



# Analysis of incidental catches of blue shark (*Prionace glauca*) in industrial longline vessels targeting swordfish (*Xiphias gladius*) in the Tropical Eastern Pacific Ocean, 2022-2025

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**Authors:** Guillermo Moran Borja<sup>1</sup>, Leonel Caicedo<sup>1</sup>, Juan Carlos Quiroz<sup>2</sup> and Guillermo Moran Velasquez<sup>3</sup>

**Abstract:** The relative catch composition of the industrial longline fishery between 2022 and 2025 is clearly dominated by swordfish (70%), with sharks representing a relevant secondary component (28%). Among sharks, the abundance of blue shark has made it possible to compile sufficient fisheries data to conduct a characterization analysis. Manta rays, rays, and other large pelagic fishes each contribute 1%, while sea turtles, seabirds, and other fishes show practically negligible proportions. Given the significant role of sharks, particularly blue shark (*Prionace glauca*), it is recommended to prioritize research on this species to determine its population status in the Eastern Pacific Ocean, increase human or electronic monitoring coverage, and conduct stratified analyses by gear, season, and area to evaluate the spatial and temporal persistence of these patterns, while also maintaining specific monitoring of vulnerable species despite their low proportions.

## Introduction

In Ecuador, the longline fishery is operated by both artisanal and industrial vessels. Some industrial longline vessels over 24 meters in length are built with steel hulls, are equipped to operate surface pelagic longline gear, and are mainly oriented toward the capture of large pelagic fishes. In the context of the fishery targeting swordfish (*Xiphias gladius*), blue shark (*Prionace glauca*) is caught incidentally and forms part of the accompanying fauna associated with fishing effort. In this context, a group of fishing companies<sup>1</sup> jointly implements a Fishery Improvement Project (FIP) known as FIP SWORDFISH.EC, directing its actions toward compliance with the Marine Stewardship Council (MSC) certification standard for the swordfish (*Xiphias gladius*) fishery. As part of this process, systematized information is available on blue shark (*Prionace glauca*) catches in steel-hulled industrial vessels over 24 meters in length, with human observers on board to collect data that allow the analysis of fishing operations for both target species and incidental catch species.



*Image 1. Steel-hulled industrial vessel over 24 meters in length.*

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The blue shark is a pelagic species that inhabits temperate and tropical waters of the oceans, mainly in productive oceanic environments and convergence zones (Nakano & Stevens, 2008; Queiroz et al., 2019). It grows faster than other pelagic elasmobranchs, reaching sexual maturity at 4-6 years in males and 5-7 years in females (Nakano & Stevens, 2008). In the Pacific, size at sexual maturity (L50) is estimated at 180-200 cm for males and 210-230 cm for females (Bustamante & Bennett, 2013). It has high fecundity, with litters of about 30 pups, a gestation period of 9 to 12 months, and total lengths exceeding 400 cm. Its diet consists mainly of pelagic fishes and cephalopods, such as squids, in tropical and subtropical oceanic ecosystems (Nakano & Stevens, 2008; Vedor et al., 2021).

This document presents a descriptive analysis of fishing operations and incidental catches of blue shark (*Prionace glauca*), covering the period from July 2022 to December 2025. Globally, the scarcity of fisheries data and information for this species makes the information collected under the FIP SWORDFISH.EC project relevant, and it constitutes a fundamental input for characterizing the fishing effort and fishing dynamics of industrial vessels that catch blue shark in the Eastern Pacific Ocean.

### **Description of fishing operations**

The data were collected between 2022 and 2025 through a private onboard observer program, whose annual coverage reached 100% of the trips made by industrial longline vessels. During this period, the program included

between four and two vessels, which varied according to the years of operation and participation within the FIP initiative.

Year	Vessel 1	Vessel 2	Vessel 3	Vessel 4	Total
2022	2	2	1		5
2023	3	4	2		9
2024	2	3		2	7
2025	3	2			5
<b>Total</b>	<b>10</b>	<b>11</b>	<b>3</b>	<b>2</b>	<b>26</b>

Table 1. Onboard observers by year.

Surface longline fishing operations generally begin during the afternoon and night with the setting operation, which lasts between 8 and 10 hours. The fishing gear is deployed from the stern using a system that regulates the tension of the mainline according to vessel speed, which influences fishing depth and catch selectivity. Hauling of the longline begins before dawn and is normally carried out on the starboard side using a hydraulic hauler.

The fishing gear consists of a polyamide monofilament mainline measuring between 60 and 75 nautical miles, from which up to 3,000 branchlines may hang, divided into three sections of different diameters and lengths. The branchlines end in a baited J-type hook No. 10. The distance between hooks ranges from 36 to 76 meters, and every four to six branchlines a floatline with a buoy is attached. In addition, radio buoys are placed every 2.5 to 3 nautical miles to monitor the fishing gear. The hooks operate at depths between 30 and 80 meters.

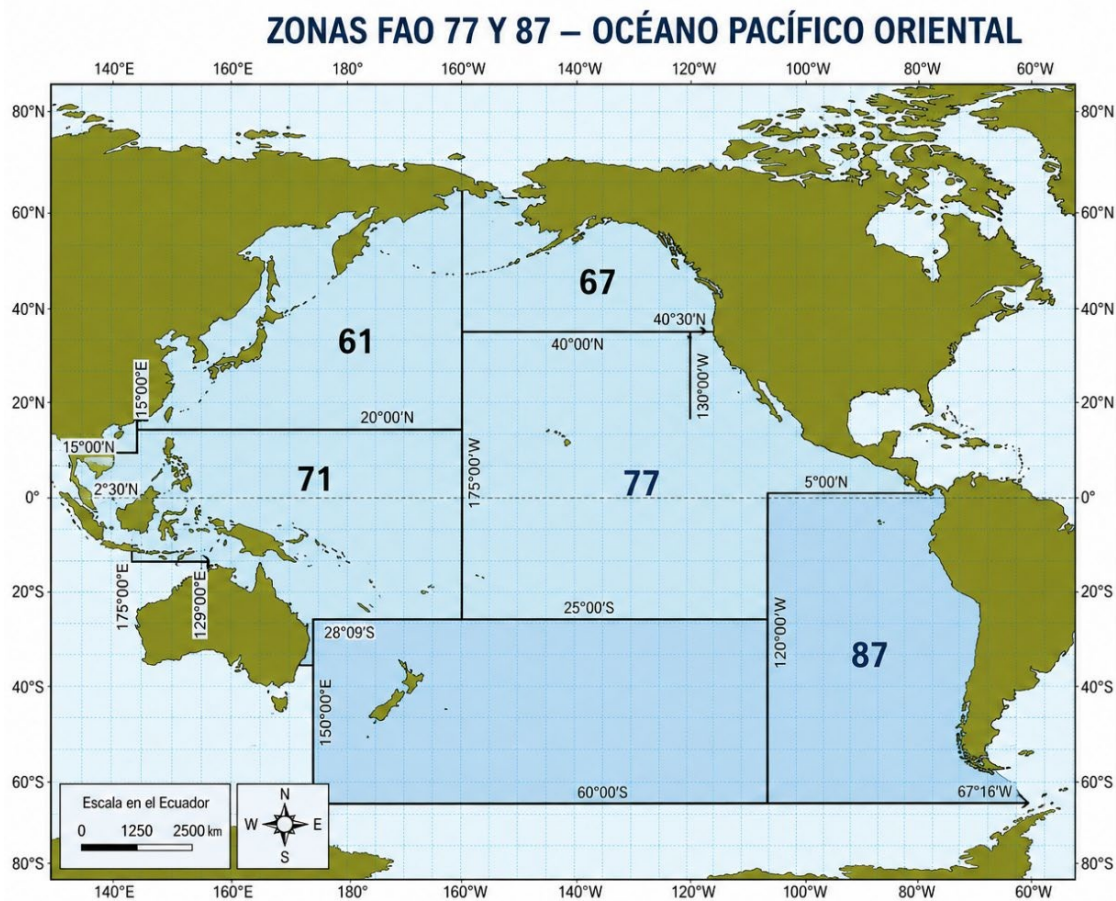


Image 2. Fishing areas delimited by FAO. Source: FAO.



Fishing effort is concentrated mainly in the tropical equatorial band of the eastern Pacific Ocean. In general terms, the spatial distribution shows that fishing activity takes place in specific operating zones, as well as in more distant areas, mainly within the areas corresponding to FAO areas 87 and 77.

### Target catch vs. incidental catch

The proportion of species and taxonomic groups caught during the 2022-2025 period is shown in Figure 1. Swordfish accounts for the vast majority of recorded catches, at 70%, followed by sharks, at 28%. Manta rays/rays and large pelagic fishes each represent a very small portion (1% each). Sea turtles and other fishes effectively show 0% in the proportions presented. These proportions indicate a catch composition strongly oriented toward the target species, dominated by a single species (swordfish), followed by the shark group as incidental catch.

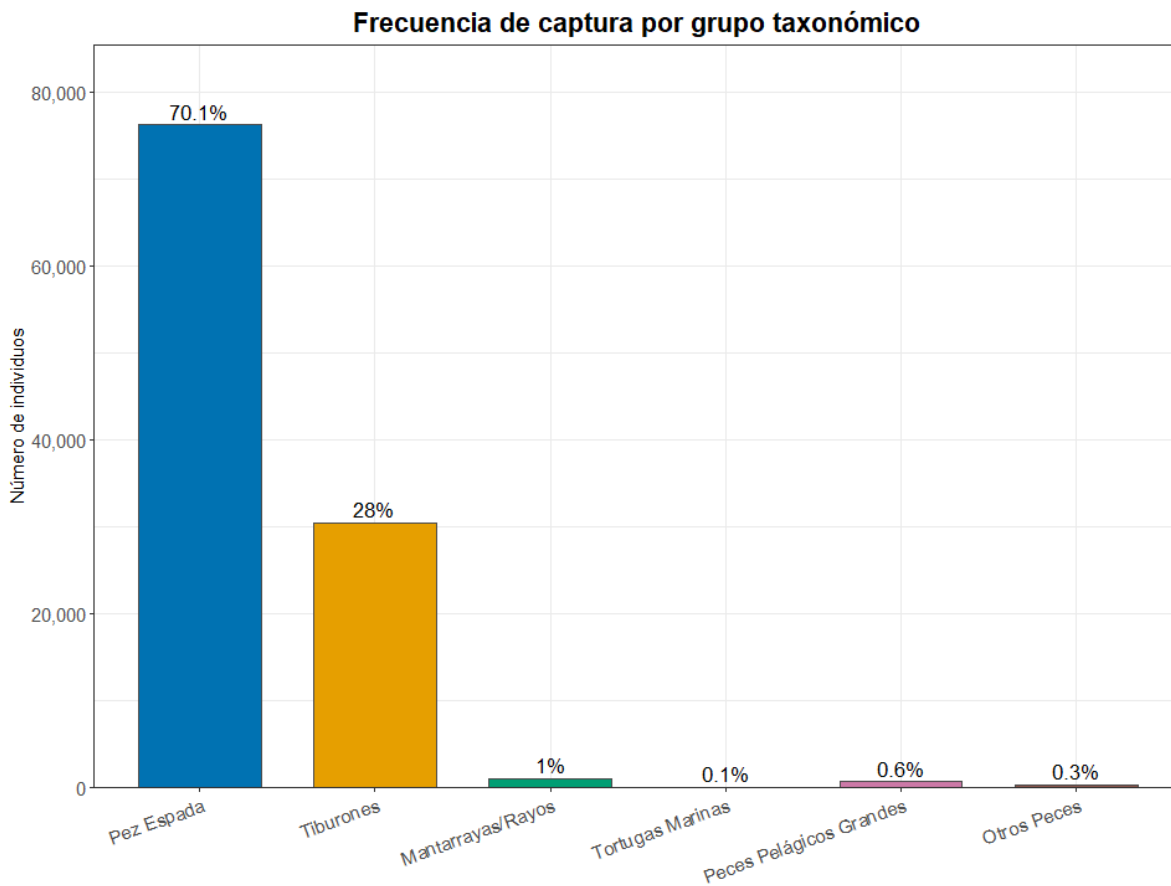


Figure 1. Composition of target catch compared with other taxonomic groups, 2022-2025 period.

### Incidental catches of sharks

In all years analyzed, the blue shark (*Prionace glauca*) was the most relevant species (54.84% of total sharks), representing the largest proportion of interactions within the elasmobranch group (Figure 2). The frequency of interaction with this species was highest in 2023, followed by 2024; it was lower in 2022 and 2025. The silky shark (*Carcharhinus falciformis*) (16.73%) and the pelagic thresher shark (*Alopias pelagicus*) (16.28%) also showed increases in 2023 and 2024 compared with the rest of the period (Figure 2). Other species - such as the spotted thresher shark, bigeye thresher shark, oceanic whitetip shark, hammerhead shark, Galapagos shark, and

shortfin mako - recorded lower frequencies of interaction and more sporadic occurrences (12.15%). It is clarified that the term "interaction" includes individuals that came into contact with the hook, whether they were caught, retained for commercialization, or returned to the sea in the case of prohibited species.

### Composición de la captura incidental de tiburones

Totales y porcentajes por especie respecto al total registrado

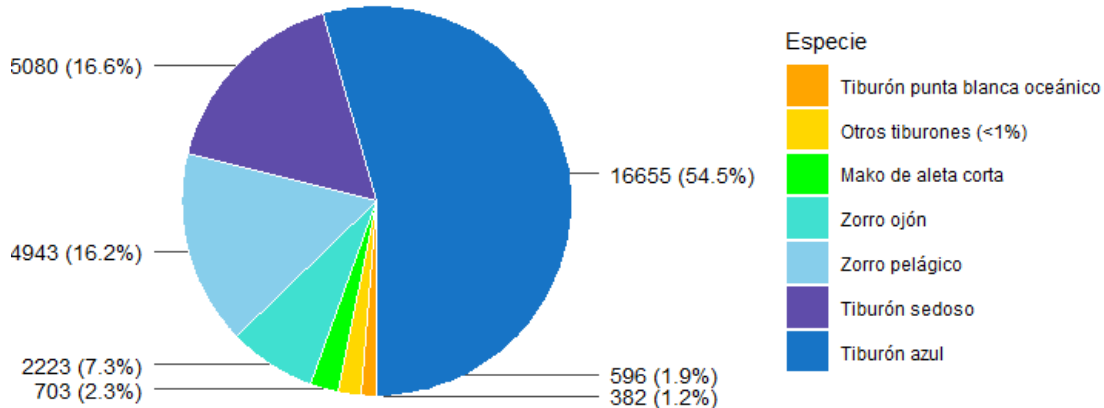


Figure 2. Shark interactions, 2022-2025.

### Blue shark (*Prionace glauca*)

In particular, based on blue shark catches recorded during the 2022-2025 period, interannual variation is observed both in sex composition and in catch levels expressed as number of individuals (Figure 3). During 2022 and 2023, females predominated in the catch, and 2023 recorded the highest total number of individuals caught during the monitoring years. In contrast, in 2024 there was a shift in sex composition, with males predominating and a slight decrease in total catch relative to the previous year. By 2025, catches showed a reduction compared with 2023 and 2024, maintaining a relatively balanced proportion between males and females, although with a slight dominance of females.

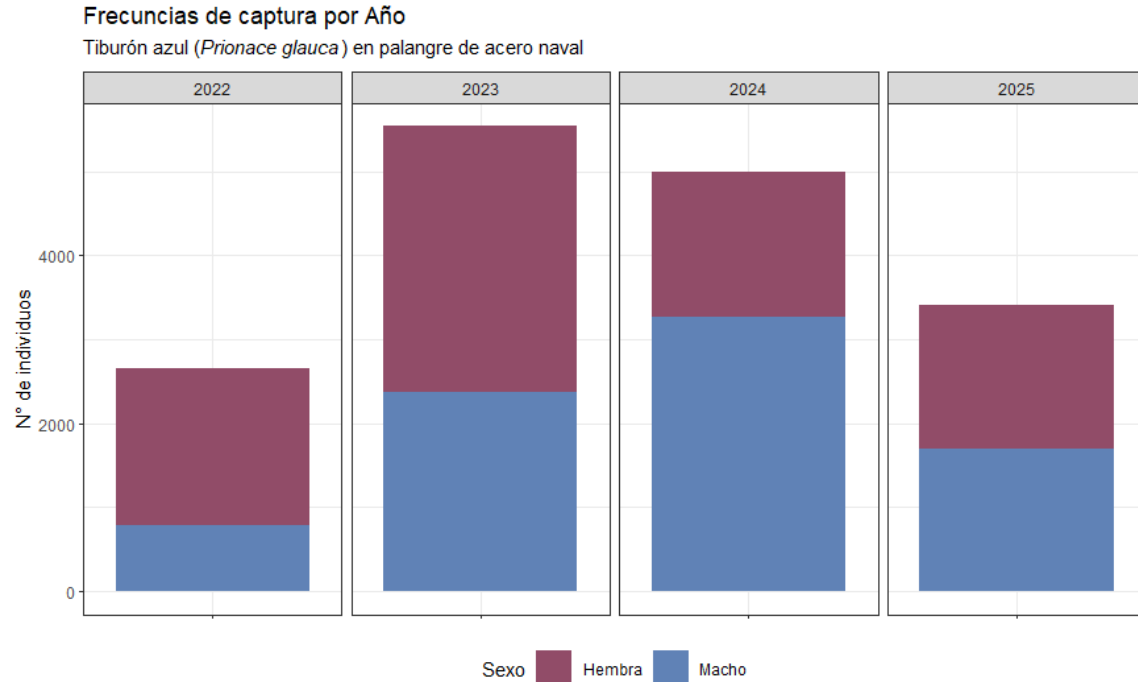


Figure 3. Catches by year and sex from 2022 to 2025.

The size-frequency distribution of blue shark shows that catches were dominated by individuals between 180 and 250 cm in length, with a unimodal pattern and a greater concentration of frequencies in the 210 to 230 cm size classes (Figure 4). Females showed consistently higher frequencies than males, with maximum values in intervals near 220 cm. Males, on the other hand, had a higher minimum size range and a distribution more concentrated in intermediate sizes, mainly between 190 and 230 cm.

During 2023 and 2024, the highest average catch frequencies were recorded, together with a broader size distribution, suggesting a greater presence of large individuals in the fishery. In contrast, in 2022 and 2025 lower relative frequencies were observed, although similar distribution patterns between sexes were maintained.

### Frecuencias de talla por año y sexo

Tiburón azul (*Prionace glauca*) en palangre de acero naval

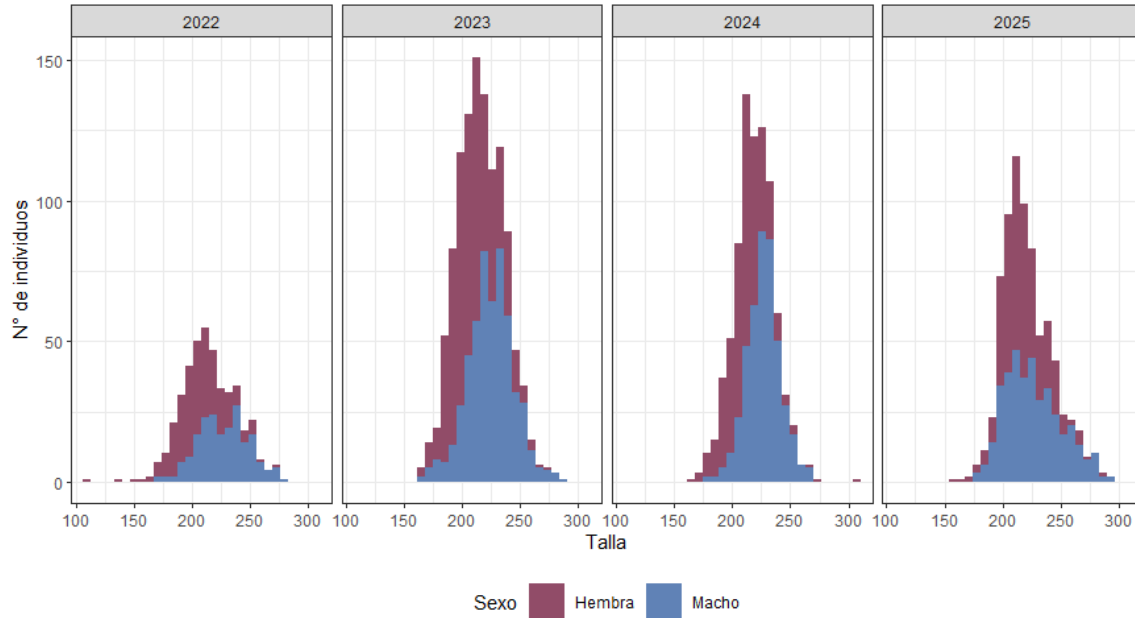


Figure 4. Size frequency of both sexes, 2022 to 2025.

The spatial distribution of blue shark catches in 1 x 1 degree quadrants revealed a concentration in the equatorial band, approximately between 5°N and 10°S, and between 120°W and 90°W (Figure 5).

The highest-intensity fishing activity was centered in areas near 105°W-95°W, where quadrants with catches exceeding 60 individuals were detected. In contrast, regions located farther south and west showed a lower catch rate and a more dispersed distribution.

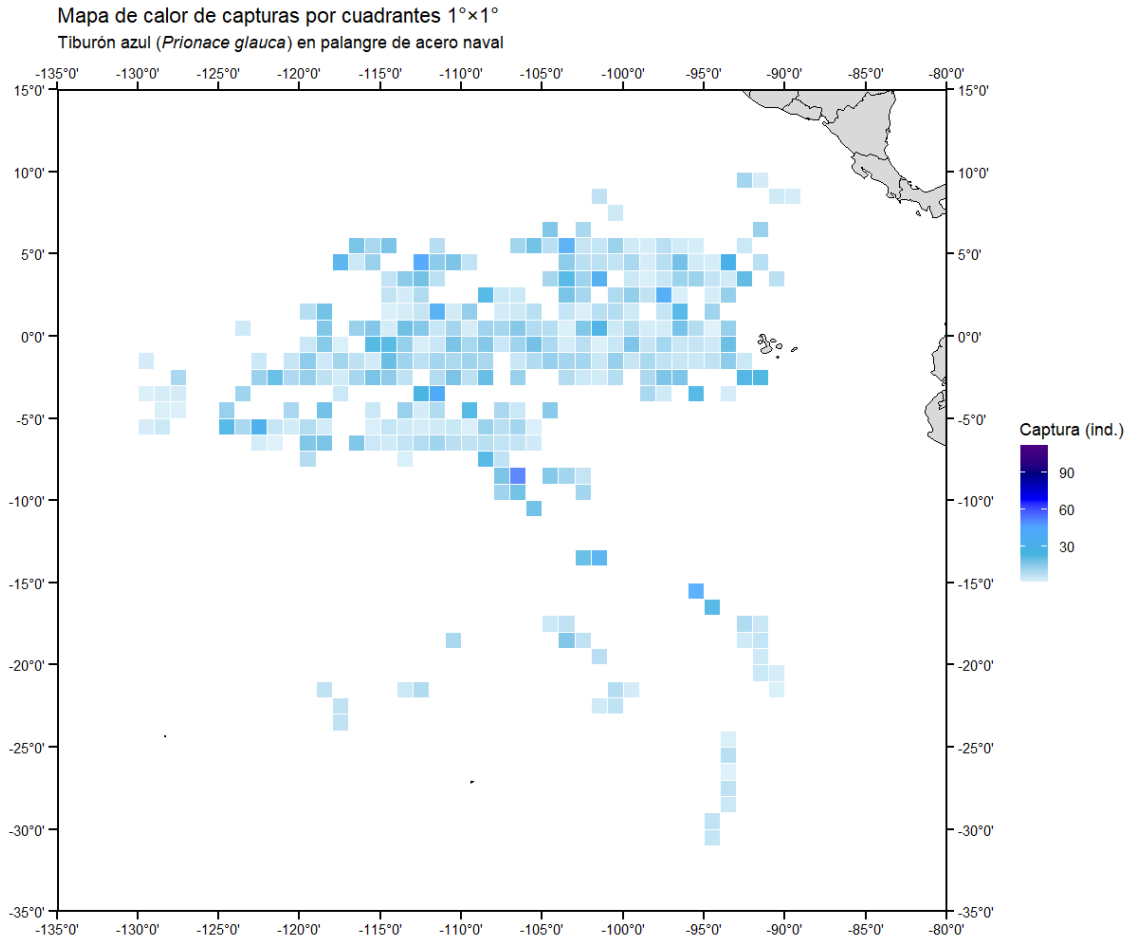


Figure 5. Cumulative spatial distribution, 2022 to 2025.

The monthly variation in CPUE (catches per 1,000 hooks) of blue shark recorded by the longline fleet between 2022 and 2025 shows marked temporal variability, both among years and among months, suggesting fluctuations in the relative abundance of the species within the fishing area. In 2022, CPUE values increased progressively toward the last quarter, reaching maximum values close to 9 catches per 1,000 hooks between October and November. In 2023, CPUE showed moderate oscillations, with minimum values around 2 catches/1,000 hooks and peaks above 6 catches/1,000 hooks toward the end of the year. In 2024, the highest values of the entire time series were recorded, with maximum values above 10 catches per 1,000 hooks in November and December, in addition to several significant increases throughout the year. In contrast, 2025 showed a more stable and moderate pattern, with values predominantly between 2 and 6 catches per 1,000 hooks, although with a notable peak at the beginning of the year.

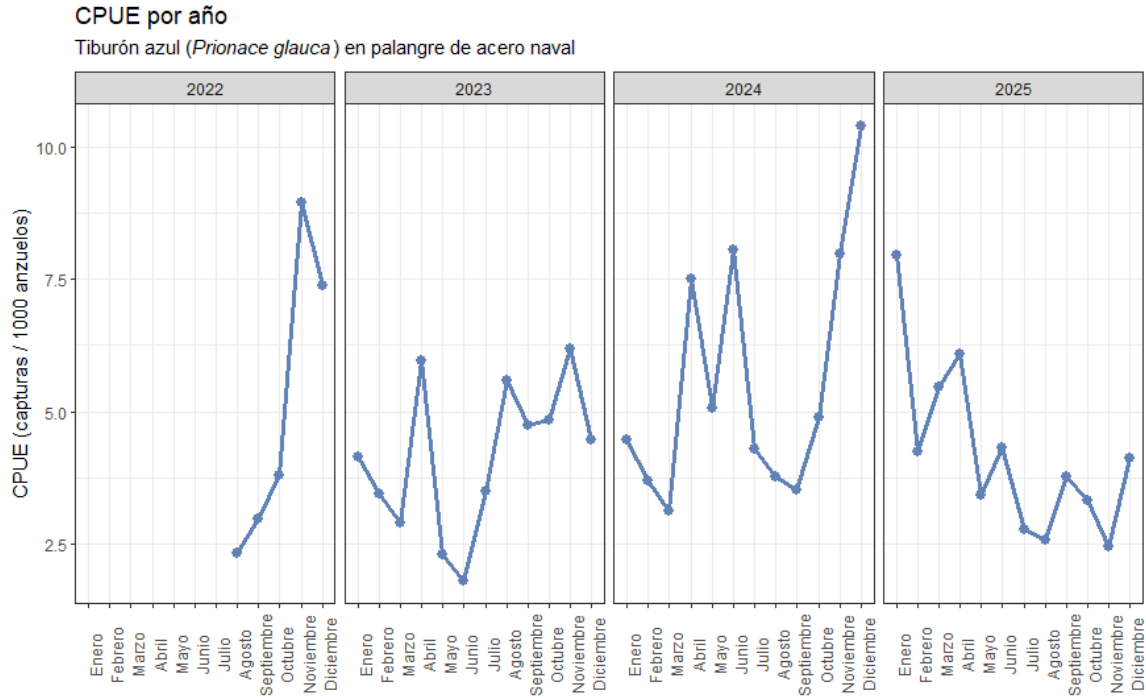


Figure 6. Monthly CPUE from 2022 to 2025.

### Spatial dynamics of CPUE

The monthly distribution of CPUE (individuals caught per 1,000 hooks) for blue shark during 2022 showed its greatest concentration in the equatorial region of the Eastern Pacific, between 5°N and 10°S (Figure 7). In August and September, moderate CPUE values were observed, with a dispersed distribution, mainly between 115°W and 95°W. In October, activity expanded toward more eastern and northern areas, maintaining intermediate values in most quadrants.

The maximum CPUE values occurred between November and December, possibly suggesting greater aggregation and relative abundance toward the end of the year. In November, quadrants between 95°W and 90°W showed high values, and in December the maximum CPUE values were reached, with some quadrants recording more than 20 catches per 1,000 hooks.

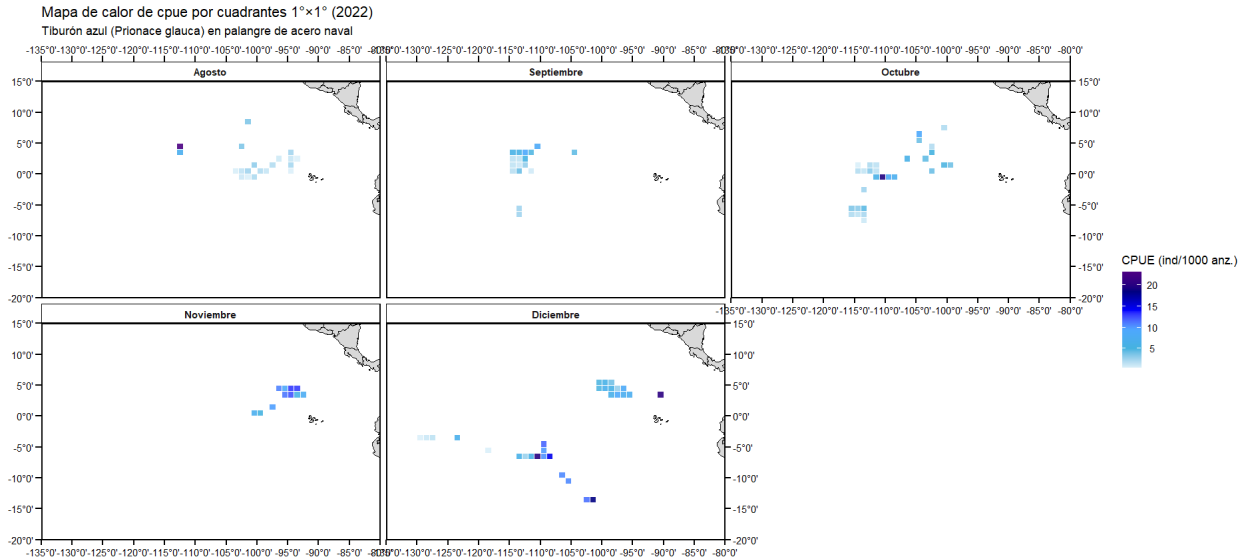


Figure 7. Spatial distribution of CPUE in 2022.

The monthly spatial distribution of CPUE (catches per 1,000 hooks) for blue shark in 2023 showed a clear concentration in equatorial oceanic waters of the eastern Pacific, mainly between 10°N and 10°S, with greater incidence between 110°W and 90°W (Figure 8). Between January and April, CPUE showed moderate values and a relatively dispersed distribution, although some high-CPUE quadrants were identified near the equatorial region. From May to July, catches showed lower values and a smaller spatial extent, suggesting a temporary reduction in relative abundance. From August onward, and more clearly in September and October, an increase in CPUE intensity and spatial extent was observed, with a greater concentration of positive quadrants near 100°W-95°W. The highest values were recorded in January and September, with maxima exceeding 40 catches per 1,000 hooks in some isolated quadrants.

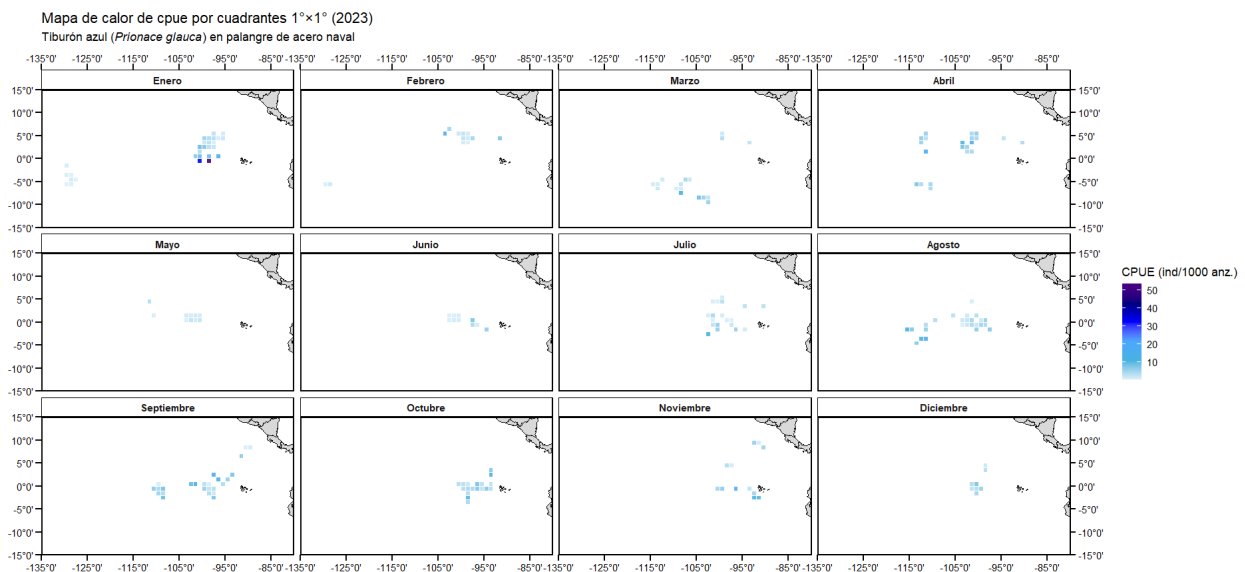


Figure 8. Spatial distribution of CPUE in 2023.

The monthly distribution of CPUE (catches per 1,000 hooks) for blue shark in 2024 showed a main concentration in equatorial waters of the eastern Pacific, between 5°N and 10°S, and 120°W and 95°W (Figure 9). Between

January and April, CPUE showed moderate values and a restricted distribution, with some higher-intensity quadrants between 110°W and 100°W. From May to August, a spatial expansion of catches was observed, with continuous presence of positive quadrants and intermediate CPUE values. The highest values were recorded in October, November, and especially December, with intensities above 20 catches per 1,000 hooks, mainly between 115°W and 105°W. During this period, greater spatial aggregation of the species and an expansion of the catch distribution area were also evident.

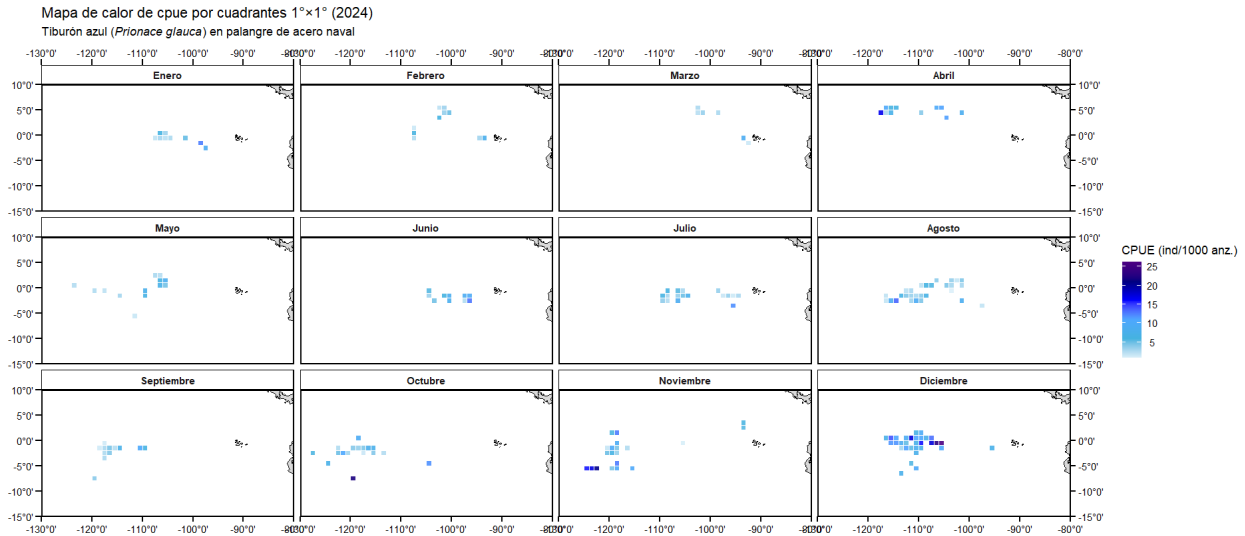


Figure 9. Spatial distribution of CPUE in 2024.

The monthly spatial distribution of CPUE (catches per 1,000 hooks) for blue shark during 2025 shows that catches were concentrated mainly in oceanic waters of the eastern Pacific, between approximately 10°N and 30°S, indicating broader spatial coverage than in previous years (Figure 10). During the first months of the year (January-April), CPUE showed moderate to high values, with important records both in the equatorial region and in more southern areas. In January and March, some quadrants showed values above 20 catches/1,000 hooks, while in April a greater concentration of records was observed in the equatorial band. Between May and August, fishing activity remained mainly in the equatorial region, with moderate CPUE values and a relatively dispersed distribution. Subsequently, between September and December, a spatial expansion of catches was again observed, including records in more eastern and southern areas, although generally with moderate intensities.

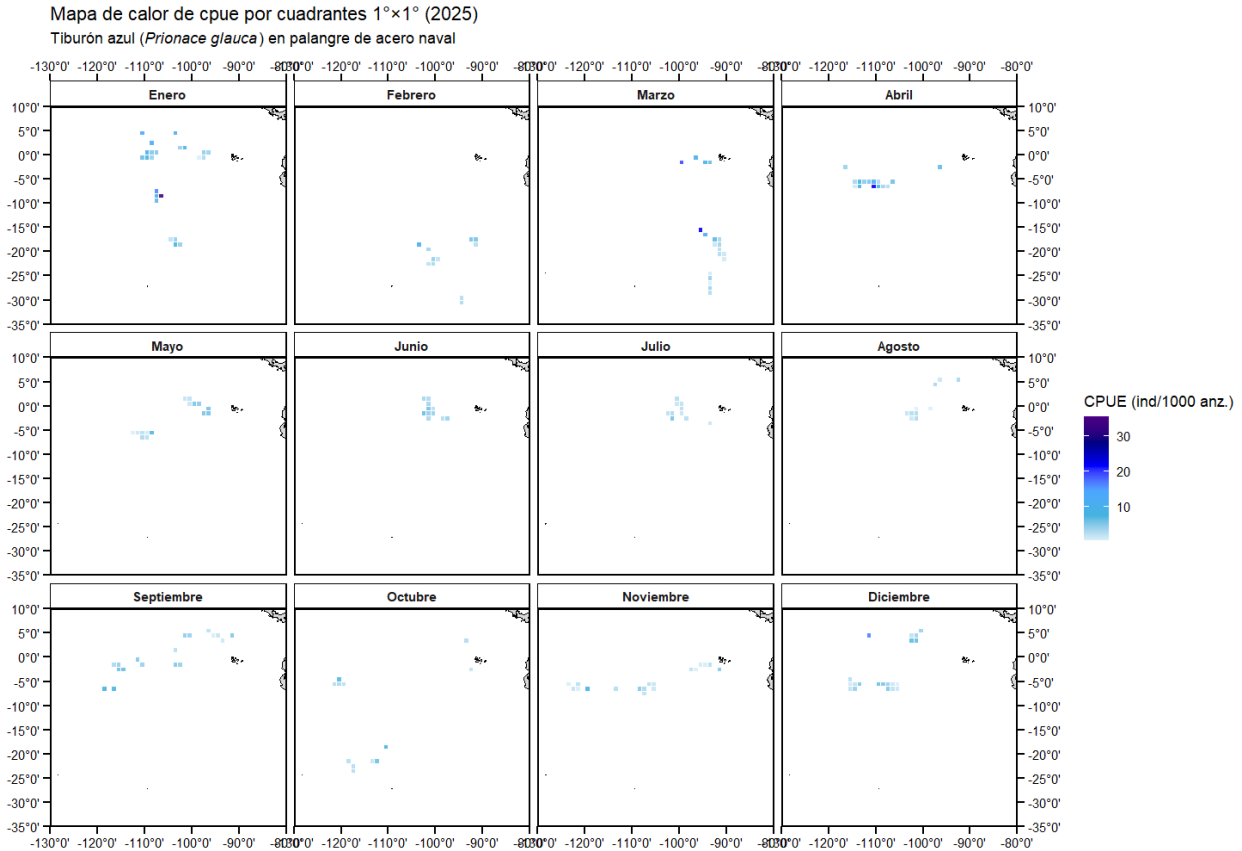


Figure 10. Spatial distribution of CPUE during 2025.

## Discussion

The results obtained in this study can be linked to recent research on the distribution and relative abundance of blue shark in the Pacific Ocean, particularly because the database generated by FIP Swordfish.ec contains variables comparable with other scientific studies: catch, effort, CPUE, geographic location, sex, and size. In the present document, the industrial longline fishery targeting swordfish shows a composition dominated by swordfish, while sharks constitute the second most important group, with blue shark as the predominant species among the elasmobranchs recorded. This information is consistent with the pattern reported in other Pacific longline fisheries, where *Prionace glauca* appears as one of the most frequent shark species due to its wide oceanic distribution, mobility, and association with productive pelagic environments (Nakano & Stevens, 2008; Peatman & Nicol, 2025).

A particularly relevant study for comparing these results is that of Li et al. (2023), who analyzed blue shark distribution in the Pacific using observer data from the Chinese longline fleet between 2011 and 2014, including biological, spatial, and environmental variables. That study applied generalized additive models to evaluate the relationship between shark length, sex, latitude, longitude, month, and sea surface temperature, finding that length was significantly influenced by geographic location, sex, and sea surface temperature. This approach is directly applicable to the FIP Swordfish.ec dataset, as it would make it possible to evaluate whether the size distribution observed in the Tropical Eastern Pacific responds to spatial patterns, sex-related differences, or environmental conditions, and not only to fleet operations.



The spatial distribution observed in these vessels, with a greater concentration of catches in the equatorial band of the Eastern Pacific, between approximately 120°W and 90°W and between 5°N and 10°S, can also be discussed in light of debates on blue shark population structure in the Pacific. Li et al. (2023) note that the population structure of the species in the Pacific remains uncertain, although they recommend, under a precautionary principle, managing it as two independent populations to ensure sustainable use. This consideration is relevant to the data provided in this study because they come from an equatorial zone that could represent an area of transition, connectivity, temporary availability, or mixing between North and South Pacific population components. Therefore, the information generated may be especially valuable for reducing knowledge gaps in an area where biological and fisheries evidence remains limited.

The size structure recorded in the document, dominated by individuals between 180 and 250 cm total length, can be compared with studies from the southeastern Pacific such as Bustamante & Bennett (2013), who analyzed reproductive and fishery aspects of blue shark and shortfin mako in waters off Chile. This comparison is useful because it allows discussion of whether this fleet primarily interacts with juvenile or adult individuals. Considering that the size at sexual maturity reported for the Pacific is approximately 180-200 cm in males and 210-230 cm in females, the information generated by the FIP Swordfish.ec observer program suggests that a significant proportion of the catch is near or above sexual maturity, although it would be necessary to formally estimate the proportion of immature and mature individuals by sex, year, and fishing area.

The monthly and interannual variability in CPUE observed between 2022 and 2025 should be interpreted by considering not only potential changes in relative abundance, but also environmental, operational, and availability-related variations of the species. Vedor et al. (2021) demonstrated that the daily vertical movements of blue shark and its vulnerability to fishing may vary with water temperature, productivity, and lunar illumination, increasing its exposure to hooks under certain conditions. Complementarily, Queiroz et al. (2019) showed that there is significant overlap between the spatial use of pelagic sharks and longline fishing effort. In this context, the nominal CPUE presented here constitutes a first approximation, but we expect to move toward a standardized CPUE that incorporates variables such as year, month, area, vessel, number of hooks, effective fishing depth, bait, sea surface temperature, productivity, and oceanographic conditions.

Finally, the data generated by this study should be strategically linked at the regional level promoted by the IATTC in cooperation with participating countries in this area for the population assessment of blue shark in the Eastern Pacific. IATTC Project H.7.d aims to participate in the development of the assessment of blue shark in the south-eastern Pacific, understand its results, and communicate them to the Commission; it also includes activities between 2022 and 2026 related to fisheries, the conceptual model, data, stock assessment, and management strategy evaluation. In this regard, the information from FIP Swordfish.ec - particularly catch, effort, CPUE, sizes, sex, spatial distribution, retention, and condition at capture - may constitute a relevant technical contribution to strengthen the representation of the Tropical Eastern Pacific in regional analyses and support a framework for sustainable use based on scientific evidence.

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