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IDENTIFICATION AND MAPPING OF POTENTIAL SHARK LANDING SITES ON THE COASTS OF ECUADOR, MEXICO AND PERU

IMPROVING DATA COLLECTION AND STOCK ASSESSMENT OF SHARKS IN THE EASTERN PACIFIC OCEAN: EXPANSION TO COASTAL STATE FISHERIES

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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REPORT

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1. INTRODUCTION

Sharks are a common target and bycatch in some pelagic fisheries in the eastern Pacific Ocean (EPO). Several of these species commonly interact with industrial longline or purse-seine tuna fisheries but are also caught in coastal areas of the region by multi-species, multi-gear artisanal fisheries.

Sharks can be particularly susceptible to climate and fishing impacts due to many species having long life spans, slow growth rates and low fecundity and reproduction frequency. For this reason, the Inter-American Tropical Tuna Commission (IATTC) has increased conservation and management efforts pertaining to sharks through the development of shark-specific resolutions, sampling and monitoring programs.

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. Article VII 1(f) recommends to *"adopt, as necessary, conservation and management measures and recommendations for species belonging to the same ecosystem and that are affected by fishing for, or dependent on or associated with, the fish stocks covered by this Convention…"*.

In an effort to collect reliable relevant information on shark species impacted by IATTC fisheries, the Commission, at its 101st meeting, adopted Resolution C-23-07— the consolidation of existing shark-related measures in IATTC Resolutions C-05-03, C-16-04, C-16-05—to strengthen shark conservation and management measures in the EPO. In addition, it called for the development of a list of shark species under the purview of the Commission. This list was developed by the staff (SAC-15-09) and discussed with the Ecosystem and Bycatch Working Group and the Scientific Advisory Committee in 2024 and a final list of 18 species was adopted by the Commission later in that same year.

Despite these conservation and management efforts, there is a lack of reliable catch, effort, and species and size composition data for sharks, especially from small-scale coastal ("artisanal") fisheries. This has hampered attempts to develop reliable stock assessments (but see IATTC, 2014; Clarke et al., 2018) for the most common species (e.g., silky shark, *Carcharhinus falciformis*).

During 2015–2021, the IATTC staff conducted extensive studies to develop a robust sampling methodology to improve data collection for shark fisheries in Central America. This project was funded by the FAO-GEF Common Oceans Program, and specifically the *Sustainable Management of Tuna Fisheries and Biodiversity Conservation in the Areas Beyond National Jurisdiction* (Common Oceans ABNJ Tuna project (phase 1 or ABNJ "Tuna1") project. During this period, several research projects were carried out to determine the impact of small-scale coastal fisheries on these species, and thus establish the baseline for a long-term shark sampling program for this fleet.

A second phase of the FAO-GEF Common Oceans Program was approved for implementation by the IATTC staff over a three-year period (2023–2026). The Common Oceans ABNJ Tuna project (phase 2) or ABNJ ("Tuna 2") project focuses on improving the monitoring and assessment of shark stocks in the EPO, using the methodology established in Central America, to be expanded into Mexico, Ecuador and Peru. It is important to note that although fisheries research and management of sharks in these countries may be considered more advanced than many other countries in the region, there is still a need to improve and harmonize the collection of sharks catch and fishing effort data for the purposes of population assessment.

2. WORK PLAN

2.1. Background

The IATTC, through various articles within the Antigua Convention, is responsible for implementing management measures for any species that is "…affected by fishing for, or dependent on or associated with, the fish stocks covered by this Convention", which includes many shark species associated with tuna fisheries in the EPO. However, the development of effective evidence-based management and conservation measures requires reliable data and a thorough understanding of shark stock structure. These measures are best derived from stock assessment, which currently face a myriad of significant challenges. These include the limited availability of reliable data pertaining to these fisheries, such as catch, effort and species and size composition, especially for the small-scale coastal fisheries of coastal EPO states, where sharks are often caught in large numbers, either as a target or bycatch.

To address this issue, over a period of seven years (2015–2021) the IATTC staff has developed a robust sampling methodology to collect shark fisheries data in Central America, where shark catches have been purported to be significant. This work, funded by the ABNJ (Tuna 1) project of the FAO-GEF Common Oceans Program, the IATTC Capacity Building Fund, and the European Union, was completed in December 2021.

The ABNJ Tuna 1 project was divided into three phases. During Phase 1, the foundation for a regional long-term data collection shark program was established by first focusing on the identification and compilation of available shark data. In addition, workshops were held on data collection, shark species assessment methods and the design of pilot sampling programs. Following completion of Phase 1 (2015–2017), Phase 2 of the project was subsequently funded from January 2018 to December 2019—with financial support from ABNJ Tuna 1 and the IATTC Capacity Fund—to further develop and test sampling designs in a pilot study that could serve as a regional framework in Central America. Improvements included the development of sampling designs for small-scale coastal fisheries to estimate shark catches, species, and size composition, and catches of the medium- and large-scale longline fleets in Costa Rica (Lennert-Cody *et al.*, 2022).

The ongoing success of the project led to additional funding from the European Union in 2020 (Phase 3) to assess logistical challenges, modify catch and effort sampling designs as needed, and develop biological sampling protocols to estimate the order of magnitude of catches of silky shark and hammerhead shark (*Sphyrna lewini*); the main species caught by tuna fisheries in Central America associated. Despite the challenges posed by the COVID-19 pandemic (delay in the start of fieldwork and reduction of survey days), data collection and analysis continued until December 2021.

The results of Phase 3 were presented at the 14th meeting of the IATTC Scientific Advisory Committee in 2023 (SAC-14) providing revised catch estimates that confirmed the catches of silky and hammerhead sharks by small scale coastal fisheries in Central America are significant and should be considered for stock assessment and management (SAC-14 INF-L). Although a long-term sampling program for shark fisheries in Central America has not been economically feasible to date (IATTC-98-02c), a new framework for such a program is available for consideration by IATTC Members (SAC-14 INF-P). This program is part of the shark research work plan proposed in the IATTC Strategic Science Plan (SAC-14-01), which was also presented at the 2023 SAC meeting. Three key documents were presented at the 15th meeting of the IATTC Scientific Advisory Committee (SAC-15) to support the advancement of research and conservation of shark species in the EPO. The first established a preliminary list of shark species that interact with pelagic fisheries in the EPO and would fall under the purview of the IATTC, which is essential for prioritizing future research efforts in the region (SAC-15-09). Second, options were presented for the development of a shark data collection program in IATTC fisheries, building on existing projects (SAC-14 INF-P, SAC-14 INF-L, SAC-15 INF-Q, AIDCP, SAC-15-10). Finally, guidelines for best handling and release practices for sharks in these fisheries were also presented, with the aim of improving post-release survival and reducing shark bycatch mortality (SAC-15-11).

As part of the second phase of the FAO-GEF ABNJ Common Oceans Program (Tuna 2), the IATTC received additional financial support to improve the monitoring and assessment of shark stocks in the EPO by extending the work conducted in Central America to other IATTC Members and Cooperating non-Member (CPCs). Despite previous IATTC sampling efforts, there is a need to improve shark data collection in other EPO coastal states where shark catches are significant, such as Ecuador (Martínez *et al*., 2015), Mexico (Bizarro *et al.,* 2009; Smith *et al.,* 2008) and Peru (Alfaro-Córdova *et al.,* 2017; González-Pestana *et al*., 2019).

Although these countries collect some data pertaining to sharks for most of their fisheries, their quality and utility for stock assessment is limited and varies between countries. In addition, there is little, if any, harmonization of data collection methods for shark fisheries among the coastal nations of the EPO that is needed to be representative of these highly migratory shark species that often straddle multiple jurisdictional boundaries.

2.2. Implementation

This document is based on the research tasks and activities of the ABNJ - Tuna 2 project, in particular on the identification of shark landing sites in Task 2. To this end, all sites where shark catches may potentially be landed have been identified and mapped (Activity 2.2).

For the identification of sites, the methodology established in ABNJ - Tuna 1 (SAC-11-13) and developed in Central America was used. The first step was to identify the sources of shark data available for each country (Task 1[1], Activity 1.1), which yielded a total of 1,167 documents, including scientific papers, internal reports of government fisheries authorities, theses, identification manuals and fisheries management documents. This literature review allowed the identification of sites where shark landings were reported. The next step was to characterize and georeference all these sites, creating for the first time a database of all locations where fisheries-related activities occur.

A detailed description of the development of this activity and the new identification and mapping strategies that were implemented is described below.

3. IDENTIFICATION OF POTENTIAL LANDING SITES OR LOCATIONS OF INTEREST (LOIs)

3.1. Organization of information

The identification of potential landing sites was carried out following the procedures used in Central America through the "Manual for the identification and characterization of landing sites of the

[1] Report submitted on 6 May 2024.

artisanal shark fishery fleet in Central America"[2] (IATTC, 2019), as part of the EPO regional implementation methodology. This process focused on the identification and precise location of the different fishing localities or communities, as well as locations of interest (LOIs), regardless of whether they are purely fishing-related or not. The compilation of this data allowed for the creation of an initial historical archive of documented artisanal fisheries landing sites in the three participating countries. This information was then corroborated using Google Earth to georeference fishing localities and landing sites. Finally, the information was entered into a Microsoft Access database to organize the identified data.

In addition, the identification of potential landing sites was subject to the political and administrative organization system of each country, as follows:

1. **Ecuador:** made up of 24 provinces (5 coastal and 1 island), 221 cantons and 1,499 parishes (1,140 rural and 359 urban), according to the National Institute of Statistics and Censuses (INEC, 2010; Figure 1). The maritime jurisdictional areas cover a total of 1,092,140.25 km², while the continental coastal zone has an area of 8,747.80 km² (POEMC, 2017). The country has distinct geographical and cultural regions, including the coast (continental coast), the mountains (Andes), the east (Amazon) and the island region or Galapagos.

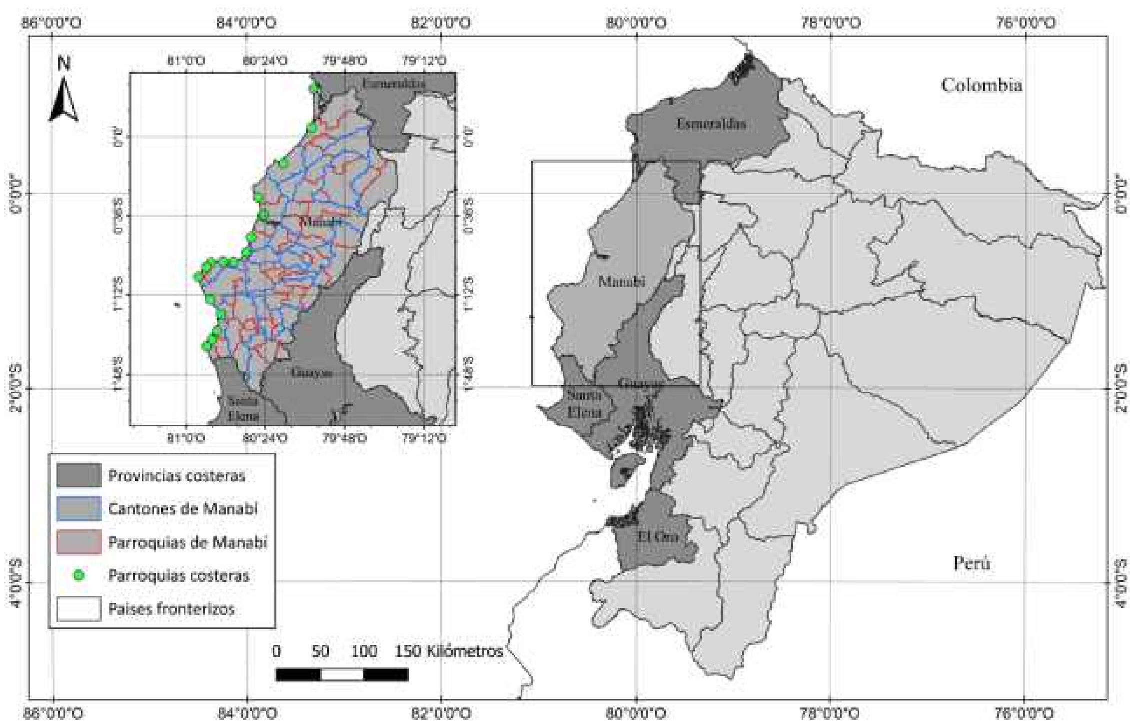

Figure 1. Description of the political/administrative division of Ecuador. The upper left box illustrates the analysis carried out in the province of Manabí, indicating the cantons (blue lines) and parishes (red lines) that comprise it; green dots indicate the coastal parishes distributed along the coast; the lower left box explains the symbols and color scheme.

[2] Manual de campo (v0.1, 2019) Proyecto ABNJ-Atún 1

2. **Mexico:** made up of 32 states, of which 11 have a coastline on the Pacific Ocean (from north to south: Baja California, Baja California Sur, Sonora, Sinaloa, Nayarit, Jalisco, Colima, Michoacán, Guerrero, Oaxaca and Chiapas; Figure 2). These states form a coastline of 7,828 km, where there are 2,050 recognized island-like elements (islands, islets, keys and rocks; INEGI, 2020; INEGI, 2015).

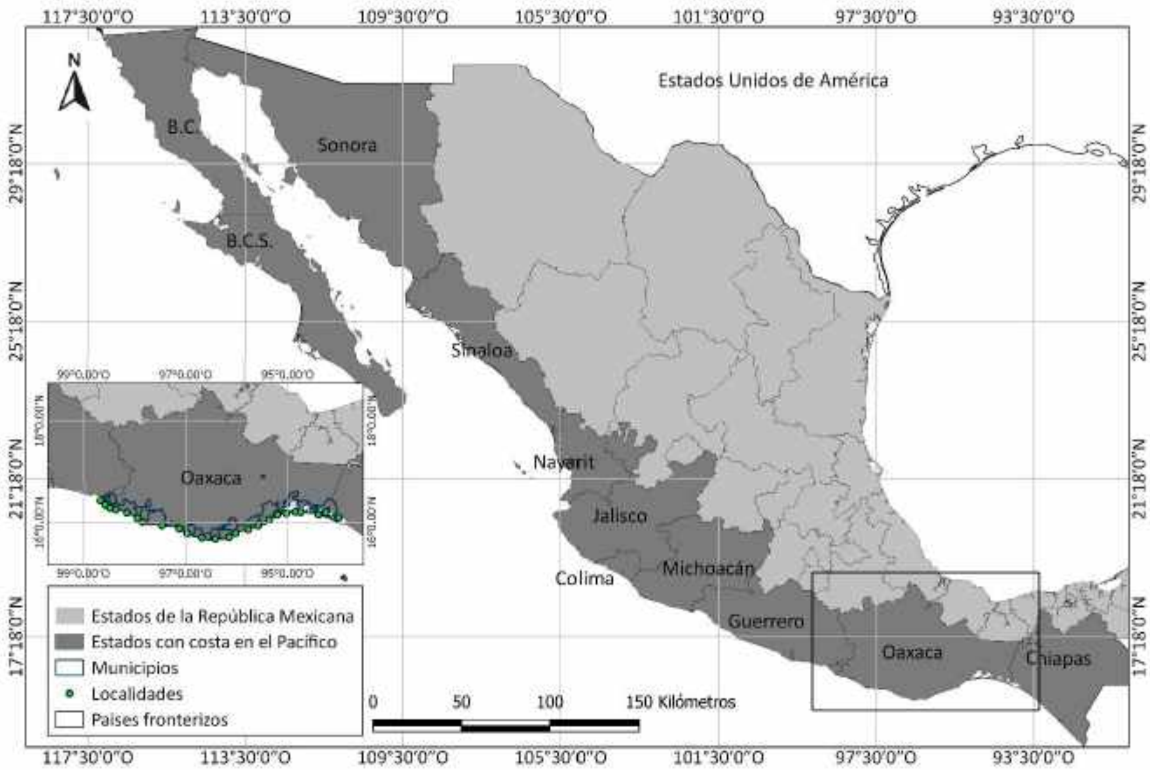

Figure 2. Political division of Mexico. B.C. stands for the state of Baja California and B.C.S. for the state of Baja California Sur. The upper left box illustrates the analysis carried out by state, with blue lines indicating the coastal municipalities of the state of Oaxaca and green dots indicating coastal communities distributed along the coast; the lower left box explains the symbols and color scheme.

3. **Peru:** made up of 24 departments (10 coastal), 1 constitutional province, 196 provinces, 1874 districts and populated centers (INEI, 2020; Figure 3). The country is divided into four major natural regions known as natural macroregions: the Peruvian Sea, the Peruvian Coast, the Peruvian Andes and the Peruvian Amazon (Beraún and Villanueva 2016).

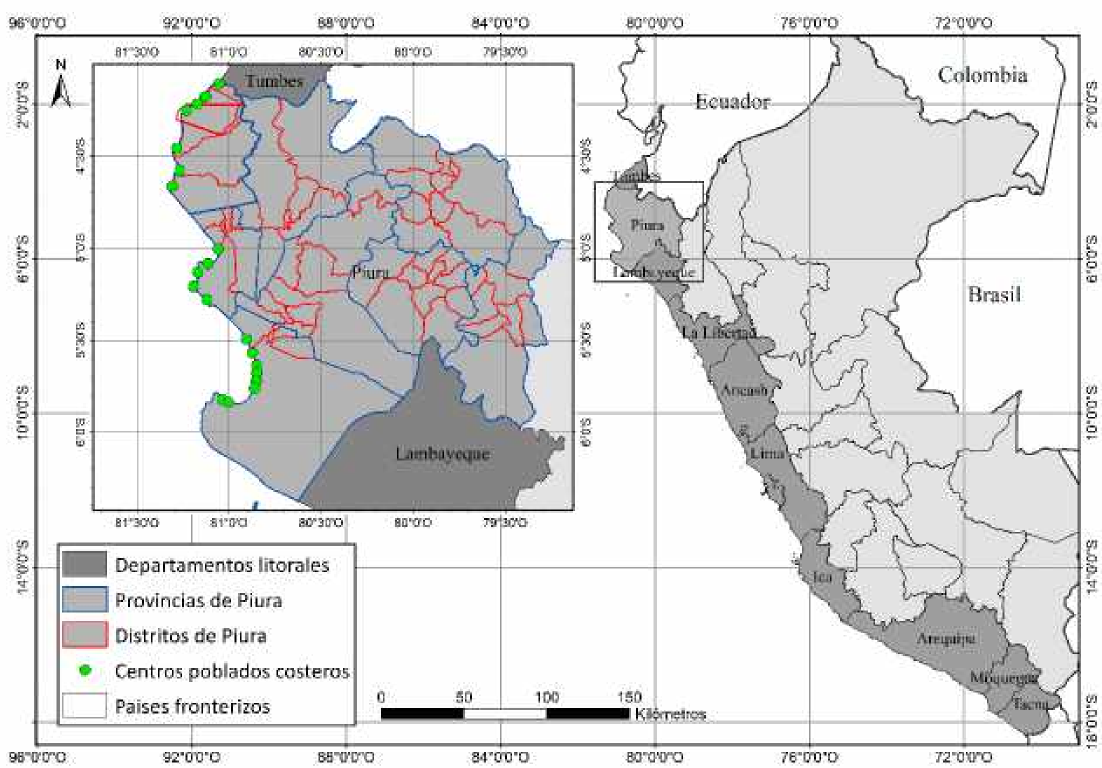

Figure 3. Administrative division of Peru, showing the 10 departments that have a coastline on the Pacific Ocean. The upper left box illustrates the district (red lines) and provincial (blue lines) subdivisions of Piura; the green dots indicate the coastal populated centers distributed along the coast; the lower left box explains the symbols and color scheme.

In order to identify the locations of interest, an exhaustive review of various sources of information was carried out, including the data collected during Task 1 of the project (metadata):

Ecuador

a. Register of *caletas* (fishing coves) or landing sites covered by the Undersecretariat of Fisheries Resources (SRP), including current fishing licenses, according to the information issued by the SRP, 2023[3].

b. Fishing bulletins issued by the Public Research Institute for Aquaculture and Fisheries (IPIAP)[4].

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[3] Information requested via letter Ref.:0446-545, 2023.

[4] Boletín Especial: Puertos, Caletas y Asentamientos pesqueros artesanales Ecuador, del IPIAP (2013).

c. Records of fishing companies or cooperatives in Ecuador.

d. Scientific publications and thesis projects (undergraduate and postgraduate) with an emphasis on sharks (metadata).

Mexico

a. Landing sites assigned in shark fishing licenses, authorized by the National Fisheries Commission (CONAPESCA, 2023).

b. Technical fishing reports from the Mexican Institute for Sustainable Fishing and Aquaculture Research (IMIPAS).

c. Scientific publications describing artisanal elasmobranch fisheries in the Mexican Pacific (Metadata).

d. Thesis projects (undergraduate and postgraduate) with topics and objectives aimed at elasmobranch species in the Mexican Pacific (Metadata).

Peru

a. Register of landing sites registered by the Peruvian Marine Institute (IMARPE).

b. Landing sites supervised by inspectors from the Ministry of Production (PRODUCE).

c. Scientific journals, bulletins and reports from the Peruvian Marine Institute related to artisanal fisheries (Metadata).

d. Scientific publications and thesis projects related to species of chondrichthyes in the Peruvian sea (Metadata).

3.2 Identification of Locations of Interest (LOIs)

In order to begin the process of identifying where shark catches are landed and to create the first regional database on artisanal fisheries in Ecuador, Mexico and Peru, a thorough review of the various documentary sources obtained during Task 1 - Metadata was undertaken.

After the literature review, satellite images were analyzed using Google Earth to identify clusters of artisanal fishing vessels in the Pacific coastal region of each country. Each identified site was assigned a unique numerical code (ID) to build a georeferenced database with several fields according to its characteristics (for more details see Section 4 below).

At this stage, all the identified sites were labeled "Locations of Interest" (LOIs), and classified into three categories:

a) Historical: if the location of the site was consistent with a previously reported location in the literature; and in the case of Mexico, if the location was consistent with that recorded in the fishing licenses authorized by CONAPESCA.
b) New: if the vessels were observed in satellite images and had not been previously reported or described in the literature.
c) Potential: if the site had suitable characteristics or fishing infrastructure for landing catches, but was not mentioned in the literature or in previous records, and no vessels were

observed through satellite images.

All identified LOIs were classified according to their size, using the format used in Part 1 of ABNJ in Central America for this purpose:

i. Sites: isolated locations covering an area of no more than 300 m in diameter.
ii. Segments: groups of locations covering an area of no more than 300 m in diameter and with a distance less than 50 m between locations.

Due to the large amount of research recorded in Task 1 - Metadata, the preliminary identification of the most important shark landing sites in each country was done systematically, without the need for a field visit to characterize all identified LOIs, as was the case in ABNJ-1. The ABNJ-2 team, through local coordinators and technical support staff, plans to meet with experts and local authorities in the second half of 2024 to verify and confirm the level of importance of the preliminary list of LOIs and to arrive at a final list.

4. INFORMATION STRUCTURE

4.1. Identification of fishing localities

The first step in identifying the locations of interest was to locate all the coastal fishing communities in each country, as well as the various nearby landing sites, respecting their respective political-administrative boundaries. In Ecuador, the coastal cantons were taken into account; in Mexico, the coastal municipalities of each state; and in Peru, the coastal populated centers; for locations far from a municipality, canton, or town, the name of the fishing community (parishes in Ecuador) was chosen. Each location was identified with a correlative number and entered into the database dedicated to this activity. For the geolocation of each locality, the municipal facilities or the nearest public institution were taken into account, such as: health centers, local government offices, port authorities, etc. In the case of Mexico, the georeference considered was the central part of the municipality, on the coast.

The information gathered during this stage was recorded and organized in Microsoft Excel spreadsheets and later entered into the Microsoft Access database for the entry of landing sites. As a result of this stage, 266 fishing localities were identified, distributed as follows: a) Ecuador: 74, b) Mexico: 100, and c) Peru: 92. Due to the different cultures and political/administrative distributions that exist between Ecuador, Mexico and Peru, some important characteristics (such as the restructuring of certain border locations within a province, department or municipality; the observation of cargo vehicles to mobilize vessels, among others) are detailed in Appendix 1.

4.2. Identification and characterization of Locations of Interest (LOIs)

A Microsoft Access database was used to tabulate and store the information collected from each site, with specific data entered for each LOI. They were also assigned a unique identification number to organize the information and data that characterized each site (Figure 4).

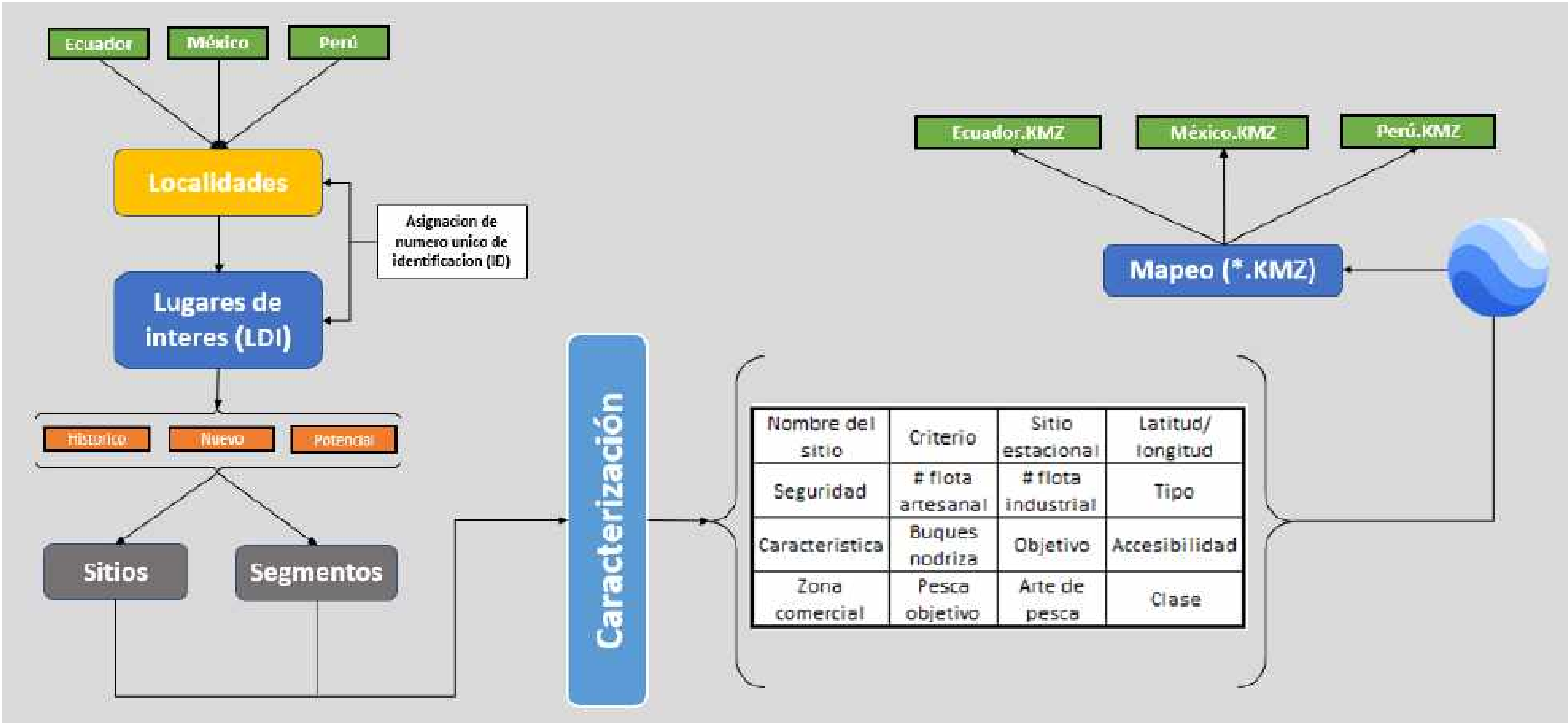

Figure 4. Flow chart of the work carried out to characterize each location of interest (LOI) and map the shark landing sites in each country.

Each identified site was recorded with general data such as country, the corresponding state or province, and the fishing locality identification number. In addition, a correlative number was assigned to each location of interest for correct identification. 2000 places were reserved for each country, distributed as follows: Mexico: 3000 to 5000; Ecuador: 5001 to 7000 and Peru: 7001 to 9000. For the grouped sites (segments), the codes assigned were: Mexico 10300 to 10500; Ecuador 10501 to 10700; and Peru 10701 to 10900. This correlative order was considered because, once the identification number is assigned, it will be part of the general database containing the information on Central America, making it easier to locate a site individually. The name of the site taken into account was that of the corresponding beach, town or fishing locality. If there was more than one site in the same locality, the name plus a correlative number was used. For example, in the fishing locality of Paita in Peru, where there are 14 landing sites, the names and correlative numbers were Paita 01, Paita 02, Paita 03, up to Paita 14.

4.3. Characterization of LOIs

For the characterization, all identified LOIs were used, classified in the three categories mentioned above (historical, new and potential). In addition, according to historical data, "seasonal" LOIs, which are established intermittently according to the time of year, taking advantage of the characteristics of the site for a certain period of time, were considered and therefore also included in the database. Sites identified as being used by motherships were also considered. Safety was also an important consideration in identifying LOIs. Historical information about the locations was used for this purpose, as well as recommendations made by fisheries authorities' technical staff during interviews and information obtained in Task 1 - Metadata.

The quality of the images provided by Google Earth made it possible to distinguish between artisanal and non-artisanal vessels (industrial, medium-scale, advanced, etc.), allowing a virtual count of each fleet. This was useful for classifying the type of place where the landing takes place, whether on the beach, in a mangrove or in an estuary.

Finally, the places where a fishing infrastructure (dock or port) was identified, with characteristics common to the three countries, were classified into three categories:

a) Public: The site does not have an area for processing marine resources (small docks and beach area).
b) Public with facilities: The site has an area for landing and processing marine resources.
c) Private: Access to the site requires a permit or authorization. The locations classified as private are mainly the docks of private fishing companies with industrial tuna fleets and, to a lesser extent, large industrial longliners (usually targeting tuna and billfish, small pelagic fish and other species), as well as marinas exclusively for sport fishing vessels.

Detailed information on the target fishery for each LOI was obtained from a literature review and statistical databases of fisheries and scientific authorities, as well as the type of fishing gear (longline, gillnet, handline, purse seine, and trawl). Other data were also collected for the sampling design, such as the purpose of the LOI (tourism, fishing, shipping, docking and/or workshop), accessibility (street, public transportation, sea transportation, rural road), adjacent commercial area. It is important to note that the way in which the LOIs were selected may have had specific characteristics, according to the information recorded in Task 1 - Metadata, and it was ensured that the basic information collected was the same. These characteristics are described below.

Ecuador: All fishing-related sites were included, such as artisanal fishing *caletas* (historically recorded by IPIAP, 2013), dedicated to coastal and ocean fishing; artisanal fishing ports and fishing facilities; port and maritime terminals; docks of private fishing companies; *chatas* for small pelagic fish; repair shops; docking sites and shipyards.

In addition, places not related to fishing were included, such as shipping docks, tourist docks (yacht club and passenger boarding docks), submarine and naval training schools, and finally naval and coast guard docks (i.e., Ecuadorian Navy).

Mexico: All the places where small vessels with artisanal fishing characteristics were observed (*panga*-type vessels with outboard motors and 6-8 m LOA) were included; village beaches with numerous artisanal fishing vessels parked in the streets or in the yards of houses; beaches where cargo vehicles adapted for towing small vessels were observed; artisanal docks with artisanal fishing vessels moored; local fishing ports with specific characteristics for landing marine resources.

Peru: All fishing related sites were included, such as workshops, docks, landing sites and processing plants. For processing plants, those with access to the sea and a landing dock were considered, as well as those authorized to land sharks intended for direct human consumption. Specific sites for invertebrate fishing (e.g., landing sites in estuaries), landing *chatas* for small pelagic fish, and areas where only traditional ancestral vessels (*caballitos de totora* (reed boats) and *balsillas* (rafts)) were observed were not included.

In order to document the infrastructures used by the three participating countries, screenshots were taken of those considered to be the most representative (Appendix 2). In addition, the information classification and mapping of each country was documented, describing the process and tools used for this task (Appendix 4).

4.4. Information classification

Using the information recorded in the Microsoft Access database, a series of queries were developed to create the layers that would be used to visualize the data from each identified LOI, which included the following information IDSitio, site name, latitude, longitude, and the data to be displayed (Appendix 3, Table 1). For example, all positive responses from shark landing sites were added. In total, 39 queries were grouped into nine folders, depending on the country. Once the queries were created, they were exported to a Microsoft Excel format for the next process of creating visualization layers in Google Earth.

4.5. Layer creation

To create the layers used in Google Earth, two methods of creating shapefiles (.shp) were developed. The first one uses RStudio, while the second one uses QGis. It is important to note that both methods create the same layer, but they differ in the applications or tools used. For a more detailed look at both processes, see Appendix 4 and 5 of this document.

4.6. Creation of KMZ files

The creation of the layers allows the LOIs to be visualized in Google Earth, taking into account the different layers described in Section 4.4 within the Excel files. Once the shapefiles are created, the process of generating the KMZ format file can begin, which will contain all the information generated during the mapping phase of the LOIs on the coasts of Ecuador, Mexico and Peru (Appendix 6).

5. PRELIMINARY RESULTS

The classification of all LOIs identified in the three countries was described, detailing their distribution by category (historical, new and potential) and their classification by site and segment. A total of 1,623 LOIs were identified in the three countries, with Mexico accounting for 45% (737) of the locations of interest, followed by Ecuador with 40% (642) and Peru with the remaining 15% (243). Of all the identified LOIs, Ecuador has the highest percentage of historical sites according to the metadata, with 60% (518), followed by Mexico and Peru with 26% (226) and 13% (114), respectively. In terms of newly identified sites, Mexico leads with 60% (350), followed by Peru and Ecuador with 21% (124) and 19% (110), respectively (Figure 1).

During this analysis, it was noted that potential sites were more abundant in Mexico, accounting for 89% (161) of all potential sites in the three countries. This may be mainly due to the length of the Mexican coastline, which is greater than that of Ecuador and Peru, or to the common practice of changing landing sites according to the time of year or fishing season, resulting in a greater number of these types of sites. Ecuador and Peru have a proportion of less than 10%, with 8% (14) and 3% (5), respectively.

With regard to the distribution of LOIs, Ecuador has a higher concentration in the province of Manabí, in the central part of the country. In Mexico, on the other hand, due to geographical conditions, fishing activity is mainly concentrated in the Baja California peninsula. Peru, in contrast, has a more even distribution along the entire coast, with the exception of Lambayaque, Moquegua and Tacna, where fewer LOIs were identified (Figure 5).

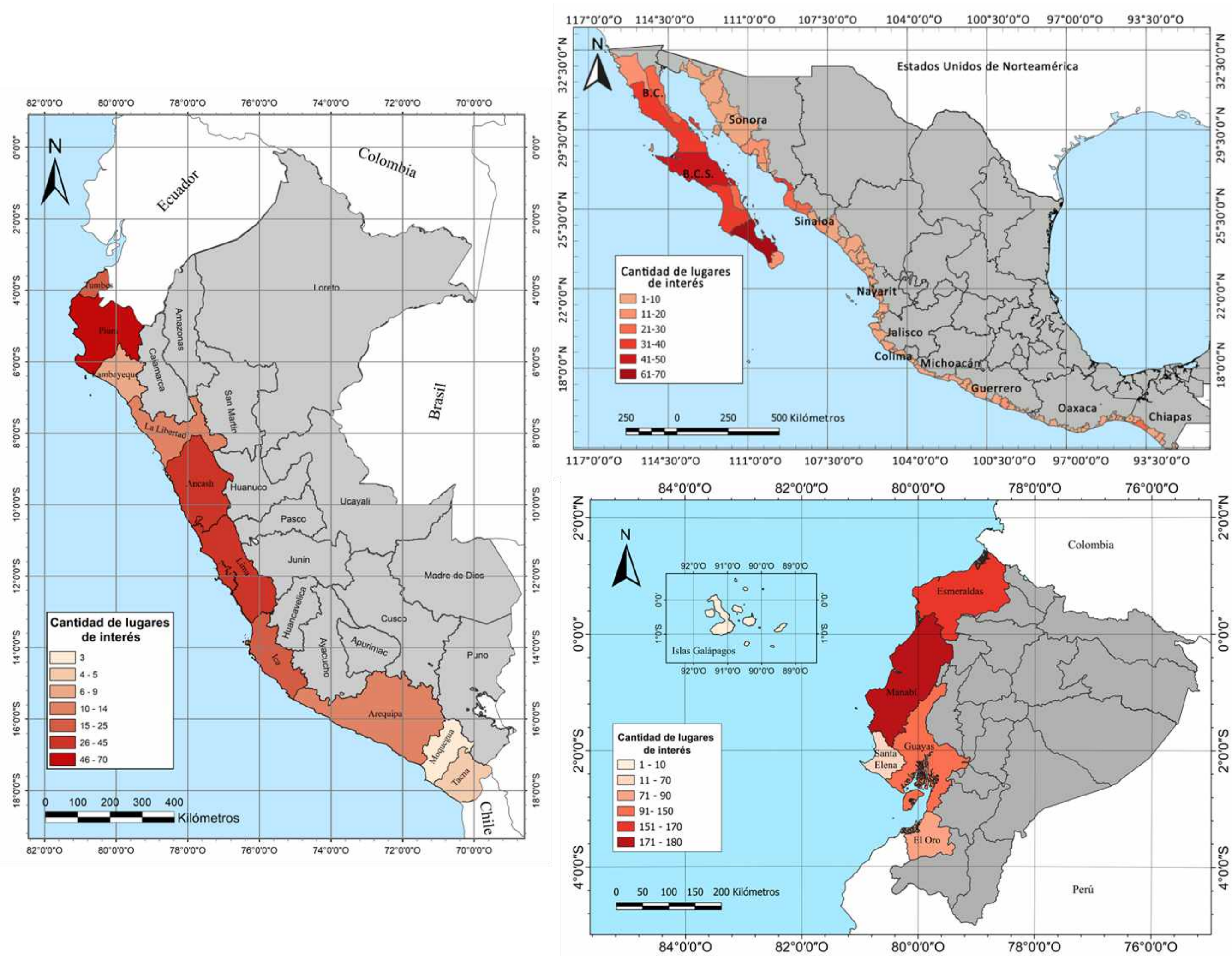

Figure 5. Distribution of locations of interest (LOIs) identified by province, state, or department for Ecuador, Mexico, and Peru, respectively. LOIs identified during mapping using Google Earth in 2024; the color scheme indicates the abundance of sites identified. For the Galapagos Islands, the LOIs include the ports of Isabela (Puerto Villamil), Santa Cruz (Puerto Ayora and Baltra), San Cristóbal (Puerto Baquerizo Moreno), and Santa María (Puerto Velasco Ibarra).

The 1,623 LOIs are categorized according to the type of their specific location, which can be: port, dock, beach, mangrove and estuary. Table 2 provides a detailed summary of the LOIs registered in the three countries (Ecuador, Mexico and Peru), showing the total number of LOIs per country and the specific distribution of each type of LOI.

In this analysis, Peru shows a significant predominance of beach LOIs, representing more than half of the total (55%). Docks also represent a significant proportion (28%), while locations in mangroves and estuaries are very low or non-existent (<2% and 0%, respectively). In contrast, in Ecuador, LOIs on beaches (36%) and estuaries (36%) together dominate the spatial locations, accounting for more than 70% of the total LOIs. Mangroves (10%) and docks (12%) are also well represented, while port locations (5%) are the least common. It is important to point out that the high percentage of sites registered in estuaries is due to the fact that Ecuador has a combination of geographical, climatic and hydrological factors that favor the formation of estuaries, which have been included in the mapping, resulting in a significant number of LOIs. In the case of Mexico, the high concentration of LOIs on beaches (66%) is notable, representing more than two thirds of the total. Locations in mangroves (14%) and estuaries (14%) also have a significant presence, while locations in ports (<1%) and docks (5%) represent the smallest proportion.

To evaluate the main objective of each LOI, the available data sources (metadata) identified during Task 1 were used. Each LOI was characterized and classified according to its main objective, whether tourism, shipping, docking, fishing, shipyard, or no information for sites with no literature data (see Table 3). It is important to emphasize that an LOI may have multiple objectives and target different species, so the information presented in Table 3 and Table 4 does not necessarily reflect a characteristic or fishery exclusive to the site. Once the LOIs were characterized, they were renamed as "sites".

For the purposes of this research, and in order to present the data more clearly, the information was categorized into four groups: tunas, billfishes and dorado (TBD); sharks (SHK); small coastal fish (SCF); and other (this group includes, for example, sites that target crustaceans, mollusks and bivalves) (Table 4).

Of the total LOIs, 1,028 were documented as landing sites for fishery products (63%), of which 562 (SKH; 55%) were identified as shark landing sites. Within the fishing sites, sites with special characteristics were recorded, such as those used seasonally or where mothership fishing fleets are located. A total of 49 special sites were identified, of which 35 (seasonal sites) are located in Mexico and eight (8) in Peru. Meanwhile, only six (6) mothership sites were found in Ecuador.

In Ecuador, the vast majority of identified LOIs are used as landing sites for fishery products (79%). In contrast, shark landing sites are less frequent, but still represent a significant proportion (SKH; 27%). In terms of spatial distribution, these sites are concentrated between the central (Manabí province) and northern (Esmeraldas province) parts of the country (Figure 6). In the case of Mexico, almost half of the LOIs are for the landing of fishery products (46%), with a notable presence of shark landing sites (SKH; 38%), and an equally important percentage for the landing of small coastal fish (SCF; 40%). In terms of distribution, they are mainly concentrated in the Baja California peninsula and Sinaloa (Figure 7). On the other hand, in Peru, the majority of LOIs are used as landing sites for fishery products (73%), of which almost half are shark landing sites (SKH; 45%), with small coastal fish (SCF; 27%) and other fishery products (27%) also being important. The spatial distribution of these sites shows the highest concentration from the central part towards the north (north of the department of Ica to the department of Tumbes) (Figure 8; Table 4).

In all three countries, the sampling design identified the place and spatial location of potential shark landing sites. These will be verified *in situ* during the site characterization work and during the visit of local coordinators to the regional offices of the fisheries authorities, where they will also meet with local experts. The sites will be classified according to the type of infrastructure available for landing (port or dock) or the type of ecosystem that facilitates landing (beach, mangrove or estuary). In Ecuador, the estuary and beach systems account for the highest percentages, 44% and 39% respectively. In the case of Mexico, the beach system has the highest percentage at 77%, while port infrastructure accounts for only 1%. In the case of Peru, the majority of sites are distributed between the dock and port infrastructure and the beach ecosystem, with 40%, 33% and 24% respectively. It is important to note that in none of the three countries do the percentages of possible shark landing sites allocated to port, dock, beach, mangrove and estuary (Table 5) represent the volume of shark catches and landings. It only refers to sites with certain characteristics where there is a possibility of sharks being landed (Figure 6, Figure 7 and Figure 8).

All these characteristics per site can be found in the KZM database created for the report and the project.

6. RESULTS: TABLES AND FIGURES

6.1. Tables

Table 1. Total number of locations of interest (LOIs) identified for Ecuador, Mexico, and Peru; category and classification shown in numbers and percentages.

Country	Historical		New		Potential		Site		Segment		Total	
	#	%	#	%	#	%	#	%	#	%	#	%
Ecuador	519	**60%**	110	**19%**	14	**8%**	599	**43%**	43	**18%**	**643**	**40%**
Mexico	226	**26%**	350	**60%**	161	**89%**	554	**40%**	183	**79%**	**737**	**45%**
Peru	114	**13%**	124	**21%**	5	**3%**	236	**17%**	7	**3%**	**243**	**15%**
Total	859	**100%**	584	**100%**	180	**100%**	1389	**100%**	233	**100%**	**1623**	**100%**

Table 2. Total locations of interest (LOIs) and their specific locations as identified by Google Earth.

Country	Total LOIs	Location of LOIs										
		Port	%	Dock	%	Beach	%	Mangrove	%	Estuary	%	Total %
Ecuador	643	34	5%	79	12%	234	36%	66	10%	230	36%	100%
Mexico	737	5	<1%	40	5%	489	66%	101	14%	102	14%	100%
Peru	243	36	15%	69	28%	134	55%	4	<2%	0	0%	100%
Total	**1,623**	**75**		**188**		**857**		**171**		**332**		

Table 3. Classification of the identified sites according to their main objective[5].

Country	Sites												
	Tourism	%	Shipping	%	Docking	%	Fishing	%	Shipyard	%	No information	%	Total %
Ecuador	158	20%	57	7%	17	2%	510	64%	8	1%	50	6%	100%
Mexico	103	12%	19	2%	396	46%	341	40%	4	<1%	0	0%	100%
Peru	23	5%	6	1%	163	35%	177	38%	92	20%	3	<1%	100%
Total	284	13%	82	4%	576	27%	1,028	48%	104	5%	53	2%	100%

Table 4. Summary of the total locations of interest (LOI), fishing landing sites and their categorization by target species: tunas, billfishes and dorado (TBD); all sharks and rays (SHK); small coastal fish (SCF); and other (this group includes, for example, sites that target crustaceans, mollusks and bivalves). Google Earth and the available data source for each country were used (Metadata, 2024).

Country	Total LOIs	Landing sites									
		Fishing		TBD		SHK		SCF		Other	
		Number	%	Number	%	Number	%	Number	%	Number	%
Ecuador	643	510	79%	218	34%	173	27%	18	3%	349	54%
Mexico	737	341	46%	7	1%	280	38%	255	40%	92	14%
Peru	243	177	73%	83	13%	109	45%	174	27%	175	27%
Total	**1,623**	**1,028**	**63%**	**308**	**30%**	**562**	**55%**	**447**	**43%**	**616**	**60%**

[5] An LOI may have multiple uses (e.g., it may be a docking site, a tourism site, and a fishing site all at the same time). Therefore, the percentage sum of the total number of sites in each country exceeds 100%.

Table 5. Percentage distribution of possible shark landing sites, according to the infrastructure available for landing, such as ports and docks; or the type of ecosystem that facilitates landing, such as beaches, mangroves and estuaries.

Country	Shark landing sites	Types of shark landing sites					Total
		Port	Dock	Beach	Mangrove	Estuary	
Ecuador	173	12%	4%	39%	1%	44%	100%
Mexico	280	1%	7%	77%	9%	7%	100%
Peru	109	33%	40%	24%	3%	0%	100%
Total	562						

6.2 Figures

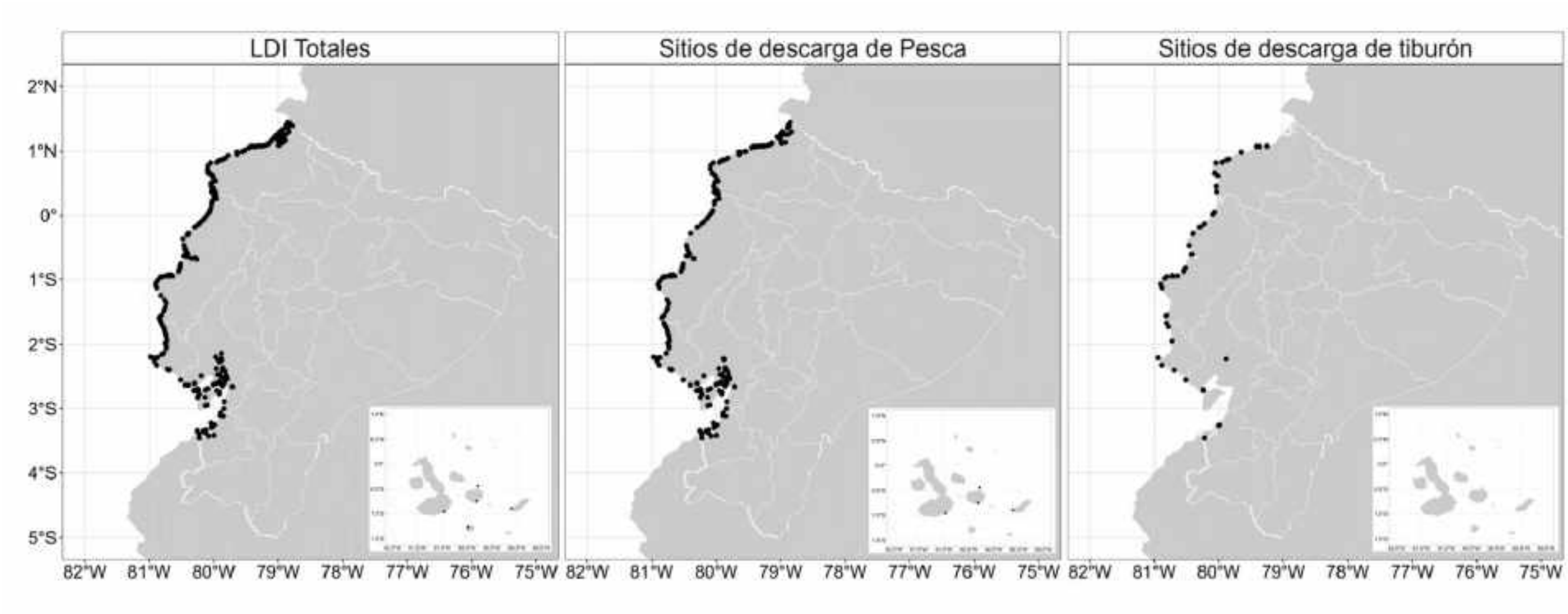

Figure 6. Spatial distribution of locations of interest (left; n= 643), recorded in Ecuador, indicated by filled circles, along the coastline; sites identified for fish landing (center; n= 510); and sites identified for shark landing (right; n= 173) (Metadata, 2023).

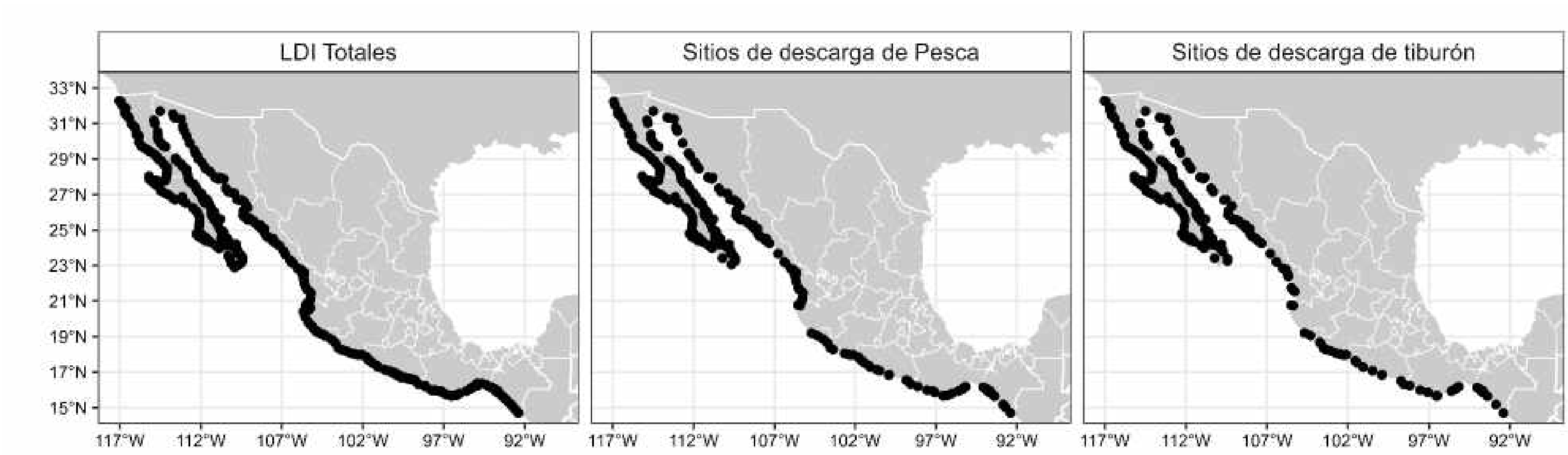

Figure 7. Spatial distribution of locations of interest (left; n= 737), recorded in Mexico, indicated by filled circles, along the coastline; sites identified for fish landing (center; n= 341); and sites identified for shark landing (right; n= 280) (Metadata, 2023)**.**

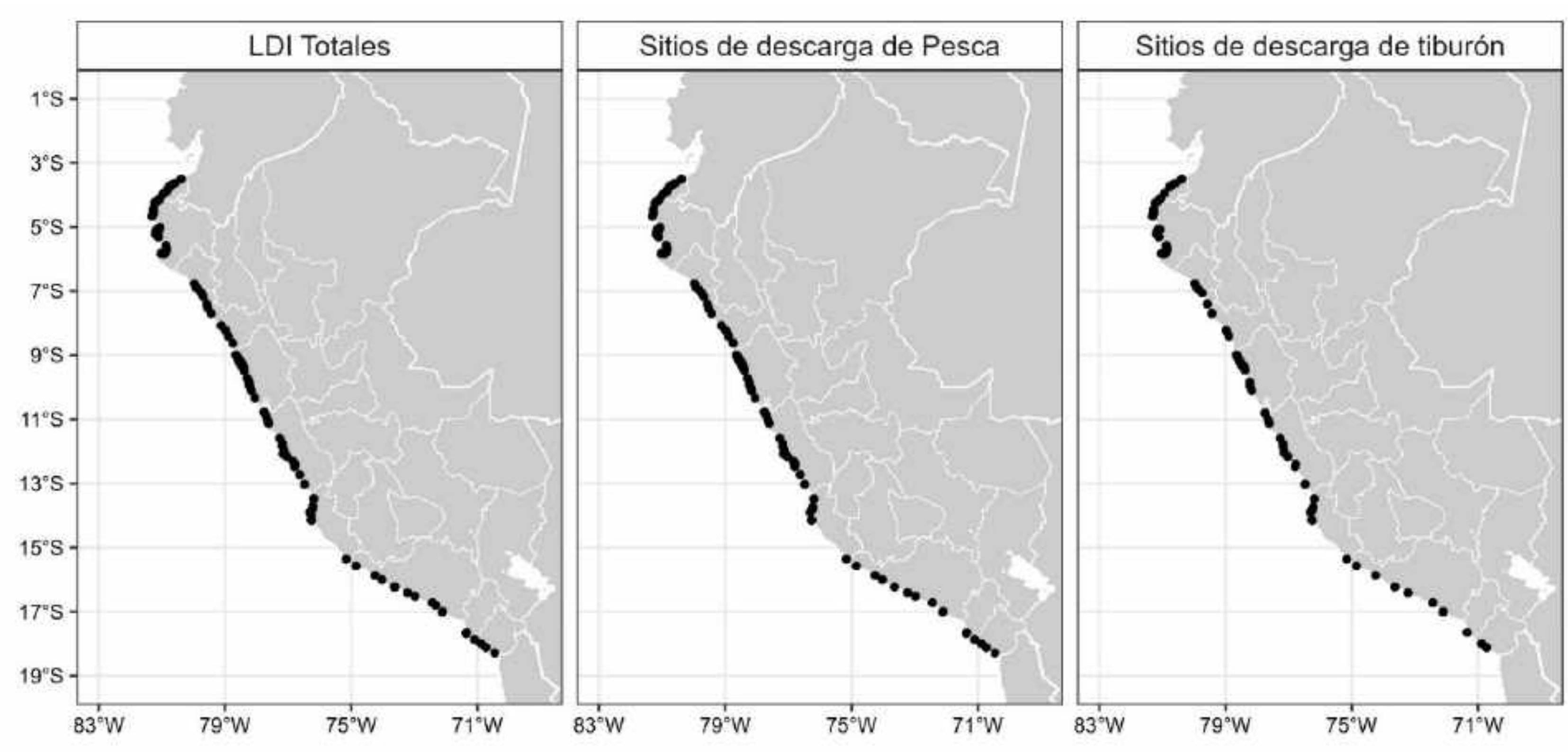

Figure 8. Spatial distribution of locations of interest (left; n= 243), recorded in Peru, indicated by filled circles, along the coastline; sites identified for fish landing (center; n= 177); and sites identified for shark landing (right; n= 109) (Metadata, 2023)**.**

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6. APPENDICES

Appendix 1

<u>Special considerations</u>

Due to the specific political division of each country, the identification and analysis of LOIs within each fishing locality was carried out independently by local coordinators and technicians from Ecuador, Mexico and Peru. The special considerations that were taken into account during this classification and identification of LOIs are described below:

Ecuador

For the selection of the coastal cantons, the geographical coordinates of the municipal facilities, called Cantonal Decentralized Autonomous Government (GAD), were taken into account. In the case of some landing sites located more than 20 km from the GAD, the parishes (both urban and rural) located on the coast were selected as a reference.

Special circumstances arose during the selection of the localities. For example, in the province of Esmeraldas, certain peripheral border locations were at a considerable distance from each other. In order to avoid subdividing multiple localities, it was decided to assign them to the corresponding canton. This approach was also used in similar cases identified in the provinces of Guayas and El Oro. For example, in both Guayaquil and Santa Rosa, there are remote areas with several small contiguous settlements that have no established administrative entity and are not even referenced in Google Earth. It is important to note that in the case of Isla Puná (Guayaquil), the parish was considered a locality due to its geographical location (Figure 1).

On the other hand, in the case of Santa Elena, the GAD of the parish of Colonche was not considered a designated locality. However, the sites of Ayangue and Monteverde were considered as such. Puerto Jelí, although close to Santa Rosa, was considered an independent locality because of its importance in terms of fishing activity. As for Machala, the parish of Jambelí was considered a locality, since the administrative boundaries of Puerto Bolívar do not completely encompass the Huayla estuary.

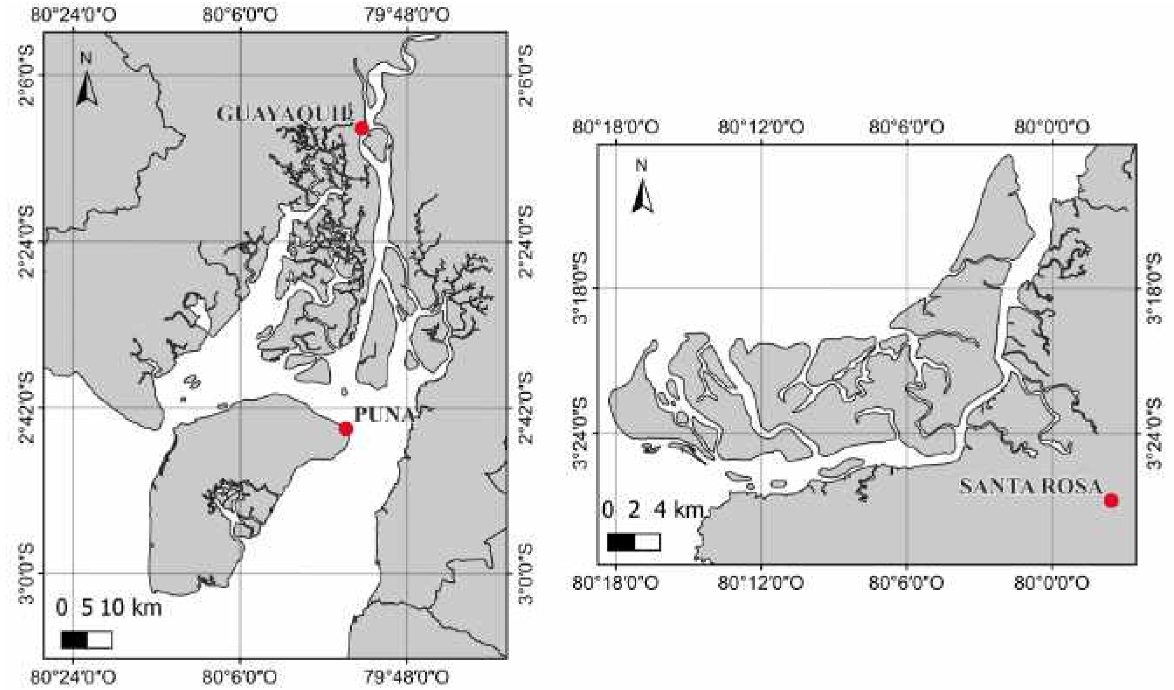


Figure 1. Cases of landing sites that are far from the cantonal center; remote places with several small settlements, located in the provinces of Guayas and El Oro.

Another particular case was Puerto Bolívar, in El Oro, where a special procedure was used. The landing sites were close together along the estuary, so it was decided to count the vessels considering a distance of 300 m as a reference, or up to a significant cut-off point (for example, a dock or a prominent structure) (Figure 2).

Figure 2. Puerto Bolívar case: a) the light blue box represents the segment within which all vessels are counted; b) the red line represents the route that the sampling technician must follow to reach all landing sites; c) the yellow icon indicates the midpoint of the segment; and d) the structure considered as the end point of the segment.

Mexico

Google Earth was used to locate the landing sites, and *panga*-type artisanal vessels were identified in the locations indicated in the documents reviewed and in those indicated by IMIPAS personnel. In some cases, no vessels were located, probably due to the insecurity of the site or the physical characteristics of the site that do not allow them to remain there. In other cases, cargo vehicles with trailers, typically used to tow smaller vessels, were identified and taken into account for the site verification (Figure 3).

Figure 3. Identification of typical vehicles with trailer attached used by fishers to launch and retrieve vessels at a typical access point on the Pacific coast of Baja California (Image: Google Earth).

In many regions of the Mexican Pacific, as mentioned above, fishermen avoid leaving their vessels at the landing sites due to the insecurity of the area and the lack of private surveillance. Another reason is the condition of the beach (rocky beach, cliffs) and its oceanography (wide tides, strong waves), which can be unfavorable for the vessels. This means that every day the fishermen arrive at the landing sites with their vessels pulled by cargo vehicles (Figure 3). For example, in the case of the landing site called Golfo de Santa Clara, in the state of Sonora, it was possible to count the number of vessels by observing them in the houses that make up the village of the same name (Figure 4). In this place, the vessels cannot remain on the beach, which is the landing site, because during the tidal cycles in this region, some of the largest tidal ranges recorded in Mexico occur.

Figure 4. Section of the village and landing site at Golfo de Santa Clara, Sonora. The part of the beach used by fishers for landing can be seen in the lower left part of the image, while vessels identified within residential properties are marked with yellow circles (Image: Google Earth).

Another task carried out as part of the identification of potential shark landing sites was the identification of medium-sized vessels that target different species of small pelagic and benthic species, but are known to have significant shark bycatches (Castillo-Geniz *et al*., 2007). Similarly, Google Earth was used to identify and classify at-sea fishing structures to differentiate between encircling and trawling vessels (Figure 5). This vessel identification and differentiation strategy could not be carried out inside the port facilities due to the difficulty of identifying fishing gear when it is not in use.

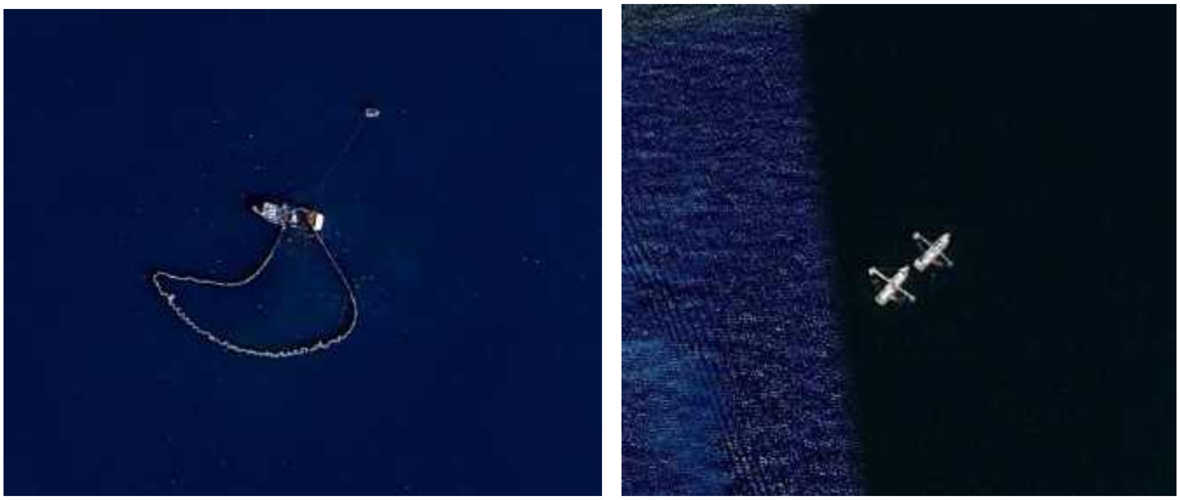


Figure 5. Vessels dedicated to catching pelagic and benthic species, identified by Google Earth. On the left, a vessel retrieving a purse-seine net, supported by its smaller auxiliary vessel; on the right, two vessels with the typical outrigger booms for trawling (Image: Google Earth).

Peru

During the mapping stage using Google Earth, a number of localities and landing sites were identified as having particular characteristics in terms of their geography and fishing activity. In this sense, locations whose bibliographic references indicate that they are exclusively dedicated to the landing of shellfish (shrimp, lobster, etc.), docks used only for tourism, ports used for the transportation of minerals and hydrocarbons, and port terminals were excluded. For example, Puerto 25 in Tumbes, where only black clams and mangrove crabs are harvested, was excluded, as was the Paita port terminal, which is used exclusively for the loading and unloading of commercial vessels (Figure 6).

Figure 6. Examples of ports and docks excluded from the study; (a and b) Paita port terminal; (c) Puerto 25 in Tumbes with its main hydrobiological resources (d and e).

It should be noted that, in various areas of the Peruvian coast, some fishermen use traditional ancestral vessels such as the *"caballito de totora"* (reed boat) and the *"balsilla"* (raft). These vessels, which do not have wells, use fishing gear consisting of small nets or hand lines. Due to their small size, low fishing capacity and the difficulty of counting them, they were not included in the mapping. This difficulty is exacerbated by the way they are beached, with the *caballitos de totora* in an upright position and the *balsillas* stacked on top of each other (Figure 7).

Figure 7. Traditional ancestral vessels used in Peru; a) *caballito de totora* (reed boat) and b) *balsilla* (raft), with their respective beaching methods (c and d).

On the other hand, populated centers were registered that did not have a public or private institution for georeferencing; in these cases, the midpoint of the locality was considered (e.g., populated center of Punta Mero) (Figure 8).

Figure 8. Georeferencing of the populated center of Punta Mero.

Some landing sites were isolated from populated centers and districts due to the geography and location of the fishing areas. In these cases, the nearest populated center was considered the locality (Figure 9).

Figure 9. Location of landing sites (yellow icons) belonging to the locality of Los Chimus (purple icon).

In certain situations, the "historical imagery" tool was used to analyze the history of satellite images and to exclude natural events such as the presence of clouds and the brightness reflected by the sea, as well as to verify the presence or absence of vessels in the different sites evaluated. It is worth mentioning that on some beaches there is a process of erosion or sedimentation that can be observed when using the "historical imagery" tool, so these cyclical changes can modify the georeferencing of beach landing sites (Figure 10).

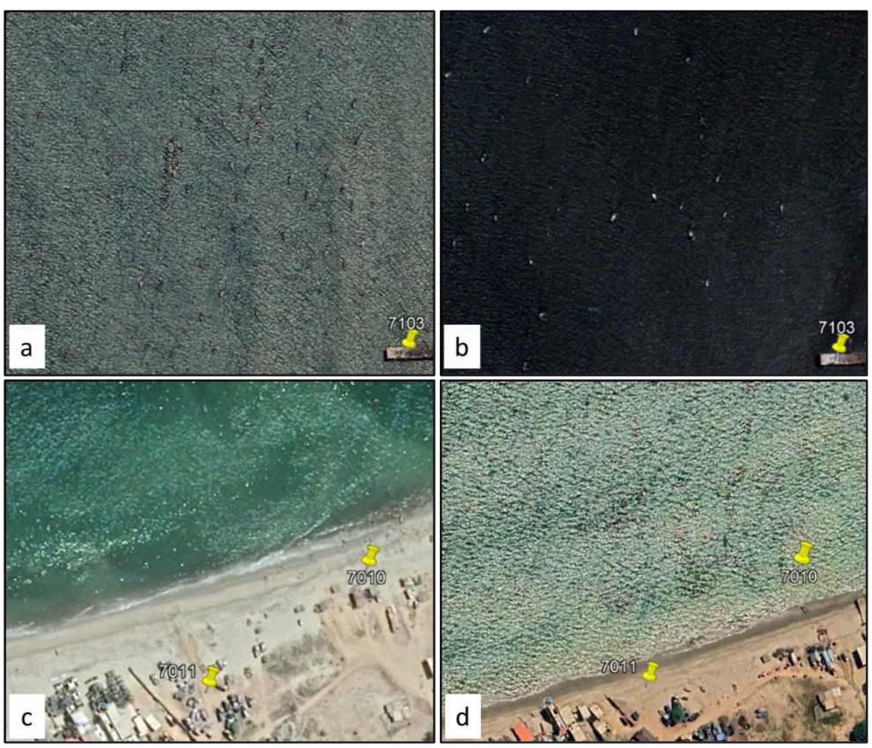


Figure 10. Variation of satellite images of the same location on different dates. (a, b) Light reflection prevents clear observation of the vessels, and in other cases (c and d) beach erosion changed the vessel landing location.

In Caleta de Carquín (department of Lima), local authorities and fishermen built three covered structures where they keep their vessels to protect them from the sun, rain and waves (Figure 11). These structures prevented the total number of vessels from being counted using Google Earth.

Figure 11. Caleta de Carquín in the city of Lima as shown by satellite (left) and on location at the landing site (right).

To count a large number of vessels, the "path" tool in Google Earth was used to avoid possible under- or overestimates. For example, in the district of Paita, department of Piura, a segment with three continuous docks and two adjacent areas used as workshops was recorded. It is important to note that, thanks to this tool, it was determined that this was the landing site with the highest number of artisanal vessels (Figure 12).

Figure 12. Paita landing sites; count of artisanal vessels landing in segment 10702, using the "path" tool in Google Earth.

There are specific cases where the length of the dock has an impact on the counting of vessels, since they moor at the end of the dock. This is the case of Puerto Eten, located in the department of Lambayeque, where the dock is about 650 m long; therefore, a search had to be carried out further away from the landing site (Figure 13).

Figure 13. Satellite view of the location of vessels off Puerto Eten showing the vessel count process using the "path" tool in Google Earth.

Appendix 2

Existing fishing infrastructures in Ecuador, Mexico and Peru.

a) Public

Ecuador:

Figure 1. a) Manta's floating artisanal dock; b) landing site on Playa de San Vicente.

Mexico:

Figure 2. Infrastructures available for artisanal fishing vessels in developed urban areas such as the port of Mazatlán, Sinaloa.

Figure 3. Example of adapted docks in the homes of artisanal fishermen in mangrove areas; private dock in the community of Barra de Navidad, Jalisco.

Figure 4. Docks for medium-scale vessels, with adapted infrastructure for artisanal fishing vessels; local dock in the community of San Blas, Nayarit.

Peru:

Figure 5. a) Artisanal dock in Eten (Lambayeque Region), b) Landing site on Zorritos beach (Tumbes Region).

b) Public with facilities

Ecuador:

In Ecuador, fishing and cabotage terminals are open to the public. However, access requires a permit issued by the port authority (Figure 6). Artisanal fishing ports, which are Ecuadorian state infrastructure, are managed by the Technical Secretariat for Public Property Management (Inmobiliar). A permit issued by this institution is required to access the loading and landing areas (Figure 7). On the other hand, the artisanal fishing facilities, also managed by Inmobiliar, allow free access and their facilities have adequate space for the collection, processing and direct sale of products (Figure 8).

Figure 6. Manta fishing terminal; a) top view; b) international terminal; and c) fishing terminal.

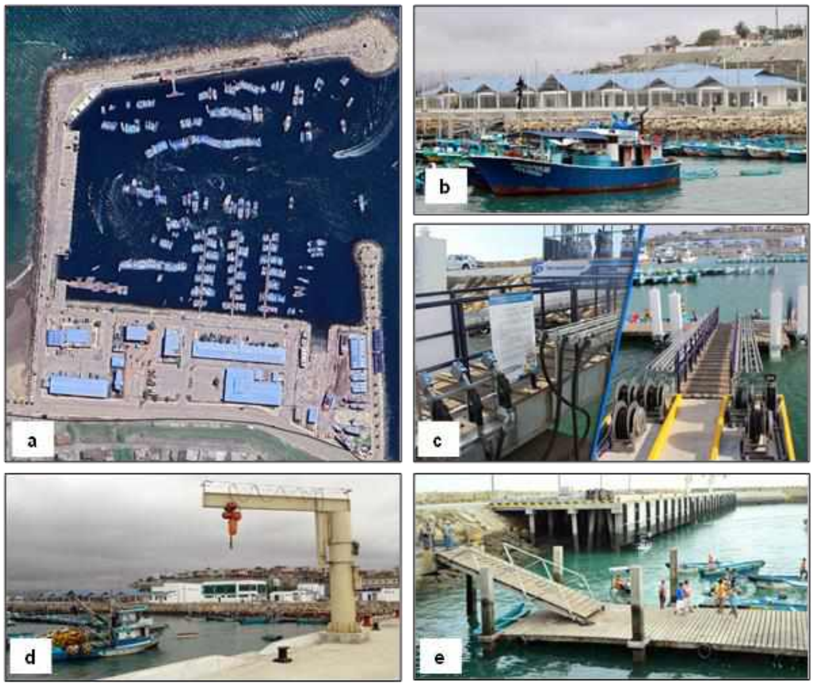


Figure 7. Artisanal fishing port of Jaramijó[6]; a) top view; b) front view; c) fuel station; d) landing area (vessels up to 30 tons); e) landing area for artisanal vessels.

Figure 8. Santa Rosa fishing facility[7]; a) top view; b) front view; c) interior view.

[6] Photos available at the following link:
https://www.flickr.com/photos/viceec/14898647232 https://www.flickr.com/photos/viceec/14898647232
https://www.flickr.com/photos/recursosnaturalesec/16214274944/in/photostream/

[7] This infrastructure offers services such as: weighing service, rental of large and small tanks, evisceration table rental. Photos available at the following link: https://www.inmobiliar.gob.ec/wp-content/uploads/2020/11/INFORME-CON-

Mexico:

Medium and large-scale fishing ports, including landing areas for smaller vessels in Mexico, are public. However, in order to enter and use the facilities, a permit is required from the Secretariat of the Navy, the institution responsible for the administration, management and security of the country's port facilities.

Figure 9. Artisanal fishing vessels moored in docks at the port of Ensenada, Baja California, equipped for medium and large-scale fishing vessels.

APORTES-CIUDADANOS-CZ4.pdf; Photos available at the following link: https://www.inmobiliar.gob.ec/wp-content/uploads/2020/11/INFORME-CON-APORTES-CIUDADANOS-CZ4.pdf ; https://chankete.com/visita-al-puerto-pesquero-de-santa-rosa/

Figure 10. Artisanal fishing dock in the port of El Sauzal, sharing space with medium-scale industrial vessels; access to this port is limited to permits issued by the Secretariat of the Navy.

Peru:

In Peru, access to landing sites such as docks, beaches and artisanal fishing landing sites may be open to the public. However, this may vary depending on the authority in charge. For example, in some docks and artisanal landing sites it is necessary to obtain an entry permit, which is issued by the authorities in charge of managing the site.

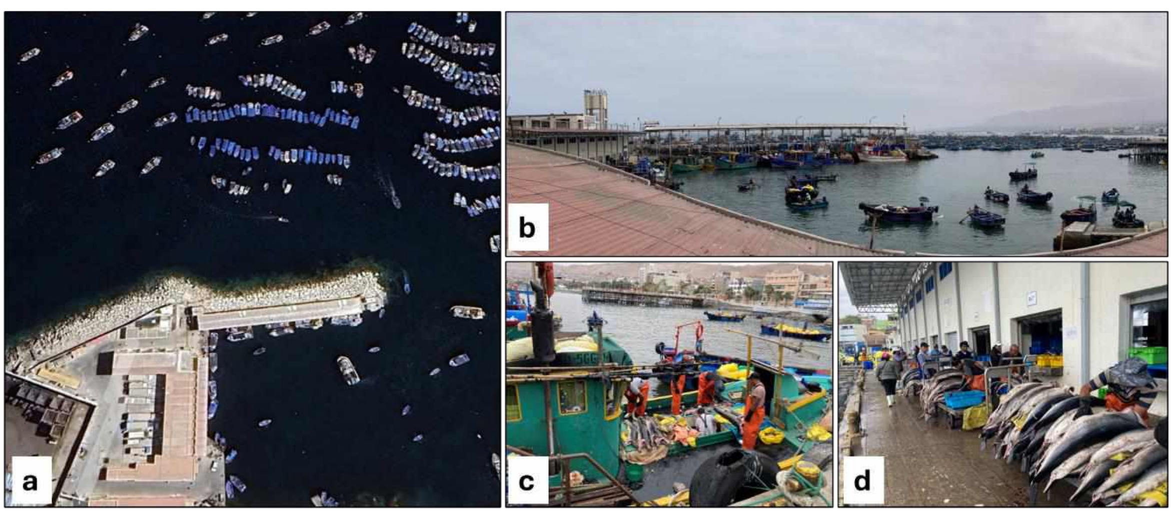


Figure 11. Artisanal fishing landing site in Ilo (Moquegua region); a) top view; b) side view; c) landing area; d) landing reception area.

c) Private

Ecuador:
These docks are mainly used by fishing and commercial companies for the loading and landing of sea products, as well as for docking private vessels.

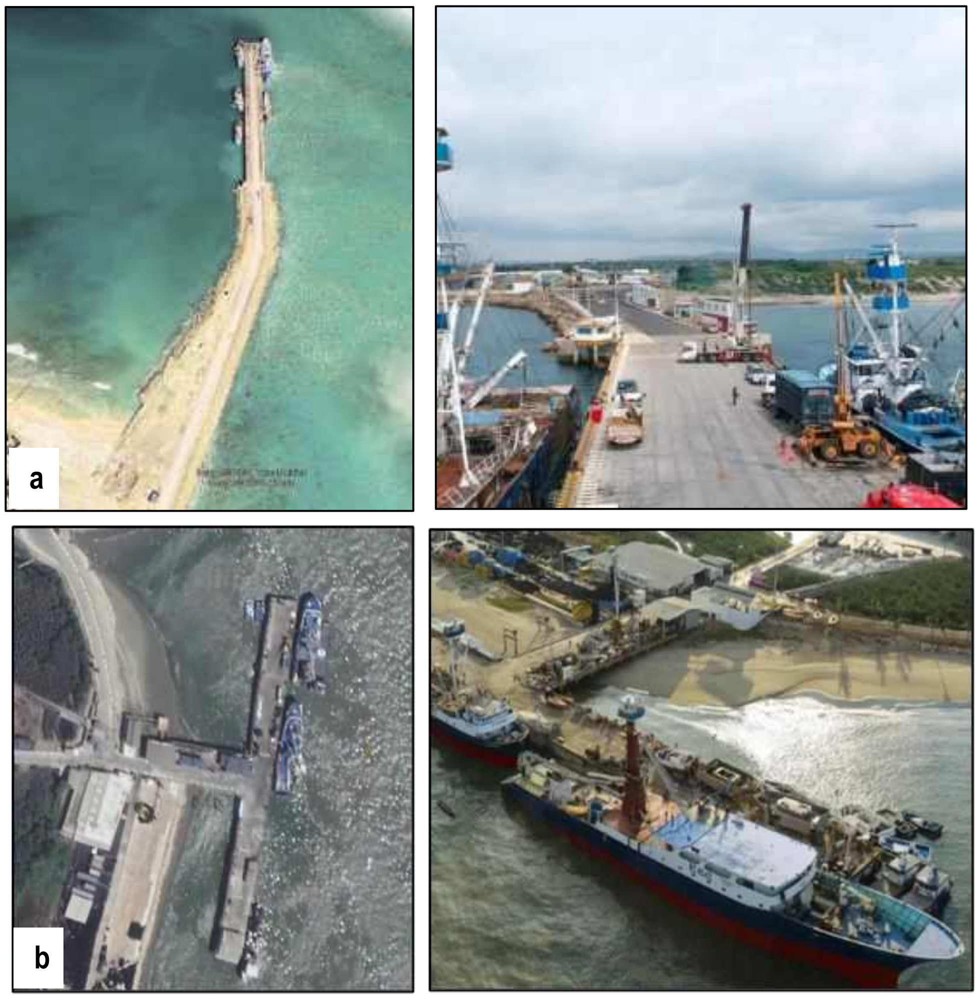


Figure 12. a) Private fishing dock of Astiesmar C.A.[8], located in the canton of Jaramijó. b) Private dock of the fishing company[9] NIRSA S.A., located in the parish of Posorja.

[8] The facilities are specifically designed to facilitate a variety of activities such as vessel maintenance, provisioning and fish landing operations, including those of large industrial longline vessels. Photos available at the following link: https://www.astiesmar.com/servicios-empresariales/

[9] They supply 14 tuna vessels, seven sardine vessels and eight smaller vessels. Within the industrial complex, the fleet has its own port facilities just 400 meters away from the processing plants. Photos available at the following link: https://nirsa.com/conocenos/

Mexico:

Most private ports in Mexico (also called marinas) are used and managed by private companies that use the vessels for recreational purposes such as sport fishing, navigation, transportation, and tourist tours. In many cases, however, there are agreements with fishermen cooperatives or groups, so it is common to see small areas within these marinas for docking and landing artisanal fishing vessels (Figure 13).

Figure 13. Private port for sport fishing vessels within the marina of Cruz de Huanacaxtle, Nayarit; including smaller artisanal fishing vessels (front of the photo).

Peru:
These docks are mainly used and managed by fishing or commercial companies for the loading and landing of sea products and/or for the docking of industrial or artisanal vessels (Figure 14).

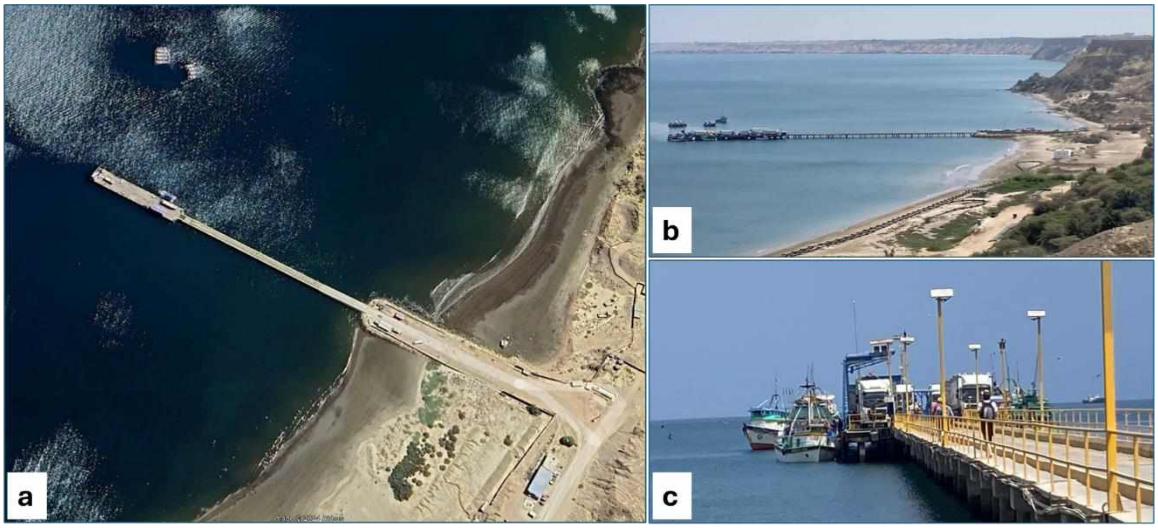


Figure 14. Private dock of the company CNC (Piura region); a) top view; b) side view; and c) landing area.

Appendix 3

Classification of information

Table 1. Distribution of queries made to the database containing the information and characteristics of each identified LOI. Once the queries were made, they were exported to a Microsoft Excel file for the next process of creating visualization layers in Google Earth.

Folder	ID	Name	Query ID
Objetivo	Turismo	ObjetivoSitioTurismo	1
	Transporte	ObjetivoSitioTransporte	2
	Atraque	ObjetivoSitioAtraque	3
	PescaTBD	ObjetivoSitioPescaTBD	4
	PescaSHK	ObjetivoSitioPescaSHK	5
	PescaSCF	ObjetivoSitioPescaSCF	6
	PescaOtro	ObjetivoSitioPescaOtro	7
	PescaLL	ObjetivoSitioPescaLL	8
	PescaGN	ObjetivoSitioPescaGN	9
	PescaLHP	ObjetivoSitioPescaLHP	10
	PescaPS	ObjetivoSitioPescaPS	11
	PescaTX	ObjetivoSitioPescaTX	12
	Taller	ObjetivoSitioTaller	13
Tipo	Playa	TipoSitioPlaya	14
	Manglar	TipoSitioManglar	15
	Muelle	TipoSitioMuelle	16
	Puerto	TipoSitioPuerto	17
	Estuario	TipoSitioEstuario	18
Seguridad	Seguro	SeguridadSeguro	19
	SegMedia	SeguridadSeguridadMedia	20
	PelMedia	SeguridadPeligrosidadMedia	21
	PelAlta	SeguridadPeligrosidadAlta	22
Nodriza	Nodriza	Nodrizas	23
Característica	Spublico	CaracteristicaSitioPublico	24
	PubFacilidad	CaracteristicaSitioPublicoFacilidad	25
	Privado	CaracteristicaSitioPrivado	26
Criterio	Historico	CriterioHistorico	27
	Google Earth	CriterioGoogleEarth	28
	Potencial	CriterioPotencial	29
Accesibilidad	Calle	AccesibilidadCalle	30
	TransPublico	AccesibilidadTransPublico	31
	TransMaritimo	AccesibilidadTransMaritimo	32
	Camino	AccesibilidadCamino	33
Zona Comercial	Marisqueria	ZonaComercialMarisqueria	34
	Restaurante	ZonaComercialRestaurante	35
	Hotel	ZonaComercialHotel	36
	PlanProcesadora	ZonaComercialPlanProc	37

Folder	ID	Name	Query ID
	AutoridadPesquera	ZonaComercialAutoridadPesq	38
Estacional	Estacional	SitioEstacional	39

Appendix 4

Layer creation
Option 1: RStudio

Each Excel file from each query was converted into a shapefile (.shp) using a script in RStudio (Appendix 7), which allows the LOIs to be sorted by certain characteristics and visualized in Google Earth. To achieve this, it is necessary to transfer the information from all the landing sites from the Access form into an Excel spreadsheet. Once the information has been edited and organized in Excel, the shapefile files needed to create the layers in Google Earth can be created.

When creating the Excel files that will generate the shapefiles, it should be noted that the information in the column headers will be displayed as a label for each point, so the following information will be used for each layer.

Table 1: Information contained in the generated Microsoft Excel sheets [10].

Total sites:	Layers:
IDSitio	IDSitio
NombreSitio	NombreSitio
Latitud	Latitud
Longitud	Longitud
TotalEmbArt	TotalEmbarArtesanal
TotalEmbNoArt	TotalEmbarNoArtesanal
Seguridad	Comentarios
SitioEstac	Fuente
Pesca (concatenado de TBD, SHK, SCF, otros)	
ArtePesca (concatenado de LL, GN, LHP, PS y TX)	
CaracteristicaSitio	
Comentario	
Fuente	

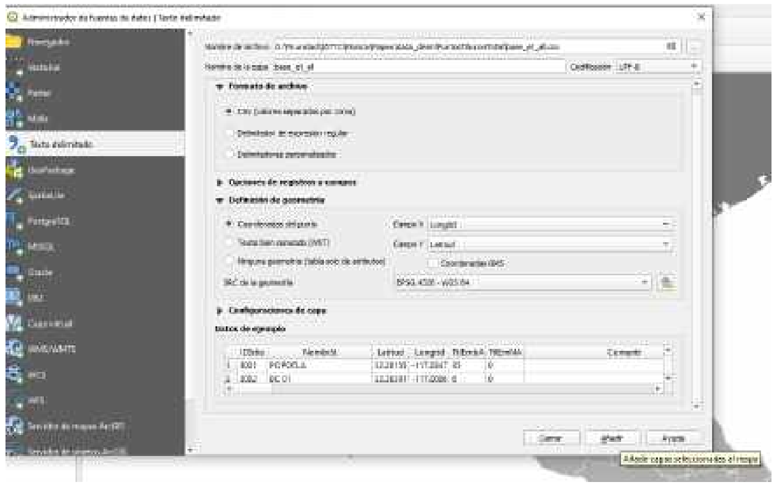
The shapefile was then opened in Google Earth and assigned an icon and color (Appendix 5, Table 1).

Option 2: QGis
The database created in Access is copied to Excel for processing and conversion to a shapefile. This format was chosen because it allows for easy transfer of information to Google Earth and the ability to add an information sheet to each LOI. In Excel, only the necessary information is retained and the database is saved as a .csv file. This file is imported into QGIS where the layer is saved as a shapefile with Google Earth compatible features (CRS: EPSG 4326-WGS 84). Additional layers with the characteristics of the LOIs can be created by creating .csv layers in Excel or by filtering the data in QGIS and creating individual layers and then saving them as shapefiles.

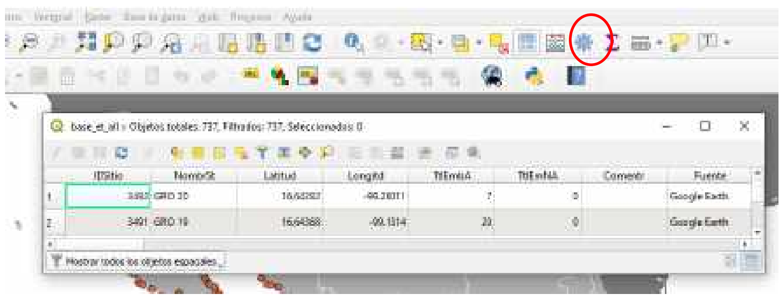
CREATING SHAPEFILE FILES IN QGIS

1. Import .csv file.
   Select Layer>Add Layer>Add delimited text layer>Add

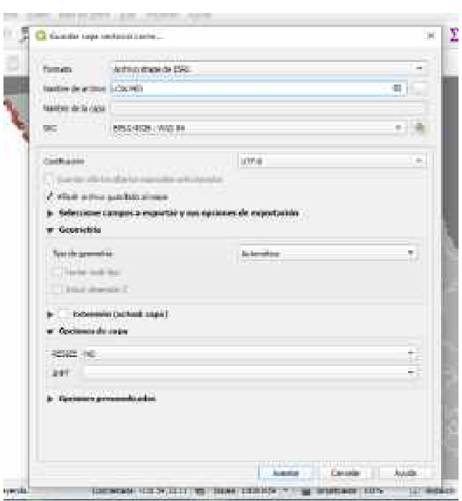
[10] A glossary of the information used to generate the labels for the total sites and layers is provided in Appendix 7.



2. Verify the information in the attributes table.



3. Save the file as a shapefile.
   Layer>Save as> ESRI shapefile



Appendix 5

Assigning special icons to each layer

Once the layers to be used in Google Earth were created, we proceeded to assign icons to each of them (Table 1), according to the information contained in each layer. As a result of this stage, which takes into account the specific characteristics of the artisanal fisheries of the three countries, the number of layers generated is as follows: a) Ecuador (37), b) Mexico (37) and c) Peru (36).

Table 1. List of generated layers and their associated icons.

Layer	Icon	Layer	Icon
AccesibilidadCalle		ObjetivoSitioPescaTX	
AccesibilidadCamino		ObjetivoSitioTaller	
AccesibilidadTransMaritimo		ObjetivoSitioTransporte	
AccesibilidadTransPublico		ObjetivoSitioTurismo	
CaracteristicaSitioPrivado		SeguridadPeligrosidadAlta	
CaracteristicaSitioPublico		SeguridadPeligrosidadMedia	
CaracteristicaSitioPublicoFacilidad		SeguridadSeguridadMedia	
CriterioGoogleEarth	site segment	SeguridadSeguro	
CriterioHistorico	site segment	SitioEstacional	
CriterioPotencial	site segment	TipoSitioEstuario	
Nodrizas		TipoSitioManglas	
ObjetivoSitioAtraque		TipoSitioMuelle	
ObjetivoSitioPescaGN		TipoSitioPlaya	
ObjetivoSitioPescaLHP		TipoSitioPuerto	
ObjetivoSitioPescaLL		ZonaComercialAutoridadPesq	
ObjetivoSitioPescaOtro		ZonaComercialHotel	
ObjetivoSitioPescaPS		ZonaComercialMarisqueria	
ObjetivoSitioPescaSCF		ZonaComercialPlanProc	
ObjetivoSitioPescaSHK		ZonaComercialRestaurante	
ObjetivoSitioPescaTBD		SitiosTotales	

Appendix 6

Creating a KMZ file

Select the shapefile (layer) you want to display, which has been dragged onto the Google Earth map. This procedure allows you to create a template (Figure 1): a) a pop-up message will appear, click on "Yes"; b) then a "Style Template Options" window will appear, select the "Create new template" option and then "OK".

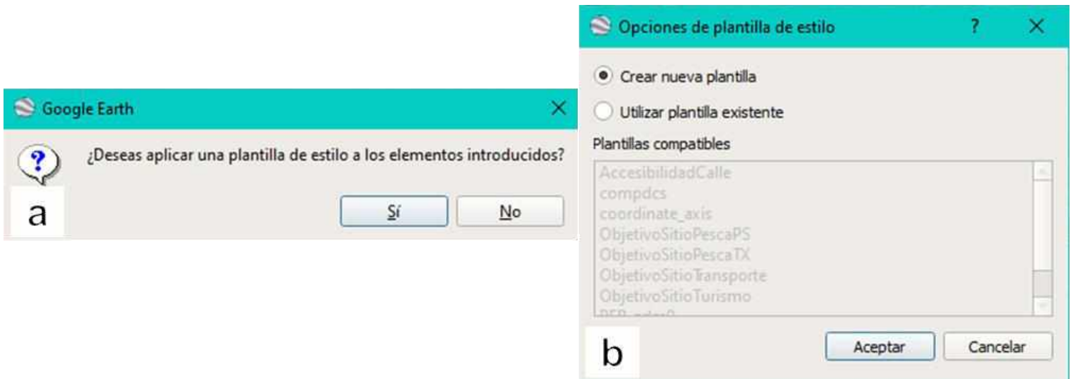


Figure 1. a) First message displayed when incorporating the shapefile into Google Earth. b) Style Template Options window.

Once the new template has been created, a Style Template Settings window will appear. Click on the "Name" tab and in the "Set name field" option, specify the attribute you want to display. In our case, we chose IDsitio (site code). Accept and save the file with a ".kst" extension (this will allow the layer to be displayed in the map viewer). This process is repeated for each of the generated layers (Figure 2).

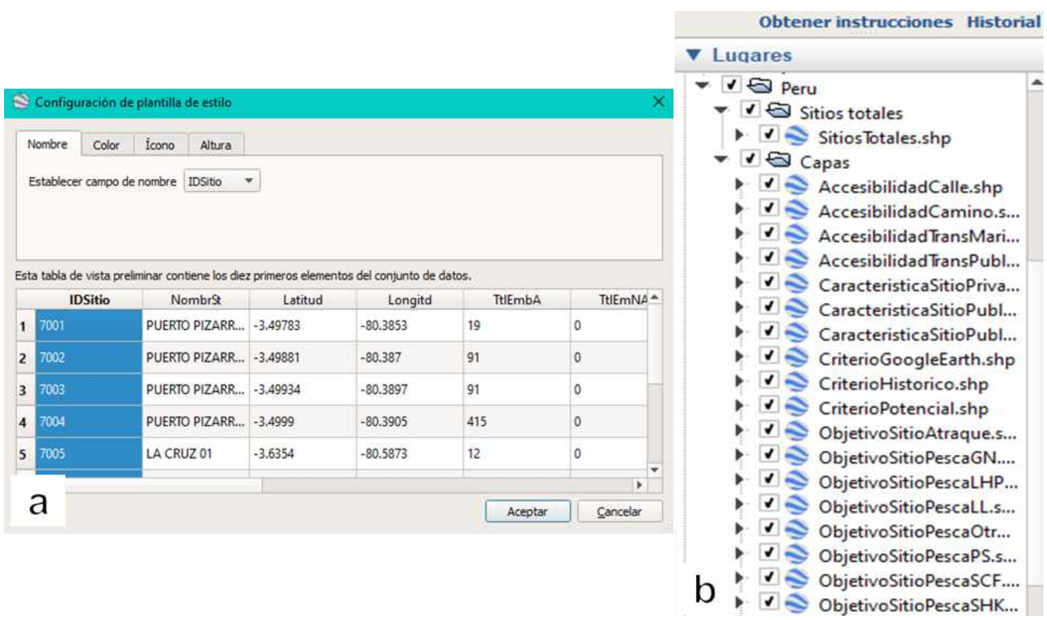


Figure 2. a) Style Template Settings window. b) View of the layers created and organized in their corresponding folders.

Afterwards, the icons are changed according to Table 1. To do this, follow these steps (Figure 3): a) right-click on the name of the layer where the icon will be changed and then click on Properties; b) select the "Style, Color" tab and then "Share Style", select the option to change the icons (found to the right of the field where the name of the layer is displayed); c) select the icon corresponding to the layer (Table 1), click and accept; d) if it is a new icon, click on "Add Custom Icon", search for the location of the icon, select and accept (it will appear with the other pre-designed icons).

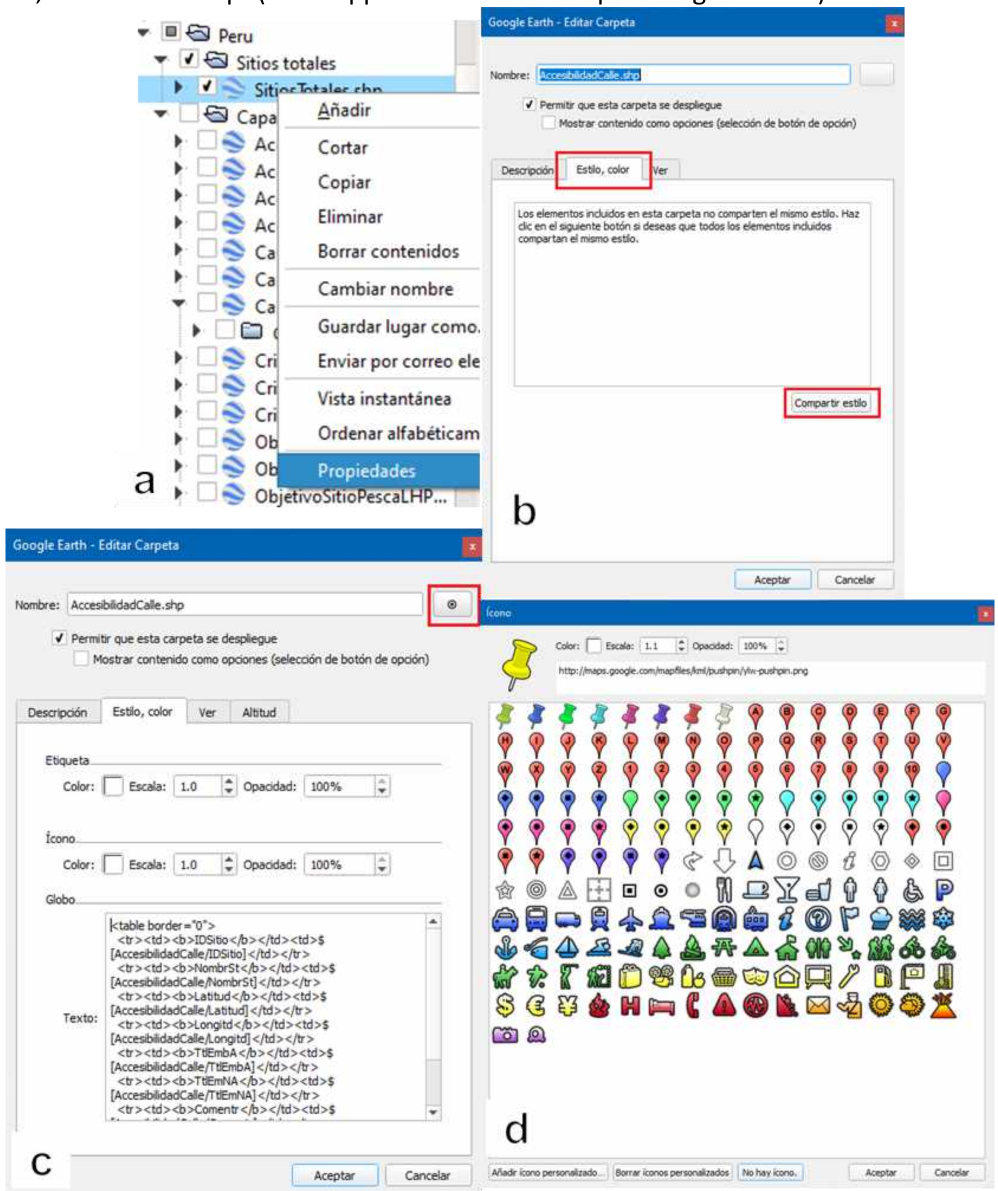


Figure 3. Steps to change icons: a) Activate "Layer Properties"; b) Properties window; c) Properties window with option to change icons; d) Properties window with option to change icons.

When all the layers have their corresponding icons, save the changes with a .kmz extension. To do this, right-click on the folder containing the .kst files, select "Save Plas As..." and browse to the location where you want to save the .kmz (*.kmz) file (Figure 4).

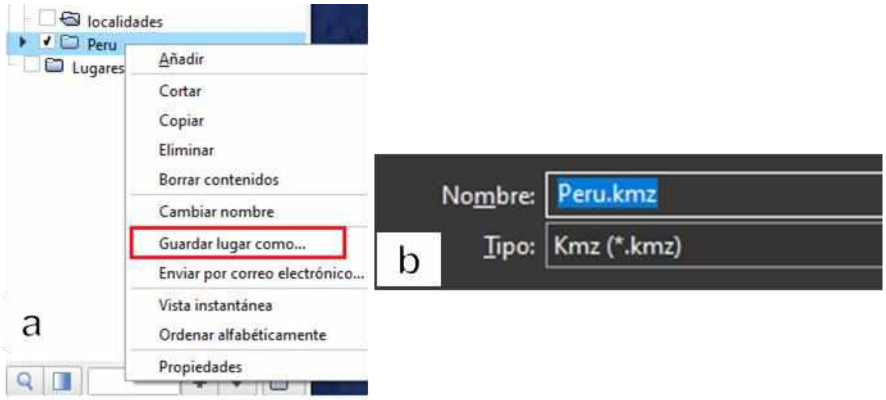


Figure 4. 1) "Save Place As" option. 2) How to save the .kmz file.

Appendix 7

Labels glossary

1. Layers

IDSitio: Site ID
NombrSt: Name of the site
Latitud: Latitude
Longitd: Longitude
TtlEmbA: Total number of artisanal vessels
TtlEmNA: Total number of non-artisanal vessels
Comentr: Comments
Fuente: Source

2. Total sites

IDSitio: Site ID
NombrSt: Name of the site
Latitud: Latitude
Longitd: Longitude
TtlEmbA: Total number of artisanal vessels
TtlEmNA: Total number of non-artisanal vessels
Segurdd: Safety
StEstcn: Seasonal site
Pesca: Fishing
ArtePsc: Fishing gear
CrctrsS: Site characteristics
Comentr: Comments
Fuente: Source

Creating shapefiles using RStudio

#><>><>><>><>><>><>><>><>><>><>><>><>><>><>><>><>><>><>><>><>><>><>><>><
Install R, link: https://cran.r-project.org/bin/windows/base/old/, we recommend version 4.3.3 (click), then download R-4.3.3-win.exe (click), run to install.
Once R is installed, download RTools, link: https://cran.r-project.org/bin/windows/Rtools/, if you have installed R version 4.3.3, then select the version RTools 4.3 (click), then download Rtools43 installer (click), run to install.
Then download RStudio, https://posit.co/download/rstudio-desktop/, select option "2:Install RStudio", and install it when the download is complete.
Open RStudio and install the following packages (copy the following lines to the console, run once):
install.packages("readxl")
install.packages("sp")
install.packages("sf")
install.packages("raster")
#Para instalar paquete "rgdal"
Install.packages("https://cran.r-project.org/src/contrib/Archive/rgdal/rgdal_1.6-7.tar.gz", type = "source", repos = NULL)

```
#><>><>><>><>><>><>><>><>><>><>><>><>><>><>><>><>><>><>><>><>><>><>
```

Script to create a shapefile

```
library(readxl)
library(sp)
library(sf)
library(raster)
library(rgdal)

# Directory
Dir0 <- "E:/Mapa/SitiosTotales"

# Load Excel file
coordenadas = readxl::read_xlsx(file.path(Dir0, "SitiosTotales.xlsx"), sheet = "Hoja1")

# Create a 'SpatialPointsDataFrame' type object and convert the file into an sf type object
coordenadas <- SpatialPointsDataFrame(coordenadas[,c("Longitud","Latitud")],
coordenadas,proj4string = CRS("+init=epsg:4326"))
coordenadas<- st_as_sf(coordenadas)
class(coordenadas)

# Graphs
plot(coordenadas)
mapview::mapview(st_transform(coordenadas,crs=4326))

# Save file in shapefile format
dir.create(file.path(Dir0,'SitiosTotales'))
Dir1 <-  paste(Dir0,'/','SitiosTotales',sep="")
st_write(coordenadas, paste(Dir1,'/','SitiosTotales','.shp',sep=""))
```

Debido al gran número de archivos Excel creados, se elaboró una lista con sus nombres (Nombres.xlsx). La cual se cargó en RStudio para convertirlos en formato shapefile y guardarlos de forma automatizada.

```
# Directory
Dir <- "E:/Mapa/Capas"

# Load Excel file
base <- readxl::read_xlsx(file.path (Dir, "Nombres.xlsx"), sheet = "Hoja1")
nam <- base$Nombres

 # Bucle to save files in shapefile format
for(j in 1:length(nam)){
  filename = paste(nam[j],'.xlsx',sep="")
  coordenadas <- readxl::read_xlsx(file.path(Dir,filename), sheet = "Hoja1")
  coordenadas <- SpatialPointsDataFrame(coordenadas[,c("Longitud","Latitud")],
  coordenadas,proj4string = CRS("+init=epsg:4326"))
  coordenadas<- st_as_sf(coordenadas)
```

```
dir.create(file.path(Dir,nam[j]))
Dir1 <-  paste(Dir,'/',nam[j],sep="")
st_write(coordenadas, paste(Dir1,'/',nam[j],'.shp',sep=""))
```

Clarke, S.C., Langley, A., Lennert-Cody, C., Aires-Da-Silva, A., Maunder, M., 2018. Pacific-wide silky shark (*Carcharhinus falciformis*) stock status assessment. *14th Regular Session of the Scientific Committee of the Western and Central Pacific Fisheries Commission, 8–16 August 2018, Busan, Republic of Korea. Document WCPFC-SC14-2018/SA-WP-08*.

Inter-American Tropical Tuna Commission (Iattc), 2014. A collaborative attempt to conduct a stock assessment for the silky shark in the eastern Pacific Ocean (1993-2010): update report. *5th Meeting of the Scientific Advisory Committee of the IATTC, 12-16 May 2014, La Jolla, California, USA. Document SAC-05 INF-F*.