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Preliminary report on proposed sampling designs for collecting fisheries-dependent data for the assessment of priority shark species populations.

Improving data collection for shark fisheries in 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 Areas Beyond National Jurisdiction"

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Summary

Sharks are a common component of targeted and bycatch catches in pelagic and coastal fisheries in the Eastern Pacific Ocean (EPO). However, the limited availability of reliable data from artisanal fisheries has historically restricted the ability to develop robust stock assessments for many of the species of greatest interest to the Inter-American Tropical Tuna Commission (IATTC).

In response to this information gap, since 2014 IATTC has promoted various initiatives aimed at improving fisheries-dependent monitoring of sharks in coastal and subregional fisheries, within the framework of the ABNJ project and funded by FAO-GEF. Starting in 2023, the

second phase of the project (ABNJ-2) incorporated Ecuador, Mexico, and Peru, with the aim of expanding monitoring coverage and moving toward regional standardization of sampling designs.

During the 2024–2025 period, participating countries laid the groundwork for establishing sampling designs adapted to their national contexts, taking into account the diversity of landing sites, types of artisanal vessels, and operational modalities. Results to date show significant progress in the collection of information on fishing effort, species composition, and spatial and temporal patterns of elasmobranch catches. At the same time, substantial differences have been identified among countries related to port infrastructure, fleet dynamics, and access to landing sites.

The integrated discussion of the results demonstrates that this heterogeneity is an inherent characteristic of artisanal fisheries in the EPO and must be explicitly incorporated into the sampling design. In this regard, the report highlights the need to consolidate and refine sampling schemes by country, type of landing site, and type of artisanal vessel; as well as to continuously strengthen the capacities of field personnel and standardize sampling protocols.

Taken together, the documented progress constitutes a solid foundation for the development of a more robust and comparable regional monitoring system. This strengthens the capacity to support future stock assessments and shark management and conservation processes in the EPO.

1. Introduction

Sharks are a common target and an important component of bycatch in pelagic fisheries in the Eastern Pacific Ocean (EPO). For this reason, the IATTC has increased its efforts toward their conservation and management through the development of resolutions and sampling programs specific to sharks. However, the lack of reliable data on catch, effort, and composition by species and size, especially from small-scale coastal (“artisanal”) fisheries, has hindered attempts to develop stock assessments for the most common species (e.g., the silky shark) ([SAC-15-10](#))

The tuna fisheries operating in the EPO, for which the IATTC is responsible, vary widely in their operational characteristics and are extensive in their spatial and temporal scope. The main “industrial” tuna fleets primarily catch tuna (skipjack, yellowfin, and bigeye) and related species (e.g., billfish, sharks, dorado, etc.) using longlines or purse seines ([SAC-15-09](#)). As a result, these fisheries interact with a wide range of coastal and pelagic shark species.

Sharks are a target and a particularly common bycatch in artisanal and industrial multi-species coastal pelagic fisheries throughout the EPO. Unfortunately, sharks are also a particularly vulnerable group, as most of the species affected by tuna fisheries are long-lived, have slow growth rates, and possess low reproductive capacity.

Through the adoption of the Antigua Convention (IATTC, 2003), which entered into force in 2010, the IATTC has recognized its responsibility to ensure the long-term sustainability of sharks and other non-target species in Article VII 1(f): *“to adopt, where necessary, measures and recommendations for the conservation and management of species belonging to the same ecosystem that are affected by fishing for fish species covered by this Convention, or that are dependent on or associated with such species...”*. As such, the IATTC has responded to growing concern about the potential negative effects of tuna fishing on sharks by implementing various conservation and management measures (CMMs) through a series of resolutions adopted since 2005 to limit or prohibit the retention of sharks ([C-05-03](#), as amended by [C-16-04](#), [C-16-05](#), [C-23-07](#), [C-24-05](#), and [C-25-08](#)), for specific species (oceanic whitetip shark [C-11-10](#) and silky shark [C-19-05](#), with amendments in [C-21-06](#), [C-23-08](#), and [C-25-09](#)), sets for whale sharks ([C-19-06](#)), or to promote handling practices that maximize shark survival after release ([C-16-05](#)). ([SAC-15-09](#)).

Since 2014, the IATTC has been involved in various projects on targeted and bycatch shark fisheries in coastal and subregional fisheries in the EPO. In its first phase (2014–2021) in Central America, it developed a working methodology for these multispecies fisheries through funding from the FAO-GEF Common Oceans Program, specifically the project *“Sustainable Management of Tuna Fisheries and Conservation of Biodiversity in Areas Beyond National Jurisdiction”* (ABNJ). This research was funded with the aim of improving data collection on shark catches in the EPO. Additionally, it received financial support from the IATTC itself (2019) and the European Union (2020–2021). This project culminated in the development of sampling designs for the Central American region through field sampling, assessing logistical challenges, and modifying, where necessary, the established designs to obtain representative catch and effort data ([SAC-14 INF-P](#)); prioritizing species of importance to the IATTC ([C-24-05](#) and [SAC-16-08](#)).

Starting in 2023, a new financial partnership between FAO and the GEF was approved to launch a new phase of the ABNJ project (Phase 2) ([SAC-14 INF-M](#)), which includes countries such as Ecuador, Mexico, and Peru, with the objective of *“Improving data collection and stock assessment for shark populations in the eastern Pacific Ocean: expansion to the fisheries of coastal states.”* Although these countries have made considerable progress in managing their fisheries, the quality of the data and its value for stock assessments are limited and vary from one country to another. Furthermore, among the coastal nations of the EPO, there is limited harmonization of data collection methods during the monitoring of shark fisheries. Furthermore, no sampling designs have been developed that account for the highly migratory and transboundary nature of shark populations within the vast EPO region, a region of management interest to the IATTC.

Since the project’s inception, three reports have been produced covering a literature review of studies conducted in each country on chondrichthyans ([SAC-16-INF-V](#)); mapping of shark landing sites and their characterization ([SAC-16-INF-W](#)); and the feasibility of biological and morphometric sampling of the main shark species landed in Ecuador, Mexico, and Peru. This document describes progress on the sampling designs implemented in each country and their standardization for the EPO region.

2. Methodology

2.1 Sampling Forms

During this phase of the study, four sampling forms were developed and applied, described in detail in the *“Feasibility Study Report for the Collection of Samples Aimed at Updating Morphometric Relationships and Obtaining Biological Samples”* (SAC-17 INF-O). Below is a summary of the forms used and their specific purpose:

1. **Form 0:** Designed to characterize the operational dynamics of the fishing fleet associated with the sampling site, including general information on the vessels and their operating patterns.
2. **Form A:** Used for the systematic recording of catch and fishing effort for each sampled vessel.
3. **Form B:** Used primarily for the biological sampling of shark and/or ray embryos, with an emphasis on the collection of reproductive information.
4. **Form C:** Used during group unloading events, particularly in fisheries targeting the capture of neonates.

The specific application procedures, as well as the variables recorded on each form, are described in greater detail in the aforementioned report.

2.2 Selection of sampling sites

The procedure for selecting sampling sites was based on information compiled from the metadata reports ([SAC-16-INF-V](#)) and the mapping of landing sites ([SAC-16-INF-W](#)). Both documents were combined to identify the best shark landing sites based on fishery statistics from scientific and fisheries authorities. Likewise, the number of vessels in each locality was considered, as well as information on catch composition, based on the literature and interviews with technical staff from the regional offices of each institution. Additionally, site accessibility was evaluated, taking into account both the fishing communities’ acceptance of the project and operational safety. It is important to note that this factor was a priority throughout the selection process.

The following is a detailed description of the methods used to select sampling sites in each country:

a. Ecuador

For the selection of sampling sites corresponding to the main shark landing points, the primary source of information was shark landing data compiled by the Undersecretariat of Fisheries Resources (SRP) during the period 2013–2022. This information was classified based on variables such as landing volume, species caught, and fishing gear used in the various fishing localities. This approach allowed for the identification of trends and patterns in fishing activities, both for the artisanal fleet (coastal and oceanic) and for first-port vessels, known as “mother” longliners.

This analysis was complemented by geospatial mapping of elasmobranch landing sites, conducted through a systematic visual analysis of satellite imagery available on Google Earth Pro. This process was supported by a literature review (technical reports, fishing permits, and scientific literature), as well as a validation process based on field observations and expert knowledge. To this end, participatory workshops were held with fisheries inspectors and specialists from the Shark Plan (PAT-EC).

As a result of the mapping and validation process, 474 fishing sites and 118 elasmobranch landing sites were identified, of which 44 landing sites were prioritized (16 primary and 28 secondary). The final selection considered accessibility criteria, prioritizing operational safety, such as the existence of alert protocols, access control, and institutional presence. These criteria were applied primarily at sites with formal port infrastructure; meanwhile, at sites located in beach areas, institutional presence and safety measures were implemented in a planned manner, particularly at the El Matal unloading sites (5200, 5201, and 5202).

For example, at sites within the town of Esmeraldas, discharges are concentrated mainly in the morning hours, requiring specific adjustments to the sampling plan. In addition, at sites in the towns of Manta, Jaramijó, and Esmeraldas, better control conditions and greater institutional support were available, facilitating stable operational coverage. In the case of Santa Rosa, activities were carried out under intermediate security protocols, with previously established precautionary measures and institutional coordination.

Likewise, relevant technical and operational aspects were considered for sampling planning, including unloading schedules, infrastructure availability, and the feasibility of maintaining a continuous presence of Sampling Technicians (STs). In this context, 12 primary sites and one secondary site were selected in Ecuador (Table 1). The latter was included for monitoring purposes, given its historical record as one of the main shark landing sites. However, recent information from the local fisheries inspectorate indicates that it currently does not record significant landings relevant to the study's objectives (Figure 1).

Table 1. Primary and secondary landing sites considered for sampling.

Location	Location ID	Site Name	Site ID
Esmeraldas	7	Esmeraldas Artisanal Fishing Port 03	5074
Esmeraldas	7	Esmeraldas Artisanal Fishing Port 04	5075
Esmeraldas	7	Esmeraldas Artisanal Fishing Port 05	5076
Esmeraldas	7	Esmeraldas Artisanal Fishing Port 06	5077
Jama	30	El Matal 02	5200
Jama	30	El Matal 03	5201
Jama	30	El Matal 04	5202
Jaramijo	37	Small-scale fishing port Jaramijo 01	5266
Jaramijo	37	Jaramijo Artisanal Fishing Port 02	5267
Manta	38	Manta 01 Waterfront Fishing Terminal	5277
Santa Rosa	38	Santa Rosa Artisanal Fishing Facility	5364
Puerto López	44	Puerto López 03	5306

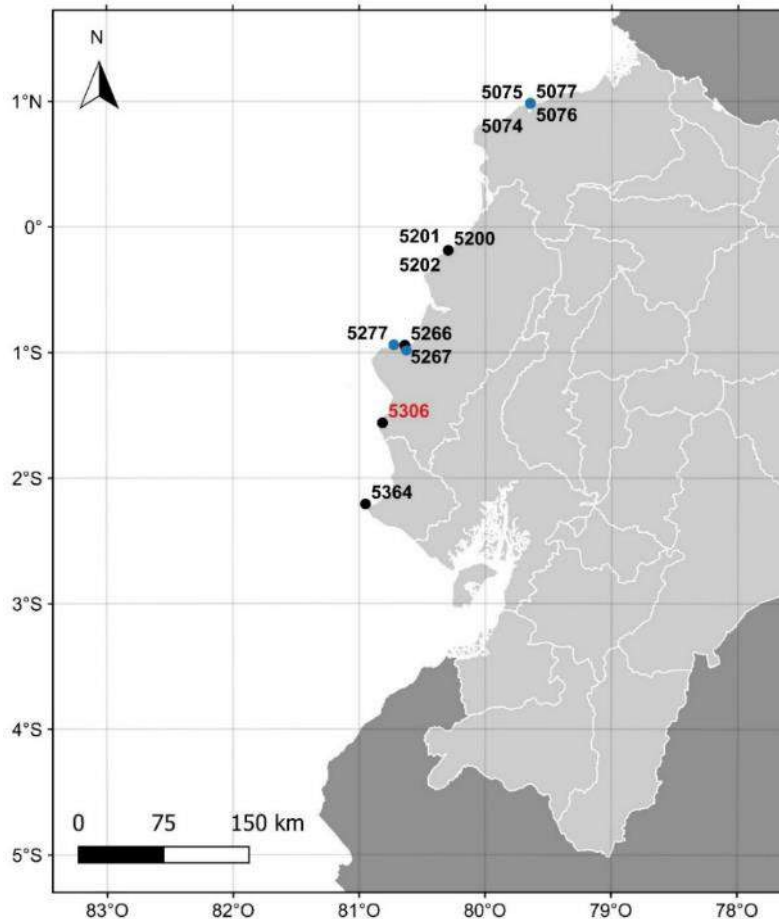


Figure 1: Geographic location of the main shark and ray landing sites in Ecuador included in the sampling design, corresponding to artisanal vessels (coastal and offshore) and the mother ship longline fleet. The black numbers identify the primary sites: Esmeraldas Artisanal Fishing Port 03, 04, 05, 06 (5074, 5075, 5076, and 5077), El Matal 02, 03, 04 (5200, 5201, and 5202), Jaramijó artisanal fishing port 01 and 02 (5266 and 5267), Manta marginal pier fishing terminal 01 (5277), and the Santa Rosa artisanal fishing facility (5364). The number in red corresponds to the secondary site Puerto López (5306). The blue dots indicate the sites where the feasibility of the Close-Kin Mark Recapture (CKMR) genetic study, targeting *Carcharhinus falciformis*, is also being evaluated.

b. Mexico

The selection of sampling sites in Mexico was based primarily on information gathered during meetings with specialists in various elasmobranch topics, both from IMIPAS and local universities.

Additionally, a database shared by CONAPESCA regarding current shark fishing permits was analyzed, taking into account the landing site and authorized fishing effort (number of vessels).

Once the main landing sites on the Mexican Pacific coast were identified, field visits were conducted, accompanied by technical and scientific staff from IMIPAS. During these visits, the sites were characterized, and interviews were conducted with the holders of shark fishing permits identified in the CONAPESCA database, which allowed for the evaluation of key conditions for implementing the monitoring program.

This preliminary work was essential for documenting aspects related to the safety of technical staff, accessibility (access routes), the number of vessels capable of catching sharks (targeted or incidentally), and daily operating costs. Thus, 36 sites were characterized, of which 18 were initially selected for monitoring (Figure 2).

However, for various reasons explained below, some sites were replaced by others, and the number of sites increased (Table 2, Figure 3). Thus, 22 sites were sampled during 2025, with the exception of the months corresponding to the shark closed season (May–July). To simplify the analysis and presentation of results, the 22 sites were grouped into 7 regions, taking into account state boundaries and changes in the composition of recorded species.

It is important to note that the selected sites do not necessarily represent those with the highest landing volume in each locality, but rather those that offer safe access and operational feasibility. The multi-species nature of artisanal fisheries and variations in safety indices make it necessary to temporarily or permanently adjust some sampling sites.

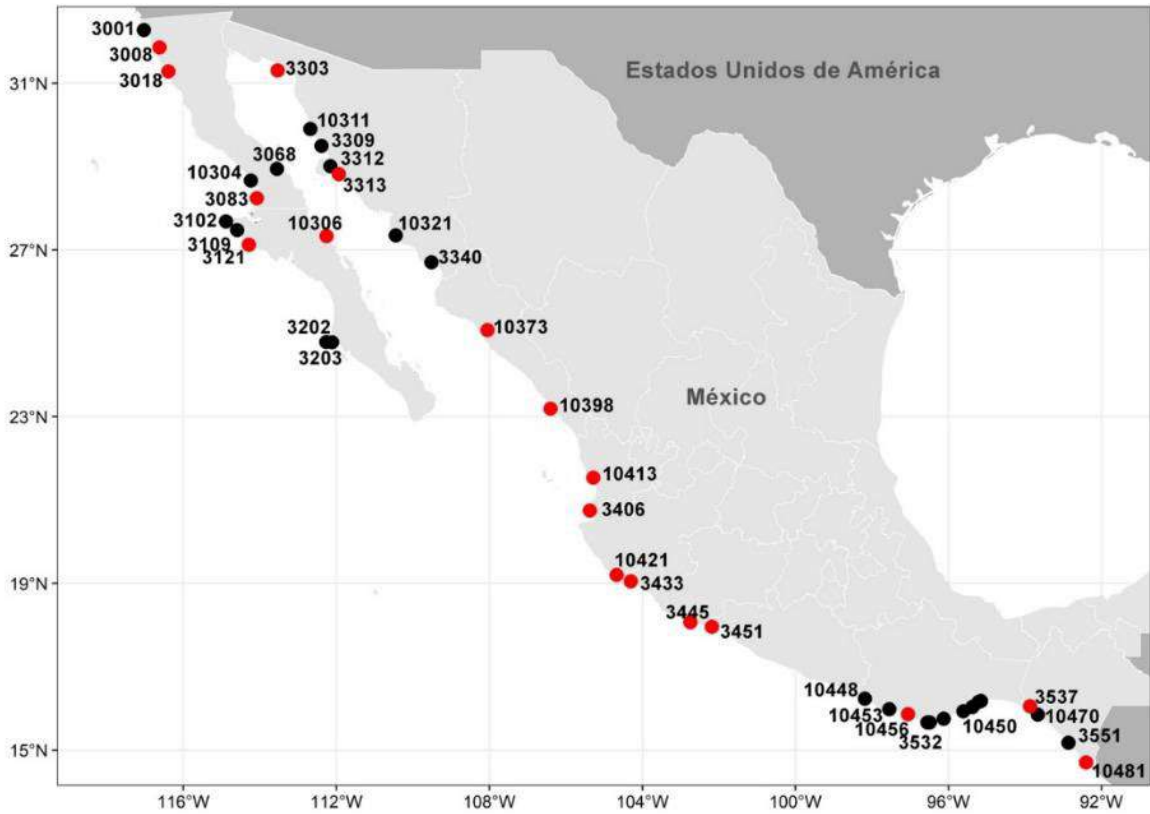


Figure 2. Distribution map of the characterized sites; circles indicate all visited sites; sites initially selected for monitoring due to their safety and accessibility are shown in red.

Table 2. Sites selected for monitoring shark and ray effort and catch; the locality ID and name are indicated; the site ID and name; the region number corresponding to each site and locality.

Location Name	Location ID	Site Name	Site ID	Region
San Quintin	6	Sta Rosaliita II	10304	1
San Quintin	6	Manuela Lagoon	3083	1
San Quintin	6	Porto Santa Catarina	3058	1
Mulege	7	Bahia Asunción	3121	2
Comondu	9	Lopez Mateos	3188	2
La Paz	10	Conquista Agraria	3271	2
Hermosillo	16	Bahia De Kino	3313	3
Puerto Peñasco	13	San Jorge	3304	3
Caborca	14	Jawey	3305	3
Pitiquito	15	Puerto Libertad	10311	3
Mazatlán	32	Isla De La Piedra	10398	4
Rosario	33	Majahual	3385	4
San Blas	39	La Nueva U	10413	4
Bahia De Banderas	41	Cruz de Huanacastle	3406	4
Cihuatlan	46	Barra de Navidad II	10421	5

Manzanillo	47	Colimilla	10423	5
Manzanillo	47	Fondeport II	3432	5
Lázaro Cárdenas	52	Caleta de Campos	3445	6
Lázaro Cárdenas	52	Lázaro Cárdenas	3452	6
San Pedro Mixtepec	81	Bahia Principal	10456	7
Sta. Maía Tonameca	86	San Agustinillo	10461	7
Tonala	89	Bahia Paredon	3537	7

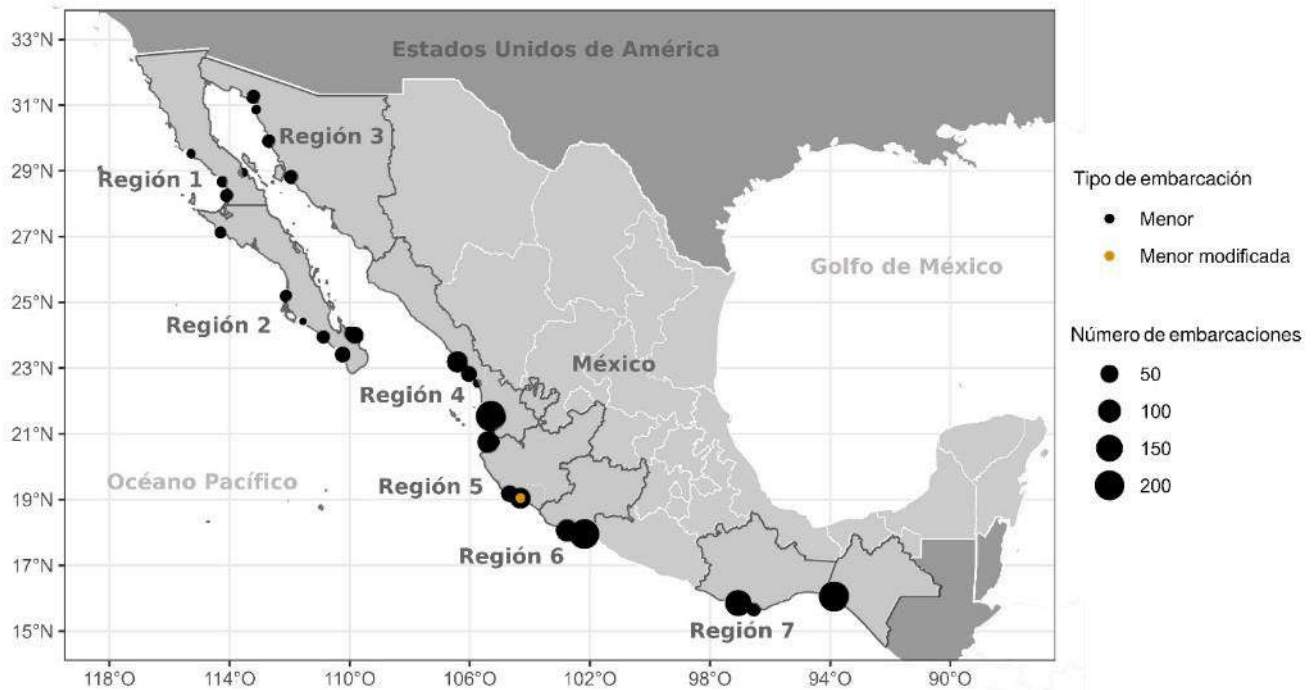


Figure 3. Distribution of the 22 sites selected for shark sampling along the Pacific coast of Mexico; each site is marked by a circle, the size of which indicates the number of registered vessels; black circles indicate small vessels and the yellow circle indicates modified small vessels; the gray boundary lines indicate the 7 strategic regions.

Finally, these 22 sites have been monitored on a monthly basis by 23 TM, belonging to various institutions and fishing organizations. Of these, 15 TM belong to IMIPAS, 2 to the National Autonomous University of Mexico, 1 to CONAPESCA, 2 to the Leyes de Reforma de Baja California Sur cooperative, and 3 to the San Jorge de Sonora cooperative.

c. Peru

Based on information provided by the Peruvian Institute of the Sea (IMARPE) during the metadata phase, 67 sites with elasmobranch landings were initially identified. However, this number was expanded to 123 potential sites through the analysis of satellite imagery, the review of metadata documents, official lists of authorized locations for shark unloading from the Ministry of Production (PRODUCE), and the application of expert criteria.

From this set of identified sites, priority sites were selected based on criteria such as landing volume, species present, type of catch (targeted or bycatch), life stages, type of cut, and information provided by fishermen and IMARPE field observers. Thus, 31 priority sites were identified, classified as 12 primary (targeted catch) and 19 secondary (bycatch) sites.

Finally, through surveys of IMARPE field observers and fishermen at the priority landing sites, relevant logistical and operational aspects were evaluated, such as the frequency and regularity of landings; the availability and quality of catch-related information (species landed, cut types, fishing gear, and vessel types); site accessibility; conditions for data collection; and the feasibility of hiring staff.

Based on this assessment, 11 sites were identified as suitable for implementing catch and effort monitoring (Figure 4, Table 3), which account for more than 80% of the national volume of elasmobranch landings, according to IMARPE.

Table 3. Primary and secondary landing sites considered for sampling, Peru, 2025; The locality and its identification number (ID) are indicated; The site name and its ID number are indicated.

Location	Location ID	Site Name	Site ID
Zorritos	4	Zorritos 01	7010
Acapulco	5	Acapulco 03	7015
Máncora	9	Máncora 01	7026
Playa Blanca	28	Playa Blanca 01 / Galileo	10704
San José	29	San José 01	7092
San José	29	San José 03	7094
Salaverry	39	Salaverry 02	7109
Salaverry	39	Salaverry 03	7110
Ancón	63	Ancón 02	10706
Pucusana	70	Pucusana 01	7193
Ilo	89	Ilo 01	7227

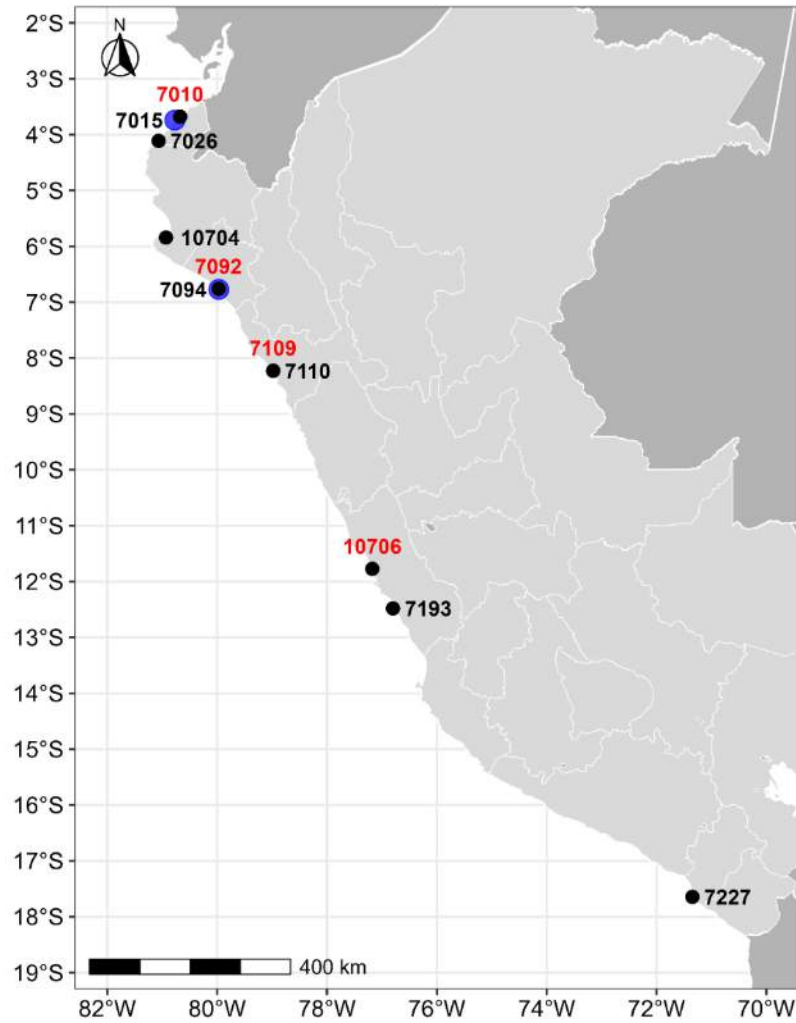


Figure 4. Landing sites monitored by sampling technicians along the coast of Peru, where elasmobranch discharges are recorded. Labels in black (primary) and red (secondary). The blue dots indicate sites where the feasibility of the Close-Kin Mark Recapture (CKMR) genetic study, targeting *Carcharhinus falciformis*, is also being evaluated.

2.3 Description of the type of discharge and methodology for collecting discharge data at the selected sites

a. Ecuador

Catch unloading was carried out according to the type of port infrastructure available at each landing site, including artisanal fishing facilities, artisanal fishing ports, industrial fishing terminals, and unloading sites located on beaches. In this context, the sampling methodology was adapted according to the characteristics of each type of infrastructure, taking into account the operational dynamics of the different unloading methods and accessibility for data collection.

For data collection, sampling technicians (STs) randomly selected vessels arriving at unloading sites, prioritizing those that reported catches of sharks and rays.

With port infrastructure:

1) Artisanal fishing facility

At the Santa Rosa artisanal fishing facility (5364), most small vessels—both coastal and ocean-going—remain anchored in the harbor, where the catch is sold. The catch is then transported in bongos or pangas to the fishing facility for cleaning, sale, or transport in refrigerated vehicles. In this context, sharks from ocean-going vessels are typically unloaded individually, while those from coastal vessels are unloaded in groups (in boxes or baskets), including species such as *Sphyrnas spp.*, *Mustelus spp.*, *Coryphaena hippurus* (during its fishing season), medium-sized fish such as rays and *Coryphaena hippurus* (during its fishing season), and smaller fish such as *Mugil cephalus* and squid (Figure 5).



Figure 5. Individual unloading of sharks from the harbor at the Santa Rosa artisanal fishing facility. a and b) transfer of large individuals from boats anchored in the harbor to small boats; c and d) individual unloading and transport of specimens to the inner area of the fishing facility.

The sampling procedure followed an operational sequence: (i) selection of vessels in the harbor; by traveling in a small panga to the vessels' arrival site for selection and sampling, (ii) followed by recording of catch and effort data on board; (iii) next, the catch is transferred¹ to the fishing facility; (iv) subsequently, fishing data were recorded at the facility; and (v) finally, the weight and biometrics of the sharks were recorded during processing. (Figure 6).



Figure 6. Sequence of the sampling procedure, including vessel selection and the recording of catch, effort, and biometric data at the Santa Rosa fishing facility (5364).

¹ Transferring the cargo from one vessel to another within the harbor to be taken to the unloading area.

2) Artisanal fishing port

At sites with artisanal fishing ports, such as Esmeraldas 04, 05, and 06 (5075, 5076, and 5077) and the Jaramijó 01 artisanal fishing port (5266), coastal and ocean-going vessels unload directly upon arriving at the floating dock. At these sites, large fish from ocean-going vessels are unloaded individually and transported to the storage facility for subsequent cleaning and marketing.

For their part, catches from coastal vessels consist mainly of demersal species and rays, and to a lesser extent of sharks of the genera *Mustelus* and *Squatina*. In these cases, unloading is mostly done in groups using crates or baskets, and the catch is transferred directly to trucks for transport. Occasionally, coastal vessels unload large rays individually, which are then placed in the port's storage facilities for processing and sale (Figure 7).



Figure 7. Methods of unloading elasmobranchs at artisanal fishing ports in Ecuador. Ocean-going vessels: a) individual unloading of *Alopias pelagicus* at the Jaramijó 01 artisanal fishing port; b–c) hoisting and individual unloading of *A. pelagicus* at unloading sites in the Esmeraldas artisanal fishing port. Coastal vessels: d) individual unloading of rays; e) group unloading of rays and smaller sharks at the Jaramijó 01 artisanal fishing port.

The sampling procedure involved, once the vessel was selected, recording the total number of individuals caught (tuna, billfish, sharks, and other fish) directly on the floating dock (pontoon). Subsequently, the catch is transferred to the port's hold where weights and biometrics are recorded, and then the catch and effort record is completed through an interview with the fishermen (Figure 8). It is worth noting that this same procedure is carried out for large rays such as *Hypanus sp.*; however, weighing is often not performed, as the product is subsequently removed for the gutting process.



Figure 8. Sequence of the sampling procedure during vessel unloading (coastal and ocean-going), including the recording of catch, effort, and biometrics at the unloading sites in the artisanal fishing

port of Esmeraldas 03, 04, 05, 06 (5074, 5075, 5076, 5077, respectively) and the Jaramijó 01 artisanal fishing port (5266).

3) Terminal and industrial fishing port

Unloading operations at the Manta 01 wharf terminal (5277) and the Jaramijó 02 artisanal fishing port (5267) are primarily used for unloading industrial mother longline vessels. At Jaramijó 02, smaller modified vessels are also unloaded, though to a lesser extent. The unloading of the fish is carried out in groups, using a “winch” available as part of the port infrastructure.

At these sites, differences were identified in the operational procedures following the hoisting of the product, depending on the landing site. At the Manta 01 (5277) wharf fishing terminal, the sharks are placed on work tables for processing, which includes finning and cleaning (Figure 9a). In contrast, at the Jaramijó 02 (5267) artisanal fishing port, sharks are typically placed directly on the ground for these activities (Figure 9b). In both cases, after unloading and initial processing, the sharks are transferred to refrigerated vehicles for transport.

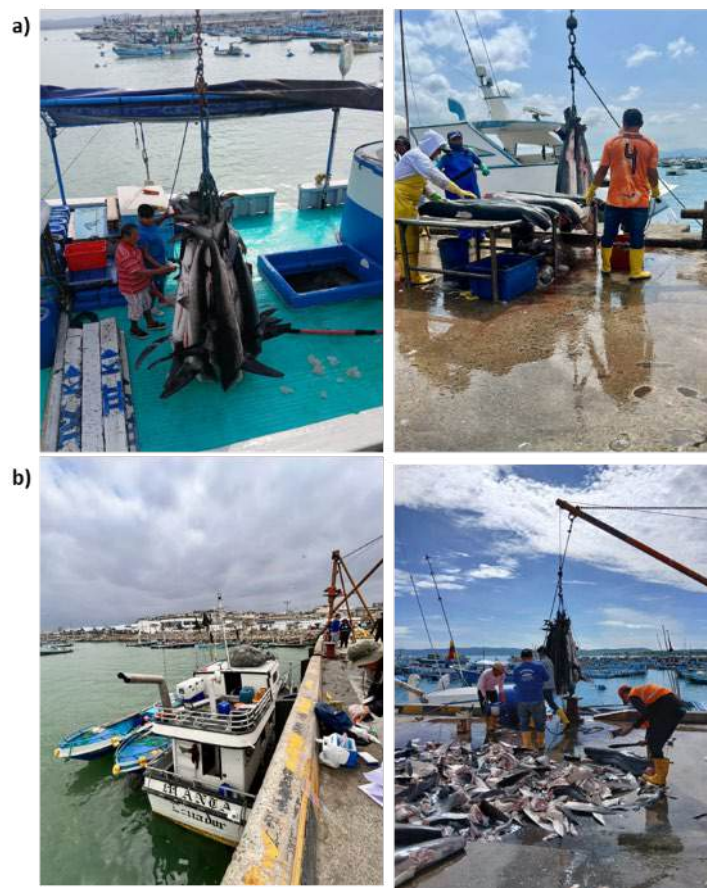


Figure 9. Group unloading of sharks associated with mother longline vessels at: a) Manta 01 wharf fishing terminal (5277) and b) Jaramijó 02 artisanal fishing port (5267). The unloading of the sharks using a winch is observed, involving both the mother ship and the smaller vessels that transfer their catch at sea for subsequent storage aboard the mother ship.

During the sampling procedure conducted by mother longline vessels at both sites, the number of individuals and the total weight of the catch were recorded. At the Manta 01 (5277) unloading site, biometric data are recorded on board the vessel when access is available (Figure 10). Meanwhile, at the Jaramijó 02 landing site (5267), this recording is carried out in the landing area, placing the individuals in spaces that do not interfere with gutting and processing activities. Finally, an interview is conducted with the vessel's captain to collect data on the fishing trip, including information on catch and effort (Figure 10).



Figure 10. Sequence of the sampling procedure during shark unloading on mother longline vessels at the unloading sites of the Manta marginal pier fishing terminal (5277) and the Jaramijó 02 artisanal fishing port (5267).

No port infrastructure:

2) Beach area

At the El Matal 02, 03, and 04 unloading sites (5200, 5201, and 5202), unloading takes place directly on the beach. To do this, both ocean-going and coastal vessels are towed by a tractor to the usual beach landing points.

At site 5201, larger sharks (primarily *Alopias spp.* and *Prionace glauca*, and less frequently members of the Carcharhinidae family) are typically unloaded individually. These specimens are gutted on board or transported to nearby storage facilities. In contrast, at sites El Matal 02 (5200) and El Matal 04 (5202), coastal vessels unload in groups, primarily sharks such as *Mustelus spp.*, *Sphyrna spp.*, and *Squatina spp.*, as well as rays and demersal fish, which are typically gutted on the beach and subsequently sold (Figure 11).



Figure 11. Unloading of small individuals, individually and in groups, using a plastic box at the El Matal beach area.

During sampling, information was collected from the moment the vessel arrived at the beach, recording fishing operation data (catch and effort) as well as biometric information on the individuals. These records were made on the beach or in the hold, depending on site conditions and the fishermen's preference or availability (Figure 12).



Figure 12. Sequence of the sampling procedure for recording catch, effort, and biometrics at the artisanal fishing facility in El Matal 02, 03, 04 (5200, 5201, 5202).

Temporal coverage of landing sites

Coverage of the landing sites was conducted continuously from Monday to Saturday, except in exceptional cases associated with operational contingencies. Sampling planning was established based on the frequency and magnitude of shark landings, as well as the operational dynamics of the artisanal fleet and “mother” longliners. In Ecuador, there were three sampling technicians (STs), who were assigned according to their knowledge of the fishing localities.

A rotation schedule for the STs was implemented to optimize the spatial and temporal coverage of the landing sites. This rotation consisted of covering the same site for three consecutive weeks (primary site). Meanwhile, for one week each month, the ST moved to another landing site (secondary site), following a monthly rotating sequence. That is, if sampling began in the first week of a month, it was conducted during the second week of the following month, and so on. This schedule was applied primarily to the Esmeraldas TM, who made a monthly rotation, covering the unloading sites in El Matal.

Similarly, the TM responsible for the Jaramijó landing sites traveled to the Manta fishing terminal one week each month to record landings associated with mother longline vessels. In the case of the TM assigned to the Santa Rosa site, coverage remained continuous, since the assigned secondary unloading site (Puerto López) did not have significant shark landings that would justify the trip.

Additionally, monthly coordination meetings were held with the Control Directorate of the Undersecretariat of Fisheries Resources (SRP), which proved essential due to the permanent presence of personnel from this institution at the landing sites. This support provided operational backing for , particularly at sites located in the Esmeraldas Artisanal Port for security reasons, as well as enabling the verification and validation of catch data from mother longline vessels through the review of fishing logs, particularly at the Manta and Jaramijó sites.

Data Collection and Quality Control

In accordance with the established methodological protocol, the information was recorded using standardized forms for the characterization of landing sites, catch, effort, and biometric data. Subsequently, the records underwent a systematic review and quality control process to ensure the consistency, integrity, and reliability of the information.

In the case of Ecuador, a total of 1,142 catch and effort forms (Form A) were recorded for 12 landing sites. Of this total, 50 records (4.4%) were classified as edited and unacceptable data, while 30 records (2.6%) were classified as data to be excluded.

The records classified as unacceptable lacked the required complete information. The main cause was the inability to interview the vessel's captain, which resulted in the absence of fishing trip data, even though information on the catch and, in some cases, biometric data were available. At the Santa Rosa site (5360), some forms did not include complete catch information because sampling was conducted on vessels that unloaded their catches over two consecutive days; for example, the target catch was unloaded on one day and the bycatch of sharks on another.

Identified types of unloading

Figure 13 presents a flowchart of the unloading and sampling process at the monitored sites, distinguishing between procedures applied with and without port infrastructure. The diagram begins with the arrival of the vessels and describes the operational routes according to the type of unloading site, including fishing facilities, artisanal ports, fishing terminals, and beach areas. In each

case, the unloading methods (individual or group), the recording of the number of individuals per species, the collection of biometric data, the recording of catch and effort, as well as the processes for transferring the catch to the hold when applicable, are detailed. Finally, the flowchart incorporates the stages of quality control and data systematization, ensuring the consistency, traceability, and validation of the collected data (Figure 13).

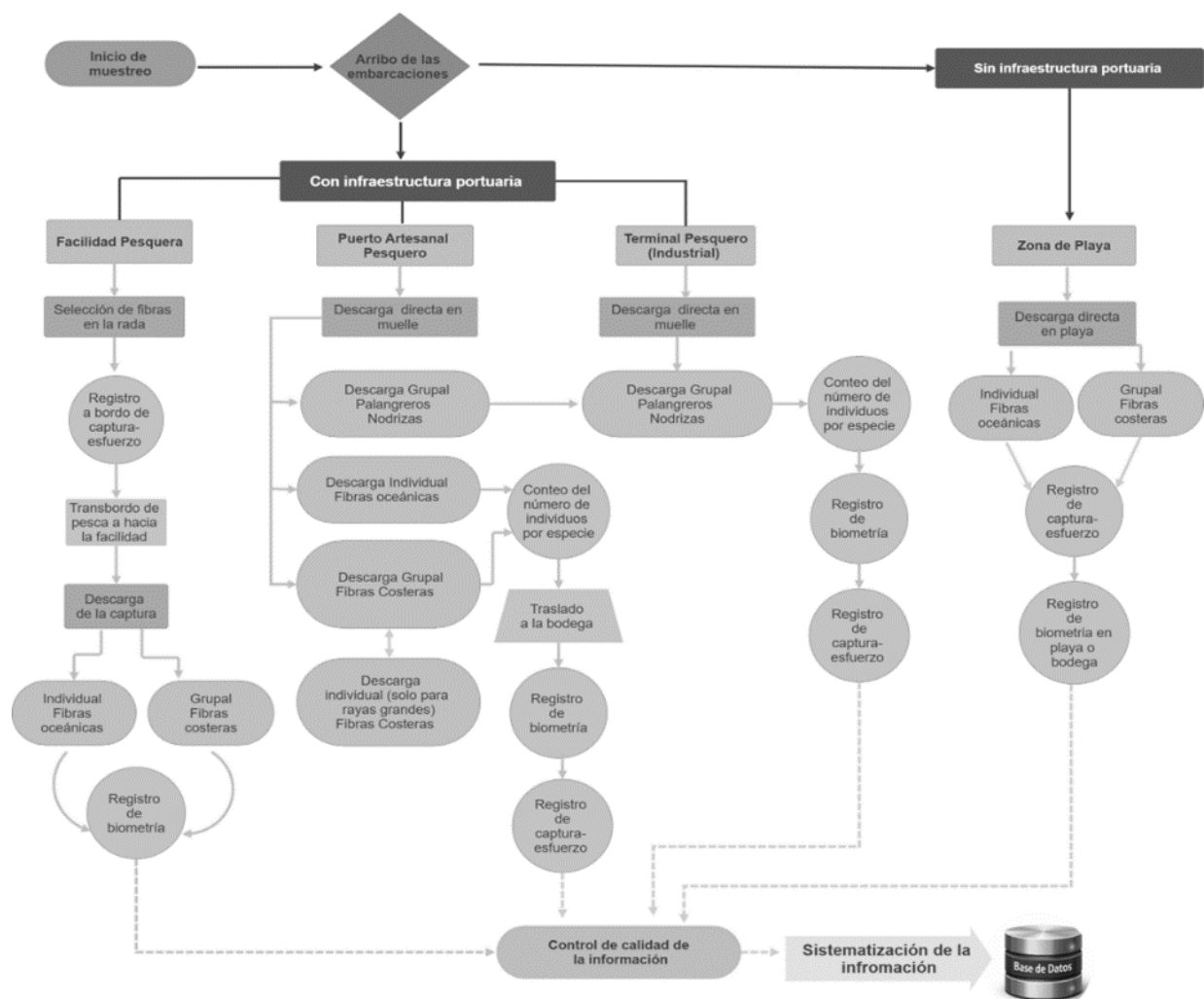


Figure 13. Flowchart of elasmobranch unloading and sampling at landing sites in Ecuador; the dark gray rectangles represent the two main variables, with and without infrastructure

b. Mexico

There are different methods for unloading sharks, depending on the available infrastructure and the dynamics of the fishing fleet at each site. In general, at the 22 sites, it was documented that individuals are unloaded one by one if they are large organisms (>1 m TL), or in groups (in sacks or boxes) if they are small organisms (>1 m TL) (Figure 14).



Figure 14. Unloading of large individuals (>1 m TL) individually and in groups of small individuals (<1 m TL) using a plastic box.

Identified types of unloading

Regarding the landing of the catch, several types of unloading (TD) were recorded, depending on whether it was carried out on the beach or at the pier. In general, seven types of unloading were identified, along with various variables where field technicians had to consider different strategies for completing forms, measuring individuals, and, where applicable, collecting biopsies (Table 4; Figure 15).

Table 4. Coding of the different types of unloading and catch transport identified at the monitoring sites.

Types of unloading (TD)	Code
Trawling from a boat and unloading at a collection center	A
Unloading on the beach, on-site processing, and storage in a cargo vehicle	B
Towing of vessel to unload from fisherman's house to cargo vehicle	C
Unloading from a small boat to a cargo vehicle	D
Unloading on the beach, on-site processing, and transport by cargo vehicle	E
Unloading at the pier and transport to a collection center or point of sale	F

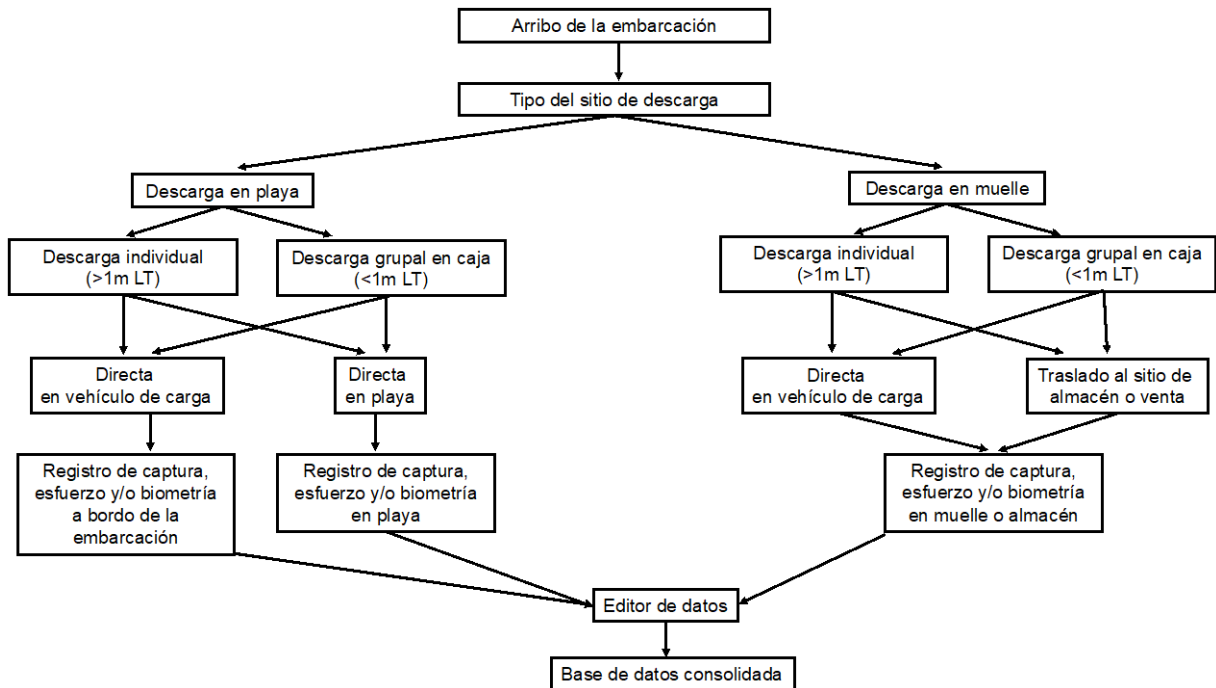


Figure 15. Flowchart of the general dynamics of unloading sharks caught in the Mexican Pacific; each box indicates the location where unloading occurs, or where data and/or biological samples are collected; the arrows indicate the different possibilities of the process.

Specifically, in Santa Rosaliita (10304), Laguna Manuela (3083), Bahía Asunción (3121), Puerto Libertad (10311), and Bahía de Kino (3313), vessels arrive at the beach, from where they are transported (by truck) to the collection center (TD A; Table 4; Figure 16). In this case, depending on various circumstances, the TM may board the vessel or go to the collection center to gather information.

In Puerto Santa Catarina (3058), the boats arrive at the beach, where they unload the catch into a cargo vehicle used as a storage facility (TD B; Table 4). Because this location is remote from the urban area, situated in a desert zone, the cargo vehicle remains on site for several days until it is fully loaded.

At the Adolfo López Mateos site (3188), the boats are towed from the beach to the fisherman's house, where a cargo vehicle arrives to collect the catch (TD C; Table 4). Normally, the fishermen at this site allow the TM to visit their homes to complete the forms and collect biological data. However, this strategy is complicated because considerable time is lost during the trips from the beach to the fishermen's homes; this results in the failure to record other boats arriving at the beach during that time.



Figure 16. Method of dragging boats on the beach, from the water's edge to the collection center.

At the Conquista Agraria site, upon arriving at the beach, the boats unload their catch directly into a cargo vehicle (TD D; Table 4; Figure 17). If the catch is unloaded directly into cargo vehicles, the TM must board the boat to collect information (complete forms) and/or collect biological samples. This procedure is relatively complicated due to the time and space constraints faced by the TM (Figure 17).



Figure 17. Unloading of individuals directly from the boat into the cargo vehicle; sampling conducted on board the boat.

In San Jorge (3304), Jawey (3305), Isla de la Piedra (10398), Majahual (3385), Barra de Navidad II (10421), Colimilla (10423), Caleta de Campos (3445), Lázaro Cárdenas (3452), Bahía Principal (10461; sometimes Type D), San Agustínillo (10461), and Bahía Paredón (3537), unloading takes place on the beach, at docks, or on artisanal ramps adapted to the beach (TD E; Table 4; Figure 18).

Once the fish have been unloaded, the catch is processed at designated sites and then transported to the collection center by truck (Figure 18). It is at these sites that the TM fills out the forms, although he has little time to do so because he must do this while the fishermen are gutting the fish.



Figure 18. Artisanal pier adapted to the beach (Bahía Paredón) to facilitate the loading and unloading of artisanal vessels; beach landing sites (San Agustínillo) with a designated area for processing the catch.

On the other hand, at La Nueva U (10413) and Cruz de Huanacastle (3406), unloading takes place at a pier, from where the fish are transported to a collection or sales site (TD F; Table 4; Figure 19). In this case, the TM must wait at the pier to record information regarding the boat and its arrival; they must then proceed to the storage or sales site to collect biological data (Figure 19).



Figure 19. Transfer of the catch unloaded at the pier; collection of biological data at the sales site in Cruz de Huanacastle.

Finally, at Fondepport II (3432), the individuals are unloaded at the dock and then placed in cargo vehicles (TD G; Table 4; Figure 20). At this site, all individuals are unloaded already gutted, so the TM takes this opportunity to record the inter-dorsal length and sex, in addition to information regarding the vessel and fishing effort.



Figure 20. Unloading of organisms caught by modified vessels at the Fondepport port in Manzanillo, Colima; collection of biological data by the TM prior to the weighing process and storage in cargo vehicles for transport to collection centers and/or sale.

Temporal coverage of unloading sites

In Region 1, at the three sites Santa Rosaliita 2 (10304), Laguna Manuela (3083), and Puerto Santa Catarina (3058), corresponding to the locality of San Quintín (ID: 6), sampling was conducted over a five-day period by technicians from IMIPAS-CRIAP Ensenada. Of this total, three days were allocated to the Laguna Manuela site, one day to Santa Rosaliita, and one day to Puerto Santa Catarina. Additionally, two days were allocated to transportation activities, considering an approximate round-trip distance of 1,200 km.

In Region 2, the sites Bahía Asunción (3121), Adolfo López Mateos (3188), and Conquista Agraria (3271) were sampled, corresponding to the localities of Mulegé, Comondú, and La Paz (ID: 7, 9, 10, respectively). In Bahía Asunción, the field technicians (TM) from the Leyes de Reforma Cooperative conducted sampling for two days each month. Meanwhile, in Adolfo López Mateos and for one day in Conquista Agraria, the field technicians from IMIPAS-CRIAP La Paz conducted sampling for two days per month.

In Region 3, the sites La Pinta (3304), Jawey (3305), Puerto Libertad (10311), and Bahía de Kino (3313) were sampled, corresponding to the localities of Puerto Peñasco, Caborca, Pitiquito, and Hermosillo (ID: 13, 14, 15, 16, respectively). The field teams (FTs) belonging to the San Jorge Cooperative allocated one day per month to sampling at La Pinta and two days at the Jawey site. The CONAPESCA FT collected data for two days per month at Puerto Libertad, while the IMIPAS-CRIAP Guaymas FTs sampled for three days per month at Bahía de Kino.

In Region 4, the sites Isla de la Piedra (10398) and Chametla (3385) were sampled, corresponding to the state of Sinaloa, in the municipalities of Mazatlán and Rosario (ID: 32 and 33, respectively). Six sampling days were allocated for these sites, carried out by a team of field technicians from UNAM. It should be noted that the sampling dates were modified based on security conditions at the sites.

For this reason, sampling in Chametla was suspended during the last two months of the study period, and this site was replaced by Teacapán (ID: 10400). On the other hand, in the state of Nayarit, two TM teams from IMIPAS-CRIAP Bahía de Banderas conducted sampling for three days per month at the sites La Nueva U (1041) and La Cruz de Huanacastle (33406), which correspond to the localities of San Blas and Bahía de Banderas (34 and 41, respectively).

In Region 5, which comprises the states of Jalisco and Colima, two TM teams from IMIPAS-CRIAP Manzanillo conducted sampling at the sites of Barra de Navidad (10421) and Colimilla (10423) one day per month; while the Fondeport Fishing Pier site (ID: 3432) was sampled for three days per month. These sites are located in the towns of Cihuatlán and Manzanillo (46 and 47, respectively).

In Region 6, the technical team from IMIPAS-CRIAP Pátzcuaro conducted sampling for four days per month at the Caleta de Campos site (3445) and for two days at the Lázaro Cárdenas site (3452), corresponding to the town of Lázaro Cárdenas (ID: 52). For sampling at these sites, two days of travel were accounted for to arrive at and depart from the site.

For Region 7, a TM team from IMIPAS-CRIAP Salina Cruz conducted sampling at Bahía Principal (10456) for two days and at the San Agustín site (10461) for one day; sites corresponding to the localities of San Pedro Mixtepec and Santa María Tonameca (81 and 86, respectively), in the state of Oaxaca. In the state of Chiapas, the Bahía Paredón site (3537), corresponding to the locality of Tonalá (ID: 89), was sampled for two days per month.

Data Collection and Quality Control

Once each sampling event was completed, the teams of sampling technicians proceeded to scan the duly completed field forms. These documents were digitized in PDF format and stored in a centralized folder on the Dropbox platform. A specific folder was established for each team, and its administration and safekeeping were the responsibility of the Support Technician in Mexico, who served as the data editor and was responsible for reviewing, organizing, safeguarding, and controlling access to the collected information.

As part of the quality control process, a systematic procedure for verifying and validating the information was implemented, which included direct and ongoing communication with each sampling technician. Through this mechanism, potential inconsistencies were clarified, incomplete records were corrected, and outliers detected during the database review were confirmed. This approach ensured the consistency and traceability of the information across the original field forms, the digitized files, and the final databases, thereby strengthening the reliability of the data used in the analysis of the artisanal shark fishery.

Subsequently, the recorded information was entered into the databases designed for each form, a process that allowed for the standardization of the information, facilitated its analysis, and reduced the risk of data loss.

c. Peru

Prior to describing the types of landings, it is important to note that the TM records information on all artisanal vessels that include elasmobranch species in their catches during their working hours. In situations of simultaneous landings, a prioritization protocol was followed:

1. Among smaller vessels (barges) and larger ones (boats or motorboats), priority was given to the initial recording of the barges, due to their lower landing volumes and shorter unloading times.
2. When simultaneous unloading of boats and motorboats was observed, priority was given to the vessel with priority species in its catch (e.g., *Prionace glauca*, *Isurus oxyrinchus*, *Sphyrna zygaena*, *Carcharhinus falciformis*, genus *Alopias*). In these cases, only basic information from the other vessel was recorded, omitting biometric data.
3. In the absence of priority species, or when these were present on both vessels, prioritization was based on unloading volume and time, giving priority to the vessel with the lower volume and shorter time. This criterion is similar to that applied in simultaneous unloadings between barges and small boats or motorboats.

Likewise, all information collected by the TM undergoes a quality control process, in which a data editor validates the records before they are stored in a standardized database. Within this operational context, in Peru, of the 11 monitored locations, two sites with beach landings, six at piers without facilities, and three at piers with facilities were identified; their landing methods are described below.

Beach Landings

At the sites of Zorritos Beach (7010; Tumbes region) and San José Beach (7094; Lambayeque region), due to the size of the vessels used to catch elasmobranchs (boats and motorboats), the catches are first transferred to smaller vessels (barges), which can operate near the shore. Unloading takes place directly on the beach, either individually or in groups (Figure 20).

Larger specimens are unloaded individually, while smaller ones are transported in boxes and, in the absence of these, in sacks. The collection of catch and effort data takes place on the beach (site 7010) or at a point immediately adjacent to it (site 7094). In the latter case, the initial unloading is carried out using motorized vehicles that transport the catch to a nearby collection center, where, in the presence of the fisherman, the TM records the catch and effort data and/or biometric data (Figure 21).



Figure 21. Sequence of unloading and handling of elasmobranchs on the beach; Unloading of the catch begins at the shore, individually or in groups; Catch and effort data are recorded directly on the beach or at a nearby collection center, to which the catch is immediately transported for weighing.

Unloading at a pier without facilities

At docks without facilities at the following locations: DPA Máncora (7026; Piura region), DPA Galileo (10704; Piura region), DPA Salaverry (7109; La Libertad region), Salaverry International Terminal private dock (7110; La Libertad region), DPA Ancón (10706; Lima region), and DPA Pucusana (7193; Lima region), the unloading of catches is carried out mainly in the section of the pier used for mooring. This can be done individually or in groups (sites 7026 and 7109); at the other sites, unloading is carried out exclusively on an individual basis (Figure 22).

For large individuals, individual unloading is performed using ropes, with or without the aid of winches to hoist the catch. In contrast, for group unloading or smaller individuals, ropes with hooks are used to hoist boxes, ropes without hooks are used for mooring and the joint transfer of the individuals, or the individual is manually released from the vessel (). At sites where infrastructure permits (sites 7026, 10704, 7110, and 7193), motorboats and small boats can dock directly at the pier to facilitate unloading. At sites 7109 and 10706, catches are first transferred to smaller vessels (barges) for unloading at the pier. In all cases, the recording of catch and effort information and/or biometric data is performed by the TM during the unloading process (Figure 22).

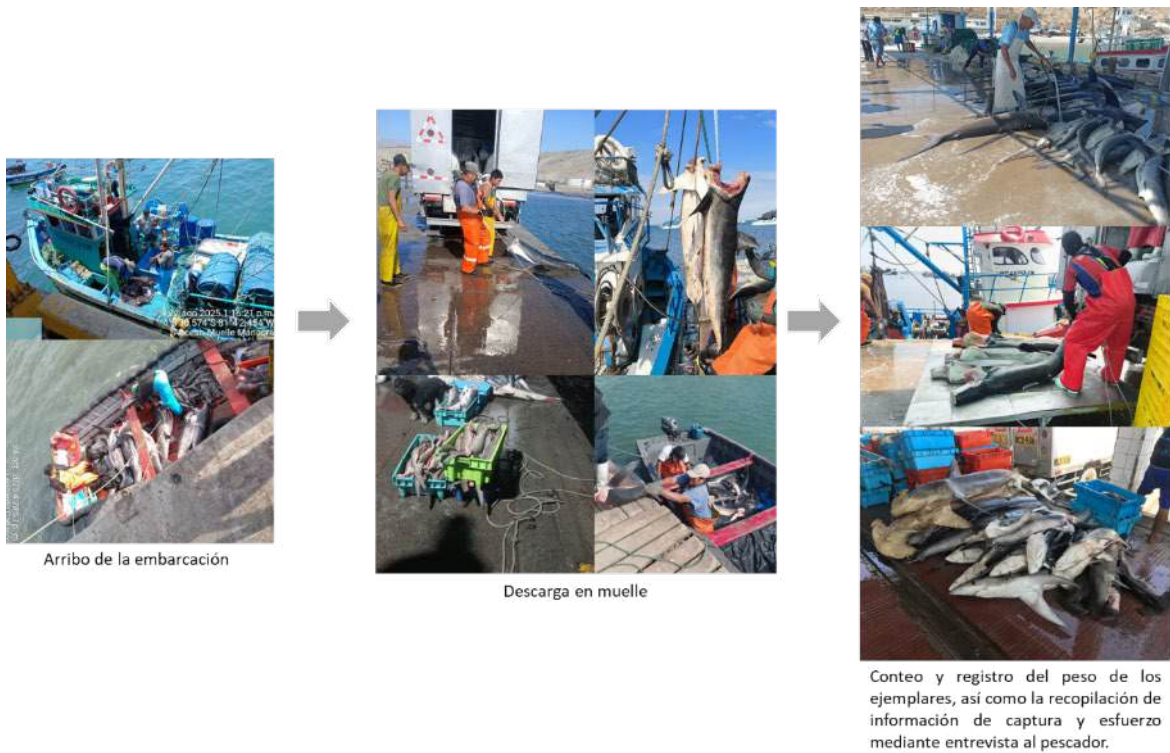


Figure 22. Sequence of elasmobranch unloading and handling at docks without facilities; The catch is unloaded directly onto the dock via individual hoisting or manual unloading; Immediate processing in the unloading area for recording catch and effort, weighing, and washing, without transfer to external areas.

Unloading at piers with facilities

At piers with facilities corresponding to the DPA Acapulco (7015; Tumbes region) and DPA San José (7092; Lambayeque region) sites, catches are first transferred to barges for unloading at the pier; this can be done individually or in groups, depending on the size of the specimens (Figure 4). At the DPA Ilo site (7227; Moquegua region), the infrastructure allows vessels to dock directly at the pier, so unloading is carried out individually (Figure 23).

Individual unloading is primarily used for large specimens, employing ropes and, when necessary, winches for hoisting (Figure 23). Group unloading is carried out using ropes with hooks to hoist boxes and, in the absence of boxes, into sacks. In exceptional situations and under appropriate conditions, group unloading may be performed directly, without the use of ropes. At site 7227, when vessels lack hoisting equipment—a recurring situation—individual unloading is performed manually by throwing the specimen from the vessel, which is then received by other personnel for placement.

At all monitored sites, the recording of catch and effort data takes place in the unloading area. However, in specific situations, the recording is carried out in areas adjacent to the unloading point. At site 7227, the catch is transported by cart to the weighing area, where data collection takes place. Similarly, at site 7092, the initial unloading takes place at the pier, and the catch is transported by

motorized vehicles to the pre-processing area, where weighing and washing are performed, as well as the recording of catch and effort data and/or biometric data (Figure 23).



Figure 23. Sequence of elasmobranch unloading and handling at docks with facilities, including unloading from the vessel, transport of the catch to the weighing, washing, and catch and effort recording areas.

Temporal coverage of unloading sites

Coverage was conducted Monday through Friday and, occasionally, on Saturdays, with flexible schedules prioritizing the hours of highest unloading frequency. This planning addressed logistical constraints related to the availability of technical staff, the distance between landing points, and accessibility to certain sites.

Monitoring is carried out by six TM technicians and one IMARPE professional, who handled data collection at a restricted-access unloading site that could not be covered on a permanent basis by the TM technicians. Technicians were assigned based on their local knowledge to optimize the operational efficiency of the sampling. In the Tumbes and Lima regions, the TM covered two landing sites, spending three consecutive weeks at the primary sites and one week at secondary sites, due to the distance between landing points and the variable frequency of landings. In the regions of Lambayeque and La Libertad, the technicians remained constantly at their designated sites and, on an exceptional basis, covered nearby points when elasmobranch landings were recorded, subsequently returning to their main site. This assignment and rotation scheme for the TM was

implemented with the aim of optimizing the spatial and temporal coverage of the monitoring, recognizing that coverage at secondary sites

Data Collection and Quality Control

Data were recorded using standardized forms and subjected to a quality control process in accordance with the methodological protocol. In Peru, 1,105 catch and effort forms (Form A) were recorded, corresponding to 11 landing sites, between February and October 2025. Of the total records, 1.3% were classified as unsuitable for analysis, mainly because they were associated with catches of unauthorized species or partial landings via transshipment, which limited the completeness of the information.

Likewise, during the first months of implementation, a small number of forms with edited information were recorded due to errors in completion, which gradually decreased over time. The constant presence of IMARPE staff at the sites facilitated the establishment of a relationship of trust with the fishermen, contributing to improved quality of the collected information.

Once the quality control process was completed, the validated records were organized into a consolidated database, which serves as the input for catch and effort analyses, as well as for conventional stock assessments.

Figure 24 presents a general flowchart that integrates the unloading methods observed on the beach, at piers without facilities, and at piers with facilities, taking into account the operational conditions that determine prior transshipment, the type of unloading, and the place of recording. In all cases, the TM records catch and effort data and, when conditions permit, collects biometric data, followed by quality control and data consolidation.

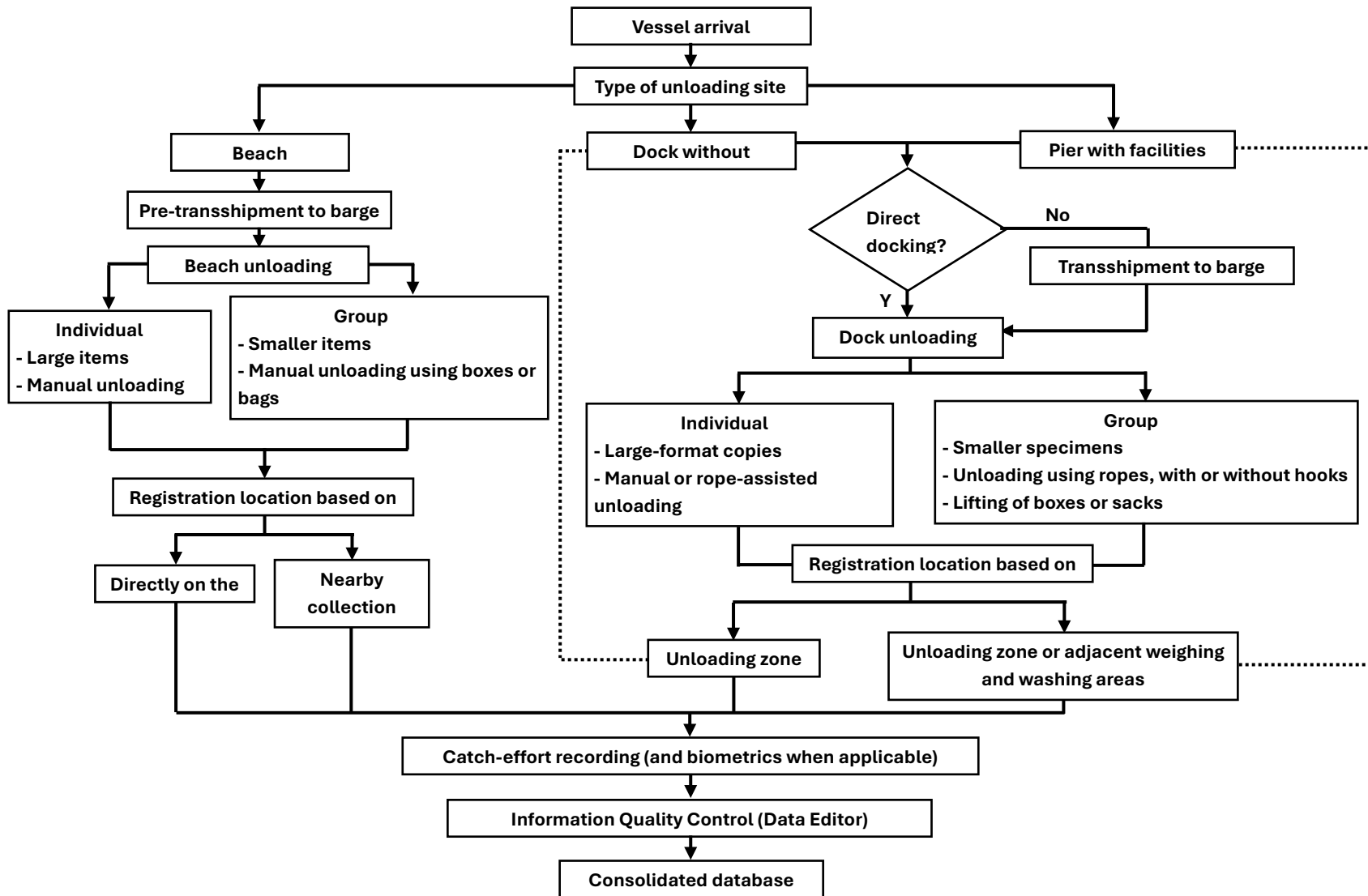


Figure 24. General flowchart of the data download and recording process, by type of download site.

3. Composition of the species unloaded

a. Ecuador

Based on the methodological procedure described above, the following presents the results regarding the composition of the elasmobranch catch recorded at the sampled unloading sites.

The landing sites with the highest total catch frequency were the Jaramijó artisanal fishing port (5,267), associated with industrial vessels, and the Manta marginal fishing terminal (5,277). It should be noted that most of the larger mother longline vessels unload in Manta; however, the number of individuals recorded at this site was relatively lower. This is explained by the sampling methodology, which was applied for one week per month in Manta, in order to provide greater coverage of the Jaramijó landing sites, where artisanal vessels and smaller-capacity mother longliners unload. (Figure 25).

In the case of artisanal fishing, the Santa Rosa Artisanal Fishing Facility (5364) recorded the highest number of shark landings, followed by tuna catches. Other sites with a high frequency of shark catches were Esmeraldas (5074, 5075, and 5077). In contrast, the Esmeraldas landing site (5076) had a higher proportion of billfish species catches (Figure 25).

Meanwhile, at the Jaramijó Artisanal Fishing Port (5266) and at El Matal 03 (5201), tuna catches predominated over other groups. The Playita Mía site (5273) had a small number of records, as most of the unloaded sharks came from longline vessels that unload at the Manta Marginal Fishing Terminal (5277), which limited the availability of reliable information on catch and effort. However, the limited data available indicated a higher presence of large fish. Finally, another landing site at El Matal 04 (5202) recorded a single catch of a coastal angel shark (*Squatina armata*) (Figure 25).

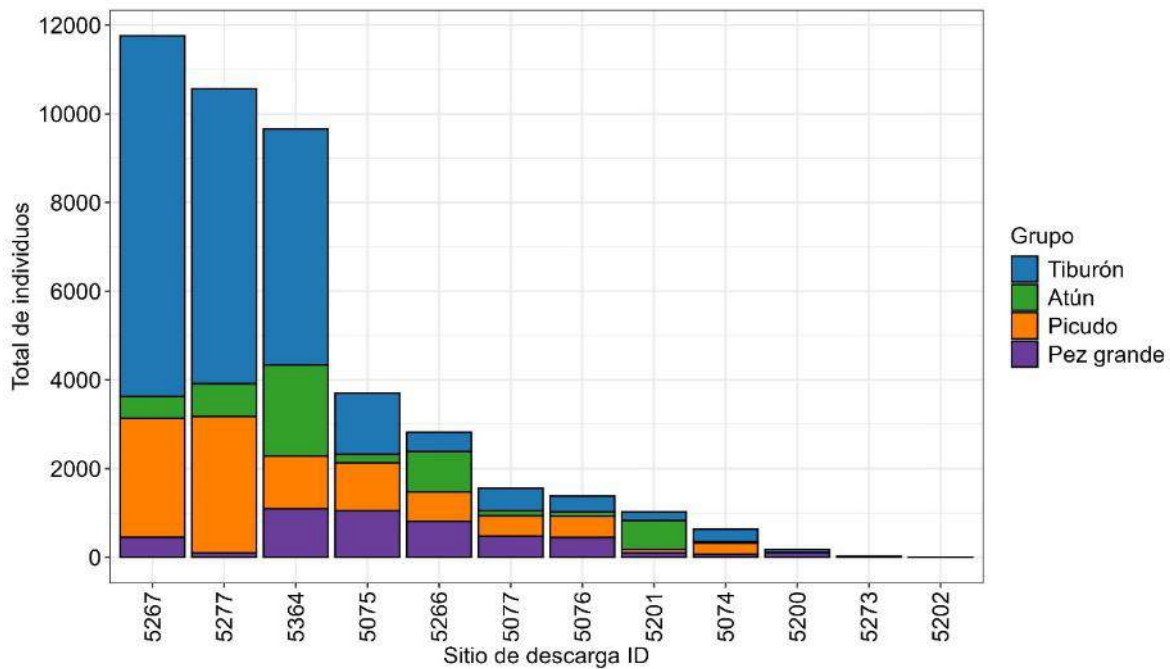


Figure 25. Distribution of total catch frequency by taxonomic group (sharks, tuna, billfish, and large fish) and landing sites in Ecuador; the numerical contribution of each group at the various sampled landing sites is indicated.

With regard to stingrays, the landing sites with the highest volumes were Jaramijó (5,266), followed by Santa Rosa (5,364), and, to a lesser extent, El Matal (5,200). These are landing sites where there is greater activity by small coastal vessels engaged in daily fishing operations (Figure 26).

Regarding rays, the sites with the highest landings were Jaramijó (5,266), followed by Santa Rosa (5,364), and, to a lesser extent, El Matal (5,200). These are landing sites where there is greater activity by small coastal vessels engaged in daily fishing operations (Figure 26).

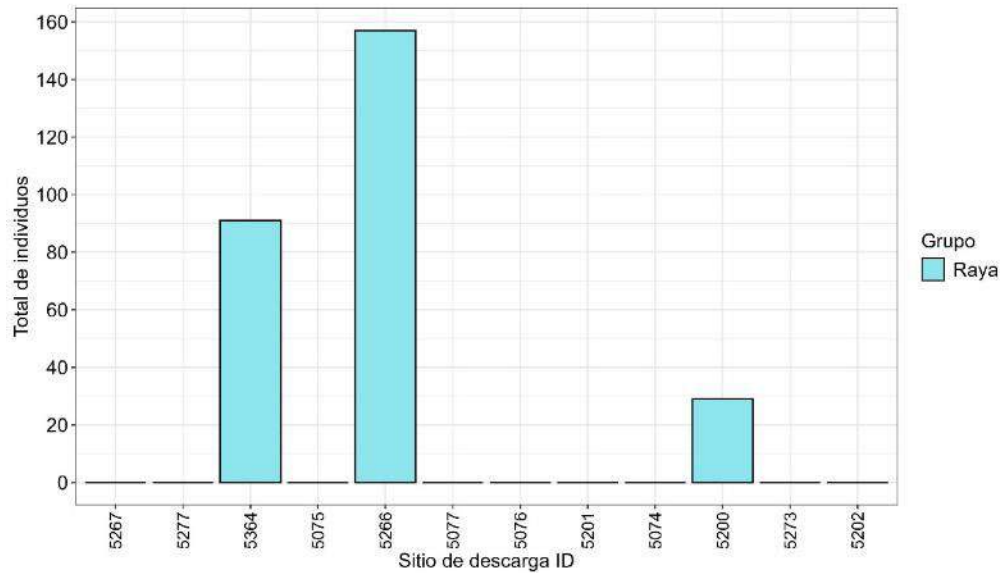


Figure 26. Total frequency of ray catches by monitored landing sites in Ecuador.

Regarding the catch composition by fleet type, it is observed that both small ocean-going vessels and mother ship longliners account for a higher percentage of shark landings, followed by billfish species (Figure 27a, b). In the case of mother ships, more than half of the individuals caught are sharks, followed by billfish species, tuna, and large fish. Among the main billfish species recorded are *Makaira nigricans*, *Istiophorus platypterus*, and *Xiphias gladius*. Within the group of large fish (*Coryphaena hippurus*, *Acanthocybium solandri*, and *Lepidocybium flavobrunneum*), *Coryphaena hippurus* (dorado) is the predominant species; however, its percentage is low in both fleets, being considerably lower in mother ship longliners (Figure 27b).

For coastal vessels, the second most representative group consists of large fish (*Hyporthodus acanthistius*, *Brotula clarkae*, and fish belonging to the families Carangidae and Serranidae), followed by ray species. The main group labeled “Others” includes primarily benthic fish and invertebrates, reflecting greater taxonomic diversity associated with this type of fleet. (Figure 27 c).

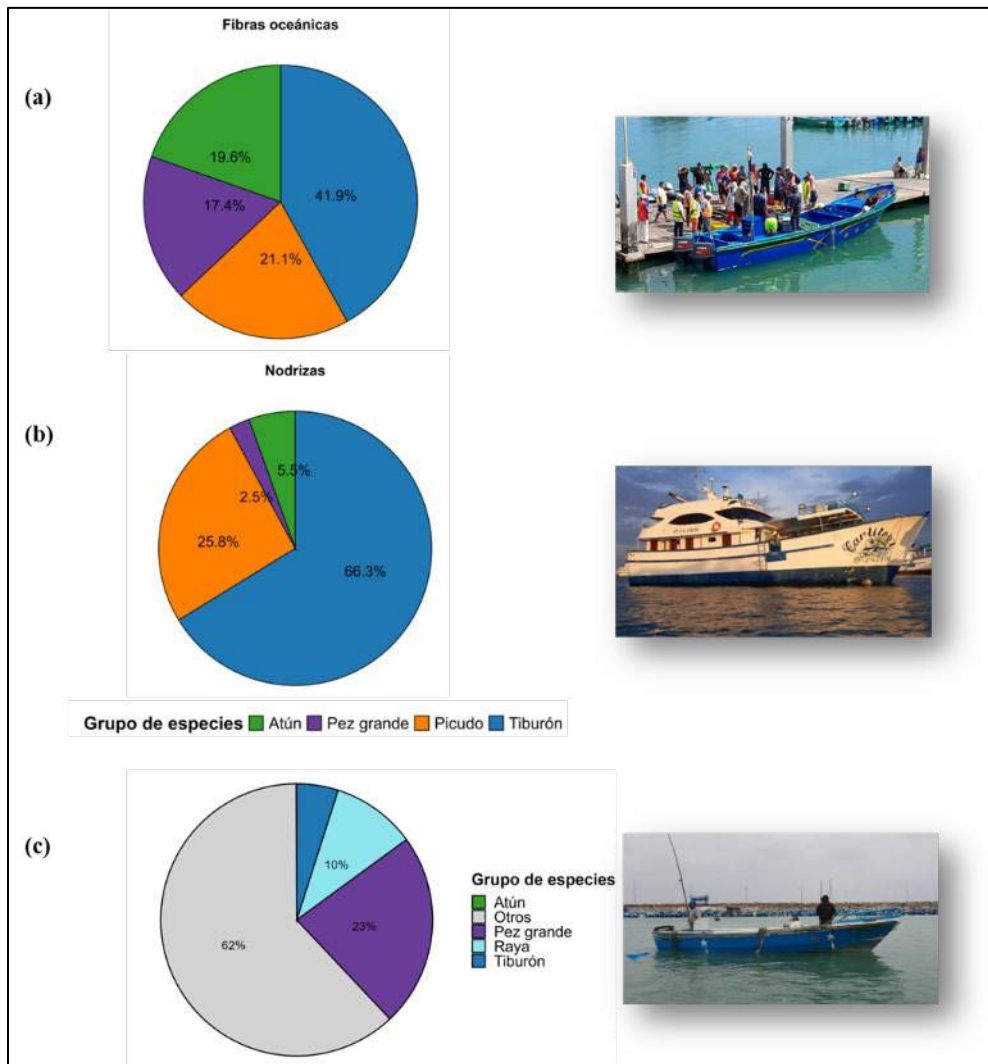


Figure 27. Percentage composition of the catch by taxonomic group according to fishing fleet type; panel (a) corresponds to ocean-going vessels; panel (b) corresponds to mother-ship longliners; panel (c) corresponds to coastal vessels.

b. Mexico

To date, the TM vessels have logged 257 days at sea, of which 189 days involved sampling; under this sampling effort, 523 Form A and 139 Form 0 reports have been completed. There is a landing record of 10,676 individuals, of which 9,167 belong to the elasmobranch group and 1,509 to the bony fish group.

Regarding species composition, 40 species of elasmobranchs and 13 species of bony fish have been identified, grouped into six main categories: shark, ray, tuna, billfish, large fish, and small fish (Figure 28). The higher representation of elasmobranchs is due to the fact that the TM prioritize sampling vessels that target this taxonomic group. However, they are instructed to sample any vessel arriving at the site that may catch elasmobranchs either intentionally or incidentally.

On the other hand, a pattern can be observed in which, from regions 1 to 3 (the northern part of the country), the most representative groups are sharks, rays, and small fish. Starting in Region 4 (central part of the country), large fish species begin to be recorded, represented mainly by tuna and dorado species. From Regions 5 to 7 (southern part of the country), billfish species begin to be recorded (Figure 28).

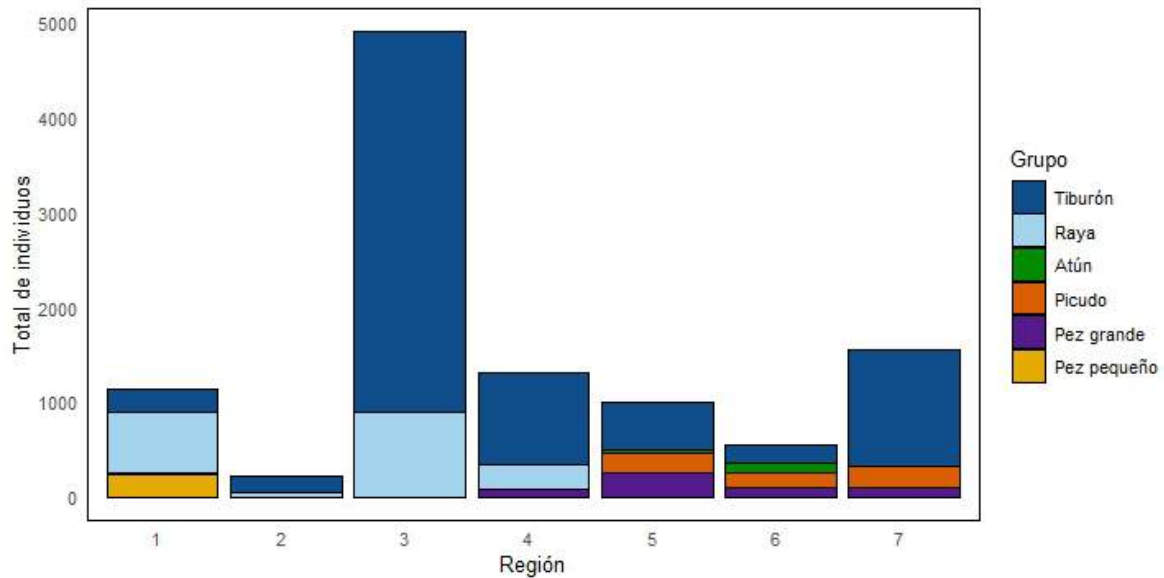


Figure 28. Total number of individuals recorded, grouped into 7 general taxonomic groups; the species composition by major groups recorded at the 22 sampling sites, distributed across the 7 strategic regions, is shown.

c. Peru

Twenty-four shark species, 17 large bony fish species, 14 ray species, 8 small bony fish species, 7 tuna species, 5 billfish species, and 3 invertebrate species have been identified. Together, these species account for 90% of landings by weight, with sharks predominating (77%), followed by rays (8%) and billfish species (5%) (Figure 29a).

By monitored landing site, in northern Peru (sites 7010 and 7015), tuna predominated, mainly *Thunnus albacares*. However, as one moves southward, a greater predominance of shark species landings is observed, with the exception of sites 7094 and 7109, where significant landing volumes of various ray species are recorded. Additionally, at sites 10706 and 7193, significant unloading volumes of various swordfish species are also recorded, with *Xiphias gladius* predominating (Figure 29b).

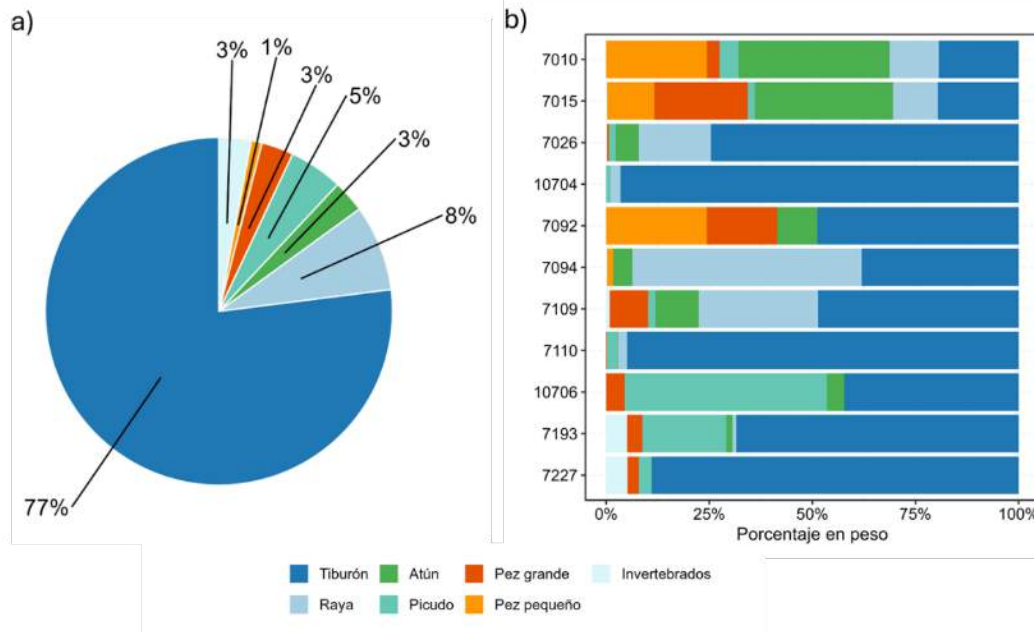


Figure 29. Percentage composition of landings by taxonomic group, showing the total percentage composition by weight (a), and the percentage composition by weight per taxonomic group at each landing site (b).

4.

a. Ecuador

The most commonly landed shark species by artisanal vessels was *Prionace glauca*, with its highest concentration at the Santa Rosa artisanal fishing facility (5364). It is important to note that modified small vessels often land at this site; these vessels have operational characteristics similar to mother longliners with limited range, although they continue to be classified as artisanal vessels. A similar situation is observed at the Jaramijó Artisanal Fishing Port (5267), where landings from modified small vessels are also recorded (Figure 30).

The second most landed species was *Alopias pelagicus*, recorded mainly at the sites of the Esmeraldas artisanal fishing port (5075, 5076, and 5077), as well as at the Jaramijó artisanal fishing port (5266) and at El Matal 03 (5201). In third place is the *Carcharhinus falciformis* shark, landed primarily at the Esmeraldas sites. The *Pseudocarcharias kamoharai* shark was highly abundant at the Santa Rosa artisanal fishing facility (5364), making it the second most commonly landed shark species at this site. Finally, the *shortfin* mako shark (*Isurus oxyrinchus*) showed a low presence in landings, with more frequent records in the southern part of the country (Figure 30).

The landing patterns of mother ship longliners are similar across the sites analyzed, with a clear predominance of the blue shark (*P. glauca*), which is the most commonly landed species at both locations. In second place is the shark *A. pelagicus*, followed, in considerably smaller proportions, by the shark *C. falciformis*. Other shark species, such as *Alopias superciliosus* and *I. oxyrinchus*, are recorded sporadically and in low abundances. (Figure 31).

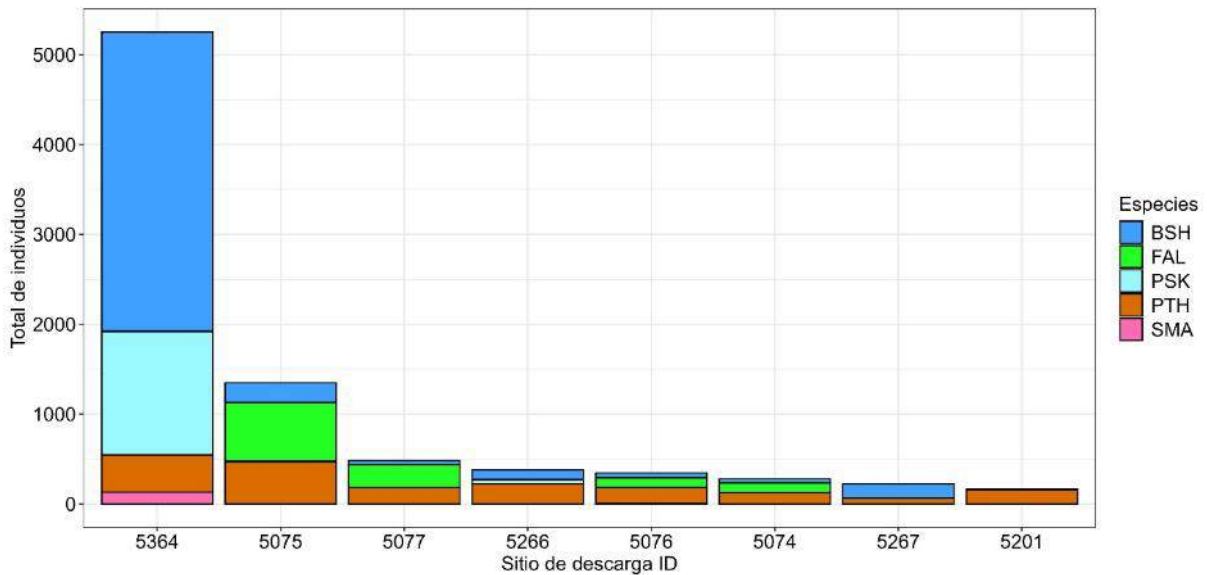


Figure 30. Frequency of records for the main shark species landed at the sampled unloading sites, originating from small ocean-going vessels; *Prionace glauca* (BSH), *Carcharhinus falciformis* (FAL), *Pseudocarcharias kamoharai* (PSK), *Alopias pelagicus* (PTH), and *Isurus oxyrinchus* (SMA).

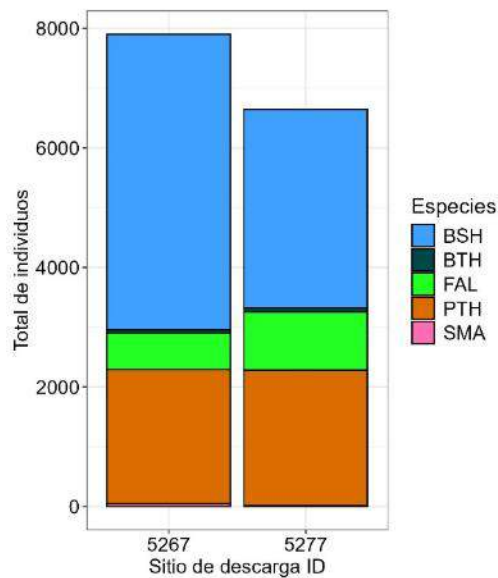


Figure 31. Landing frequency of the main shark species landed at the sampled unloading sites, originating from mother longline vessels: *Prionace glauca* (BSH), *Alopias superciliosus* (BTH), *Carcharhinus falciformis* (FAL), *Alopias pelagicus* (PTH), and *Isurus oxyrinchus* (SMA).

During landings by small coastal vessels, a higher incidence of rays was observed, with *Hypanus longus* being the most frequently recorded species, with a higher concentration in Jaramijó (5,266), followed by El Matal (5,200), and to a lesser extent, in Santa Rosa (5,364). Another species with a high presence in landings is the guitarfish *Pseudobatos planiceps*, which was recorded mainly in Santa Rosa (5,364), while its presence in Jaramijó was very low.

The third most frequently recorded species was the guitar ray (*Rhinobatos leucorhynchus*), which was consistently observed at all three discharge sites. Finally, the marbled stingray (*Gymnura marmorata*) and the guitar ray (*Zapteryx xyster*) had a more localized distribution, being recorded most frequently at Santa Rosa and Jaramijó, respectively. It is important to note that at the El Matal site (5202), a single individual of the *S. armata* shark was recorded, which is not reflected in the general analyses as it is not one of the main shark species landed (Figure 32).

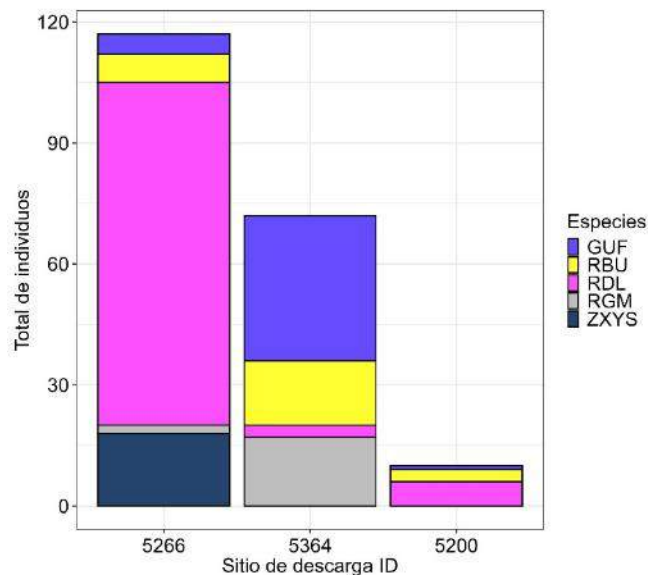


Figure 32. Frequency of ray species landed by coastal vessels at the sampled ID landing sites; *Pseudobatos planiceps* (GUF), *Rhinobatos leucorhynchus* (RBU), *Urotrygon chilensis* (JUC), and *Zapteryx xyster* (ZXYs).

b. Mexico

Species identification was carried out based on knowledge of the TM and the common name recorded by the fisherman. Likewise, when there were doubts about the species, a photograph of the individual was collected for subsequent verification using identification guides from species of the region. Of the 9,167 elasmobranchs documented, 7,315 sharks and 1,852 rays were identified, corresponding to 25 and 15 species, respectively (Figure 33).

Regarding the identified shark species, the sharks *Mustelus henlei* (n= 3,954; CTN) and *C. falciformis* (n= 1,914; FAL) are the most representative; followed by *S. lewini* (SPL; 460) and *Rizoprionodon longurio* (n= 319; RHU). On the other hand, regarding guitarfish, *P. productus* (RBP; n= 955) and species of the Rajiformes group were the most representative (SRX; n= 247).

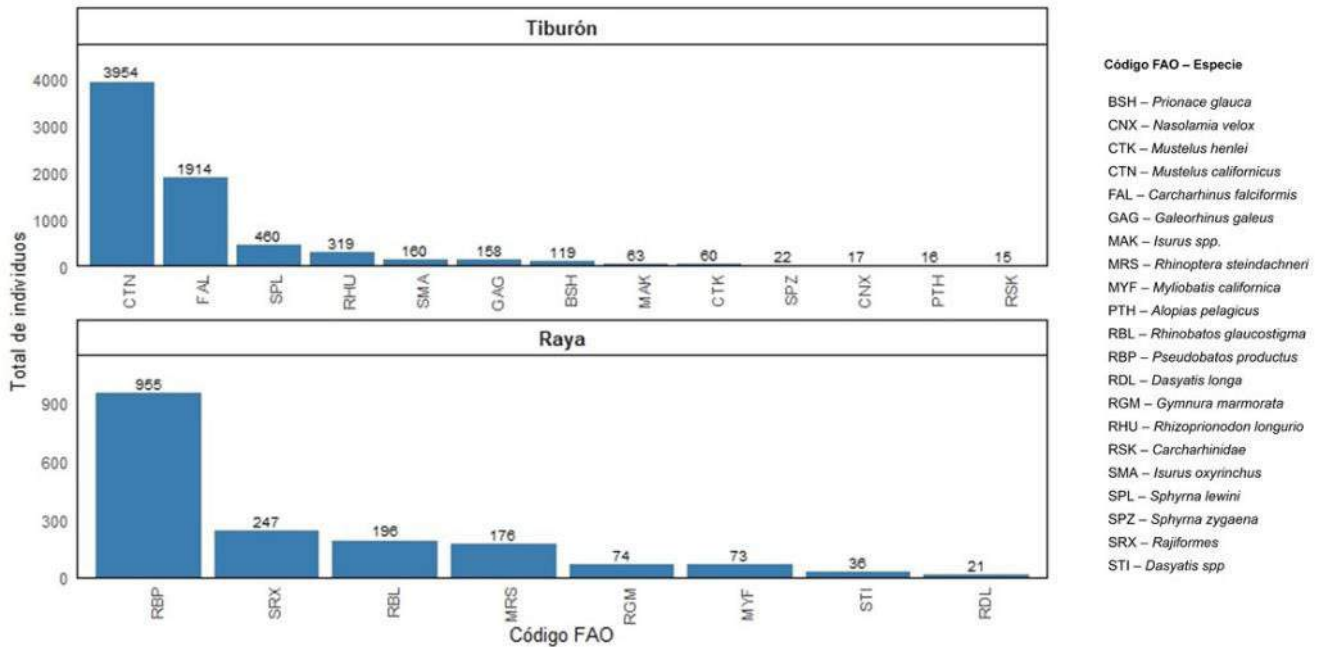


Figure 33. Frequency of records for shark and ray species; the FAO codes for each documented species are indicated; only species with more than 10 recorded individuals are represented.

Regionally, a distinct species composition was observed for both sharks and rays. In the northern region, the species composition is dominated by species inhabiting temperate waters; in contrast, in the central and southern regions, the species composition is dominated by species from tropical environments. In summary, Figure 34 describes the species found:

- Region 1 (Puerto Santa Catarina, Santa Rosaliita, Laguna Manuela): The most common species were *Pseudobatos productus*, *Galeorhinus galeus*, and *Myliobatis californica*. It is worth noting that in Puerto Santa Catarina, *Prionace glauca* accounted for 71.4% of the records, followed by *Isurus oxyrinchus* (28.6%). In Santa Rosaliita, *I. oxyrinchus* accounted for 34.6% of the records.
- Region 2 (Bahía Asunción, López Mateos, Conquista Agraria): The most common species were *Mustelus henlei*, *Pseudobatos productus*, and *Prionace glauca*. Significant diversity was recorded (10 shark species, 4 ray species).
- Region 3 (San Jorge, Jawey, Bahía de Kino): The most common species were *Mustelus californicus*, *Pseudobatos productus*, and unidentified species of the Rajiformes group. These species, typical of coastal/benthic environments, are primarily caught using bottom gillnets during the shrimp season.

- Region 4 (Sinaloa and Nayarit: Isla de Piedra, Majahual, Cruz de Huanacastle, La Nueva U): The most representative species were *Sphyrna lewini*, *Rhizoprionodon longurio*, and *Carcharhinus falciformis*. A notable diversity was documented (10 shark species, 7 ray species).
- Region 5 (Jalisco and Colima: Barra de Navidad, Colimilla, Fondepport): The most common species was *Carcharhinus falciformis*, caught mainly at Fondepport (n=248) and Colimilla (n=238). The other reported species (6 shark species) were present in low numbers (<14 individuals).
- Region 6 (Michoacán: Caleta de Campos, Lázaro Cárdenas): Only surface longline fishing targeting pelagic species is used. The most common species were *Carcharhinus falciformis*, *Prionace glauca*, and *Alopias pelagicus*. In Caleta de Campos, *C. falciformis* accounted for 100% of landings; in Lázaro Cárdenas, 58%, followed by *Sphyrna lewini* (39%).
- Region 7 (Oaxaca and Chiapas: Bahía Principal, San Agustínillo, Bahía Paredón): The most common species were *Carcharhinus falciformis*, *Sphyrna lewini*, and *Alopias pelagicus*. *C. falciformis* dominated the catches at all three sites (83%, 100%, and 92%, respectively).

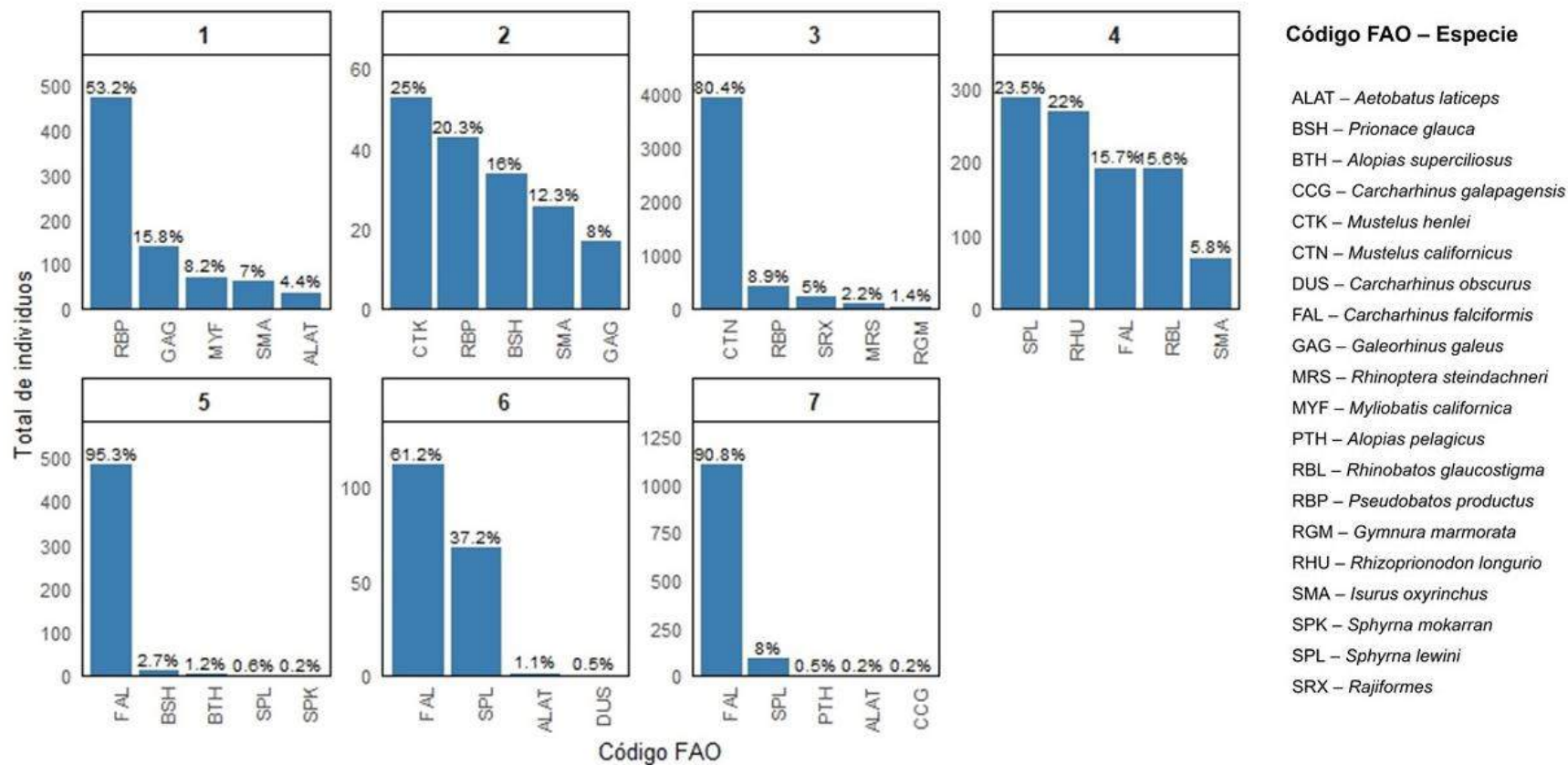


Figure 34. Frequency of records for the five main species of sharks and rays documented in each of the seven regions; FAO codes for each documented species are indicated; only species with more than 10 recorded individuals are shown.

c. Peru

Of the 24 shark species recorded, those with the highest landings by number were *P. glauca* (BSH: 57.4%), *S. zygaena* (SPZ: 20.2%), *Mustelus whitneyi* (MUW: 7.8%), *I. oxyrinchus* (SMA: 6.6%), and *A. pelagicus* (PTH: 6.1%). Together, they accounted for 90% of the total shark landings at the 11 sampling sites (Figure 35).

As for rays, *Myliobatis chilensis* (MYH: 73.3%), *Mobula mobular* (RMM: 17.8%), *Mobula thurstoni* (RMO: 2.5%), *Dasyatis brevis* (RDV: 2.4%), and *Mobula munkiana* (RMU: 1.2%) together accounted for more than 95% of the recorded landings (Figure 35).

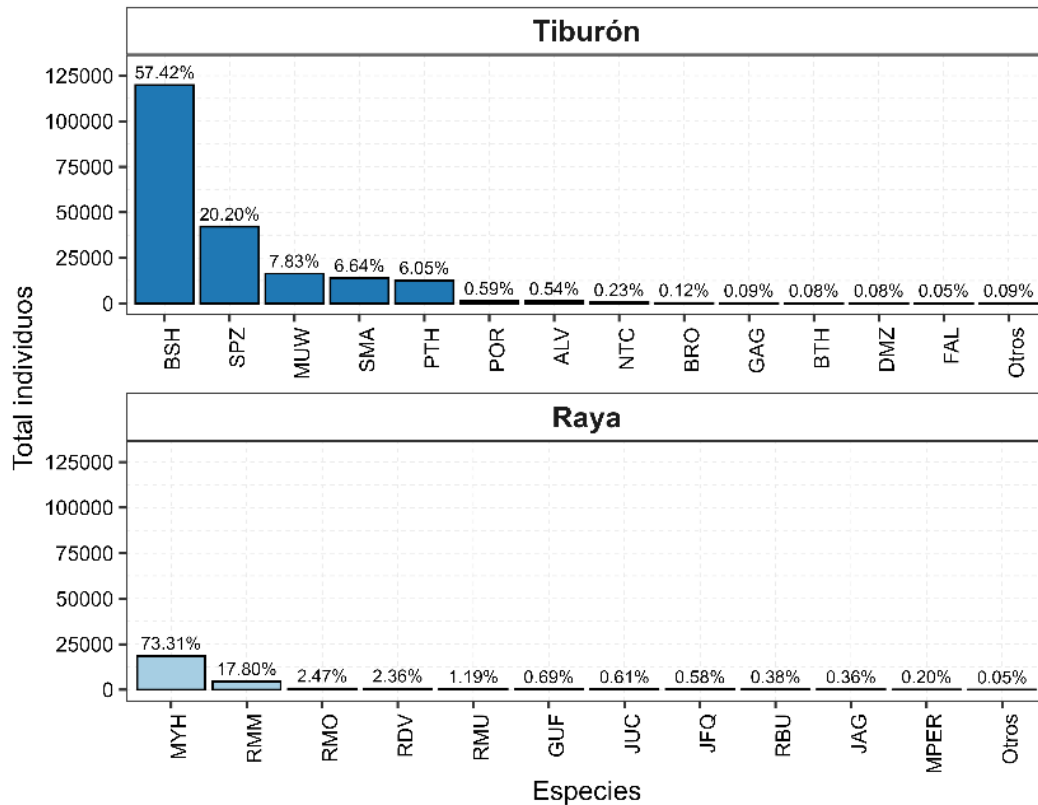


Figure 35. Frequency and percentage of individuals by shark and ray species recorded in landings; shark species *Prionace glauca* (BSH), *Sphyrna zygaena* (SPZ) *Mustelus whitneyi* (MUW), *Isurus oxyrinchus* (SMA), *Alopias pelagicus* (PTH), *Lamna nasus* (POR), *Alopias vulpinus* (ALV), *Notorynchus cepedianus* (NTC), *Carcharhinus brachyurus* (BRO), *Galeorhinus galeus* (GAG), *Alopias superciliosus* (BTH), *Squatina armata* (DMZ), *Carcharhinus falciformis* (FAL); ray species *Myliobatis chilensis* (MYH), *Mobula mobular* (RMM), *Mobula thurstoni* (RMO), *Dasyatis brevis* (RDV), *Mobula munkiana* (RMU), *Pseudobatos planiceps* (GUF), *Urotrygon chilensis* (JUC), *Raja equatorialis* (JFQ), *Rhinobatos leucorhynchus* (RBU), *Rostroraja velezi* (JAG), *Myliobatis peruvianus* (MPER).

In terms of life stages, a higher proportion of juveniles and adults was recorded among sharks. A predominance of adult specimens was observed in the species *P. glauca*, *I. oxyrinchus*, *A. pelagicus*, and *A. supersiliosus*. In contrast, juvenile specimens predominated in *Sphyrna zygaena*, *M. whitneyi*,

Notorhynchus cepedianus, *Carcharhinus brachyurus*, and *C. falciformis*. For most rays, it was not possible to identify the life stage of the unloaded specimens due to the predominant method of cutting during unloading (cutting in half), which is particularly evident in species of the genus *Mobula* (Figure 36).

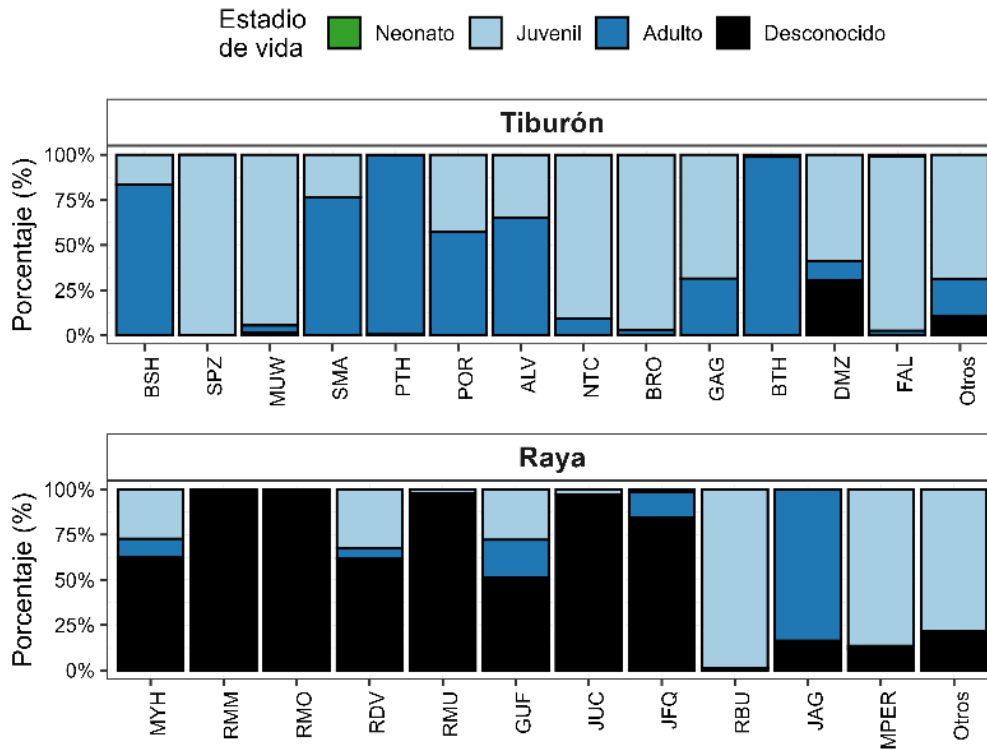


Figure 36. Percentage of individuals by life stage and species of sharks and rays recorded in landings; shark species *Prionace glauca* (BSH), *Sphyrna zygaena* (SPZ), *Mustelus whitneyi* (MUW), *Isurus oxyrinchus* (SMA), *Alopias pelagicus* (PTH), *Lamna nasus* (POR), *Alopias vulpinus* (ALV), *Notorynchus cepedianus* (NTC), *Carcharhinus brachyurus* (BRO), *Galeorhinus galeus* (GAG), *Alopias superciliosus* (BTH), *Squatina armata* (DMZ), *Carcharhinus falciformis* (FAL); Skate species: *Myliobatis chilensis* (MYH), *Mobula mobular* (RMM), *Mobula thurstoni* (RMO), *Dasyatis brevis* (RDV), *Mobula munkiana* (RMU), *Pseudobatos planiceps* (GUF), *Urotrygon chilensis* (JUC), *Raja equatorialis* (JFQ), *Rhinobatos leucorhynchus* (RBU), *Rostroraja velezi* (JAG), *Myliobatis peruvianus* (MPER).

By landing site, in northern Peru, *S. zygaena* is predominantly landed at sites 7010 and 7015. This trend shifts southward, where a higher proportion of species of the genus *Alopias* is recorded (e.g., at site 7026, *A. pelagicus* and *A. vulpinus* predominate; while at site 10704, *A. pelagicus* predominates). Subsequently, *Sphyrna zygaena* is again predominant at sites 7092 and 7109, with the exception of the site 7094 (beach), where *M. whitneyi* predominates, an endemic and abundant species in this landing area. Further south, the presence of *Sphyrna zygaena* decreases, while *I.*

oxyrinchus begins to appear in landings, with a marked predominance of *Prionace glauca* finally observed from site 7109 to site 7227 (Figure 37a).

Regarding rays, sites in northern Peru show higher landings of *Rhinoptera bonasus* and *M. mobular*. As one moves southward, the predominance of *M. mobular* increases, with the exception of sites 7094, 7109, and 7193, where a greater predominance of *Myliobatis chilensis* is observed (Figure 37b).

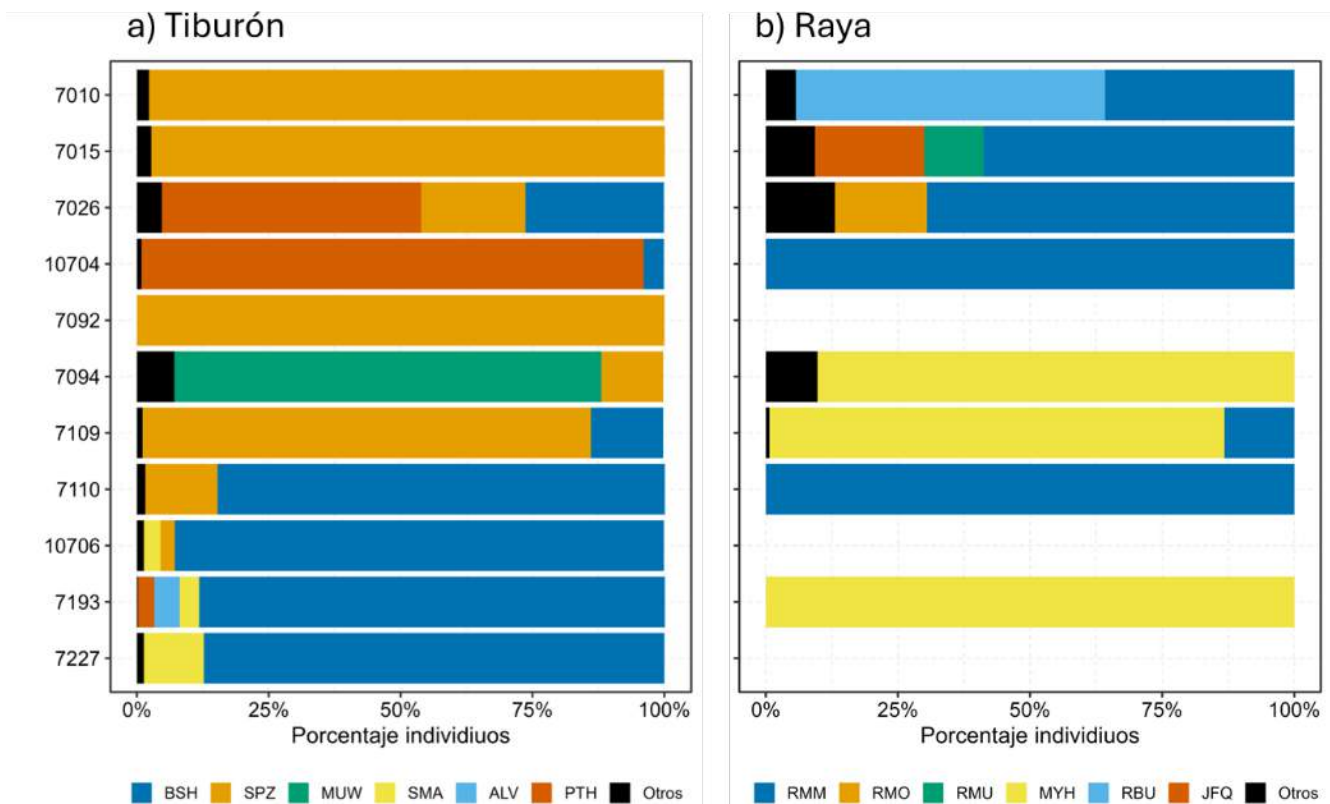


Figure 37. Spatial patterns of species dominance in shark and ray landings along the coast of Peru; shark species *Prionace glauca* (BSH), *Sphyrna zygaena* (SPZ), *Mustelus whitneyi* (MUW), *Isurus oxyrinchus* (SMA), *Alopias vulpinus* (ALV), *Alopias pelagicus* (PTH); ray species *Mobula mobular* (RMM), *Mobula thurstoni* (RMO), *Mobula munkiana* (RMU), *Myliobatis chilensis* (MYH), *Rhinobatos leucorhynchus* (RBU), *Raja equatorialis* (JFQ).

5. Challenges identified during the implementation of the sampling

During the implementation of the sampling design, various operational, logistical, safety, and environmental factors were identified that influenced access to landing sites and the collection of catch and effort data. The main challenges faced in each country and the mitigation measures adopted are described below.

a. Ecuador

The implementation of the sampling in Ecuador faced multifaceted challenges that affected operations at various sites:

- **Operational and Logistical:** At the Santa Rosa Artisanal Fishing Facility (5364), direct unloading in the harbor by ocean-going vessels forced the sampling technician (ST) to conduct monitoring at that point and follow the product's transport to the facility to complete the record. Likewise, in sectors with multiple nearby unloading sites (e.g., Esmeraldas and El Matal Artisanal Fishing Ports), prioritizing one site made it impossible to cover other points simultaneously, which may introduce biases in vessel counts that must be considered when interpreting the results.
- **Infrastructure:** At the Esmeraldas Artisanal Fishing Port (sites 5075 and 5077), the significant deterioration of the floating docks posed a safety risk to fishermen and technical staff, requiring the alternative use of a nearby concrete wall during low tide.
- **Safety:** The safety situation was a critical factor. At the Jaramijó 01 Artisanal Fishing Port (5266), an increase in sea-based assaults during April affected the willingness of victimized fishermen to provide effort data. At the Port of Esmeraldas, armed attacks within the port during May and June restricted fishing activity to the morning hours, limiting the sampling schedule.
- **Supply and External Factors:** In Santa Rosa, periodic fuel shortages toward the end of the month (especially between April and August) limited the frequency and duration of fishing trips. In addition, two environmental events significantly impacted operations: an oil spill in Esmeraldas (March) that temporarily prohibited vessels from setting sail, and a national tsunami warning (July) that suspended activities in several coastal areas.

Table 5 provides a summary of the main challenges identified and the actions taken to minimize their impact on the conduct of sampling activities.

Table 5. Accessibility challenges and mitigation measures during the implementation of sampling.

Location	Site ID	Name	Type of challenge	Description of the challenge	Impact on sampling	Actions Taken
Santa Rosa	5364	Santa Rosa artisanal fishing facility	Operation	Direct unloading in the harbor by ocean-going vessels	Difficulty in recording catch and effort at a single point	Monitoring in the harbor and escorting the transfer to the fishing facility
Jaramijó	5266	Jaramijó Artisanal Fishing Port 01	Security	Increase in robberies at sea (April)	Incomplete information on fishing effort	Permanent presence of the technician and building trust
	5267	Jaramijó 02 Artisanal Fishing Port				
Esmeraldas	5075	Esmeraldas 04 Artisanal Fishing Port	Infrastructure	Deterioration of floating docks	Risks to fishermen and technical staff	Alternative use of the wall and operational adjustments
	5077	Esmeraldas Artisanal Fishing Port 06				
Esmeraldas	5074	Esmeraldas Artisanal Fishing Port 03	Logistics	Multiple nearby ID unloading sites	Partial coverage of unloading	Site prioritization and consideration of biases
	5077	Esmeraldas 06 Artisanal Fishing Port				
Jama	5200	El Matal 02	Logistics	Several nearby unloading points	Partial event logging	Targeted planning
	5202	El Matal 04				
Esmeraldas	5074	Artisanal fishing port Esmeraldas 03	Security	Violence and gang activity	Restriction on sampling times	Sampling concentrated in the morning hours
	5075	Esmeraldas 04 artisanal fishing port				
	5076	Esmeraldas 05 artisanal fishing port				
	5077	Esmeraldas Artisanal Fishing Port 06				
Santa Rosa	5364	Santa Rosa Artisanal Fishing Facility	Supply	Fuel Shortage	Reduction in fishing operations	Temporary consideration in the analysis
Esmeraldas	5074	Esmeraldas 03 artisanal fishing port	Environmental	Oil spill (March)	Temporary suspension of fishing	Suspension of sampling
	5075	Esmeraldas 04 Artisanal Fishing Port				
	5076	Esmeraldas 05 Artisanal Fishing Port				
	5077	Esmeraldas Artisanal Fishing Port 06				
All	All	All discharge sites in the mainland coastal zone.	Environmental (natural events)	Tsunami warning (July)	Preventive suspension	Rescheduling of activities

b. Mexico

The extensive Mexican Pacific coastline (7,828 km; INEGI, 2020) and the distribution of the 22 selected sampling sites among 737 identified sites of interest posed considerable logistical and security challenges:

- **Logistics and Distances:** The need to monitor sites far from urban areas required trips lasting between 1 and 8 hours for the field technicians. This resulted in excessive expenses for fuel, lodging, and wages, further limiting the number of effective sampling days at remote sites (e.g., Region 1 in Baja California, Regions 6 and 7).
- **Accessibility and Safety:** Although most sites are accessible via roads used by fishermen, safety is not guaranteed due to illicit activities. Verifying safe conditions prior to arrival was hindered by the lack of cell phone or internet service in some locations. It is estimated that approximately 30% of the selected sites prioritized safety over other criteria of fishery importance. Whenever a risk was detected, sampling was relocated to a safer site within the same region.
- **Local Cooperation:** At some sites (e.g., Conquista Agraria), a lack of cooperation from fishermen resulted in incomplete information, requiring a change in the sampling site.

Table 6 details the specific challenges by site, their impact, and the strategies implemented, which included budget adjustments for long trips, hiring local field staff in unsafe areas, and changing sites when necessary.

Table 6. Description of challenges identified at sampling sites; the following are indicated: Location; Site ID; Site Name; Type of Challenge; Description of Challenge; Actions Implemented to Address the Challenge.

Location	Site ID	Name	Type of challenge	Description	Impact on sampling	Actions taken
San Quintín	10304	Santa Rosaliita II	Distance	Arrival between 7–9 hours	Limited sampling days; high cost	Budget adjustments
	3083	Laguna Manuela	Distance	Arrival in 7–9 hours	Limited sampling days; high cost	Budget adjustments
La Paz	3271	Conquista Agraria	Social	Lack of cooperation from fishermen	Incomplete sampling data	Site change
Puerto Peñasco	3304	San Jorge	Safety	Unsafe area	Restrictions on access for technical staff	Hiring of local technician
Caborca	3305	Jawey	Security	Unsafe area	Restrictions on access for technical staff	Hiring of local technicians
Pitiquito	10311	Puerto Libertad	Security	Unsafe area	Restrictions on access for technical staff	Hiring of local technician
Mazatlán	10398	Isla de la Piedra	Security	Unsafe area	Restrictions on access for technical staff	Hiring of local technician
Rosario	3385	Majahual	Security	Unsafe area	Temporary inability to conduct sampling	Change of location
Lázaro Cárdenas	3445	Caleta de Campos	Distance	Arrival in 7–9 hours	Limited sampling days; high cost	Budget adjustments
	3452	Lázaro Cárdenas	Distance	Arrival within 7–9 hours	Limited sampling days; high cost	Budget adjustments
San Pedro Mixtepec	10456	Main bay	Distance	Arrival in 7–9 hours	Limited sampling days; high cost	Budget adjustments
Santa María Tonameca	10461	San Agustinillo	Distance	Arrival between 7–9 hours	Limited sampling days; high cost	Budget adjustments
Tonalá	3537	Bahia Paredón	Distance	Arrival in 7–9 hours	Limited sampling days; high cost	Budget adjustments

c. Peru

In Peru, the challenges centered on managing institutional access, data quality, and operational safety for personnel:

- **Institutional Access and Access to Private Sites:** Access to all landing sites depended on prior and ongoing coordination with the scientific authority (IMARPE), which, while creating institutional dependency, ensured sustained access. At private docks (sites 10704 and 7110), restrictions were greater, requiring specific permits. In one case (10704), direct recording by the TM was not possible, so data collection was carried out by an IMARPE field observer under the same protocols, maintaining standardization.
- **Quality and Complexity of Information:** The relationship of trust with the fishermen allowed for adequate data collection in most cases. However, specific limitations were identified when catches of unauthorized species were recorded or during trips involving transshipment, where the fisherman in charge of the partial unloading did not have detailed information on the fishing effort. To safeguard analytical quality, these records were excluded from the final database.
- **Operational Safety:** No critical safety conditions were identified during unloading activities at regular times. However, at remote sites and during nighttime hours, the limited availability of transportation posed a potential risk. To mitigate this, priority was given to hiring TM residents in the localities of the landing points, reducing travel and improving safety conditions and the continuity of monitoring.

The main challenges, common to several sites, included adapting to unloading schedules, managing access, and building trust with fishermen. The mitigation strategies consistently applied were: sampling during peak hours, the use of local technicians, coordination with the scientific authority (IMARPE), and strengthening the technical-fisherman relationship, as summarized in Table 7.

Table 7. Description of challenges identified at sampling sites; the following are indicated: Location; Site ID; Site Name; Type of Challenge; Description of Challenge; Actions implemented to address the difficulty in Peru.

Location	Location ID	Site Name	Type of Challenge	Description	Impact on sampling	Actions Taken
Zorritos	7010	Zorritos 01	Social and Operational	Unloading schedule, access, fisherman confidence	Reduced coverage, sampling discontinuity, data quality	Sampling during peak hours, local technician at unloading, scientific coordination, and technician–fisherman liaison
Acapulco	7015	Acapulco 03				
Máncora	7026	Máncora 01		Unloading schedule, accessibility, access, fisherman’s trust		Coordination with site manager and scientific authority, and technical–fisherman liaison
Playa Blanca	10704	Playa blanca 01 / Galileo (muelle privado)				
San Jose	7092	San jose 01		Unloading schedule, access, fisherman trust		Sampling during peak hours, local technician at unloading, scientific coordination, and technical-fisherman liaison
San Jose	7094	San jose 03				
Salaverry	7109	Salaverry 02				Sampling during peak hours, on-site unloading technician, coordination with the site manager and scientific authority, and liaison between technicians and fishermen.
Salaverry	7110	Salaverry 03 (muelle privado)				Local technician during unloading, coordination with site manager and scientific authority, technician–fisherman liaison
Ancón	10706	Ancón 02				Sampling during peak hours, local unloading technician, scientific coordination, and technical liaison with fishermen
Pucusana	7193	Pucusana 01				
Ilo	7227	Ilo 01				

6. Discussion

The sampling design implemented in the countries participating in the ABNJ-2 project reflects a coordinated effort to generate fishery-dependent information on sharks and rays in the Eastern Pacific, in a context characterized by a high diversity of artisanal fleets, heterogeneous port infrastructures, and fishing dynamics that vary in space and time. Despite these structural differences, the results obtained demonstrate significant progress in methodological standardization, monitoring coverage, and the characterization of the interaction between coastal fisheries and elasmobranchs.

In Ecuador, the sampling design focused on expanding the spatial and temporal coverage of monitoring, progressively incorporating biometric measurements and strengthening the quality control of records. The Ecuadorian experience highlights the importance of adapting sampling protocols to local infrastructure conditions, clearly differentiating between ports with facilities and beach landing sites. This operational flexibility allowed for the capture of relevant patterns in species composition, fishing effort, and landing times. At the same time, it revealed persistent challenges associated with incomplete records and the temporal variability of landings. The identification of clear differences between coastal and oceanic fishing zones, as well as between vessel types, highlights the value of disaggregated sampling for properly interpreting catch structure.

In Mexico, the discussion focused primarily on structural limitations in identifying and selecting sampling sites based on administrative sources and official metadata. The highly dynamic and, in many cases, temporary nature of landing sites, particularly in northern regions, reduces the reliability of formal records as an indicator of actual effort. Given this scenario, the human component of the sampling design emerges as a critical factor: the active participation of national scientific institutions and the relationship of trust between TM and fishermen proved decisive in ensuring access to sites, the completion of forms, and the collection of biological samples. From a biological perspective, the results show marked regional contrasts in species composition, with a predominance of demersal sharks in the north and pelagic species in the central and southern parts of the country. This information is key to directing future monitoring efforts toward priority species and regions at the regional level.

In Peru, the sampling design prioritized focusing efforts on a limited number of strategic sites, selected based on biological, fisheries, and operational criteria. This approach addressed the need to ensure continuity and consistency in a context of highly dispersed landings and logistical constraints. The Peruvian experience highlights the importance of prioritizing data quality over the quantity of records, especially in scenarios where traceability between catch, fishing trip, and landing is compromised by transshipments or a lack of adequate infrastructure. Likewise, significant limitations in determining life stages were identified, stemming from processing practices prior to unloading, which underscores the need to integrate this information with other monitoring and assessment approaches.

Across the board, the three countries agree that the recorded species composition reflects a complex spatial and temporal interaction between artisanal fleets and elasmobranchs, influenced

by the type of fishing gear, the area of operation, and local fishery dynamics. These differences do not constitute a weakness in the design but rather provide essential information for understanding regional heterogeneity and adjusting sampling schemes to finer scales. Furthermore, accumulated experience shows that access to landing sites, social acceptance of monitoring, and ongoing training of field staff are components as relevant as the technical aspects of the design.

Taken together, the information generated by Ecuador, Mexico, and Peru establishes a solid foundation for fisheries-dependent monitoring of sharks and rays in the Eastern Pacific. The sampling design, although constrained by operational and structural limitations specific to each country, has proven effective in describing spatial and temporal catch patterns, identifying priority species, and guiding future sampling decisions. These results constitute a fundamental input for regional assessment and management processes and lay the groundwork for integration with broader analytical approaches, such as Close-Kin Mark-Recapture, within a framework of regional cooperation and institutional strengthening.

Implications for future sampling design

The implementation of the sampling design in the participating countries enabled significant progress in the collection of fishery-dependent data on sharks and rays in the Eastern Pacific. However, the results also show that the operational complexity of artisanal fisheries and the heterogeneity of national contexts require a consolidation period to refine sampling schemes and strengthen their representativeness at the national and regional levels.

The temporal variability observed in landings, associated with seasonal, environmental, and operational factors, limits the ability to fully characterize catch patterns when sampling is concentrated in limited time windows. Greater continuity in data collection would allow for a more robust capture of this variability, reduce potential biases, and improve the empirical basis for comparative analyses and subsequent evaluation processes.

Likewise, structural differences among landing areas—including ports with infrastructure, wharves without facilities, and beach areas—directly influence recording procedures, the traceability of information, and the quality of the data obtained. Accumulated experience demonstrates the need to adjust and validate protocols differentiated by type of landing area, ensuring that standardized procedures are applied consistently and adapted to local conditions.

The diversity of artisanal vessels, which encompasses different sizes, ranges, and operating modes, influences fishing effort, species composition, and the feasibility of biological sampling. In this context, it is essential to refine sampling designs by vessel type, defining appropriate coverage levels and differentiated strategies that allow for a representative capture of the interaction between the different segments of the fleet and elasmobranchs.

Across the board, the quality and consistency of the information depend on the ongoing strengthening of field staff capacities and the standardization of data collection processes. The consolidation of technical teams, improvements in taxonomic identification and biometric data

collection, as well as the reduction of incomplete records, require extended cycles of implementation, evaluation, and feedback.

Overall, the project results indicate that refining the sampling design is a key step in maximizing the scientific and operational value of the data generated. A refined framework organized by country, type of landing area, and type of artisanal vessel will strengthen regional comparability, enable more comprehensive analyses—including advanced approaches such as Close-Kin Mark-Recapture—and lay a solid foundation for the assessment, management, and conservation of elasmobranchs in the Eastern Pacific.