Analysis of historic fishing activity within the proposed National Marine Sanctuary for the Pacific Remote Islands

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Contents

1 Executive summary

A proposed National Marine Sanctuary designation for the Pacific Remote Islands (PRI) raises questions about how closing the expansion area would affect fishing activity in this region. As the United States considers designating this Sanctuary, it is particularly important to understand how the US tuna purse seine and drifting longline fleets landing in American Samoa (AS) has historically used this proposed area. This analysis uses AIS vessel monitoring data obtained through Global Fishing Watch (GFW) to quantify: 1) historic purse seine and drifting longline fishing effort in this area; 2) historic activity of US- and foreign-flagged purse seine, longline, and fish carrier vessels (e.g., transshipment vessels) associated with the AS tuna cannery in Pago Pago; and 3) historic US-flagged purse seine activity associated with other ports in the Pacific. Additionally, using catch data reported by the Western & Central Pacific Fisheries Commission (WCPFC), this analysis also quantifies: 4) historic purse seine catch trends in and around the proposed Sanctuary. This analysis was conducted by the Environmental Markets Lab (emLab), an interdisciplinary team of scientists based at the University of California Santa Barbara (UCSB) that conducts data-driven research on how to tackle the world's most pressing environmental problems. This is an objective technical report that does not make any recommendations or claims about whether or not the proposed Sanctuary should be designated.

Pacific Remote Islands Marine National Monument currently covers roughly 1,275,000 km^2 across five discontiguous areas: 1) Wake Atoll, 2) Johnston Atoll, 3) Jarvis Island, 4) Kingman Reef/Palmyra Atoll, and 5) Howland Island/Baker Island. The Wake Atoll, Johnston Atoll, and Jarvis Island areas currently extend to the US Exclusive Economic Zone (EEZ) boundary. However, the Howland Island/Baker Island and Kingman Reef/Palmyra Atoll areas are currently rectangular shapes that do not fully extend to the US EEZ boundary. The proposed PRI Sanctuary would extend from these existing areas to reach the US EEZ boundary, which would roughly provide an additional 686,000 km^2 of protection. Because the proposed Sanctuary would not affect existing monument regulations that restrict commercial fishing, this analysis focuses on the two areas that are within the proposed Sanctuary but are not currently within the existing monument boundaries.

The analysis finds that during the last five years (2018-2022), the US-flagged purse seine fleet spent 0.52% of their effort fishing in the proposed Sanctuary out of the entire Pacific. Meanwhile, the US-flagged drifting longline fleet spent 0.00% of their effort fishing in the proposed Sanctuary out of the entire Pacific. Focusing only on fishing trips that landed in Pago Pago in AS, the US-flagged purse seine fleet spent 4.16% of their effort fishing in the proposed Sanctuary out of the entire Pacific, while the drifting longline fleet spent 0.00% of their effort in the proposed Sanctuary. The vast majority of effort occurring on purse seine trips that eventually land in Pago Pago happened in the high seas (60.24%) or within non-US EEZs (33.54%), while the vast majority of effort occurring on drifting longline trips that eventually land in Pago Pago occurred the American Samoa EEZ area (98.28%). There also appear to be a general trends of declining overall fishing effort across the Pacific during the last several years for both the US-flagged purse seine and drifting longline fleets.

Focusing on US-flagged purse seine vessels authorized to fish in the WCPFC region between 2018 and 2022, 34 unique vessels made 86 fishing trips landing in 34 ports across the Pacific. For trips ending in Port Noro, Solomon Islands, 8.84% of fishing effort occurred within the proposed expansion area. Other ports that had more than 1% of fishing effort occurring within the proposed Sanctuary included Barber's Point, Oahu (6.31%), Manzanillo, Mexico (5.17%), Pago Pago, American Samoa (4.27%), and Mazatlan, Mexico (3.63%).

Between 2018 and 2022, 22 trips by fish carrier vessels (i.e., potential transshipment vessels) landed in Pago Pago. These carrier vessels were flagged to Panama, Netherlands, and South Korea. Prior to landing in Pago Pago, these carriers encountered 9 fishing vessels at sea across 32 unique encounters (i.e., potential transshipment events). The encountered fishing vessels were purse seines flagged to South Korea, Tuvalu, and Kiribati, as well as a Tuvalu-flagged vessel of unknown gear type. There were no US-flagged vessels observed encountering carrier vessels that eventually landed in Pago Pago.

The spatial catch data reported by WCPFC across the last 5 years of reported data indicates that 0.10% of the US-flagged purse seine catch came from 1x1 degree pixels fully within the proposed Sanctuary, while 2.30% of purse seine catch came from pixels that partially overlap with the proposed Sanctuary.

This analysis is not a causal impact assessment of what would happen if the proposed National Marine Sanctuary designation is implemented; rather it is a historical empirical analysis of the activity that has been observed in this area in the past. While there are some limitations with both AIS-based data and the WCPFC-reported catch data, this analysis uses the best currently available data to provide important baselines for the fishing activity that has historically been observed in and around the proposed Sanctuary. We hope this objective technical report can be used to inform the NOAA Office of National Marine Sanctuaries' discussions on potentially designating a new Sanctuary for the Pacific Remote Islands.

2 Research questions

In this analysis, we answer the following four research questions. The Methods and Results sections are structured to correspond to these four questions.

1. What was the historic purse seine and longline fishing effort in and around the proposed Sanctuary between 2013-2022?
2. What was the historic use of Pago Pago by purse seine and longline fishing vessels and fish carrier vessels between 2013-2022? Were those vessels operating inside or outside the proposed Sanctuary before landing at the harbor?
3. Aside from Pago Pago, which ports have the US tuna purse seine fleet historically used between 2013-2022? Were those vessels operating inside or outside the proposed Sanctuary before landing at the harbor?
4. How much purse seine and longline catch has historically occurred within the WCPFC region?

3 Methods

3.1 Creating a shapefile for the boundaries of the proposed Sanctuary

To create a shapefile for the proposed Sanctuary, we start with the shapefile of the current PRI National Monument from the World Database on Protected Areas (WDPA). We then take the US EEZ from Marine Regions 11, subset the EEZ to the two Howland Island/Baker Island and Kingman Reef/Palymrya Atoll areas where the proposed Sanctuary would be implemented, and then find the shape that extends between the current PRI Monument boundaries and the EEZ. We can see the current PRI National Monument and proposed PRI National Marine Sanctuary areas in Figures 1 (zoomed-out Pacific-wide view) and 2 (zoomed-in to the proposed Sanctuary area). For many of the following maps, we will provide two versions of the figure - one zoomed out to a Pacific-wide view, and one zoomed-in to the proposed Sanctuary area. The PRI Sanctuary shapefile will be used for much of the following analysis. Note that the proposed Sanctuary would encompass the existing PRI Monument units (shown in red), as well as the two additional protected areas (shown in blue). This analysis focuses on the two areas that are within the proposed Sanctuary but are not currently within the existing monument boundaries.

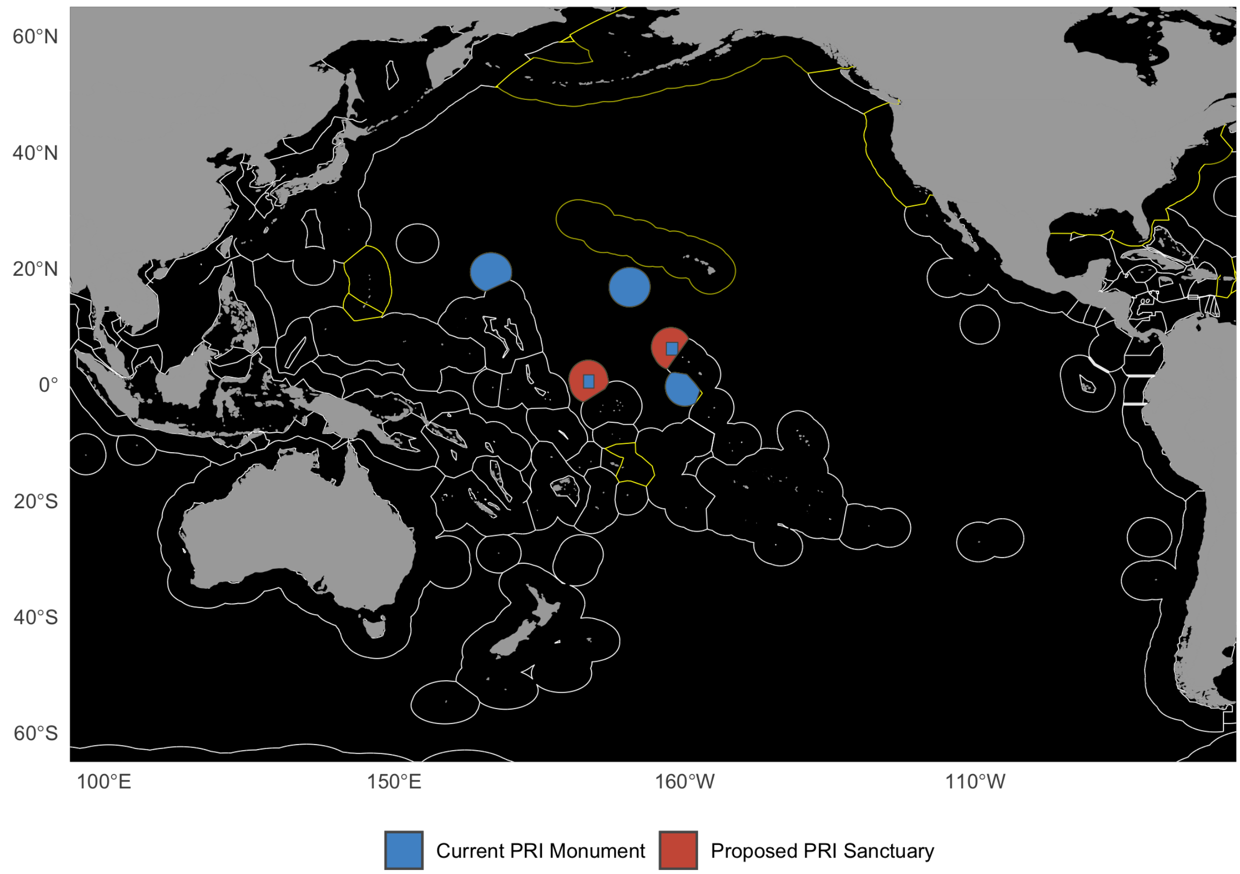

Figure 1: Current PRI Monument and proposed Sanctuary (zoomed-out to entire Pacific region). The current PRI Monument area is shown in blue, and the additional proposed Sanctuary protections are show in red. The proposed Sanctuary would cover all blue and red areas. The US EEZ is shown as a yellow outline, and all other EEZs are shown in white outlines.

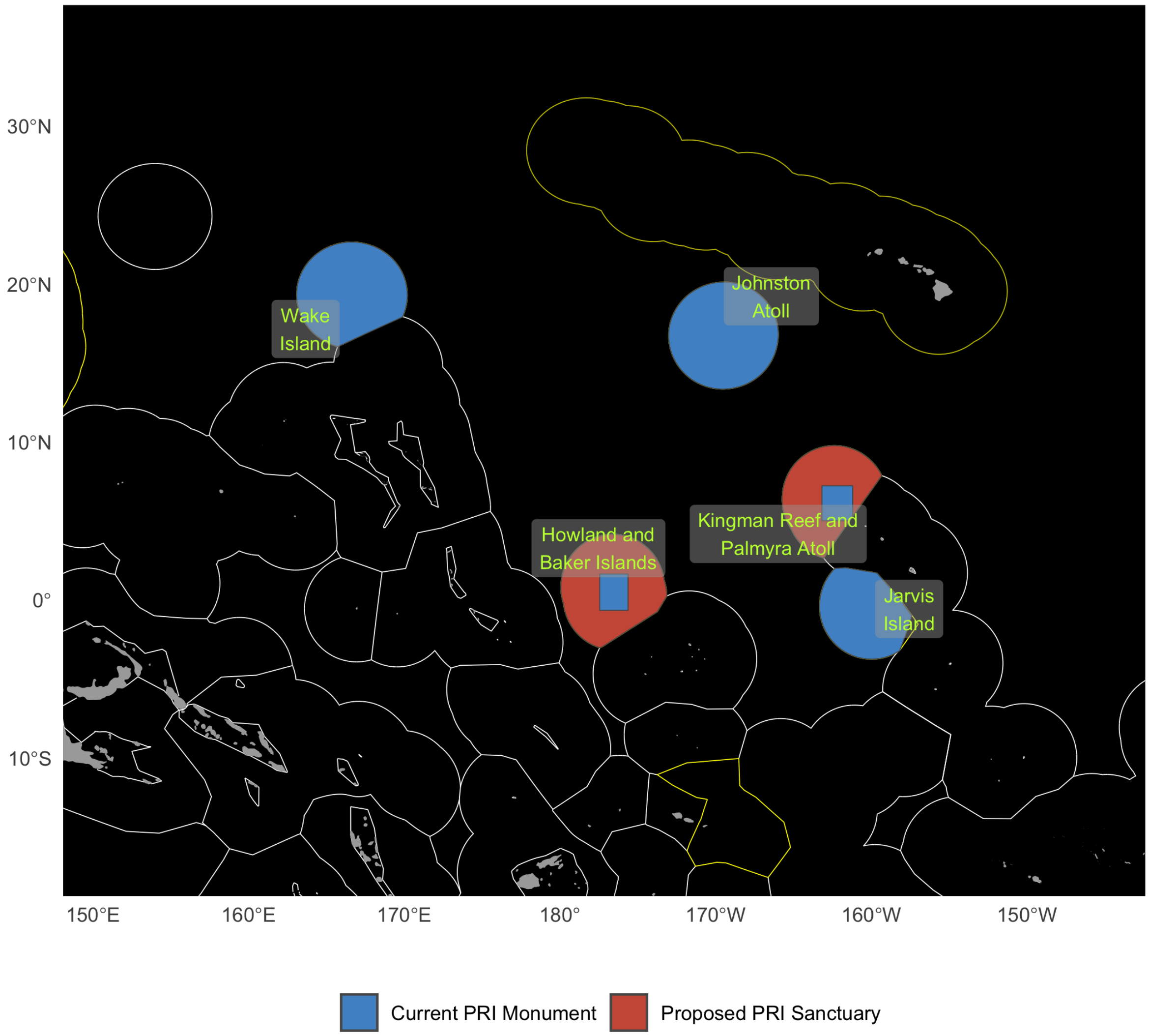

Figure 2: Current PRI Monument and proposed Sanctuary (zoomed-in to PRI area).The current PRI Monument area is shown in blue, and the additional proposed Sanctuary protections are show in red. The proposed Sanctuary would cover all blue and red areas. The US EEZ is shown as a yellow outline, and all other EEZs are shown in white outlines. The five five discontiguous PRI areas are also labeled.

3.2 Analyzing Global Fishing Watch (GFW) data (for Research Questions 1, 2, and 3)

3.2.1 Fishing activity (for Research Questions 1, 2, and 3)

We start with the entire GFW dataset of individual fishing vessel AIS pings from 2013 - 2022. Each ping provides the raw latitude, longitude, timestamp, and identification information from a single vessel. Using these messages as our base, we perform the following steps to process the data for this analysis:

1. Filter AIS pings to only those occurring in the Pacific, our broad region of interest, and also only to those broadcast by purse seine or drifting longline vessels, our gear types of interest.

2. For each AIS ping, determine whether or not the vessel was fishing using the GFW fishing detection algorithm.

3. For each AIS ping, determine whether or not it spatially falls within the proposed Sanctuary and/or the WCPFC RFMO area. Also determine which EEZ the ping occurs in (if any).

4. Assign each ping to a "trip" leveraging the GFW trips and ports databases. Trips are defined as all AIS pings bounded between two port visits by a particular vessel. Thus for each AIS ping, we know which port the vessel was in before the ping (i.e., starting port name and country), and we know which port the vessel lands at after the ping (i.e., ending port name and country).

5. Classify each ping according to whether or not it occurred on a trip that eventually landed in the port of Pago Pago, the location of the tuna cannery in American Samoa.

6. For each ping, determine vessel information including flag and gear type leveraging the GFW vessel information database. Aggregate any gear types that GFW classifies as being associated with purse seines to a single "Purse seine" gear type.

7. For each ping, determine whether or not the vessel was US-flagged and authorized to purse seine fish in the WCPFC RFMO. To do so, we leverage the GFW vessel registry database, which provides vessel registries over time from the major RFMOs. For any given year, we can thus determine whether or not each US-flagged vessel was authorized to purse seine fish in the WCPFC RFMO. Note that not all US-flagged purse seines that were observed fishing within the WCPFC were authorized to purse seine fish according to the WCPFC registries contained in the GFW registry database. Figures under Research Questions 1 and 2 include all US-flagged purse seines, regardless of whether or not they were authorized to purse seine fish. Research Question 3 focuses on just those that were authorized to purse seine fish in the WCPFC during any given year.

8. Aggregate ping-level data to the scale of interest for each particular component of the analysis. We can therefore:

- Summarize fishing effort by year inside and outside the proposed Sanctuary (disaggregating by gear, flag, and whether or not the vessel was a US-flagged authorized purse seine vessel)

- Summarize the number of unique fishing vessels by year inside and outside the proposed Sanctuary (disaggregating by gear, flag, and whether or not the vessel was a US-flagged authorized purse seine vessel).
- Summarize the number of fishing trips that end in each port (which can be further subset to the Pago Pago, and disaggregating by gear, flag, and whether or not the vessel was a US-flagged authorized purse seine vessel).
- Summarize where those trips fished before landing at port, including a breakdown of inside and outside the proposed Sanctuary (disaggregating by gear, flag, EEZ area, and whether or not the vessel was a US-flagged authorized purse seine vessel).

- Prepare data for mapping by aggregating fishing effort from raw high-resolution lat/lon coordinates to a lower resolution more appropriate for mapping, 0.1 x 0.1 degree pixels (disaggregating by gear, flag, and whether or not the vessel was a US-flagged authorized purse seine vessel).

3.2.2 Carrier vessels (e.g., reefers) and encounters (e.g., transshipment) (for Research Question 2)

We start with the entire GFW database of carrier vessel (e.g., reefer) trips from 2013 - 2022, leveraging GFW's curated carrier vessel database. Using these trips as our base, we perform the following steps to process the data for this analysis:

1. Filter trips to those that were done by carrier vessels (e.g., reefer) leveraging the GFW curated carrier vessel database.

2. For each trip, determine vessel information including carrier flag leveraging the GFW curated carrier vessel database.

3. Classify each each trip according to whether or not it eventually landed in the port of Pago Pago, the location of the tuna cannery in American Samoa.

4. For each trip, determine if any vessel-to-vessel encounters (e.g., potential transhipment events) occurred during the trip, as well as where they occurred, and with what vessel(s). Filter to only those trips that had encounters with fishing vessels.

5. For each encounter, determine whether or not it spatially falls within the proposed Sanctuary.

6. For each encounter with a fishing vessel, determine the flag and gear type of the fishing vessel. Only include encounters that occurred between carriers and fishing vessels.

7. Aggregate trip-level data to the scale of interest for each particular component of the analysis. We can therefore:

- Summarize the number of carrier trips by year that ended in Pago Pago (disaggregating by flag).

- Summarize the number of encounters by year that occurred on trips that ended in Pago Pago (disaggregating by carrier flag, fishing vessel flag, fishing vessel gear type, and whether or not the encounter occurred within the proposed Sanctuary).

3.2.3 Opportunities and limitations with GFW data

Using data now made available through GFW, the emLab research team is able to monitor movement patterns of fishing and fish carrier (e.g., reefer) vessels with high spatial and temporal resolution. This provides unprecedented opportunities for observing the world's fishing fleets. For this analysis, we leverage these powerful data that are publicly available and have previously been documented in rigorous peer-reviewed publications. However, there are a number of important caveats that should be acknowledged about the use and interpretation of these data, particularly as it applies to this project:

- **Automatic Identification System (AIS) data**: GFW leverages AIS data. While many fishing and fish carrier vessels carry AIS, particularly large-scale vessels operating in open waters, not all vessels carry AIS. Additionally, vessels that carry AIS can intentionally disable their AIS systems. AIS reception quality also varies across space and time due to the quality of the AIS transponder, satellite coverage, and proximity to other vessels and terrestrial receivers. Therefore, activity measured using AIS is generally an underestimate. Finally, there has been a generally increasing trend over time in both the quality of AIS reception as well as the quantity of vessels carrying AIS. The trend is particularly strong in early years of the GFW dataset (2013-2015), although stabilizes from 2016 onwards. We typically therefore recommend that trend analyses should focus only on data from 2016 onwards, so that any observed trends reflect actual changes in fishing effort on the water, not in changes of AIS reception quality or vessel coverage. For this analysis we are including 2013-2015 data for completeness and transparency, but we recommend against putting too much emphasis on any results or trends observed from these early years.

- **Fishing effort and fish catch**: GFW has developed sophisticated algorithms that can infer fishing effort and gear type (e.g., hours spent fishing by particular gears) based on patterns of vessel movement (see Kroodsma et al. 2018). This was done by training a machine learning algorithm on expert-labeled vessel tracks of known gear types. Therefore, GFW is able to classify each individual AIS message as fishing or not fishing (e.g., transiting or remaining stationary), as well as the duration of time that corresponds to each message (e.g., hours). The model is highly effective at detecting purse seine fishing (F1 score of 0.79) as well as drifting longline fishing (F1 score of 0.93) (Kroodsma et al. 2018). However, these inferred estimates of effort are based on models and are not directly observed. Additionally, there is no way to currently infer catch using these data (e.g., how many tons of fish were caught and of what species). Therefore, while claims can be made with high levels of confidence about where fishing occurs by particular gears and how much fishing effort occurs, it is not possible to make claims about how much catch or revenue this corresponds to or of which species.

- **Port visits**: GFW has developed an algorithm to detect when vessels enter ports and when they leave them. This algorithm, while powerful, requires assumptions to identify potential port visits, including the speed the vessel slows down to, as well as the proximity and time spent near port areas. It is therefore possible that not all port visits will be detected. Additionally, there is no way to confirm that if a fishing or fish carrier vessel arrives at a port that fish was actually landed at the port nor the quantify of the catch. It could be possible that fish was transshipped within the port itself, without being landed.

- **Encounters (i.e., potential transshipment events)**: GFW has developed an algorithm to detect encounters between two vessels (see Miller et al. 2018). When two vessels significantly slow down and are in very close proximity to each other for a certain duration of time, it can be assumed that the vessels are having an encounter/rendezvous. This algorithm, while powerful, requires assumptions about what constitutes an encounter, including the speed of the two vessels, proximity to each other, and time duration over which they are in close proximity. When encounters are detected between a fishing vessel and a fish carrier vessel, this could indicate a potential transshipment event (e.g., a transfer of fish from the fishing vessel to the fish carrier vessel). However, there is no way to confirm that fish were actually transferred between the vessels during the encounter, nor the quantity of fish or of which species.

3.3 Analyzing WCPFC RFMO catch data (for Research Question 4)

Non-spatial catch data come from the WCPFC Tuna Fishery Yearbook - Annual Catch Estimates, which provides catch estimates from 1950-2021 disaggregated by gear, flag, and species. Reported catch estimates cover the entire WCPFC Statistical Area. We filter the data to catch by purse seines or longlines. We then aggregate annual catch data either by flag (US-flagged or other-flagged) and summing across species, or by species and summing across flags.

Spatial catch data come from the WCPFC Public Domain Aggregated Catch/Effort Data. We focus on the purse seine dataset that disaggregatse catch by flag, and we use the finest spatial resolution available (1x1 degrees). These data are provided up through 2021 (from the "Aggregated data, grouped by 5x5 degree latitude/longitude pixels, FLAG and YEAR" dataset.) We do not perform any analysis with the WCPFC-report spatial catch data for longlines, since the finest resolution for longline data is 5x5 degrees, which is too coarse compared to the size of the proposed Sanctuary.

For creating the maps, we aggregate the most recent 5 years of catch data for each gear by pixel and flag (US-flagged or other-flagged). The maps therefore represent the aggregate 2017-2021 catch for purse seines.

For creating time series trends, we spatially overlay the pixels with the proposed Sanctuary, determine which pixels fall fully inside the proposed Sanctuary, partially inside the proposed Sanctuary, or fully inside the proposed Sanctuary, and then for each of these areas we aggregate each year of catch data for each by pixel and flag (US-flagged or other-flagged). Since the pixel size for purse seine spatial catch data is 1x1 degrees, not all pixels fall entirely inside or outside the proposed Sanctuary area - some can only be classified as partially inside. For any pixels that partially overlap the proposed Sanctuary boundaries, it cannot therefore be said how much of this catch actually fell within the proposed Sanctuary boundaries or not. Note also that due to reporting, spatial catch data is not as comprehensive as the non-spatial catch data. Therefore, while looking at trends based on the spatial catch data can partially illuminate spatial trends inside and outside the proposed Sanctuary, the non-spatial catch data is more accurate for illuminating overall trends within the entire WCPFC region.

4 Results

4.1 Analysis of historic purse seine and longline fishing activity in and around the proposed Sanctuary

4.1.1 Historic purse seine activity

We first look at a series of five maps that show purse seine fishing effort across the Pacific, as well as in the region of the proposed PRI Sanctuary. Each map spatially aggregates effort over the last 5 years (2018-2022) in order to show recent general spatial trends in fishing activity. The first map shows purse seine effort across the entire Pacific, aggregating across all flags (Figure 3).

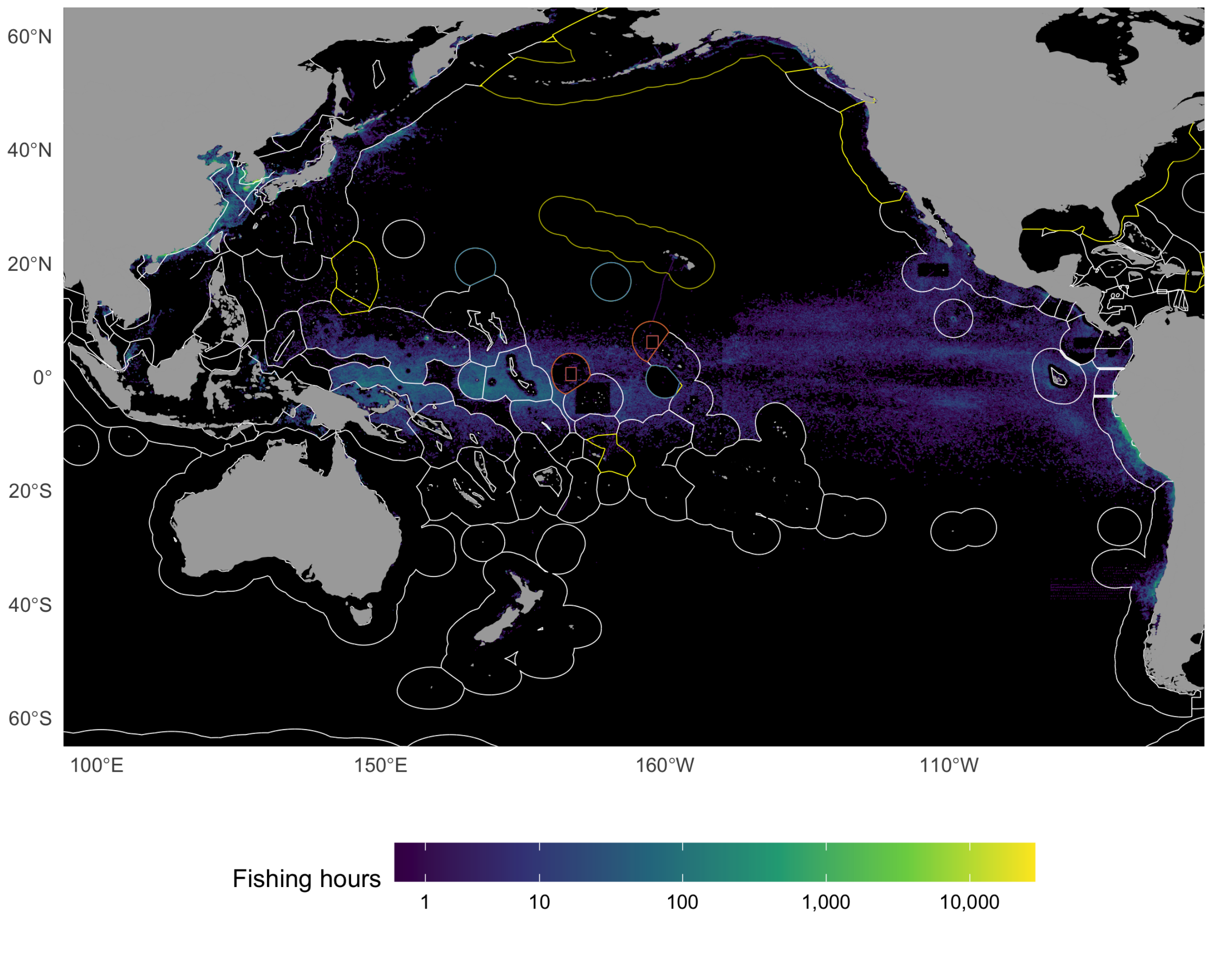

Figure 3: Purse seine fishing effort (hours) across the entire Pacific, aggregated across flags and most recent 5 years (2018-2022). The current PRI Monument area is shown as a blue outline, the additional proposed Sanctuary protections are show as a red outline, the US EEZ is shown as a yellow outline, and all other EEZs are shown as white outlines.

The next map also shows purse seine effort across the entire Pacific, but this time only looking at US-flagged purse seine vessels (Figure 4).

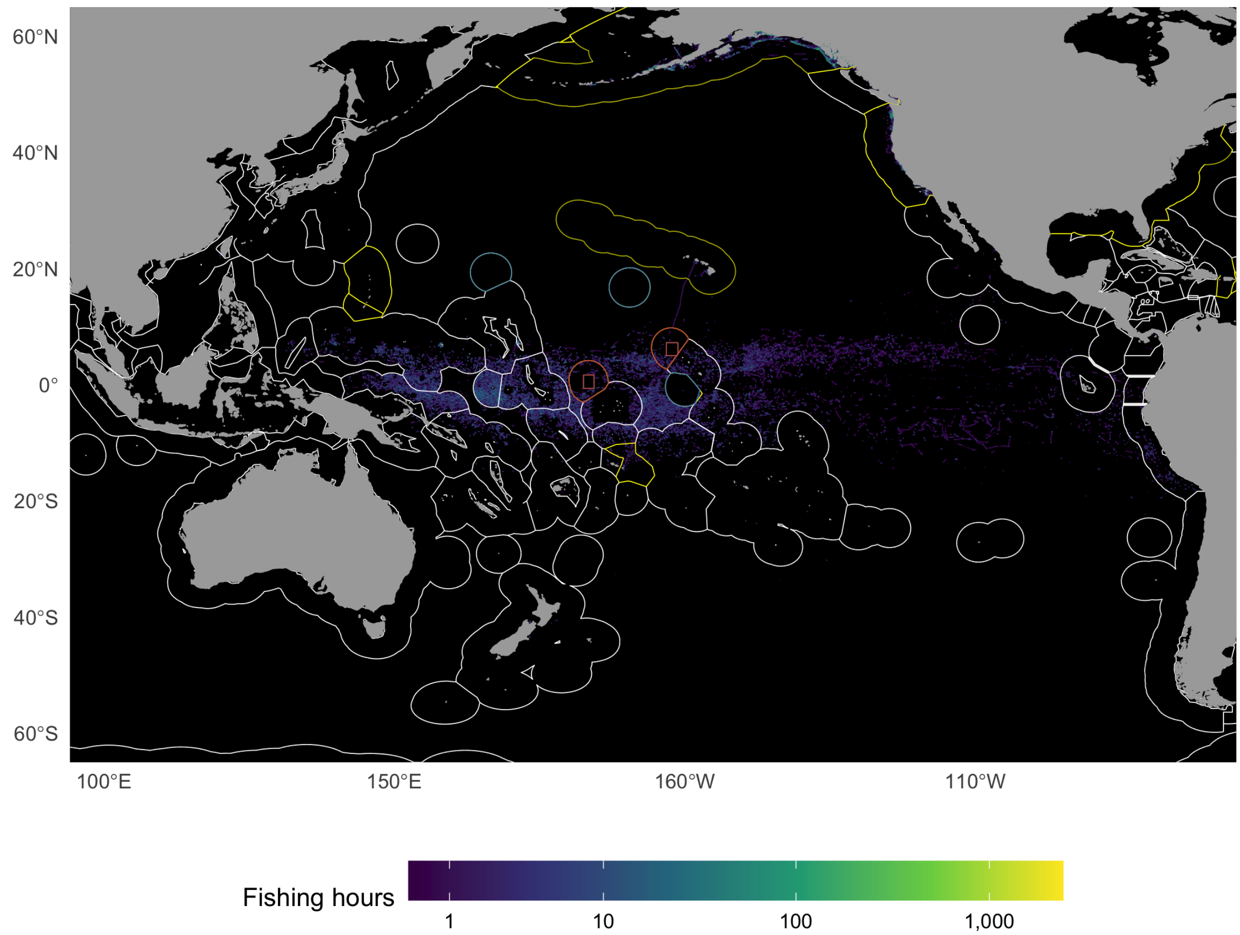

Figure 4: Purse seine fishing effort (hours) across the entire Pacific, aggregated across US-flagged vessels and most recent 5 years (2018-2022). The current PRI Monument area is shown as a blue outline, the additional proposed Sanctuary protections are show as a red outline, the US EEZ is shown as a yellow outline, and all other EEZs are shown as white outlines.

Next we zoom in to the PRI area, first looking at effort by purse seines across all flags (Figure 5).

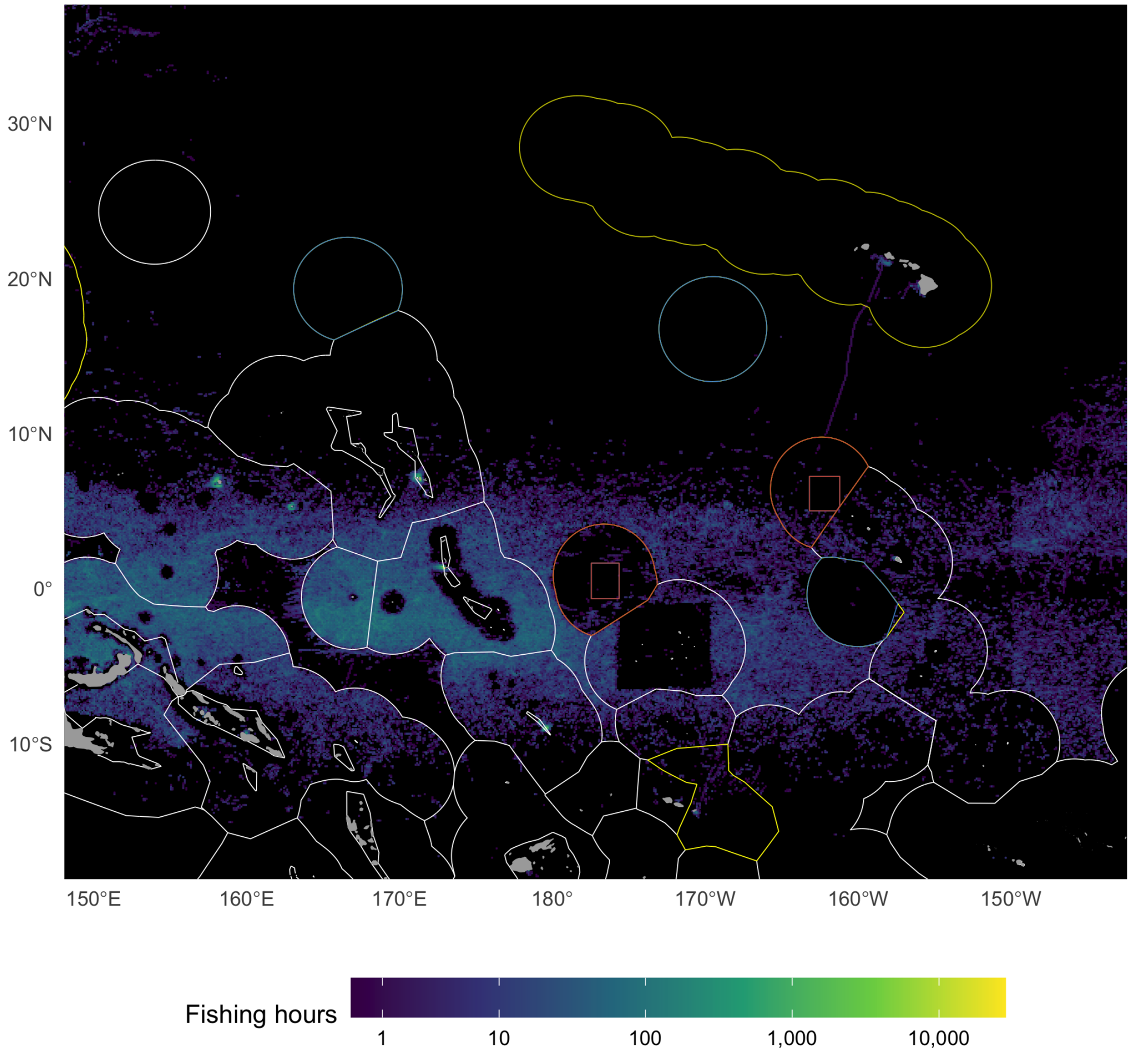

Figure 5: Purse seine fishing effort (hours) in and around the proposed Sanctuary, aggregated across all flags and most recent 5 years (2018-2022). The current PRI Monument area is shown as a blue outline, the additional proposed Sanctuary protections are show as a red outline, the US EEZ is shown as a yellow outline, and all other EEZs are shown as white outlines.

The next map also shows purse seine effort in the PRI region, but this time only looking at US-flagged purse seine vessels (Figure 6).

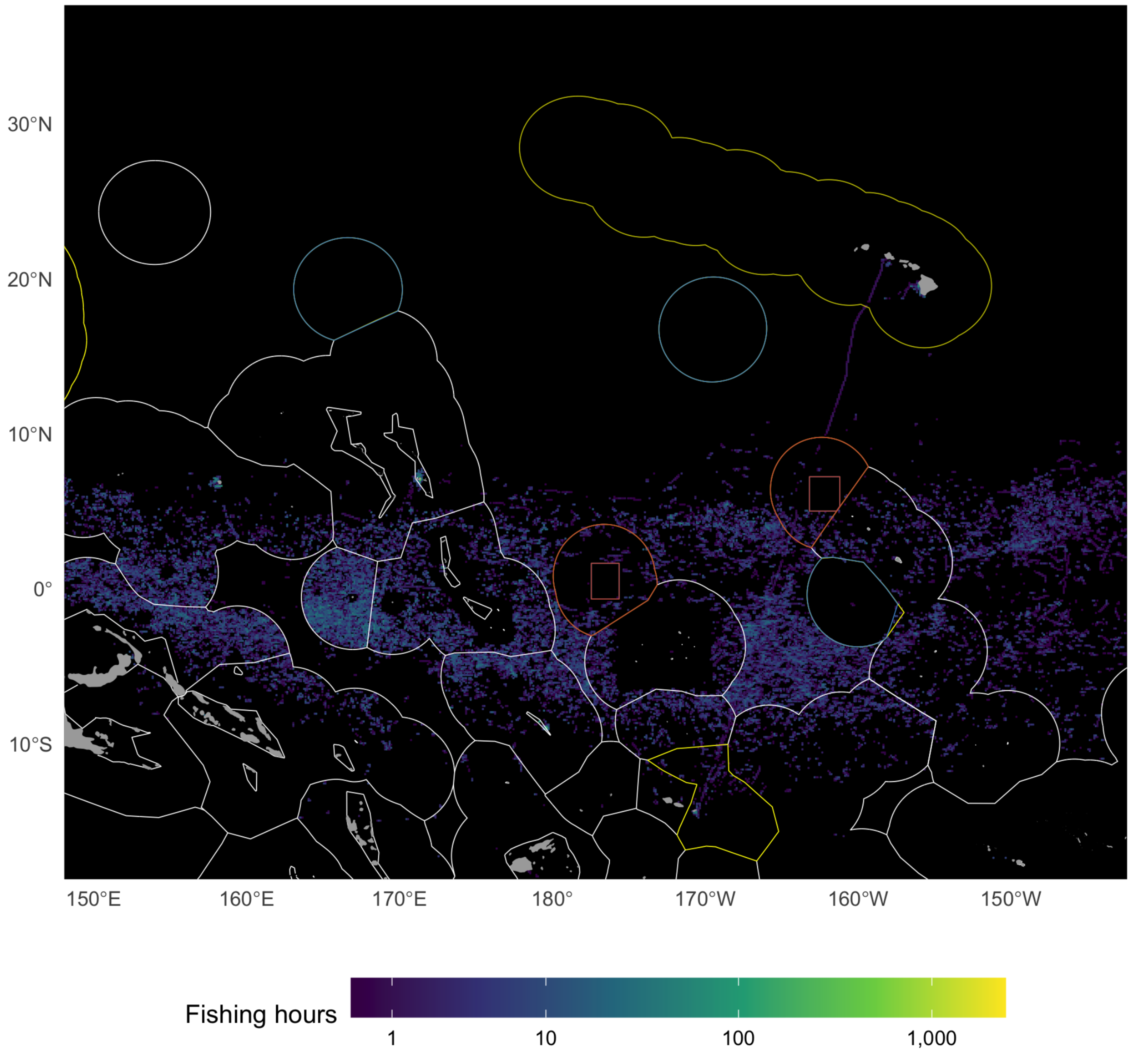

Figure 6: Purse seine fishing effort (hours) in and around the proposed Sanctuary, aggregated across US-flagged vessels and most recent 5 years (2018-2022). The current PRI Monument area is shown as a blue outline, the additional proposed Sanctuary protections are show as a red outline, the US EEZ is shown as a yellow outline, and all other EEZs are shown as white outlines.

In the final map of this section, we zoom back out to the entire Pacific region. This map only includes US-flagged purse seine vessels that were ever observed fishing within the proposed Sanctuary area between 2018-2022 (Figure 7). This map therefore shows the general spatial fishing distribution of US-flagged purse seines that have recently used the proposed PRI Sanctuary area for fishing.

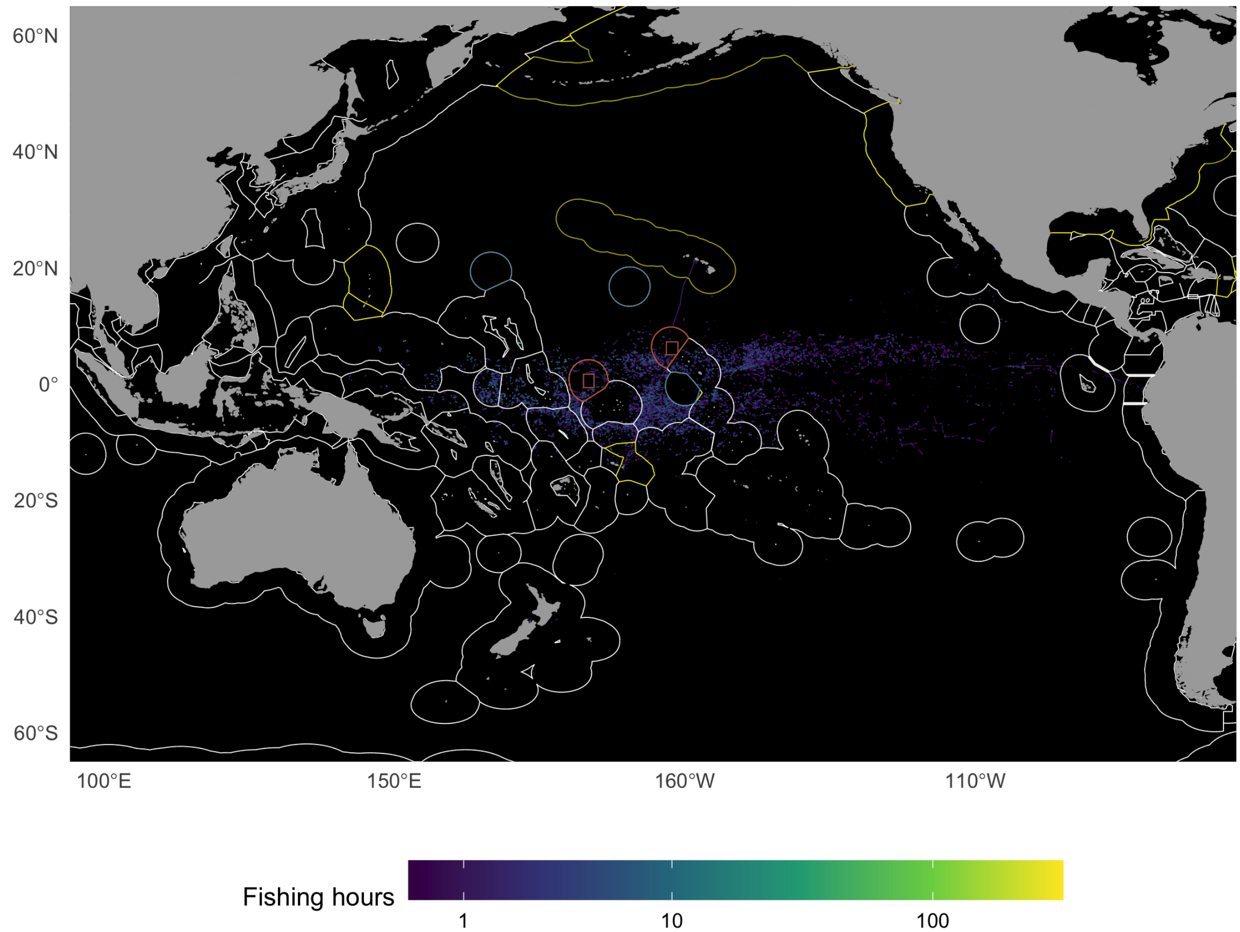

Figure 7: Purse seine fishing effort (hours) across the entire Pacific, aggregated across most recent 5 years (2018-2022), subsetting to just those US-flagged vessels that were observed to fish within the proposed Sanctuary sometime between 2018-2022. The current PRI Monument area is shown as a blue outline, the additional proposed Sanctuary protections are show as a red outline, the US EEZ is shown as a yellow outline, and all other EEZs are shown as white outlines.

Next we look at the time series trend of US-flagged purse seine fishing effort inside and outside the proposed Sanctuary boundaries (Figure 8 and Table 1). The top panel shows absolute fishing effort (hours) inside and outside the proposed Sanctuary over time; the bottom panel shows the percent of fishing effort over time that occurred within the proposed Sanctuary. Between 2013 and 2022, the percentage of fishing effort by this fleet that occurred within the proposed Sanctuary out of the entire Pacific ranged from 0.06% to 1.06% in any given year. Looking across all years from 2013 to 2022, 0.41% of the US purse seine fleet's fishing effort was spent inside the proposed protected area.

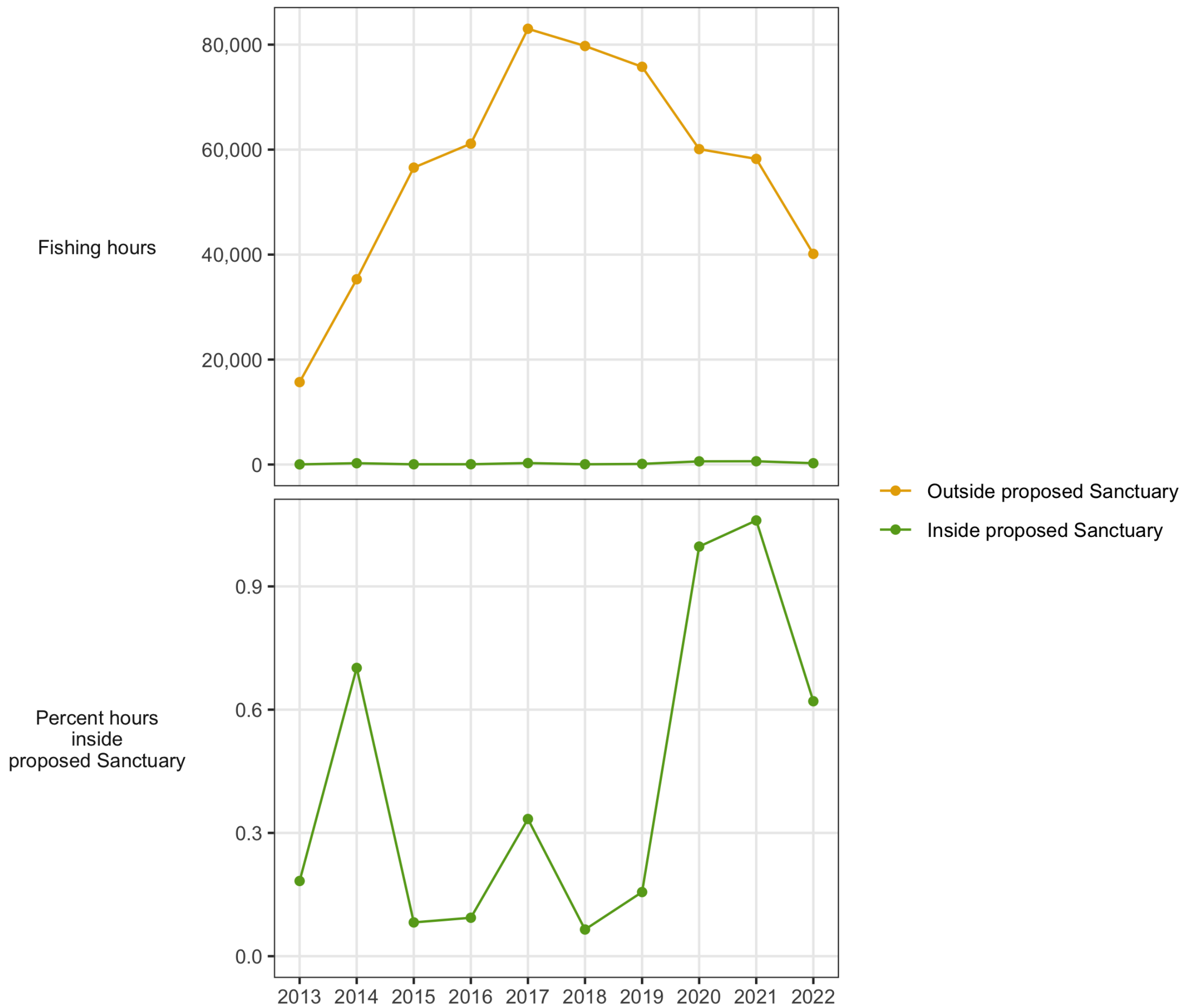

Figure 8: Purse seine fishing effort (hours) over time inside the proposed Sanctuary by the US-flagged fleet; outside the proposed Sanctuary across the entire Pacific; and the percent of fishing effort inside the proposed Sanctuary out of the entire Pacific.

Table 1: Purse seines fishing effort (hours) over time inside the proposed Sanctuary by the US-flagged fleet; outside the proposed Sanctuary across the entire Pacific; and the percent of fishing effort inside the proposed Sanctuary out of the entire Pacific. The second to last row summarizes across the last 5 years (2018-2022), and the last row summarizes across all years.

Year	**Hours inside Sanctuary**	**Hours Outside Sanctuary**	**Percent hours inside Sanctuary**
2013	28.79	15,701.74	0.18
2014	249.41	35,297.33	0.70
2015	46.55	56,570.01	0.08
2016	57.27	61,136.65	0.09
2017	278.17	83,023.84	0.33
2018	51.82	79,741.19	0.06
2019	118.49	75,777.83	0.16
2020	605.15	60,093.54	1.00
2021	624.19	58,231.89	1.06
2022	250.61	40,133.36	0.62
Last 5 years (2018-2022)	**1,650.26**	**313,977.81**	**0.52**
Across all years	**2,310.45**	**565,707.38**	**0.41**

Next we look at the time series trend of the number of unique US-flagged purse seine fishing vessels fishing inside and outside the proposed Sanctuary boundaries (Figure 9 and Table 2). The top panel shows absolute number of unique vessels fishing inside and outside the proposed Sanctuary over time; the bottom panel shows the percent of unique vessels over time that fished within the proposed Sanctuary. Between 2013 and 2022, the percentage of vessels in this fleet that fished within the proposed Sanctuary out of the entire Pacific ranged from 1.77% to 4.94% in any given year. Looking across all years from 2013 to 2022, 6.35% of the US purse seine vessels fished inside the proposed protected area.

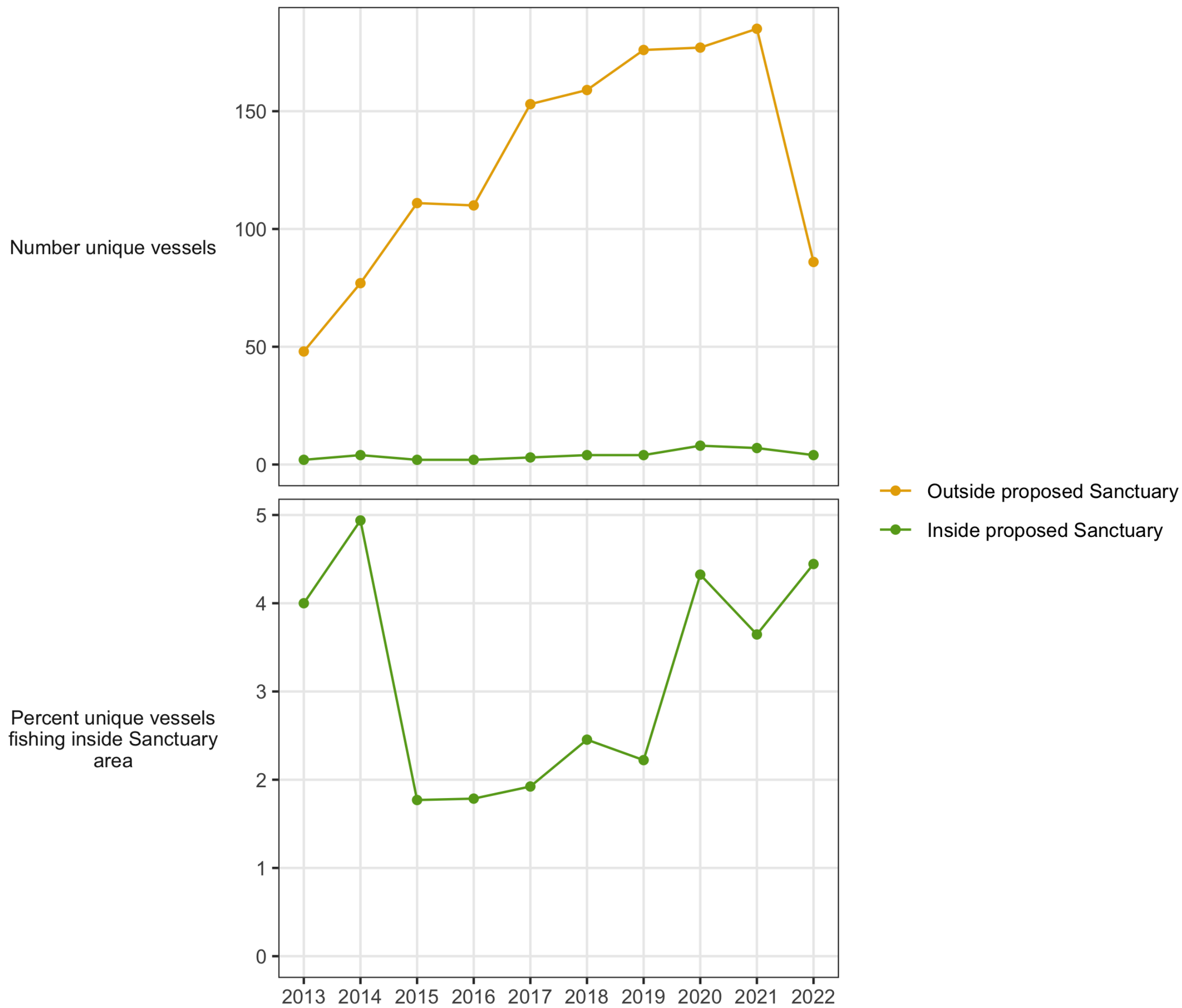

Figure 9: Number of unique purse seine vessels fishing over time inside the proposed Sanctuary by the US-flagged fleet; outside the proposed Sanctuary across the entire Pacific; and the percent of fishing effort inside the proposed Sanctuary out of the entire Pacific.

Table 2: Number of unique purse seines vessels fishing over time inside the proposed Sanctuary by the US-flagged fleet; outside the proposed Sanctuary across the entire Pacific; and the percent of fishing effort inside the proposed Sanctuary out of the entire Pacific. The second to last row summarizes across the last 5 years (2018-2022), and the last row summarizes across all years.

Year	Vessels inside Sanctuary	Vessels Outside proposed Sanctuary	Percent vessels inside Sanctuary
2013	2	48	4.00
2014	4	77	4.94
2015	2	111	1.77
2016	2	110	1.79
2017	3	153	1.92
2018	4	159	2.45
2019	4	176	2.22
2020	8	177	4.32
2021	7	185	3.65
2022	4	86	4.44
Last 5 years (2018-2022)	**12**	**260**	**4.41**
Across all years	**20**	**295**	**6.35**

4.1.2 Historic drifting longline activity

We now look at a series of five maps that show drifting longline fishing effort across the Pacific, as well as in the region of the proposed PRI Sanctuary. Each map spatially aggregates effort over the last 5 years (2018-2022) in order to show recent general spatial trends in fishing activity. The first map shows drifting longline effort across the entire Pacific, aggregating across all flags (Figure 10).

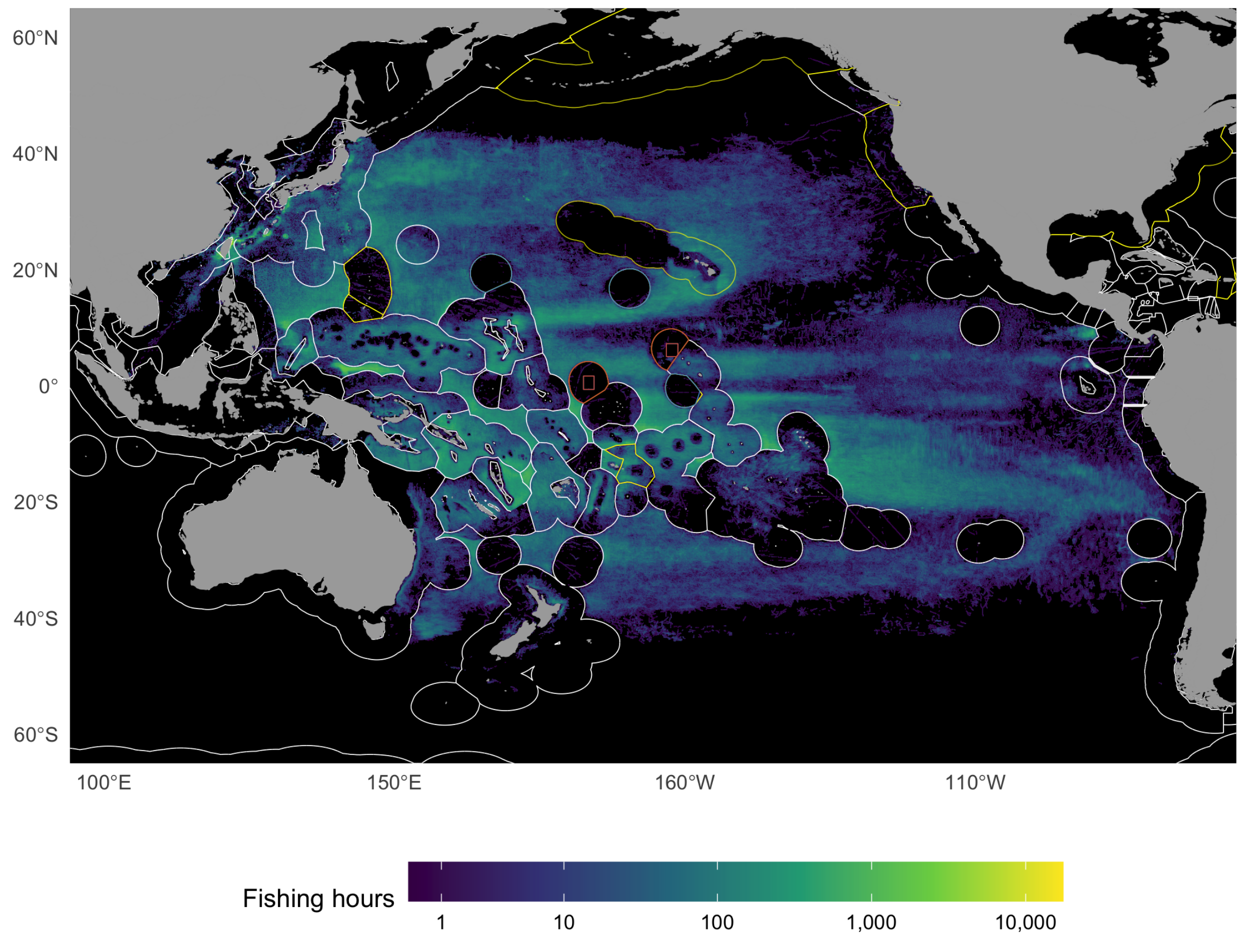

Figure 10: Drifting longline fishing effort (hours) across the entire Pacific, aggregated across flags and most recent 5 years (2018-2022). The current PRI Monument area is shown as a blue outline, the additional proposed Sanctuary protections are show as a red outline, the US EEZ is shown as a yellow outline, and all other EEZs are shown as white outlines.

The next map also shows drifting longline effort across the entire Pacific, but this time only looking at US-flagged drifting longline vessels (Figure 11).

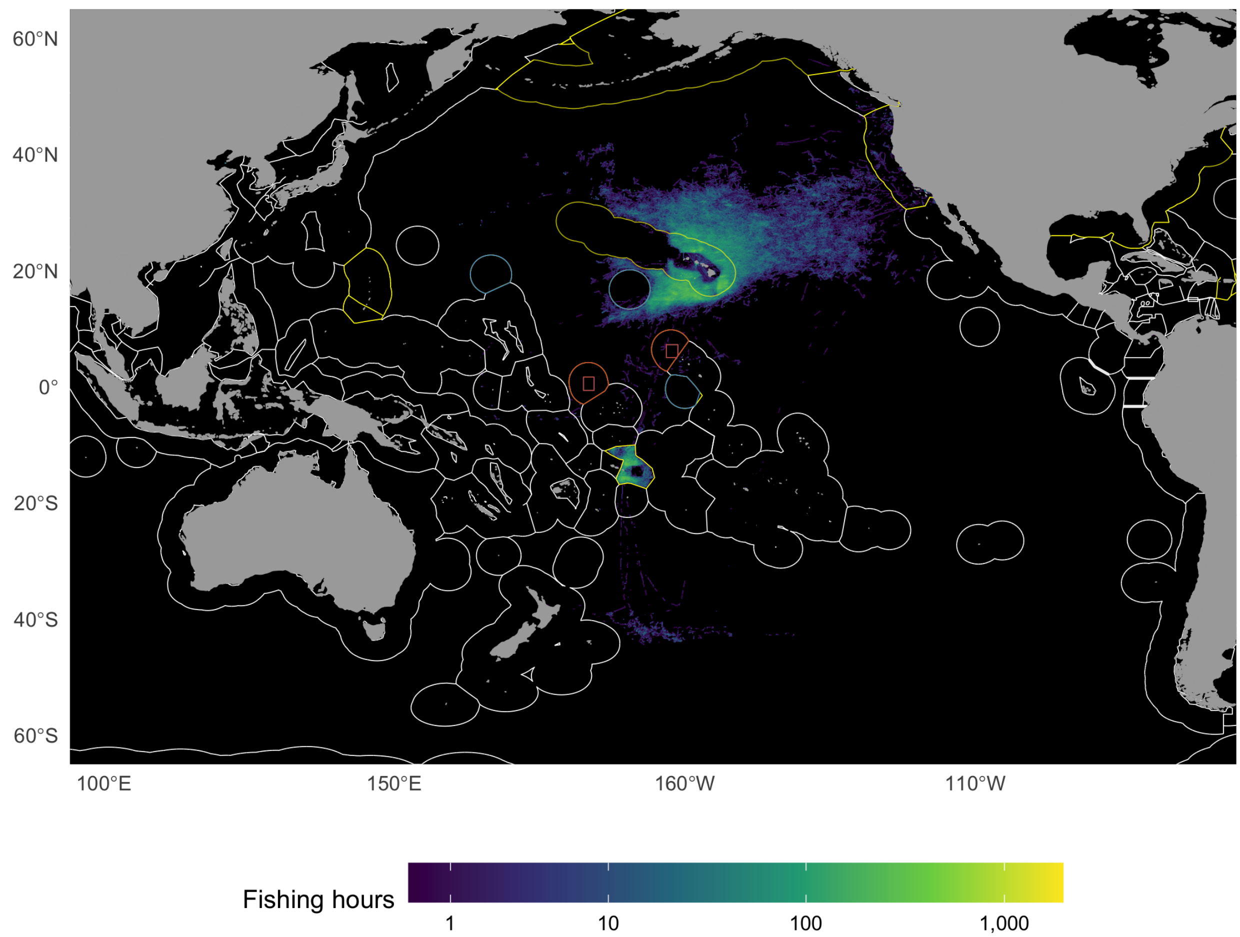

Figure 11: Drifting longline fishing effort (hours) across the entire Pacific, aggregated across US-flagged vessels and most recent 5 years (2018-2022). The current PRI Monument area is shown as a blue outline, the additional proposed Sanctuary protections are show as a red outline, the US EEZ is shown as a yellow outline, and all other EEZs are shown as white outlines.

Next we zoom in to the PRI area, first looking at effort by drifting longlines across all flags (Figure 12).

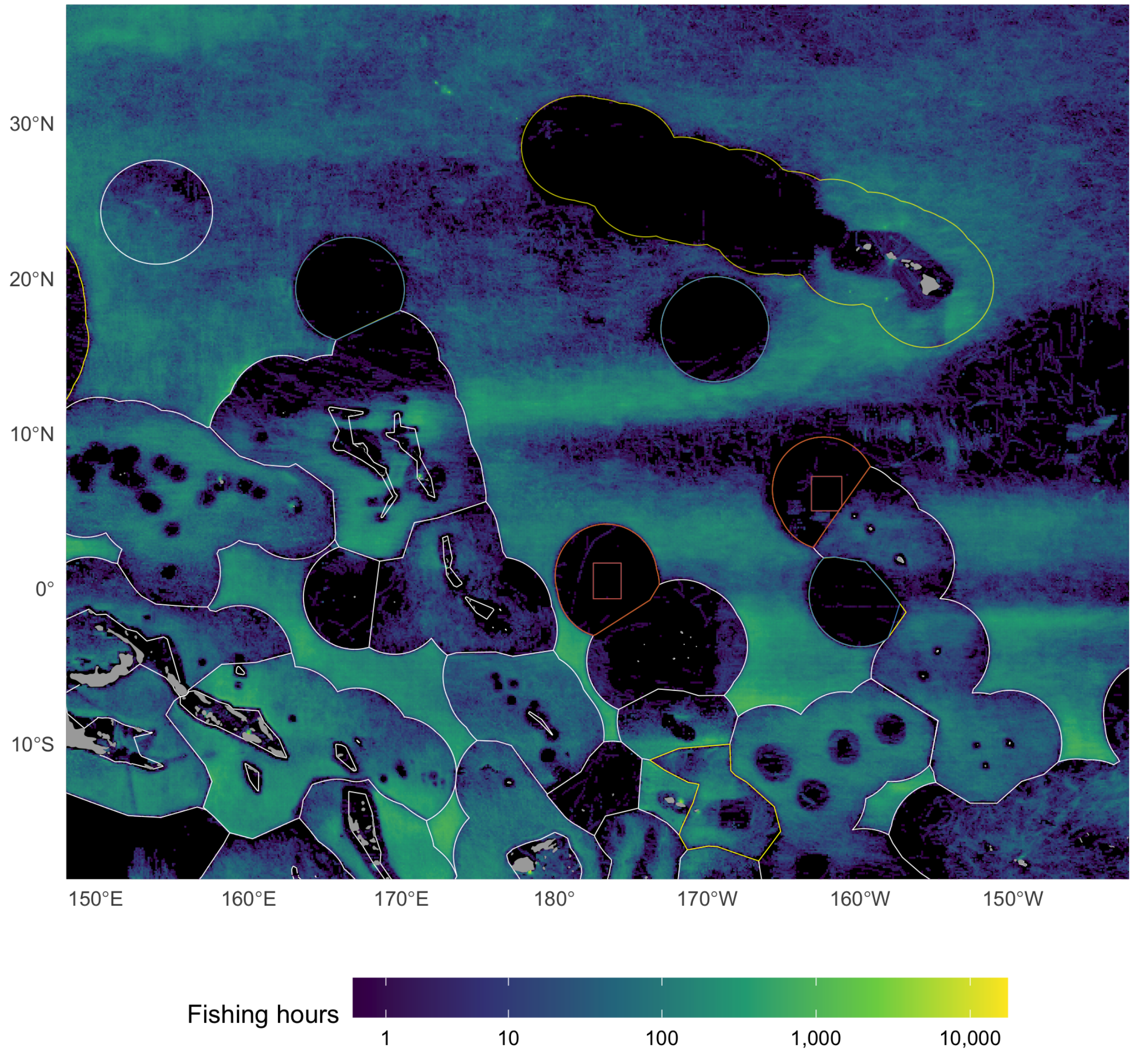

Figure 12: Drifting longline fishing effort (hours) in and around the proposed Sanctuary, aggregated across all flags and most recent 5 years (2018-2022). The current PRI Monument area is shown as a blue outline, the additional proposed Sanctuary protections are show as a red outline, the US EEZ is shown as a yellow outline, and all other EEZs are shown as white outlines.

The next map also shows drifting longline effort in the PRI region, but this time only looking at US-flagged drifting longline vessels (Figure 13).

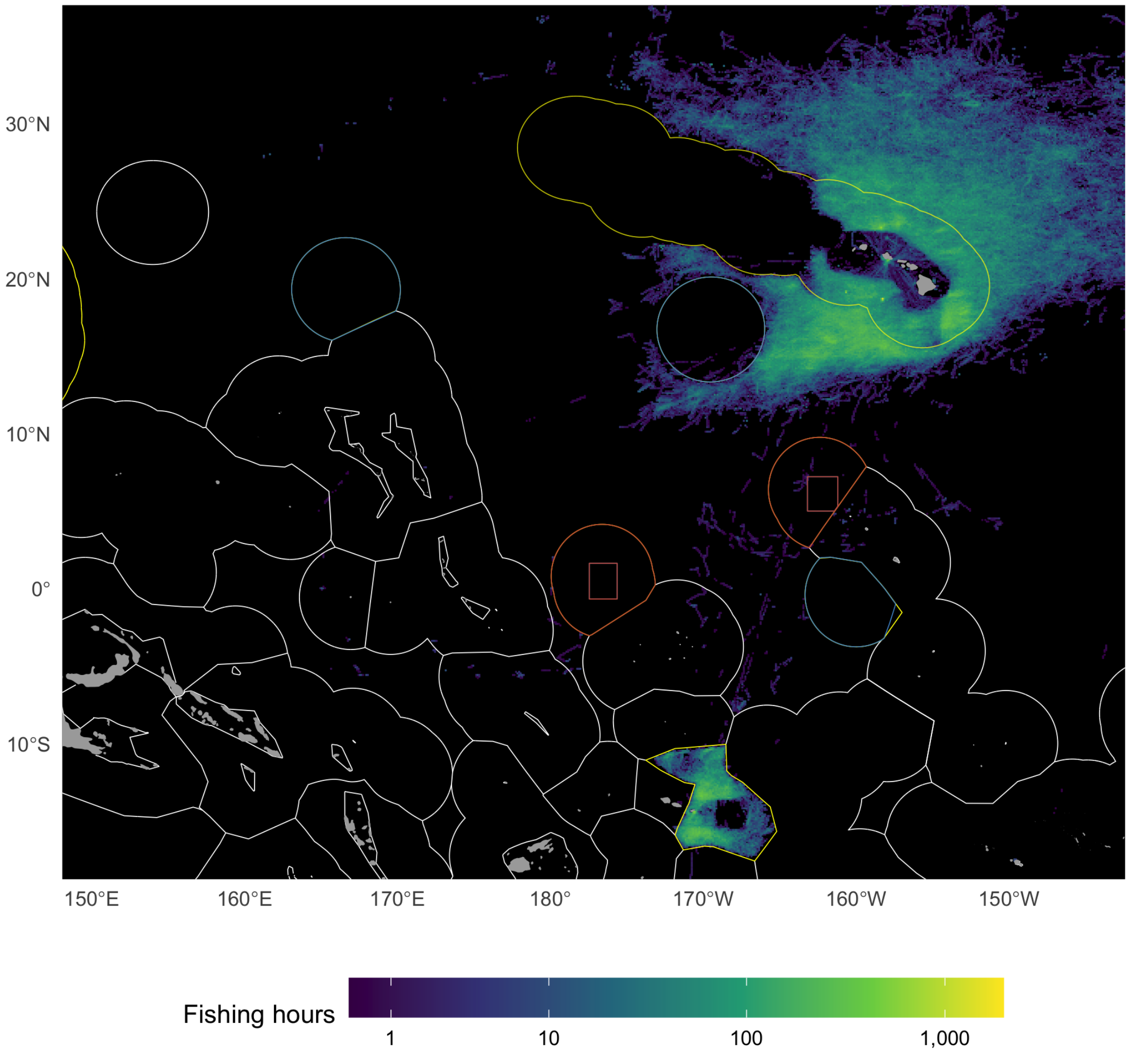

Figure 13: Driftling longline fishing effort (hours) in and around the proposed Sanctuary, aggregated across US-flagged vessels and most recent 5 years (2018-2022). The current PRI Monument area is shown as a blue outline, the additional proposed Sanctuary protections are show as a red outline, the US EEZ is shown as a yellow outline, and all other EEZs are shown as white outlines.

In the final map of this section, we zoom back out to the entire Pacific region. This map only includes US-flagged driftling longline vessels that were ever observed fishing within the proposed Sanctuary area between 2018-2022 (Figure 14). This map therefore shows the general spatial fishing distribution of US-flagged purse seines that have recently used the proposed PRI Sanctuary area for fishing.

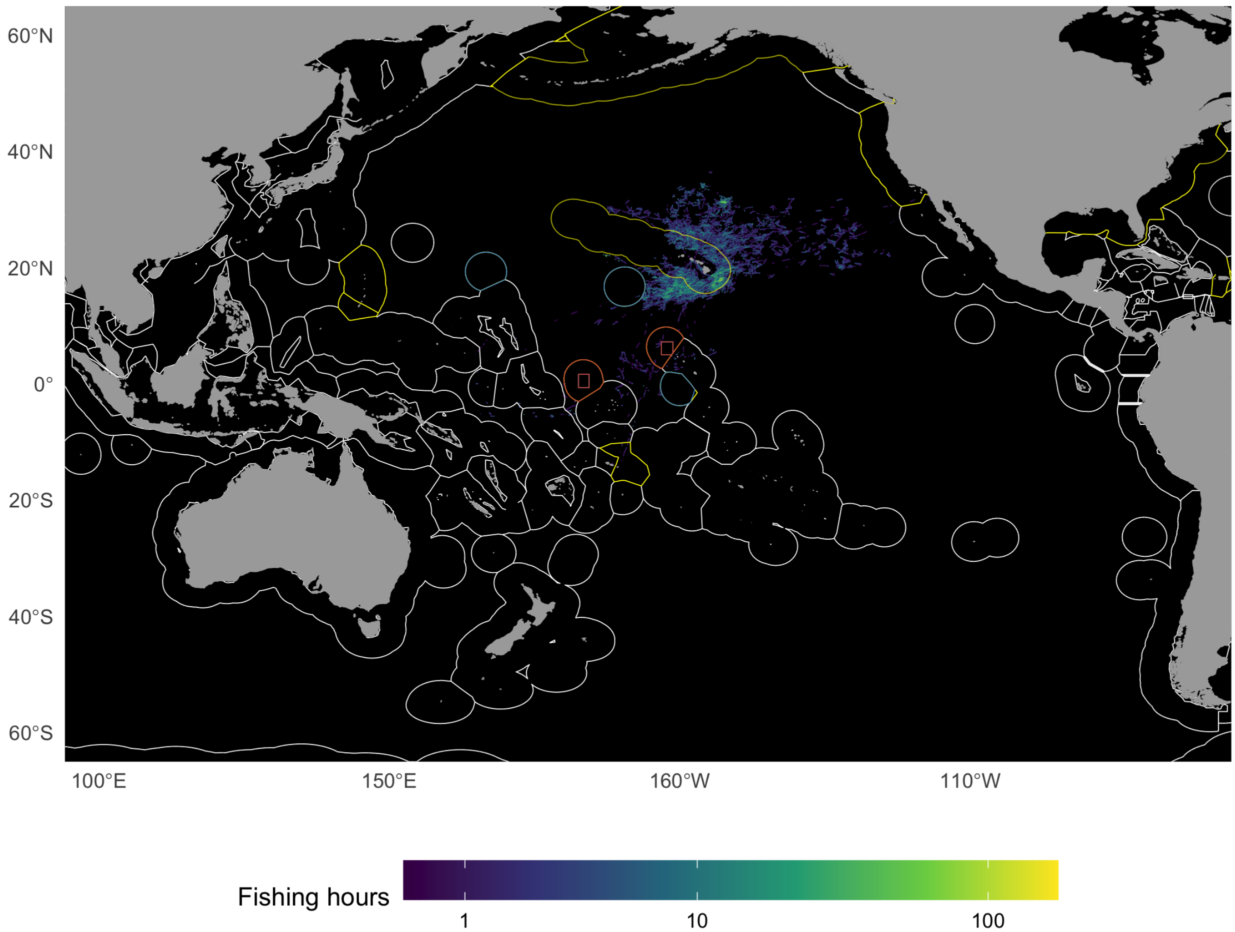

Figure 14: Drifting longline fishing effort (hours) across the entire Pacific, aggregated across most recent 5 years (2018-2022), subsetting to just those US-flagged vessels that were observed to fish within the proposed Sanctuary sometime between 2018-2022. The current PRI Monument area is shown as a blue outline, the additional proposed Sanctuary protections are show as a red outline, the US EEZ is shown as a yellow outline, and all other EEZs are shown as white outlines.

Next we look at the time series trend of US-flagged drifting longline fishing effort inside and outside the proposed Sanctuary boundaries (Figure 15 and Table 3). The top panel shows absolute fishing effort (hours) inside and outside the proposed Sanctuary over time; the bottom panel shows the percent of fishing effort over time that occurred within the proposed Sanctuary. Between 2013 and 2022, the percentage of fishing effort by this fleet that occurred within the proposed Sanctuary out of the entire Pacific ranged from 0% to 0.08% in any given year. Looking across all years from 2013 to 2022, 0.02% of the US drifting longline fleet's fishing effort was spent inside the proposed protected area.

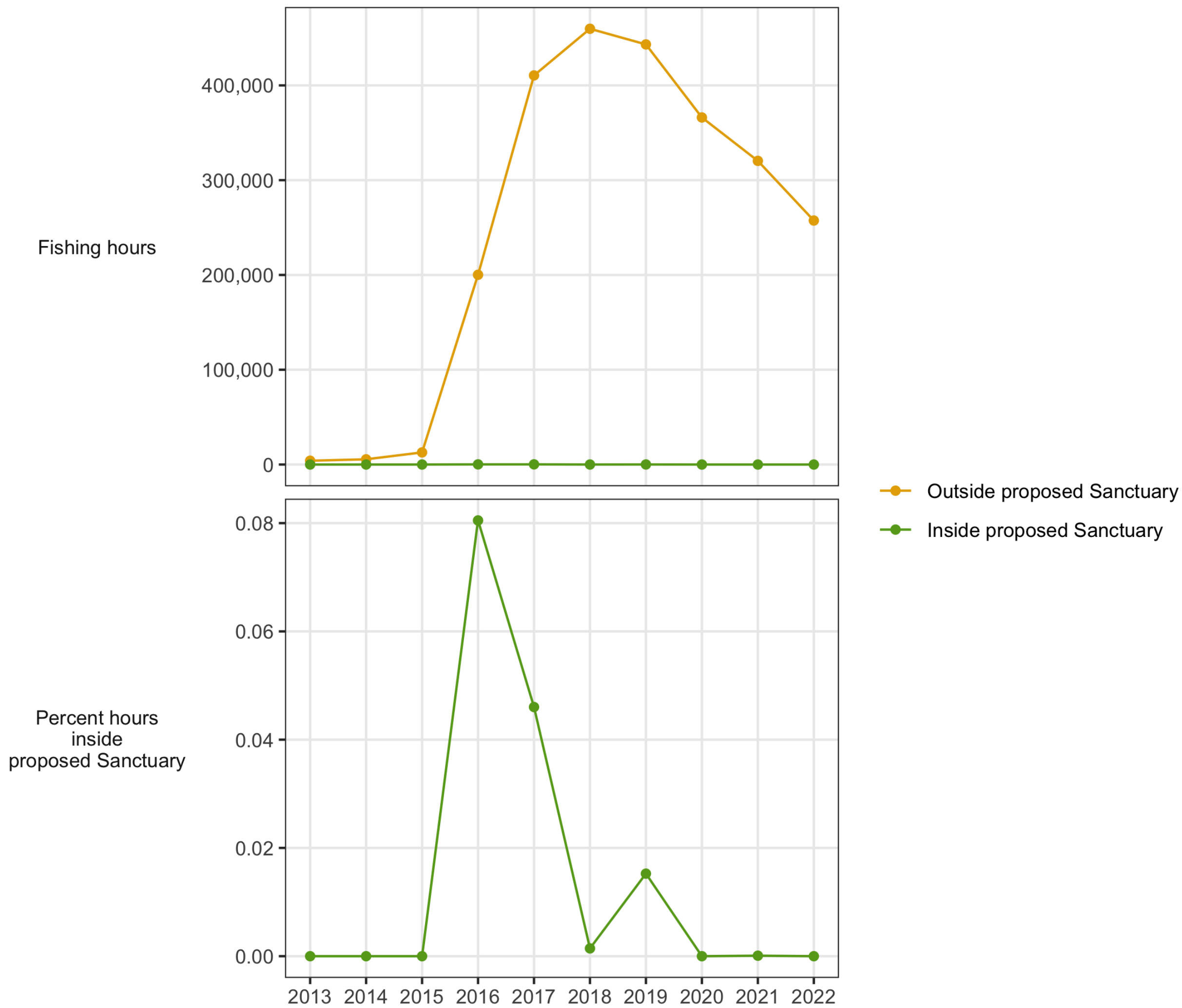

Figure 15: Drifting longline fishing effort (hours) over time inside the proposed Sanctuary by the US-flagged fleet; outside the proposed Sanctuary across the entire Pacific; and the percent of fishing effort inside the proposed Sanctuary out of the entire Pacific.

Table 3: Drifting longlines fishing effort (hours) over time inside the proposed Sanctuary by the US-flagged fleet; outside the proposed Sanctuary across the entire Pacific; and the percent of fishing effort inside the proposed Sanctuary out of the entire Pacific. The second to last row summarizes across the last 5 years (2018-2022), and the last row summarizes across all years.

Year	**Hours inside Sanctuary**	**Hours Outside Sanctuary**	**Percent hours inside Sanctuary**
2013	0.00	4,015.56	0.00
2014	0.00	5,509.79	0.00
2015	0.00	12,789.67	0.00
2016	161.26	200,176.13	0.08
2017	189.03	410,500.81	0.05
2018	6.62	459,725.47	0.00
2019	67.60	443,222.08	0.02
2020	0.00	366,130.17	0.00
2021	0.30	320,353.27	0.00
2022	0.00	257,399.57	0.00
Last 5 years (2018-2022)	**74.51**	**1,846,830.56**	**0.00**
Across all years	**424.81**	**2,479,822.52**	**0.02**

Next we look at the time series trend of the number of unique US-flagged drifting longline fishing vessels fishing inside and outside the proposed Sanctuary boundaries (Figure 16 and Table 4). The top panel shows absolute number of unique vessels fishing inside and outside the proposed Sanctuary over time; the bottom panel shows the percent of unique vessels over time that fished within the proposed Sanctuary. Between 2013 and 2022, the percentage of vessels in this fleet that fished within the proposed Sanctuary out of the entire Pacific ranged from 0% to 3.21% in any given year. Looking across all years from 2013 to 2022, 6.25% of the US purse seine vessels fished inside the proposed protected area.

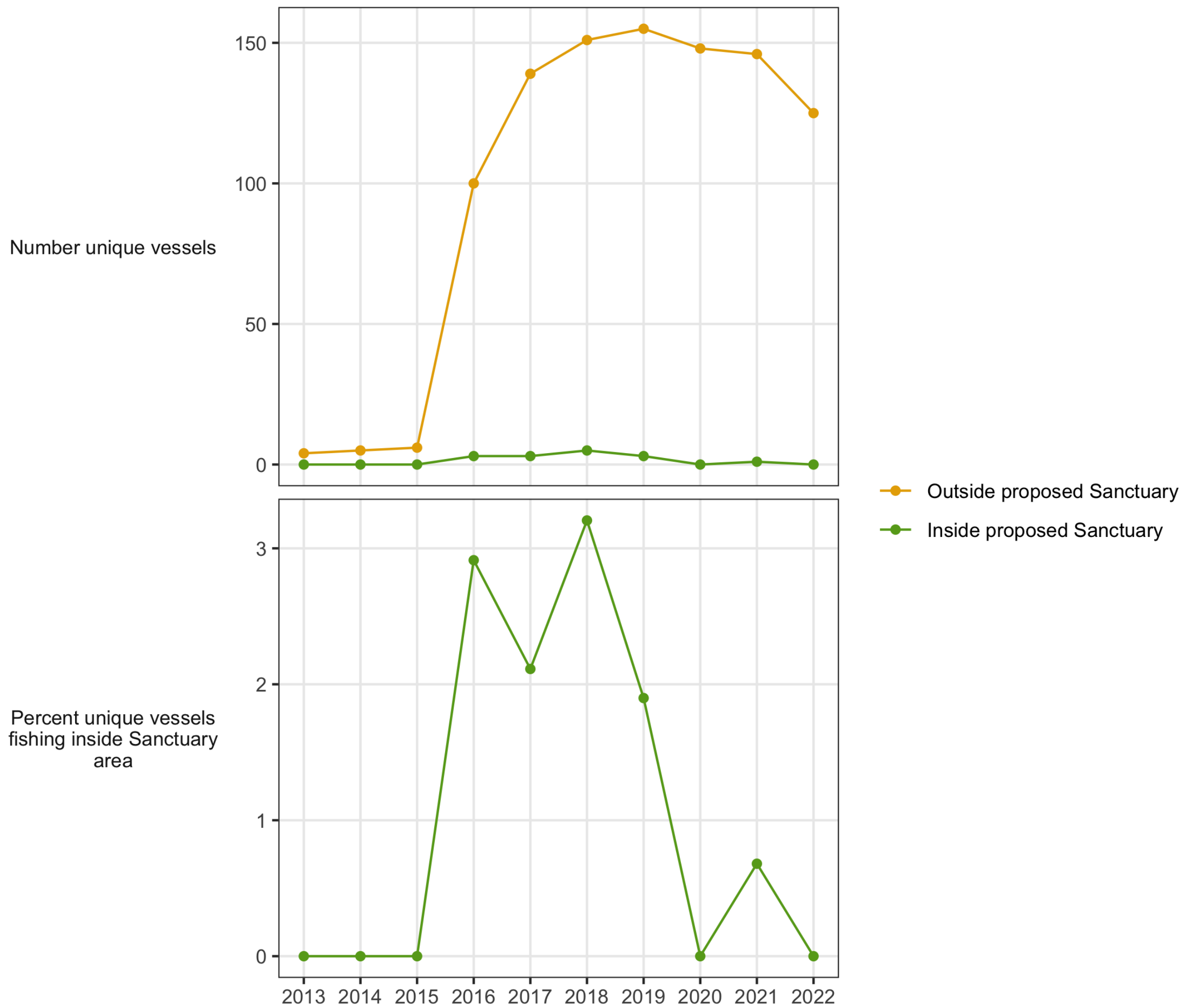

Figure 16: Number of unique drifting longline vessels fishing over time inside the proposed Sanctuary by the US-flagged fleet; outside the proposed Sanctuary across the entire Pacific; and the percent of fishing effort inside the proposed Sanctuary out of the entire Pacific.

Table 4: Number of unique drifting longlines vessels fishing over time inside the proposed Sanctuary by the US-flagged fleet; outside the proposed Sanctuary across the entire Pacific; and the percent of fishing effort inside the proposed Sanctuary out of the entire Pacific. The second to last row summarizes across the last 5 years (2018-2022), and the last row summarizes across all years.

Year	**Vessels inside Sanctuary**	**Vessels Outside proposed Sanctuary**	**Percent vessels inside Sanctuary**
2013	0	4	0.00
2014	0	5	0.00
2015	0	6	0.00
2016	3	100	2.91
2017	3	139	2.11
2018	5	151	3.21
2019	3	155	1.90
2020	0	148	0.00
2021	1	146	0.68
2022	0	125	0.00
Last 5 years (2018-2022)	**8**	**184**	**4.17**
Across all years	**13**	**195**	**6.25**

4.2 Analysis of historic activity associated with Pago Pago, the location of the AS tuna cannery

This section will focus only on fishing activity that occurred during fishing trips that landed in Pago Pago, the location of the tuna cannery in American Samoa. First we look at a map of the Pacific of purse seine and drifting longline fishing effort, only focusing on those fishing trips that landed in Pago Pago. We aggregate across the last 5 years (2018-2022), and disaggregate by fishing flag (either US-flagged vessels, or all other flags).

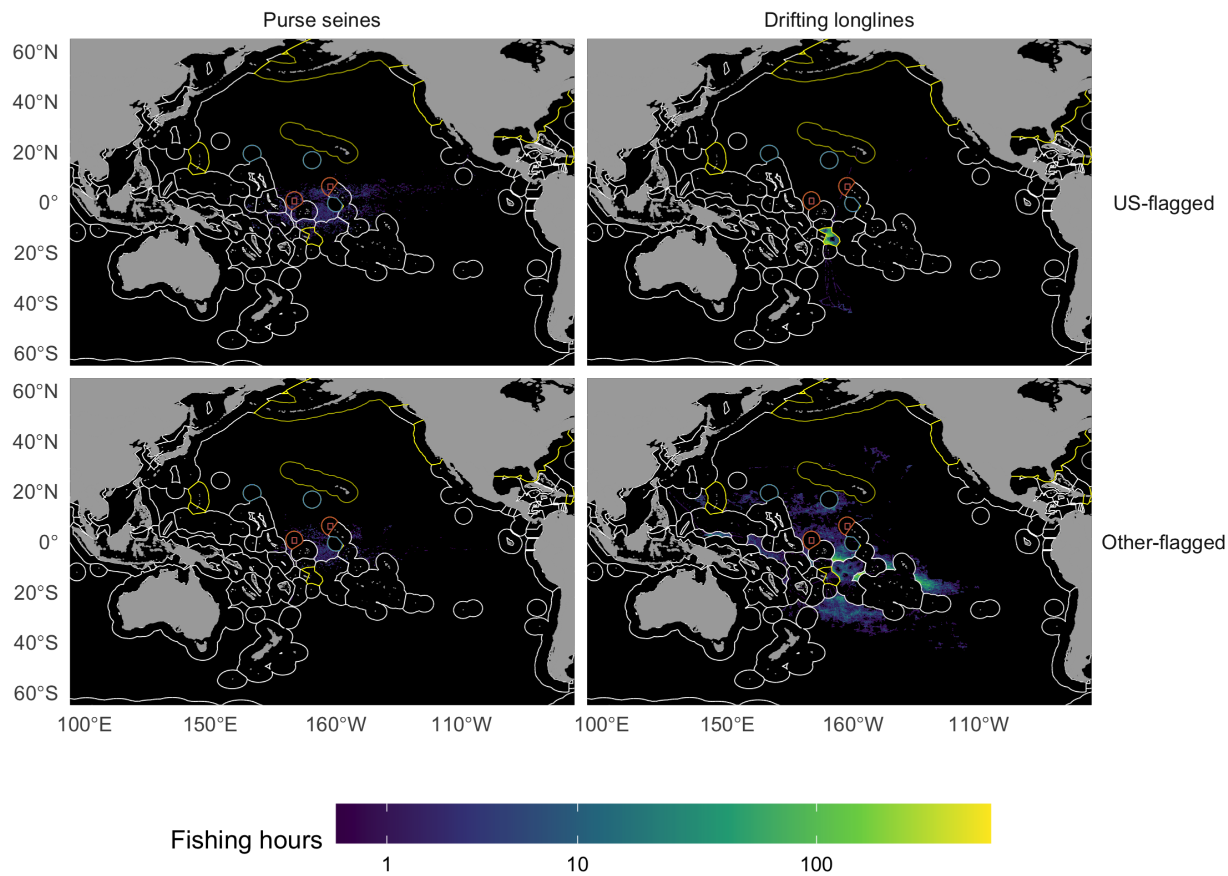

Figure 17: Purse seine and drifting longline fishing effort (hours) across the entire Pacific, aggregated across the last 5 years (2018-2022), and only for trips that landed in Pago Pago. The current PRI Monument area is shown as a blue outline, the additional proposed Sanctuary protections are show as a red outline, the US EEZ is shown as a yellow outline, and all other EEZs are shown as white outlines. Pago Pago is shown as a yellow cross.

Next we look at the time series trend of US-flagged purse seine fishing effort inside and outside the proposed Sanctuary boundaries for trips that ended in Pago Pago, American Samoa (Figure 18, Table 5). The top panel shows absolute fishing effort (hours) inside and outside the proposed Sanctuary over time; the bottom panel shows the percent of fishing effort over time that occurred within the proposed Sanctuary. Between 2013 and 2022, the percentage of of fishing effort from US purse seine vessels landing in Pago Pago that was spent inside the proposed protected area ranged from 0.4% to 10.73% in any given year. Looking across all years from 2013 to 2022, 2.65% of fishing effort from US purse seine vessels landing in Pago Pago was spent inside the proposed protected area.

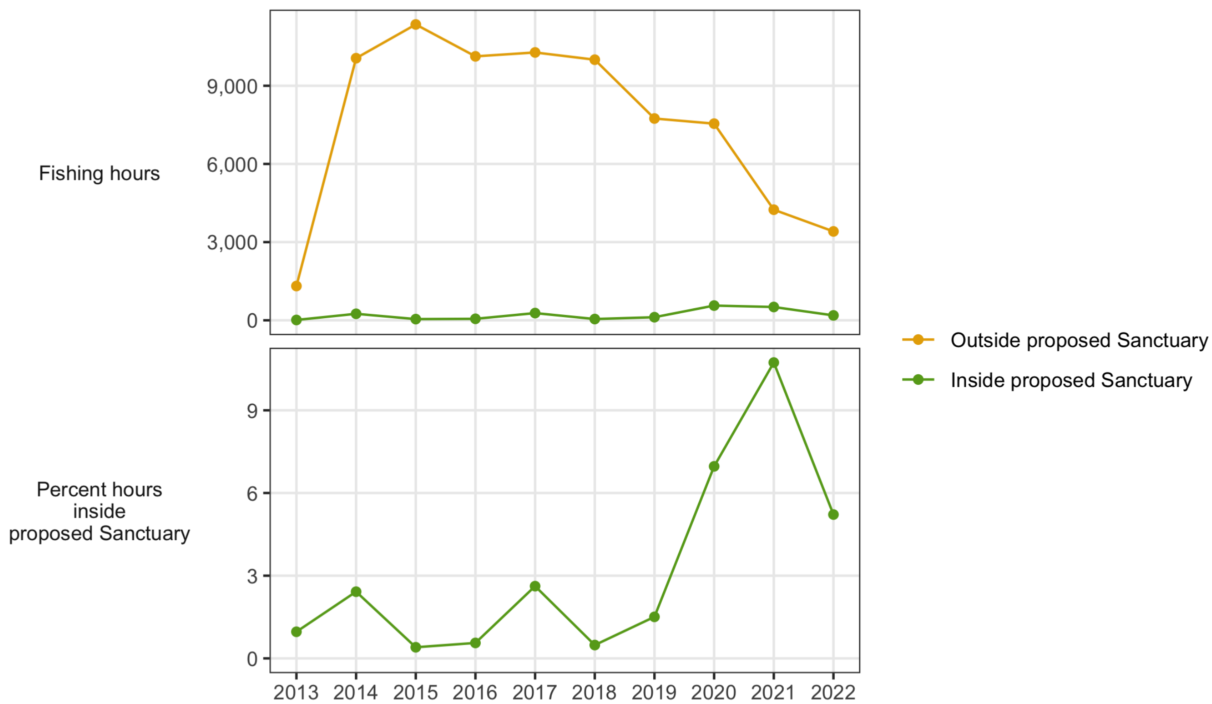

Figure 18: Purse seine fishing effort (hours) over time inside the proposed Sanctuary by the US-flagged fleet on trips ending in Pago Pago; outside the proposed Sanctuary across the entire Pacific; and the percent of fishing effort inside the proposed Sanctuary out of the entire Pacific.

Table 5: Purse seines fishing effort (hours) over time inside the proposed Sanctuary by the US-flagged fleet on trips ending in Pago Pago; outside the proposed Sanctuary across the entire Pacific; and the percent of fishing effort inside the proposed Sanctuary out of the entire Pacific. The second to last row summarizes across the last 5 years (2018-2022), and the last row summarizes across all years.

Year	**Hours inside Sanctuary**	**Hours Outside Sanctuary**	**Percent hours inside Sanctuary**
2013	12.82	1,314.75	0.97
2014	249.41	10,057.70	2.42
2015	45.97	11,352.58	0.40
2016	57.09	10,128.39	0.56
2017	276.57	10,278.65	2.62
2018	48.54	9,999.94	0.48
2019	118.49	7,743.94	1.51
2020	565.05	7,546.00	6.97
2021	510.26	4,243.98	10.73
2022	187.75	3,410.24	5.22
Last 5 years (2018-2022)	**1,430.11**	**32,944.11**	**4.16**
Across all years	**2,071.96**	**76,076.17**	**2.65**

Next we look at the time series trend of US-flagged drifting longline fishing effort inside and outside the proposed Sanctuary boundaries for trips that ended in Pago Pago, American Samoa (Figure 19, Table 6). The top panel shows absolute fishing effort (hours) inside and outside the proposed Sanctuary over time; the bottom panel shows the percent of fishing effort over time that occurred within the proposed Sanctuary. Between 2013 and 2022, the percentage of of fishing effort from US drifting longline vessels landing in Pago Pago that was spent inside the proposed protected area ranged from 0% to 0.01% in any given year. Looking across all years from 2013 to 2022, 0% of fishing effort from US drifting longline vessels landing in Pago Pago was spent inside the proposed protected area.

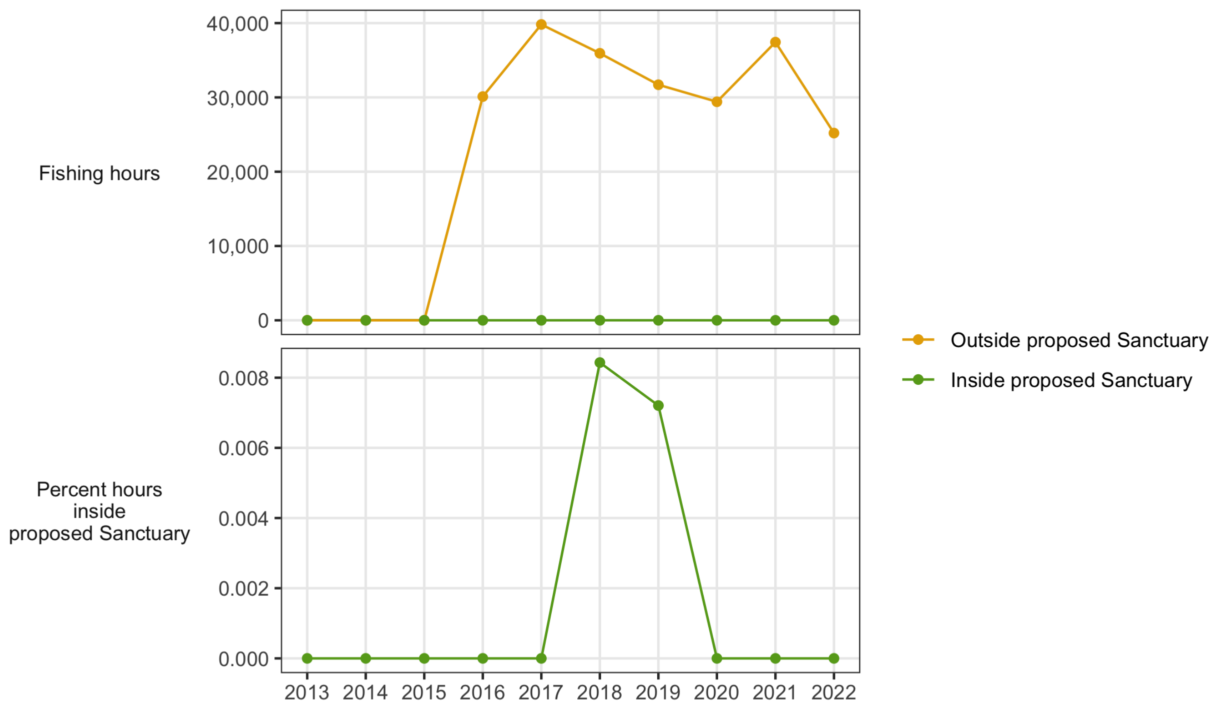

Figure 19: Drifting longline fishing effort (hours) over time inside the proposed Sanctuary by the US-flagged fleet on trips ending in Pago Pago; outside the proposed Sanctuary across the entire Pacific; and the percent of fishing effort inside the proposed Sanctuary out of the entire Pacific.

Table 6: Drifting longlines fishing effort (hours) over time inside the proposed Sanctuary by the US-flagged fleet on trips ending in Pago Pago; outside the proposed Sanctuary across the entire Pacific; and the percent of fishing effort inside the proposed Sanctuary out of the entire Pacific. The second to last row summarizes across the last 5 years (2018-2022), and the last row summarizes across all years.

Year	**Hours inside Sanctuary**	**Hours Outside Sanctuary**	**Percent hours inside Sanctuary**
2013	0.00	0.00	0.00
2014	0.00	0.00	0.00
2015	0.00	0.00	0.00
2016	0.00	30,112.35	0.00
2017	0.00	39,818.17	0.00
2018	3.03	35,940.29	0.01
2019	2.29	31,706.11	0.01
2020	0.00	29,411.68	0.00
2021	0.00	37,438.46	0.00
2022	0.00	25,199.51	0.00
Last 5 years (2018-2022)	**5.32**	**159,696.05**	**0.00**
Across all years	**5.32**	**229,626.57**	**0.00**

Next we look at time series trends of the EEZ regions that US purse seine vessels fished in before landing in Pago Pago (Figure 20 and Table 7). We look at both EEZ regions inside and outside the proposed Sanctuary. We disaggregate each US EEZ area (e.g., American Samoa and Hawaii), aggregate all other non-US EEZs, and also look at the high seas. In any given year, most fishing by the US purse seine fleet occurs in the high seas or non-US EEZs, both of which are outside the proposed Sanctuary. Between 2018-2022 for trips landing in Pago Pago, 60.24% of the US purse seine fishing effort occurred on the high seas, and 33.54% occurred in non-US EEZs. These non-US EEZs were (in alphabetical order) Clipperton Island, Cook Islands, Costa Rica, Ecuador, Fiji, French Polynesia, Gilbert Islands, Line Group, Marshall Islands, Mexico, Micronesia, Nauru, New Zealand, Papua New Guinea, Phoenix Group, Samoa, Solomon Islands, Tokelau, Tonga, Tuvalu, Vanuatu, and Wallis and Futuna.

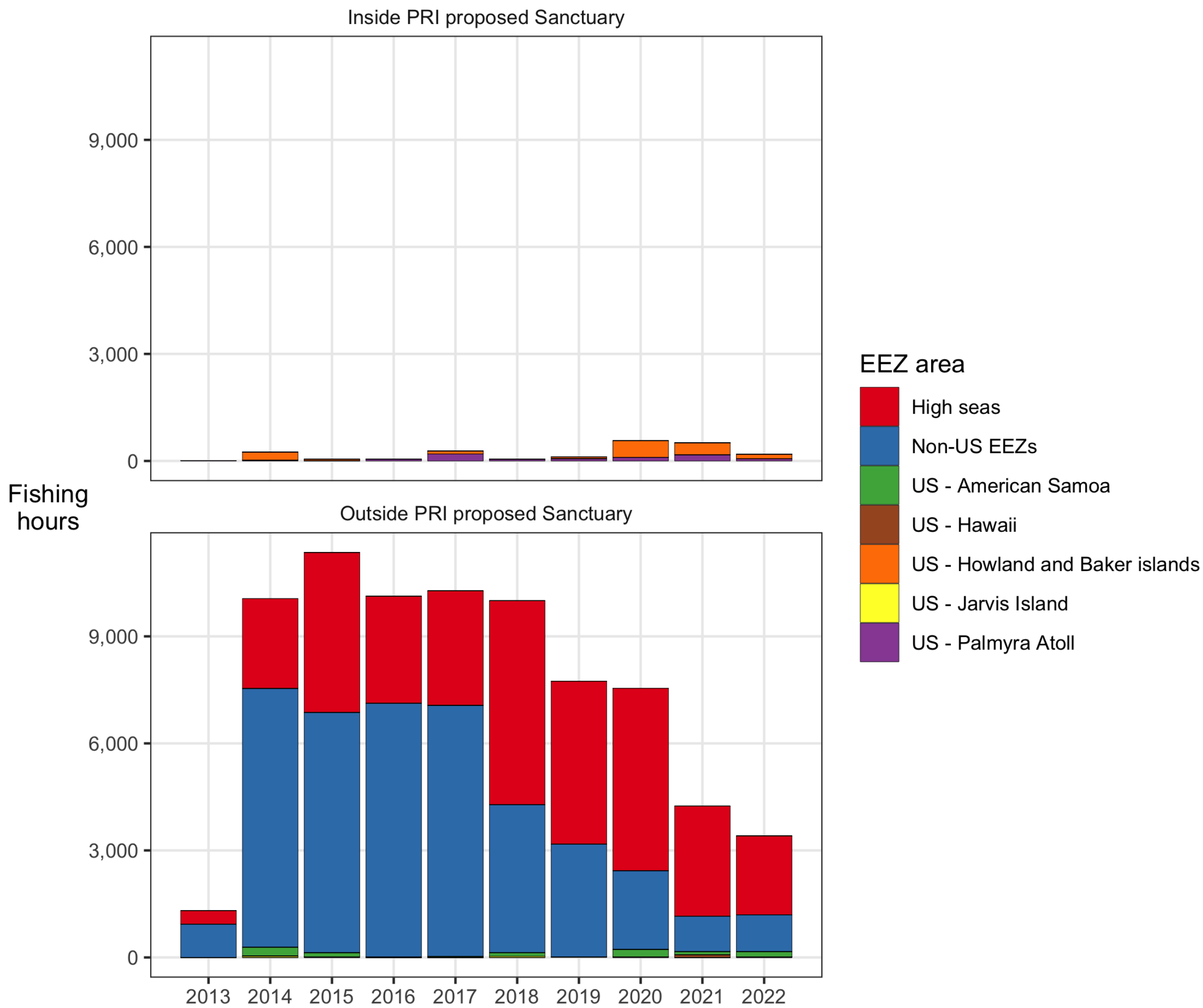

Figure 20: Purse seine fishing effort (hours) over time for trips that landed in Pago Pago, by the US-flagged fleet, and looking across all EEZs and the high seas (non-US EEZs are grouped together as 'Non-US EEZs'). The top panel shows trends for areas inside the proposed Sanctuary, the bottom panel shows trends for areas outside the proposed Sanctuary. The fill of the bars represents either different US EEZ areas, the high seas, or non-US EEZs.

Table 7: Purse seines fishing effort (hours) aggregated across the last 5 years (2018-2022) for trips that landed in Pago Pago, by the US-flagged fleet, and looking across all EEZs and the high seas (non-US EEZs are grouped together as 'Non-US EEZs').

EEZ area	**Inside currently unprotected area proposed as a Sanctuary**	**Hours fishing in area**	**Percent total hours**
US - American Samoa	No	565.66	1.65
US - Hawaii	No	85.70	0.25
US - Howland and Baker islands	No	3.76	0.01
US - Howland and Baker islands	Yes	989.05	2.88
US - Jarvis Island	No	46.74	0.14
US - Palmyra Atoll	No	6.81	0.02
US - Palmyra Atoll	Yes	441.06	1.28
High seas	No	20,707.20	60.24
Non-US EEZs	No	11,528.24	33.54

Next we look at time series trends of the EEZ regions that US drifting longline vessels fished in before landing in Pago Pago (Figure 21 and Table 8). We look at both EEZ regions inside and outside the proposed Sanctuary. We disaggregate each US EEZ area (e.g., American Samoa and Hawaii), aggregate all other non-US EEZs, and also look at the high seas. In any given year, most fishing by the US drifting longline fleet occurs in the American Samoa EEZ (98.28%), which is outside the proposed Sanctuary. Between 2018-2022 for trips landing in Pago Pago, 1.61% of the US drifting fishing effort occurred on the high seas, and 0.1% occurred in non-US EEZs. These non-US EEZs were (in alphabetical order) Cook Islands, Niue, Samoa, Tokelau, and Tonga.

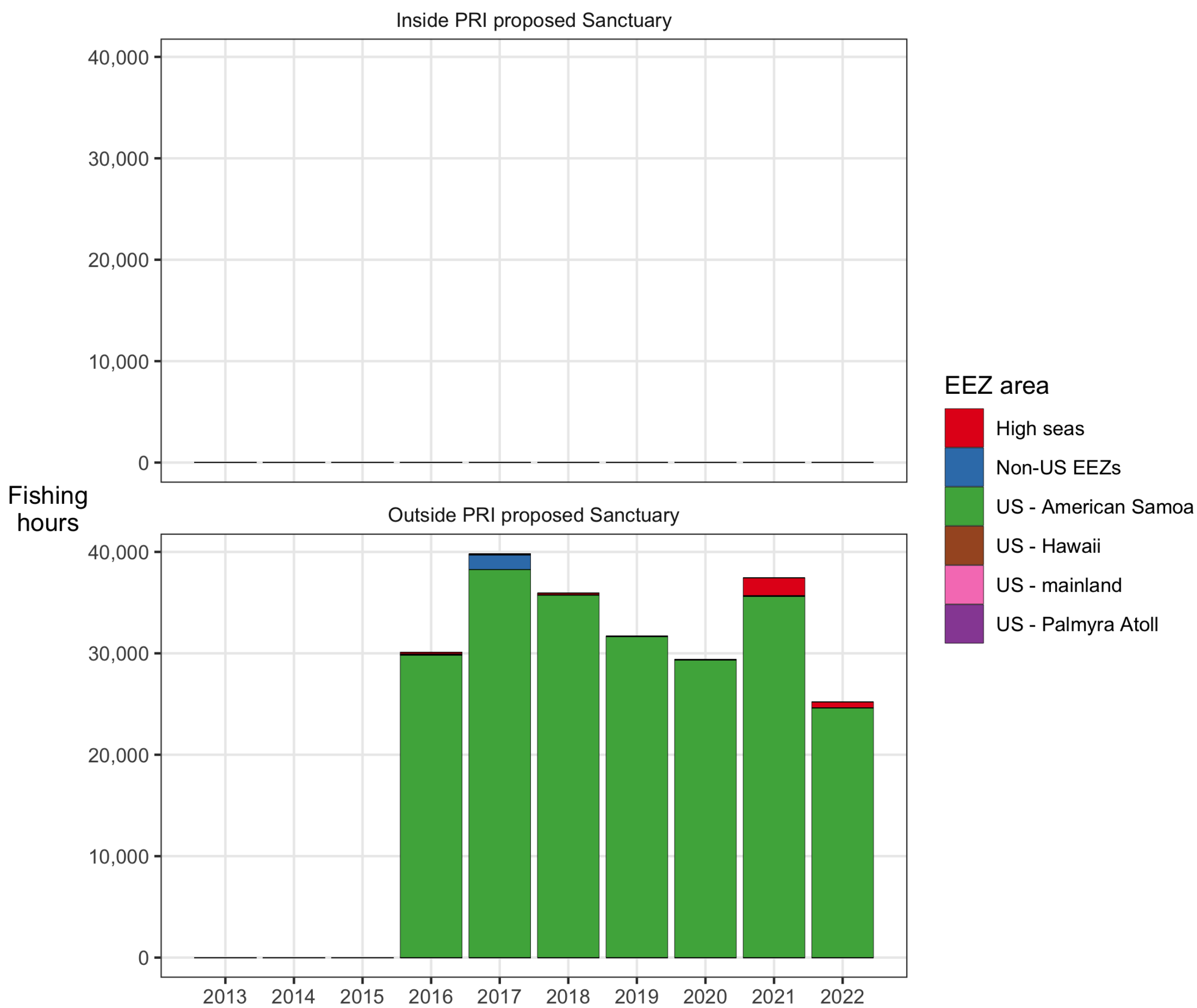

Figure 21: Drifting longline fishing effort (hours) over time for trips that landed in Pago Pago, by the US-flagged fleet, and looking across all EEZs and the high seas (non-US EEZs are grouped together as 'Non-US EEZs'). The top panel shows trends for areas inside the proposed Sanctuary, the bottom panel shows trends for areas outside the proposed Sanctuary. The fill of the bars represents either different US EEZ areas, the high seas, or non-US EEZs.

Table 8: Drifting longlines fishing effort (hours) aggregated across the last 5 years (2018-2022) for trips that landed in Pago Pago, by the US-flagged fleet, and looking across all EEZs and the high seas (non-US EEZs are grouped together as 'Non-US EEZs').

EEZ area	**Inside currently unprotected area proposed as a Sanctuary**	**Hours fishing in area**	**Percent total hours**
US - American Samoa	No	156,950.88	98.28
US - Hawaii	No	11.72	0.01
US - Palmyra Atoll	Yes	5.32	0.00
High seas	No	2,571.25	1.61
Non-US EEZs	No	162.19	0.10

Next we look at time series trends of effort before landing in Pago Pago, by both the US-flagged purse seine fleet as well as purse seines from all other flags fished in (Figure 22 and Table 9). We disaggregate effort by whether or not it occured within the proposed additional Sanctuary boundaries. Beteween 2018-2022, 25.03% of purse seine fishing effort landing in Pago Pago harbor was from other non-US flags.

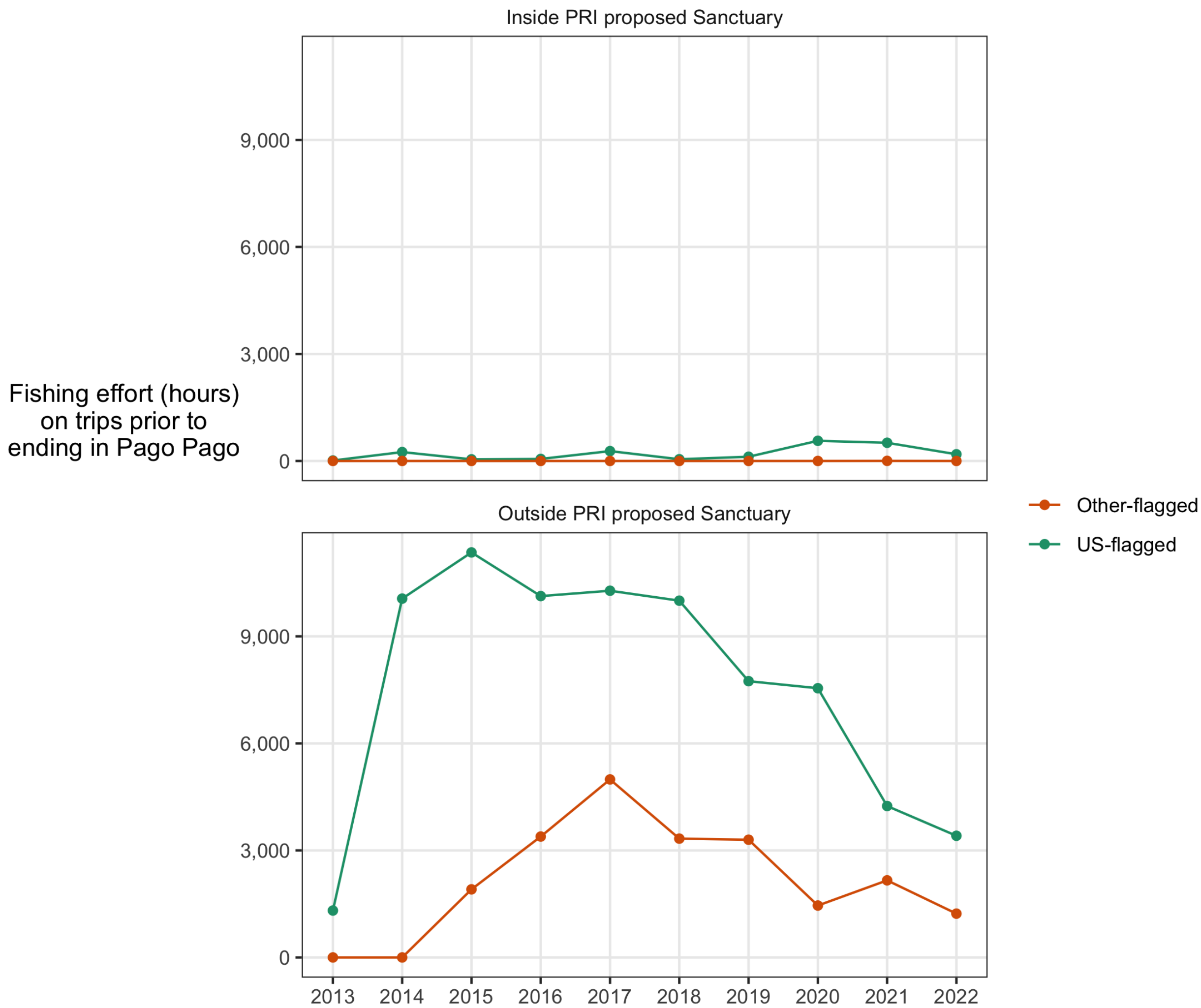

Figure 22: Purse seine fishing effort (hours) over time for trips that landed in Pago Pago, by the US-flagged fleet and by all other fishing flags. The top panel shows trends for areas inside the proposed Sanctuary, the bottom panel shows trends for areas outside the proposed Sanctuary.

Table 9: Purse seines fishing effort (hours) aggregated across the last 5 years (2018-2022) for trips that landed in Pago Pago, by either the US-flagged fleet or by all other flags, disaggregating by effort inside and outside the proposed additional Sanctuary area.

Flag	**Inside currently unprotected area proposed as a Sanctuary**	**Hours fishing in area**	**Percent total hours**
US-flagged	No	32,944.11	71.85
US-flagged	Yes	1,430.11	3.12
Other-flagged	No	11,472.39	25.02
Other-flagged	Yes	2.82	0.01

Next we look at time series trends of effort before landing in Pago Pago, by both the US-flagged drifting longline fleet as well as drifting longlines from all other flags fished in (Figure 23 and Table 10). We disaggregate effort by whether or not it occured within the proposed additional Sanctuary boundaries. Between 2018-2022, 78.75% of drifting longline fishing effort landing in Pago Pago harbor was from other non-US flags.

Figure 23: Drifting longline fishing effort (hours) over time for trips that landed in Pago Pago, by the US-flagged fleet and by all other fishing flags. The top panel shows trends for areas inside the proposed Sanctuary, the bottom panel shows trends for areas outside the proposed Sanctuary.

Table 10: Drifting longlines fishing effort (hours) aggregated across the last 5 years (2018-2022) for trips that landed in Pago Pago, by either the US-flagged fleet or by all other flags, disaggregating by effort inside and outside the proposed additional Sanctuary area.

Flag	**Inside currently unprotected area proposed as a Sanctuary**	**Hours fishing in area**	**Percent total hours**
US-flagged	No	159,696.05	21.25
US-flagged	Yes	5.32	0.00
Other-flagged	No	591,727.91	78.75
Other-flagged	Yes	3.09	0.00

Next we look at the number of trips ending in Pago Pago each year (Figure 24 and Table 11). We look at trips by gear type (purse seines and longlines), as well as for carrier vessels (e.g., reefers). We look at this for both US-flagged vessels, and all other-flagged vessels. Aggregating across 2013-2022, the number of trips for each vessel type and flag were US-flagged purse seines (434), other-flagged purse seines (101), US-flagged drifting longlines (526), other-flagged drifting longlines (588), US-flagged carrier (e.g., reefer) (0), and other-flagged carrier (e.g., reefer) (7). For US-flagged purse seines, there is a generally declining trend since 2014 in the number of trips ending in Pago Pago.

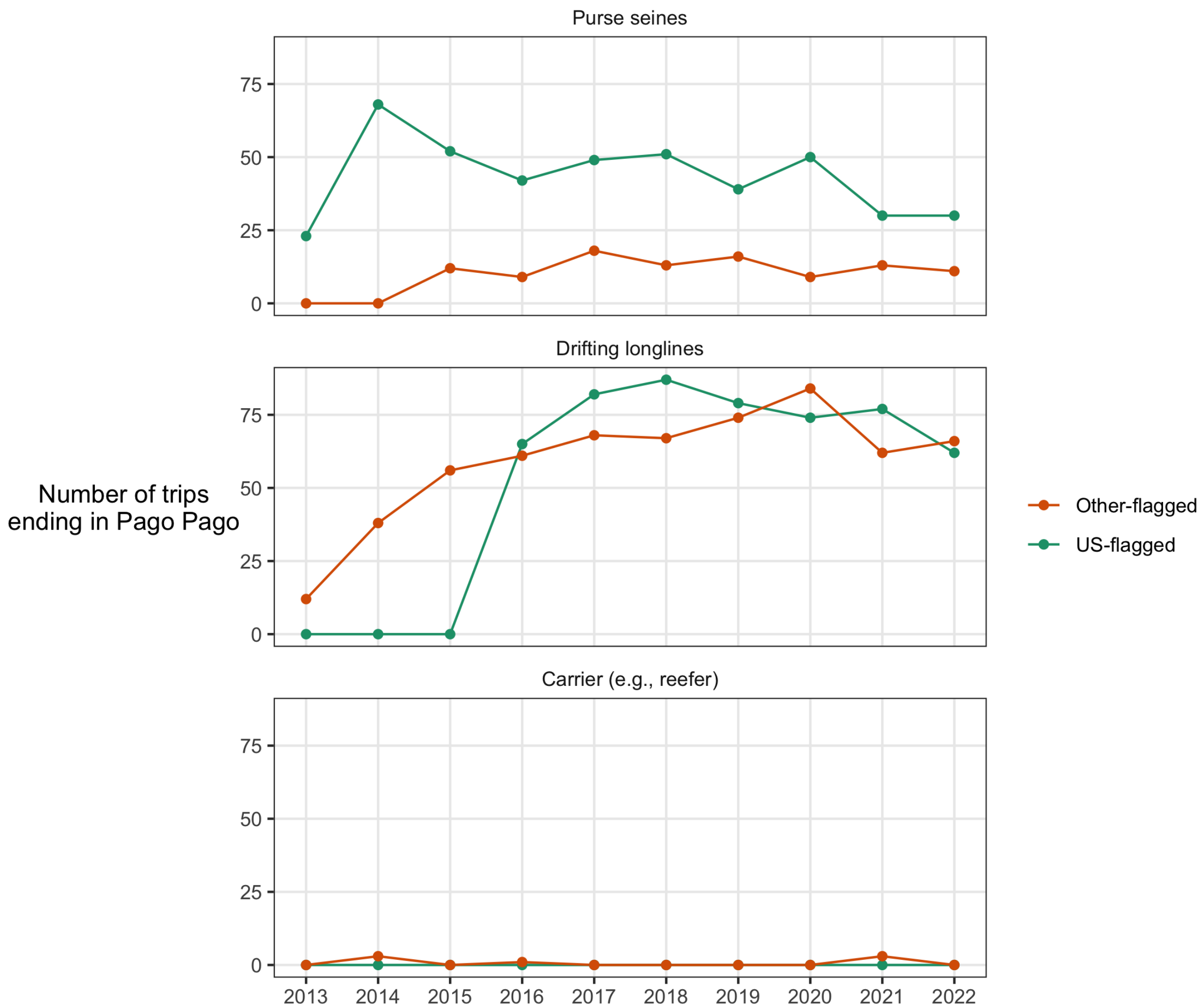

Figure 24: Number of purse seine, drifting longline, and carrier (e.g., reefer) trips ending in Pago Pago each year, for US-flagged vessels and other-flagged vessels.

Table 11: Number of purse seine, drifting longline, and carrier (e.g., reefer) trips ending in Pago Pago each year, for US-flagged vessels and other-flagged vessels. The last row summarizes the total number of trips across years for each gear and flag.

Year	US-flagged purse seines	Other-flagged purse seines	US-flagged drifting longlines	Other-flagged drifting longlines	US-flagged carriers	Other-flagged carriers
2013	23	0	0	12	0	0
2014	68	0	0	38	0	3
2015	52	12	0	56	0	0
2016	42	9	65	61	0	1
2017	49	18	82	68	0	0
2018	51	13	87	67	0	0
2019	39	16	79	74	0	0
2020	50	9	74	84	0	0
2021	30	13	77	62	0	3
2022	30	11	62	66	0	0
Total	434	101	526	588	0	7

We next dive deeper into the activity of carrier vessels (e.g., reefers) prior to landing in Pago Pago. First we look at a map of the location of any vessel-to-vessel encounters that occurred on carrier trips prior to landing in Pago Pago. These represent potential transshipment locations, although whether or not catch was actually transferred cannot be observed using AIS data. Prior to landing in Pago Pago across 3 trips occurring between 2018 and 2022, these carriers encountered 9 unique fishing vessels at sea across 32 unique encounters (i.e., potential transshipment events). There were no observed encounters between carrier and fishing vessels within the proposed Sanctuary across the entire 2013-2022 dataset.

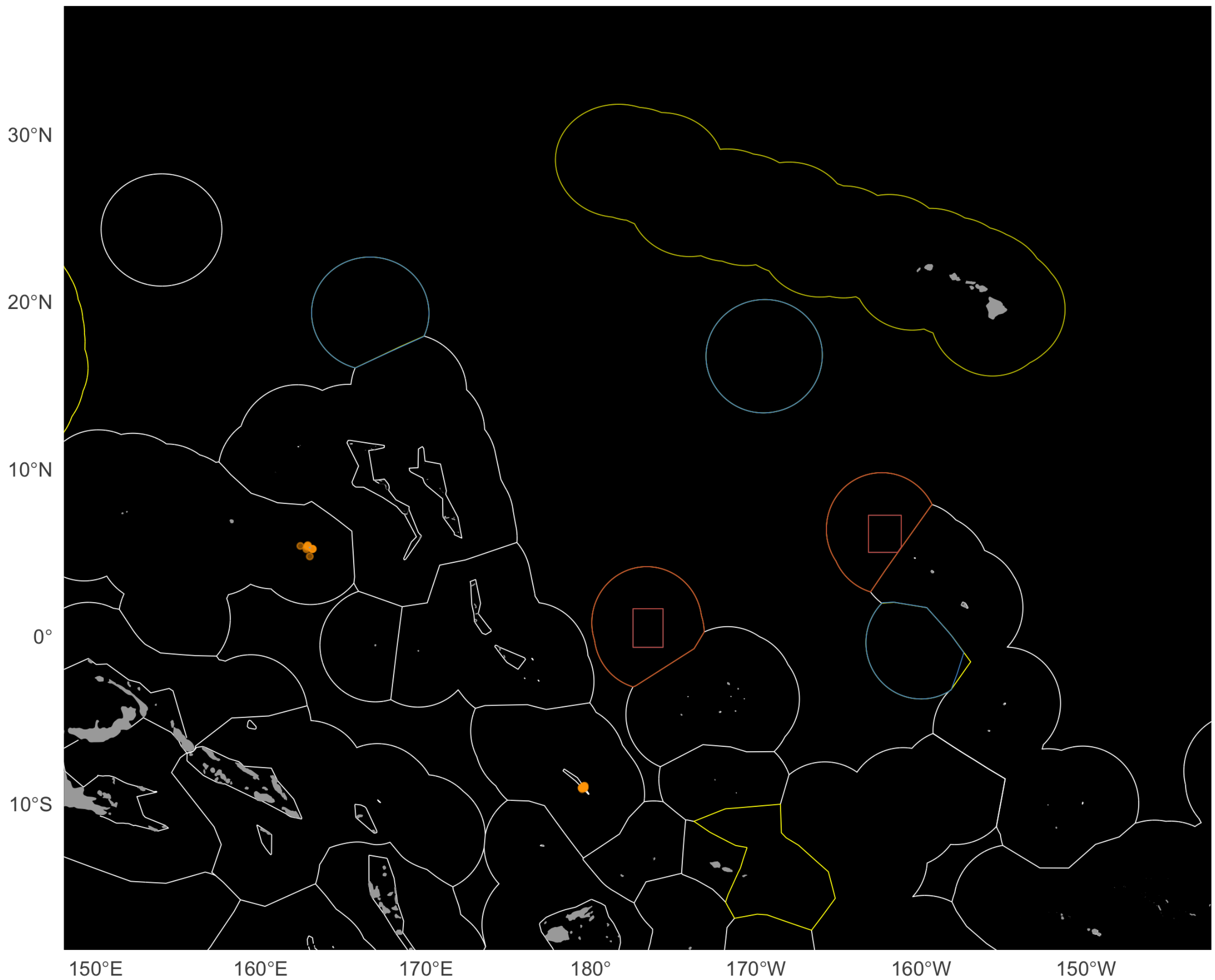

Figure 25: Location of all vessel observed encounters with carriers (e.g., reefers) that landed in Pago Pago, in and around the proposed Sanctuary from the last 5 years (2018-2022). Encounters are shown as orange dots, and Pago Pago is shown as a yellow cross. The current PRI Monument area is shown as a blue outline, the additional proposed Sanctuary protections are show as a red outline, the US EEZ is shown as a yellow outline, and all other EEZs are shown as white outlines. There were no observed encounters between carrier and fishing vessels within the proposed Sanctuary across the entire 2013-2022 dataset.

For the carrier vessel encounters with fishing vessels that occurred on trips prior to landing in Pago Pago, we next look at the gear types and flags of those vessels (Figure 26 and Table 12). Encounters occurred between carriers and China drifting longlines, Kiribati purse seines, South Korea purse seines, Tuvalu unknown gear type, and Tuvalu purse seines. There were no US-flagged fishing vessels that had encounters with carriers that landed in Pago Pago, across the entire 2013-2022 time period.

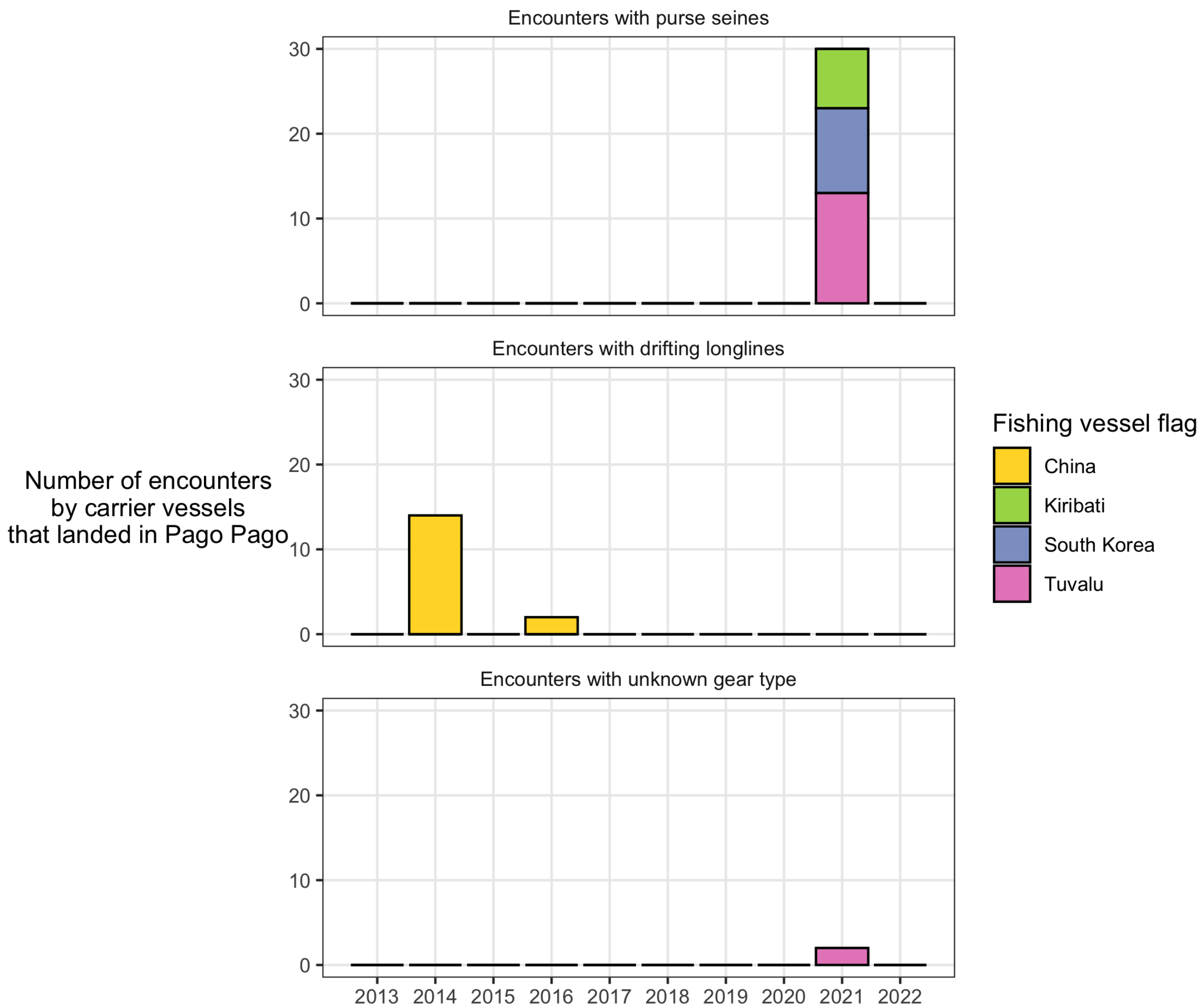

Figure 26: Number of encounters by carrier vessels that landed in Pago Pago. The encounters are disaggregated by the fishing gear vessel type with which each carrier had an encounter, as well as the flag of that fishing vessel. There were no US-flagged fishing vessels that had encounters with carriers that landed in Pago Pago, across the entire 2013-2022 dataset.

Table 12: Number of encounters by carrier vessels that landed in Pago Pago. The encounters are disaggregated by the fishing gear vessel type with which each carrier had an encounter, as well as the flag of that fishing vessel. There were no US-flagged fishing vessels that had encounters with carriers that landed in Pago Pago, across the entire 2013-2022 dataset. There were also no observed encounters between vessels within the proposed Sanctuary across the entire 2013-2022 dataset.

Year	China drifting longlines	Kiribati purse seines	South Korea purse seines	Tuvalu unknown gear type	Tuvalu purse seines
2014	14	0	0	0	0
2016	2	0	0	0	0
2021	0	7	10	2	13

We finally look at the flags flown by the carrier vessels themselves (Figure 27 and Table 13). Across 2013-2022, Carrier vessels landing in Pago Pago were flagged (in alphabetical order) to Panama, South Korea, and Vanuatu.

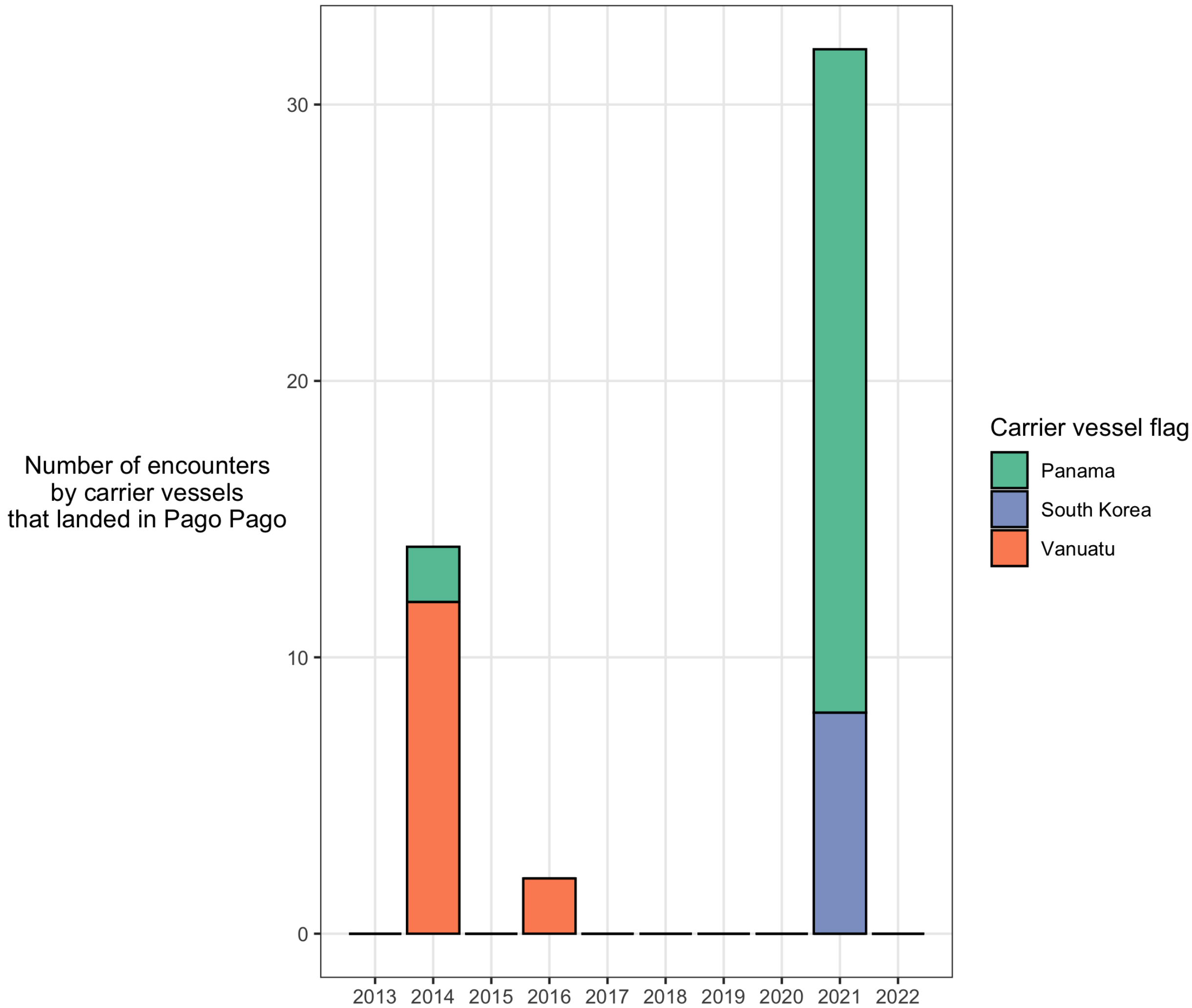

Figure 27: Number of encounters by carrier vessels that landed in Pago Pago, by carrier vessel flag. Note that all of these encounters occurred outside the proposed Sanctuary, and all of the carriers were non-US-flagged vessels.

Table 13: Number of encounters by carrier vessels that landed in Pago Pago, by carrier vessel flag. Note that all of these encounters occurred outside the proposed Sanctuary, and all of the carriers were non-US-flagged vessels.

Year	South Korea	Panama	Vanuatu
2021	8	24	0
2014	0	2	12
2016	0	0	2

4.3 Analysis of historic activity associated with other ports by the US-flagged WCPFC purse seine fleet

This section focuses only on the activity of US-flagged purse seine vessels that were authorized to purse seine fish in the WCPFC in any given year, according to the GFW registry database. We first look at a list of these vessels (Table 14). There were 46 US purse seine vessels registered to fish in the WCPFC during at least one year between 2013 and 2022. Of these, 12 were registered in 2022 (and were also observed fishing in the WCPFC in 2022). 34 were registered during at least one year between 2018 and 2022 (and were also observed fishing in the WCPFC during the years they were registered).

Table 14: US-flagged purse seiners authorized to fish in the WCPFC during any year between 2013-2022. Identification information is given for each vessel, along with the number of years between 2013-2022 which the vessel is registered to fishing in the WCPFC, whether they fished in 2022, whether they were registered in the WCPFC 2022, whether they fished during at least one year between 2018-2022, and whether they were registered in the WCPFC during at least one year between 2018-2022.

Vessel name	MMSI	IMO	Call sign	Years WCPFC	Fished in 2022	Registered in 2022	Fished in 2018-2022	Registered in 2018-2022
ANDREA	338,000,000	7,365,227	WDH8159	2	No	No	No	No
CAPECOD	36,764,000	7,806,283	WDD5547	5	No	No	No	No
CAPEELIZABETH3	303,343,000	9,018,892	WDF8203	5	No	No	Yes	Yes
KOORALE	303,345,000	7,233,280	WDC4205	1	No	No	Yes	Yes
FRIESLAND	338,013,000	9,310,953	WDE6789	8	Yes	Yes	Yes	Yes
SEATRADER	338,074,000	9,097,379	WDE2379	6	No	No	Yes	Yes
ANDREA	338,285,000	7,365,227	WDH8159	2	No	No	No	No
PACIFICPRIDE	338,298,000	9,417,397	WDE5728	5	No	No	Yes	Yes
SEAFOX	338,394,000	9,097,329	WDE2381	6	No	No	Yes	Yes
SEAENCOUNTER	338,539,000	7,823,360	WTF4069	6	No	No	Yes	Yes
JEANETTE	338,540,000	7,505,865	WCX7689	2	No	No	No	No
JUDIBANA	338,622,000	7,334,280	WDG5637	4	No	No	Yes	Yes
CAPEFERRAT	338,712,000	7,803,267	WDE2398	10	Yes	Yes	Yes	Yes
OCEANCHALLENGER	338,793,000	9,517,264	WDE3526	7	No	No	Yes	Yes
CAPEANN	338,873,000	9,698,551	WDH8357	3	No	No	No	No
CAPEHORN	350,107,000	8,718,079	WDF9777	3	No	No	No	No
CAPEBRETON	365,878,412	7,803,255	WDE2397	4	No	No	No	No
OCEANGALAXY	366,020,000	8,996,310	WDE5890	10	Yes	Yes	Yes	Yes
PACIFICRANGER	366,270,000	9,394,789	WDE5730	6	No	No	Yes	Yes
CAPEHATTERAS	366,827,000	8,215,493	WDE7213	3	No	No	No	No
PACIFICPRINCESS	366,878,000	7,806,271	WDC3424	5	Yes	Yes	Yes	Yes
SEAQUEST	366,903,000	9,097,355	WDD9174	5	No	No	Yes	Yes
CAPEBRETON	366,926,988	7,803,255	WDE2397	2	No	No	No	No
CAPEBRETON	366,927,000	7,803,255	WDE2397	6	Yes	Yes	Yes	Yes
SEABOUNTY	367,084,000	8,996,188	WDE5895	6	No	No	Yes	Yes
CAPEFINISTERRE	367,133,000	7,912,094	WDA4699	6	Yes	Yes	Yes	Yes
RAFFAELLO	367,168,000	7,212,377	WDD9140	1	No	No	No	No
OCEANENCOUNTER	367,170,000	8,996,281	WDD9182	7	No	No	Yes	Yes
OCEANEXPEDITION	367,179,000	9,097,367	WDD9952	10	Yes	Yes	Yes	Yes
AMERICANEAGLE	367,318,980	8,974,398	WDD9994	5	No	No	Yes	Yes
AMERICANENTERPRISE	367,340,920	9,294,628	WDE3560	2	No	No	Yes	Yes
SEAHONOR	367,344,000	9,517,276	WDE4114	3	No	No	Yes	Yes
PACIFICBREEZE	367,359,220	7,395,624	WDE4890	3	No	No	No	No
AMERICANTRIUMPH	367,383,720	8,743,672	WDE6712	5	No	No	Yes	Yes
OCEANWARRIOR	367,463,000	9,097,317	WDD9953	6	No	No	Yes	Yes
CAPECOD	367,640,000	7,806,283	WDD5547	6	Yes	Yes	Yes	Yes
DANIELA	367,649,000	7,107,716	WDJ4303	5	No	No	Yes	Yes
WESTERNPACIFIC	367,666,000	7,508,893	WDD5296	5	No	No	Yes	Yes
EVELINADAROSA	367,738,980	8,131,441	WDI8477	6	No	No	Yes	Yes
OCEANCONQUEST	367,767,000	9,097,343	WDD8838	8	Yes	Yes	Yes	Yes
CAPTVINCENTGANN	367,794,880	9,018,880	WDJ6149	6	Yes	Yes	Yes	Yes
SEADEFENDER	368,046,000	8,996,190	WDD8934	4	No	No	Yes	Yes
CAPEMAY	368,489,000	8,103,028	WDE2195	8	Yes	Yes	Yes	Yes
RAFFAELLO	369,253,000	7,212,377	WDJ4712	5	Yes	Yes	Yes	Yes
ISABELLA	369,576,000	8,111,465	WDE5192	3	No	No	Yes	Yes
OCEANENCOUNTER	544,137,120	8,996,281	WDD9182	1	No	No	No	No

Before looking at the activity of these WCPFC-registered purse seines, it is worth noting that not all US-flagged purse seine vessels that were observed in GFW to be fishing in the WCPFC region were on the WCPFC registry in the year they were observed fishing, according to the GFW registry database. These vessels are summarized in Table 15, which also provides the total number of fishing hours that each vessel spent inside the WCPFC region aggregated across the years they were not registered.

Table 15: US-flagged purse seine vessels that were observed fishing in the WCPFC during at least one year in which they were not on the WCPFC authorized purse seine vessel list, according to the GFW vessel registry database. Identification information is given for each vessel, along with the total number of fishing hours in the WCPFC that occurred in years during which they were not authorized to fish (summing across 2013-2022).

Vessel name	**MMSI**	**IMO**	**Call sign**	**Fishing hours**
COMMITMENT	367474080	Unknown	WDF6420	12,973.03
KAIA	367509670	9653719	WDF9870	9,287.88
LADYLEEDAWN	367328720	Unknown	WCX9276	7,974.61
VIGILANT	367642380	Unknown	WDH6864	6,892.46
APRILLANE	367609850	Unknown	WDH3687	5,150.52
BRANKOSTORM	367762190	Unknown	WDJ2836	4,220.61
CVINCENTGANN	303137000	9018880	WDG2517	3,456.59
RAVEN	367369280	Unknown	WQZ9612	2,549.53
PACIFICQUEST	367692450	Unknown	WDI3839	2,057.75
LINNEA	367436240	Unknown	WDF3128	2,054.08
ROLFY	367035740	Unknown	WCY8996	1,995.46
PILLARBAY	367002510	Unknown	WDC3090	1,912.98
SHAWNARAE	368027000	Unknown	WDE9141	1,879.50
ALEUTIANSPIRIT	366726650	Unknown	WCW9448	1,809.83
ALEUTLADY	367387730	Unknown	WDE7006	1,769.96
AMERICANVICTORY	367377660	9556674	WED6234	1,764.25
GUARDIANANGEL	367788510	Unknown	WDJ5525	1,710.28
Unknown	369970455	Unknown	Unknown	1,611.86
Unknown	338133712	Unknown	Unknown	1,311.88
Unknown	367488940	Unknown	Unknown	1,233.80
JAMBOREE	367546080	Unknown	WDG5383	1,127.77
NORTHERNSTAR	367377520	Unknown	WDE6220	1,071.30
CAMERON	366816240	Unknown	WDG7289	779.55
VANELLIOTT	367169580	7309687	WDD6201	769.57
ALASKANBELLE	367523450	Unknown	WDG3191	727.79
OCEANCAT	368044290	Unknown	WDK3342	726.43
MISSBRITTA	367713260	Unknown	WDI5909	719.97
SEABARB	366671015	Unknown	WDH5149	664.05
SABRINA	367382540	Unknown	WDE6623	631.88
STORSILD	368038850	Unknown	WDK2778	631.54
CHARLEY	368017810	Unknown	WDJ8577	601.96
ACE	367626660	Unknown	WDH5310	541.86
Unknown	367507250	Unknown	Unknown	540.58
SITKINAK	367515240	Unknown	WDG2397	509.87
KULSHAN	367410660	Unknown	WDE8872	438.27
KAPEA	367753850	Unknown	WDI9955	437.43
INFINITEGLORY	367593330	Unknown	WDG9995	432.58
TRITON	338151615	Unknown	WTD2748	398.86
CHICHAGOF	367131260	7100421	WDD3431	380.37
CAPEKARLUK	367135720	Unknown	WCW8463	346.00
SYDNEYMORGAN	367565250	Unknown	WDG7238	334.69
OPTIMUS	367594860	Unknown	WDH2147	323.77
KENDRAH	367379340	8938887	WDE6370	323.25
NEPTOON	367160330	Unknown	Unknown	313.36
Unknown	367323000	Unknown	Unknown	263.98
HAILMARY	367681360	Unknown	WDI2752	191.20
SEADIAMOND	367743080	Unknown	WDI8881	177.42
BOULDERBAY	367722550	Unknown	WDI6818	161.57
ALINCHAK	367317870	Unknown	WDD9905	160.98
MISSLORI	367044880	Unknown	WDL6436	117.83
PROVIDENCE	368076020	Unknown	WDK6588	113.04
KIPPER	367164230	Unknown	WDD5823	112.44
TYEE1	367568640	Unknown	WDG7573	109.00
KONAROSE	367091920	Unknown	WCW4451	74.72
Unknown	366942640	Unknown	Unknown	72.34
WESTERNEDGE	367562440	Unknown	WDG6957	61.44
SUSAN	366572170	Unknown	WB3463	60.71
ADVERSITY	367119270	Unknown	WAX2892	59.93
PACIFICPREDATOR	367455530	Unknown	WDF4759	54.14
MAKO	367675010	Unknown	WDI2127	38.91
SEABARB	366710150	Unknown	WDH5149	31.82
CAPECHEERFUL	367734510	Unknown	WDI8020	30.95
EVERMORE	367580950	Unknown	WDG8775	21.09
INVINCIBLE	367565560	9702352	WDG7267	3.62

We next look at a map and bar chart of all of the ports across the Pacific where US-flagged, WCPFC-registered purse seines landed between 2018 and 2022 (Figures 28. 34 US-flagged, WCPFC-registered purse seine vessels landed at 34 ports across the Pacific.

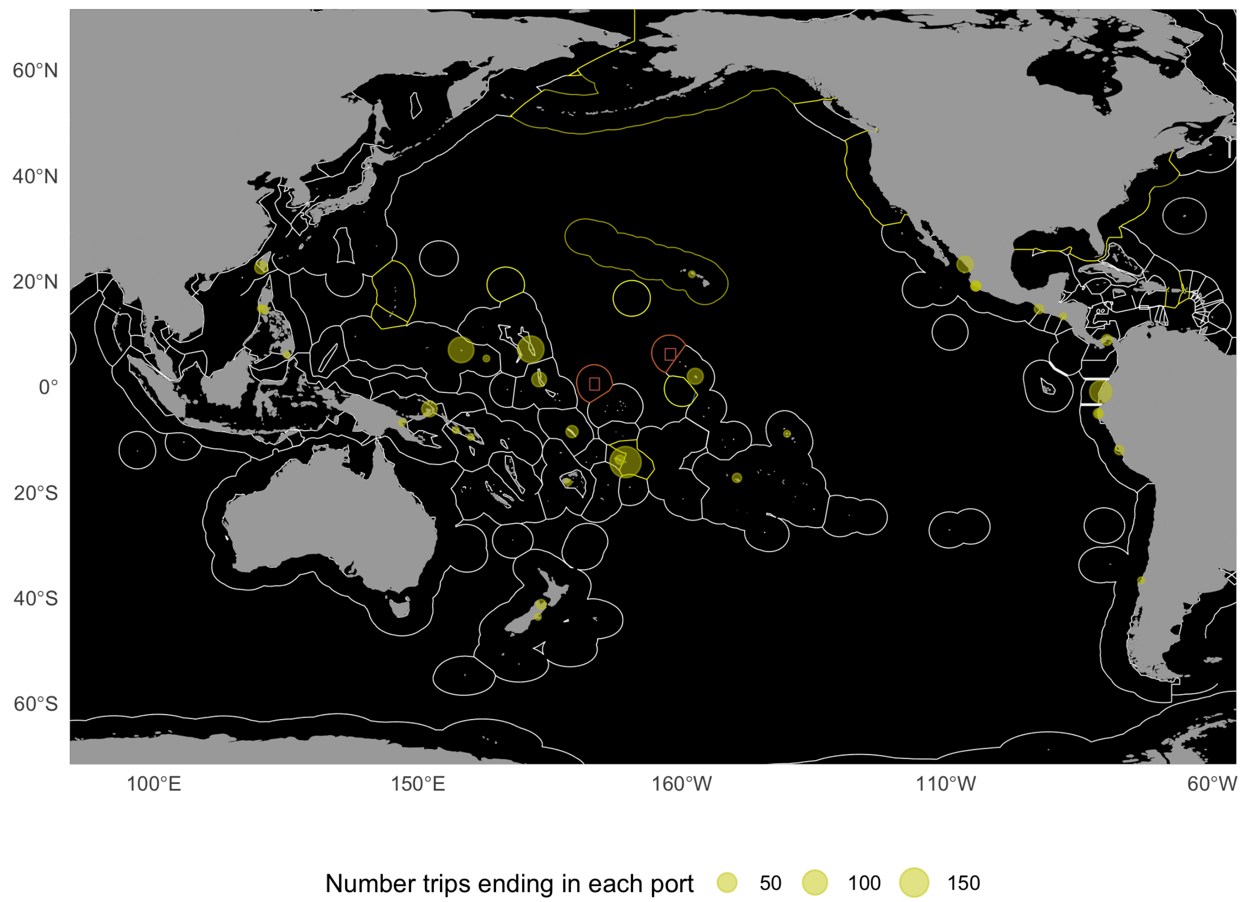

Figure 28: Map of ports where the US-flagged WCPFC purse seine fleet ended their trips, aggregated across the last 5 years (2018-2022). The size of each point is scaled to the number of trips that ended in each port. The current PRI Monument area is shown as a blue outline, the additional proposed Sanctuary protections are show as a red outline, the US EEZ is shown as a yellow outline, and all other EEZs are shown as white outlines.

The five most visited ports by the US-flagged WCPFC-registered purse seine fleet across 2018-2022, in order of the most number of trips that landed at each port, were Pago Pago Harbor, American Samoa (183 trips), Majuro, Marshall Islands (121 trips), Pohnpei, Micronesia (Federated States of) (109 trips), Manta, Ecuador (72 trips), and Mazatlan, Mexico (28 trips) (Figure 29 and Table 16).

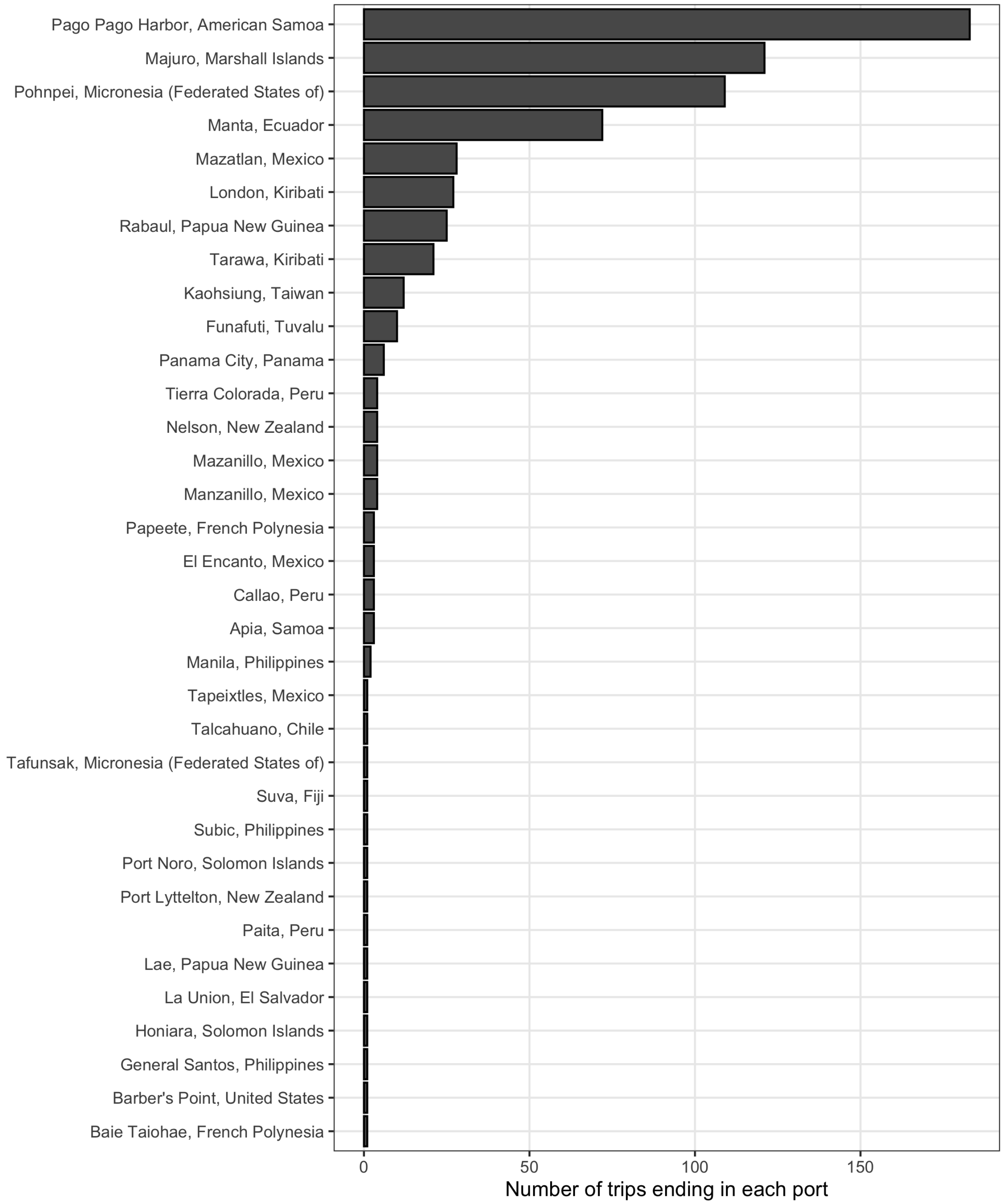

Figure 29: Number of trips ending in each port by the US-flagged WCPFC purse seine fleet, aggregating across the last 5 years (2018-2022).

Table 16: Number of trips ending in each port by the US-flagged WCPFC purse seine fleet, aggregating across the last 5 years (2018-2022).

Port name	**Number of trips ending in port**
Pago Pago Harbor, American Samoa	183
Majuro, Marshall Islands	121
Pohnpei, Micronesia (Federated States of)	109
Manta, Ecuador	72
Mazatlan, Mexico	28
London, Kiribati	27
Rabaul, Papua New Guinea	25
Tarawa, Kiribati	21
Kaohsiung, Taiwan	12
Funafuti, Tuvalu	10
Panama City, Panama	6
Manzanillo, Mexico	4
Mazanillo, Mexico	4
Nelson, New Zealand	4
Tierra Colorada, Peru	4
Apia, Samoa	3
Callao, Peru	3
El Encanto, Mexico	3
Papeete, French Polynesia	3
Manila, Philippines	2
Baie Taiohae, French Polynesia	1
Barber's Point, United States	1
General Santos, Philippines	1
Honiara, Solomon Islands	1
La Union, El Salvador	1
Lae, Papua New Guinea	1
Paita, Peru	1
Port Lyttelton, New Zealand	1
Port Noro, Solomon Islands	1
Subic, Philippines	1
Suva, Fiji	1
Tafunsak, Micronesia (Federated States of)	1
Talcahuano, Chile	1
Tapeixtles, Mexico	1

For the fishing trips conducted by the US-flagged WCPFC-registered purse seine fleet across 2018-2022, we next look at the amount of time spent fishing inside the proposed Sanctuary, as well as the percentage of time spent fishing inside the proposed Sanctuary out of the entire Pacific (Figure 30). While trips landing in Pago Pago spent the most amount of time fishing inside the proposed Sanctuary prior to landing in port in terms of total effort (1,430.11 hours across 2018-2022), five ports had fishing effort within the proposed Sanctuary that exceeded 1% of effort observed prior to landing in each respective port: Port Noro, Solomon Islands (8.84%), Barber's Point, United States (6.31%), Mazanillo, Mexico (5.17%), Pago Pago Harbor, American Samoa (4.27%), and Mazatlan, Mexico (3.63%).

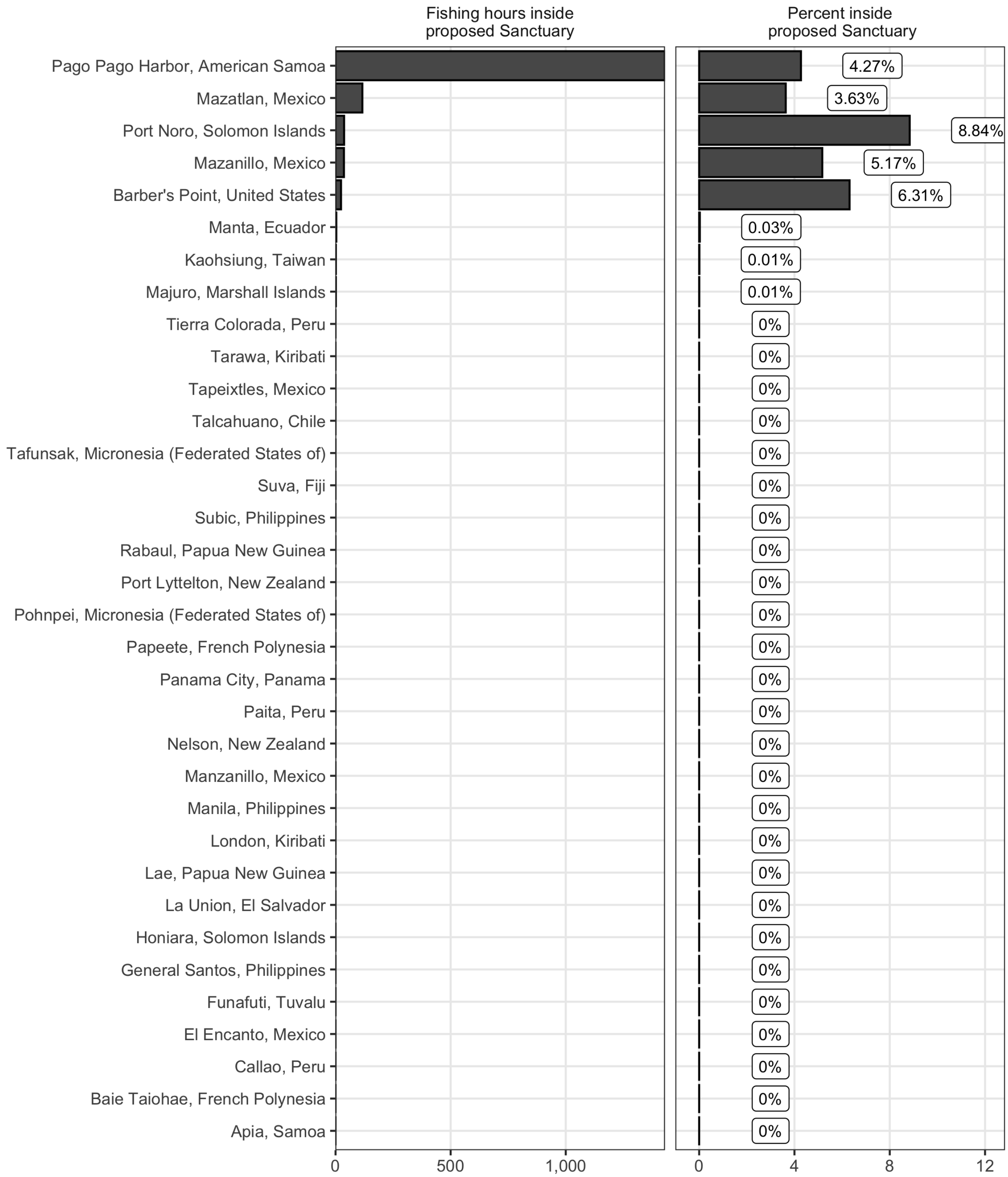

Figure 30: Fishing effort (hours) that occurred within the proposed Sanctuary on trips prior to landing in each port; Percentage of fishing effort that occurred within the proposed Sanctuary out of the entire Pacific prior to landing in each port. This focuses on the the US-flagged WCPFC purse seine fleet, aggregating across 2018-2022.

4.4 Analysis of historic catch using publically available WFPFC purse seine and longline catch data

In this final section we look at WCPFC-reported catch data. First we look at a time series of the nominal (e.g., non-spatial) catch data for purse seines, looking at both US-flagged catch as well as catch by other flags (Figure 31). Nominal catch data represent catch across the entire WCPFC region.

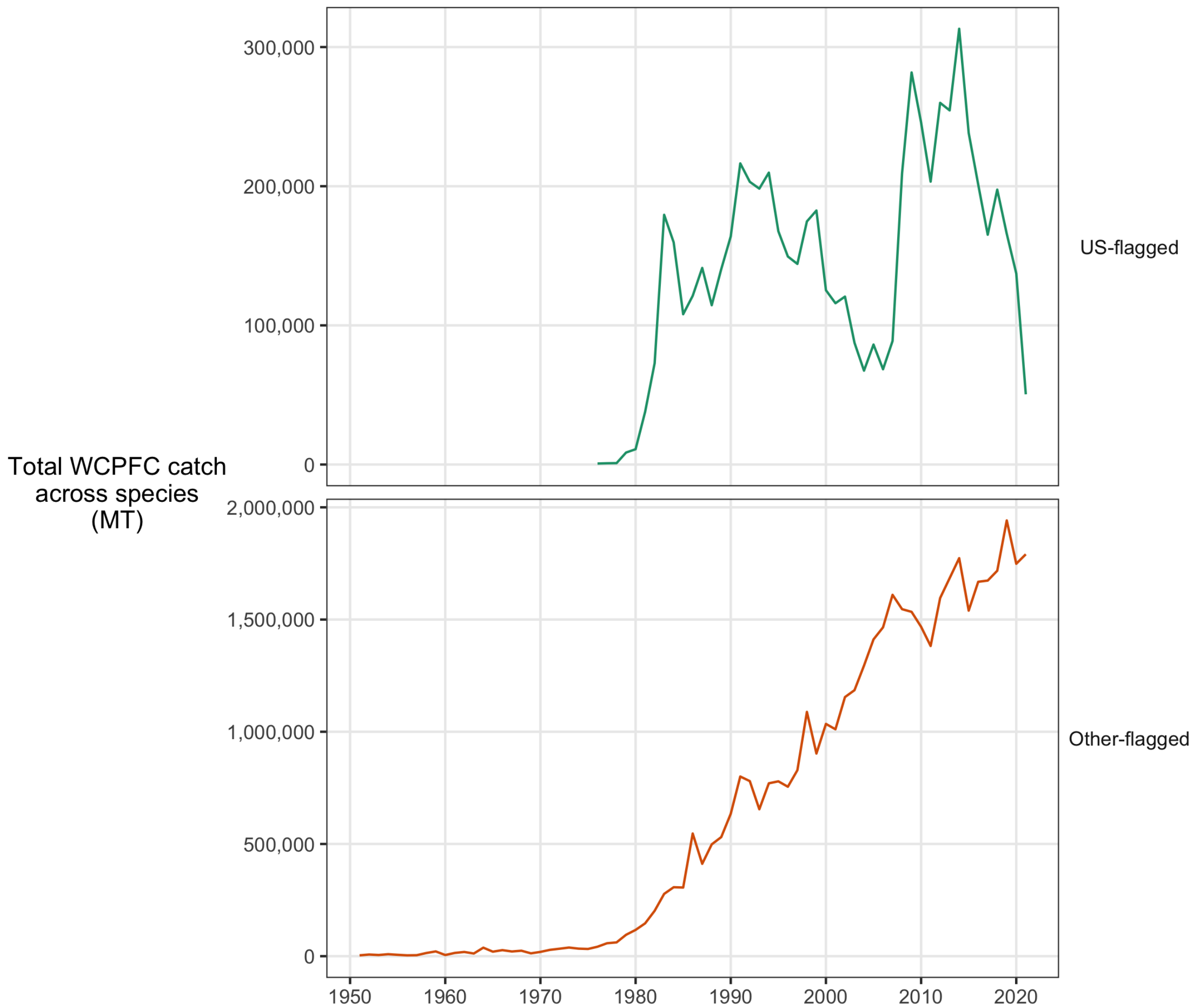

Figure 31: Purse seine non-spatial catch (MT) reported by the WCPFC across the entire region and across all species, by flag and year.

Next we look at a time series of the nominal (e.g., non-spatial) catch data for longlines, again looking at both US-flagged catch as well as catch by other flags (Figure 32). Nominal catch data represent catch across the entire WCPFC region.

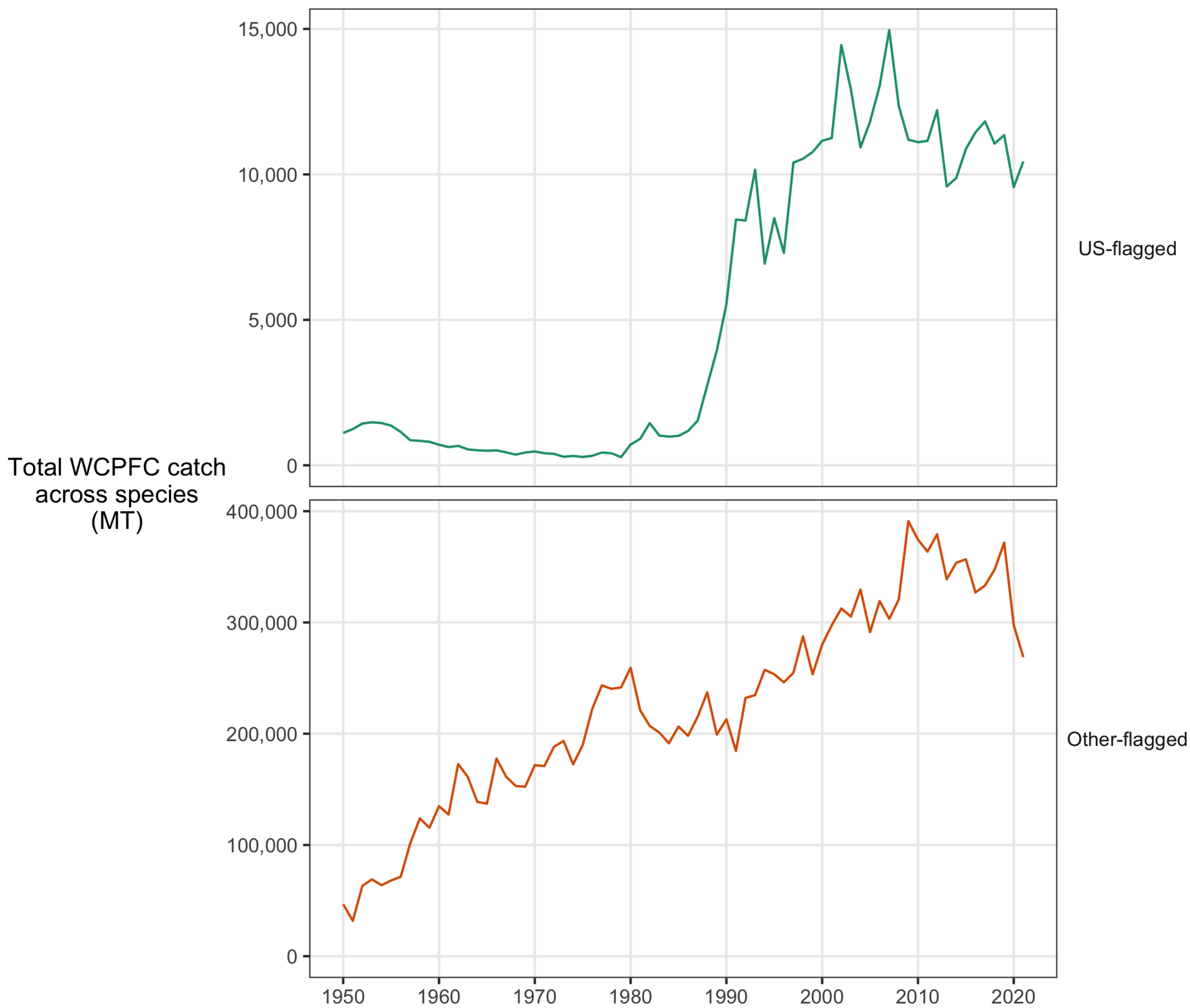

Figure 32: Longline non-spatial catch (MT) reported by the WCPFC across the entire region and across all species, by flag and year.

We can also look at nominal, non-spatial catch for different species over time. First we look at catch by purse seines, aggregating across all fishing flags (Figure 33).

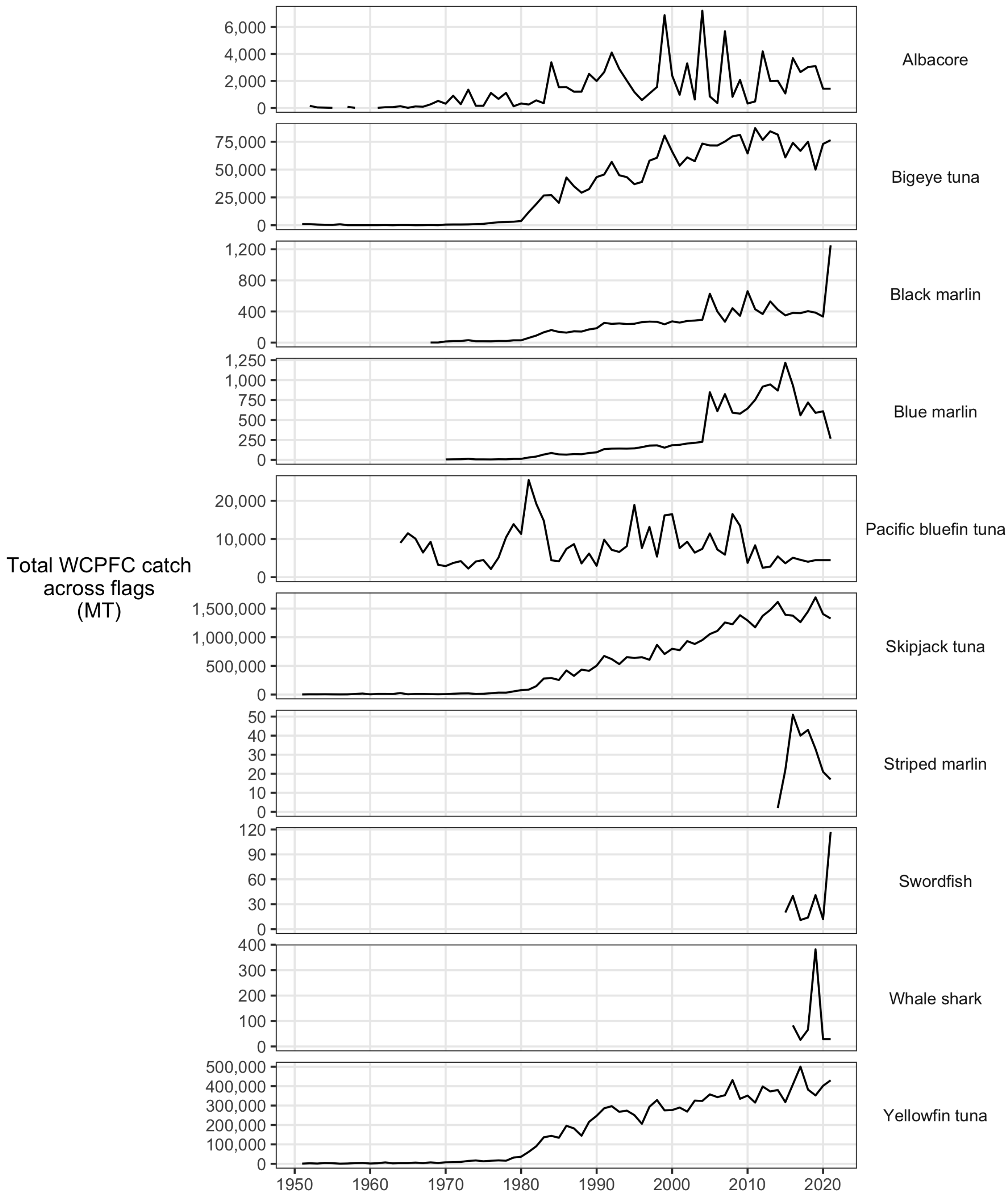

Figure 33: Purse seine non-spatial catch (MT) reported by the WCPFC across the entire region and across all flags, by species and year.

We can also look at catch by longlines, againa ggregating across all fishing flags (Figure 33).

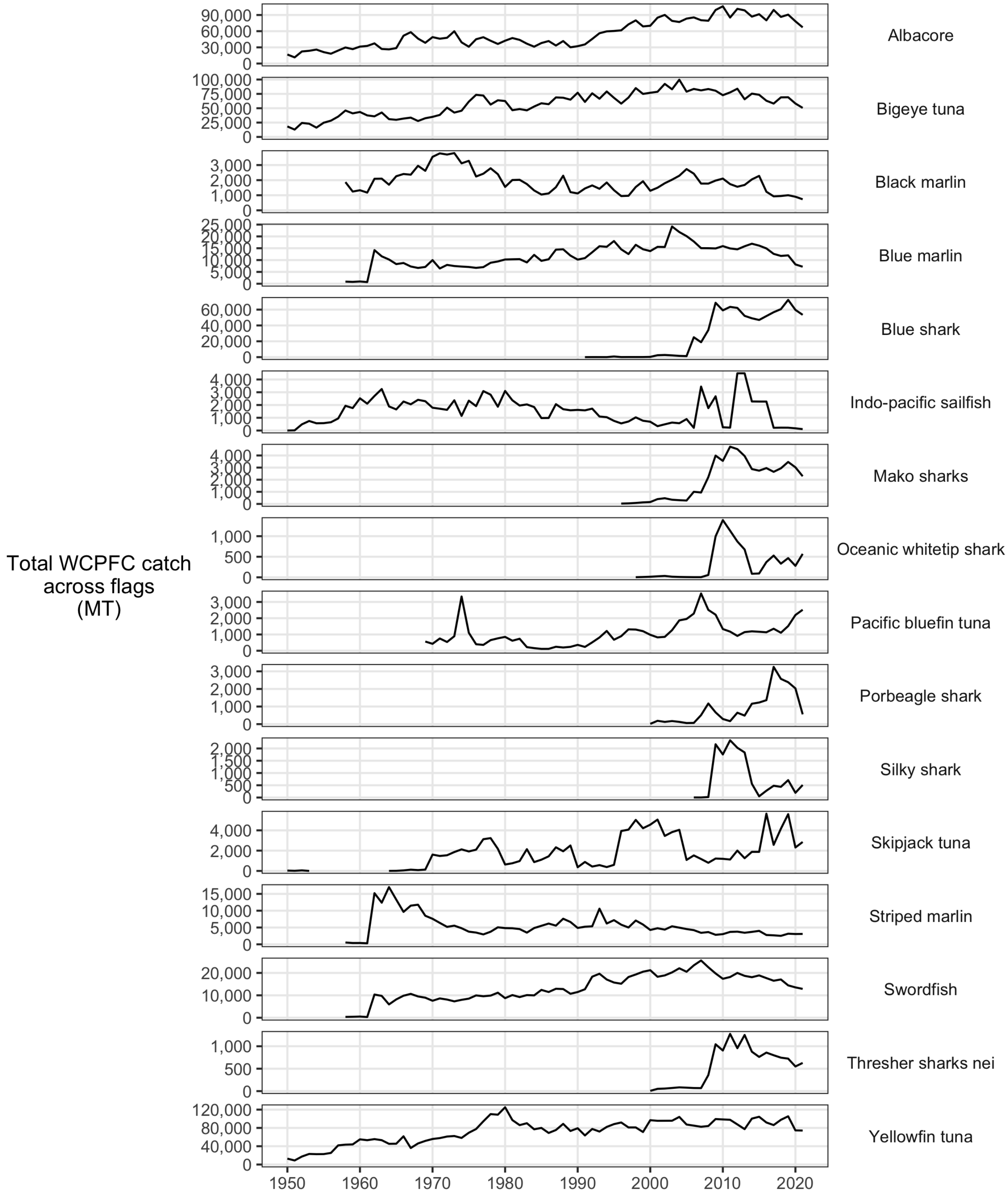

Figure 34: Longline non-spatial catch (MT) reported by the WCPFC across the entire region and across all flags, by species and year.

We next turn our attention to the WCFPC-reported spatial catch data. First we can look at a map of the spatial catch data, looking across the entire WCPFC region, aggregating across 2017-2021, and disaggregated by fishing flag (US-flagged or other-flagged) (Figure 35).

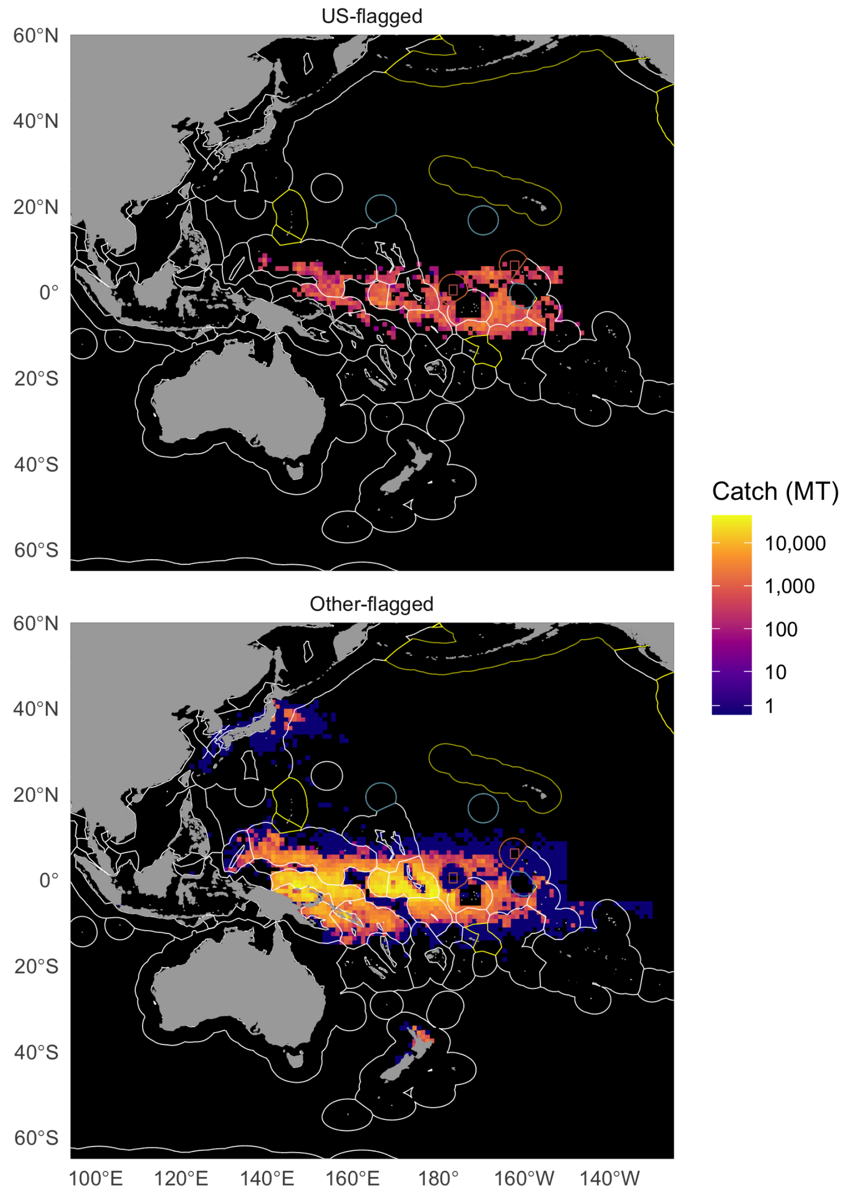

Figure 35: Spatial purse seine catch (MT) reported by the WCPFC for the most recent 5 years of available data (2017-2021) at the finest available spatial resolution (1x1 degrees). The current PRI Monument area is shown as a blue outline, the additional proposed Sanctuary protections are show as a red outline, the US EEZ is shown as a yellow outline, and all other EEZs are shown as white outlines.

We next overlay the spatial catch data with the proposed Sanctuary boundaries. Note that since the WCPFC spatial data are provided at a 1x1 degree pixel size, some pixels fall full outside the proposed Sanctuary, some fall fully inside, and some partially overlap the proposed Sanctuary. For any pixels that partially overlap the proposed Sanctuary boundaries, it cannot therefore be said how much of this catch actually feel within the proposed Sanctuary boundaries or not. We can look at the time series trend of purse seine catch falling within these three regions, disaggregated by flag (Figure 36).

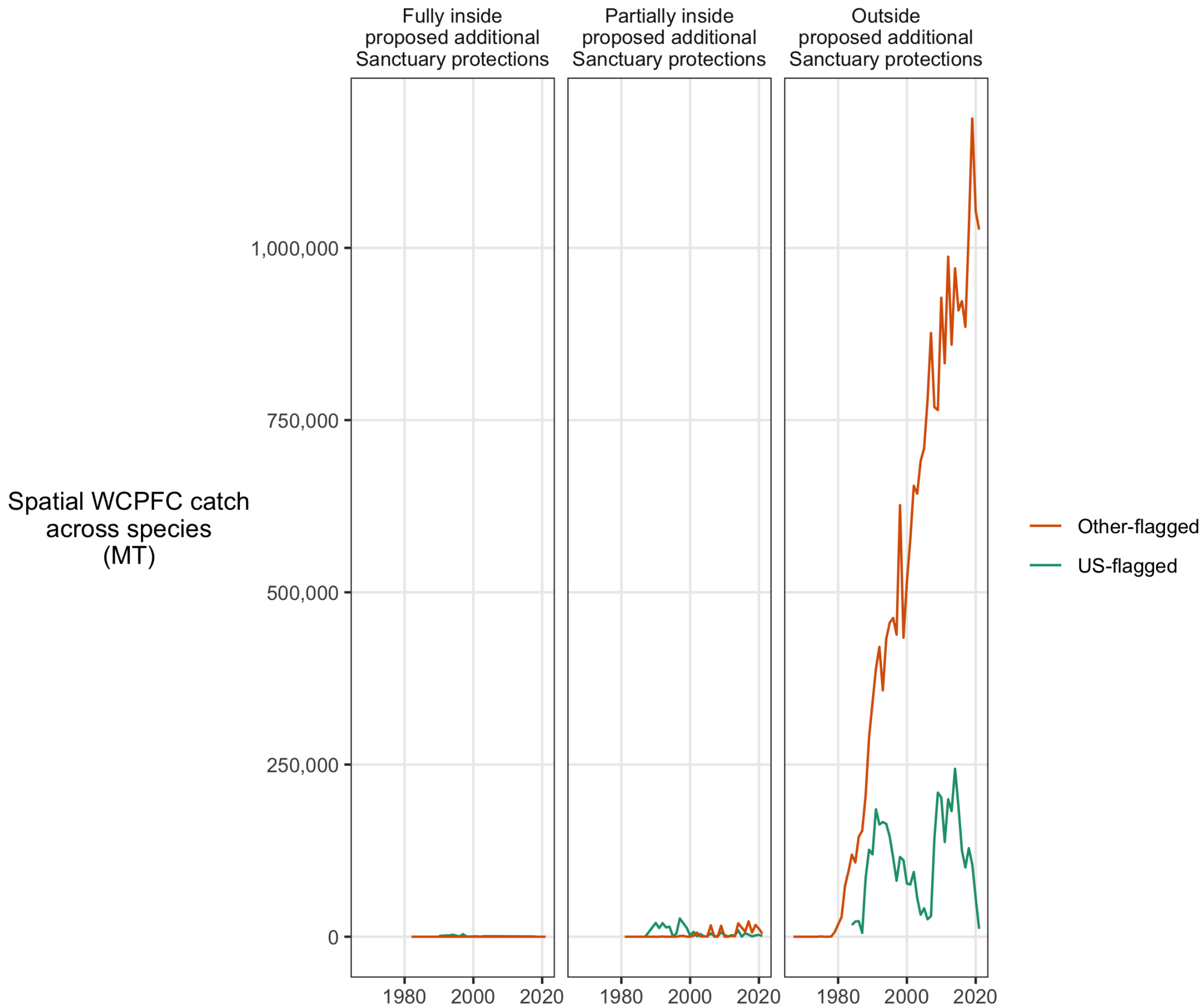

Figure 36: Time series of purse seine catch (MT) based on the WCPFC-reported spatial catch data, by flag, aggregating across pixels that are fully inside the proposed Sanctuary; partially inside the proposed Sanctuary; or fully outside the proposed Sanctuary. This aggregates catch across all species.

Focusing on just the last 5 years of spatial catch data (2017-2021), and only looking at the US-flagged fleet, we can calculate the amount of reported catch that occurred in these 3 regions (Table 17). Us-flagged purse seines caught 394.38 metric tonnes (0.1%) within the proposed Sanctuary; 9,488.83 metric tonnes (2.3%) in areas that partially overlap the proposed Sanctuary; and 402,154.4 metric tonnes (97.6%) fully outside the proposed Sanctuary.

Table 17: US-flagged purse seine reported spatial catch by the WCPFC during the last 5 years of the dataset.

Area	**Reported catch (MT)**	**Percent total reported catch**
Fully inside proposed additional Sanctuary protections	394.38	0.1
Partially inside proposed additional Sanctuary protections	9,488.83	2.3
Outside proposed additional Sanctuary protections	402,154.42	97.6

5 Conclusion

As NOAA's Office of National Marine Sanctuaries considers the designation of a new Sanctuary for the Pacific Remote Islands, it is critical to understand how US-flagged purse seine and longline vessels have historically used this proposed protected area for fishing. While looking at historical fishing activity does not provide a causal impact assessment of what would happen in the future if this new Sanctuary is designated, it nevertheless provides an objective historical baseline for what has been observed in the past in this region. This analysis shows relatively low levels of historical fishing effort inside the currently unprotected area proposed as a new National Marine Sanctuary. We hope this technical report can be of use to stakeholders as the potential new Sanctuary designation is discussed.

6 References

Kroodsma, D.A., Mayorga, J., Hochberg, T., Miller, N.A., Boerder, K., Ferretti, F., Wilson, A., Bergman, B., White, T.D., Block, B.A. and Woods, P., 2018. Tracking the global footprint of fisheries. Science, 359(6378), pp.904-908. (Link)

Miller, N.A., Roan, A., Hochberg, T., Amos, J. and Kroodsma, D.A., 2018. Identifying global patterns of transshipment behavior. Frontiers in Marine Science, 5, p.240. (Link)