscar Sosa, a specialist in elasmobranchs, who is currently conducting a project entitled "Marine Megafauna in the Baja California peninsula: its monitoring for an ecosystemic and climate change analysis". This study takes a broad look at different species of sharks and rays in the region.

Another institution that was contacted was the Institute of Marine Science and Limnology (ICML) of the National Autonomous University of Mexico (UNAM), where Dr. Felipe Amezcua, representative of the Ichthyology and Fisheries Laboratory, provided us with a list of the most important shark and ray sampling sites in the state of Sinaloa. They also offered the support of their laboratory and technical personnel for the information gathering activities during the monitoring phase.

d. Non-Governmental Organizations (NGOs)

In order to determine the existence of study or monitoring programs for shark and ray species carried out by non-governmental organizations, the 10 most important civil associations recognized for their conservation work in the marine environment of the Mexican Pacific were contacted. Through virtual meetings and telephone calls, an interview was conducted with the scientific technical staff of each organization, where it was verified that eight of them are not currently conducting any conservation studies related to shark or ray species (Appendix III). However, the civil association ECOCIMATI reported that the projects "Conservation of the Coronados Archipelago through the monitoring of bony fish and chondrichthyans" and "Integral solutions to the interaction between white sharks and anthropogenic activities in northwestern Mexico" are still in force. The civil association Pelagios Kakunjá reported the validity of the following projects: 1) "Characterization of the movement and residence patterns of different species of sharks and rays inhabiting the Revillagigedo Archipelago"; 2) "Movement and residence patterns of bull, blacktip and lemon sharks using acoustic and satellite telemetry in Cabo Pulmo National Park"; 3) "Movement, residence and migratory patterns of common hammerhead sharks in the Espiritu Santo Archipelago"; 4) "Seasonality, population dynamics and site fidelity of the most representative shark species in Bahía de La Paz, B.C.S."; and 5) "Relative abundance and richness of pelagic shark species in Cabo San Lucas, B.C.S.".

Finally, WWF and PRONATURA Noroeste agreed to collaborate on this project by seeking sources of funding, infrastructure and technical personnel. In addition, a cooperation agreement is expected to be signed with PRONATURA Noroeste to define the objectives and scope of this cooperation.

3. Management summary: Existing total shark catch estimates

In the 2006 version of the Red Book, Sustainability and Responsible Fishing in Mexico (INAPESCA, 2006), IMIPAS reported a quantitative analysis of silky sharks and scalloped hammerhead sharks in the artisanal shark fishery in Puerto Madero, Chiapas, for the period 1980-1998. For silky sharks, they estimated that under natural conditions the population could increase by 16.3% per year, with a net reproduction rate of 7.83 and a possibility of doubling every 4 years. Under harvesting conditions, they estimated fishing mortality rates of 0.174 and 0.149 for 1997 and 1998 respectively, with an annual increase of 3-5% and a population doubling time of 20.6 and 13.5 years respectively. For the scalloped hammerhead shark, an annual increase under natural conditions of 25%, a net reproductive rate of 19.4 and a population doubling time of 2.8 years were estimated. For this species, fishing mortality rates of 1.33 and 0.798, an annual population decline of 6% and a net reproductive rate interval of 0.000007-0.001 were estimated for 1997 and 1998, respectively, under harvesting conditions.

In the Gulf of California, Saldaña-Ruiz *et al.* (2017) conducted a historical reconstruction of shark fishery landings during 1939-2014 and found that the largest landings were recorded in 1979, totaling approximately 17,500 tons. They also estimated the species composition during 1960-2014 based on a literature review that included scientific articles, technical reports, academic theses, and management documents. This work identified 38 species of sharks, the most representative groups being *Mustelus* spp. and *Sphyrna* spp. as well as the Pacific sharpnose shark (*Rhizoprionodon longurio*), angelshark, silky shark and blacktip shark. Species such as the bull shark (*Carcharhinus leucas*) and the whitenose shark (*Nasolamia velox*) showed significant declines throughout the time series, and species such as the blue shark, pelagic thresher shark and shortfin mako shark showed increases after 1986, when the development of a fishing fleet of larger artisanal vessels (>10.5 m LOA) began.

IMIPAS indicates that shark fisheries in Mexico are at maximum sustainable yield (DOF, 2023a). Due to the limited availability of catch and effort information, only some species have been quantitatively assessed. This is the case for the assessments conducted by the International Scientific Committee (ISC) in 2020 of the north Pacific blue shark (DOF, 2023a; ISC, 2021). This work found that the current spawning biomass is 65% above the level corresponding to maximum sustainable yield. Similarly, the ISC conducted an assessment of the north Pacific shortfin mako shark in 2018, which found that the stock is not overfished and that the calculated spawning abundance is 36% higher than the estimated spawning abundance at maximum sustainable yield. Finally, in 2018, the U.S. National Marine Fisheries Service (NMFS), in collaboration with Mexican specialists, conducted a stock assessment of the common thresher shark off the west coast of North America. They found that the estimated number of mature females was 62% of the unfished level, above the minimum limit of the estimated stock size.

Peru

1. Fisheries authority and scientific authority

Articles 66, 67 and 68 of Peru's Political Constitution establish that natural resources are national patrimony and that the State is obliged to promote their sustainable use and the conservation of biological diversity. The Peruvian fisheries sector is regulated by the General Fisheries Law (Decree No. 25977 of 1992) and its Regulations approved in 2001 (Supreme Decree No. 012-2001-PE).

The national governing body that promotes, regulates and controls the development of this activity is the Ministry of Production - PRODUCE (created by Law No. 27779 of 2002), through the Vice-Ministerial Office of Fisheries and Aquaculture, whose only office is located in the Lima region. It should be noted that PRODUCE has shared responsibilities with the regional governments in terms of artisanal fisheries and aquaculture (created by Law No. 27867 of 2002). Through the Regional Directorate of Production (DIREPRO), which is responsible for the

formulation, adaptation, implementation, monitoring and evaluation of compliance with public policies in the sector regarding industry, fishing and aquaculture at the regional level. To date, there is no official information on the total number of vessels targeting or bycatching chondrichthyans; there is only limited information on current fishing permits (see Table 3). It should be noted that PRODUCE is the agency responsible for issuing official statistics (landings, number of vessels, number of fishermen, etc.) in Peru.

The specialized technical agency of PRODUCE, dedicated to scientific research, as well as to the study and knowledge of the Peruvian sea and its living resources, is the Peruvian Institute of the Sea (IMARPE). It was created by Supreme Decree No. 021 of 6 September 1963, with the purpose of providing the Peruvian state with accurate and timely scientific advice for the sustainable use of the living resources of the sea and continental waters. Its headquarters are located in the constitutional province of Callao in the department of Lima. It has ten Coastal Laboratories (LC) at the national level with regional jurisdiction [LC Tumbes (Tumbes region), LC Paita (Piura region), LC Santa Rosa (Lambayeque region), LC Huanchaco (La Libertad region), LC Chimbote (Áncash region), LC Huacho (Lima region), LC Pisco (Ica region), LC Camaná (Arequipa region), LC Ilo (Moquegua y Tacna region) and LC Puno (Puno region)]; and a scientific station in the city of Pucallpa in the Ucayali region. Like PRODUCE, IMARPE does not have information on the number of vessels of the artisanal chondrichthyan fishery, only on total artisanal fishing.[43]

On the other hand, Supreme Decree No. 030-2005-AG establishes that the Ministry of the Environment (MINAM), in its capacity as the scientific authority, is primarily responsible for the implementation of the measures necessary for the application of the CITES Convention. Its functions include the preparation of non-detriment findings (NDF). In the case of sharks, IMARPE provides the data to MINAM for the preparation of the NDFs, which are sent to PRODUCE's Vice-Ministry of Fisheries and Aquaculture to establish the requirements for CITES species that importers and exporters must comply with.

The information available from national institutions (PRODUCE and IMARPE) is shown below (Table 12).

Table 12. Summary of information available from national institutions. Peru, 2023.

Institution	Available Data	Inspection/ Sampling	Coverage
LANDINGS			
IMARPE	By species, fishing gear, fishing days, fleet, spatial data.	S	Since 1996
PRODUCE	Total landings not classified by species. CDT: By species, fishing gear, fishing days, fleet, spatial data.	I	Total record: since 2012 CDT: since 2018
SIZE AND SEX COMPOSITION			
IMARPE	Size and sex composition of artisanal catch and spatial data.	S	Since 2021
DISTRIBUTION, ABUNDANCE (CPUE) AND BIOMASS (WEIGHT)			
IMARPE	Spatial distribution, CPUE of the longline fleet and artisanal curtain nets (*Sphyrna zygaena*, *Prionace glauca*, *Isurus Oxyrinchus*), biomass in tons of *Sphyrna zygaena*.		*I. oxyrinchus* and *P. glauca*: 1996-2018 *S. zygaena*: since 1997

[43] Castillo *et al*., 2018; in 2015, the population of artisanal fishers was estimated at 67,427 individuals and the number of vessels engaged in this activity at 17,920.

EXPORTS		
PRODUCE	Shark-based products	Since 2010
NATIONAL MANAGEMENT		
PRODUCE	Standards PAN-Tiburón	Standards: since 2001 PAN-Tiburón: since 2014
MINAM	Non-detriment extraction report	Since 2016

2. Data collection system

IMARPE, as the scientific authority, collects catch and effort data for the main species (including chondrichthyans) landed by the artisanal fleet through its Artisanal Fisheries Information Collection System. From 1996 to the end of 2000, it monitored between 28 and 45 landing sites along the Peruvian coast. Subsequently, between 2001 and 2014, it monitored between 21 and 37 sites. Since 2015, it has monitored around 56 sites, maintaining the same methodology and sampling intensity (Castillo *et al.,* 2018), and currently monitors 62 landing sites. During the collection of information, the field observers stay at the assigned landing sites between 8 and 12 hours per day (usually from Monday to Saturday), depending on the dynamics of the landings, and collect the information through direct interviews with the fishermen at the time of the vessel's arrival. The information collected includes the characteristics of the fishing unit, the duration of the trip, the fishing area, the number of crew members, the fishing gear and the catch by species (Guevara - Carrasco and Bertrand, 2017). It should be noted that the collection of information from the Artisanal Fisheries Information Collection System is for research purposes, which is an approximation of the actual estimate.

Since 2021, as a complement to the Artisanal Fisheries Information Collection System, monitoring of shark and ray fisheries has been carried out at seven landing sites, where field observers carry out biometric sampling of the main species landed at the dock, collect information from the sampled vessel and data from the fishing trip. The sampling is not constant and is scheduled according to the dynamics of the landings of these resources. It should be noted that since 2022, the fisheries monitoring program has been carried out with the financial support of the NGO The Nature Conservancy (TNC-Peru).

The coverage of the observer and sampling program is shown in Figure 14. The map with locations where chondrichthyan landings were recorded (January 1996 - January 2023) is shown in Figure 15.

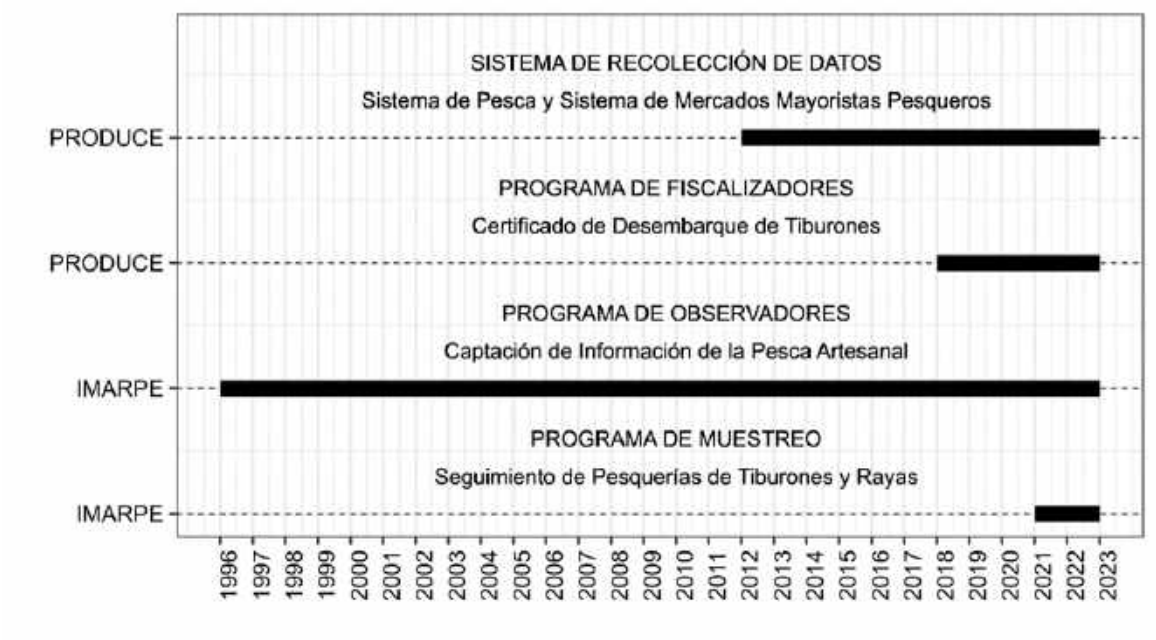

Figure 14. Coverage in years of collection systems, monitoring and control programs of public institutions, 1996-2023, Peru. PRODUCE: Ministry of Production, IMARPE: Peruvian Institute of the Sea.

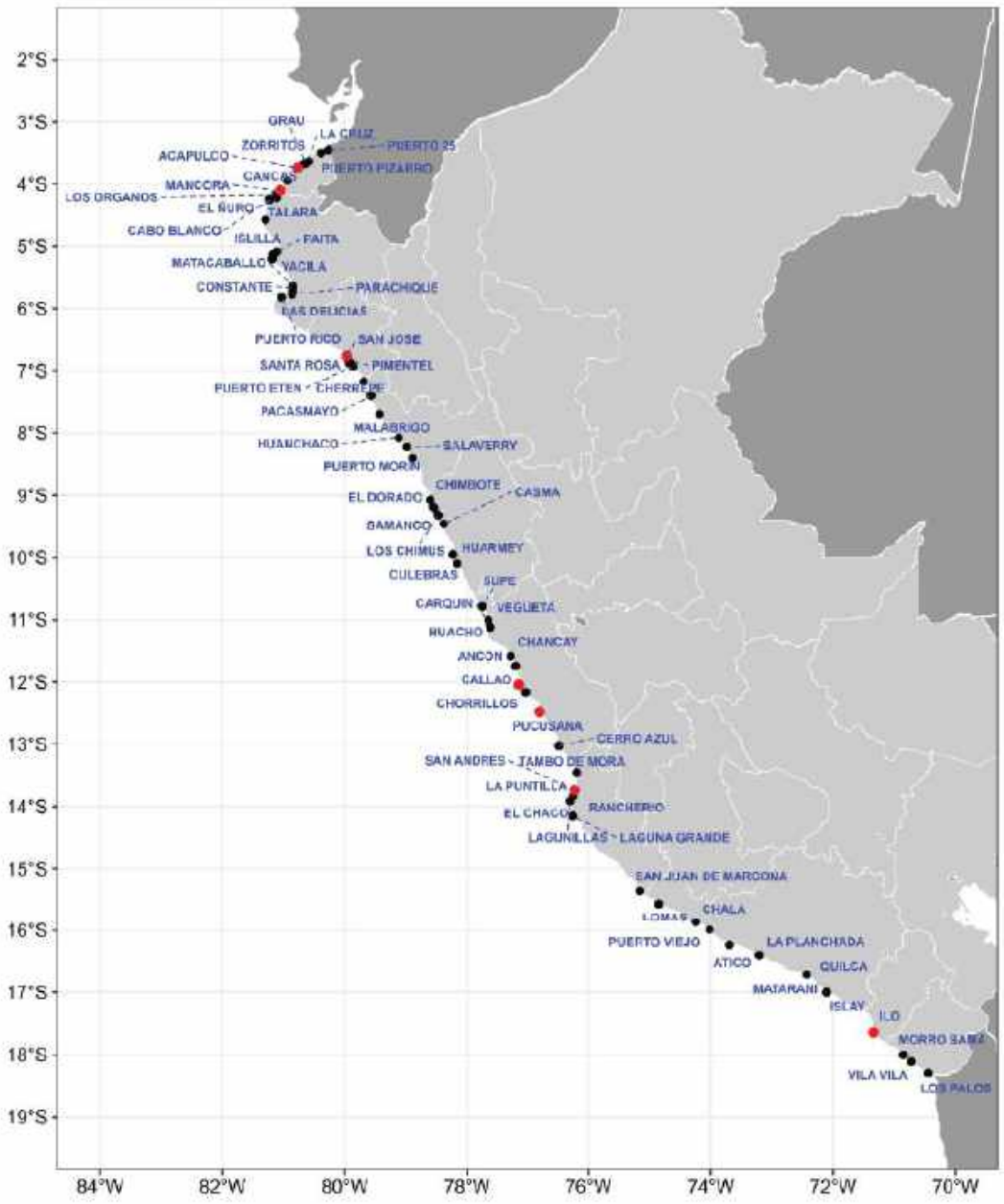

Figure 15. Landing sites identified by IMARPE, 1996-2023, where chondrichthyan landings (bycatch or target) were recorded by field observers; not all landing sites are considered as main sites. The sampling program is carried out in Acapulco, Máncora, San José, Callao, Pucusana, San Andrés and Ilo (red dots).

As for the fisheries authority, PRODUCE has been issuing shark landing certificates (CDT, Appendix VI) at authorized landing sites since 2018. These certificates contain information on the species landed and the catches made by the fishing vessel in order to determine the legal origin and traceability of the resource. It should be noted that, to date, the inspectors monitor 58 authorized landing sites (21 private and 37 public) and have at their disposal 118 inspectors whose operational capacity is planned according to fishing activities.

Likewise, since 2012, through its data collection systems (Fishing System and Wholesale Fish Markets System), this institution has been collecting information on the volume of landings of sharks and rays from the different production agents under the administrative jurisdiction of the fisheries and aquaculture sector, supplemented

by official data from the National Superintendence of Tax Administration (SUNAT) (exports). This information does not include landings by species. It is important to mention that Peru does not have official volumes of total landings or landings by species of chondrichthyans.

The coverage of the data collection system and monitoring program is shown in Figure 14. The names of the inspected sites are detailed in Appendix V and shown on the map with the number of inspected landing sites in Figure 16.

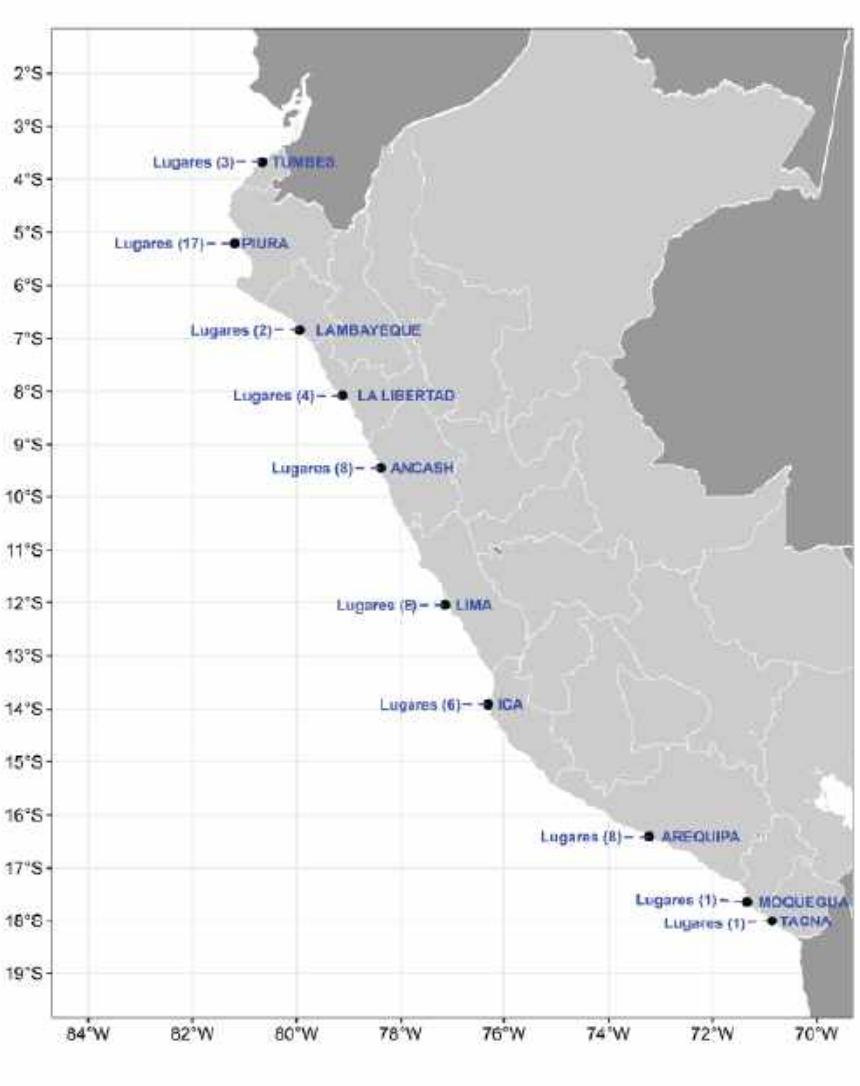

Figure 16. Landing sites inspected by Ministry of Production (PRODUCE) inspectors in 2023. The numbers in parentheses indicate authorized shark landing sites, see Appendix V.

3. Research

a. Fisheries authority:

- The Ministry of Production, through its annual bulletins, provides information on landings and management regulations. This institution shared landing data, forms, fishing permits by vessel, and inspected landing sites (Table 13).

b. Scientific authority:

- The reports and research of the Peruvian Institute of the Sea, published through its bulletin, include studies on landings (Estrella-Arellano *et al*., 1998a, 1998b, 1998c, 1999a, 1999b, 2000a, 2000b, 2001; Flores *et al*., 1994, 1996, 1998a, 1998b, 1999; Marcelo *et al*., 2001), fisheries (Guevara-Carrasco and Bertrand, 2017), biology and fisheries (Elliott *et al*., 1995, 1996, 1996, 1997a, 1997b; Castañeda, 2001), identification guides (Romero Camarena, 2018, 2019; Zavalaga *et al*., 2021a, 2021b), stock indicators (Pérez-Huaripata *et al*., 2021), among others. It also publishes on its website internal reports of studies that have led to management measures, as in the case of the smooth hammerhead shark stock assessment, which is updated annually. It shared information on landings, size structure, landing sites and reports (Table 13).
- The Ministry of the Environment provided information on non-detriment findings and reports (published on the website) on situational diagnosis based on the compilation of national and international information for the smooth hammerhead shark, shortfin mako shark and manta ray species corresponding to the genus *Mobula* spp. (Table 13).

c. Universities:

- Undergraduate theses were mainly recorded at universities in the regions of Lima and La Libertad, with the largest number at the Universidad Científica del Sur (UCSUR, Lima), followed by the Universidad Nacional de Trujillo (UNT, La Libertad). Most of the theses were carried out with the support of IMARPE or NGOs and were found in the digital repositories of universities and public institutions. The registered master's and doctoral theses written outside of Peru were written by Peruvian students.

d. Non-Governmental Organizations (NGOs):

- There are several research efforts, such as those funded by OCEANA on the value chain of shark fisheries (Grillo and Gozzer, 2019), shark fin identification guide (Hernández *et al.,* 2018), among others. For WWF, evaluation of the implementation of the National Action Plan for the Conservation of Sharks, Rays and Related Species in Peru (Romero-Camarena, 2023), release manuals in collaboration with industry and scientific authorities, among others. PRODELPHINUS release manuals in collaboration with industry (Acuña-Perales *et al.,* 2020), among others.
- Some monitoring programs are conducted on board vessels or at docks during certain times of the year. For example, PRODELPHINUS collects catch and effort information on board vessels at certain times of the year. WWF collects information through electronic monitoring on vessels. ECOCEANICA collects catch and effort data, size structure and tissue samples at the dock. It should be noted that the information collected by the NGOs is mainly processed and analyzed for scientific publications or undergraduate or graduate theses.
- The NGO working with the scientific authority (IMARPE) is The Nature Conservancy - Peru (TNC - Peru), with whom they have been collecting catch and effort data, size structure, and tissue samples at the dock since 2022; all the information collected is for the exclusive use of IMARPE. These data are used for the analysis of biological and fishery indicators that contribute to the knowledge of the Peruvian chondrichthyan fishery and the development of future management measures.

Table 13. Summary of information shared by national institutions.[44]

Institution	Data	Period
LANDINGS		
IMARPE	Information on the artisanal fleet on an annual scale by month, species, port and fishing gear.	January 1996 - January 2023
PRODUCE	On an annual scale by month and region. Not classified by species (total, shark or ray).	2015 - 2022
SIZE AND SEX COMPOSITION		
IMARPE	Total size structure graph for *Prionace glauca* and *Isurus oxyrinchus*	2021 - 2023
MISCELLANEOUS		
IMARPE	Landing sites with shark records and monitored by their sampling program. Links to published reports.	
PRODUCE	Landing Certificate Form (CDT), fishing permits by vessel, inspected landing sites.	
MINAM	Non-detriment findings and reports (*Sphyrna zygaena*, *Isurus oxyrinchus* and *Mobulas* spp.*)*	

4. Summary of the best existing total shark catch estimates

Currently, Peru does not have official landing volumes, although there are different sources of information, such as IMARPE's Artisanal Fisheries Information Collection System and Shark Landing Certificates (CDT) and PRODUCE's information collection program. It should be noted that the IMARPE information and the CDTs, which were introduced in 2018, have data at the species level and per vessel fishing trip. Both represent only an approximation of the actual estimate, due to the uncertainty of the total catch at the country level (Pérez-Huaripata *et al.,* 2021). Since chondrichthyans are generally beheaded and gutted on board to be landed in ports or landing sites, it is difficult to identify them and record the total weight of species caught (IMARPE, 2022). However, through the Atlas of Artisanal Fishing (Guevara-Carrasco and Bertrand, 2017), IMARPE made an estimate of landings through the process of extrapolation of its database for the period 1997-2012. The extrapolation was carried out on a daily and monthly scale for each year, by landing site, by type of fishing gear and species, obtaining weight volumes for six chondrichthyan species (*M. whitneyi* humpback smooth-hound, shortfin mako shark, blue shark, smooth hammerhead shark, Peruvian eagle ray and Pacific guitarfish), for the main landing sites of the species, main fishing gear, region and average landings per month.

Although the works by González-Pestana *et al*., 2016 and 2022, did not make catch estimates, the effort to try to reconstruct landings (in weight), with information from FAO (reports and FishStatJ software) and IMARPE (reports and landing data), is noteworthy. Their results showed landings series for blue shark, shortfin mako shark, smooth hammerhead shark, common thresher shark, humpback smooth-hound *M. whitneyi*, angelshark, manta ray species of the *Myliobatis* spp. genus, Pacific guitarfish and diamond stingray.

[44] Information collected through December 2023.

VI. Summary of data sources: Metadata

Ecuador

A total of 323 documents related to sharks and rays were identified, consisting of 175 scientific articles, 78 theses (63 undergraduate, 11 graduate, 4 doctoral), 59 reports[45], 3 manuals and 8 management documents[46] (Figure 17). The provinces that contributed the most studies were Guayas (n = 34), Pichincha (n = 30), followed by Manabí (n = 23), Santa Elena (n = 16) and Galapagos (n = 9). At the international level, 211 publications were indexed in different scientific journals (Figure 18).

National institutions that have published research on sharks and rays include the Universidad San Francisco de Quito (USQF), Universidad de Guayaquil, Universidad de Santa Elena (UPSE) and Universidad Laida Eloy Alfaro de Manabí (ULEAM), as well as the Public Institute for Aquaculture and Fisheries Research (Figure 19). It is worth mentioning that only institutions/journals with more than one published document were considered for the data analysis.

The 323 studies were carried out by 211 researchers, of which 11 have the largest number of papers that have contributed to chondrichthyan research in the Ecuadorian Pacific. It is important to mention that the database only included the name of the main author of each scientific article and those that had more than one published paper, so the graphs generated do not represent co-authorships or authors with only one publication. It is important to note that many of the publications found were led by researchers mainly affiliated to national and international institutions, such as CICIMAR in Mexico, PNG, CDF, UCLA in the USA, among others (Figure 20).

The earliest studies found date from 1927 and 1933, after which there is no record of any research related to or directed at sharks in the period 1934-1967. From 1968 to 2006, the number of publications varied between one and three per year. In 2007 there was an increase in the number of documents, although there was a decrease between 2008 and 2012. In the period 2013-2022, there was a significant increase in research on chondrichthyans, similar to that found by Mejía *et al.* (2023), which showed a higher number of publications between 2020 and 2022. Scientific articles were the most common type of document in terms of number, and the most researched topics or approaches focused on ecology, followed by fisheries and biology (Figure 21).

In ecology, the dominant themes were trophic aspects of spatial distribution and abundance, the latter being one of the dominant themes for Galapagos. In fisheries, the dominant topics were catch, species composition, management, and size composition. For biology, on the other hand, species identification and reproduction were the dominant themes (Figure 22).

With regard to theses, the period 2012-2022 showed an increase in the number of undergraduate theses. Within this period, biology was the dominant topic in 2015, while ecology and fisheries were the dominant topics in 2020 (Figure 23). Scientific article publications in biology were mainly focused on species identification, length-weight relationships and reproduction. On the other hand, in the ecology approach, the topics were related to feeding, distribution and abundance. In the fisheries approach, however, the dominant topics were catch and anthropology (Figure 24).

In terms of research related to fisheries, they were mainly carried out on longline fishing techniques (n = 25), developed between 2012-2022, followed by gillnets (n = 15), carried out in 2010, with a higher frequency between 2014-2021. For the analysis of the most studied fleet types in Ecuador, a special regional classification was used that is applied for the ABNJ-Tuna II project (artisanal, medium-scale and industrial) and does not

[45] The reports cover fisheries technical documents prepared by management and scientific bodies.
[46] Documents classified under the management category contain regulatory and management information.

correspond to the official classification of the fishing fleet described in previous sections. As a result, approximately 60% of the documents were focused on the artisanal fleet, followed by studies that analyzed artisanal and industrial fisheries, which accounted for 13%, while research on vessels specialized in scientific studies accounted for 11%. Finally, studies on the industrial and medium-scale fleets accounted for 10% and 6%, respectively (Figure 25).

In terms of taxonomic groups, it was found that sharks predominate in research since the first study found in 1927 to 2022. Meanwhile, rays remain largely unexplored. However, since 2014, there has been an increase in studies focused on rays, especially between 2015 and 2021 (Figure 25). In the case of chimaeras, only three technical reports were identified with information corresponding to this group: one as accompanying fauna in demersal fisheries, another as part of the list of species identified in Ecuadorian waters, and finally the Chondrichthyan Field Guide of Ecuador, 2023.

The most studied species in Ecuador, according to the documents identified for this study, were scalloped hammerhead shark, silky shark, blue shark, pelagic thresher shark, shortfin mako shark, bigeye thresher shark, blacktip shark, Galapagos shark and tiger shark (*Galeocerdo cuvier*). It should be noted that the most common study topics for these species were mainly focused on fisheries, ecology and data-limited analyses (Figure 26).

With respect to the study topics on the fisheries of the most important species, catch and species composition were the main topics. To a lesser extent, aspects such as import/export and size composition were studied. In the field of ecology, the most prominent topics for the same group of sharks were feeding and spatiotemporal distribution. Although genetic structure studies were less frequent, they focused on shark species belonging to the genus *Sphyrna* spp. In addition, in the field of biology, research was developed on species identification, physiology and reproduction. It is important to note that for the Galapagos region, about 11 Productivity-Susceptibility Analyses (PSA) were found in which sharks were analyzed within the group of species studied (Figure 27).

With regard to chondrichthyan species, which have been understudied, this group of species has the peculiarity of inhabiting deep waters. The number of research papers found was less than three, focused on biology and fisheries (Figure 28).

Mexico

As a result, 549 documents related to shark and ray studies conducted in the Mexican Pacific were obtained, categorized into scientific articles, reports, theses, manuals, and management documents. According to these categories, scientific articles contributed the largest number of documents (50.3%), followed by undergraduate and graduate theses (37.5%), technical reports (10%), and management documents and manuals (8% and 3%, respectively) (Figure 29). These documents show a distribution pattern with a higher number of documents generated in the northern states of Mexico (with a Pacific coastline) than in the southern states (Figure 30). This pattern could correspond to the presence of academic/scientific institutions such as CICESE and CICIMAR, located in the states of Baja California and Baja California Sur, respectively, which are internationally recognized (Figure 31). The authors of these documents included Mexican and foreign researchers, as well as government agencies responsible for fisheries management (CONAPESCA; IMIPAS). The author with the largest number of documents is CONAPESCA, with 41 documents, mainly consisting of statistical yearbooks, official standards and technical reports. Other authors with a significant number of documents are Becerril-García (nine documents) and Márquez-Farías, Escobar-Sánchez and IMIPAS (seven documents each; Figure 32).

The 549 documents were generated between 1882 and 2023, although there was an exponential increase in production between 2004 and 2007, with the highest numbers in 2014 (30 documents), 2016 (37 documents),

2020 (41 documents) and 2021 (31 documents) (Figure 33). The decrease in document production between 2020 and 2021 seems to be related to the measures adopted in Mexico in the face of the COVID-19 pandemic. It is possible that, for the same reason, document production decreased in the years following the pandemic and returned to levels similar to those before COVID-19.

Regarding the frequency of documents by category over time, it can be observed that documents in the report and thesis categories have a more consistent presence over time (Figure 34). This could be due to the obligation of governmental institutions to report on their activities and the interest of academic institutions in the study of this group of fish. It can also be observed that both theses and scientific articles show a similar significant increase since 2004. It is possible that this similarity is due to the fact that one or more scientific articles correspond to an undergraduate or graduate thesis. However, a specific analysis of the documents that make up both categories is still needed to explain this correlation.

To characterize the documents over time and by topic, they were classified into biological, ecological, stock assessment and fisheries approaches (Figure 35). For both scientific articles and thesis documents, the main approaches recorded were ecological, fisheries and biological. It is important to note that the production of these types of documents with a fisheries approach started significantly in the 2000s, and in the case of the ecological approach, there has been an increase from 2002 to date. In the case of reports, most of the documents have been classified in the fisheries category because they correspond to reports of federal institutions responsible for the management of fishery resources. Perhaps for this reason, they show a more stable pattern over time.

In addition to the four (4) main approaches into which all documents were categorized, each approach had sub-focuses that helped to better characterize them (Figure 36). For example, it was found that the main sub-focuses registered within the biological approach were reproduction and physiology. In the ecological approach, the main sub-focuses recorded were feeding and horizontal movement. For fisheries, the main sub-focuses were catch and management. Finally, in population assessment, the main sub-focuses were population simulation, reproduction, and environmental preferences.

In terms of theses, the oldest are undergraduate theses, with a first record in 1947 and a constant production since 2003 (Figure 37). Graduate theses contribute the largest number of documents, with a higher production between 2017-2020, and doctoral theses present a constant production since 2007, with an increasing production in the last 5 years. The theses were classified into the following approaches: biology, ecology, fisheries, and stock assessment, in order to know the subject of the study. Among these approaches, the most recurrent are biology and ecology in graduate theses.

Considering only the documents classified as scientific articles (276 publications), it can be observed that throughout their production time (1947-2023), the oldest ones correspond to the fisheries approach, and for the rest of the approaches (biology, ecology and stock assessment), their constant production occurs in the last decade (2003-2023) (Figure 38). With respect to the sub-approaches, a similar behavior to the total number of documents can be observed. In the biological approach, the most recurrent sub-focuses were reproduction, morphometrics, species identification and physiology. In the ecology approach, the most recurrent sub-focuses were feeding, species identification and horizontal movement. In the fisheries approach, the most recurrent sub-focus was catch. Finally, in the stock assessment approach, the most recurrent sub-focuses with the same number of documents (2) were population simulation, reproduction and horizontal movement.

In order to know the level of management and interest in shark fisheries in Mexico, the documents were also classified by fishery, fleet and taxonomic group (Figure 39). In terms of fisheries, it was found that the highest proportion of documents corresponded to gillnet and longline fisheries. In the case of the fishing fleet, the

highest proportion of documents corresponded to artisanal fisheries. In the case of the taxonomic group, the most representative subject is sharks, followed by rays, and sharks and rays as a whole. In general, these three approaches show an increase in production since 2007.

Taxonomically, it was found that the 549 documents are dedicated to one or more chondrichthyan species, registering a total of 156 species (Figure 40). Of these species, 89 have three or more papers, while 67 have two or one paper. The shark group was the most dominant, with the most representative species being the scalloped hammerhead shark with 105 papers and a predominant focus on fisheries with 37 papers. This is followed by the blue shark with 100 papers, with a predominance of the fisheries approach with 46 papers. In third place is the silky shark with 96 papers, with a predominance of the fisheries approach with 35 papers. In the study of the different shark species documented, the most recurrent sub-focuses within biology were physiology, morphology and reproduction. In ecology, the most recurrent topics were feeding, physiology and parasitology. In fisheries, the most recurring sub-focuses were catch, management/control, and fishery characterization. Finally, in stock assessment, the most recurring sub-focuses were catchability and species composition (Figure 41).

On the other hand, the species that make up the ray group are the least studied, as well as the least known shark species. A common feature of most of these species is that they are recognized by their benthic habits. For this group of species (<2 papers), the most common approaches were ecology and biology (Figure 42).

Peru

The Peruvian counterpart for this project was IMARPE, with whom visits to five regional headquarters were coordinated to evaluate logistical support and to learn about the dynamics of landings at the main sites identified by the regional headquarters' researchers (see Appendix II, Peru section). Possible collaborations with universities, NGOs and the Peruvian CITES scientific authority are currently being evaluated.

A total of 295 documents were recorded: 118 reports, 93 scientific articles, 40 theses, 33 management documents and 11 manuals (Figure 43), distributed in seven coastal departments of Peru (Figure 8). The highest number of documents was recorded in the department of Lima, followed by those published internationally (mainly publications in indexed journals[47]). In Lima, an increase was recorded from 2013, while international documents from 2016 (Figure 44).

Among the main academic, governmental and non-governmental institutions, international organizations and civil society, the documents produced by the Universidad Nacional de Trujillo (UNT, thesis), Universidad Científica del Sur (UCSUR, theses), IMARPE (reports and manuals), PRODUCE (standards and reports), MINAM (reports), OCEANA (reports and manuals), CPPS (reports), Revista de Biología Marina y Oceanografía (international publication) and Fisheries Research (international publication) stand out (Figure 45). In addition, more than 120 authors have been identified who have written scientific articles, reports, theses and manuals. Figure 46 shows the main authors with more than one published document, highlighting three government institutions that have developed research related to fisheries (IMARPE, MINAM and PRODUCE), stock assessment (IMARPE) and biology (IMARPE). In contrast, the main authors in the indexed journals and reports have focused on topics related to ecology, biology and fisheries (catches): González-Pestana (2016-2022), Estrella-Arellano (1998-2001), Flores (1994, 1996, 1998 and 1999), and Elliot (1995-1997).

The total number of registered documents covers the period from 1967 to 2023, with the highest number occurring after 2014, the year in which PAN SHARK-PERU was established (Figure 47). Scientific papers focused

[47] International includes thesis papers, reports and publications in indexed journals.

on biology, ecology and fisheries studies. Reports focus on fisheries, and the last eight years have seen an increase in population assessment studies (Figure 47). The number of theses in biology, ecology and fisheries has increased since 2014, the number of manuals focused on fisheries and biology has increased since 2013, and the number of management standards has increased since 2016 (Figure 47).

Focus on species identification, morphometrics, and reproduction dominated biology (Figure 48). In ecology, there were more documents on feeding, genetic structure of the population and environmental preferences (Figure 48). Information on fisheries focused mainly on catch (landings), management, size composition, fishery characterization, fish trade and heavy metal analysis (Figure 48). Since 2016, only six documents have focused on stock assessment were recorded, and five of them correspond to the reports produced annually by IMARPE for the smooth hammerhead shark (Figure 48).

Theses have been recorded since 1975; three correspond to the *bachellor* degree, which is academic research that marks the end of the university career. These theses were identified in 1975, 1977 and 2020 and focus on fisheries, biology and ecology studies, respectively (Figure 49). The largest number of theses correspond to undergraduate degrees (n=30) and focus on biology, ecology and fisheries studies (Figure 49). Graduate theses (n= 6) focus on ecology and fisheries studies, while Ph.D. theses (n= 1) focus on ecology (Figure 49). The time series for theses shows an increase in biology, ecology and fisheries studies from 2016 (Figure 49).

Of the 93 scientific articles registered, 31 had a biological approach, highlighting the topics of species identification, morphometry and reproduction; 33 in ecology, highlighting topics related to feeding, genetic structure of the population and environmental preferences; and 29 with a focus on fisheries. Unlike biology and ecology studies, where the largest number of publications start from 2021, this approach presents a variety of topics related to catches, fishery characterization, size composition, fish trade, among others, mainly since 2014 (Figure 50).

Of the total number of documents, most did not specify the type of fishery, but a greater number of studies were observed with data from vessels using gillnets, longlines and both gears together (Figure 51). Most documents used information from the artisanal fleet, followed by studies without information on the type of fleet (Figure 51). In terms of taxonomic groups, studies on sharks or sharks and rays as a whole stand out; however, since 2016 there has been an increase in studies on rays only (Figure 51).

The most studied chondrichthyan species in Peru include smooth hammerhead shark, blue shark, shortfin mako shark, common thresher shark, Pacific guitarfish, humpback smooth-hound *M. whitneyi*, Chilean eagle ray, Peruvian eagle ray, copper shark, and tope shark, among others (Figure 52). It should be noted that all of these species have studies on biology, ecology and fisheries; only the smooth hammerhead had more than one study related to population assessment (Figure 52).

By species, the most studied topics in biology are species identification and taxonomy. Reproduction studies have been recorded on species such as the smooth hammerhead shark, the humpback smooth-hound *M. whitneyi*, the Chilean eagle ray, the Peruvian eagle ray and the Velez ray *Rostroraja velezi*; length-length relationships for the blue shark, length-weight relationships for the sharptooth smooth-hound *Mustelus dorsalis*, while growth parameters for the smooth hammerhead shark and morphometric studies have been carried out on several species (Figure 53). There are several studies in ecology, highlighting those of the smooth hammerhead shark in feeding, stomach content, genetic stock structure, breeding area studies, stable isotopes and environmental preferences; devil fish *M. mobular* in feeding, stomach content, genetic stock structure, stable isotopes and environmental preferences (Figure 53). For fisheries, almost all species have studies related to catch, management, and characterization of the fishery; the three main species studied have studies on

almost all topics related to fisheries, with the exception of blue shark, which has all studies (Figure 53). As mentioned above, there is only one specific stock assessment study for the smooth hammerhead shark.

Figure 54 shows the least studied species, with a focus on biology.

VII. Figures: Summary of data sources

Ecuador

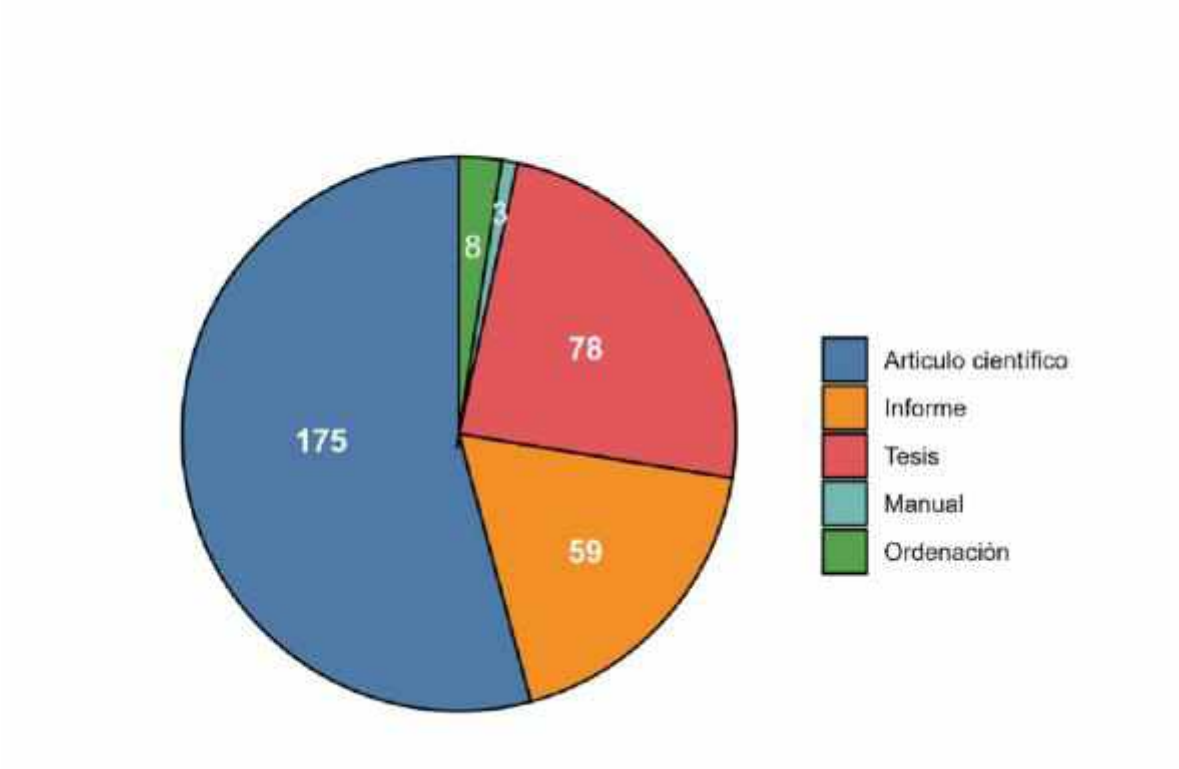

Figure 17. Documents related to chondrichthyan studies conducted in Ecuador, 1927-2023.

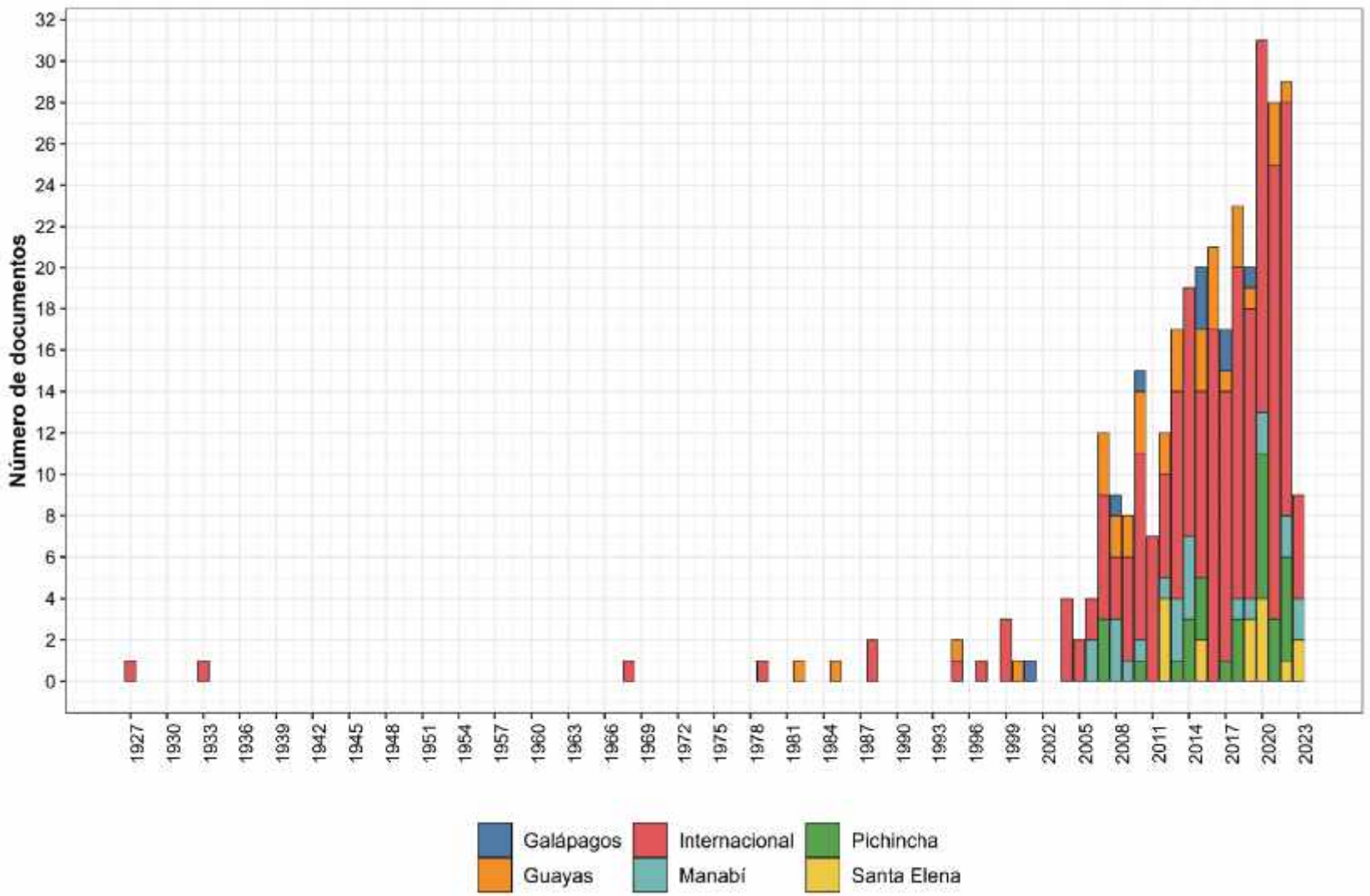

Figure 18. Number of publications on chondrichthyans by province of Ecuador, 1927-2023.

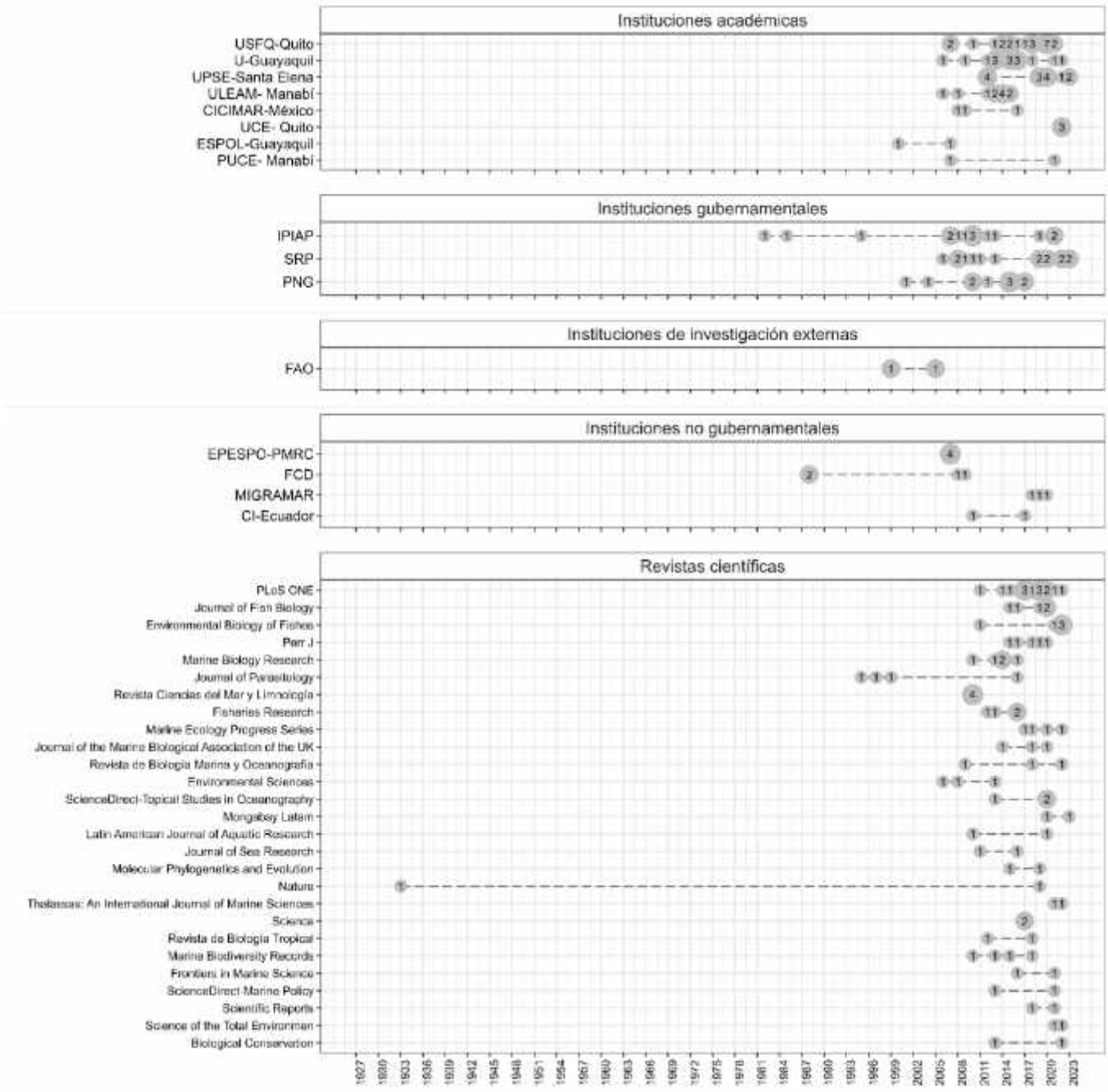

Figure 19. Number of documents on chondrichthyans by academic, governmental and non-governmental institutions, external research institutions and scientific journals in Ecuador, 1927-2023.

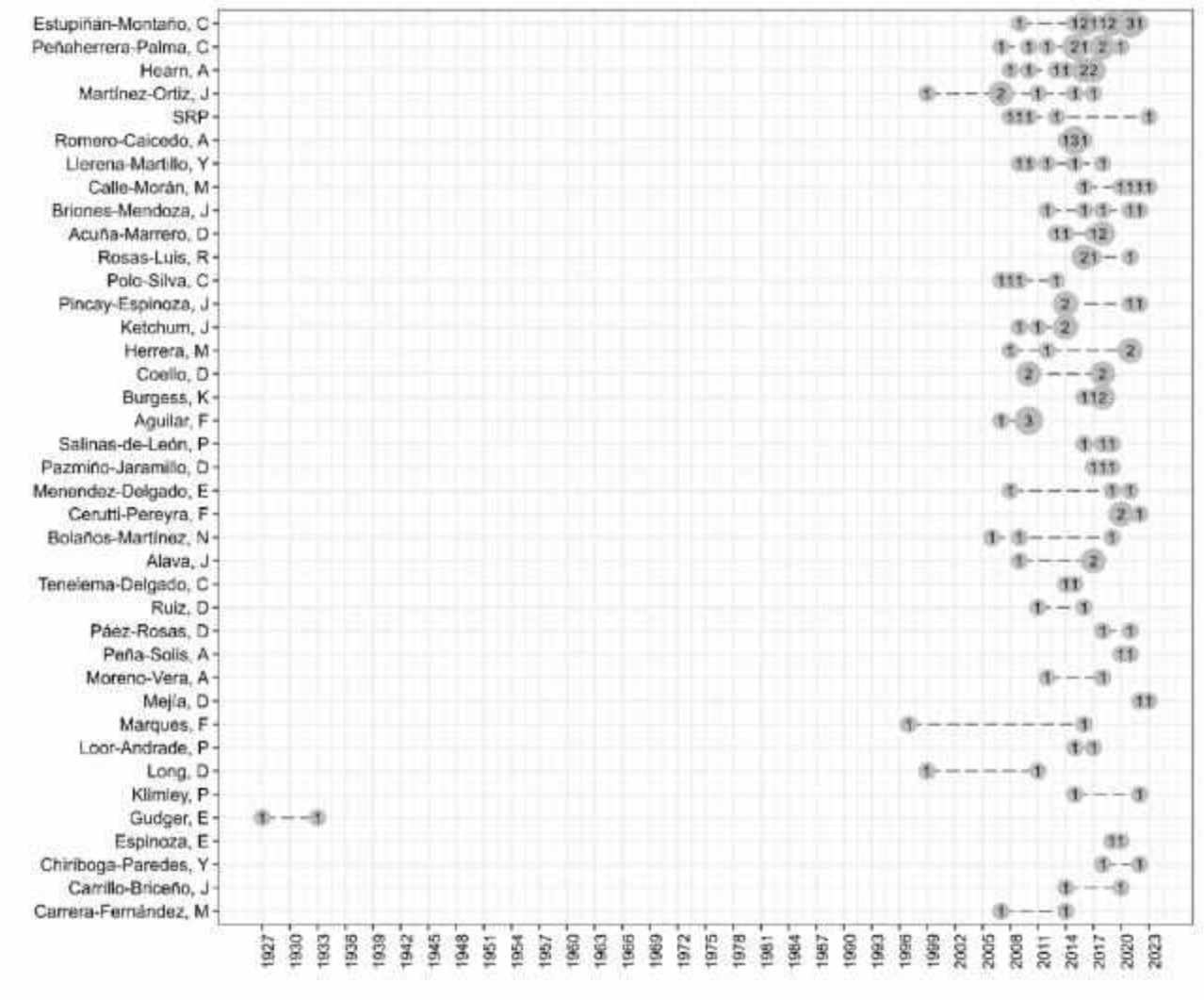

Figure 20. Main authors with research on chondrichthyan species in Ecuador, 1927-2023; this graph only includes the first author and does not include co-authors who have published more than one paper, and is in order of importance.

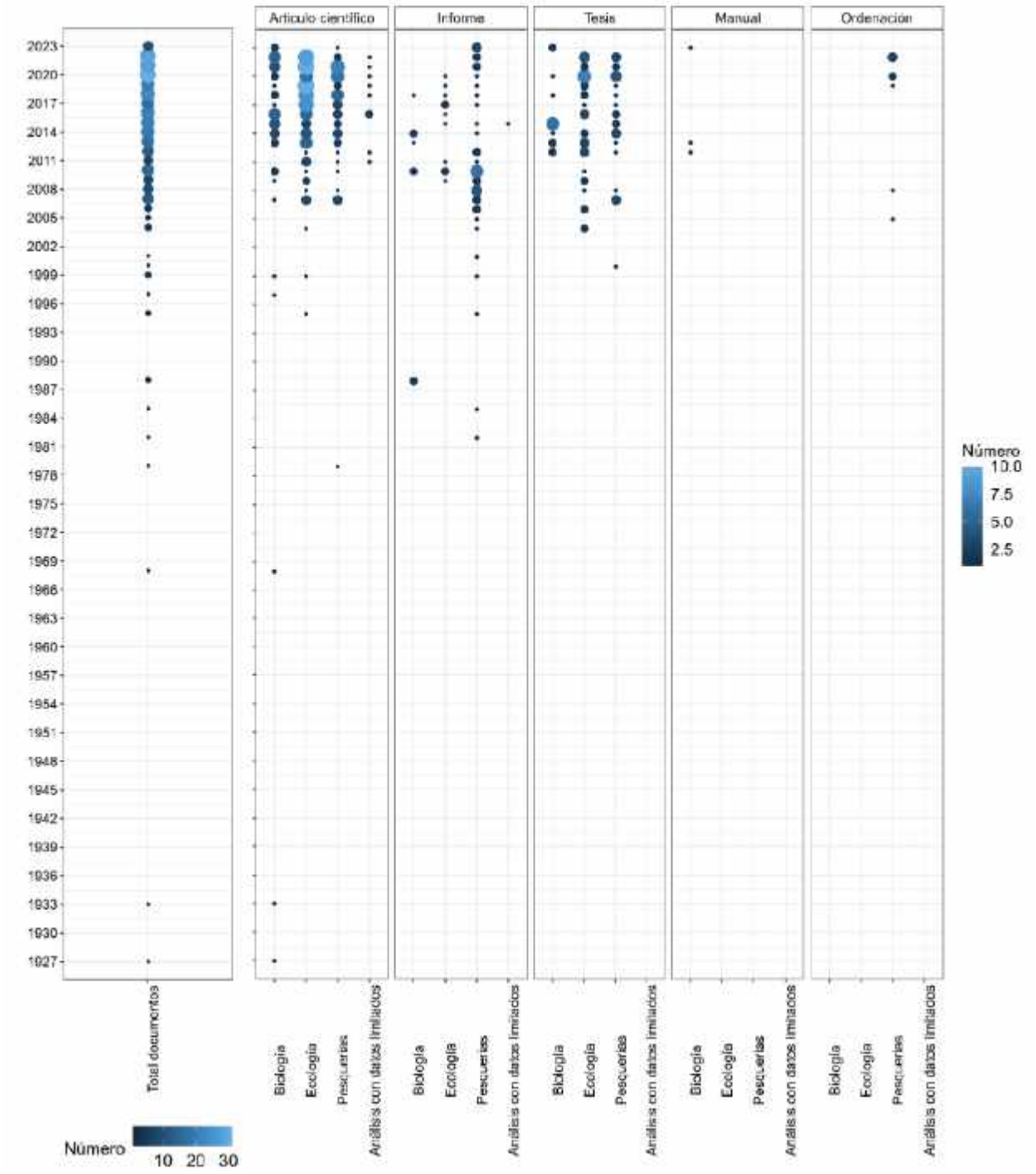

Figure 21. Chronology of the total number of documents identified, by type (scientific article, report, thesis, manual and management document) and focus (biology, ecology, fisheries and stock assessment) in Ecuador, 1927-2023.

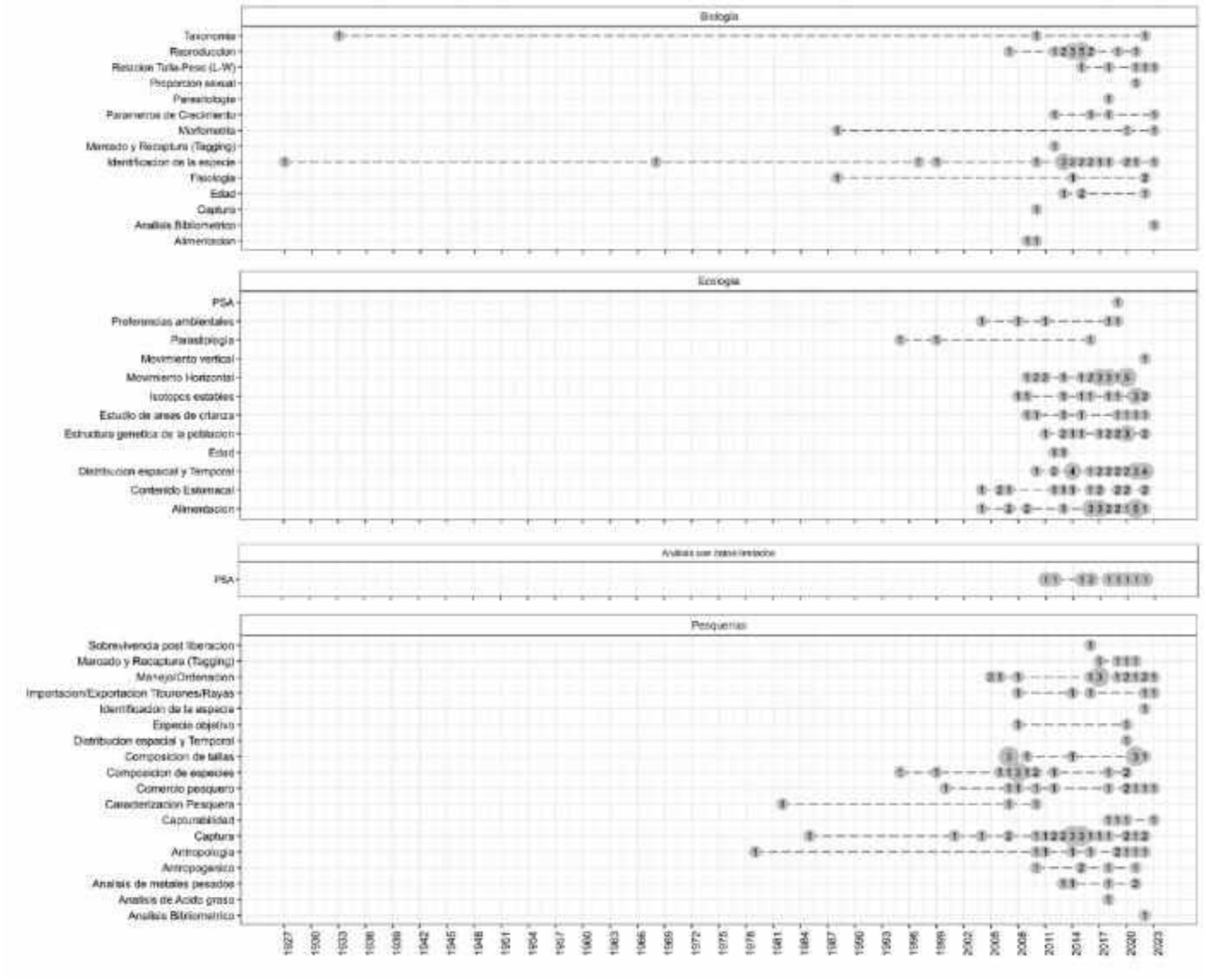

Figure 22. Chronology of the number of documents identified by approach and sub-focus in Ecuador, 1927-2023.

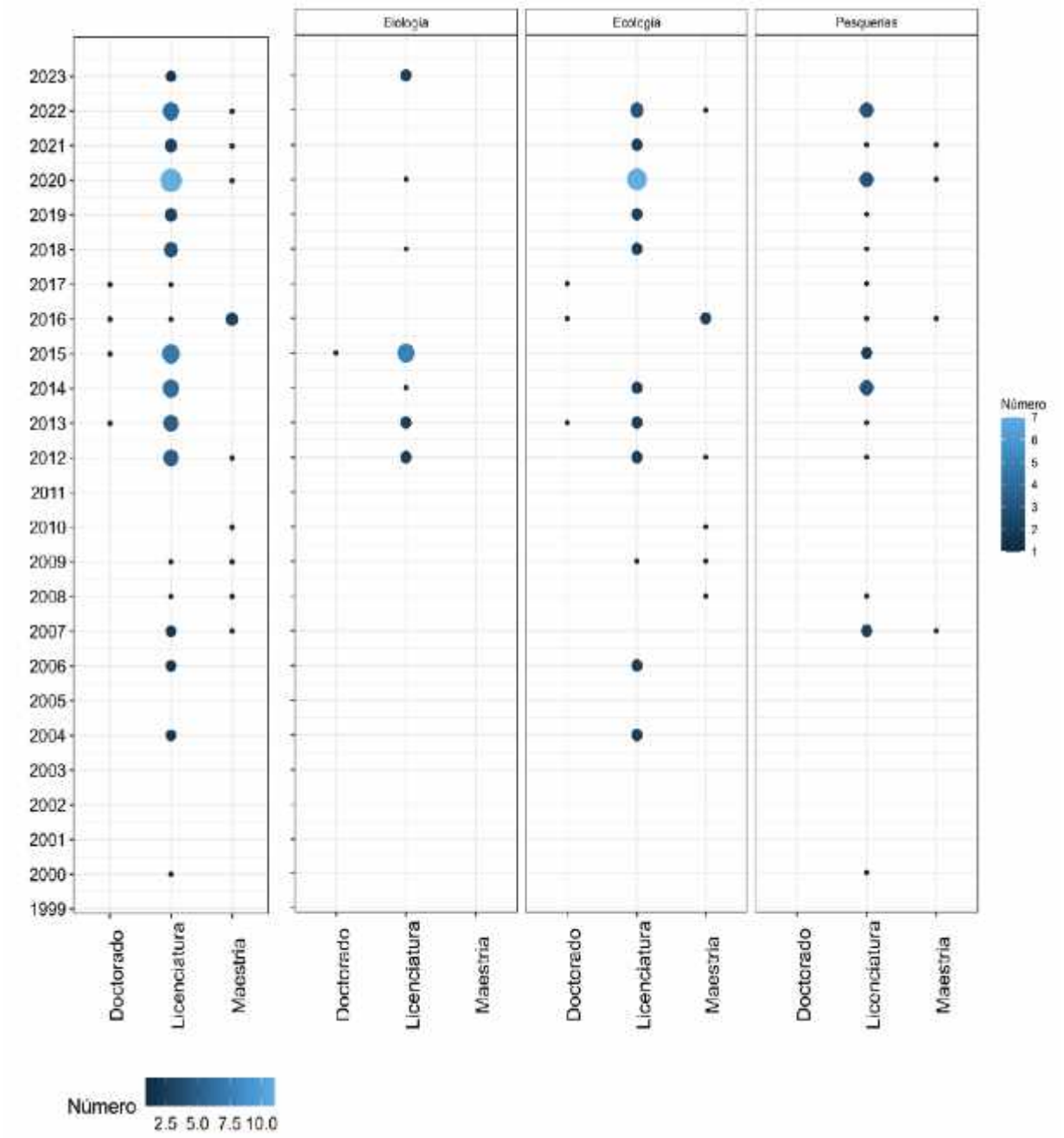

Figure 23. Chronology of the number of types of theses identified (undergraduate, graduate and PhD), and type of thesis by approach in Ecuador, 1999-2023.

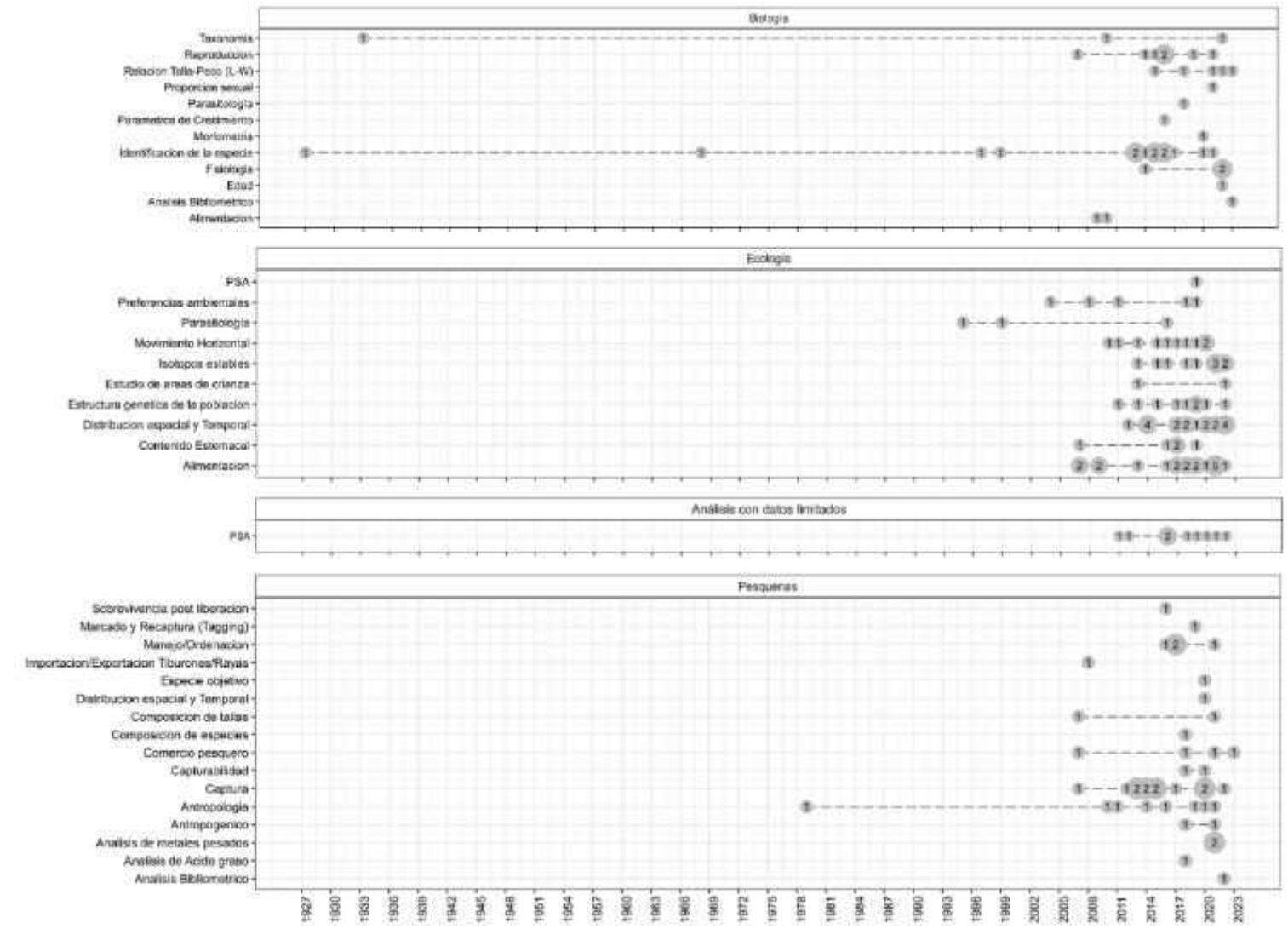

Figure 24. Chronology of number of scientific articles by approach and sub-focus in Ecuador, 1927-2023.

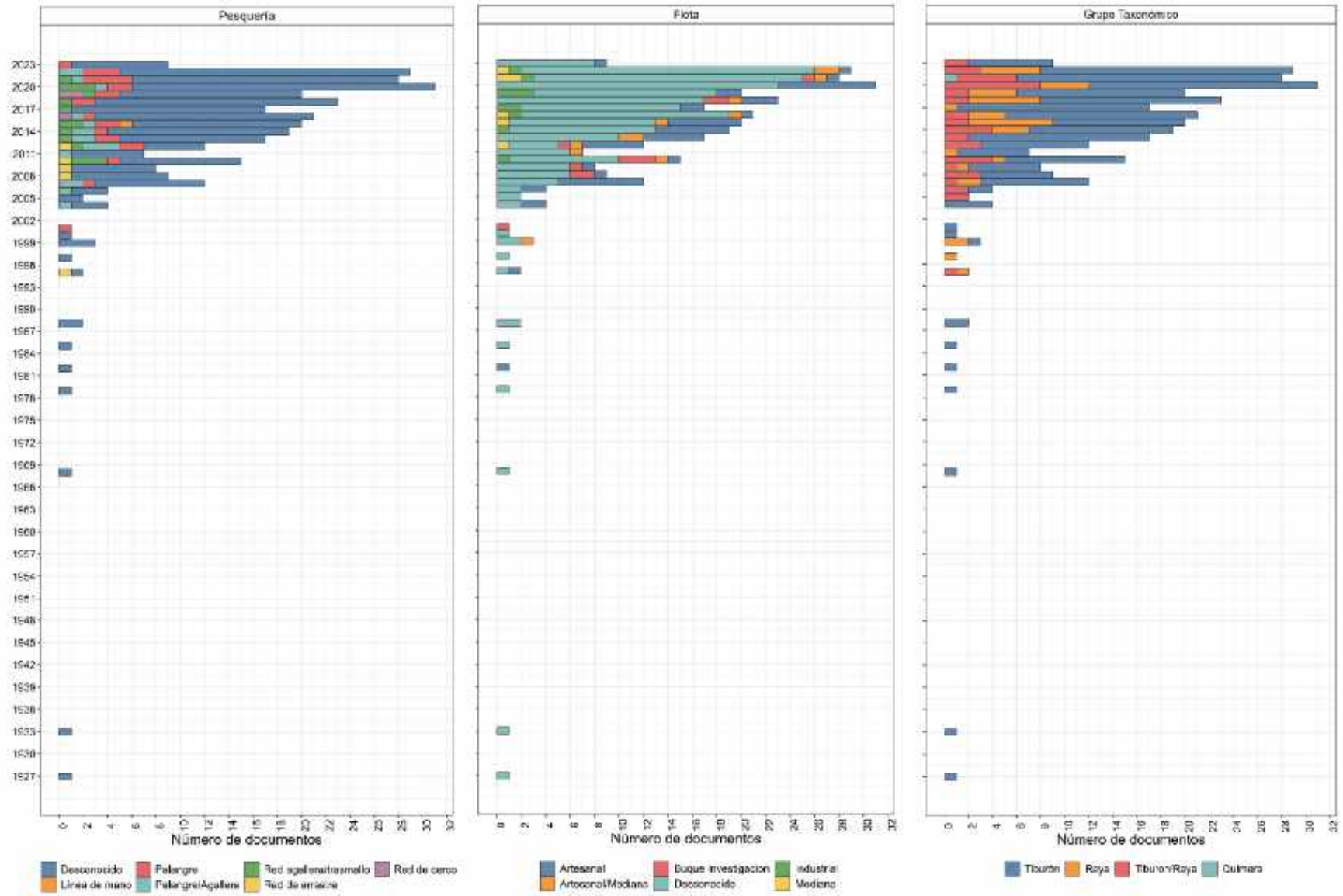

Figure 25. Number of studies by taxonomic groups, type of fishery and fishing fleet, Ecuador, 1927-2023.

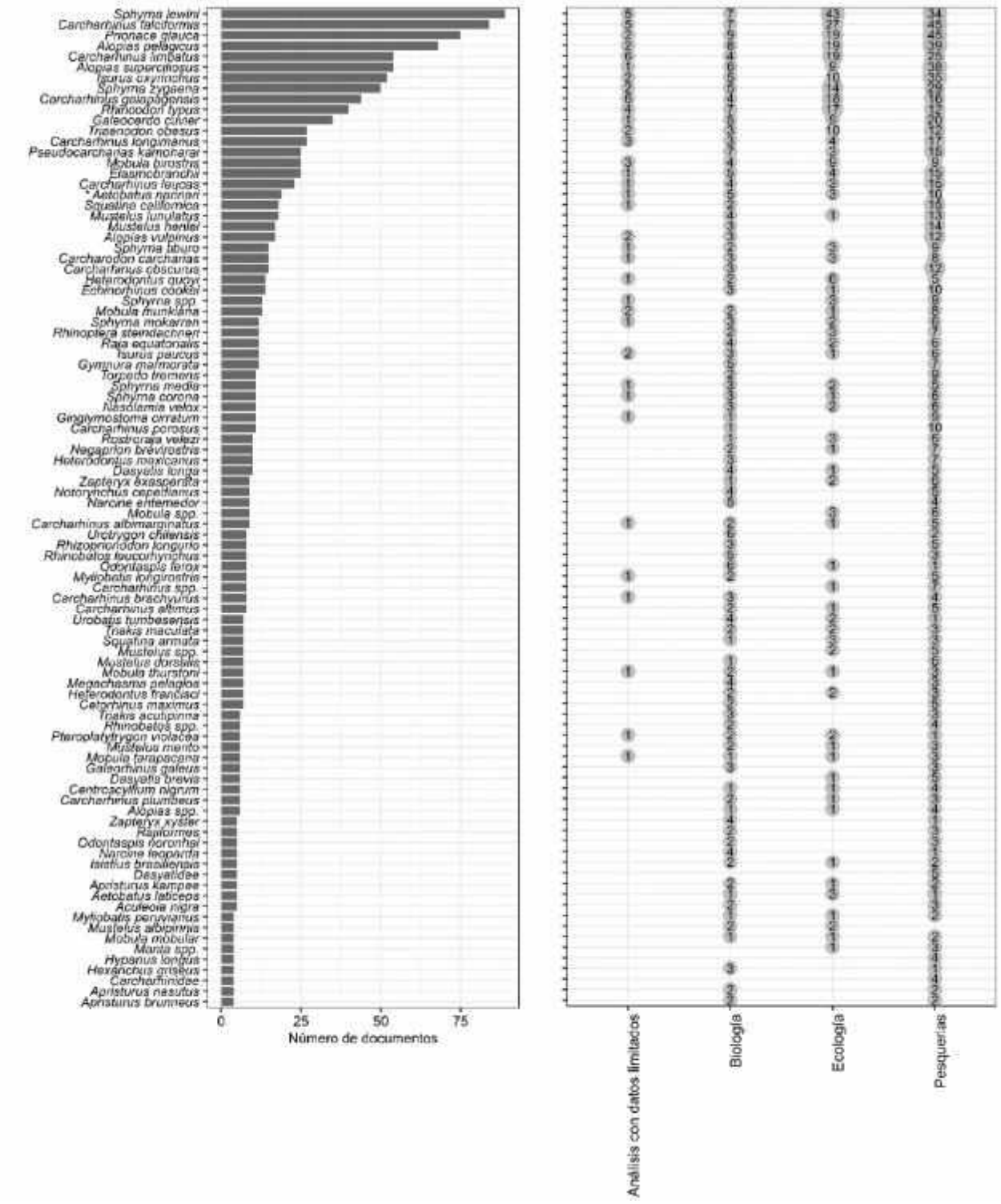

Figure 26. Main species studied in Ecuador, according to frequency of occurrence, distributed by type of approach, 1927-2023. The names of the species reported in the reviewed documents have been respected, even if they have changed and both names have been taken into account; for example, the species *Aetobatus narinari* (*) changed its scientific name to *Aetobatus laticeps* (Fallas-Madrigal *et al.,* 2021) and *Dasyatis longa* changed to *Hypanus longus.*

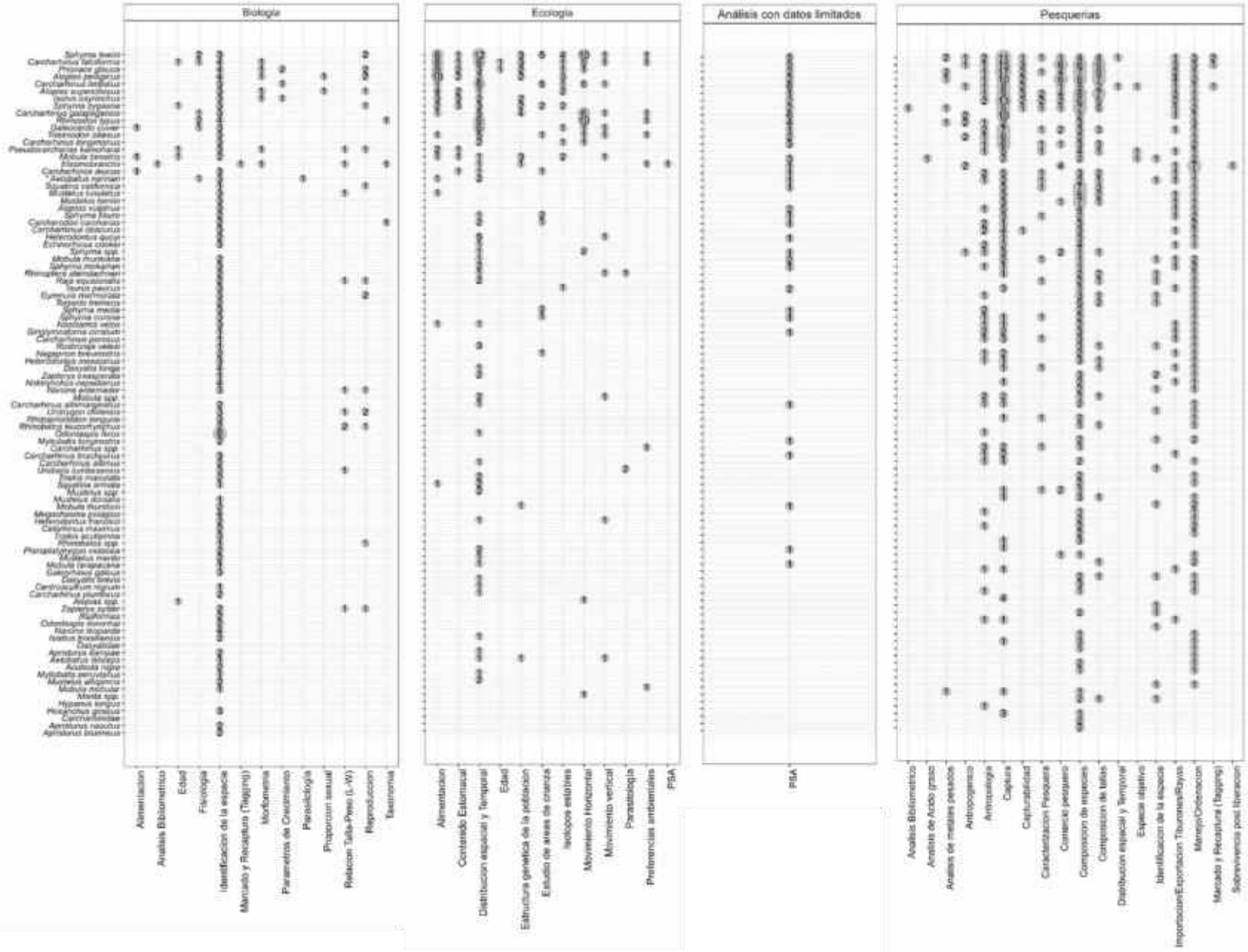

Figure 27. Number of documents of the most studied species by approach and sub-focus in Ecuador, 1927-2023.

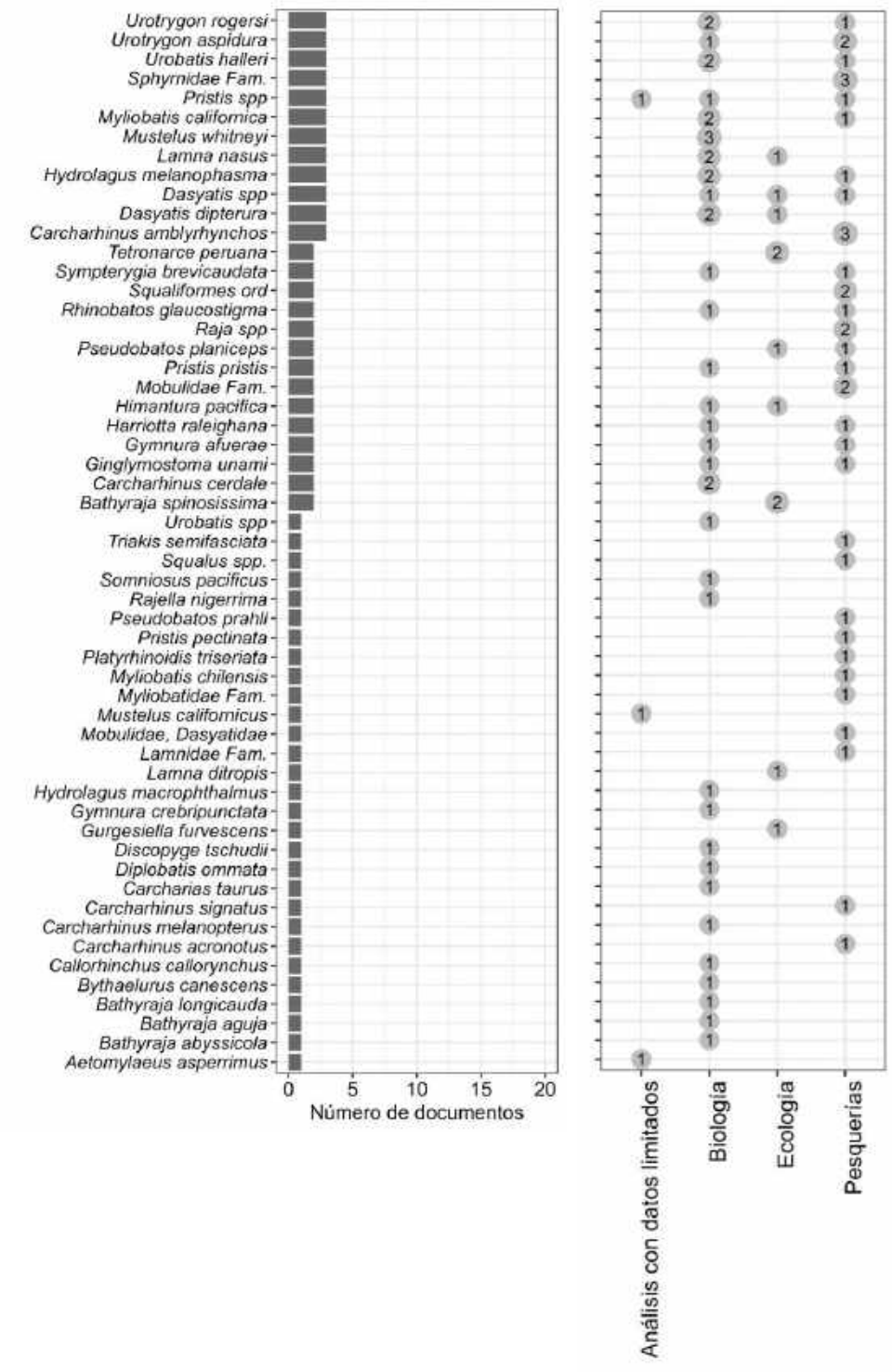

Figure 28. Total number of documents of the least studied species in Ecuador, broken down by species and type of approach, 1927-2023.

Mexico

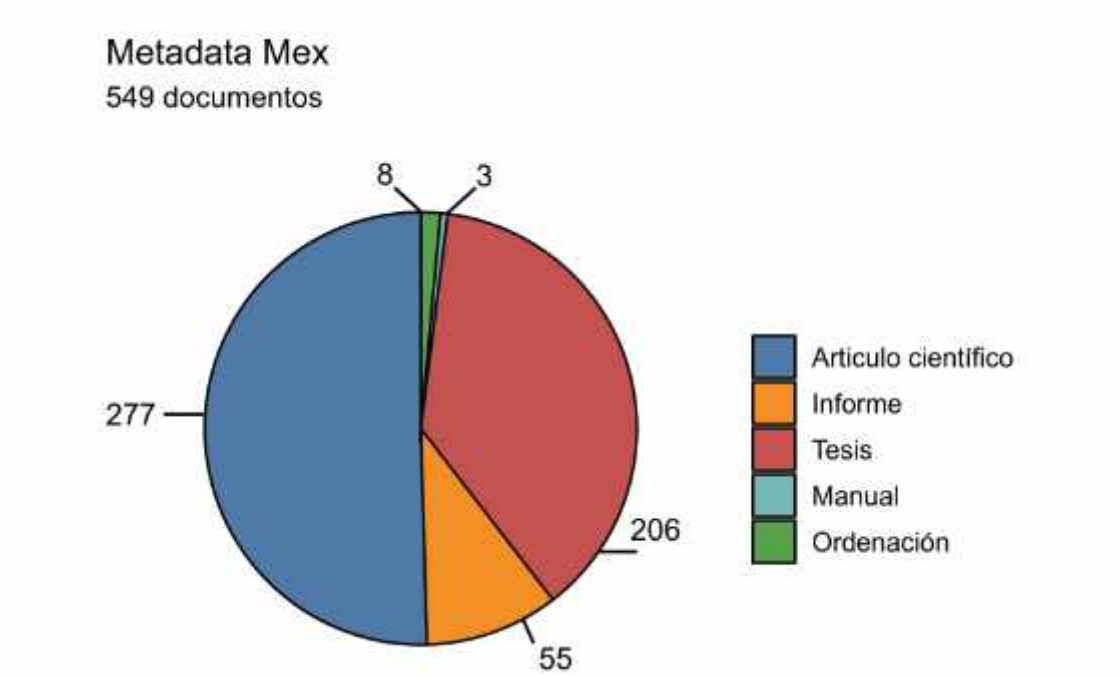

Figure 29. Documents related to chondrichthyan studies conducted in the Mexican Pacific; the color scale on the right indicates the category of the document.

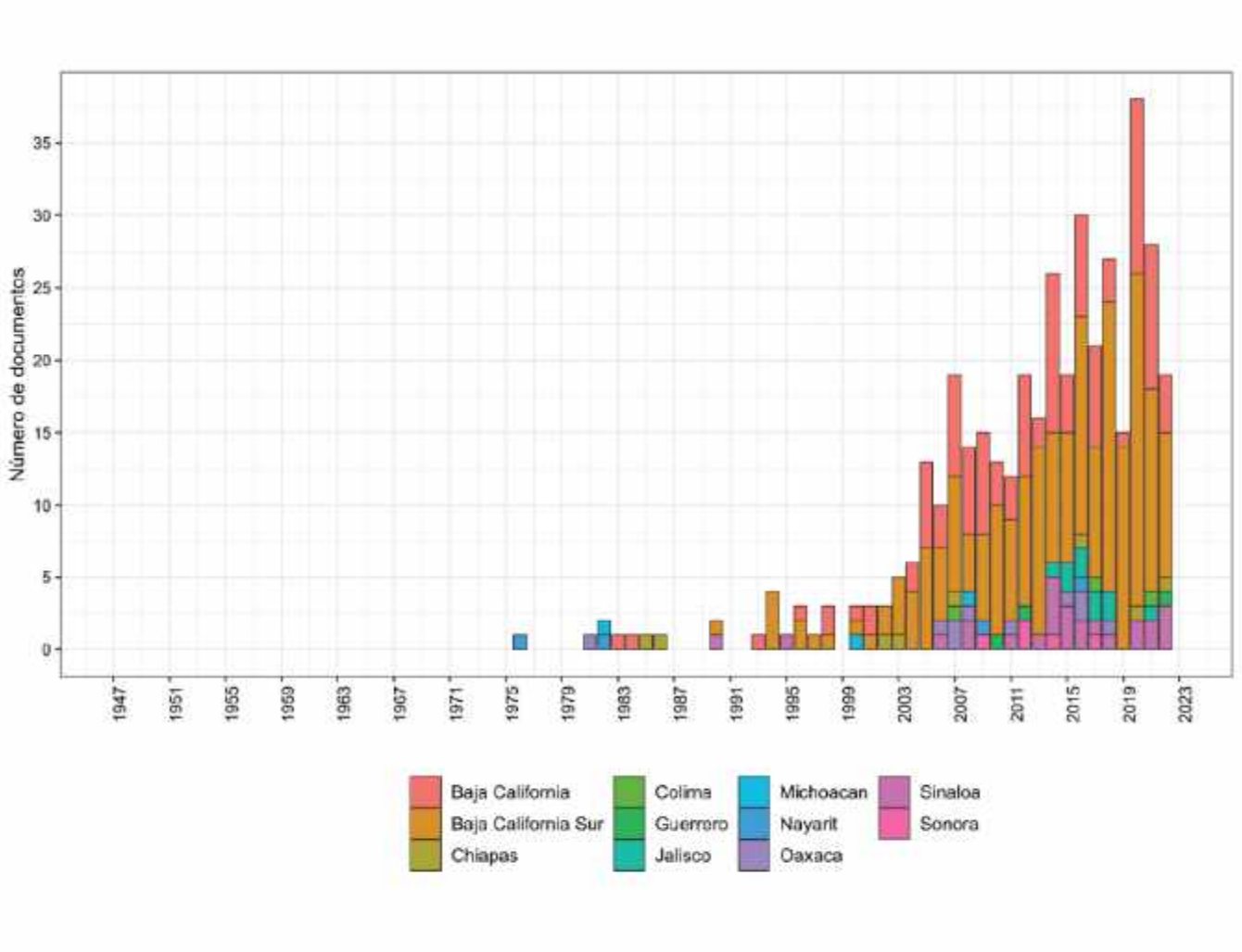

Figure 30. Distribution of documents by Mexican Pacific states, showing the number of documents (y-axis) and the time period of production (x-axis); the color scale indicates the different states with a coastline on the Mexican Pacific. This graph does not include documents produced by states that do not have a coastline on the Mexican Pacific. (n= 131).

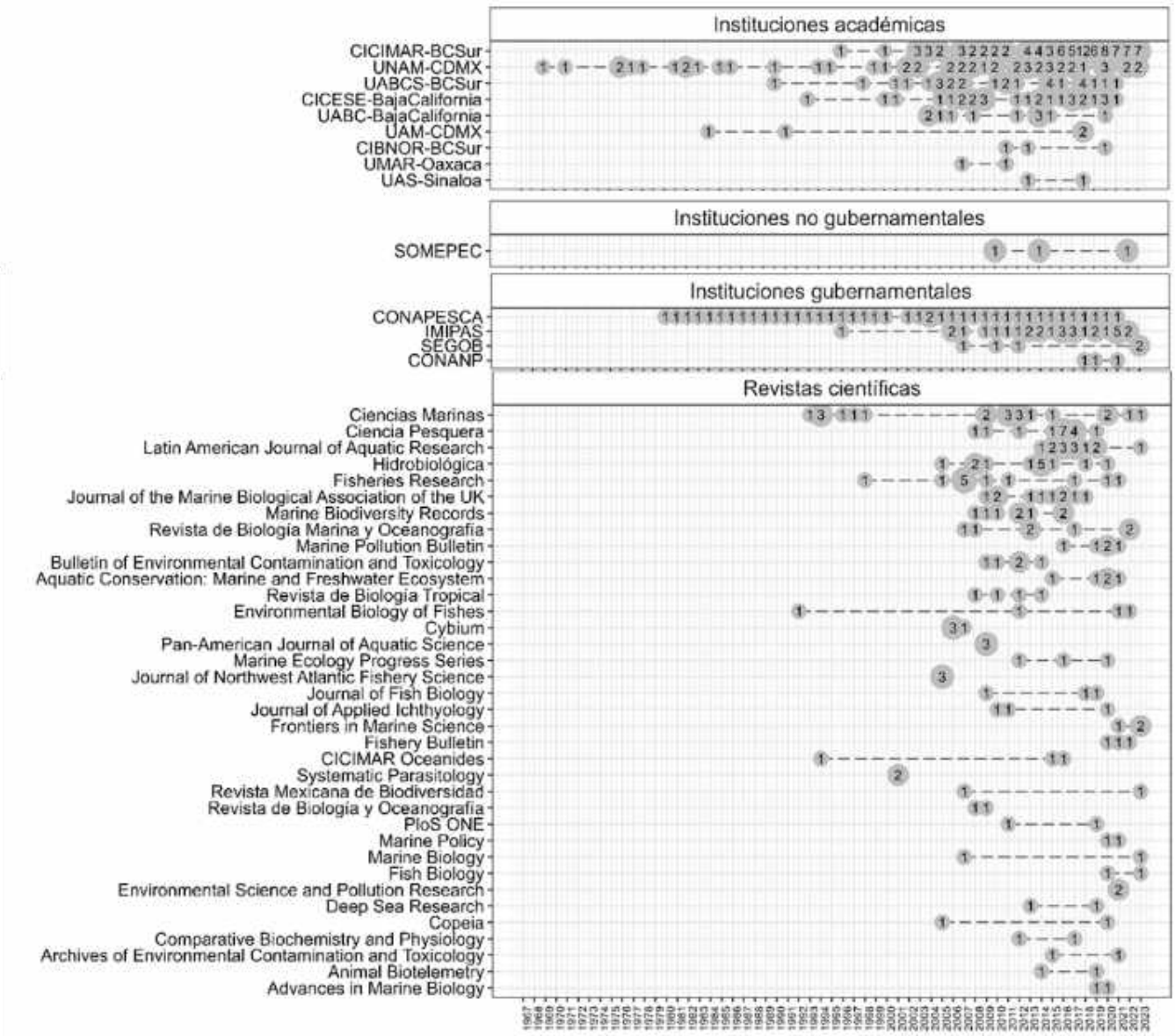

Figure 31. In order of representativeness, the documents on sharks and rays produced by different academic institutions, non-governmental institutions, governmental institutions and scientific journals are presented. The period of production of the document (x-axis) and the different institutions[48] that produced it (y-axis) are indicated; each bubble is located in the year of its publication and the number inside indicates the number of publications for that year. For visual purposes, this graph does not include institutions with less than two papers (n=27); this graph does not represent inter-institutional collaboration in research or paper production.

[48] CICIMAR: Centro Interdisciplinario de Ciencias Marinas; UNAM: Universidad Nacional Autónoma de México; UMAR: CICESE: Centro de Investigación Científica y Educación Superior de Ensenada; UABCS: Universidad Autónoma de Baja California Sur; CIBNOR: Centro de Investigaciones Biológicas del Noroeste; UABC: Universidad Autónoma de Baja California; Universidad del Mar; UC: Universidad de California; UDG: Universidad de Guadalajara; UAS: Universidad de Sinaloa; UAM: Universidad Autónoma de México; UANL: Universidad Autónoma de Nuevo León; ECOSUR: El Colegio de la Frontera Sur; CAM: (pendiente); UNISI: (pendiente); UNICACH: Universidad de Ciencias y Artes de Chiapas; UCOL: Universidad de Coloma; UNISON: Universidad de Sonora; IMIPAS: Instituto Mexicano de Investigación Pesquera y Acuícola; CONAPESCA: Comisión Nacional Pesquera; SEGOB: Secretaría de Gobernación; CONANP: Comisión Nacional de Áreas Naturales Protegidas; NOAA: National Oceanic and Atmospheric Administration; PSRC: Pacific Shark Research Center; MBARI: Monterey Bay Aquarium Research Institute; Scripps, Institution of Oceanography; SOMEPEC: Sociedad Mexicana de Peces Cartilaginosos.

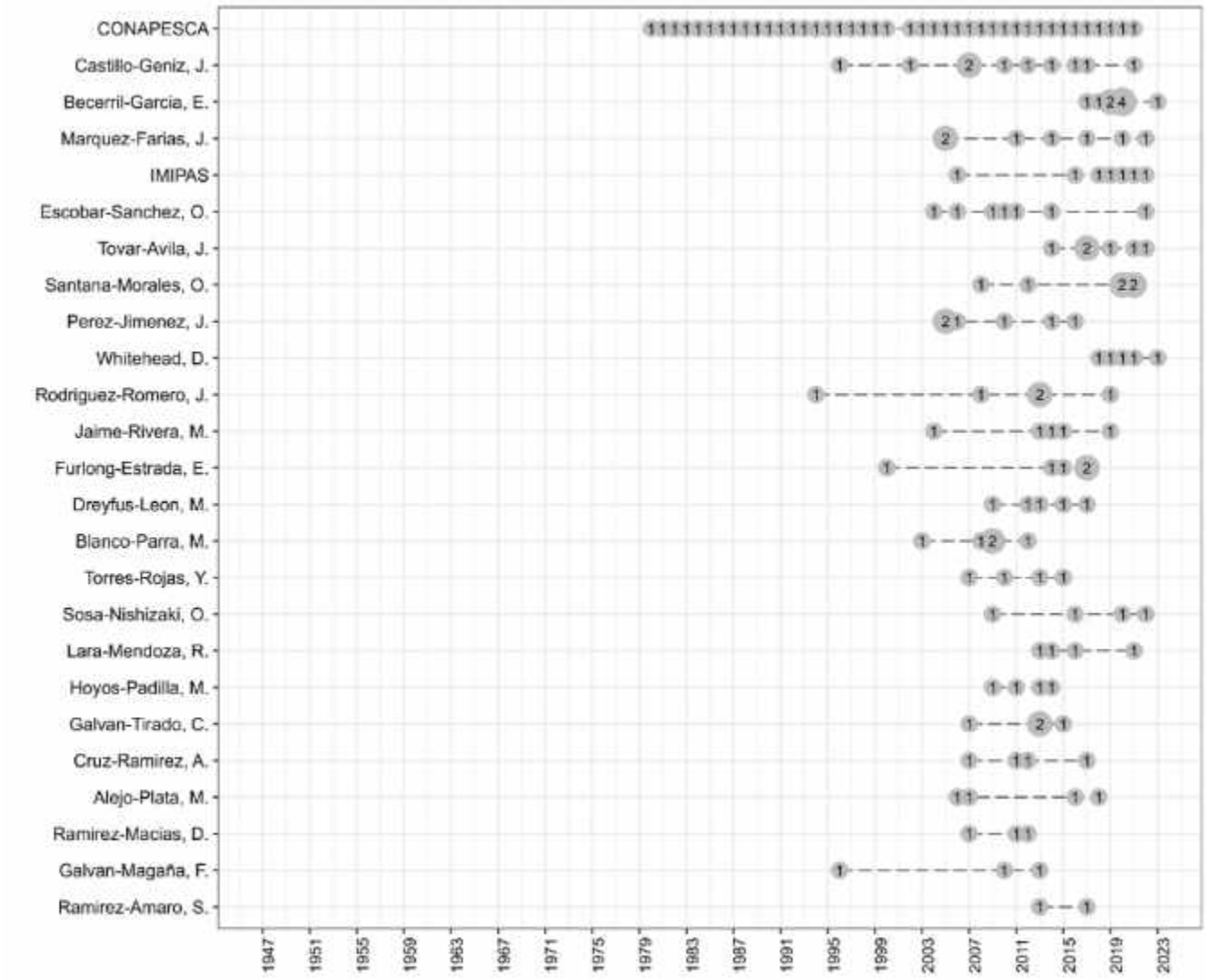

Figure 32. Number of documents produced by first author (y-axis) and year of publication (x-axis); each bubble is located in the year of publication and the number inside indicates the number of publications for that year. For visual purposes, this graph does not include authors with less than 2 publications, nor does it show co-authorships.

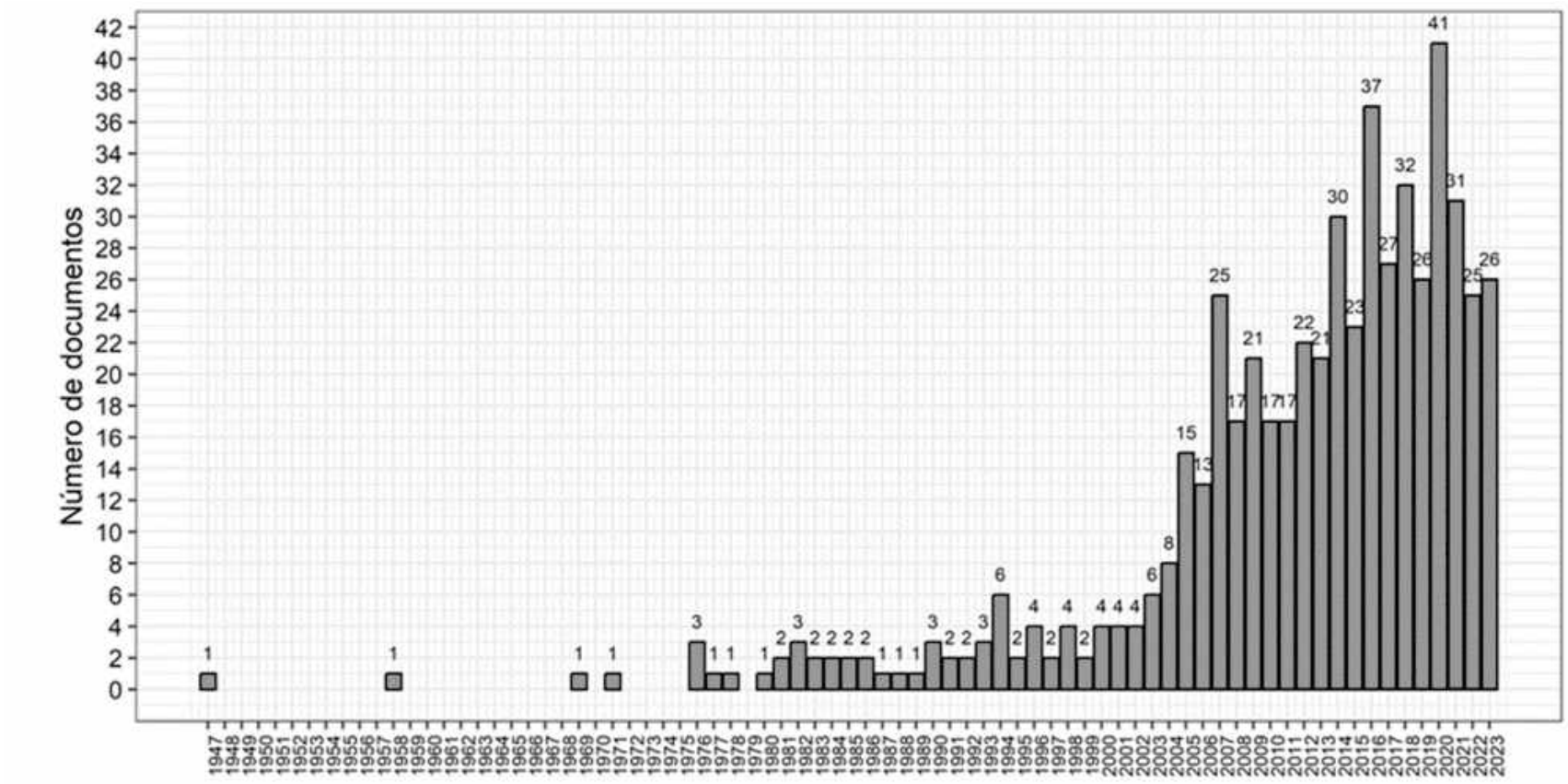

Figure 33. Period of document production of shark- and ray-related studies; year of production (x-axis) and number of documents (y-axis) are shown; for visual purposes, this graph does not represent a document produced in 1882.

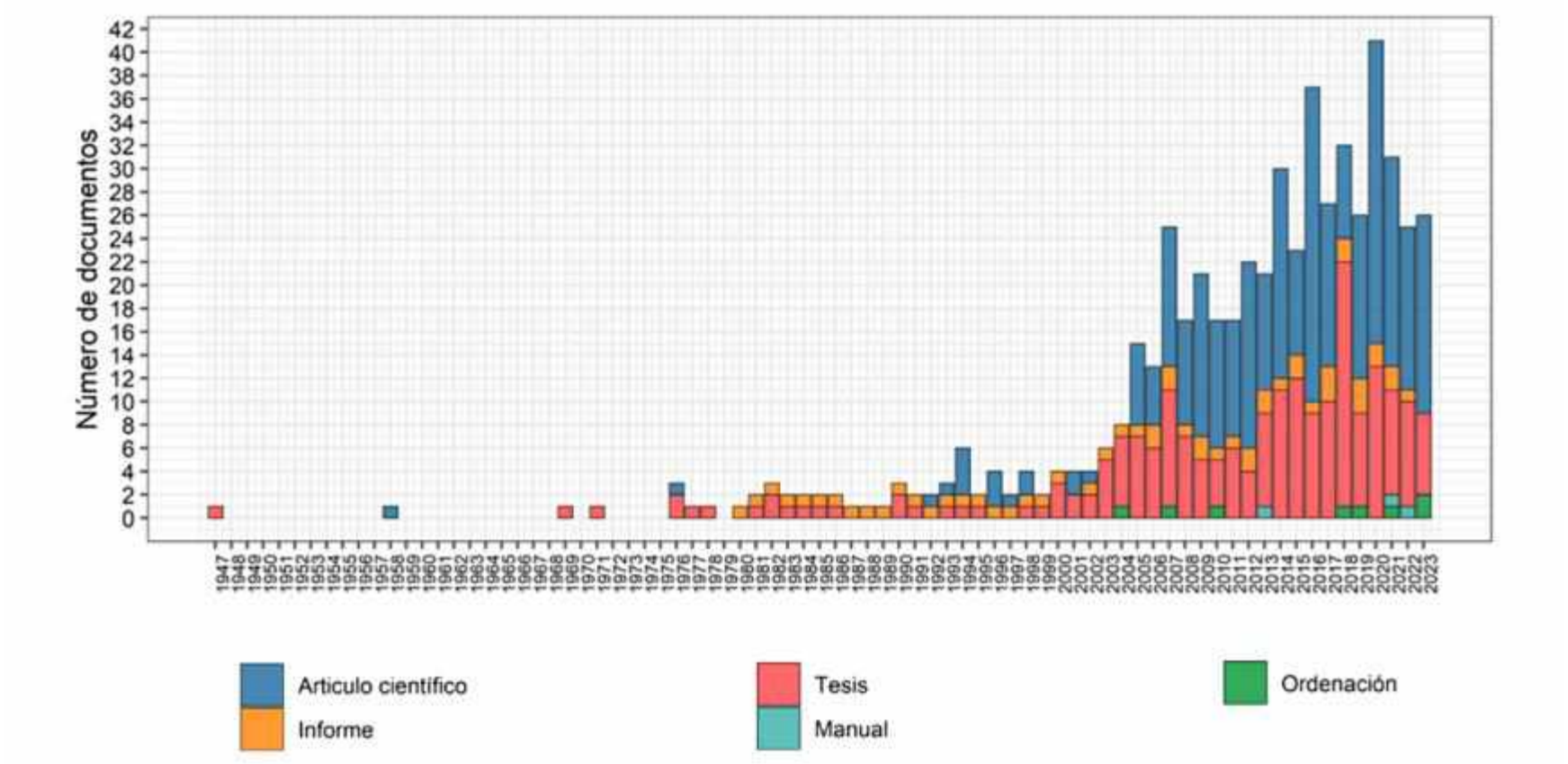

Figure 34. Behavior over time of the production of documents related to shark and ray studies in the Mexican Pacific; the year of production is shown (x-axis), the bars indicate the number of documents (y-axis), and the color scale indicates the category.

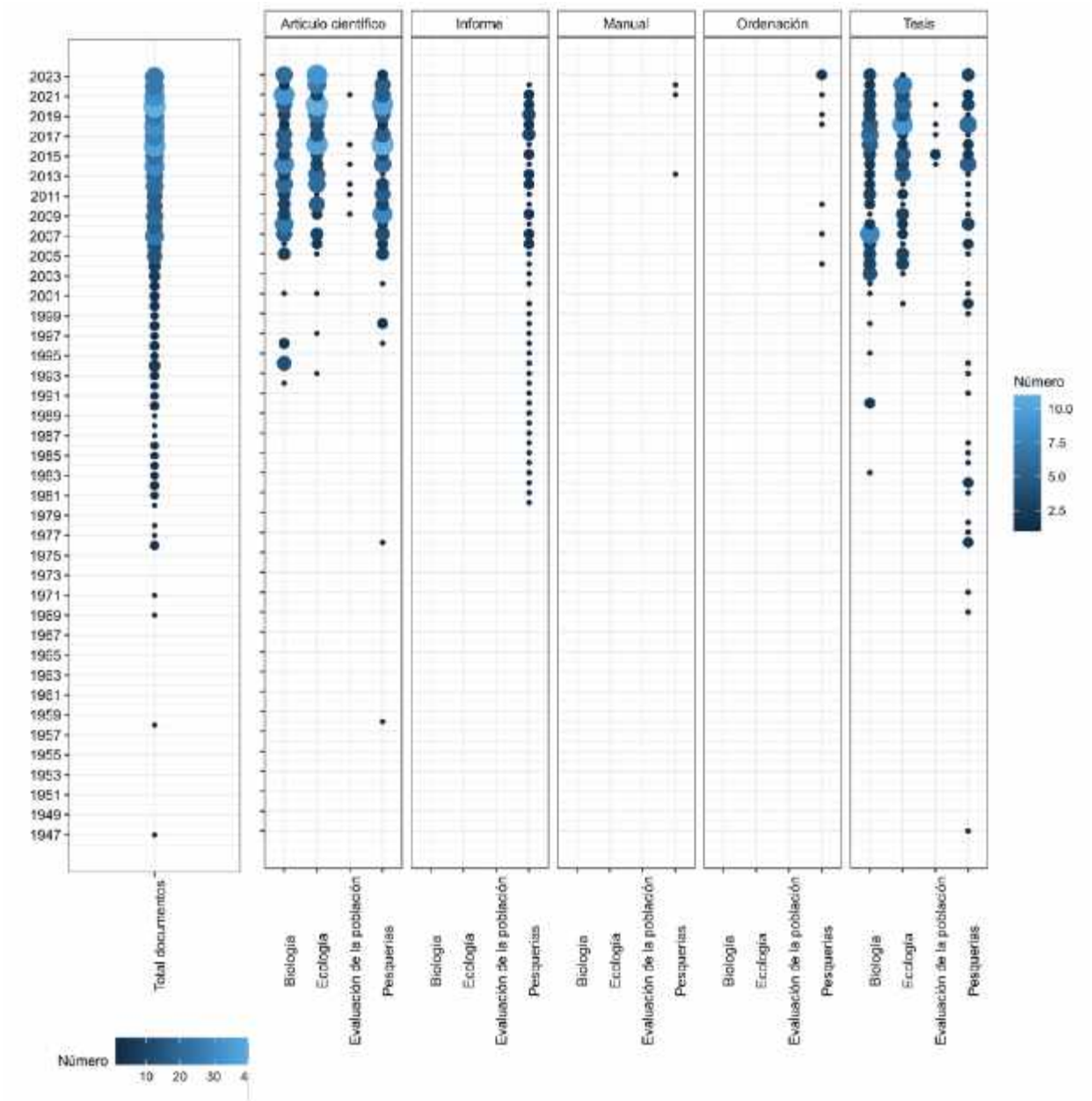

Figure 35. General classification of documents (scientific article, report, thesis, manual and management document), main approaches for each type of document (x-axis) and time of production (y-axis); the color scale indicates the number of documents produced over time and by approach.

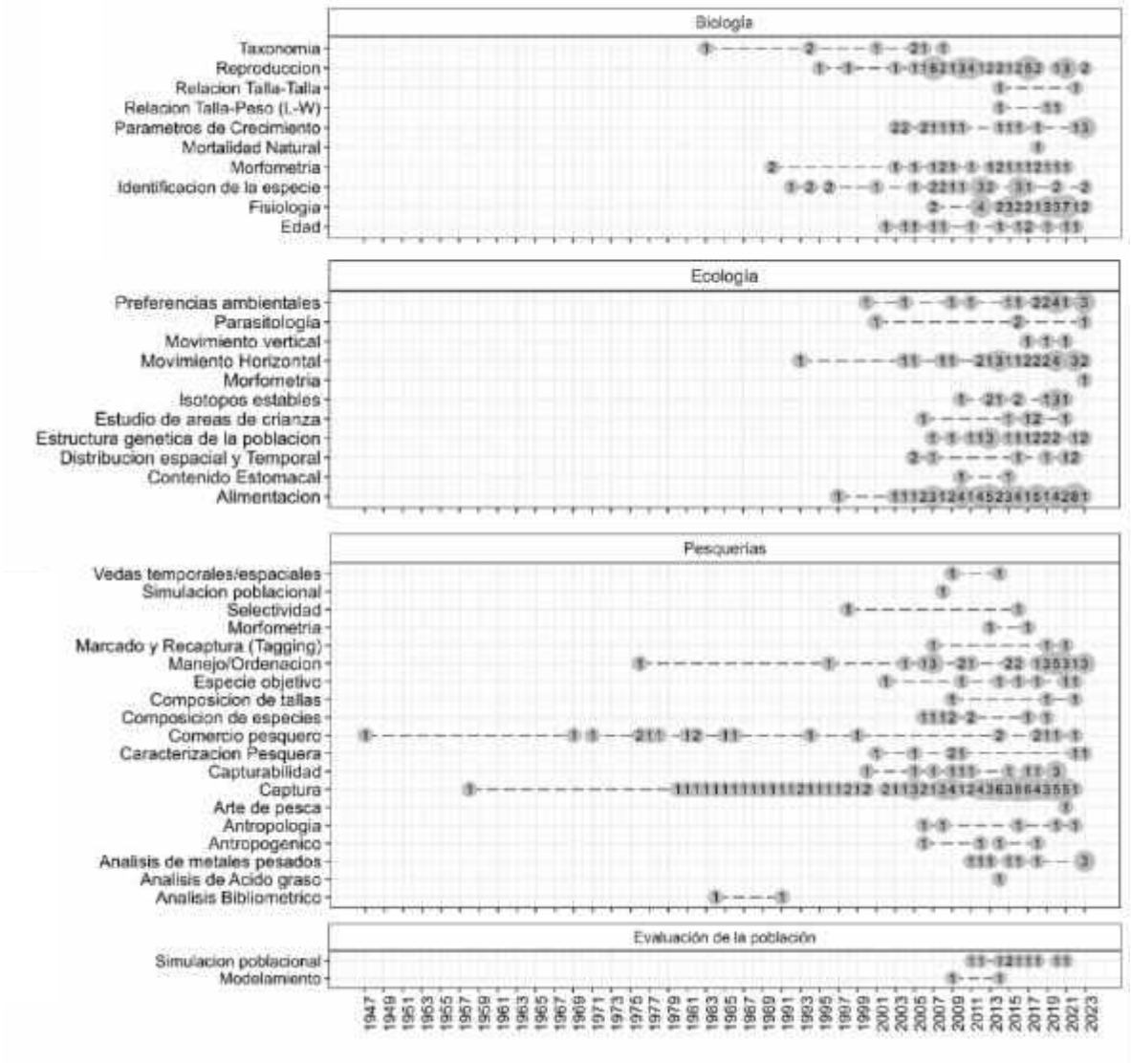

Figure 36. Classification of documents by approach and sub-focus; each rectangle indicates the focus (biology, ecology, fisheries and stock assessment), with their respective sub-focuses (y-axis) and year (x-axis).

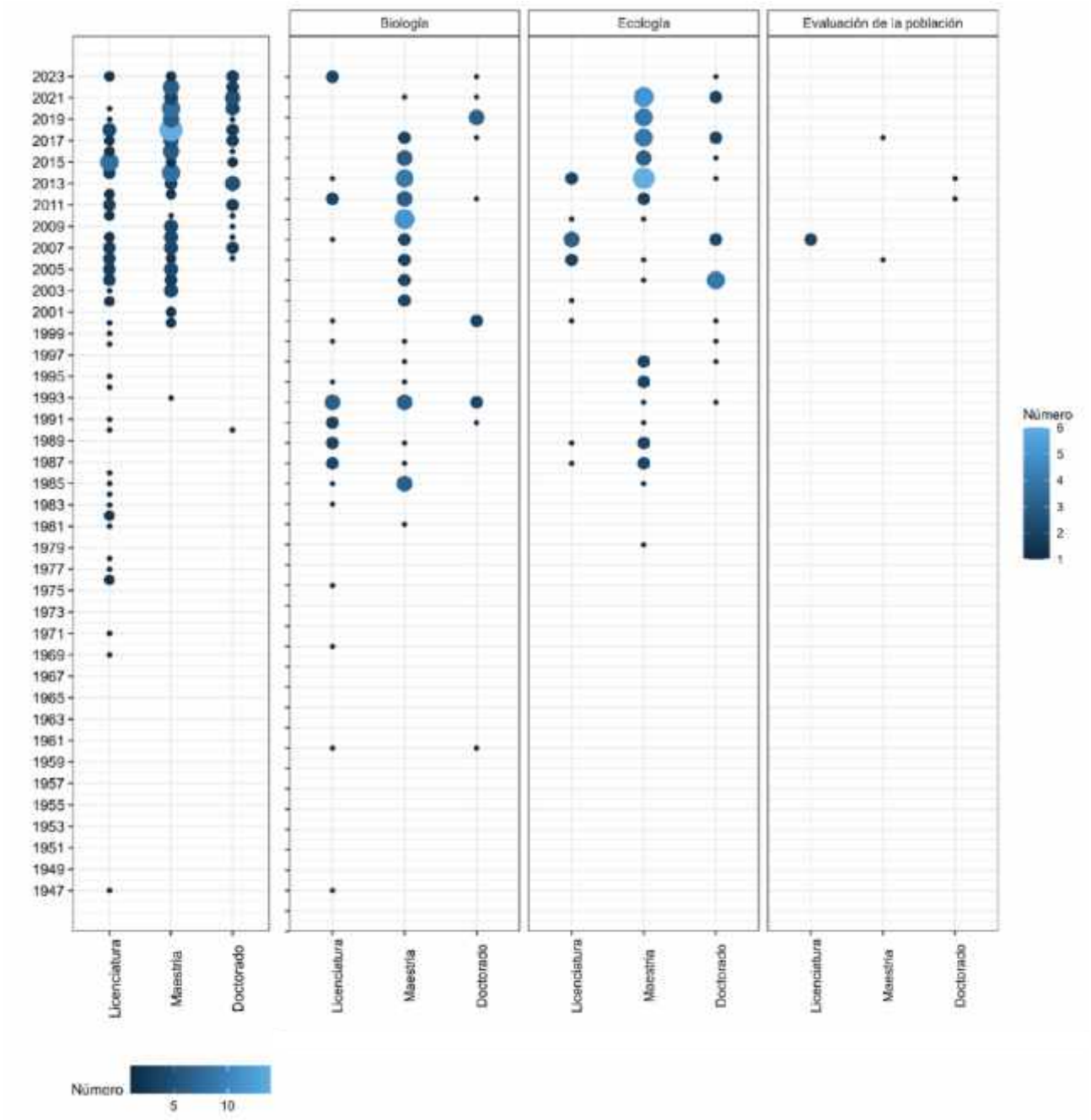

Figure 37. Year (y-axis) and proportion of theses classified by undergraduate, graduate and PhD degree (x-axis); the color scale indicates the number of documents by academic degree; for visual purposes, this graph does not include documents with limited data (n= 5).

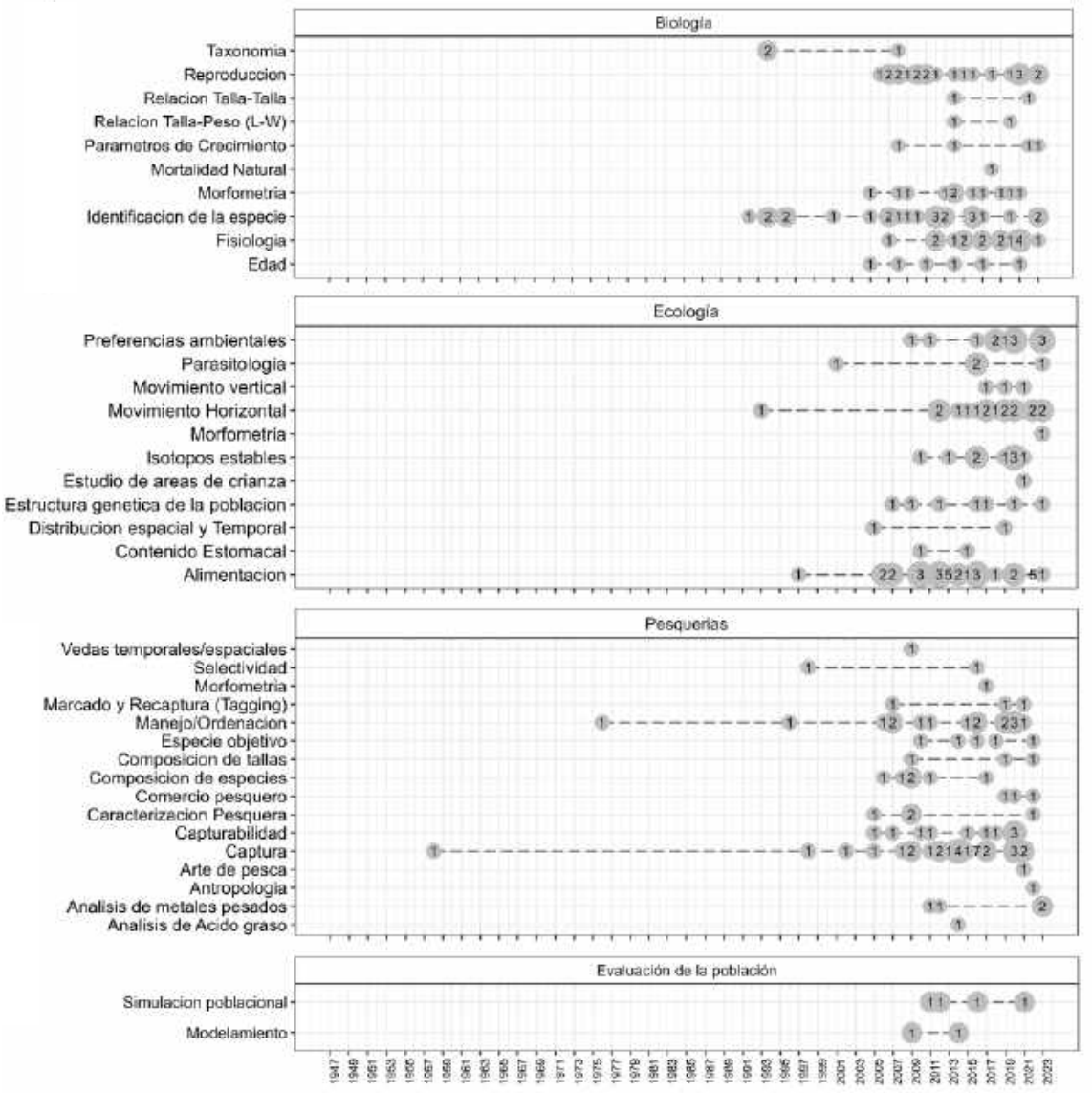

Figure 38. Classification of papers cataloged as scientific articles, by approach and sub-focus; each rectangle indicates the focus (biology, ecology, fisheries, and stock assessment), with their respective sub-focuses (y-axis) and year (x-axis); for visual purposes, this graph does not include papers with limited data.

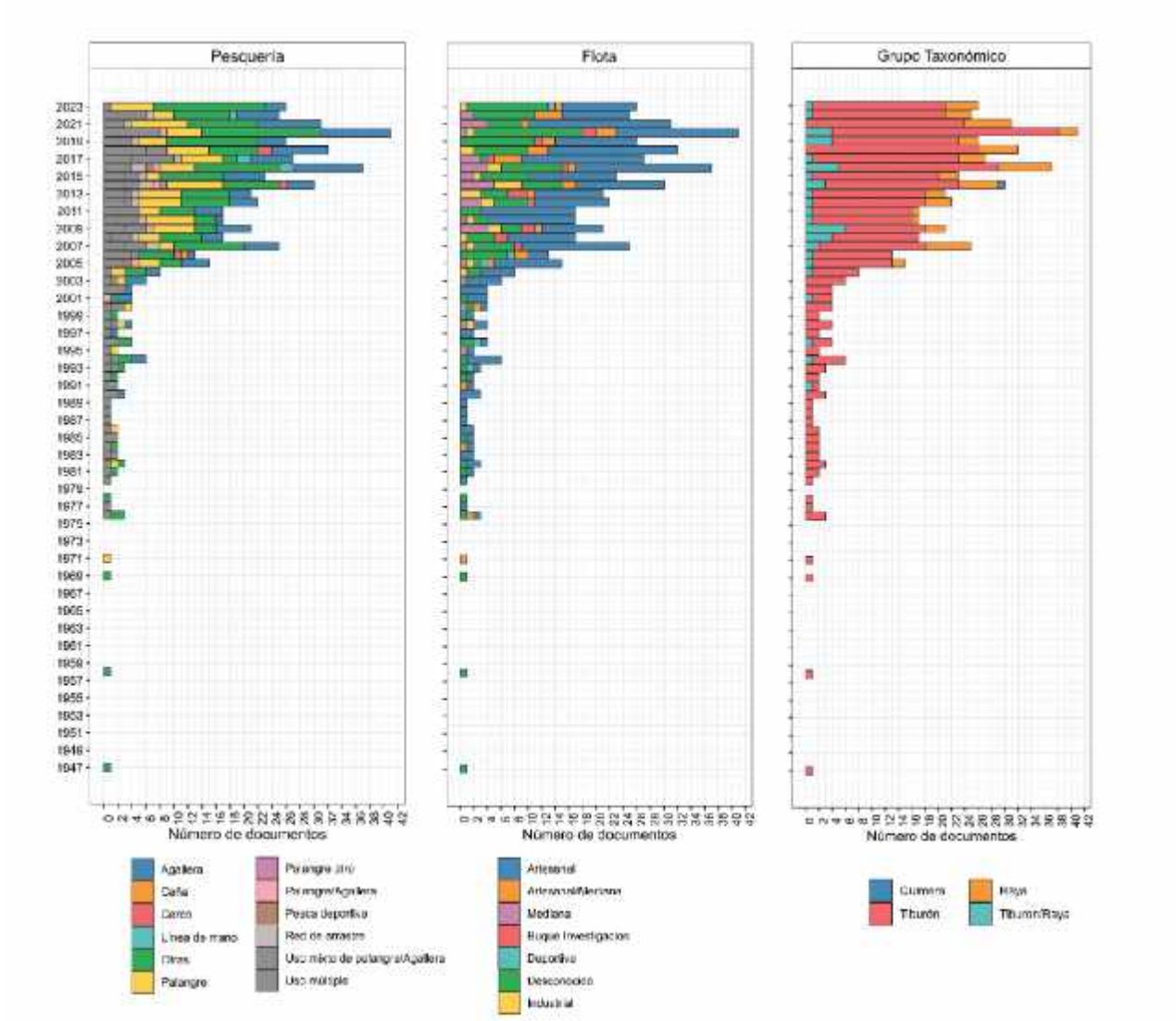

Figure 39. Classification of documents by fishery approach (gillnet, trawl, purse-seine, handline, longline, longline/gillnet), fleet (artisanal, artisanal/medium scale, research vessel, unknown, industrial) and taxonomic group (shark, ray, shark/ray, chimaeras). The y-axis indicates the year of the document and the bars indicate the number of documents produced per year (x-axis); the color scales indicate the different types of fisheries, fleets and taxonomic groups.

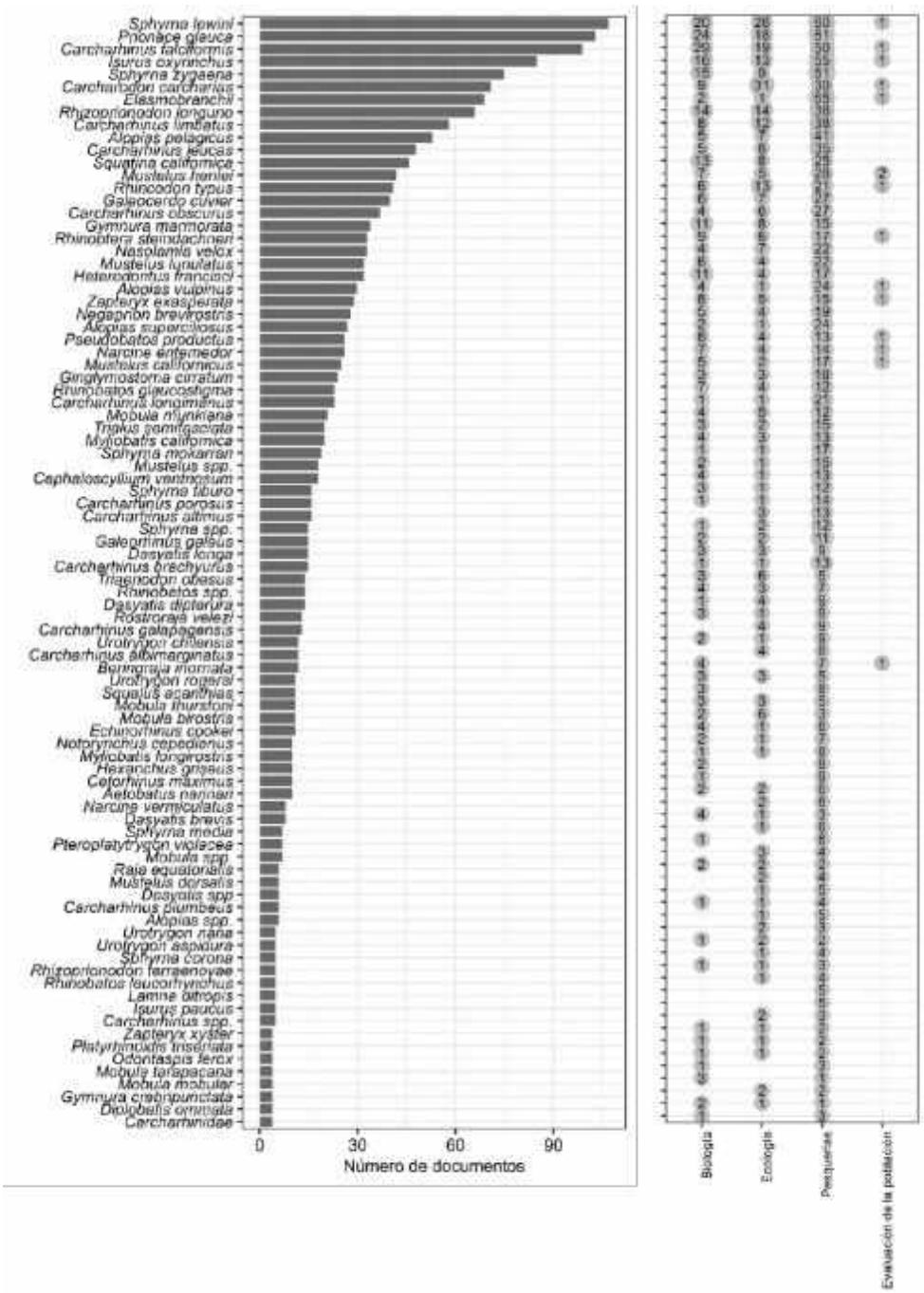

Figure 40. Number of documents by species and approach; on the left, the species are listed in order of importance (y-axis), with the bars indicating the number of documents obtained per species (x-axis); on the right, the number of documents by approach is indicated within each circle (x-axis).

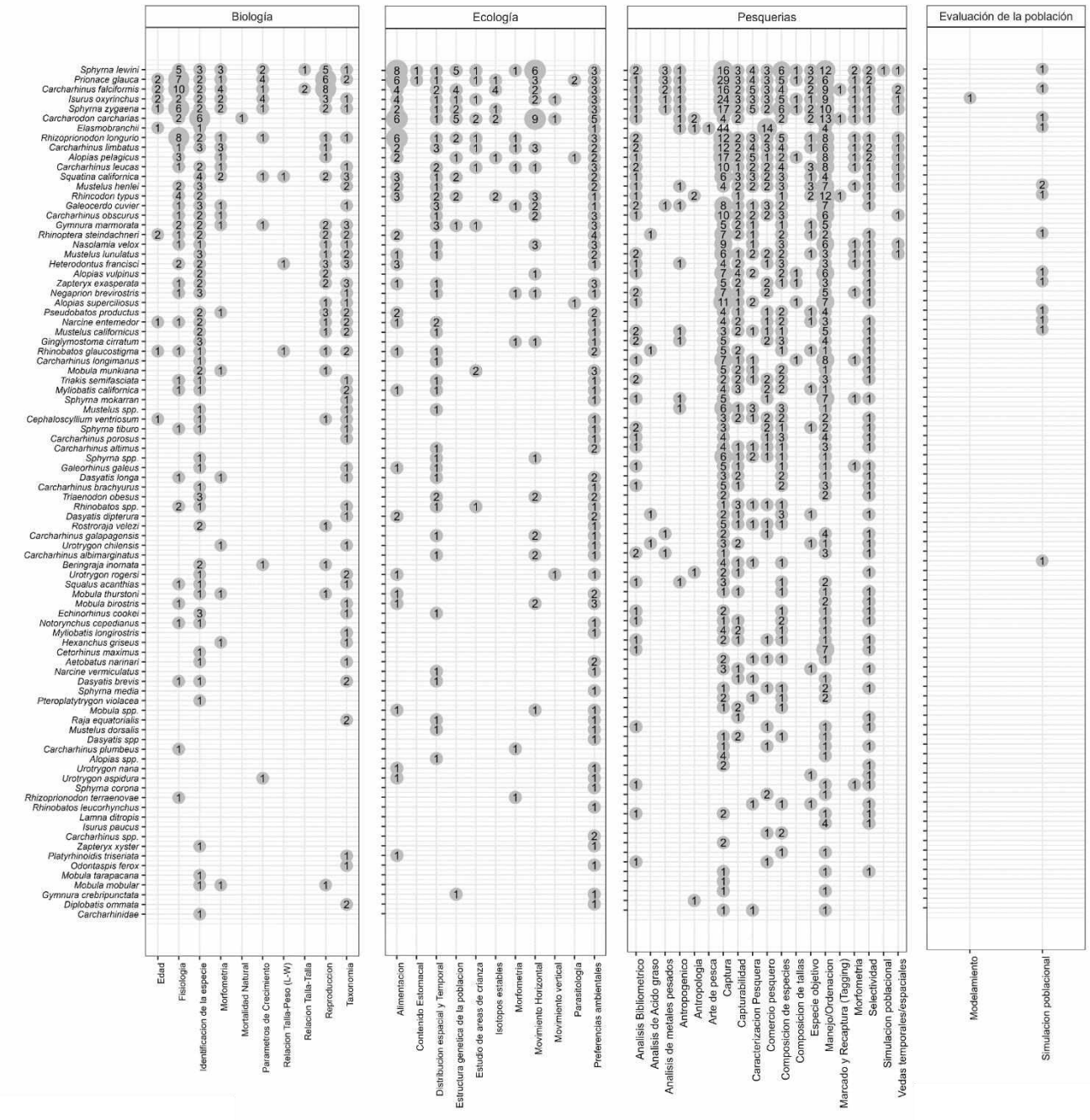

Figure 41. Number of documents of the most representative species, by approach and sub-focus; the y-axis lists the species in order of importance; the circles indicate the number of existing documents by approach (top of each rectangle) and sub-focus (x-axis).

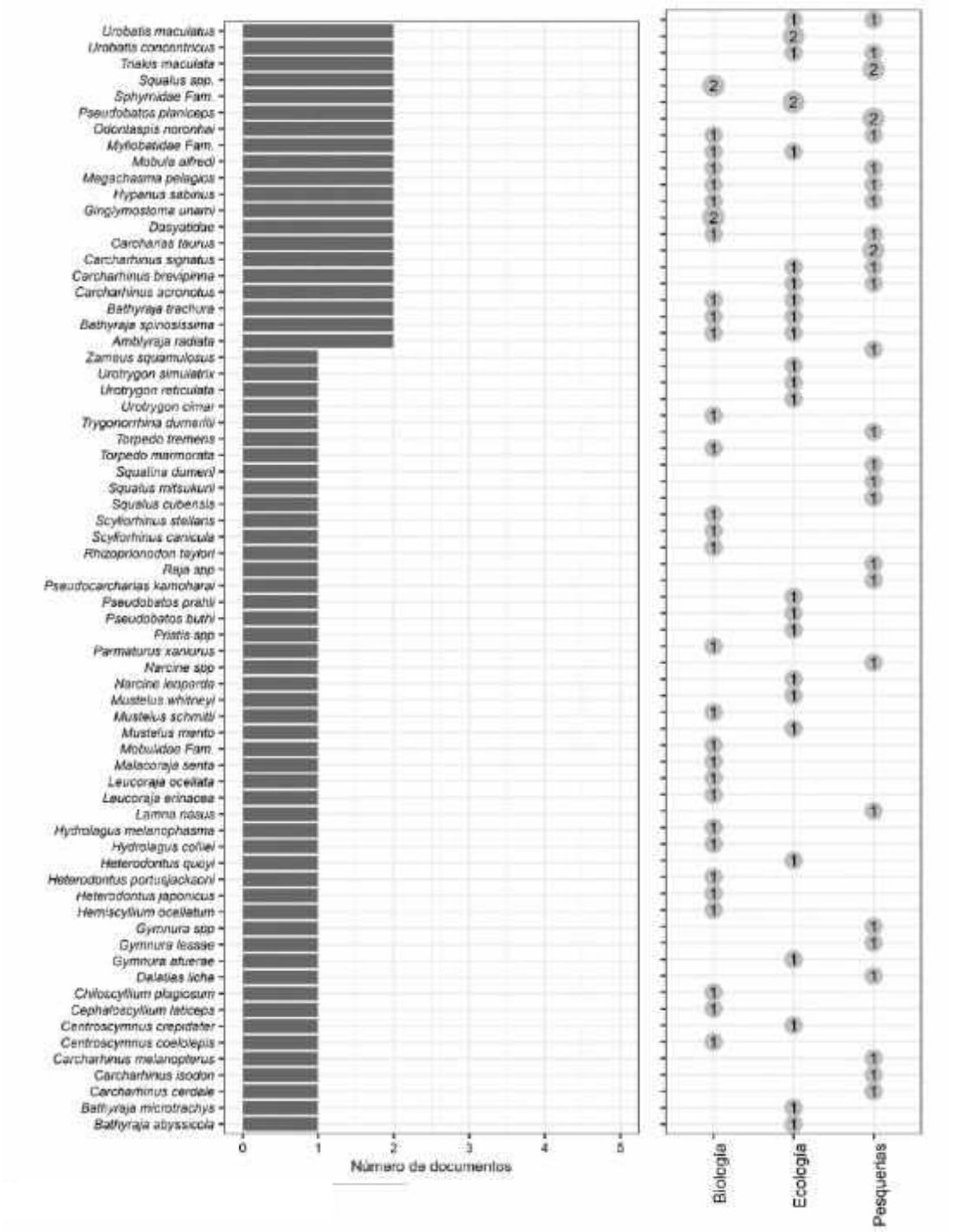

Figure 42. Species with the lowest number of documents, distributed across the biology, ecology and fisheries approaches; species are listed in order of importance (y-axis) and the number of publications is indicated (x-axis); in the right rectangle, the number of publications and the approach of the study are indicated in circles (x-axis).

Peru

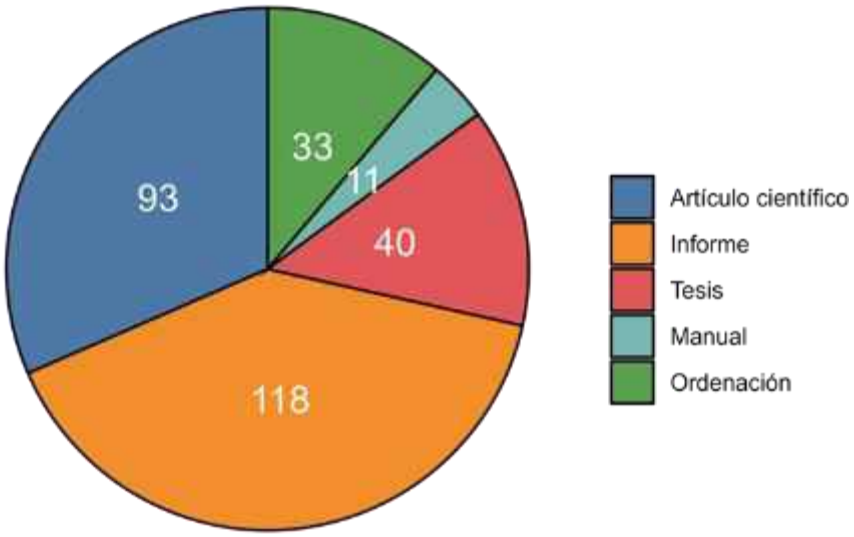

Figure 43. Total number of document types identified for Peru, 1967-2023.

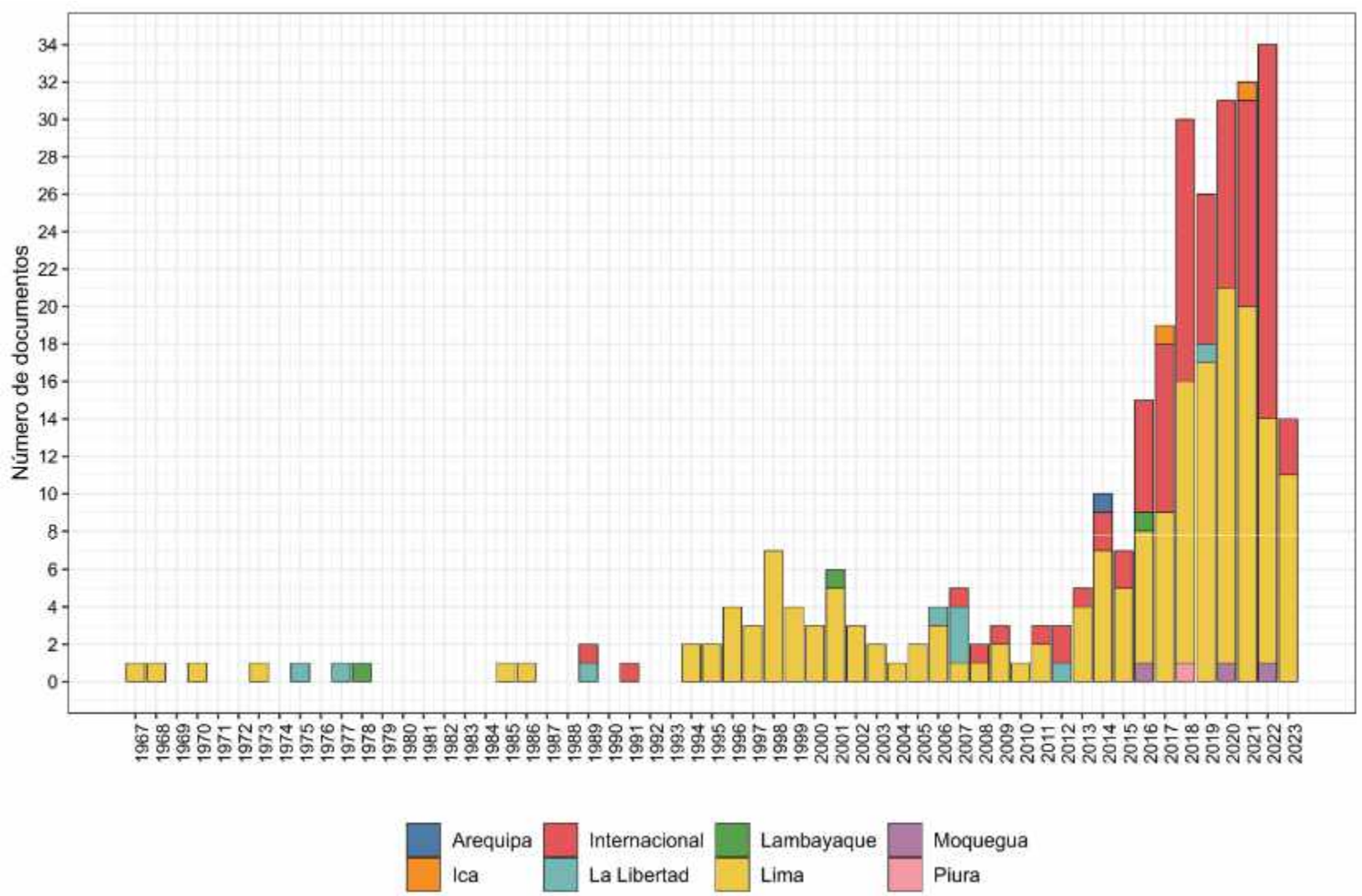

Figure 44. Total number of documents on chondrichthyans by department in Peru, 1967-2023.

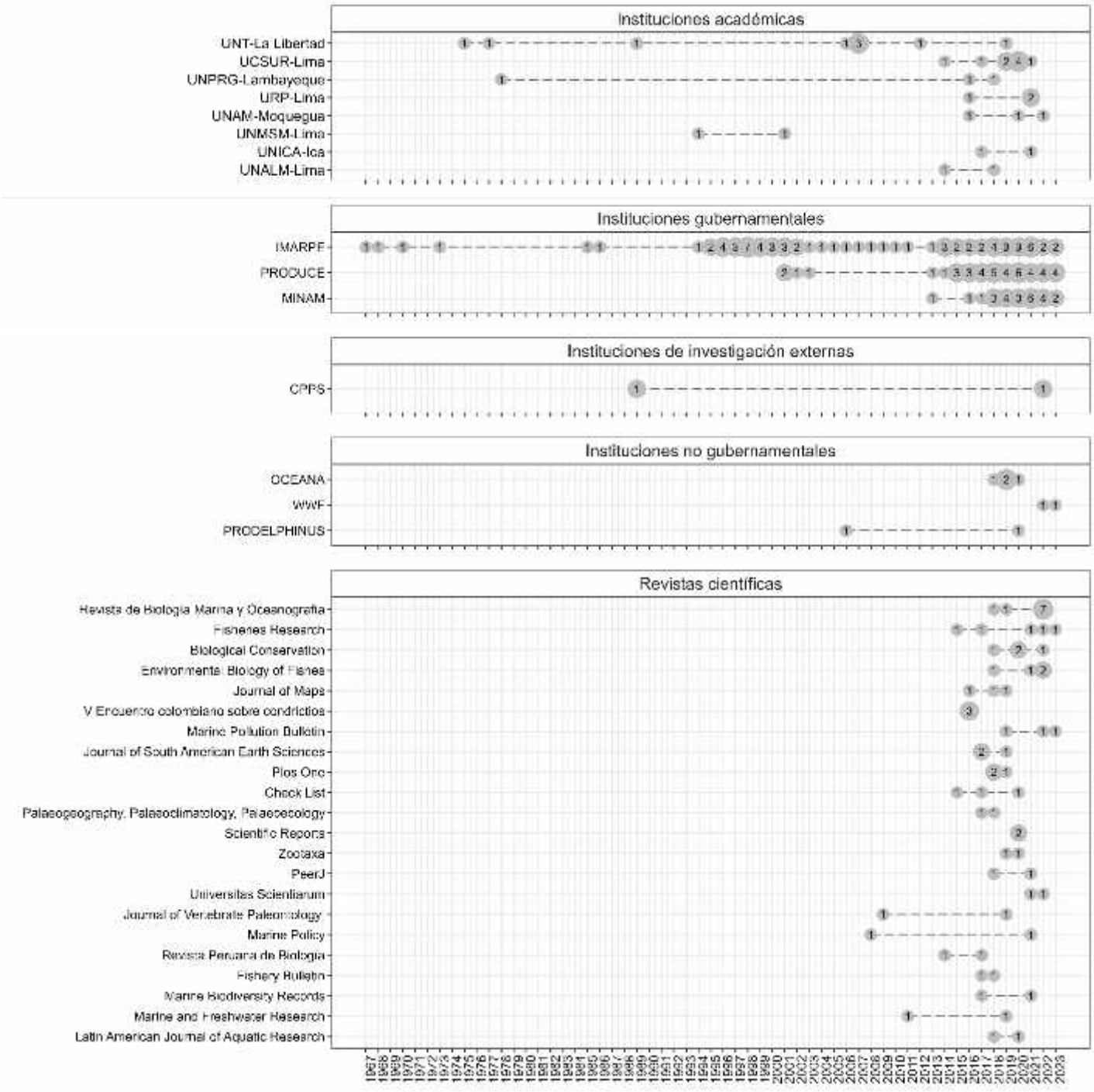

Figure 45. Number of papers on chondrichthyans by academic, governmental and non-governmental institutions, external research institutions and scientific journals in Peru, 1967-2023. All institutions with more than one research paper were considered. UNT: Universidad Nacional de Trujillo, UCSUR: Universidad Científica del Sur, UNPRG: Universidad Nacional Pedro Ruiz Gallo, URP: Universidad Ricardo Palma, UNAM: Universidad Nacional de Moquegua, UNMSM: Universidad Nacional Mayor de San Marcos, UNICA: Universidad Nacional San Luis Gonzaga, UNALM: Universidad Nacional Agraria La Molina, IMARPE: Instituto del Mar del Perú, PRODUCE: Ministerio de la Producción, MINAM: Ministerio del Ambiente, CPPS: Comisión Permanente del Pacífico Sur.

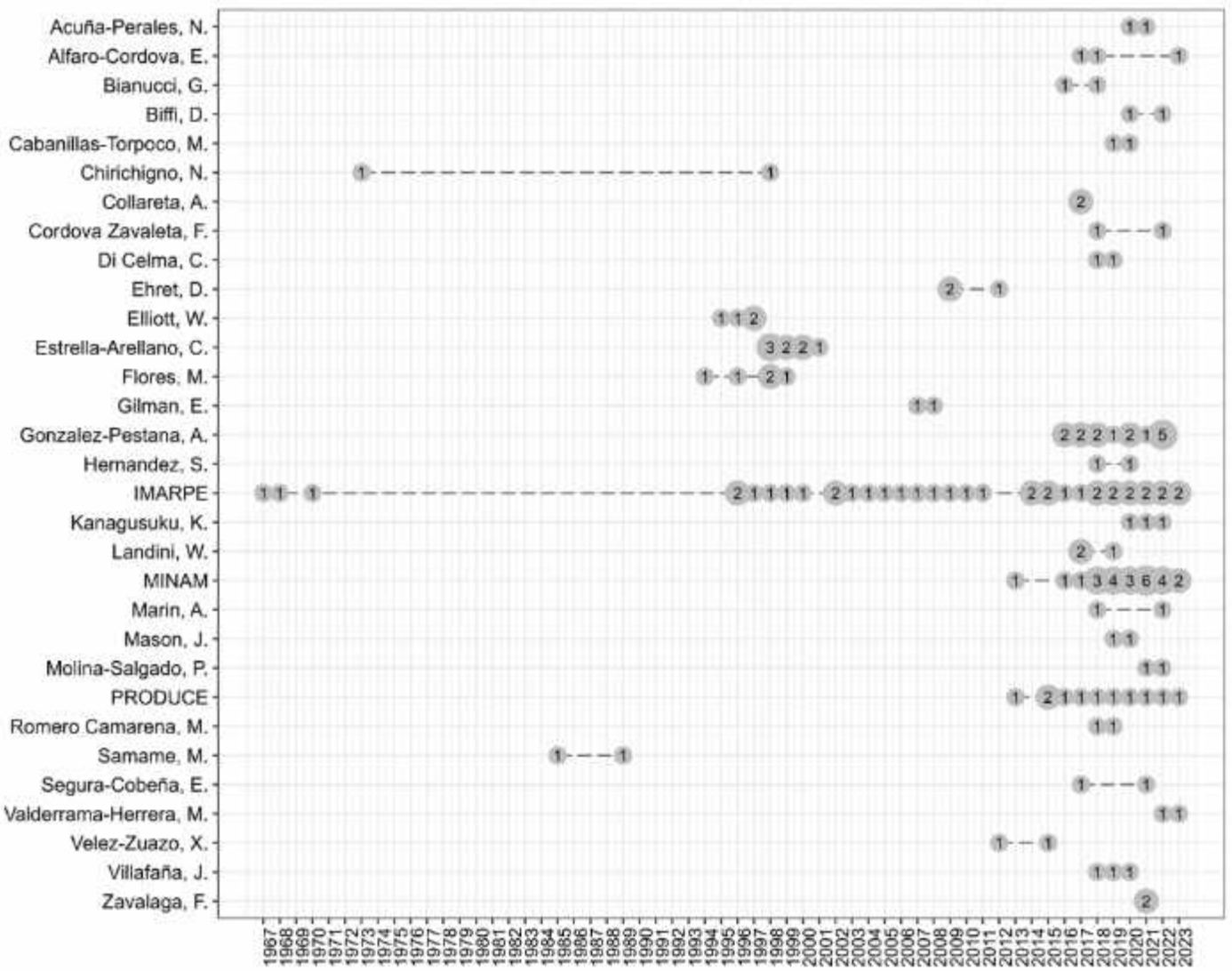

Figure 46. Main authors with research on chondrichthyan species in Peru, 1967-2023. All authors with more than one paper were considered. IMARPE: Instituto del Mar del Perú, MINAM: Ministerio del Ambiente, PRODUCE: Ministerio de la Producción.

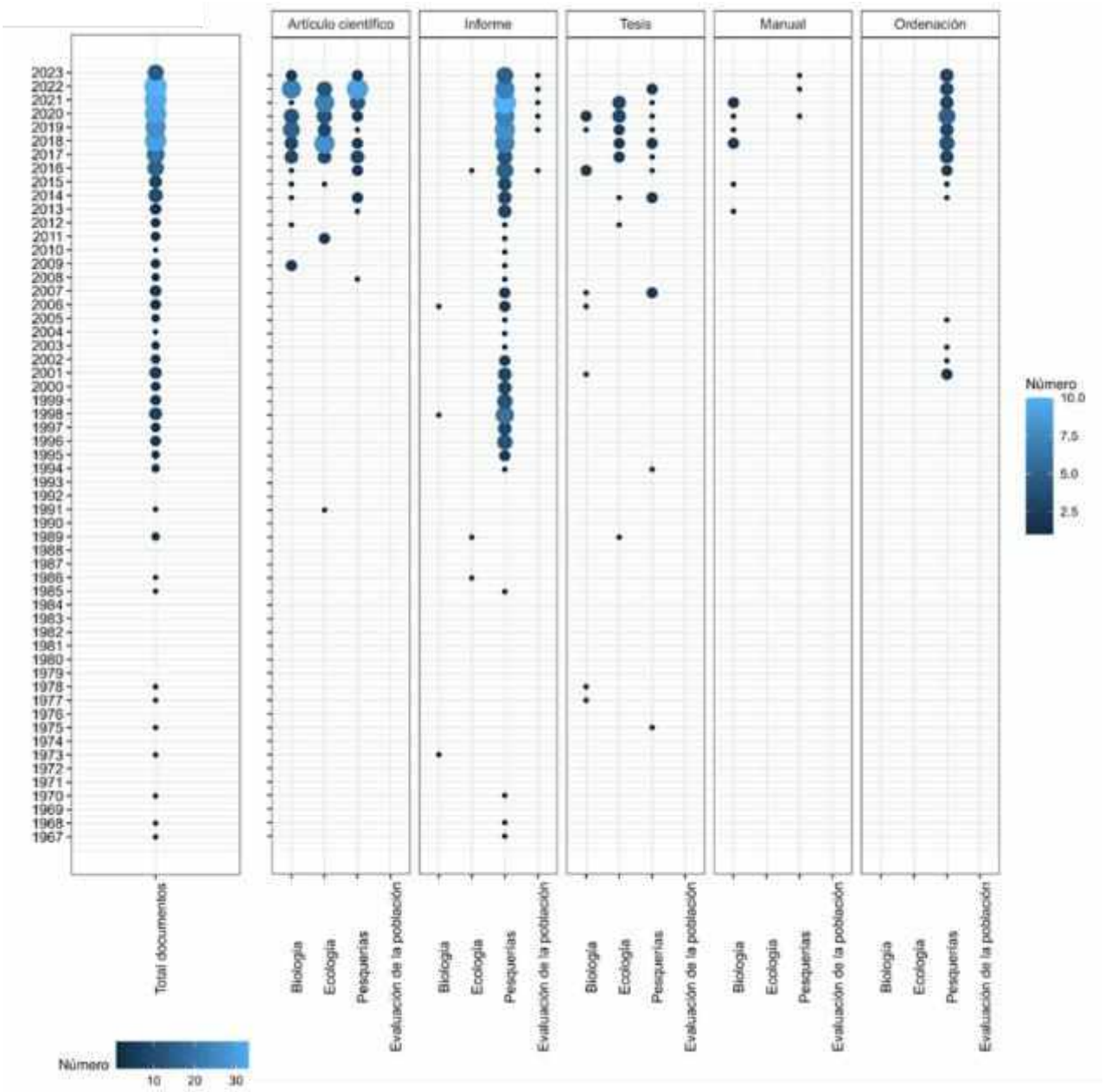

Figure 47. Chronology of the total number of documents identified, and documents by type (scientific article, report, thesis, manual and management document) and approach (biology, ecology, fisheries and stock assessment) in Peru, 1967-2023.

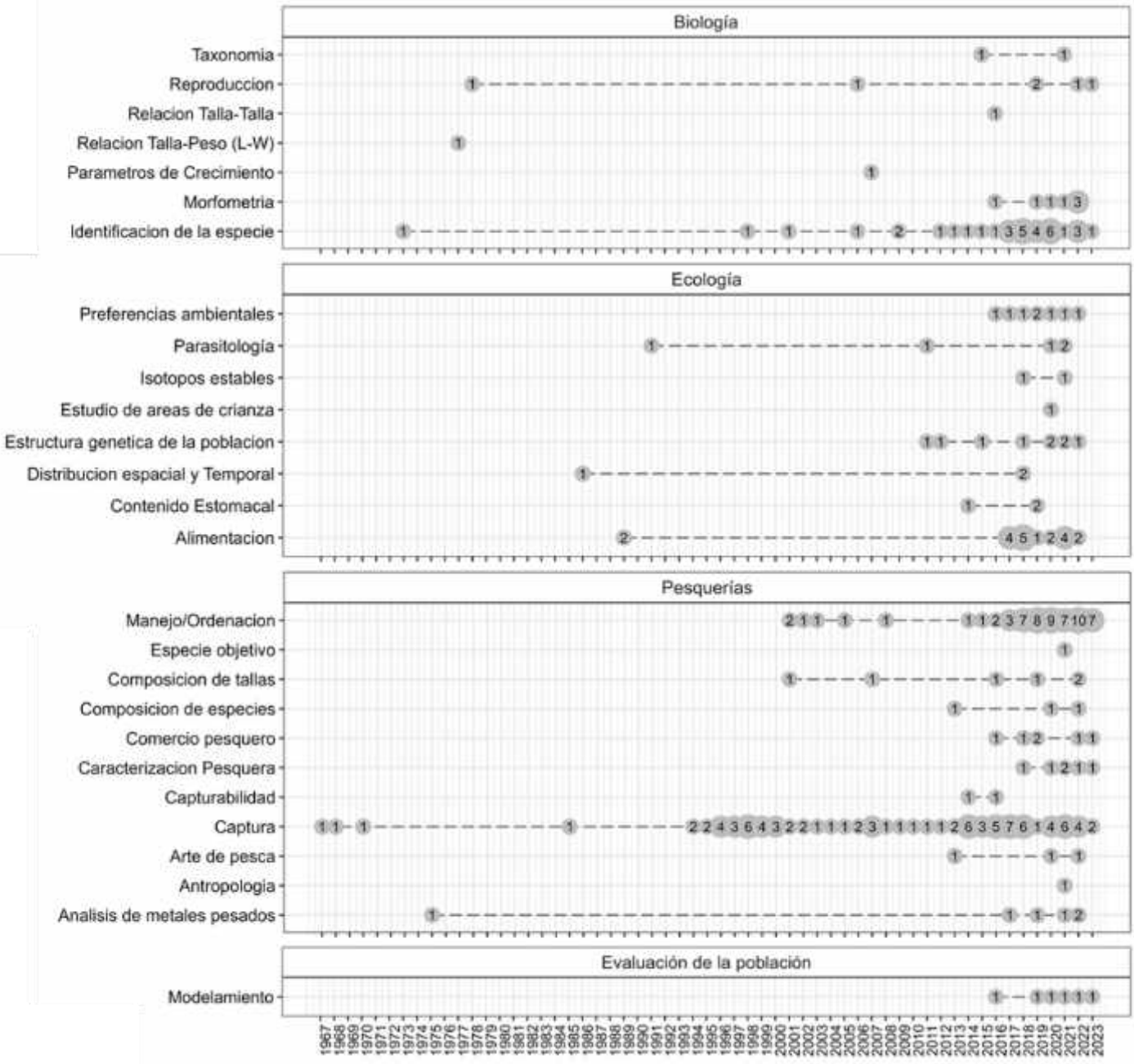

Figure 48. Chronology of the number of documents identified by approach and sub-focus in Peru, 1967-2023. The numbers in the gray circles correspond to the number of documents identified.

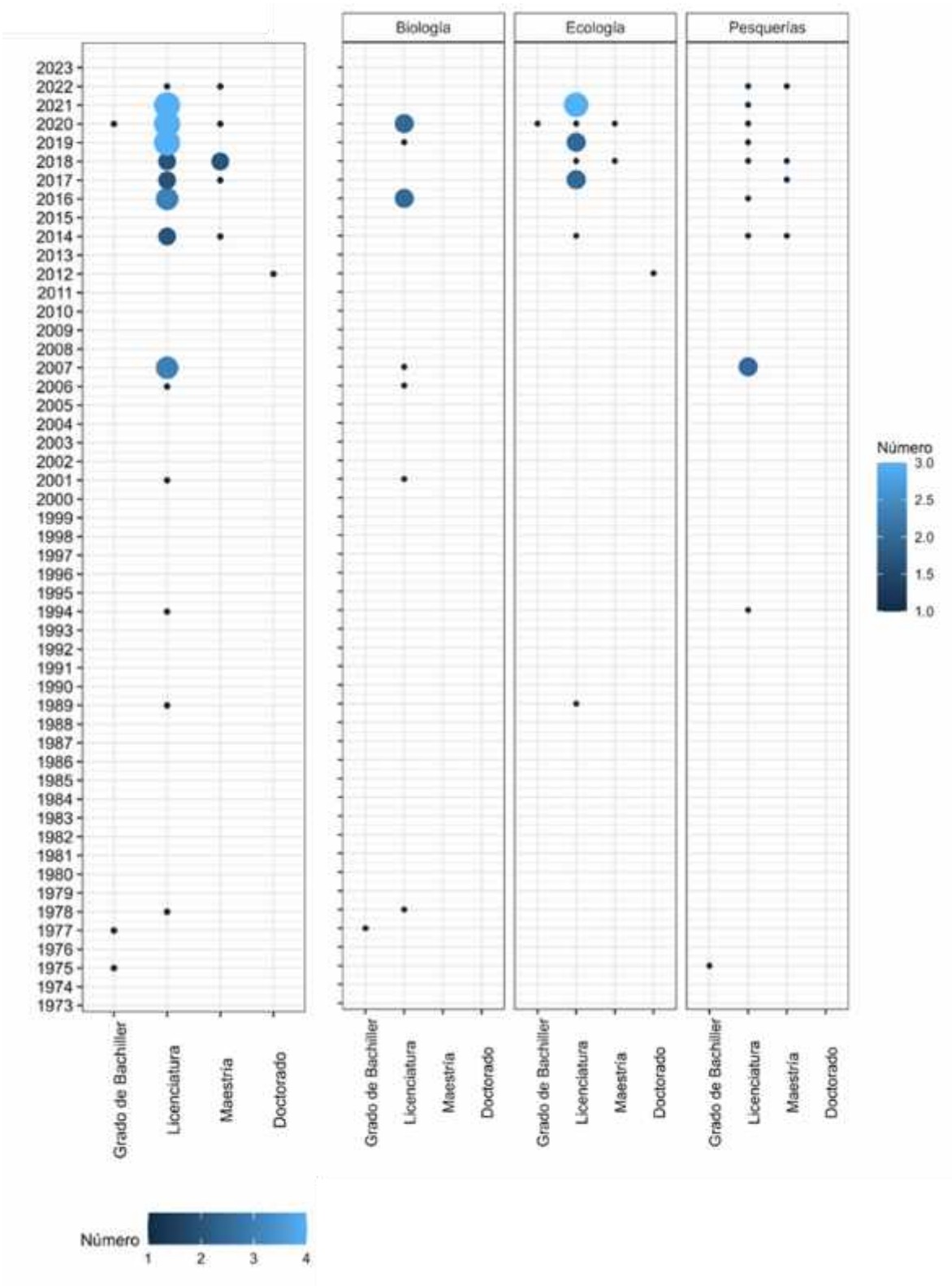

Figure 49. Chronology of the number of type of theses identified (*bachiller*, undergraduate, graduate and PhD degree), and type of thesis by approach in Peru, 1973-2023.

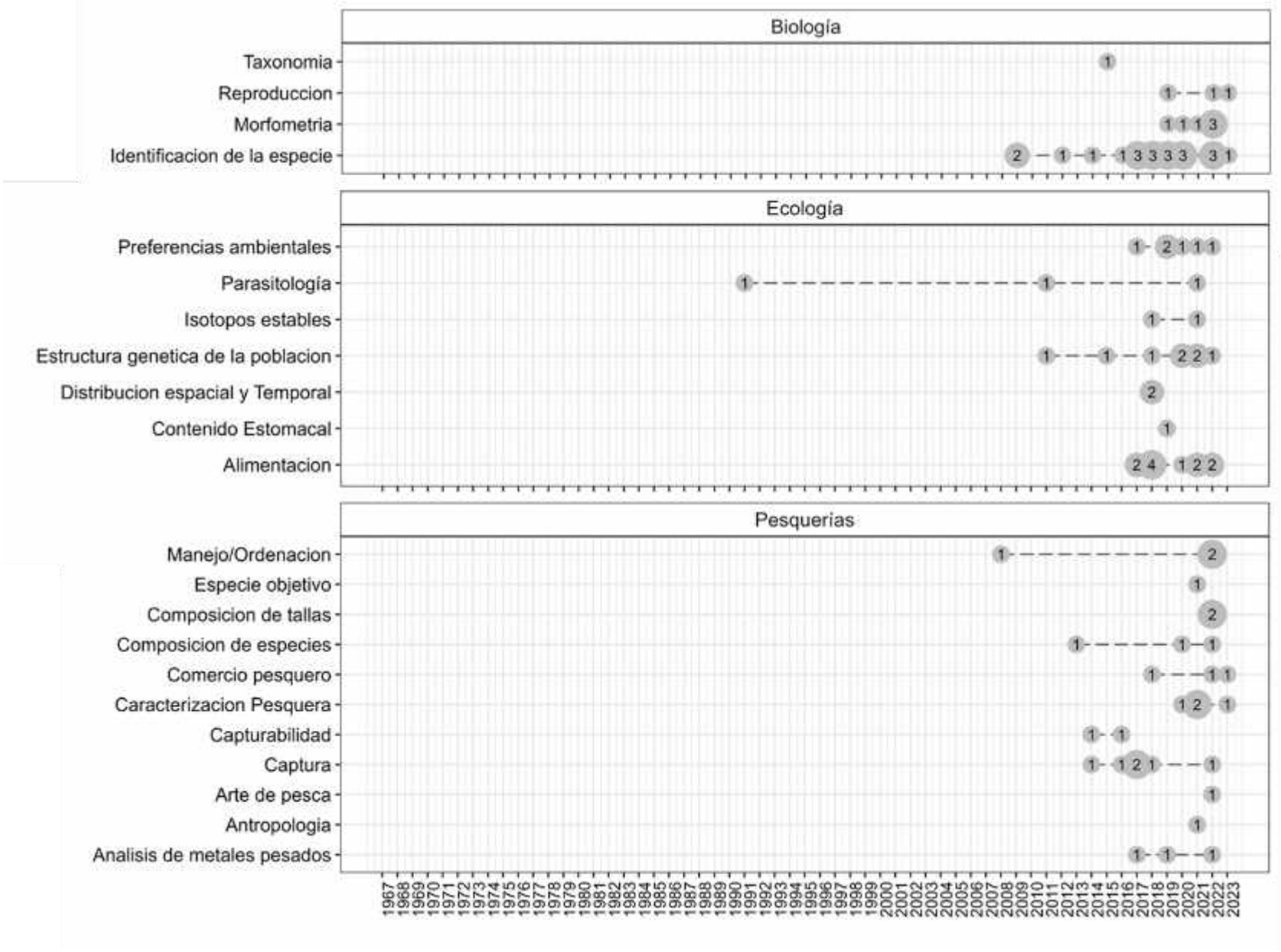

Figure 50. Chronology of the number of scientific articles by approach and sub-focus in Peru, 1967-2023. The numbers in the gray circles correspond to the number of documents.

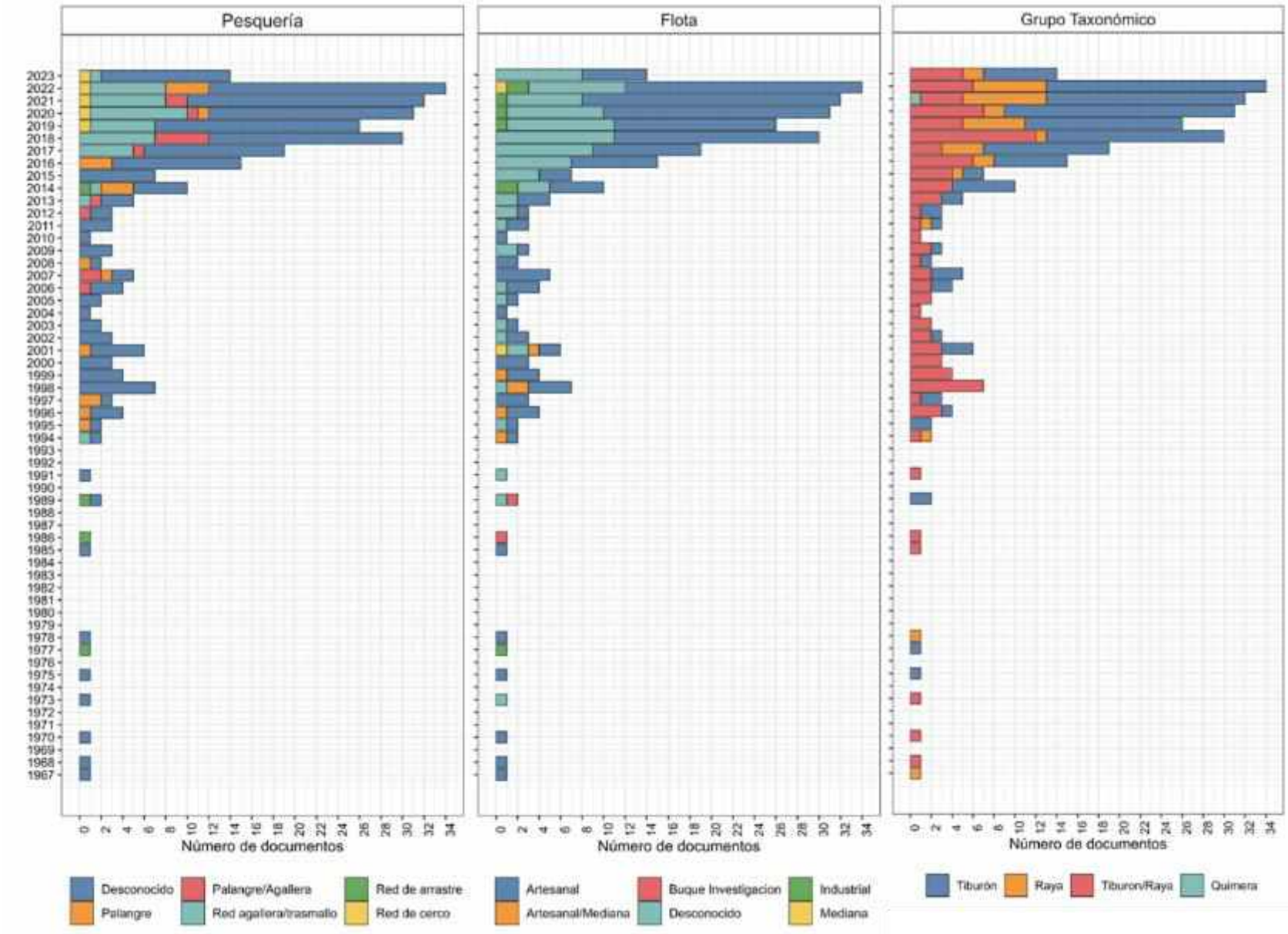

Figure 51. Number of documents by type of fishery, fleet and taxonomic group in Peru, 1967-2023.

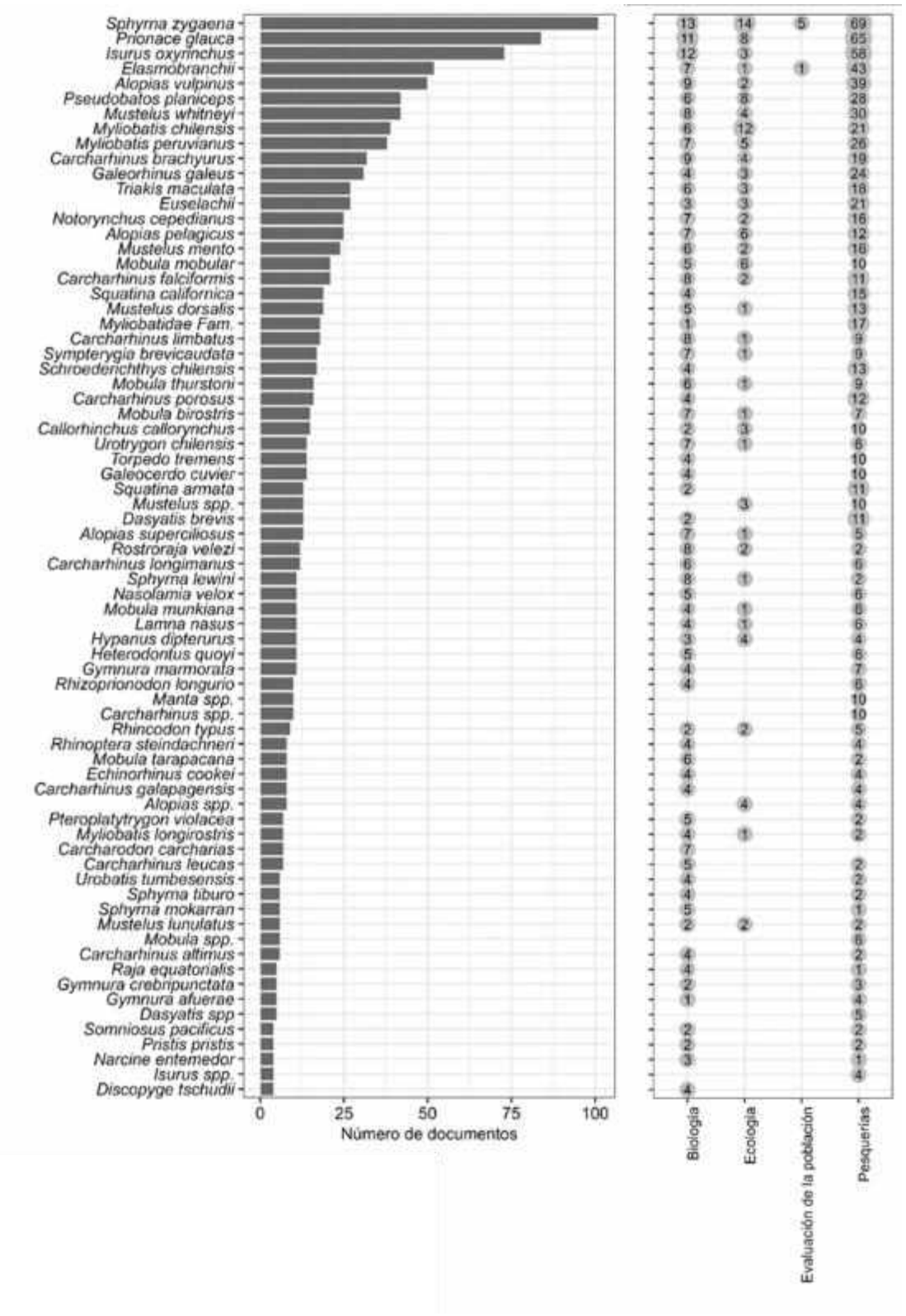

Figure 52. Total number of documents of the main species studied in Peru, distributed by species and type of approach, 1967-2023. The numbers in the gray circles correspond to the number of papers. Species with more than three research papers were considered.

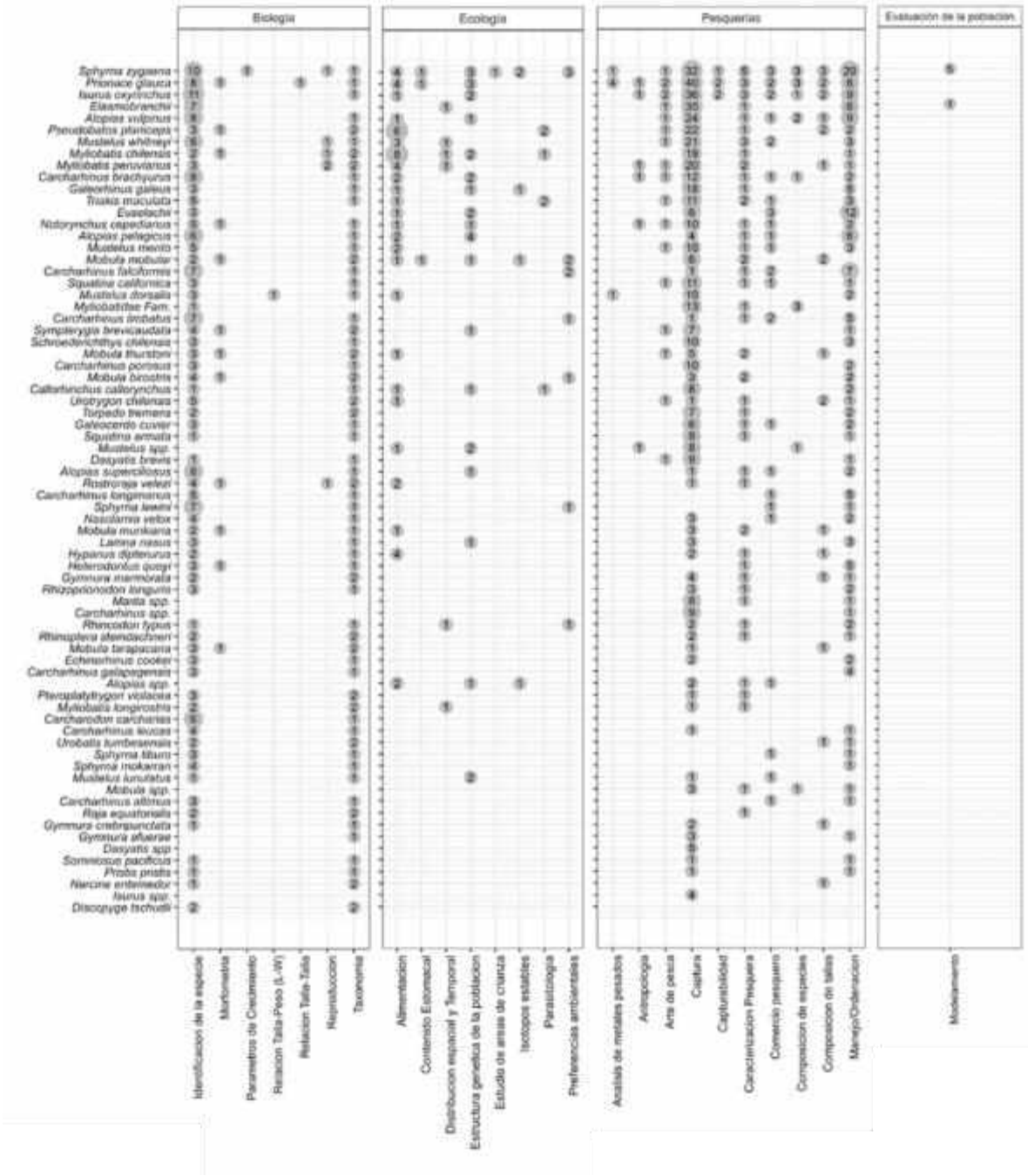

Figure 53.
Number of documents of the most studied species by approach and sub-focus in Peru, 1967-2023. The numbers in the gray circles correspond to the number of papers. Species with more than three research papers were considered.

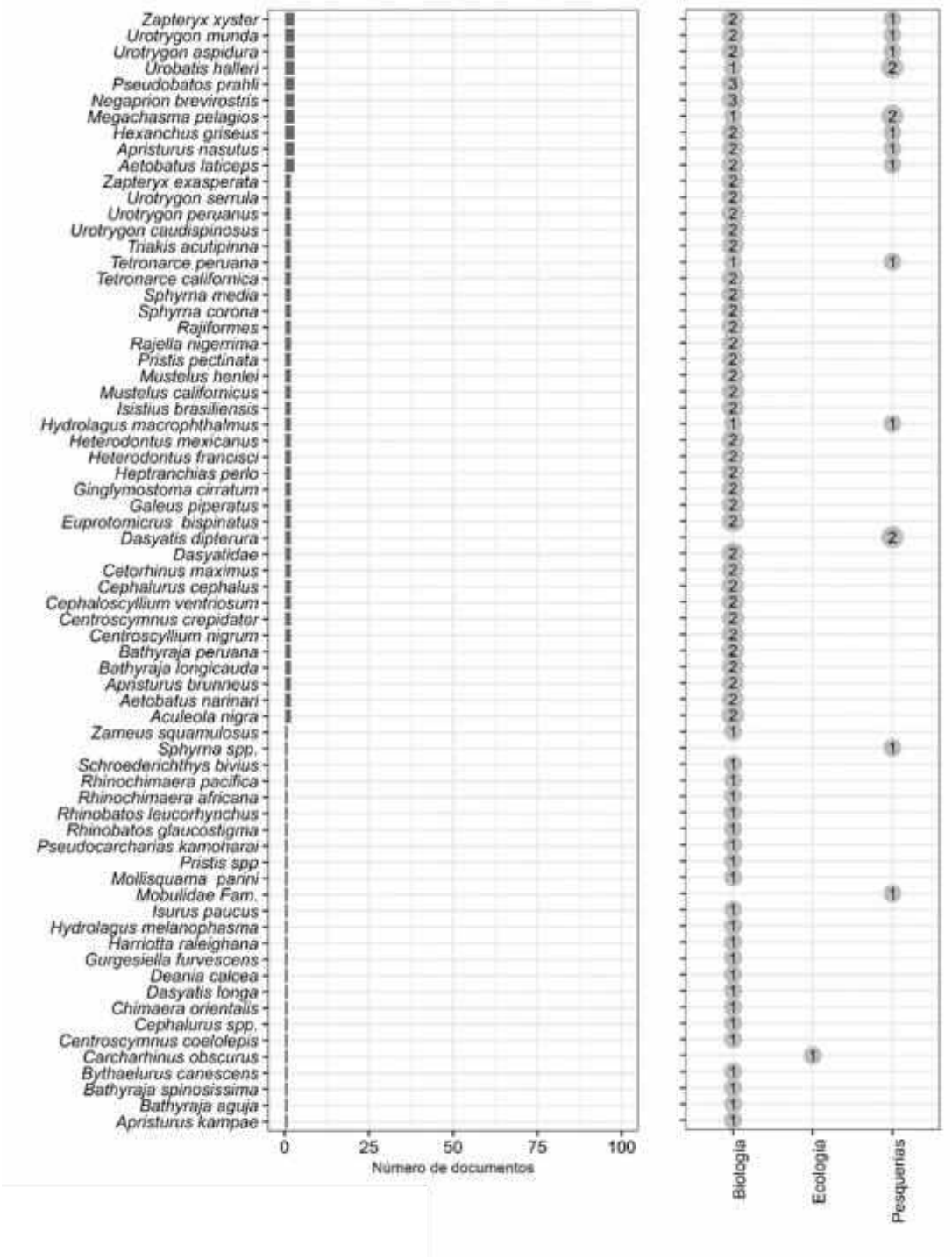

Figure 54. Total number of documents of the least studied species in Peru distributed by species and type of approach, 1967-2023. The numbers in the gray circles correspond to the number of papers. Species with less than four research papers were considered.

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