Global Fishing Watch

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Analysis of the Southeast Pacific Distant Water Squid Fleet

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Category: Fleet analysis (2021 Data)

Region: Southeast Pacific

Global Fishing Watch

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Caveats and disclaimer

AIS provides the only open-source monitoring tool for high seas fishing. AIS relies on voluntary transmission, and is restricted to the vessels which have AIS devices installed and operating, making the data records incomplete. An additional source of uncertainty in AIS-based data relates to poor satellite reception, in areas with high vessel traffic, such as the South China Sea and the English Channel. That said, the reception is generally good in the focal area of this report, however, the boats operating within the squid fishery often use Class B AIS transponders that broadcast at a lower rate when the vessels move slower than two knots. The majority of squid vessels fish by drifting with the currents[1] at a speed less than two knots, therefore the AIS messages received by these vessels and estimates surrounding their AIS-based fishing effort will be conservative. Nevertheless, in the absence of any other information, these data can be used to characterize the spatial extent and relative activity of the squid fleet in the area.

'Encounter events' are identified when AIS data indicates that two vessels may have conducted a transshipment, based on the movements of the two vessels. Global Fishing Watch identifies encounters from AIS data as locations where two vessels, a carrier and fishing vessel, were within 500 meters for at least two hours and traveling at a median speed less than 2 knots, while at least 10 km from a coastal anchorage.

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[1] Taconet, M., Kroodsma, D., & Fernandes, J.A. 2019. Global Atlas of AIS-based fishing activity - Challenges and opportunities. Rome, FAO. page 352. http://www.fao.org/3/ca7012en/CA7012EN.pdf

Executive summary

The number of fishers that catch squid has increased in recent years, with fishing capacity in commercially important squid fisheries growing globally. The southeast Pacific is no exception. Between 1990 and 2018, the annual reported catch from the high seas has increased from ~5,000 to ~278,000 tons from three commission members; China, Chinese Taipei, and Republic of Korea (SC7-SQ01 Squid). The high seas distant water fleet has grown from a flag State reported 6 vessels in 1990 to 528 in 2019 (SC8 - SQ01_rev1_clean). The distribution of the jumbo flying squid ranges from southern Chile, up to North American waters, and extends out into the high seas, into an area that is jointly managed by Member States via the South Pacific Regional Fisheries Management Organization (SPRFMO). Fisheries targeting the jumbo flying squid *(Dosidicus gigas)* are of clear socio-economic importance in Chile, Peru and Ecuador on a commercial and artisanal fisher scale, as well as to the international distance water fleet.

During the 2020 Commission meeting, SPRFMO introduced its first conservation and management measure (CMM) directly related to the management of the squid, however, the fishery still lags behind fisheries targeting other species in the Pacific. For example, vessels are required to be authorized on the SPRFMO Vessel List, in order to fish within the SPRFMO area, however transshipment of squid (the at-sea transfer of catch), unlike other targeted species in the Convention Area, do not require prior authorization from the flag States to confirm compliance with SPRFMO CMMs. Due to the importance of the squid fishery to coastal States in the region, strengthening of these regulations along with effort or catch limits in accordance with other species in the Pacific would better reflect a precautionary approach.

Global Fishing Watch (GFW), in support of partnerships with some coastal States in Latin America, uses remotely observed satellite data and artificial intelligence machine learning to better understand the extent and activity of the squid fleet operating in the Southeast Pacific in 2021. By combining multiple sources of open-source data, namely AIS-based data on vessel positions and the publicly accessible SPRFMO vessel registry and implementation reports, we investigated fishing activity by vessel flag across the high seas squid fishing grounds in the southeast Pacific. A total of 527 squid fishing vessels were active in the region, 98.7% of which were flagged to China, operating at a combined total of ~98,543 fishing days within the year.

The at-sea vessel support of the squid fleet was extensive, with a total of 46 carrier vessels active on AIS in the area. An analysis of the onward voyages of the carriers that had encounters with squid fishing vessels within the area of interest, highlighted the range of ports utilized by these carrier vessels. Carriers visited ports in Chile, China, Panama, the Republic of Korea, and Singapore, all of which are members or CNCPs to SPRFMO. With the exception of China, where the majority (68%) of port visits were made, the port State had designated its ports under the SPRFMO port control CMM.

Our analysis demonstrates the utility of machine learning applied to AIS-based data to monitor fishing activity and improve transparency on a particular fishery. However, the analysis has caveats: AIS devices can be turned off, 34% of the vessels identified on AIS had data gaps longer than 24 hours and devices can be misused, and approximately 10% of the fleet exhibited AIS irregularities that lead to confusion in terms of identity or location. Our analysts have developed

techniques to identify vessels misusing AIS, but the practice still creates real challenges for monitoring control and surveillance (MCS) of the fleet. RFMO members and CNCPs should mandate the continual use of AIS Type-A in line with SOLAS regulation V/19.2.4 for distant water fishing and ensure AIS devices are legally operated.

To further investigate the AIS-based estimates of the squid fleet, additional data was derived from visible infrared imaging radiometer suite (VIIRS). The additional data source can complement AIS-based data, in particular they can be used to detect vessels not visible on AIS. The satellite imagery from 2021 appears to indicate that there was typically good compliance with EEZ limits by the distant water squid fleet and illegal fishing of this type was minimal. Continued satellite monitoring and at sea patrols appear to provide a degree of deterrence and should be continued.

This analysis demonstrates how transparency and public data can be used as a tool by relevant authorities to conduct monitoring, control and surveillance efforts. States in the region are global leaders in advancing the adoption of transparency for greater ocean governance, providing a precedent for setting a high standard regarding transparency of high seas fishing in the region.

Analysis of the Southeast Pacific Distant Water Squid Fleet

1 Overview

The jumbo flying squid (*Dosidicus gigas*) is the most abundant cephalopod species in the Southeast Pacific Ocean and one of the most important cephalopod fisheries in the world ([Ibáñez et al., 2015](#)). The range of this species extends from southern Chile to the North American coast ([FishSource](#)), falling within the remit of the South Pacific Regional Fisheries Management Organization (SPRFMO), where it is the second-largest fishery of this intergovernmental management body.

This species is of clear socio-economic importance, both commercially on the high seas within the SPRFMO area and within the exclusive economic zones (EEZ) of Chile and Peru, as well as for small-scale fishers. In Peru, the squid fishery constitutes the largest artisanal fishery.

The high seas squid fishery has seen a substantial increase in fishing effort and associated catch in the SPRFMO Convention Area. Between 1990 and 2018, the annual reported catch from the high seas has increased from ~5,000 to ~278,000 tons from three commission members: China, Chinese Taipei, and the Republic of Korea ([SC7-SQ01 Squid](#)). The fleet has grown from around six vessels in 1990 to 528 in 2019 ([SC8 - SQ01_rev1_clean](#)). As a result, the squid fleet represents 74 percent of the total vessels registered to SPRFMO in 2020 and are classified by the commission as liners, often referred to as squid jiggers and fish carrier vessels, and they have a significant footprint in the region.

In support of partnerships with some coastal States in Latin America, Global Fishing Watch has been monitoring the activity of the squid fleet in the Southeast Pacific Ocean to understand the footprint of the fleet, as well as its behavior and risks of illegal, unreported and unregulated (IUU) fishing. During June and November of 2021, Global Fishing Watch generated a series of [six montly periodic reports](#) on the fleet's activity. This report summarizes that work into an annual document and updates our 2020 annual report that takes into account new information from SPRFMO.

1.1 Aim of the analysis

Using our public data and machine learning, Global Fishing Watch is investigating the distant-water squid fleet. Our analysis draws on a combination of sources of information:

1. Automatic identification system (AIS),
2. Visible infrared imaging radiometer suite (VIIRS),
3. SPRFMO registry and compliance reports.

The report will outline compliance challenges and seek to inform inspection, enforcement and compliance efforts conducted by SPRFMO and its members. The report will also inform civil society of the key factors to consider in seeking to secure the sustainability of the squid fishery.

The analysis focuses on the area of interest (AOI) described below (Figure 1) between January and December, 2021. This area was selected based on historical activity of the squid fleet in the region, in particular along Peru's EEZ, around the Ecuadorian Galapagos' EEZ, and an area on the equator about 1,000 nautical miles west of the Ecuadorian Galapagos' EEZ.

Figure 1: Area of interest within the Southeast Pacific
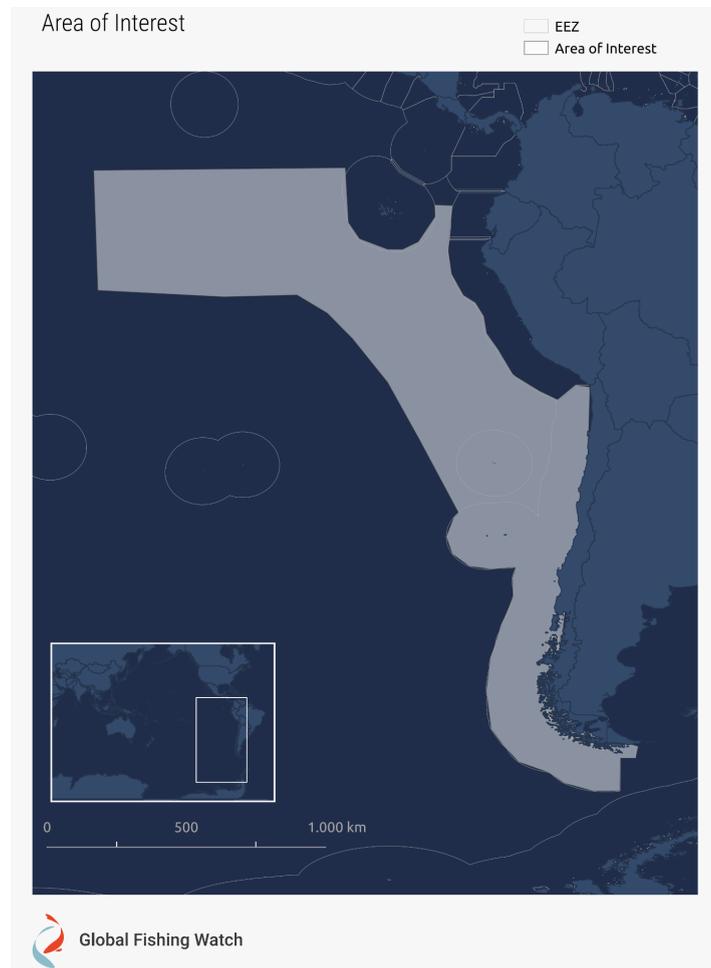
2 Vessel tracking analysis

Using AIS data and the Global Fishing Watch fishing effort algorithm for nighttime squid fishing,[2] a total of 548 unique MMSI numbers associated with 527 vessels completed an estimated total of 852,939.5 fishing hours, or 98,543 fishing days over the year.

The status of the top 10 vessels detected in the AOI is summarized in Table 1.

Table 1: Top 10 squid fishing vessels operating in the Southeast Pacific, 2021[3]

Note: [Click to see the full list of vessels](#)[4]

Vessel	MMSI	Fishing days[5]	AIS positions	Vessel class	Flag*
NINGTAI28	412420653	287	312,554	Squid jigger	CHN
NINGTAI65	412420929	272	308,190	Squid jigger	CHN
HONGPU31	412549164	288	306,356	Squid jigger	CHN
JINHAIYANG1	412420531	265	305,983	Squid jigger	CHN
JIADE58	412549193	252	301,009	Squid jigger	CHN
JIADE56	412549192	262	298,993	Squid jigger	CHN
NINGTAI815	412549301	302	298,735	Squid jigger	CHN
LURONGYUANYU 833	412549277	285	298,298	Squid jigger	CHN
FUYUANYU7670	412440763	277	297,237	Squid jigger	CHN
LIAOYU6	412206009	277	297,131	Squid jigger	CHN

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The number of AIS messages received per vessel operating inside the focal area varied significantly, ranging from 312,554 transmissions received over 287 days to vessels with only two transmissions from just one single day. The squid jigger HUA YING 201, for example, had long periods with no AIS data. This boat was detected on AIS as active within the AOI; however, on April 9, 2021, the AIS gap event started and continued until June 2, 2021. The second greater AIS gap event for the HUA YING 201 started on October 14 and continued until December. **A gap of this length is unlikely to have been caused by a reception issue and is consistent with the possibility of the AIS device being deliberately disabled. Vessels with limited AIS data available are less trackable in their movements and compliance with EEZ limits and transshipment regulations is unknown. GFW utilizes a set of criteria to identify gaps unlikely to be caused by reception issues,**

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[2] Global Fishing Watch has developed algorithms to automatically detect different types of fishing activity from vessel tracking data. Kroodsma, D. *et al*, 2018. [Tracking the global footprint of fisheries](#). Science, 359(6378), pp.904-908.

[3] At the time of reporting SPRFMO had not published the 2021 list of Active Vessels for comparison.

[4] https://docs.google.com/spreadsheets/d/1e30NwiblrC092uI83ktF5L1RvLWZ8es_0vPKr3TcKTs/edit#gid=542325584

[5] This study considered a 'fishing day' as any 24-hour period where the Global Fishing Watch algorithm detected at least 1 hour of movements that were consistent with nighttime squid jigging.

here referred to as suspected disabling events[6]. These criteria involve thresholds pertaining to gap length, distance from shore, reception quality in the area of the event, and positions being transmitted by the vessel.

Of the 527 unique vessels identified operating inside the study AOI, 178 (34%) had suspected disabling events in AIS data inside the study AOI longer than 24 hours. A fleet of this size is a challenge to monitor for coastal States and management bodies. AIS provides a level of transparency and oversight not afforded by what is currently being reported. RFMO members and CNCPs should mandate the continual use of AIS Type-A in line with SOLAS regulation V/19.2.4 for distant water fishing.

Furthermore, the International Labour Organization identifies "days at sea" as an indicator of risk in their Fishing Labor Risk Analysis[7]. In addition, a study found total time on the high seas and distance from port to be two key indicators of forced labor in fisheries. AIS analysis of the Southeast Pacific distant water squid fleet identified vessels with long trip lengths into the study AOI and away from port. AIS is an effective tool for monitoring duration at sea and when vessels with extended periods at sea request entry into port or enter coastal waters, an inspection of the working conditions should be prioritized by the port or coastal authority. In addition, SPRFMO member States and CNCPs ratify and implement the International Labour Organization's Work in Fishing Convention (2007) C188 to ensure safe and legal working conditions exist on board vessels operating inside the convention area.

Clear seasonal and spatial patterns in the squid fleet operating in the region are evident. Squid fishing vessels changed their fishing grounds throughout the year (Figure 2), with the highest AIS-detected fishing effort in October, November, and December. In addition, squid fishing vessels were an average of 100 nautical miles from EEZs. The seasonal movement of the squid fleet can be characterized in 2021 as:

- **January-March**: Fishing vessels concentrated close to the western limit of the Ecuador EEZ (Galapagos).
- **April-June**: Fishing vessels continued close to the western limit of the Ecuador EEZ (Galapagos).
- **July-Septembe**r: Fishing vessels continued close to the western limit of the Ecuador EEZ (Galapagos).
- **October-December**: Fishing vessels moved from the western Ecuador EEZ (Galapagos) to the high seas adjacent to Peru's EEZ. Vessels operated farther south along with Peru's EEZ limits and west of Ecuador EEZ (Galapagos).

There is a wide distribution of the squid fleet in the Southeast Pacific. The AIS data revealed that, within the Southeast Pacific, the zones with the most significant scale and persistence of the fleet were in the limits of Peru's EEZ and the Ecuador EEZ (Galapagos).

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[6] Methods for identifying suspected disabling events are still provisional.
[7] 2020. ILO training package on inspection of labor conditions on board fishing vessels.
https://www.ilo.org/wcmsp5/groups/public/---ed_dialogue/---sector/documents/instructionalmaterial/wcms_766744.pdf

Figure 2: AIS-detected squid fishing activity by quarter

AIS-detected squid fishing activity in the Southeast Pacific with the average and the maximum number of active vessels within the AOI during each quarter of 2021.
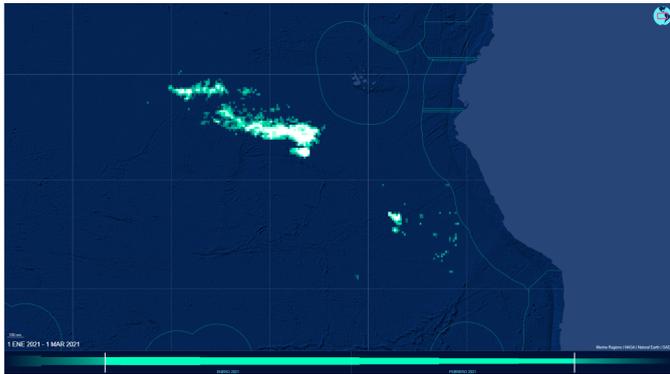
Quarter 1 (January-March)
Average: 465 vessels
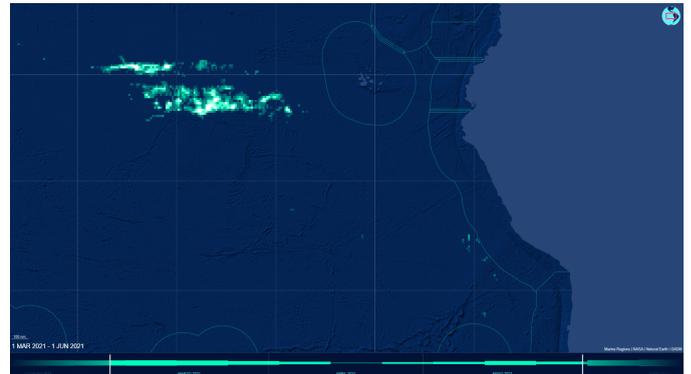
Quarter 2 (April-June)
Average: 431 vessels
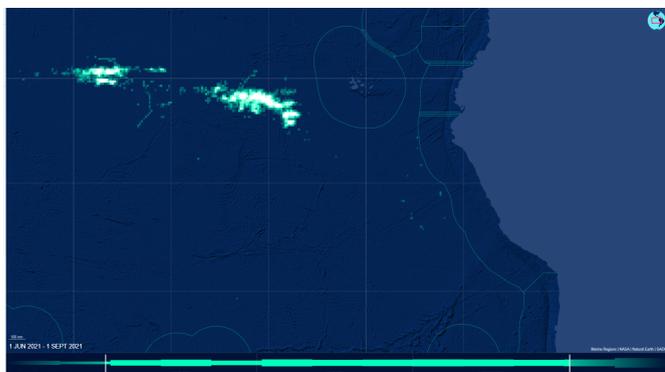
Quarter 3 (July-September)
Average: 388 vessels
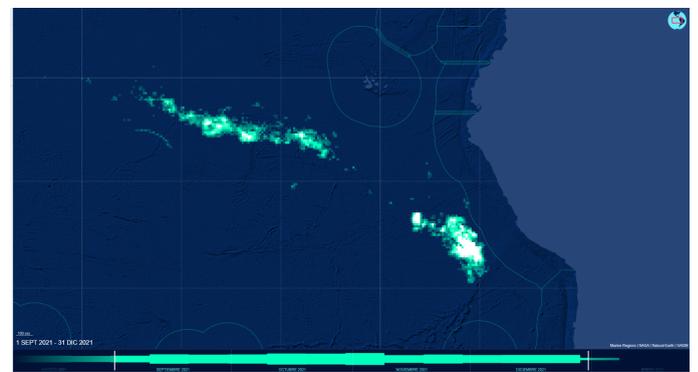
Quarter 4 (October-December)
Average: 442 vessels

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Figure 3: Quarterly fishing activity of squid vessels

The fishing activity of squid vessels found operating at some point during 2021 within the Southeast Pacific AOI, color coded by quarter.

● Jan-Mar   ● Apr-Jun   ● Jul-Sep   ● Oct-Dec
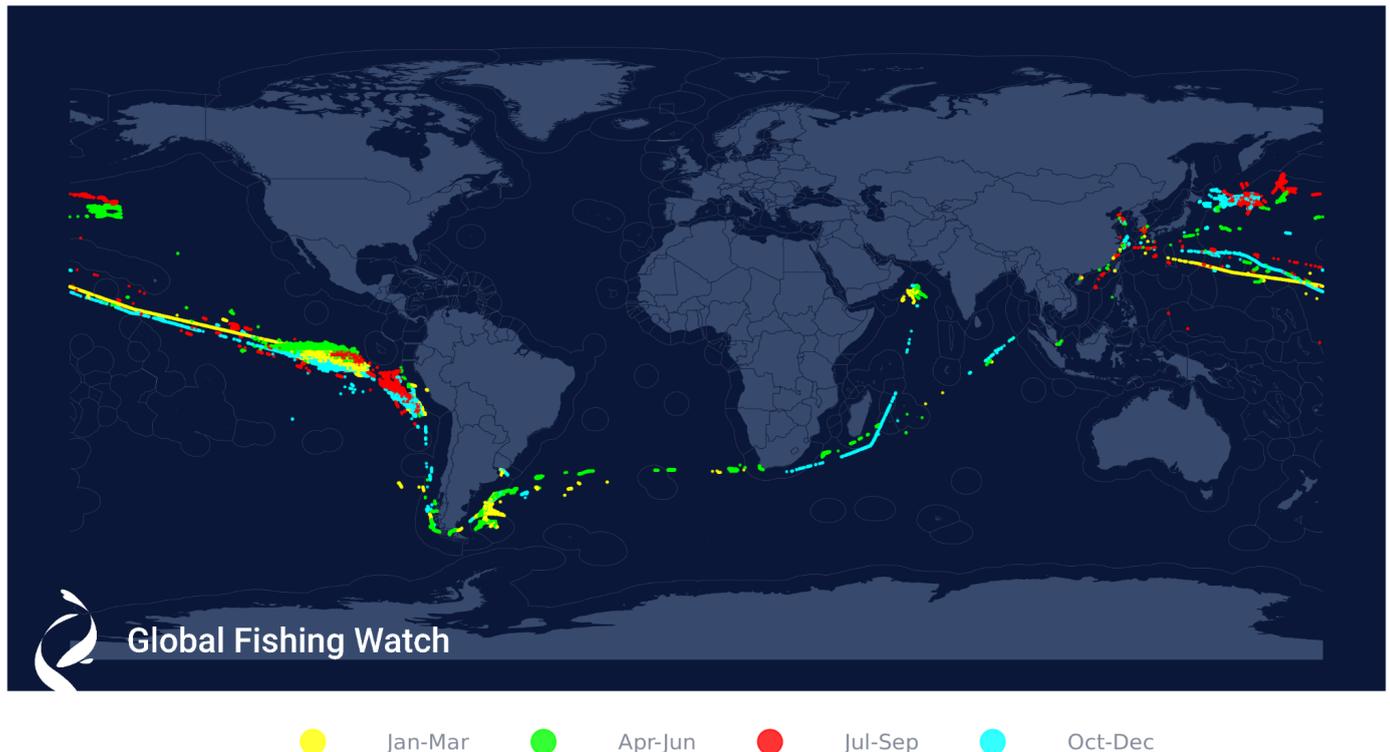
© 2021 Global Fishing Watch

AIS can be a valid tool for the monitoring of the fleet, and the use of AIS to supplement existing MCS tools to support monitoring should be accepted by SPRFMO member States and CNCPs, and incorporated in the commission's compliance framework. It is recommended to cross reference the reported data once the list of active vessels for 2021 is available with what is observed on AIS inside the SPRFMO Convention Area.

A total of three vessels that were found to be operating inside the AOI in 2021 could not be matched to the Commission Record of Vessels Authorized to Fish in the Convention Area. One vessel, the ZHOUYU810, did not have an SPRFMO authorization status. However, the vessel had movements consistent with squid fishing (see workspace). SPRFMO CMM 05-2021[8] for the Establishment of the Commission Record of Vessels Authorized to Fish in the Convention Area in 2021, which supersedes CMM 05-2019, required member States to authorize vessels to operate inside the SPRFMO Convention Area and notify the secretariat. The purpose is to ensure vessels operating inside the convention area are being monitored, reporting catch and are compliant with all CMMs. The unmatched vessels were either broadcasting an identity on AIS that did not match an authorization record, or the vessel was not broadcasting a clear identity on AIS (Table 2, Figure 4).

A vessel is considered unidentified when the AIS data lacks information on name, IMO number, MMSI, call sign or other information that helps to identify its name or flag (Table 2: SPRFMO authorization status unidentified). Two vessels were broadcasting an MMSI number but without a

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[8]https://www.sprfmo.int/assets/Fisheries/Conservation-and-Management-Measures/2021-CMMs/CMM-05-2021-Record-of-Vessels-12Mar2021.pdf

name, IMO, or call sign that would allow the vessel to be correctly identified. The flag State should investigate apparent manipulation of AIS information and cooperate with coastal and port States to provide detailed information on vessel activity that appears to occur along or within EEZs. In addition, the flag States should verify that their flagged vessels are broadcasting accurate AIS information in line with IMO Resolution A.1106(29) to ensure transparency in their operations and safety of navigation.

Table 2: Unidentified or unmatched vessels

Three vessels that were observed operating inside the SPRFMO Convention Area in 2021 could not be matched to an authorized vessel, either because the SPRFMO authorization was unmatched, or the vessel was unidentified.

	MMSI	Vessel name	IMO number	Callsign	Flag	SPRFMO authorization
1	412671870	ZHOUYU810	8783397	BKWI2	CHN	Unmatched
2	135596547	Unknown	Unknown	Unknown	Unknown	Unidentified
3	800032634	Unknown	Unknown	Unknown	Unknown	Unidentified

Figure 4: Unidentified or unmatched vessel tracks

The AIS-based tracks for 3 vessels that were detected operating inside the area of interest, but could not be matched to a SPRFMO authorized vessel in 2021.
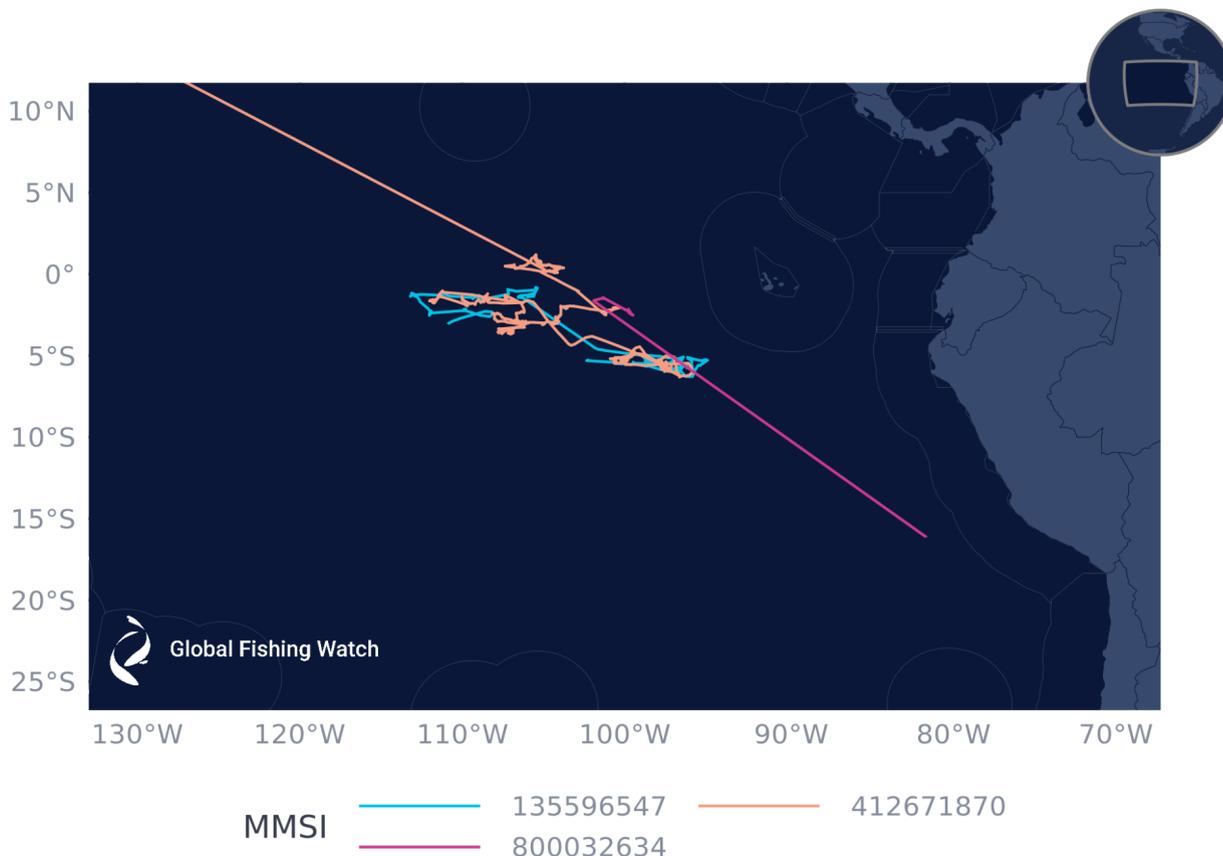
3 AIS misuse and irregularities

The AIS system was primarily designed for safe navigation and the reduction of collisions at sea. Depending on the functionality of the device, some elements of the system can be tampered with, including changing the vessel identity information, changing the MMSI number, and some systems even appear to allow for the manipulation of a ship's position. The International Maritime Organization (IMO) includes broadcasting falsified AIS data as a fraudulent activity when done to "*materially alter the ship's identifying information or to reflect the AIS data of an entirely different vessel.*"

Manipulation of AIS needs to be understood and Global Fishing Watch has established expertise to ensure that such manipulation is detected and the analysis formulated with such activity represents the likely truth.

Three types of AIS irregularities were observed in the fleet: vessels using multiple MMSI numbers, one MMSI number used by multiple vessels, and false locations.

3.1 Vessels using multiple MMSI numbers

This type of irregularity happens when the vessel broadcasts its AIS location using two MMSI numbers. The MMSI number is unique for each vessel and the number should be assigned by the flag State. Consequently, operating a vessel with different numbers is irregular and potentially contravening IMO regulations and flag State rules on maritime radio licensing.

Twenty-one squid vessels appeared to be using multiple AIS devices with different MMSI numbers, and between them, they operated 42 MMSI numbers within the AOI during 2021 (Figure 5 and 6). The fishing vessels with multiple AIS, all of which were authorized by the SPRFMO, were flagged to China.

It is unknown whether the discrepancies in MMSI numbers reflect different broadcasting devices, or are due to satellite signal detection error, or human error at the point handling the AIS device. The true reason behind vessels operating with multiple AIS devices with different MMSI and identity information is not clear. The dilemma does, however, highlight the real challenge of monitoring, control, and surveillance of these vessels from remotely observed data.

Figure 5: Fishing vessels using multiple MMSI numbers
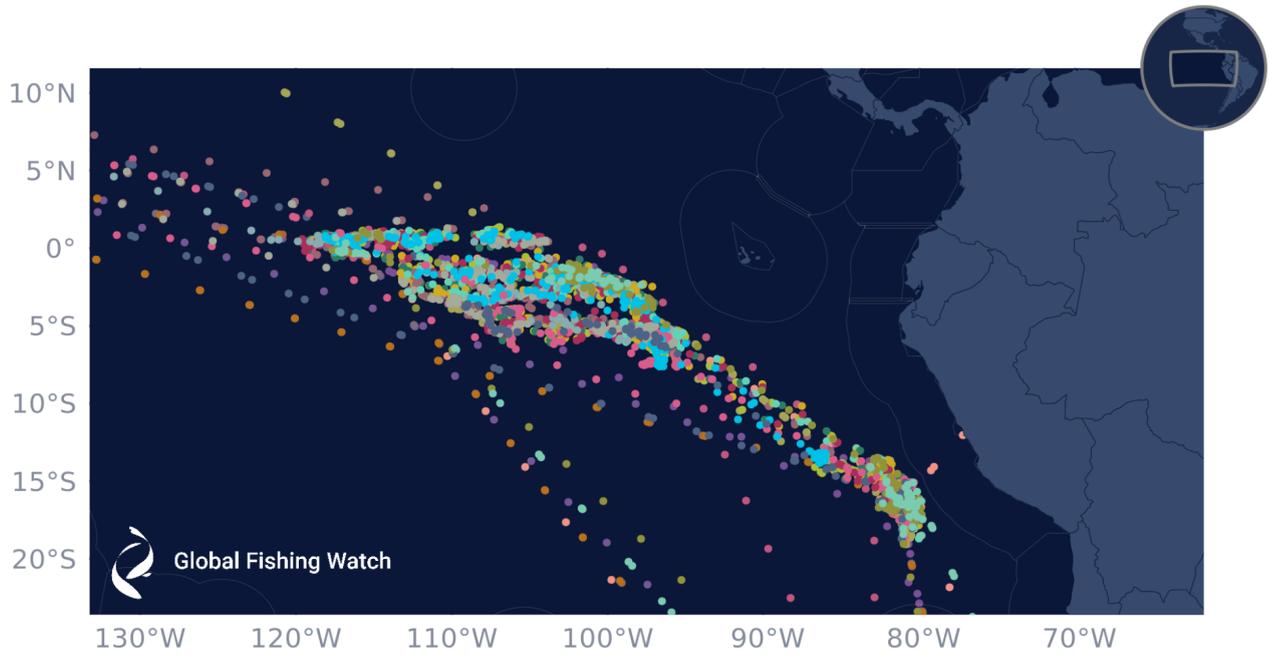
IMO					
• 8528802	• 8529040	• 8676037
• 8774853	• 8775986	• 8776239
• 8777659	• 8778500	• 8778770
• 8779085	• 8779994	• 8786557
• 8786569	• 8786571	• 8786583
• 8786595	• 9819595	• 9819612
• 9862504	• 9870783	• 9888261

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Figure 6: AIS Positions Transmitted by Squid Vessels Using Two or More MMSI Numbers

Vessel using multiple MMSI numbers
Number of AIS positions transmitted

First MMSI ■ **Second MMSI**

Vessel	First MMSI	Second MMSI
NINGTAI58	462	78,471
NINGTAI65	2,157	308,190
ZHOUYU908	101,740	257,204
JULONGJIAYA28	16,127	14,021
HANYI3	106,169	484
LURONGYUANYU701	216,667	1,923
SHUNZE805	2,695	13,893
HAN YI 788	7,804	18,039
PU YUAN 716	2	100,779
HANYI78	11,226	30,161
JINGYUAN608	145,814	51,965
HAI FENG 1	25,766	3,591
NING TAI 6	11,305	31,029
NINGTAI717 (ex RUND...	6	63,033
LURONGYUANYU197	6,940	62,787
LU RONG YUAN YU 277	56,776	65,749
LU RONG YUAN YU 278	17,379	44,610
LURONGYUANYU715	600	44,678
LU RONG YUAN YU 717	47,980	34,844
ZHOUYU916	67,967	188,862
ZHOUYU921	12,886	166,870

0%   25%   50%   75%   100%

3.2 False AIS position messages

In some instances, vessels can broadcast an AIS position outside of the reception footprint of the receiving satellite. The false AIS positions make the vessel look like they are operating in an offset location to where they actually are. This could be a result of data getting corrupted or a product of the system being tampered with in a deliberate attempt to disguise a vessel's location. Follow up from the relevant authorities would help determine the cause of such an issue. Global Fishing Watch has developed a [technique](#)[9] to correct the offset where a vessel's track is repositioned within the footprint of the receiving satellite and stationary objects like coastlines and ports are used to identify the most likely true positions for the vessel.

Ten vessels were identified with AIS positions outside of the receiving satellites footprint. The vessels were flagged to China and the false AIS positions made the vessels look like they were

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[9] Details of this offset correction can be found in a GFW blog from 2016
https://globalfishingwatch.org/data/when-vessels-report-false-locations/

operating in the southwest Pacific (Figure 7). It is unknown if this is a fault with the AIS units or a deliberate way of concealing their location.

Figure 7: Vessels within the squid fleet that are broadcasting false locations

Example of AIS tracking data from vessels within the squid fleet that are broadcasting false locations. False positions cause vessels to appear near New Zealand because all vessels are using exactly the same offset.
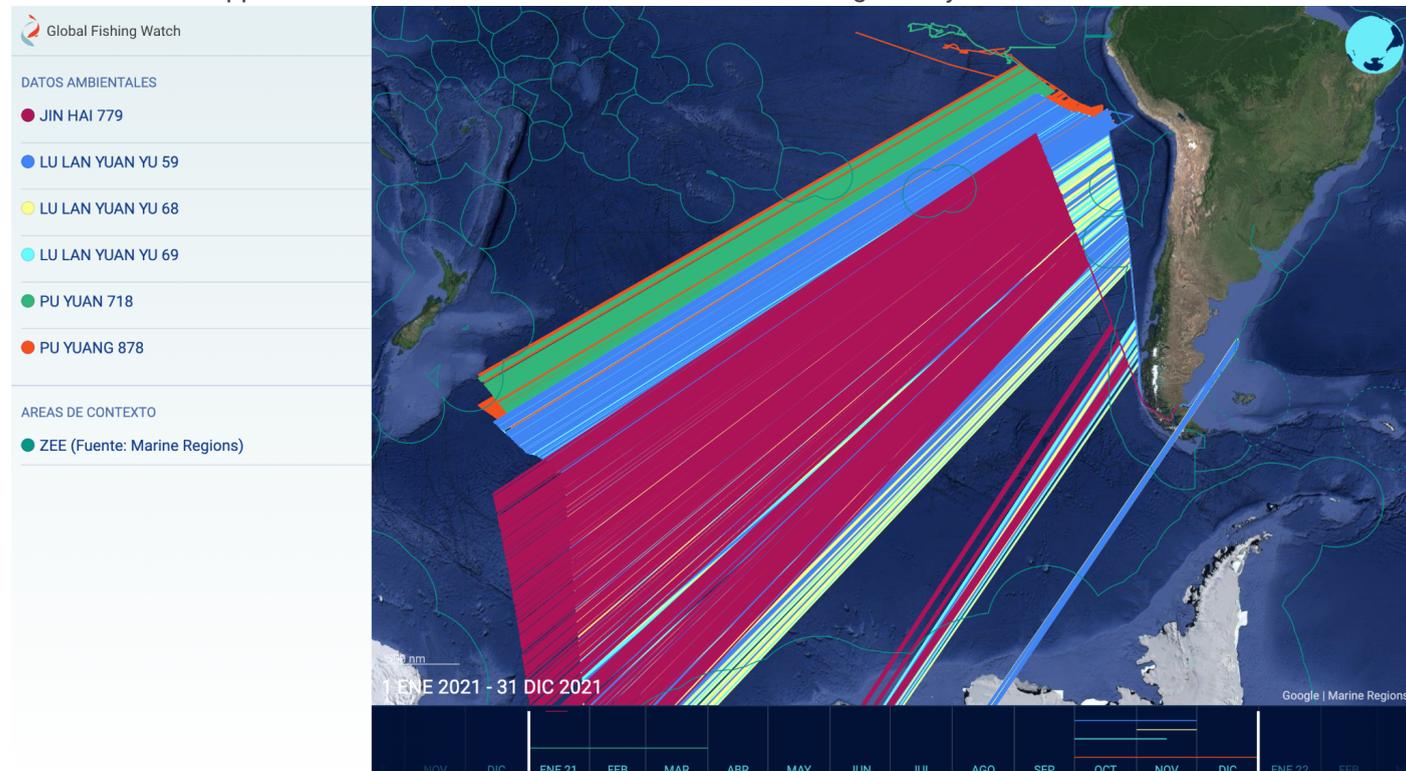
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Table 3: Vessels detected with false AIS position messages

	MMSI	Vessel name	IMO	Callsign	Flag	SPRFMO authorization	Total AIS positions
1	412440453	FUYUANYU788	8784418	BVSL7	CHN	Authorized	117,265
2	412440556	FUYUANYU7883	9828766	BVZA7	CHN	Authorized	233,713
3	412549046	HONGPU9	9892250	BZUH5	CHN	Authorized	184,607
4	412421087	JINHAI779	9844502	BZW3N	CHN	Authorized	22,975
5	412333655	LULANYUANYU59	9843168	BZTS7	CHN	Authorized	20,331
6	412333656	LULANYUANYU68	9843170	BZTS8	CHN	Authorized	21,697
7	412333657	LULANYUANYU69	9843182	BZTS9	CHN	Authorized	38,206
8	412549172	PUYUAN718	8528814	BZYU3	CHN	Authorized	97,640
9	412420681	PUYUANG878	8780292	BZ1VP	CHN	Authorized	57,415
10	412320029	JINGYUAN608	8676037	BZZT7	CHN	Authorized	51,965

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Although there is a high proportion of AIS use by the distant water squid fleet inside the study AOI, there are also multiple instances of AIS misuse and irregularities. The most significant is the transmission of false vessel information. SPRFMO member States and CNCPs enforce national regulations around the registration and use of AIS that implements IMO Resolution A.1106(29).

4 Support Vessels - Transshipment and Bunkering

A large part of the business model for operating high seas fleets, like the Southeast Pacific squid fleet, is that vessels are supported by refrigerated cargo vessels called carrier vessels and fuel tankers called bunkering vessels. Carrier vessels meet with fishing vessels at sea in order to move the catch off the fishing vessel, known as transshipment, and take it to port. Carrier vessels also carry out crew changes and resupply the fishing vessels with food and other essentials. Bunker vessels provide a fuel bunkering service at sea. The reason behind both of these at-sea services is to allow fishing vessels to fish for longer without having to return to port.

The SPRFMO currently requires carrier vessels to be authorized by the flag State and included on the commission record of vessels; a register that is publicly available. Unlike some of the other target fisheries for which transshipment of catch is regulated by SPRFMO under CMM 2018 and 2021, a transshipment event of jumbo flying squid does not need to be authorized by the flag State of the fishing or carrier vessels, removing the opportunity for even the most basic flag State oversight. Irrespective of target catch, currently SPRFMO does not have any management measures in place that apply to fuel bunkering of fishing vessels at sea.

Based on AIS data, we identified 46 support vessels operating within the AOI in 2021. Forty of these were carrier vessels and six tanker vessels. The majority of these carrier and bunker vessels were flagged to Panama, followed by China, Liberia, and finally Chinese Taipei with a single flagged carrier vessel.

4.1 Encounters

Analysis of the AIS data identified 46 support vessels (40 carrier vessels and 6 bunker vessels) with a total of 2,511 encounters with squid fishing vessels in the Southeast Pacific region. Support vessels were flagged to Panama with 26, China with 15, Liberia with four, and Chinese Taipei with one. The majority of encounters were conducted by carriers flagged to Panama and China, which accounted for 72.2 percent and 17.9 percent of the total, respectively. Encounters were highly concentrated outside the western and southern Galapagos EEZ, and off Peru's EEZ (Figure 8).

Figure 8: Distribution of encounters between support vessels and squid vessels

Encounters by non-fishing vessels with active fishing squid jiggers, aggregated by carrier flag State. Each dot represents a possible transshipment event.
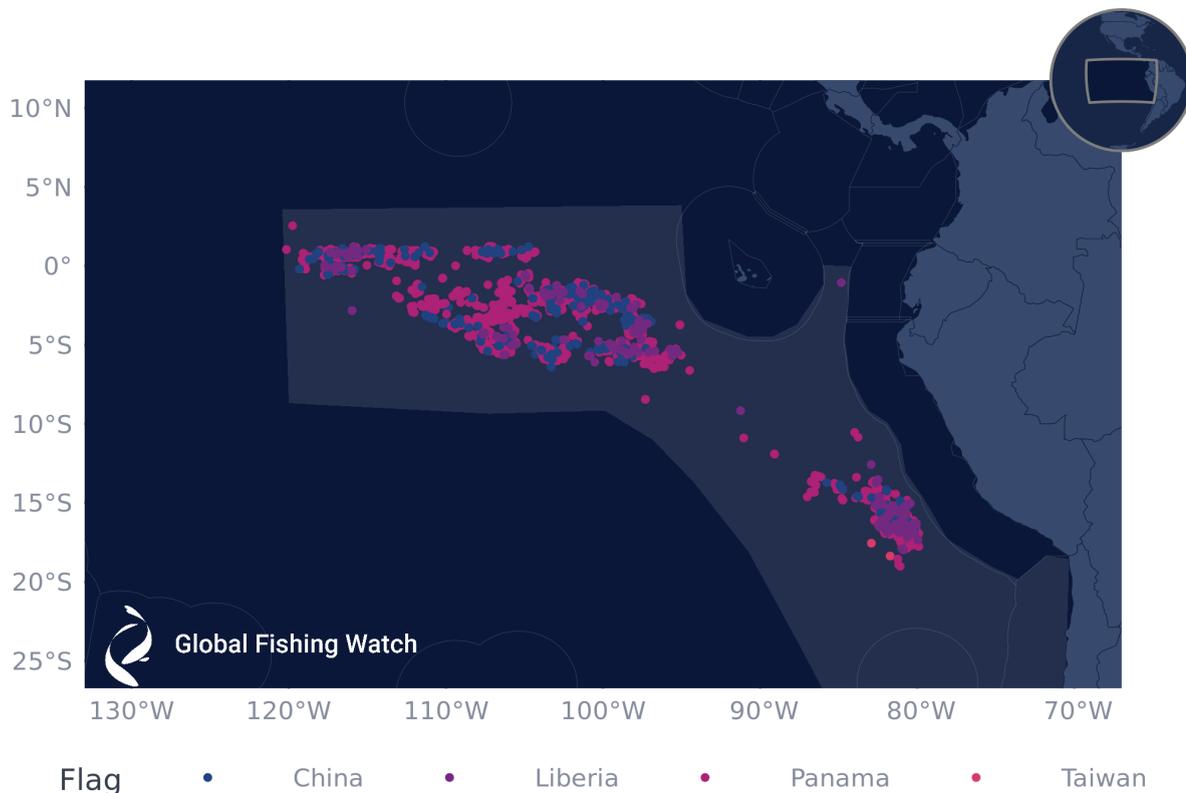
4.2 Loitering events

Loitering events are identified when a single carrier vessel exhibits behavior consistent with encountering another vessel at-sea, but no second vessel is visible on AIS, also known as a "dark vessel." Loitering events are estimated using AIS data to determine vessel speed, duration at a slow speed and distance from shore. Loitering events are an important source of information that can be used as a first step to identifying where vessels with unexplained slow speeds may warrant further investigation. Slow speeds, however, may not necessarily indicate transshipment activity and can be related to any number of unrelated events, such as a mechanical issue.

Fourty-three non-fishing vessels had a total of 3,792 loitering events in the Southeast Pacific during 2021 (Figure 9). Carriers with those events were flagged to Panama, Liberia, China, and Chinese Taipei. In most cases, vessels with loitering events had at least one encounter event. Carriers with a small number of AIS-based estimates of encounter events all have detected loitering events. This could indicate that additional encounters may be occurring at sea that are not apparent with AIS data alone.

Figure 9: Distribution of loitering events by support vessels

Loitering events by non-fishing vessels, aggregated by carrier flag State. Each dot represents a possible loitering event.

Transshipment in the SPRFMO region for squid occurs at a scale that is challenging for management. Yet it operates with weaker management requirements than other species in SPRFMO or overlapping RFMOs like IATTC. Allowing transshipment to occur without a provision for flag State authorization and even the most basic checks against IUU catch being transshipped creates a loophole for vessels that weakens transshipment controls for the whole region. Additionally, a lack of transparency regarding what is being reported as a squid transshipment makes oversight by flag, coastal or port States challenging.

Table 4: Top 10 Support vessels operating in the Southeast Pacific

List of the top 10 non-fishing vessels operating in the Southeast Pacific region during 2021. Click to see the full list of vessels.

Number	MMSI	Vessel name	Flag	Type	Number of encounters with squid vessels
1	374245000	OCEANSPLENDID	PAN	Tanker	262
2	354003000	SHENJU	PAN	Fish carrier	198
3	356155000	TRITONREEFER	PAN	Fish carrier	137
4	351960000	MINGHANG5	PAN	Fish carrier	127
5	357172000	YONGHANG3	PAN	Fish carrier	124
6	357832000	YONGXIANG9	PAN	Fish carrier	122
7	351383000	CHENGHANG	PAN	Fish carrier	115
8	412421088	JIN ZHOU	CHN	Fish carrier	106
9	636018227	WEI NING	LBR	Fish carrier	105
10	351020000	SHUNZELENG6	PAN	Fish carrier	95

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5 Port State Analysis

Port States used by the high seas squid fleet operating in the SPRFMO Convention Area provide one of the best opportunities for authorities to carry out vessel compliance checks, especially if these States have ratified and are implementing the Port State Measures Agreement (PSMA). There are two distinct port activities by the fleet that present this opportunity: visits by the fishing vessels to Latin American ports for services like refueling, crew changes, and resupply, and the landing of catch by carrier vessels in port.

5.1 Port visits by fishing vessels to Latin America ports

In 2021, AIS analysis identified visits by two squid vessels to Callao ports, mostly in the months between February and March. As the only port State utilized along the Pacific Latin American coastline, Peru as a PSMA state has a unique opportunity to provide a degree of enforcement regarding the activities of squid vessels operating on the high seas. Further data sharing and cooperation between coastal States in the region will strengthen steps to build a comprehensive risk assessment and inspection program that will support Peru's implementation of PSMA and provide a key enforcement point for squid vessels operating on the high seas.

5.2 Port visits by carrier vessels after squid transshipments

The purpose of transshipment is to get the catch to the supply chain as efficiently as possible and this is usually through the closest port to the processing facility.

A total of 50 port visits by carrier vessels after an encounter with a squid vessel inside the study AOI were identified from AIS in 2021. Carriers visited ports in five countries: Chile, Panama, China, the Republic of Korea, and Singapore (Table 5). The country with the most port visits was China with 34 visits, representing 68 percent of the total port visits. The second port with the most visits was Balboa in Panama, where a total of 9 visits (18%) were registered. In addition, there is a list of 8 carriers for which no port visits could be identified in all of 2021, despite them being involved in various encounters throughout the year. This requires further analysis, but could suggest vessel behavior needing to be clarified.

All of the port States identified for carriers visiting after operating inside the study AOI are members of a CNCP to a SPRFMO. Furthermore, in line with CMM 07-2019 - Conservation and Management Measure on Minimum Standards of Inspection in Port, all of the ports visited have been designated by the member or CNCP except for those in China which has yet to designate ports. It is recommended that China provide a list of designated ports where the minimum standards on port controls can be met for visiting foreign vessels. Effective implementation of comprehensive port State controls, paired with information sharing— and cooperation amongst member States and other RFMOs—can help decrease the risk of IUU-caught fish entering the supply chain and can increase transparency of transshipment activity at sea and in port. SPRFMO should continue to support its members and CNCPs to implement comprehensive port State controls, in line with CMM 07-2021, to ensure good governance and effective oversight. Data on implementation of CMM 07-2021 should also be collated and made public.

Table 5: Port visits by carriers after the encounter with squid fishing vessels

Count of port visits by carriers after encountering a squid vessel inside the study AOI. Ports are listed by name and port State.

Port	Country	Number of port visits
Zhoushan	China	23
Balboa	Panama	9
Weihai	China	7
Busan	Republic of Korea	4
Singapore	Singapore	2
Punta Arenas	Chile	1
Fuzhou	China	1
Suizhong	China	1
Taizhou	China	1
Yanwoshan	China	1

6 VIIRS image analysis

Analysis using AIS tracking is effective in providing a whole range of new insights and transparency on the activities of fleets like the high seas squid fleet. The challenge, however, remains that vessels are able to switch off AIS transmissions, rendering the vessel "dark." It has also been shown that [cases](#) of IUU fishing often include the switching off of AIS. Satellite-based remote sensing imagery can provide an additional source of information on the activity of fishing vessels without relying on tracking devices being switched on.

The Suomi National Polar-orbiting Partnership (NPP) satellite has a sensor with a spatial resolution of approximately 0.74 km^2, capable of detecting low light signals from Earth. Called the Visible Infrared Imaging Radiometer Suite (VIIRS), it is able to detect fishing vessels that use bright lights to attract target species to the surface, such as the squid fishery in the eastern equatorial Pacific. VIIRS imagery requires the sky to be relatively clear to detect vessels but provides good coverage, one full global scene every 24 hours, and is available in near real time.

The distribution of daily VIIRS vessel detections over the Southeast Pacific Ocean for 2021 showed a seasonal pattern of the fishing points of the squid fleet that supports the AIS analysis. During the first and second quarter of 2021, the fleet was located along the eastern equatorial Pacific (Figure 10).

For the third quarter, the squid fleet mainly extended along the south of Galapagos Islands EEZ limit, and by the end of the third quarter started to move along to the south of Peru's EEZ. And, in the last quarter of 2021, the fleet was concentrated next to Peru's EEZ. Finally, in December, 21% of the fleet returned to the high seas adjacent to Argentina's EEZ and the other 79% returned to the eastern equatorial Pacific fishing area in the eastern part of the study AOI. On average, squid fishing vessels were operating at 100 miles distance from EEZs.

Matching VIIRS detections with AIS transmissions creates an estimate of how many vessels in a fleet broadcast AIS tracks. For each AIS vessel track in the area of the detection, the course and speed required to be in the location of the VIIRS detection at the same time are calculated. Using the speed and course, the likelihood is then estimated for whether a VIIRS detection is matched with a AIS vessel track. The likelihood distributions were pre-calculated by GFW based on a large-scale review of historical AIS data. Finally, for a match to happen, the VIIRS-AIS pairs need to have a likelihood score greater than a threshold, and in the case of multiple matches, the highest score above the threshold is chosen.

When this analysis is applied to the squid fleet in three distinct areas inside the study AOI, it appears to show a high proportion of squid vessels operating with AIS switched on. Figure 11 shows the number of VIIRS detections as a bar graph for three areas of the study AOI. The bars are split by detections. The line graph overlaid represents the daily count of squid vessels transmitting on AIS. If the bars were greater than the bar chart, it would indicate the existence of a "dark fleet." For these three regions, the bars are less than the daily AIS count of squid vessels, suggesting a high proportion of the fleet is using AIS. In the case of the high seas area around 1000nm west of Ecuador EEZ (Galapagos) and the high seas area adjacent to the Peruvian EEZ, the daily AIS count of squid vessels is actually higher than the VIIRS detections. This is likely a result of clouds obscuring the images or a very tightly packed fleet where multiple vessels are closer than the image resolution of 0.74 km^2 and are counted as a single vessel detection.

Analysis of AIS data shows no distant water vessels operating within any of the coastal State waters inside the study AOI in 2021. To supplement the AIS analysis, VIIRS vessel detections were used to identify potential nighttime fishing incursions into the EEZs by large industrial squid vessels. The VIIRS vessel detections in this region closely match the operations of the larger high seas squid vessels through 2021 and provide a good proxy for monitoring the fleet and potentially vessels operating without AIS that warrant investigation by patrols at sea. The Coastal States should incorporate the data source into their fisheries enforcement and maritime security regimes to prioritize targeting of dark vessels identified inside EEZs.

**Figure 10: Annual VIIRS detection by each quarter, 2021**

Annual VIIRS detection by each quarter for 2021, shown over the main fishing squid areas, south outside the Galapagos EEZ and north and south outside the Peru EEZ.
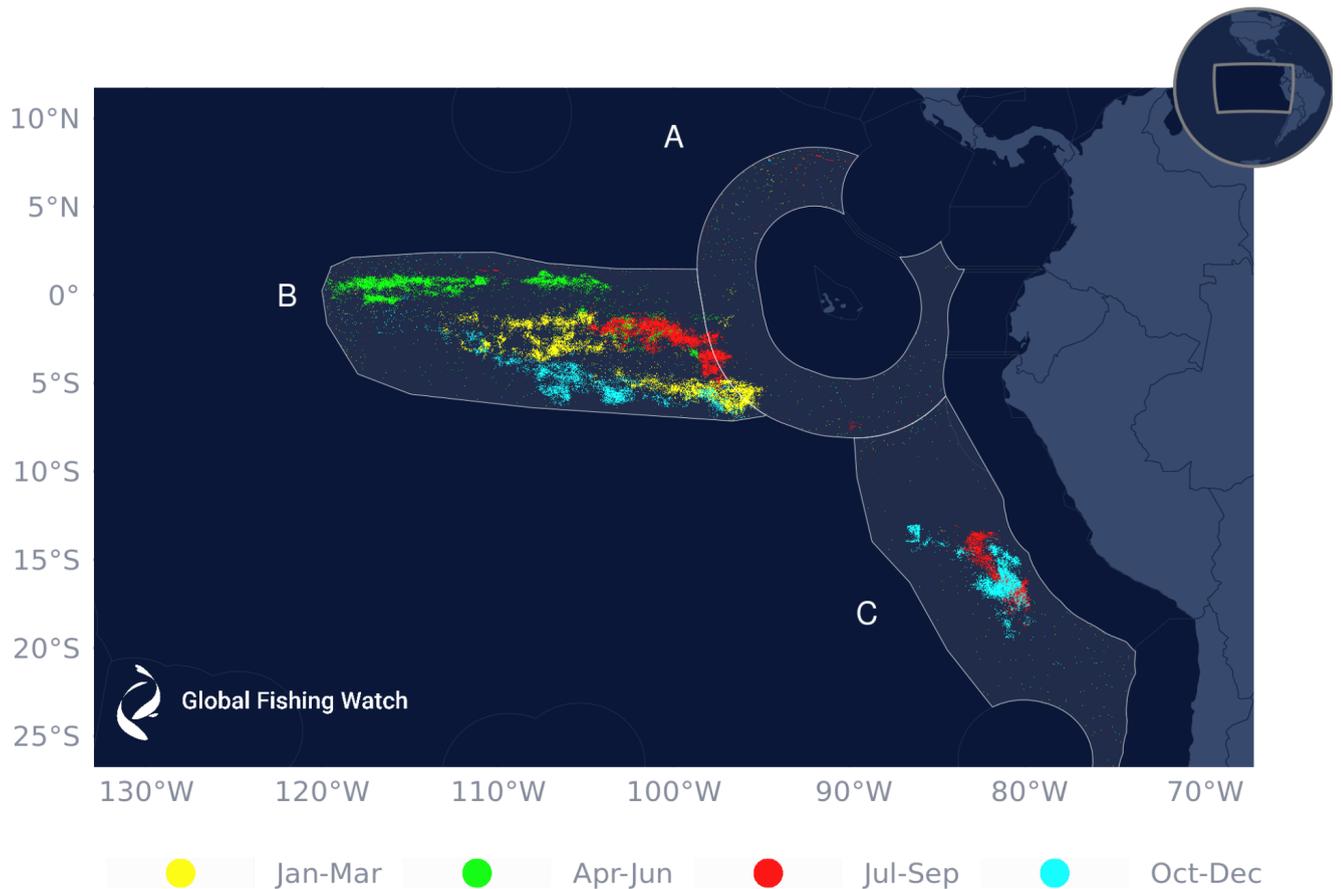
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Figure 11: Daily count of VIIRS detection matched/unmatched to ais vessels and daily count of MMSI for the squid fishing areas

Daily count of VIIRS detection matched/unmatched to AIS vessels (blue/pink bar respectively) and daily count of MMSI for the squid fishing areas (blue line). Note: HS refers to High seas
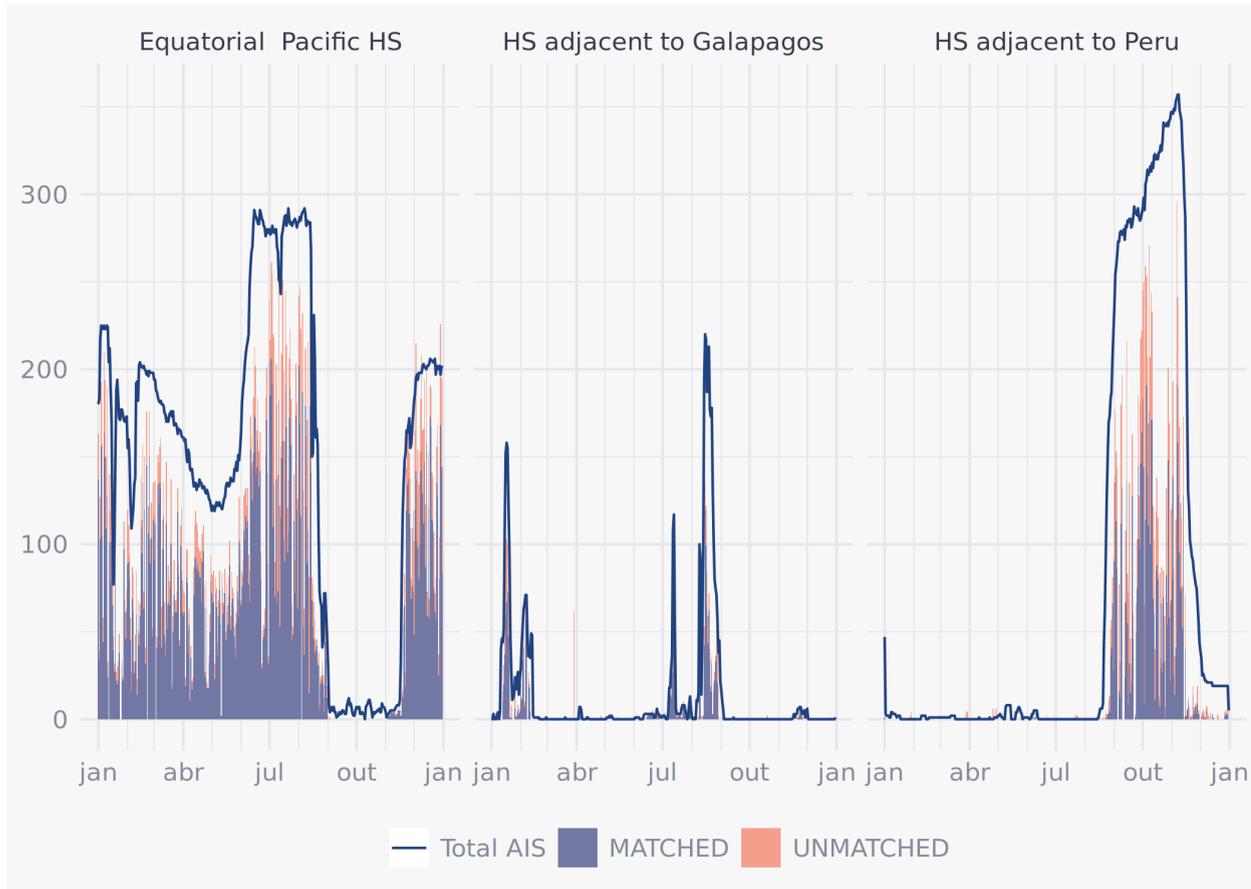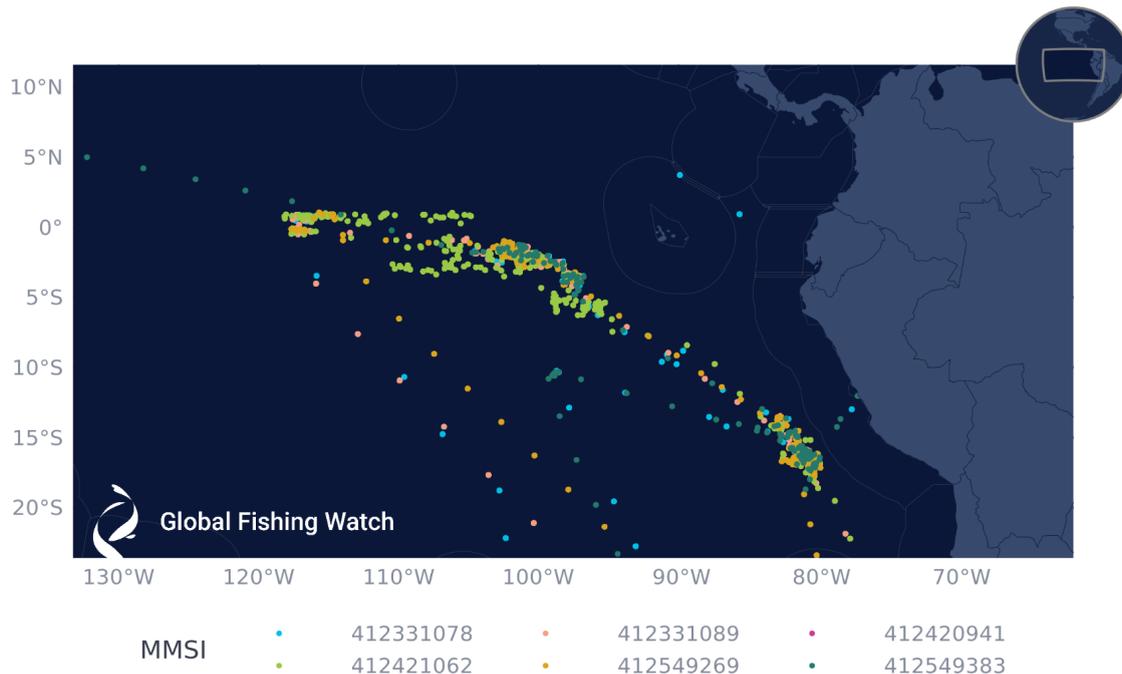

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7 Vessel History - Links to IUU Fishing

A review of historic media reports, IUU vessel lists and national IUU fishing reports identified six vessels authorized via the SPRFMO record of vessels and seen operating in the Convention Area in 2021 that have been linked to possible IUU fishing cases from 2014 to 2020 (Table 6). For example, the HUA LI 8 had been the subject of an INTERPOL Purple Notice for suspected IUU fishing in February 2016. It was not broadcasting AIS when it was intercepted by a routine patrol of the Argentine Navy, which claimed it caught the vessel fishing within Argentina's EEZ. Later, while sailing to China, the HUA LI 8 was arrested by the Indonesian Navy on March 21, 2016. Two years later, the HUA LI 8's owner, Zhoushan Huali Ocean Fisheries Company, was able to register in the SPRFMO, despite the vessel's history of illegal fishing. The vessel has been authorized to operate in the SPRFMO's area from February 8, 2018 to date. During 2021, it has been fishing along the border of Argentina's EEZ.

Figure 12: Example of vessels with historical IUU events

Six squid vessels with historical IUU events. The Chinese flagged HUA LI 8 and RUN DA 608 tracks appear inside the study AOI in 2021.

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Table 6: Vessels identified with links to historic IUU fishing cases

List for six vessels registered and authorized by the SPRFMO in 2021 with links to IUU fishing activities between 2014 and 2020. The list was compiled in collaboration with the Sustainable Fisheries Partnership.

ID	Vessel Name	MMSI	IMO	Flag	Type of fishery	SPRFMO List 2020	Media report	AIS positions 2021
1	HUA LI 8	412420941	8779774	China	Squid	Authorized	Argentina	93,142
2	HUA XIANG 801	412421062	9822695	China	Squid	Authorized	Argentina	24,421
3	LU RONG YUAN YU 688	412331078	8775883	China	Squid	Authorized	Argentina	128,024
4	NINGTAI717 (ex RUNDA608)	412549269	8778770	China	Squid	Authorized	Peru	6
5	JING YUANG 626	412331089	9784568	China	Squid	Authorized	Argentina	114,436
6	LU RONG YUAN YU 688	412331076	8708256	China	Squid	Authorized	Argentina-Peru	6,025

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SPRFMO CMM 04-2020 - *Conservation and Management Measure Establishing a List of Vessels Presumed to Have Carried Out Illegal, Unreported and Unregulated Fishing Activities in the SPRFMO Convention Area* defines IUU fishing activities in relation to SPRFMO CMMs. A review of CMMs and the convention does not show any recognition of IUU vessel lists compiled by other RFMOs or consideration of vessel activity outside of the convention area.

8 Conclusions

Using open-sourced data, this report addresses gaps in transparency and governance that are blocking the sustainable and equitable management of the jumbo flying squid fishery. Open-source data can play an important role in highlighting the risk of IUU fishing and "tip and queue" enforcement bodies to investigate those observations, collect evidence, and apply the appropriate penalty where relevant.

Compared to squid fisheries in the North Pacific, Indian Ocean, and Atlantic, the fishery inside the SPRFMO Convention Area has the most developed regulatory framework covering vessel authorization, monitoring and reporting. However, implementing the relevant CMMs across a fleet of this scale operating on the high seas is challenging without cooperation between enforcement bodies and transparency of the fishing operations. The analysis identified three vessels that could not be matched to an SPRFMO authorization which, if confirmed, would indicate the possibility of unregulated squid fishing occurring. To further strengthen the control of unregulated fishing, member States, where possible, should make greater efforts to utilize CMM 11-2015 *Conservation and Management Measure Relating to Boarding and Inspection Procedures in the SPRFMO Convention Area* to carry out at-sea boarding and inspections.

Compared to the 2020 season, the distant water squid fleet reduced the number of active vessels in the area of interest by 14%. Additionally, fishing vessels did not operate closer than an average of 100 nautical miles from coastal States EEZs, the first time since 2015 that the fleet has not operated right up to the EEZ boundaries. Likewise, the number of vessels with irregularities in the use of AIS decreased by 3%.

The study identified that 34% of vessels had gap events greater than 24 hours, one of the outcomes is that many of the encounters between carrier vessels and fishing vessels are not detectable on AIS and cannot be reliably verified against implementation reports or active vessel lists. Greater efforts are required to validate activity in the fishery that is compliant with the CMMs regarding authorized and active vessels in the area and transshipments activity. Requiring vessels to continuously broadcast on AIS would go a long way in strengthening existing mechanisms for port controls and at-sea boarding and enable cross-checking of vessel compliance with the VMS and catch reporting CMMs.

Vessels with historic links to IUU activity have again been identified operating inside the SPRFMO region, SPRFMO recognizes and incorporates other RFMO IUU lists[10]. However, the challenge in the global high seas squid fishery is the Atlantic and Indian Ocean do not have an RFMO managing the fishery and there are no clear mechanisms for SPRFMO to recognize IUU activity in these regions within its own system.

States in the region are leading globally in the adoption of transparency as a tool to drive greater ocean governance. Such action significantly enhances our ability to analyze fishing vessel activity within the eastern Pacific region. Several countries in Latin America—Belize, Brazil, Chile, Costa Rica, Ecuador, Panama, and Peru—are committed to sharing or have already published their vessel tracking information on the Global Fishing Watch map. Considering the importance of the Southeast Pacific squid fishery to coastal States and distant water fishing nations, all flag States that have not made this vessel information publicly available or mandated and monitored the use of AIS should do so as a matter of priority.

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[10] GFW reported inaccurately that SPRFMO did not recognise other RFMO IUU listings in its review of the 2020 Analysis of the [Southeast Pacific Distant Water Squid Fleet](#) and would like to correct that misinterpretation of the CMM

Global Fishing Watch is an international nonprofit organization dedicated to advancing ocean governance through increased transparency of human activity at sea. By creating and publicly sharing map visualizations, data and analysis tools, we aim to enable scientific research and transform the way our ocean is managed. We believe human activity at sea should be public knowledge in order to safeguard the global ocean for the common good of all.

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