

# Industrial fishing compliance with a new marine corridor near the Galapagos Islands

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This document includes various calculations, figures, and analyses used to study industrial fishing around the Galapagos Marine Reserve.

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## Figures

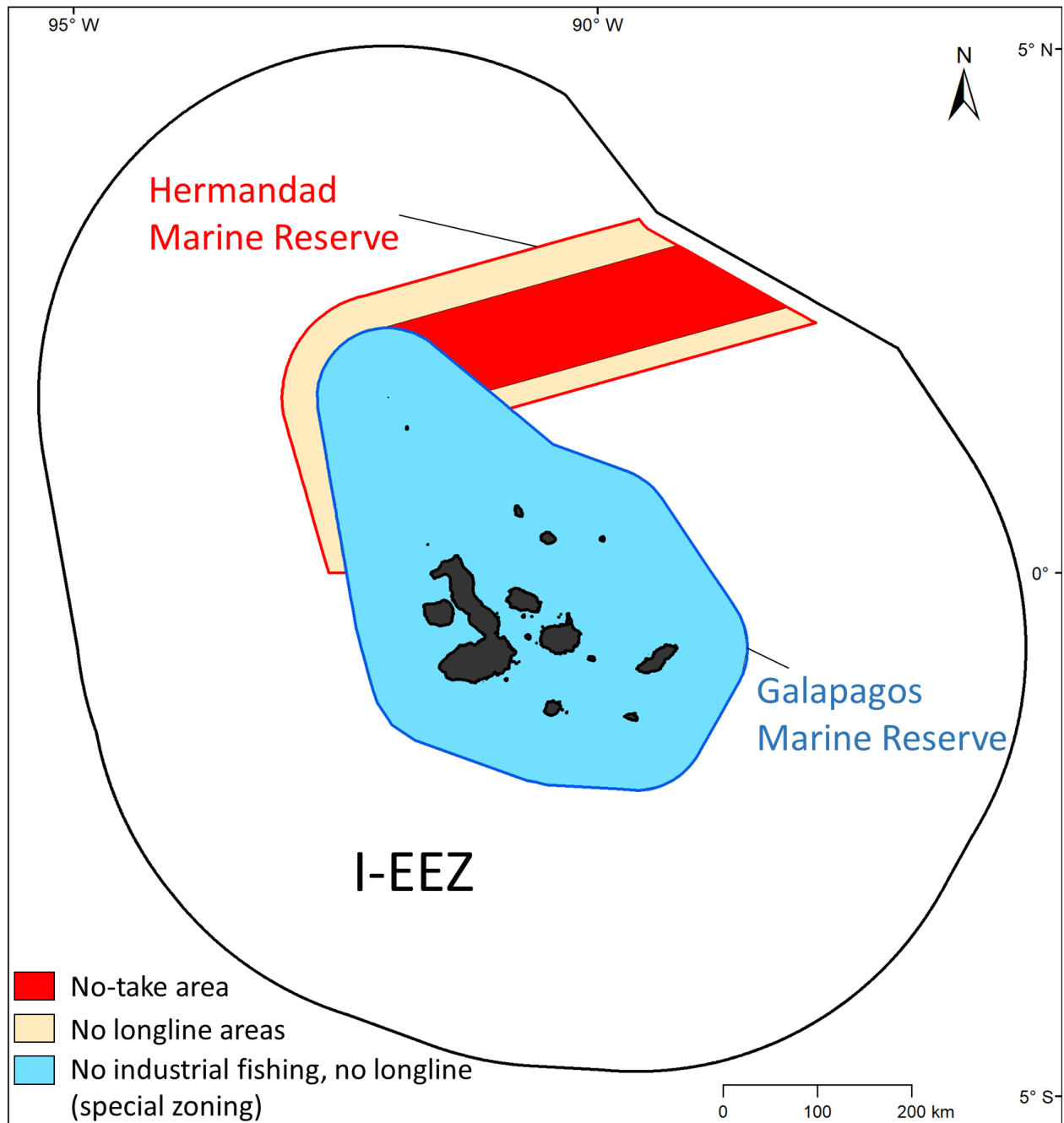


Figure 1: Study area showing the Hermandad Marine Reserve (red contour), with no-take areas (red) and no-longline areas (light orange); the Galapagos Marine Reserve (blue contour), where no industrial fishing nor longline are allowed; and the insular EEZ (I-EEZ) with a black contour.

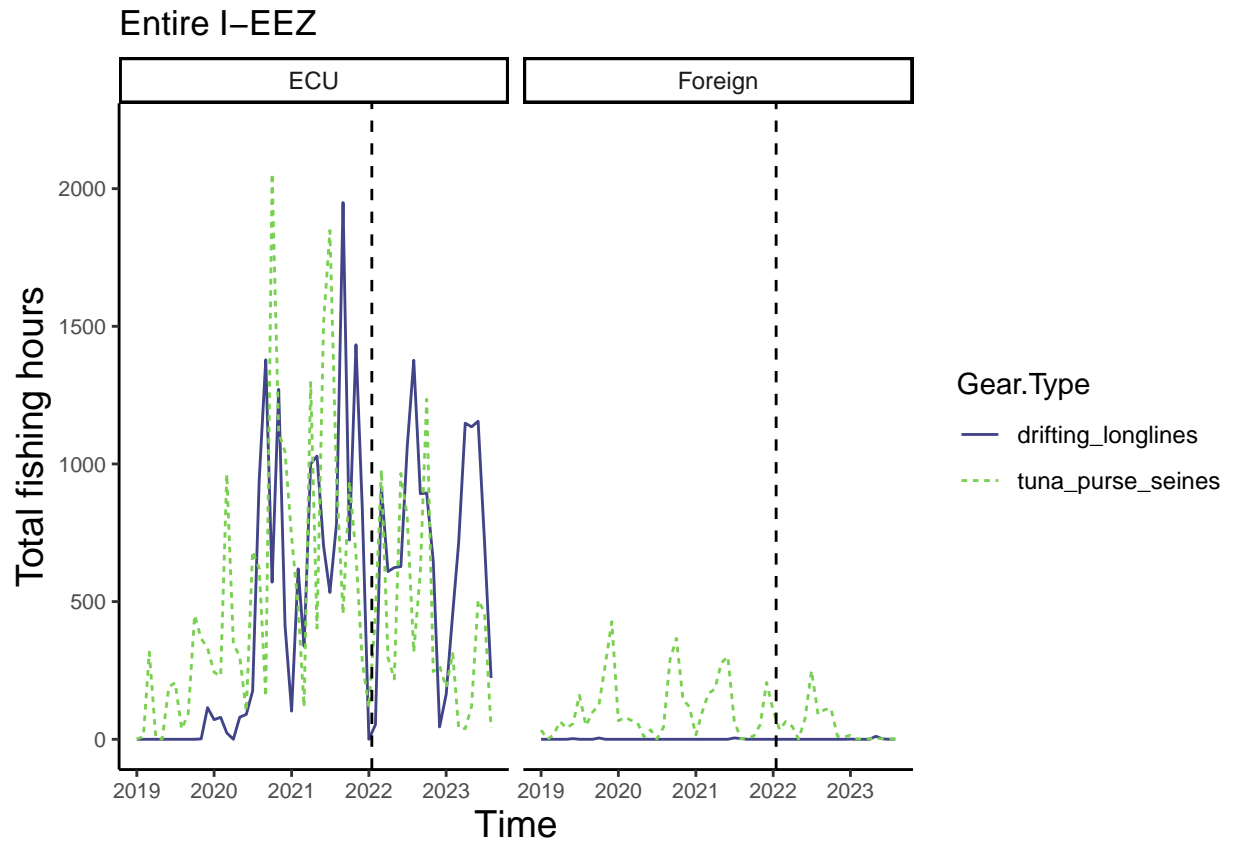


Figure 2: Total monthly industrial fishing effort (hours) in the Ecuadorian Insular Exclusive Economic Zone (I-EEZ) for different gear types for the Ecuadorian (ECU) versus all foreign fleets. The vertical dashed line indicates the announcement of the new Hermandad Reserve (which is 10% of the entire I-EEZ by size).

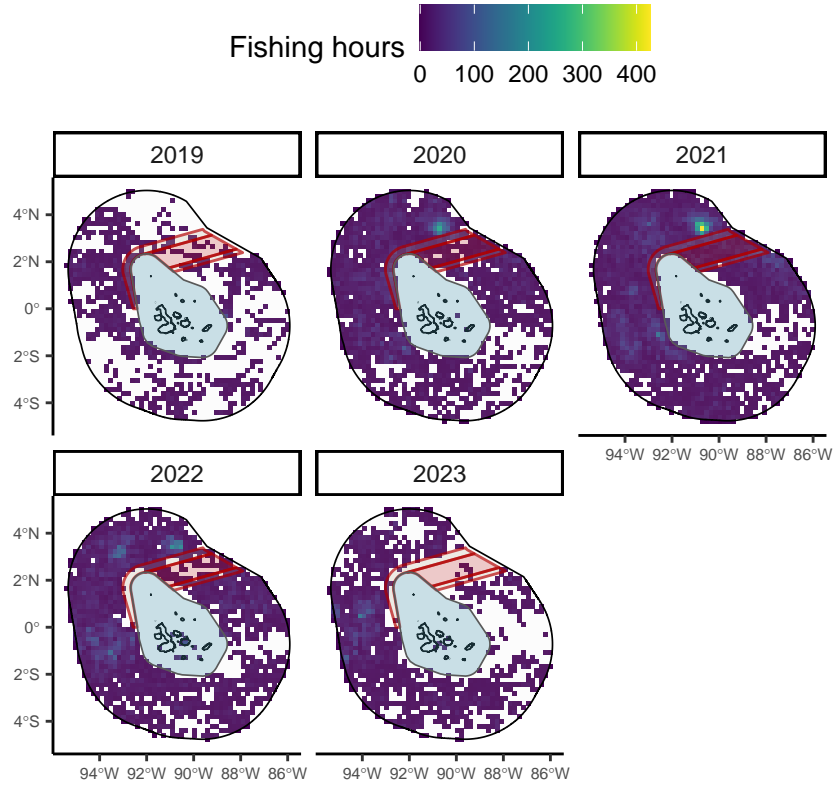


Figure 3: Total industrial fishing effort in the Ecuadorian Insular Exclusive Economic Zone (I-EEZ) over time. Non-colored cells indicate no recorded fishing activity.

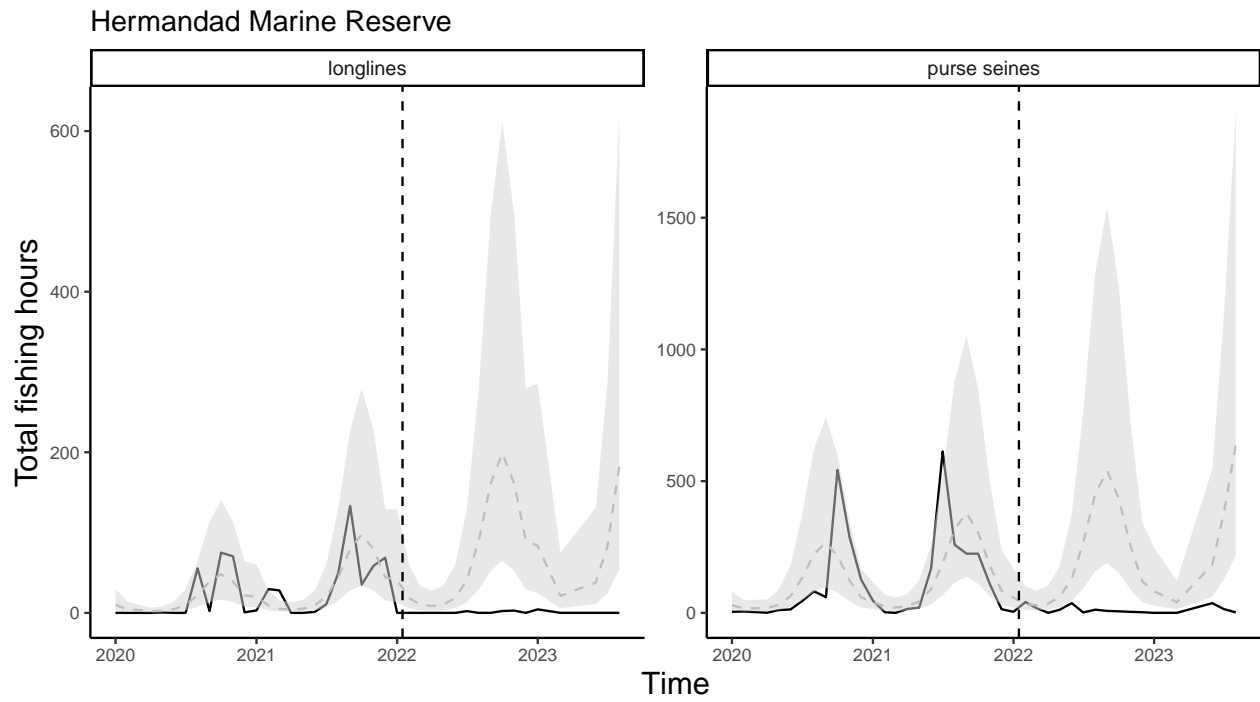


Figure 4: Total monthly industrial fishing effort (hours) in the area of the Hermandad Marine Reserve for different gear types. The vertical dashed line indicates the announcement of the new Hermandad Reserve. The fitted curves are based on pre-closure fishing history with one standard deviation around the mean prediction.

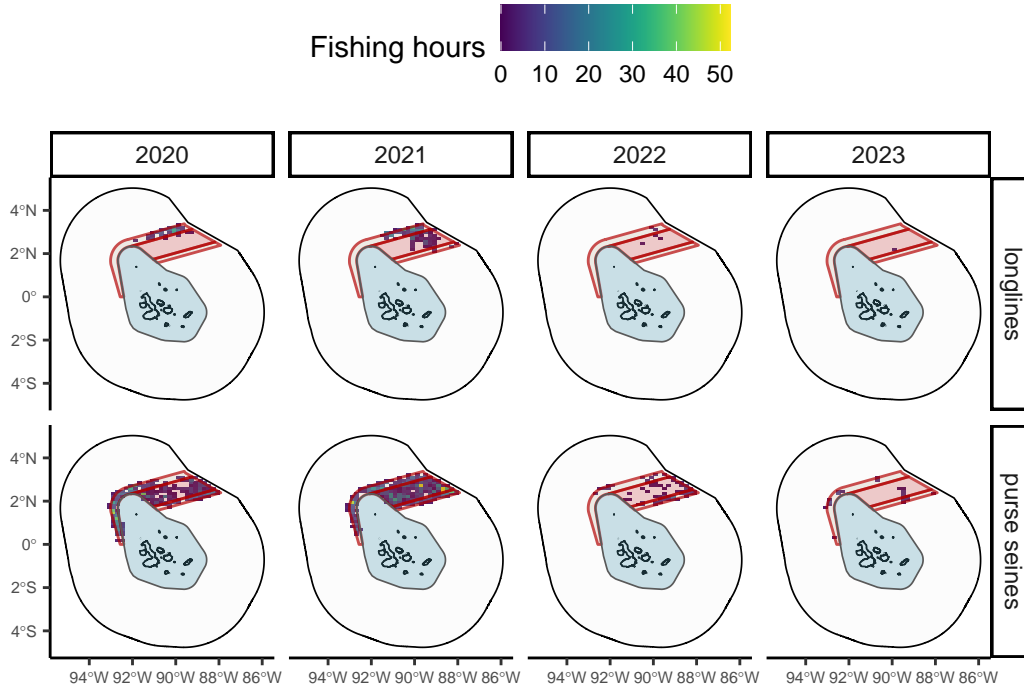


Figure 5: Total yearly industrial fishing effort (hours) in the area of the Hermandad Marine Reserve for different gear types. The reserve was announced at the start of 2022.

## Abstract

- From 2019-2023, we identified 145 large, industrial (non-artisinal) fishing vessels (912.5241379 tons on average or 53.0915493 meters) from 10 countries fishing within Insular Exclusive Economic Zone of Ecuador (I-EEZ) around the Galapagos Islands.
- In this time window, we observed 64,626 hours of fishing within the EEZ and 0% of these fishing hours were within the Galapagos Marine Reserve. - However, 0.8768165' of the fishing effort was accounted for by Ecuadorian vessels using tuna purse seines and drifting longlines in equal proportions, while the effort of foreign vessels was accounted for by tuna purse seines.
- In addition, we studied the effect of a 2022 ruling to close 60,000 square kilometers of fishing area, known as the Hermandad Marine Reserve. We documented a 88.2614351% decrease in fishing effort within the Hermandad protected area after its implementation. There did not appear to be an increase in effort leading up to the reserve's implementation nor a shift in fishing effort distribution elsewhere after.

## Results

Across the entire Ecuadorian Insular Exclusive Economic Zone (I-EEZ) around the Galapagos Island, we documented 64,626 hours of fishing by 145 unique vessels between 2019 and 2022 (Figs. 2,3).

Ecuador accounted for 92.3% of this fishing, but we also detected fishing (in decreasing order) by vessels from Panama, Nicaragua, Venezuela, Great Britain, The United States, and Colombia. Approximately, 0% of these fishing hours were within the Galapagos Marine Reserve, almost exclusively by Ecuadorian vessels (). The majority (3.74%) of fishing effort could not be assigned to a more specific type of fishing mode, highlighting the difficulty of working with smaller vessels in the region. However, for trips that could be assigned to a more specific fishing mode, longlining (%), pole and line (%) and purse seines (96.26%) were the most common. These patterns were similar across the whole I-EEZ and within the Galapagos Marine Reserve, but there were more tuna purse seines outside the Galapagos Marine Reserve. Increasing trends over the course of years should be interpreted with caution as there was also an increase in fishing vessels observed in the area over time, which could be a real increase in vessels or an increase in vessels using AIS systems. Seasonally, we observed higher fishing effort later in the year, with a peak in October.

The Hermandad Reserve was officially declared on January 14th (need to check), 2022. Almost all of the fishing within the Hermandad Reserve prior to its implementation was drifting longlines or tuna purse seines. In 2021, only 8% of the fishing within the I-EEZ was within the Hermandad Reserve area. There was a 88% decrease in fishing effort within the Hermandad protected area after its implementation at the start of 2022. This effort doesn't appear to have shifted elsewhere as total fishing effort in the Ecuadorian Insular Exclusive Economic Zone (I-EEZ) in 2022 was less than in 2021. In addition, any remaining fishing effort in 2022 was by ECU vessels as opposed to foreign boats. From 2020 to 2021, there was a 75% (need to enter exact number) fishing effort in the region of the future Hermandad Reserve compared to only a 37% increase in the rest of the I-EEZ. Thus, it is possible that fishing effort increased in the area as it was being proposed.

## Preliminary findings

- 10 countries had fishing vessels within the Ecuadorian Insular Exclusive Economic Zone (I-EEZ)
- There were 145 unique vessels identified as fishing between 2019 and 2022
- Between 2019 and 2022, there were  $6.4626 \times 10^4$  hours of fishing within the Ecuadorian Insular Exclusive Economic Zone (I-EEZ) (Fig. 2). Approximately, 0% of these fishing hours were within the Galapagos Marine Reserve.
- There was a 88% decrease in fishing effort within the Hermandad protected area after its implementation at the start of 2022. This effort doesn't appear to have shifted elsewhere as total fishing effort in the Ecuadorian Insular Exclusive Economic Zone (I-EEZ) in 2022 was less than in 2021. In addition, any remaining fishing effort in 2022 was by ECU vessels as opposed to foreign boats.



## Discussion calculations

## **Supplementary Material**

### **Supplemental material for: Industrial fishing compliance with a new marine corridor near the Galapagos Islands**

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## Ecuadorian Insular Exclusive Economic Zone (I-EEZ)

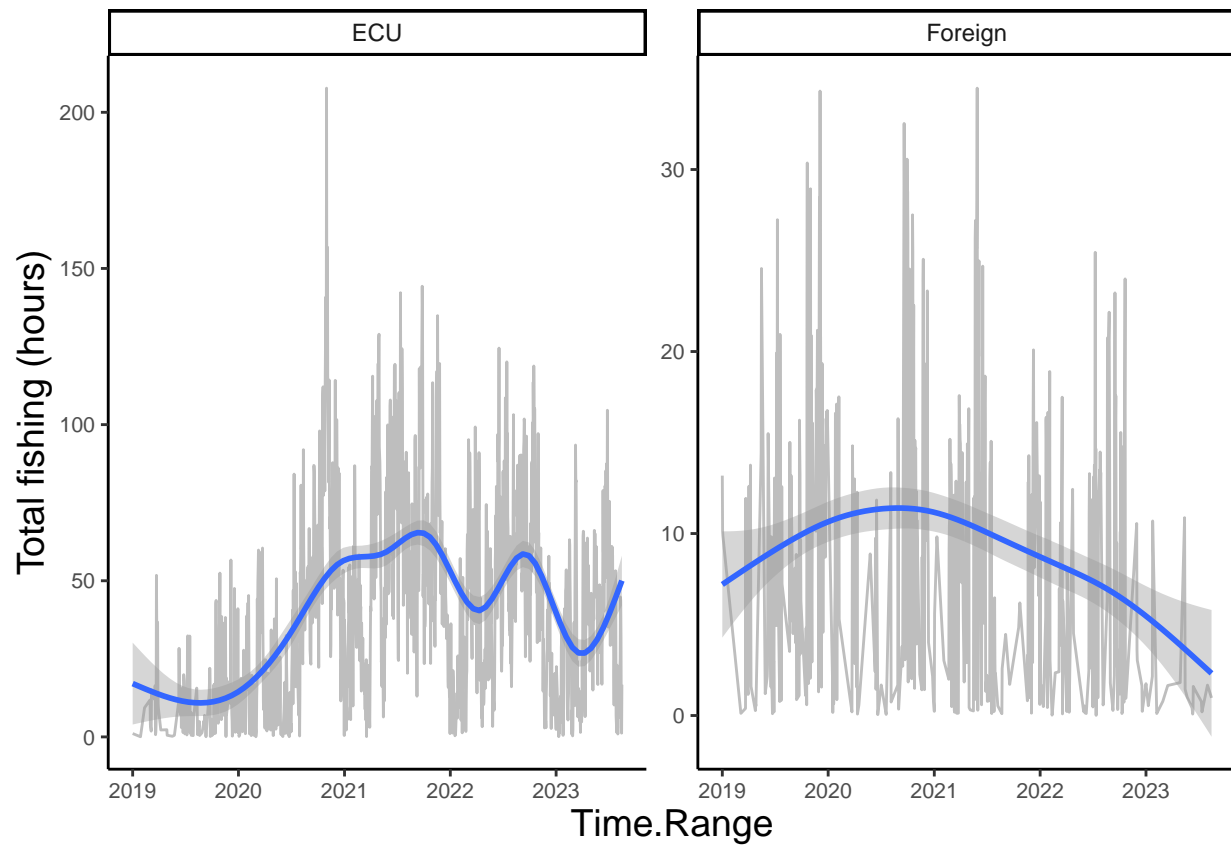


Figure S1: Total fishing effort (hours) in the Ecuadorian Insular Exclusive Economic Zone (I-EEZ) with a loess smoothing curve fit to the data.

Table S1: Total fishing hours in the Ecuadorian Insular Exclusive Economic Zone (I-EEZ) by year.

Year	Apparent.Fishing.Hours
2019	3474.84
2020	14254.72
2021	22274.94
2022	17123.66
2023	7497.48

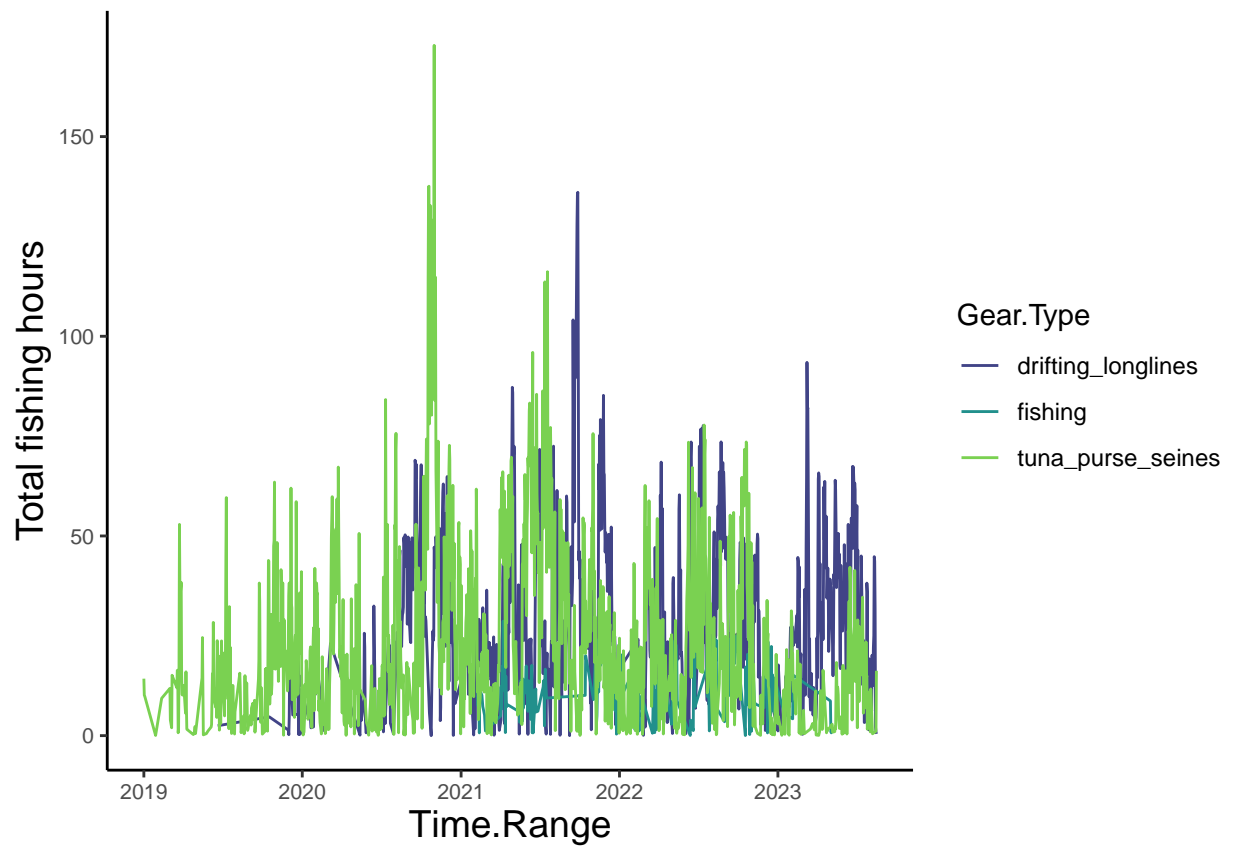


Figure S2: Total fishing effort (hours) in the Ecuadorian Insular Exclusive Economic Zone (I-EEZ) for different gear types

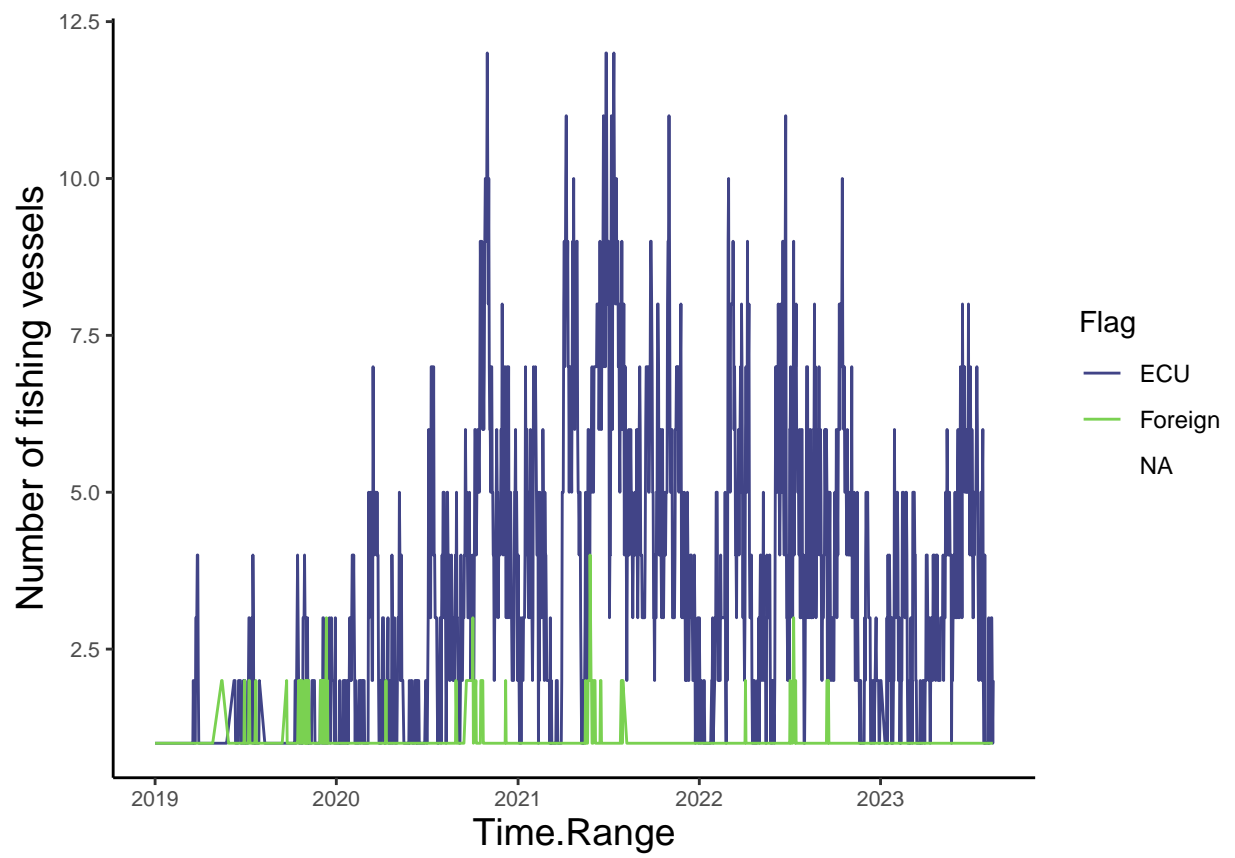


Figure S3: Total number of vessels over time.

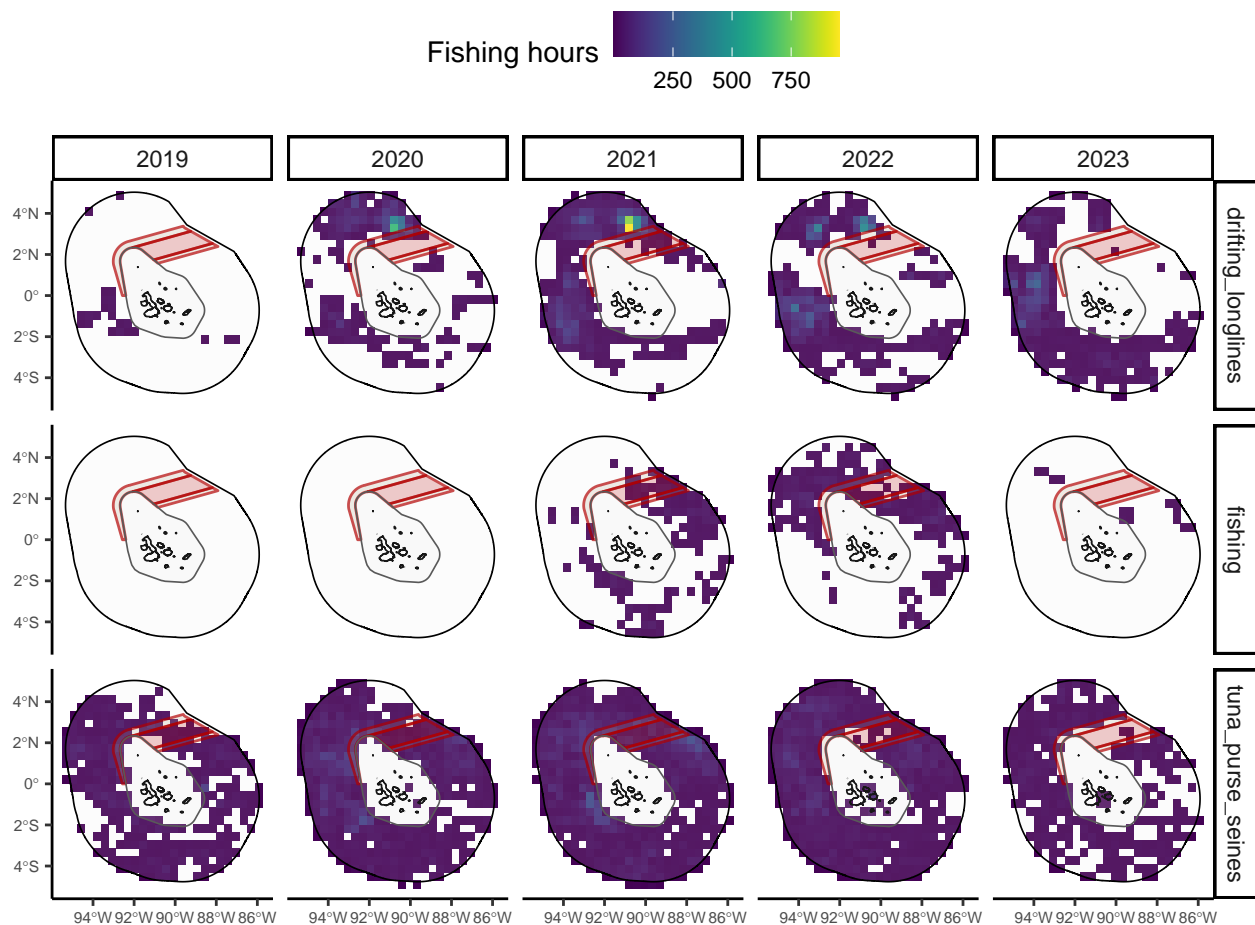


Figure S4: Total fishing effort by gear type in the Ecuadorian Insular Exclusive Economic Zone (I-EEZ) over time

## Galapagos Marine Reserve

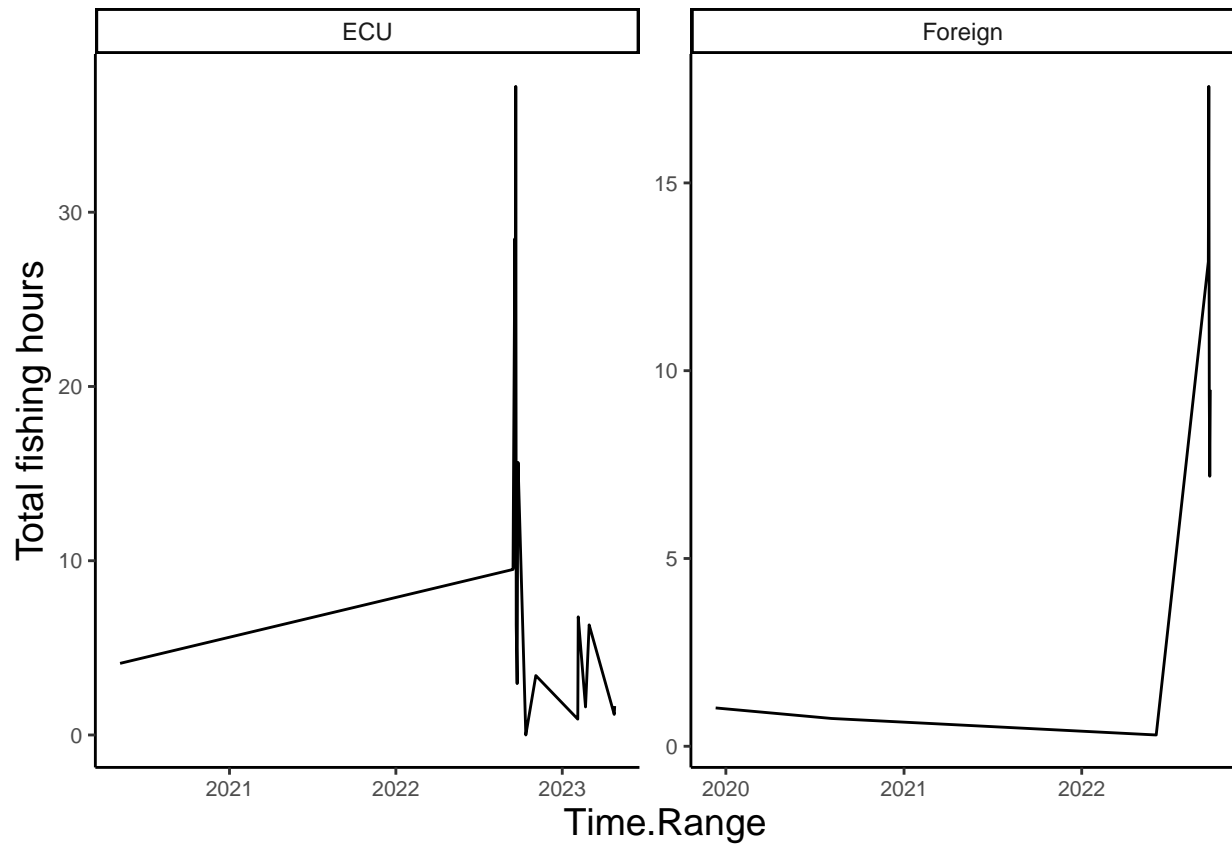


Figure S5: Total fishing effort (hours) in the Galapagos Marine Reserve

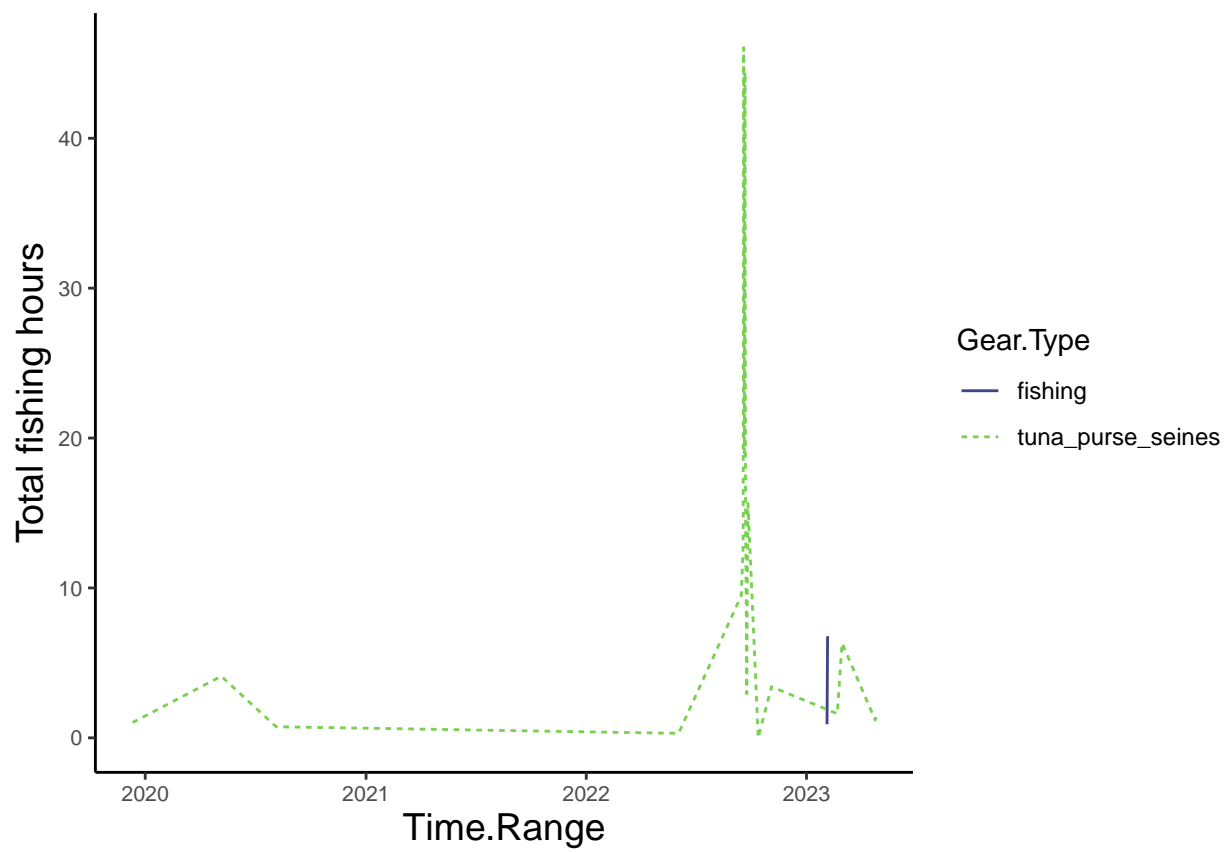


Figure S6: Total fishing effort (hours) in the Galapagos Marine Reserve for different gear types



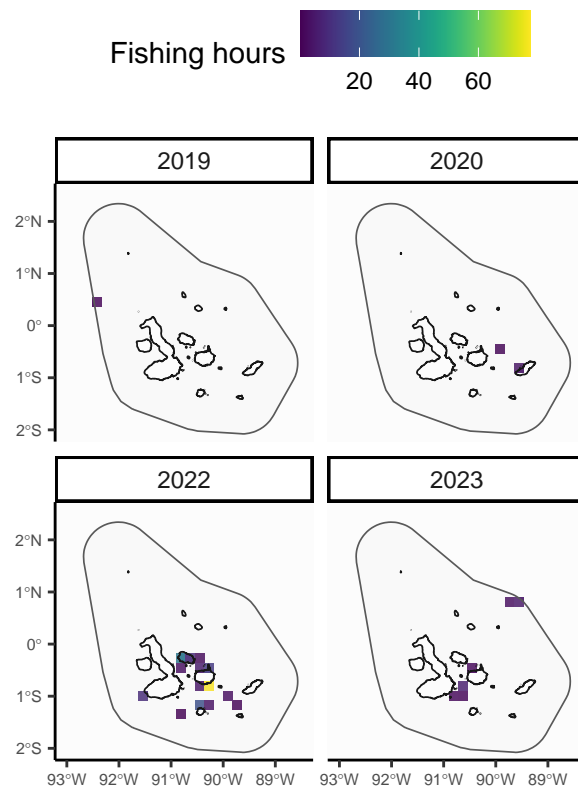


Figure S7: Total fishing effort (hours) in the Galapagos Marine Reserve over time

## Hernandad fishing

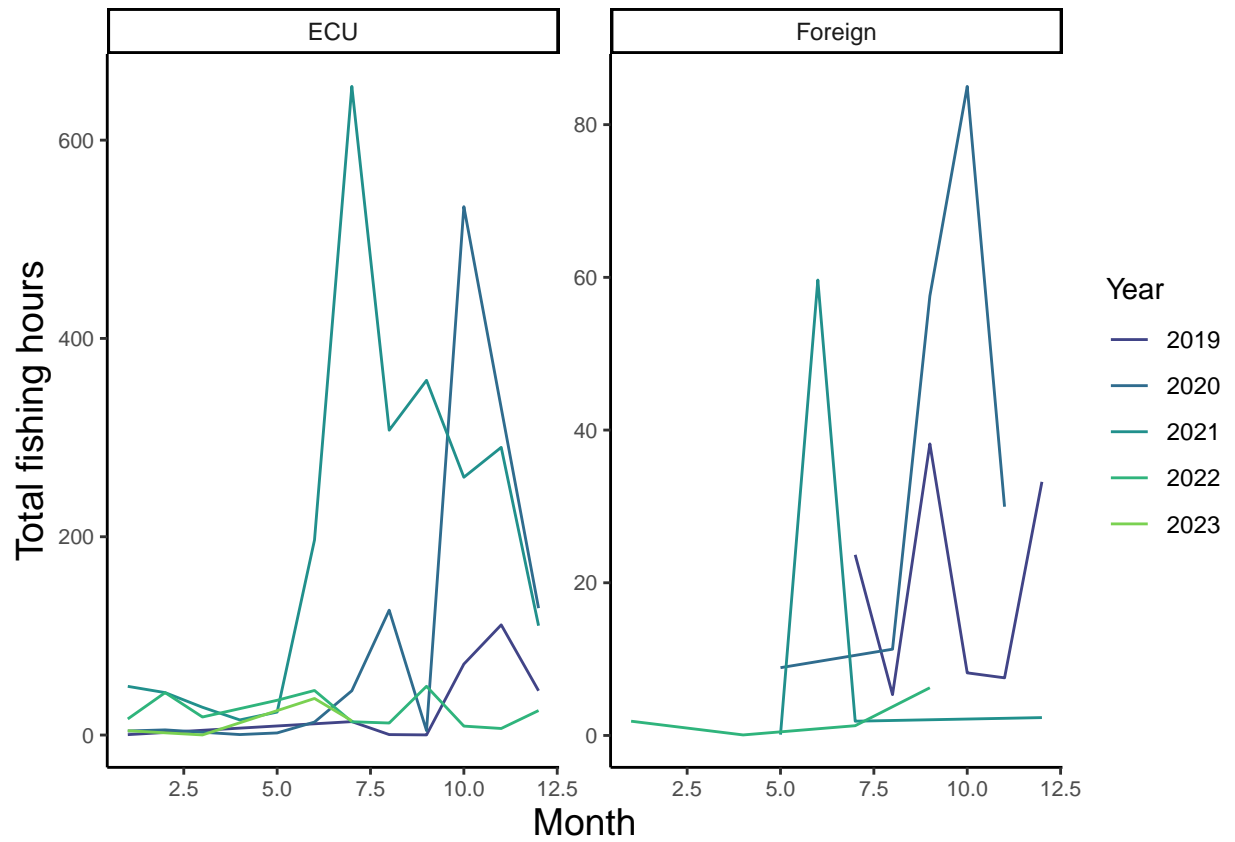


Figure S8: Total fishing effort (hours) in the Hernandad Marine Reserve for both Ecuador and foreign vessels

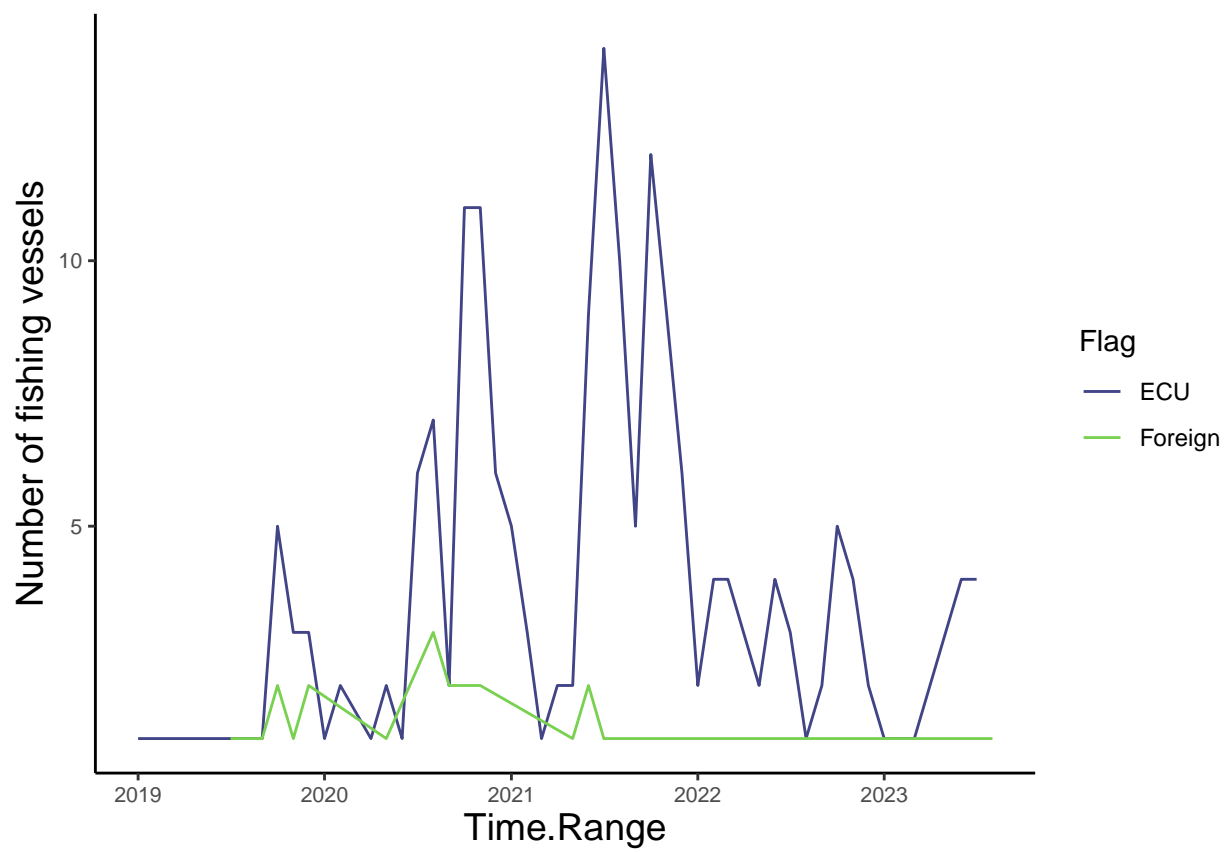


Figure S9: Total number of vessels over time

Table S2: Total fishing hours in the Hermandad Marine Reserve by year. The reserve was officially declared at the start of 2022

Year	Apparent.Fishing.Hours
2019	358
2020	1383
2021	2399
2022	282
2023	57

Table S3: Total fishing hours in the Hermandad Marine Reserve by vessel flag. The reserve was officially declared at the start of 2022

Year	Flag	Apparent.Fishing.Hours
2019	ECU	242
2019	Foreign	116
2020	ECU	1191
2020	Foreign	193
2021	ECU	2335
2021	Foreign	64
2022	ECU	272
2022	Foreign	9
2023	ECU	56
2023	Foreign	2

Table S4: Total fishing hours in the Hermandad Marine Reserve by gear type. The reserve was officially declared at the start of 2022

Year	Gear.Type	Apparent.Fishing.Hours
2019	tuna_purse_seines	358
2020	drifting_longlines	204

Year	Gear.Type	Apparent.Fishing.Hours
2020	tuna_purse_seines	1179
2021	drifting_longlines	417
2021	fishing	287
2021	tuna_purse_seines	1694
2022	drifting_longlines	7
2022	fishing	129
2022	tuna_purse_seines	146
2023	drifting_longlines	4
2023	tuna_purse_seines	53

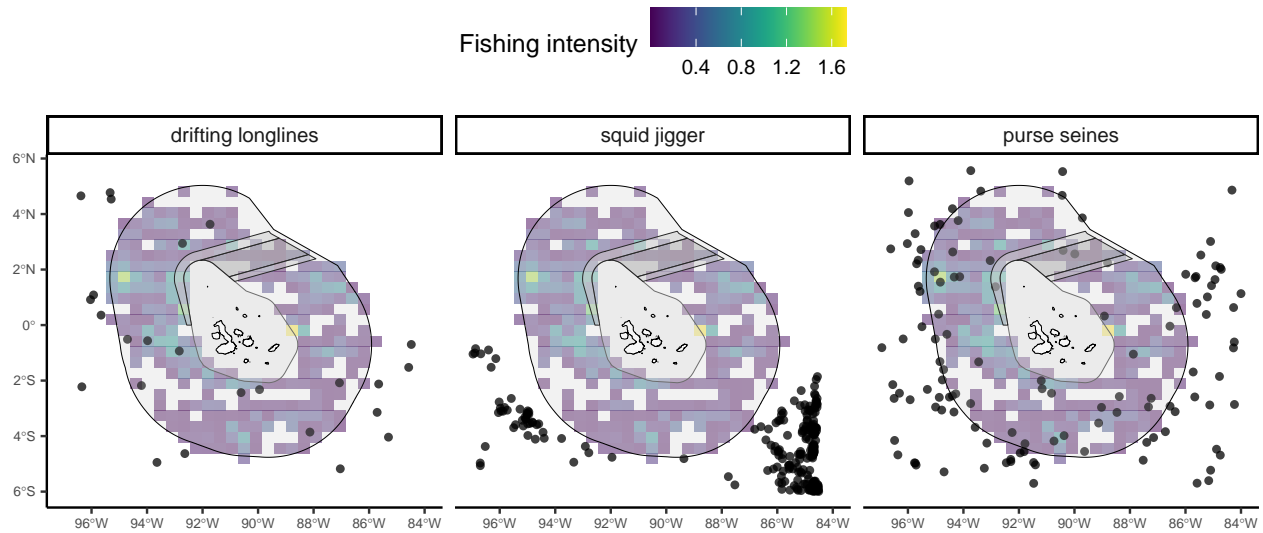


Figure S10: Locations (transparent circles) of AIS disabling events for different gear types overlaid on map of total fishing effort within the exclusive economic zone