Analysis of Possible Transshipment Activity in the Indian Ocean Tuna Commission Convention Area in 2017 through the Use of AIS Data

Prepared By: Global Fishing Watch

Contents

12   Key Findings 52

13   Conclusion 55

Annex 2: Detailed Methodology 60

    AIS Description 60

    AIS Based Data Methods 60

List of Acronyms

AIS – Automatic Identification System

VMS – Vessel Monitoring System

IOTC - Indian Ocean Tuna Commission

CCSBT - Commission for the Conservation of Southern Bluefin Tuna

PSMA – Port State Measures Agreement

MCS – Monitoring Control and Surveillance

GFW - Global Fishing Watch

CHN – China

JPN – Japan

KOR – Korea

LBR – Liberia

MYS – Malaysia

OMN – Oman

PAN – Panama

SPG – Singapore

SYC – Seychelles

TWN – Taiwan, Province of China (referred to as 'Taiwan' in this document)

Executive Summary

Within the Indian Ocean Tuna Commission (IOTC) Convention Area, at-sea transshipments between longline vessels and carriers are permitted. When these transshipments occur on the high seas, the vessels involved should comply with IOTC transshipment regulations. This includes, in part, requesting specific authorisation from the flag State for each transshipment conducted, being monitored by an observer embarked on the carrier, declaring the type and quantity of product transshipped, and both vessels holding an authorisation by their respective flag State to transship at-sea inside the IOTC Convention Area. Transshipment of IOTC-managed species outside the bounds of this IOTC transshipment regulatory framework likely impacts proper overall oversight and control of the activity by IOTC flag State authorities, thereby posing significant risks to sustainability initiatives adopted by the Commission. Current IOTC Resolution 18-06 on transshipment is targeted at controlling authorised transshipments. Without additional mechanisms such as a centralised VMS, there remains a gap in Monitoring Control and Surveillance (MCS) capacity for IOTC management authorities to easily detect and respond to suspected IUU activity.

The intention of this study is, through the use of commercially available Satellite Automatic Identification System (AIS) data combined with the application of machine learning technology and analysis of publicly available information, analyse the track histories of carrier vessels operating in the IOTC Convention Area in 2017 with the objective to:

1. Provide IOTC policy makers with greater transparency and understanding regarding carrier vessel activities occurring within the IOTC Convention Area to better inform them regarding carrier vessel fleet movement patterns including spatial dynamics, encounters with fishing vessels, and highly frequented ports; and

2. Enable IOTC policy makers to make better informed decisions regarding the management of transshipment occurring at-sea within the IOTC Convention Area to strengthen the current IOTC transshipment regulatory framework where needed to address potential management gaps or loopholes related to reporting, monitoring and data-sharing.

The AIS-derived data resulting from this study is also intended to be a source of additional information for the IOTC Compliance Committee and Contracting Parties (Members) and

Cooperating Non-Contracting Parties (CPCs) to consider when validating reported activity by authorised carrier vessels and identifying where unauthorised activity may be occurring.

A review of AIS data for the Indian Ocean basin identified a total of 19 IOTC-authorised carrier vessels operating inside the Convention Area in 2017. This matched the number of active authorised carriers reported by IOTC. However, a further 13 CPC and non-CPC flagged carrier vessels (excluding Taiwan, Province of China flagged carriers whose authorisation could not be confirmed) were observed active inside the Convention Area that did not appear listed as authorised by IOTC or any overlapping tuna RFMO. The movements of these carrier vessels, in IOTC waters specific to tuna fisheries, suggests possible transshipping at-sea occurred. These potentially unauthorised events represent activity that may have occurred outside of IOTC transshipment regulations and indicate a need for strengthened monitoring of CPC and non-CPC carrier activity in the IOTC area of competence.

Of the total 1,259 transshipments reported in 2017 by the IOTC observer programme, this study only identified 171 encounters by authorised carriers with fishing vessels that were also transponding on AIS. An additional 609 loitering events by authorised carriers were identified which indicate a possible transshipment event occurred between a carrier operating with AIS and a second vessel with no AIS. The primary reason for the low identification from AIS of the authorised transshipment events is likely a combination of low AIS usage by fishing vessels in the Indian Ocean related to a lack of comprehensive national AIS requirements for the authorised fishing vessel fleets as well as a history of piracy in the northwest Indian Ocean that increased the frequency of vessel masters turning off their AIS transponders to avoid being detected by pirates.

The study also identified key ports visited by carriers after actively operating in IOTC waters. Carriers identified as potentially unauthorised were observed with loitering events inside the IOTC area of competence. These carriers made 23 visits to ports in countries not party to the PSMA and 16 visits to ports in countries party to the PSMA. As such, further work to strengthen CPC port controls in line with IOTC Resolution 16-11 on Port State Measures should be considered. Likewise, the Commission may wish to engage those non-CPC port States not party to the PSMA where these carriers made port visits to advocate for adequate inspections to be made on carrier vessels which had indications of activity in IOTC waters that may have been noncompliant without evidence of proper authorisation.

The study as well found 33 instances where longline fishing vessels met at-sea. These encounters often occurred between two vessels of the same flag; however, a number of the events occurred between vessels of different flags. In these cases, flag State authorities of both vessels are unlikely to "see" the event occurring without the benefit of Vessel Monitoring Stem (VMS) data-sharing, which is nearly non-existent between IOTC CPCs. The identification of this activity occurring suggests that the circumstances of the encounters may warrant further investigation by the appropriate flag State authorities to determine whether they involved the transfer of fish product. If so, CPCs may wish to consider strengthening IOTC regulations to either clearly prohibit this type of activity or ensure when it occurs, proper reporting and documentation protocols are explicitly required.

The study concludes that greater transparency of transshipment activities occurring at-sea within the IOTC Convention Area is needed. Implementation of a more centralised IOTC VMS coupled with increased sharing of transshipment declaration data and standardised publicly available authorised vessel lists would help ensure the availability and use of the most accurate data on vessel activity. These tools could also be supplemented by mandating the use of AIS to provided even more comprehensive and transparent remote monitoring of fishing vessels when they operate at sea. Consequently, a much more effective and efficient way to monitor transshipments in the IOTC Convention Area could be implemented to not only assist flag State authorities in controlling those vessels involved, but also to support the interests of other stakeholders as well, such as the IOTC and CCSBT Secretariats and industry members.

The study also identified the urgent need for IOTC to establish stronger data sharing agreements with other regional fishery management organisations (RFMOs) that overlap in the area and manage species of interest documented to have been transshipped by IOTC-authorised carriers (e.g. both CCSBT and the Southern Indian Ocean Fisheries Agreement (SIOFA)) to aid in enhanced assessment of vessel activity and fish catch occurring within the Convention Area.

1   Introduction

Global Fishing Watch, in partnership with The Pew Charitable Trusts (Pew), is undertaking an assessment of at-sea transshipment activity occurring inside the Convention Areas of the five global tuna RFMOs to help expand greater understanding of this activity and inform policy development towards strengthening current transshipment regulations and controls in the tuna fisheries. This work includes a series of annual reports covering potential transshipment-related activity that is observable from analysis of AIS data and review of publicly available information and data related to transshipment activity. These reports are designed to be RFMO-specific and cover calendar years 2017 through to 2019. This study is the first report in this series.

The second element of this work that complements these reports is the development of a publicly available web-based Carrier Vessel Portal (CVP) specifically focused on information and activities of carrier vessels authorised by the five tuna RFMOs. The purpose of the CVP is to provide interested users an easy, single point of access platform for data related specifically to carrier vessels and at-sea transshipments. Initially, the CVP is envisaged to display AIS data linked with RFMO vessel authorisation data with the intention to display additional information as it becomes publicly available; for example, Secretariat annual reports, RFMO transshipment declarations, observer reports or other related data.

AIS use in fishing fleets is increasing with more and more flag States mandating its use through their own national fisheries regulations[1]. Fish carriers over 300GT in size are already required to broadcast on AIS as mandated by the International Maritime Organisation (IMO). These developments make the use of AIS and subsequent analysis of AIS reporting a vital, emerging tool for greater understanding of fishing activity that supports and complements existing national and RFMO MCS programmes. One of its uses is providing for a greater understanding of the interactions of fishing vessels of differing flag States where VMS data is not publicly available or shared.

Intended users of the CVP, still currently in development, include RFMO Secretariats and flag, coastal and port State authorities. However, the open nature of the platform and publicly available data that can be accessed through the CVP also allows opportunities for industry to conduct greater due diligence by affording them a greater understanding of vessel activity and potential illegal fishing risks directly associated with their supply

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[1] Notably the EU and US require AIS on fishing vessels over 15m and 20m respectively.

chains. The outputs of the CVP could also provide the environmental Non-Governmental Organisation (NGO) community a tool for informing their own respective advocacy programmes.

1.1   IOTC Transshipment Regulation

The IOTC is an intergovernmental organisation made up of member governments that share mutual interests in managing and conserving tuna stocks in the Indian Ocean. A multilateral treaty, the Agreement for the Establishment of the Indian Ocean Tuna Commission, was approved by the Council of the Food and Agriculture Organisation of the United Nations (UN) in 1993 and the agreement entered into force in 1996. The Agreement is open to Indian Ocean coastal countries and to countries or regional economic integration organisations which are members of the UN or one of its specialised agencies, and are fishing for tuna in the Indian Ocean (FAO 1993). There are currently 31 Members and two Cooperating Non-Contracting Parties that belong to IOTC (collectively termed CPCs). Vanuatu was a Member of the Commission but withdrew in 2015. Taiwan, Province of China (hereafter called "Taiwan") a major distant water fishing entity, is not a member of the UN and is ineligible for IOTC membership, but cooperatively participates at the IOTC. However, despite working cooperatively with IOTC and having an active fleet of fishing vessels fishing in IOTC Convention Area waters, Taiwan's fishing vessels are not listed on the IOTC authorised vessel list.

Although it has not been formally defined by IOTC, the term "carrier vessel" refers to vessels that are duly authorised by their flag State and have been entered by the IOTC Secretariat on the IOTC Record of Carrier Vessels to receive tuna and tuna-like species and sharks from large-scale tuna longline fishing vessels (LSTLVs). The current *IOTC Resolution 2018-06 on Establishing a Programme for Transshipment by Large-Scale Fishing Vessels* was adopted by IOTC at its 22nd Session (IOTC 2018). This Resolution included adoption of a definition of Large-Scale Tuna Vessels (LSTVs) which is *"any fishing vessel targeting tuna and tuna like species that are over 24 meters in length overall (LoA) and on the IOTC Record of Authorised Fishing Vessels"*. The Resolution requires all transshipments of tuna, tuna-like species and sharks caught in association with tuna fisheries by LSTVs take place in-port in accordance with rules outlined in the Resolution. There is an exception to the general prohibition of at-sea transshipment for Large Scale Tuna Longline Vessels (LSTLVs) if the activity takes place in accordance with rules outlined in the Resolution. Although the Commission has agreed on a definition for LSTVs, there is still no precise definition for LSTLVs. In practice, this Resolution means

that purse seine tuna vessels in the IOTC Area of Competence are required to transship in port, whereas longline fleets have the option of transshipping at-sea. It is IOTC Resolution 2018-06 regarding the high seas transshipment programme that this study is focused on.

The rules governing in-port transshipment only apply to LSTVs fishing for tuna and tuna like species which are included on the IOTC authorised vessel list. The in-port transshipments require both the fishing and carrier vessels to provide pre- and post-notifications to relevant port and flag States. To support the objective of the transshipment measure, the Resolution requires the port and landing States to verify the accuracy of the information received from the vessels and cross-reference the information with catch reports held by the LSTV's flag State.

Resolution 18-06 outlines that the procedures for at-sea transshipment are only applicable for LSTLVs and authorised carrier vessels. CPCs authorise their LSTLVs to participate in at-sea transshipments and only those LSTLVs that have been granted prior authorisation from their flag State are permitted to conduct at-sea transshipment. LSTLVs can seek authorisation from its flag State up to 24 hours prior to an intended transshipment. While LSTLVs are required to provide pre-notifications of at-sea transshipments to their flag State, the Resolution is not specifically clear regarding carrier vessel notification requirements. However, the master of the carrier vessel is required to confirm that the LSTLV they are transshipping with is participating in the IOTC Regional Observer Program, including confirmation of payment of required fees. Currently, carrier vessels are still not required by the Resolution to include their IMO Number on any transshipment reporting or declaration documents.

Carrier vessels are required to be authorised to receive transshipments at-sea in the IOTC Convention Area. The Commission established and maintains an IOTC Record of Carrier Vessels authorised to receive tuna and tuna-like species and sharks at-sea from LSTLVs. For the purposes of the Resolution, carrier vessels not entered on this record are deemed not to be authorised to receive tuna and tuna-like species and sharks in at-sea transshipment operations. However, the IOTC Resolution does not specify that carrier vessels must be flagged to an IOTC CPC. This loophole allows States with no direct connection to IOTC and have no obligation to comply with IOTC Resolutions to have their flagged carrier vessels be authorised by IOTC CPCs to conduct transshipment at-sea in the IOTC Convention Area. This creates ambiguity as to whether effective flag State control can be exercised in controlling and holding to account the activities of these non-

CPC flagged carrier vessels when they transship at-sea in the IOTC Convention Area. Furthermore, there is no clear mechanism for IOTC CPCs to review compliance or take action in the event of illegal fishing being detected in conjunction with the activities of these non-CPC carrier vessels while operating in the IOTC Area of Competence (van der Geest 2019).

IOTC Resolution 18-06 is also ambiguous in relation to the catch location of tuna and tuna-like species that are transshipped. The Resolution simply refers to authorised carrier vessels authorised to receive transshipments from LSTLVs in the IOTC area of competence. There is no reference to catch being required to be caught in IOTC Convention Area waters.

Resolution 18-06 requires that all carrier vessels be equipped with VMS but does not provide any specifications nor references the relevant IOTC Resolution (15-03) that established VMS requirements for fishing vessels (IOTC 2015). For fishing vessels, IOTC requires VMS on all vessels on the high seas and all vessels 24 meters length overall (LoA) or greater with reporting solely to the flag State Fisheries Monitoring Center. This leaves smaller fishing vessels operating inside their own flag State waters exempt from VMS requirements and therefore able to potentially conduct transshipments on the high seas undetected, especially if the transshipments are conducted with carrier vessels not authorised by IOTC (van der Geest 2019).

Authorised carrier vessels are also required to have an observer from the IOTC Regional Observer Program (ROP) onboard to observe each at-sea transshipment operation. The observer is required to be onboard prior to the commencement or continuation of any at-sea transshipment. The Consortium of Marine Resource Assessment Group (MRAG) and Capricorn Fisheries (CapFish) is responsible as the Observer Coordinator for the appointment and placement of technically trained observers on all authorised carrier vessels planning to transship at-sea in the IOTC Convention Area. Observers are not explicitly required to inspect vessel authorisations permitting at-sea transshipment, or to estimate the quantities of non-target or other species onboard vessels; however, this may occur in practice and made available at the request of the observer. The Resolution is unclear on specifically where and when observer reports are sent although there is a clear requirement for observers to complete daily reports.

The IOTC Secretariat reported that 777 LSLTVs from fleets flagged to China, Taiwan, Japan, Korea, Malaysia, Oman and Seychelles were authorised to participate in the IOTC at-sea transshipment program in 2017 (IOTC Secretariat 2018b). These CPCs submitted

to IOTC information on those specific carrier vessels which they authorised to receive at-sea transshipments from their LSTLVs. A total of 88 carrier vessels were expressly authorised to receive at-sea transshipments from the fleets which participated in the program. From these 88 carrier vessels, IOTC reported that 19 carrier vessels flagged to Japan, Korea, Malaysia, Seychelles, Panama, Singapore and Taiwan were used by the participating fleets in 2017 for at-sea transshipments following submissions of requests for observer deployments by the participating fleets, and subsequent approval of the deployments by the IOTC Secretariat (IOTC Secretariat 2018b). It should be noted that both Panama and Singapore are considered non-CPCs of IOTC.

For 2017, a total of 61 observer deployments were approved by the IOTC Secretariat although one of the approved deployments was subsequently cancelled. A total of 1,259 transshipment operations were observed at-sea involving 395 different LSTLVs (MRAG and CapFish 2018). Of the total 1,259 transshipment events in 2017, 68 percent (approximately 856 events) involved the fleet of LSTLVs flagged to Taiwan (MRAG and CapFish 2018). Importantly, these vessels are not technically subject to comply with IOTC obligations as Taiwan is unable to be a party to the IOTC treaty, although they do cooperate with the Commission.

1.2 IOTC Area of Competence

The IOTC area coincides with FAO Statistical Areas 51 and 57 and incorporates the CPC EEZs within that area for tuna management purposes.

Southern bluefin tuna is managed by the Commission for the Conservation of Southern Bluefin Tuna (CCSBT) and the range of this species overlaps with the southern portion of IOTC. CCSBT sets no geographic limits of competence; it extends over all national waters and the high seas where southern bluefin tuna are found. This creates an overlapping region where both RFMOs have competence for the different fisheries under their respective conventions. These overlapping waters pose a complex challenge for identifying potential unauthorised or unreported transshipment activity, requiring a robust understanding of both the target species involved and vessel authorisation information. To help understand the geographic range of southern bluefin tuna, CCSBT provides a map of its typical range (Figure 1); however, southern bluefin can also be caught outside of this range depending on environmental conditions.

The IOTC and CCSBT Secretariats have signed a Memorandum of Understanding (MoU) (IOTC and CCSBT 2015) to share relevant information; however, this agreement is targeted at making activity that is authorised and related to both RFMOs easier to share.

The agreement is not specifically intended to help identify potential unauthorised activity occurring within the overlapping area.
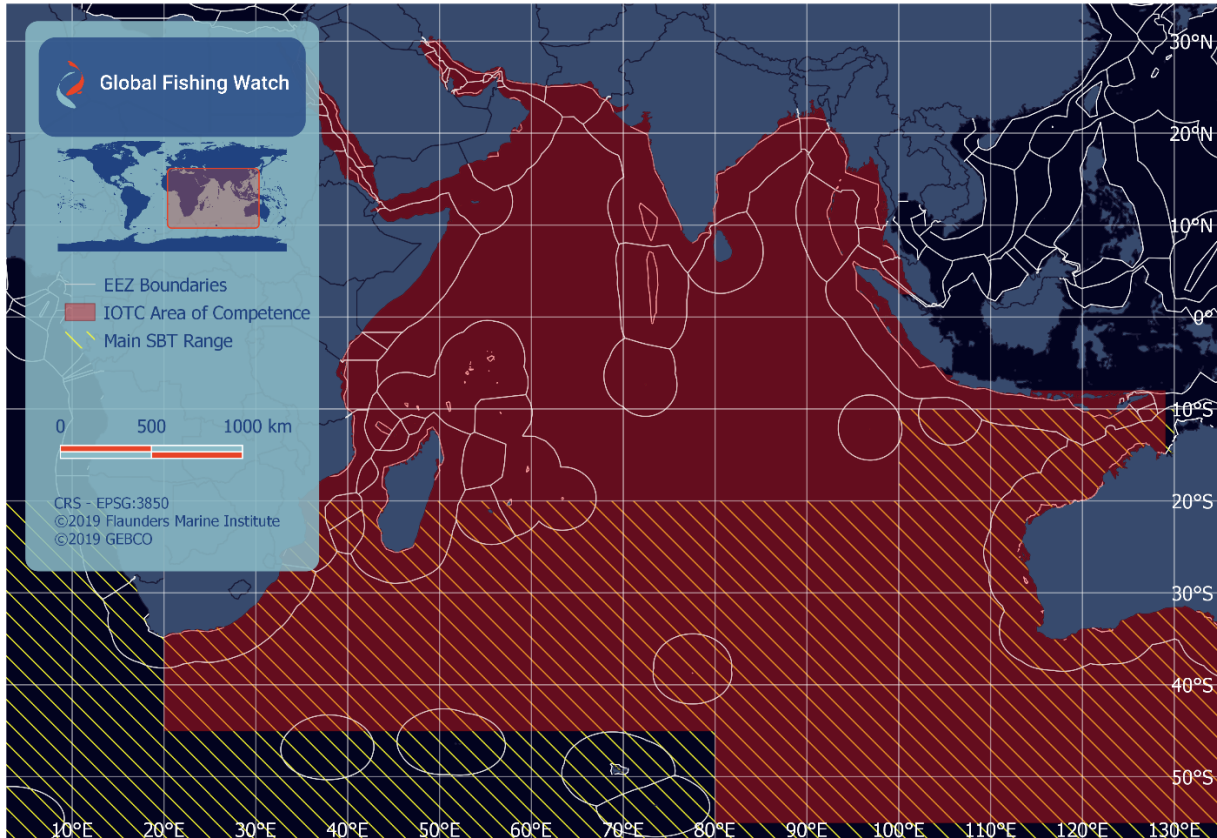

Figure 1 - Overlapping tuna RFMO areas of competence in the Indian Ocean

2   Study Objective

The intention of this study is, through the use of commercially available Satellite Automatic Identification System (AIS) data combined with the application of machine learning technology and analysis of publicly available information, analyse the track histories of carrier vessels operating in the IOTC Convention Area in 2017 with the objective to:

1. Provide IOTC policy makers with greater transparency and understanding regarding carrier vessel activities occurring within the IOTC Convention Area to better inform them regarding carrier vessel fleet movement patterns including spatial dynamics, encounters with fishing vessels, and highly frequented ports; and

2. Enable IOTC policy makers to make better informed decisions regarding the management of transshipment occurring at-sea within the IOTC Convention Area to strengthen the current IOTC transshipment regulatory framework where needed to address potential management gaps or loopholes related to reporting, monitoring and data-sharing.

In addition, the analysis conducted by GFW in this study also provides usable data on vessel activity consistent with transshipping which can:

3. Show the value of AIS analysis as a monitoring tool that complements the existing IOTC MCS structure using VMS, flag State authorisations, observer reporting, and transshipment and catch documentation;

4. Provide data that can be directly used by national or regional compliance staff in investigating potential unauthorised or IUU transshipment activity inside the IOTC Convention Area; and

5. Complement the upcoming CVP that is being developed by GFW, in partnership with Pew, that is intended to give tuna fisheries stakeholders[2] access to AIS data and relevant publicly available information related to possible transshipments within a single platform.

It is important to state that this study does not accuse any vessel of non-compliance or IUU fishing activity and acknowledges that AIS data is only one piece of the full picture.

The primary intent is to create greater understanding and transparency as to transshipment operations occurring within the IOTC Area of Competence to better inform policy makers when considering policy proposals designed to enhance management control and oversight of transshipment. In addition, the incidents identified in this study as possible non-compliant activity may warrant further investigation by the Secretariat and relevant flag and coastal State authorities who have access to additional proprietary information necessary to make that determination and take appropriate enforcement or regulatory action.

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[2] Intended users are port, flag and coastal state managers, fish buyers and retailers, consumers, NGOs and fishing vessel insurers and investors.

3   AIS Analysis Methods

GFW uses AIS data to provide insight into vessel movements and fishing activity throughout the world, including possible transshipment behaviour (i.e., Miller et al. 2018; Boerder et al. 2018; Sala et al. 2018). The GFW database was used in conjunction with public registry data to analyse possible transshipment activity within the IOTC Convention Area occurring between carrier and fishing (i.e., 'donor') vessels during the year of 2017. A full description of AIS and data methods is described in Annex 2 and explained in detail in Kroodsma et al. 2018 and Miller et al. 2018. The GFW database contains a table of 'encounters' between two vessels and 'loitering' events by carrier vessels. Encounters may indicate possible transshipment activity between two vessels, and is estimated using AIS data, including distance between the two vessels, vessel speeds, and duration in a given area. Loitering by a single carrier vessel may also indicate a possible transshipment event in which AIS data is missing for the second vessel. Loitering is also estimated using AIS data, including vessel speed, duration in a given location, and distance from shore. Only encounters between carrier and longline vessels and two longline vessels were examined for this report (See Annex 2). The GFW database also contains an estimate of port visits conducted by vessels (See Annex 2), based on AIS data, including vessel speed, location, and duration in a given anchorage. This information was used to analyse port visits by carrier vessels after encounters or loitering events.

For every encounter, loitering, and port event the authors inspected the authorisation of the vessel during the time of the event. The authorisation of a vessel was established by using the publicly available vessel authorisation list produced by IOTC[3], the CCSBT[4], and the Taiwan Fisheries Agency's list of IOTC authorised vessels[5].

In the situation where a carrier vessel had an encounter with a fishing vessel at-sea in IOTC waters during a timeframe in 2017 when it was not authorised according to these public registries, the authors considered the vessel to be 'unauthorised'. Therefore, if one of these public authorisation lists provided limited data, it may have impacted the determinations made by the authors. Improving access to publicly available historical vessel authorisation lists, IOTC and other RFMOs would enable a more complete and accurate picture of vessel patterns and movements to all stakeholders in the fishery and

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[3] https://www.iotc.org/vessels/date

[4] https://www.ccsbt.org/en/content/ccsbt-record-authorised-vessels

[5] https://www.fa.gov.tw/en/Record_of_Vessel/index.aspx

ensure effective monitoring and control of fishing activities occurring inside the Convention Area.

The full version of the data analysed, including event and vessel information details, is included in the following annex of this report:

4   Summary of IOTC Fish Carrier Activity in 2017

Of the 88 total authorised carriers listed in the IOTC Record of Authorised Vessels (as of 24 April 2018), GFW identified 65 of these authorised carriers broadcasting on AIS. The IOTC Secretariat reported 19 carriers were used by the participating fleets in 2017 for conducting high seas transshipments.

- 53 of the 65 authorised carriers that were broadcasting on AIS entered the IOTC Area of Competence during 2017; in addition, AIS confirmed there was 19 IOTC authorised carrier vessels with encounter or loitering events in IOTC Convention Area waters in 2017.

- A further 12 authorised carriers were observed on AIS operating outside the IOTC area of competence within waters of another RFMO.

- In addition to the carriers listed on the IOTC authorisation lists, the AIS analysis identified seven Taiwanese carriers operating in the IOTC Convention Area waters in 2017. Taiwan is a non-CPC of IOTC but cooperatively participates at the IOTC.

A category of encounters left out of this report were related to a fleet of squid jiggers operating on the high seas in the IOTC Convention Area close to the maritime boundaries of the Oman and Yemen Exclusive Economic Zones (EEZs). A total of 11 encounters were observed in this area occurring between these squid jiggers and four different carrier vessels, all unauthorised by IOTC. However, the target species of this fleet is not covered by an RFMO in this specific geographic area and the risk was relatively low that these squid jiggers had gear onboard that would allow them to target tuna[6].

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[6] The details of these encounters involving squid vessels can be requested from Global Fishing Watch.

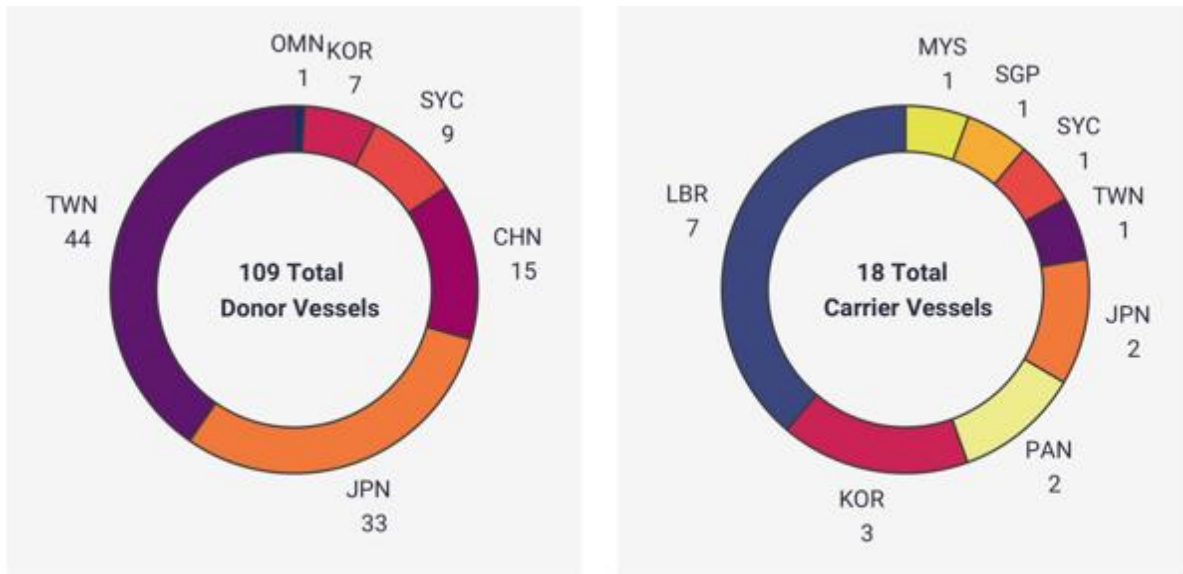# 5 Encounters by Authorised Fishing and Carrier Vessels

Encounters between authorised fishing (referred to in this report as "donor" vessels) and carrier vessels observed on AIS represent the lowest risk for non-compliant activity. Encounters between authorised vessels are known to occur within the IOTC transshipment at-sea programme and have been properly reported and observed. The AIS data, however, does provide a greater understanding into the "patterns of life" occurring between the IOTC LSLTV and carrier fleets and affords relevant IOTC stakeholders the opportunity to cross check AIS-derived encounters with publicly available IOTC-reported transshipment data, potentially identifying any unreported activity or anomalous behaviour within the fleet.

5.1 Authorised Count Trends

The authors identified 171 at-sea encounters between authorised carrier and donor (fishing) vessels within the IOTC Convention Area during 2017. The data, including likely encounter date and location, and donor and carrier vessel information (available in Annex 1-0001-0098) can be used to validate authorised transshipments documented by IOTC observers. However, the total count of authorised encounters identified from AIS is much smaller than the 1,259 monitored transshipments made by LSTLVs reported by the IOTC Observer Programme for 2017. The primary reason for the small number of authorised transshipments captured by AIS is likely a result of a combination of low uptake and use of AIS by the longline fishing fleets operating in the Indian Ocean, piracy risks in the northwest Indian Ocean that reduce active AIS usage by vessel masters and a lack of national regulation or enforcement around the use of AIS which contributes to situations dominated by practice, such as that exhibited by many EU-flagged vessels that are normally required to operate AIS, but typically only switch it on only in port. Overall, the use of AIS by fishing vessels in the Indian Ocean is proportionately smaller than either the Pacific or the Atlantic (Kroodsma *et al 2018*).

In addition, the distribution of flag States carrying out the encounters differs between those observed on AIS and those reported by observers. The IOTC carrier observer annual report highlighted Taiwan as the predominant flag of donor vessels and Taiwan, Vanuatu, and the Republic of Korea as the predominant flag of carrier vessels. AIS analysis observed authorised encounters conducted by 19 distinct carriers and 109 distinct donor vessels (Figure 2). The donor vessels were primarily Taiwanese flagged (40%), followed by Japanese (30%) vessels, Chinese (14%), and Seychelles (8%) LSTLVs. The carrier

vessels were largely composed of Liberian flagged vessels (39%), followed by Korean (17%), Panamanian (11%), and Japanese (11%) flagged carrier vessels.

Source: Global Fishing Watch

Figure 2 - Distinct Authorised Carrier and Donor vessels

AIS identified encounters primarily occurred between Japanese-flagged donor vessels and Liberian-flagged carriers (44 encounters) (Figure 3). Both flag States also have a proportionally high number of encounters with other flag States. The second and third largest number of encounters involves Taiwanese-flagged donor vessels with Singaporean and Liberian-flagged carrier vessels (Figure 3).
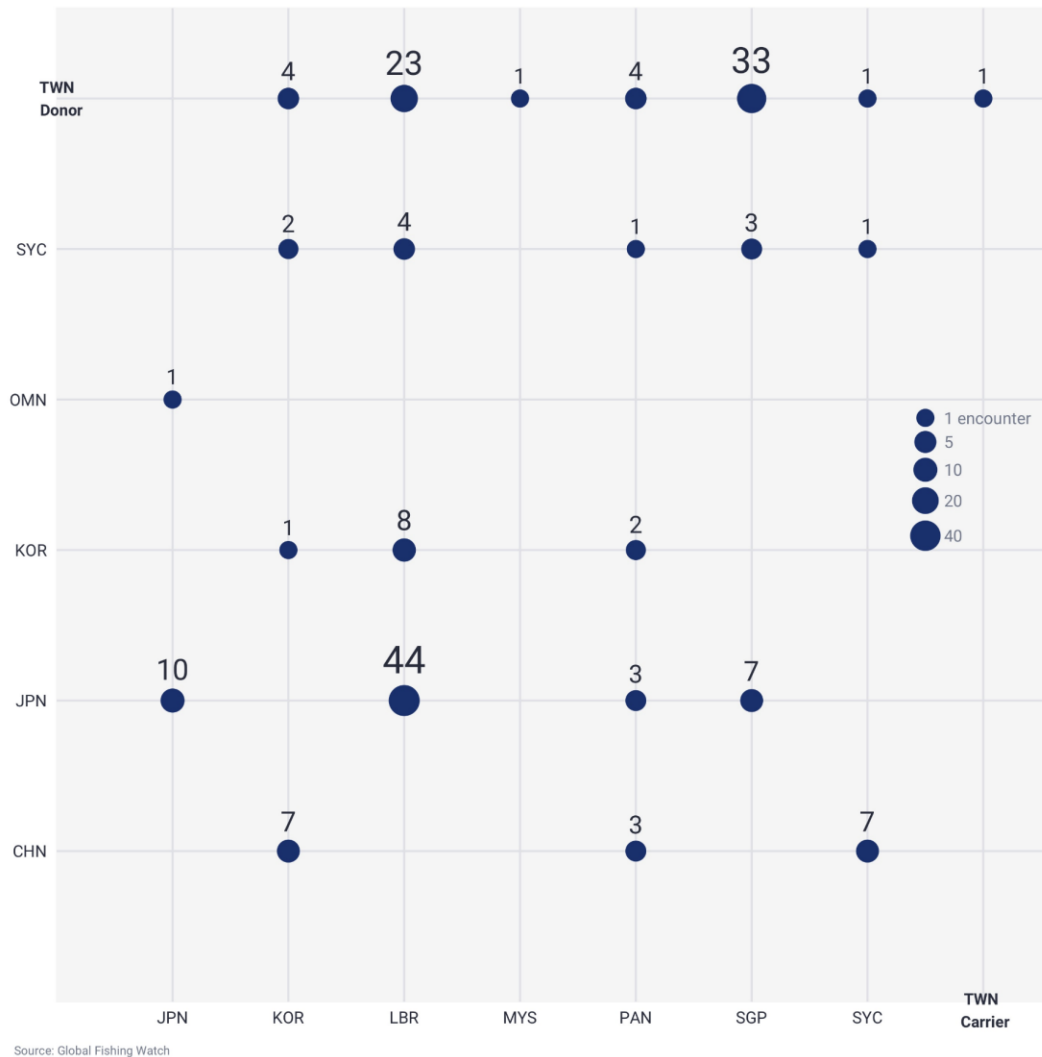
Figure 3 - Count of Encounters between Authorised Donor and Carrier Vessels

The contrasting results between the data reported in the IOTC Observer Programme for 2017 (MRAG and CapFish 2018) and the findings emanating from encounters observed on AIS between authorised carrier and donor vessels highlights both the potential use and limitations of AIS data. The dominance of Japanese donor vessels and Liberian carriers in authorised encounters may suggest that these fleets conduct a higher proportion of transshipments within the IOTC Convention Area than the ROP accounts for; or more likely, they are broadcasting AIS on more vessels than other fishing fleets operating within the IOTC Convention Area. Another possible difference could be related to Taiwanese vessels that might have been misidentified as unauthorised due to incomplete historical authorised vessel records for Taiwanese carriers prior to December 2017 (see section 4).

5.2 Spatial Analysis

The IOTC ROP report for 2017 (MRAG and CapFish 2018) illustrates observed transshipments largely occurring on the high seas off the southwest coast of Madagascar and outside the Seychelles and Mauritius EEZs with scattered transshipments along the IOTC Convention Area east of both of these EEZs. The location of encounters observed on AIS by authorised vessels is consistent with observed IOTC transshipments in 2017 (Figure 4 and 5). However, the IOTC ROP report does not provide detail on the flag State of both the carrier and donor vessels for each observed transshipment. Therefore, it is difficult to compare the findings of this report, which do indicate some possible flag State spatial patterns of activity. For instance, authorised Japanese donor vessels were observed operating primarily in the eastern region of the IOTC Convention Area (Figure 4). Almost all of these vessels' encounters were with authorised Liberian flagged-carrier vessels and occurred in the southeast IOTC Convention Area (Figure 3).
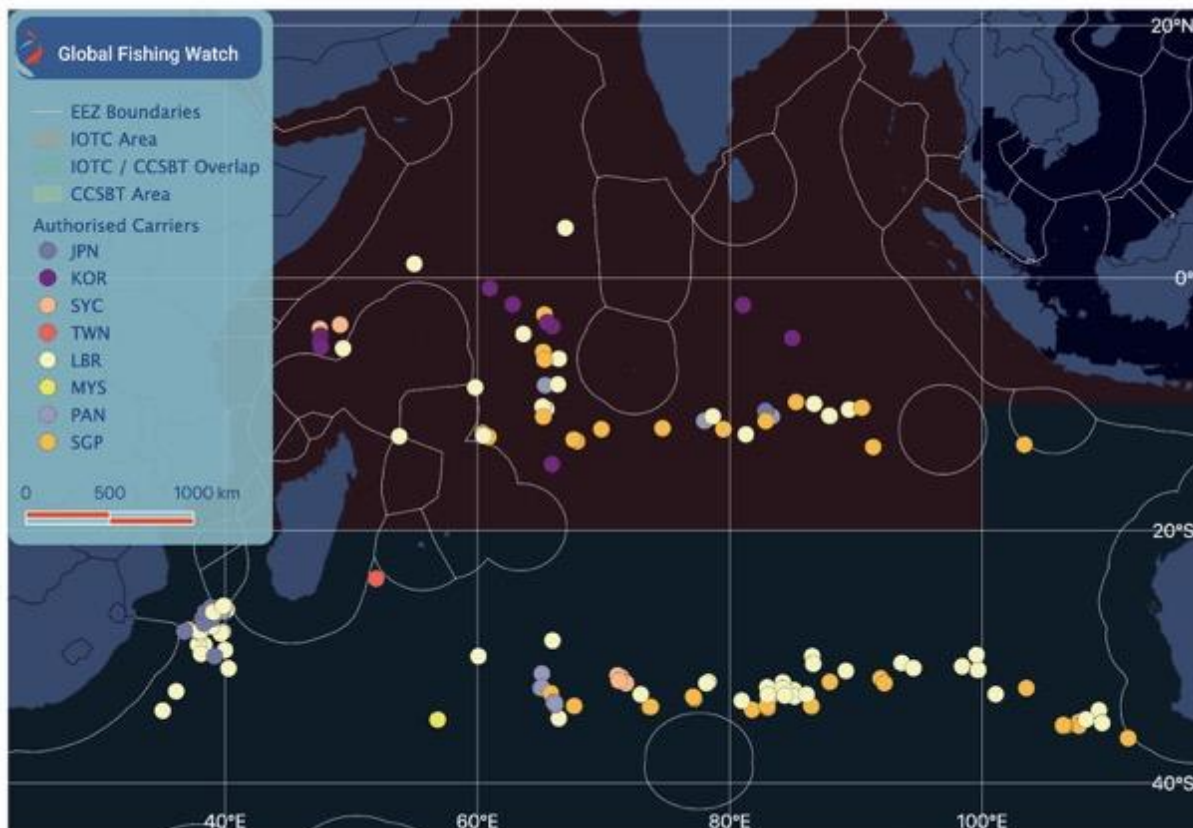

Figure 4 - Authorised Carrier Flags in Encounters within the IOTC Convention Area in 2017

Figure 5 - Authorised Donor Flags in Encounters within the IOTC Convention Area in 2017

Authorised Chinese-flagged donor vessels were observed operating only in the central western part of the IOTC Convention Area, primarily outside the Seychelles EEZ where they encountered Korean-flagged carriers (Figures 4 and 5).

By noting that certain LSTLV fleets only encounter carrier vessels within a specific region can help increase understanding of tuna fleet dynamics occurring in the Indian Ocean and inform policy makers looking to strengthen transshipment controls. Understanding these dynamics can also increase efficiency in the use of scarce enforcement resources, vessel monitoring, and regulatory programmes by identifying potential gaps in flag State oversight and responsibility; thereby building a case for expanding observer programmes or introducing electronic monitoring technology.

Specific information on where transshipments were authorised and reported to the Secretariat, such as transshipment declarations, is not publicly available; however, the

annual report published by the IOTC ROP (MRAG, and CapFish 2018) includes a chartlet of all observed transshipments for the year in question. Figure 6 shows the chartlet produced for the 2017 report overlaid with AIS-derived authorised encounters identified in this study. The process to overlay the two datasets uses georeferencing of the IOTC image used in the 2017 report and is not accurate enough to make any firm determination on specific transshipment events shown on the chartlet. However, it does show a clear correlation between the two data sets, and provides insight into a new methodology for comparing AIS data with reported transshipment data to help identify anomalies or data gaps.

Figure 6 - Map showing the AIS derived authorised encounters (yellow circles) overlaid on a map produced by IOTC showing transshipment locations during 2017 (red circles, MRAG, and CapFish 2018).

6 Encounters between Fishing and Carrier Vessels with Unconfirmed Authorisation

Encounters between donor fishing vessels and fish carriers where one or both vessels have been identified as unauthorised poses a serious risk that tuna or other IOTC-managed species are being transshipped outside the IOTC transshipment regulation framework and oversight by observer monitoring. This activity would constitute IUU fishing and, if validated, suggests an urgent need for strengthening the monitoring and control of at-sea transshipments in the IOTC Area of Competence.

Vessels involved in the encounters identified in this section were either not matched with an authorised vessel on IOTC historic authorisation lists or the relevant authorisation list was not available from the flag state of a non-CPC country.

Due to the complex nature of the overlapping competence between the IOTC and CCSBT Convention Areas, unauthorised encounters were analysed in two parts:

1. **Unconfirmed authorisation encounters in IOTC** - The authors examined encounters where one or more vessels appear unauthorised by either IOTC or CCSBT (categorised as *unauthorised*).

2. **Encounters impacted by CCSBT** - A second category was identified where both of the vessels involved in an encounter were authorised by CCSBT and the implication depends on the composition of the species caught and transshipped. Species data or CCSBT transshipment declarations were not available to the authors for these encounters; as such, the information is included primarily for situational awareness.

The data is available in Annex 1-0099-0176 and Annex 1-0177-0289, respectively.

The methodology to identify when a vessel is authorised relies on the identity of that vessel being correctly broadcast on AIS. This is not always the case with some vessels which broadcast misspelt names or even previous names. Some of the vessels preliminarily identified as unauthorised may be cleared as having correct authorisations after further investigation by relevant authorities.

6.1 Unconfirmed authorisation encounters in IOTC

Encounters where one or more vessels involved in the encounter could not be matched with an IOTC historic authorisation list or the authorisation list from a flag State of a non-CPC country was not available.

6.1.1 Count Trends

The study identified a total of 53 encounters between donor and carrier vessels where one or more of the vessel's authorisation could not be confirmed.

- Of the 53 unconfirmed authorisation encounters, 35 of these involved a Taiwanese carrier. As previously indicated, the Taiwan Fisheries Agency registry of IOTC authorised carriers only dates back to December 2017. As such, it is expected that on investigation by the flag State these Taiwan carrier vessels will be identified as authorised. However, without full public disclosure of this basic, but vital, information it is not possible to make an accurate third-party independent validation to confirm authorisation status. Therefore, all Taiwanese-flagged carrier activity is included in this section of the study.

  Taiwanese-flagged donor fishing vessels are highlighted as having the second most infringements related to 'authorisation to fish' as reported under the ROP in 2017 (IOTC Secretariat 2018c). However, the outcome of the investigations into the identified infringements by flag State authorities are not public, so the full nature or outcome of these infringements is unknown.

- The remaining 18 unauthorised encounters include:

  - One Seychelles-flagged donor vessel meeting an authorised Korean carrier in the northern IOTC Convention Area.

  - Two Panamanian-flagged carriers meeting authorised Seychelles and Taiwanese-flagged donor vessels in the southern IOTC area.

The only encounter in which a donor vessel was potentially unauthorised rather than the carrier occurred between a Seychelles-flagged donor vessel and Korean-flagged carrier vessel. This encounter occurred outside the Seychelles EEZ and the donor would likely have required authorisation for this activity.

Panama is considered a non-CPC to IOTC and there is no clear mechanism for IOTC parties to review compliance or take action in the event of non-compliance or illegal fishing being detected by Panamanian-flagged vessels. In light of the activity by

Panamanian-flagged carriers that could be related to unauthorised transshipment activity occurring inside the IOTC Area of Competence, the authors recommend Panamanian maritime and fisheries authorities are engaged by the IOTC Secretariat to investigate and provide a report to the Commission on the activity. In addition, CPCs should consider revisiting IOTC Resolution 14/06 to close the loophole that allows non-CPC flagged carrier vessels to be authorised to engage in at-sea transshipment in IOTC Convention Area waters.
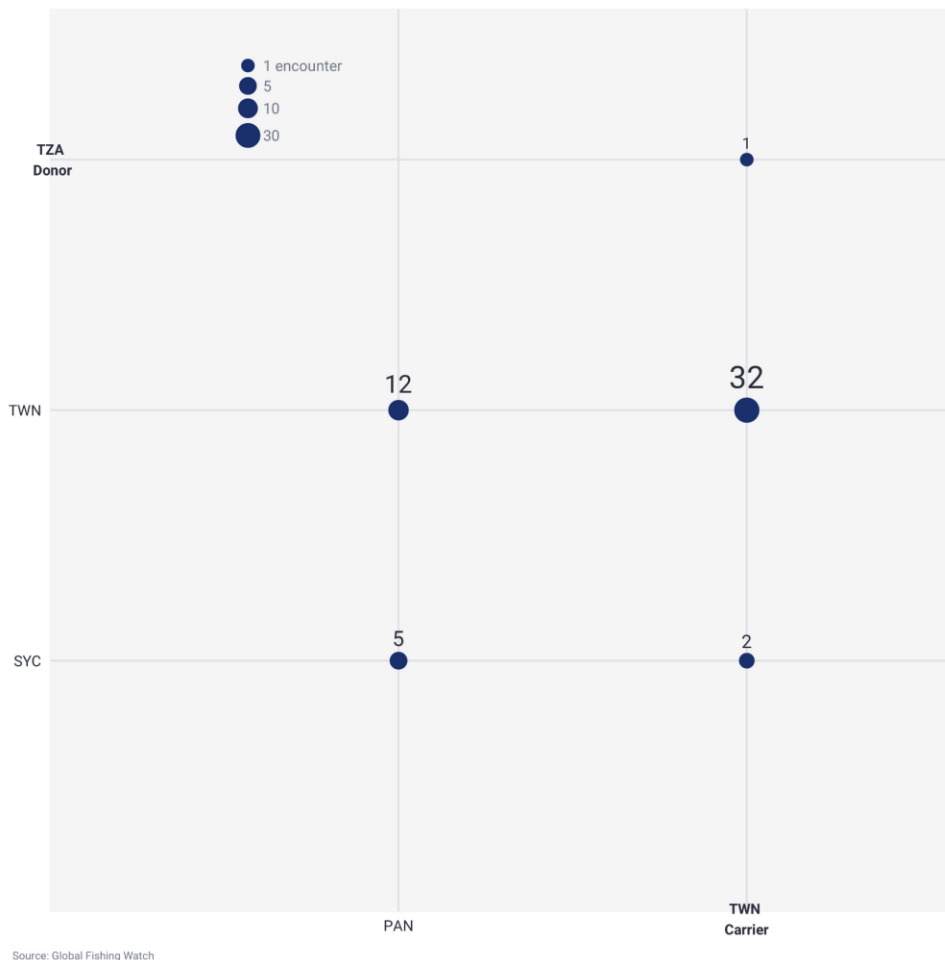

Source: Global Fishing Watch

Figure 7 - Count of Encounters between Donor and Carrier vessels where the full authorisation could not be confirmed

Carries Unauthorized - Donors Authorized

Figure 8 - Distinct Carrier and Donor vessels involved in an encounter where one vessel had unconfirmed authorisation in 2017

The specific vessels listed in IOTC compliance reports (IOTC Secretariat 2018a, IOTC Secretariat 2018b, IOTC Secretariat 2018c), typically did not appear on the AIS encounter lists (authorised or unauthorised). This suggests these vessels are not using AIS and, therefore, their activities and operations cannot be reviewed as a part of this study.

Taiwanese and Seychelles-flagged vessels, representing the two fleets of vessels with unconfirmed authorisation encounters identified via AIS in this study, are also noted in 2017 IOTC reports for possible repeated infringements and infractions regarding authorisation to fish (IOTC Secretariat 2018a and IOTC Secretariat 2018c). Therefore, although lack of comprehensive vessel usage of AIS and incomplete vessel registry information caused gaps in this study, the alignment of donor vessel flag States involved in encounters with unconfirmed authorisation with observer-based data on infringements indicates the validity of using AIS data to help monitor IOTC transshipment activity in conjunction with reported data. It also suggests the issue of unauthorised transshipment activity occurring in IOTC waters is larger than the observed AIS activity indicates. As such, combining different sources of proprietary data including VMS, observer reports and transshipment declaration data with AIS as a complementary dataset would help build a more complete picture for management authorities and provide greater certainty as to the level of unauthorised activity occurring in IOTC waters.

6.1.2   Spatial Analysis

Nearly all encounters with carrier vessels occurred in the southwest Indian Ocean, south of Madagascar and east of South Africa. This is a region where both IOTC species and southern bluefin tuna managed by CCSBT are caught, making cooperation between the two RFMOs important for any follow-up investigations into this activity.
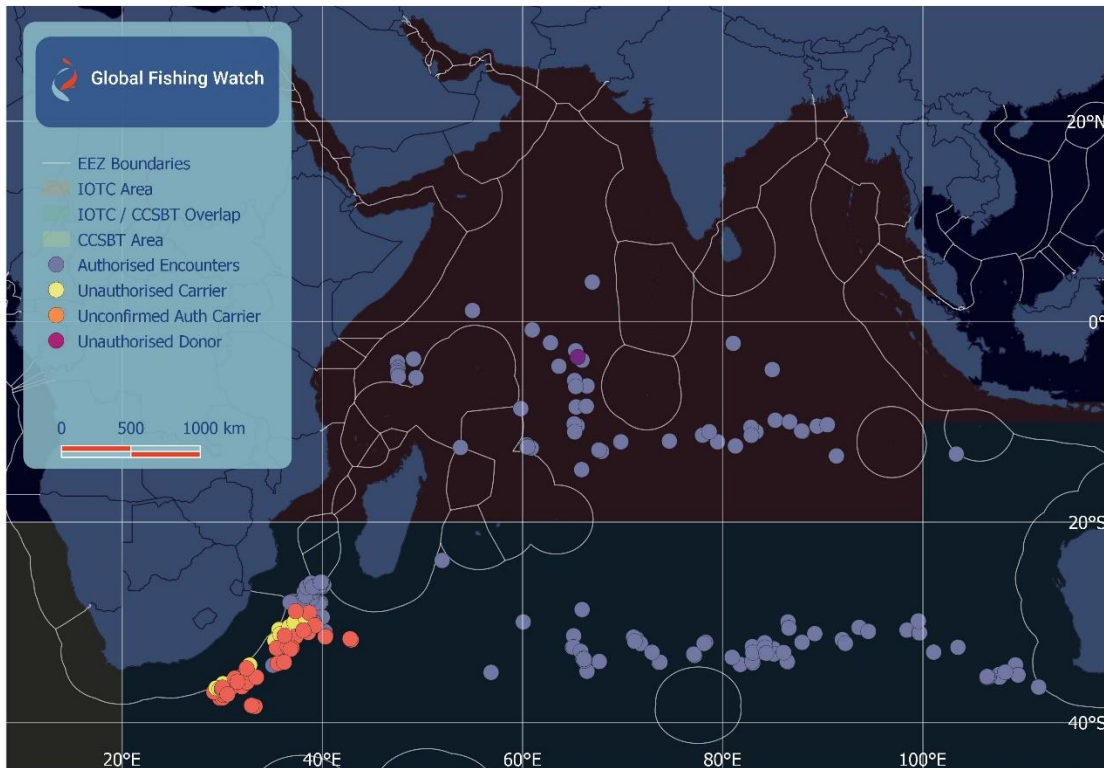

Figure 9 - Encounters by Vessels with unconfirmed authorisation in the IOTC Convention Area in 2017

It is valuable to understand the trends in location of unauthorised activity to focus scarce enforcement resources and utilise monitoring in an efficient and effective manner. For instance, AIS suggests unauthorised encounters tend to occur south of Madagascar, which may be an important location within the IOTC Convention Area to focus monitoring efforts (Figure 9). Flag State specific fleet dynamics and trends can also inform management. For instance, both the unauthorised Panamanian and Taiwanese-flagged carriers appeared to only have encounters with donor vessels on the high seas, off the South African EEZ (Figure 10).
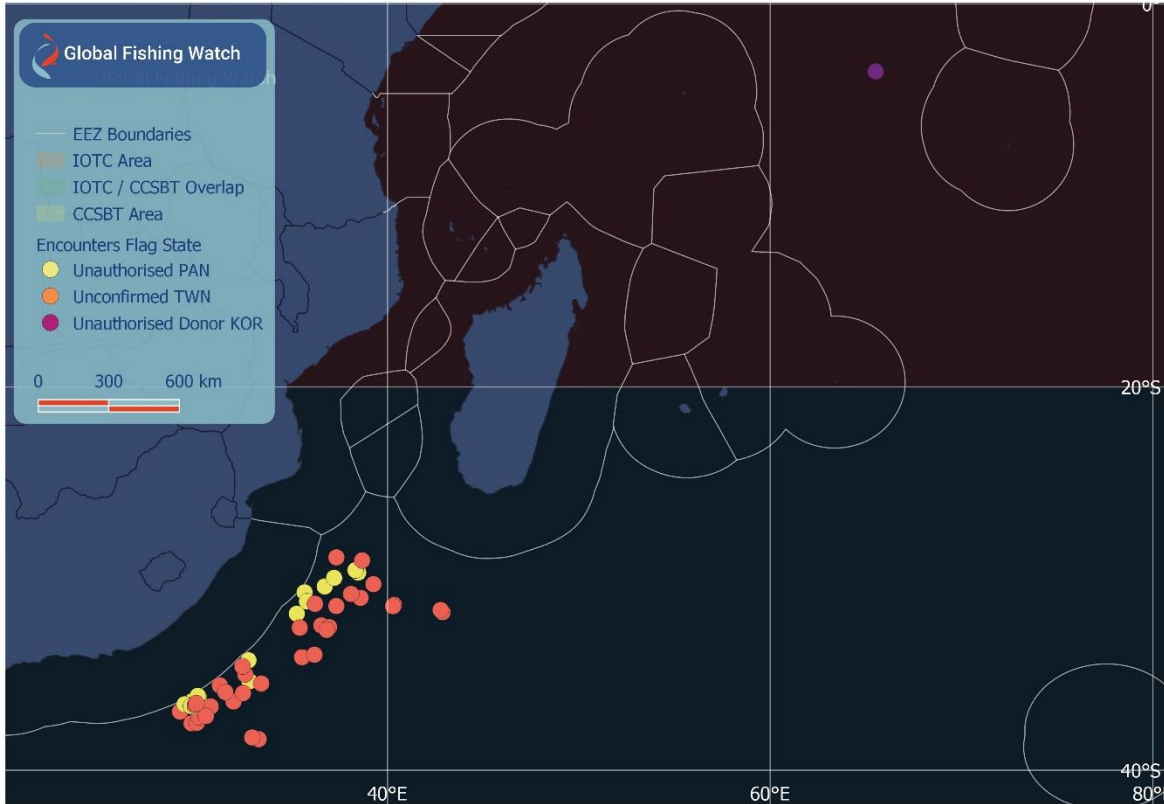
Figure 10 – Encounters with unconfirmed authorisation by Vessel Flags in the IOTC Convention Area in 2017.

6.2 Encounters Impacted by CCSBT

The category of encounters involving vessels that may be targeting either IOTC or CCSBT species or a mix of both is the most complex to evaluate. To do so with a high degree of confidence requires access to proprietary data on transshipment declarations, logbook data, observer reports and VMS data from the two RFMOs. This evaluation is best accomplished through exercise of the MoU between IOTC and CCSBT and relevant flag State authorities of vessels involved. Regardless, it is recommended that a review and analysis of AIS data such as is done in this study is included as component of these efforts.

6.2.1 Count Trends

IOTC and CCSBT manage different species in overlapping areas and have separate vessel authorisation lists. Therefore, it was important to take CCSBT vessel authorisations into

account in this study's preliminary analysis. There were two instances affected by CCSBT Authorisation:

1. *Two CCSBT authorised vessels that have an encounter within the IOTC Area of Competence are likely to be within the CCSBT transshipment regulations.* Review of AIS data allows for strengthening of the existing IOTC/CCSBT MoU and a chance for both RFMOs to investigate any encounters that are not recorded properly as authorised transshipments to one or both RFMOs.

   The study identified 37 encounters between two CCSBT-authorised vessels that may have been authorised by CCSBT which occurred in waters that either overlapped the IOTC Area of Competence or occurred solely within IOTC waters (Table 1).

2. *An encounter between a CCSBT-only authorised vessel and an IOTC-only authorised vessel.* In every occasion this included a Taiwanese-flagged carrier that was only authorised by CCSBT. However, as previously noted, a publicly available historical IOTC authorisation list for Taiwan-flagged carriers was not available prior to December 2017 so it was not possible for the authors to validate the IOTC authorisation status of these carrier vessels. It is possible Taiwan authorities can confirm these vessels were indeed authorised in 2017 to operate in IOTC waters.

   The authors identified 28 encounters which occurred in waters that overlapped between CCSBT and IOTC or occurred solely within IOTC waters where the IOTC authorisation of the Taiwanese carrier involved could not be confirmed (Table 1).

Unless the current data sharing MoU between IOTC and CCSBT is enhanced to include the application of AIS data, it is possible that some vessels are able to operate outside the RFMO transshipment management framework as the flag State authorities of a vessel involved in an at-sea transshipment are likely unable to view VMS data of the other vessel involved if it is flagged to a differing State. This limits the ability of the flag State authorities of both vessels to identify all encounters and cross-check and validate reported information emanating from the vessels. Strengthening the regulations governing the use of AIS and adopting analysis of AIS as a monitoring tool via the data sharing MoU would give the RFMO Secretariats greater visibility of all transshipment activities occurring within their respective areas of competence and allow them to engage with flag State authorities to fill any relevant data gaps created through limited sharing of VMS data between CPCs.

Table 1 - Count of Encounters Impacted by CCSBT Authorisation by Flag State

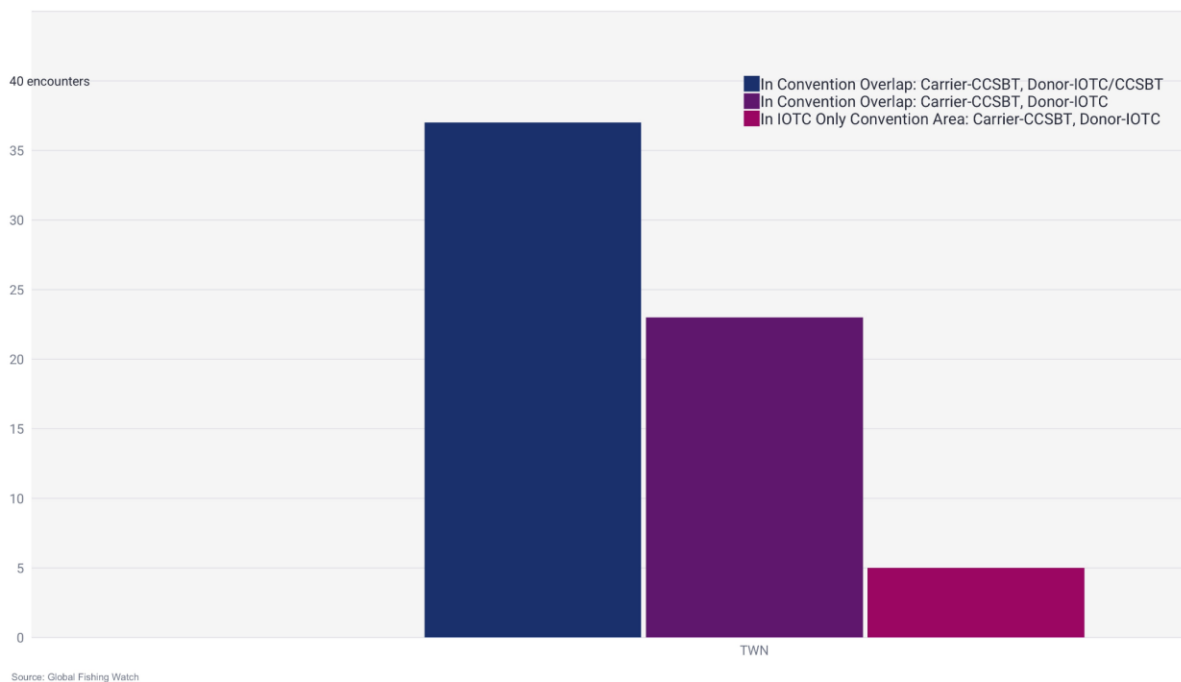| Donor-Carrier Flags	Authorisations	Count
TWN - TWN	In Convention Overlap: Carrier-CCSBT, Donor-IOTC	23
TWN - TWN	In Convention Overlap: Carrier-CCSBT, Donor-IOTC/CCSBT	37
TWN - TWN	In IOTC Only Convention Area: Carrier-CCSBT, Donor-IOTC	5

Figure 11 - Count of Encounters Impacted by Vessel CCSBT Authorisation

6.2.2   Spatial Analysis

The geolocations of unauthorised encounters impacted by CCSBT do not largely differ from authorised and unauthorised encounters discussed thus far (Figure 12 and 9). These encounters generally occur within the western portion of the IOTC Convention Area (Figure 12). Most of the encounters occur south of Madagascar. Specifically, encounters between CCSBT authorised carriers and donors authorised by both CCSBT and IOTC tend to occur off the South African EEZ, whereas encounters between CCSBT carriers and

IOTC donors tend to occur further out on the high seas, south of Madagascar (Figure 12). Encounters within IOTC-only Convention Area waters with CCSBT-only authorised carriers appear to occur primarily around the EEZs of the Maldives and British Indian Ocean Territory (Figure 12).
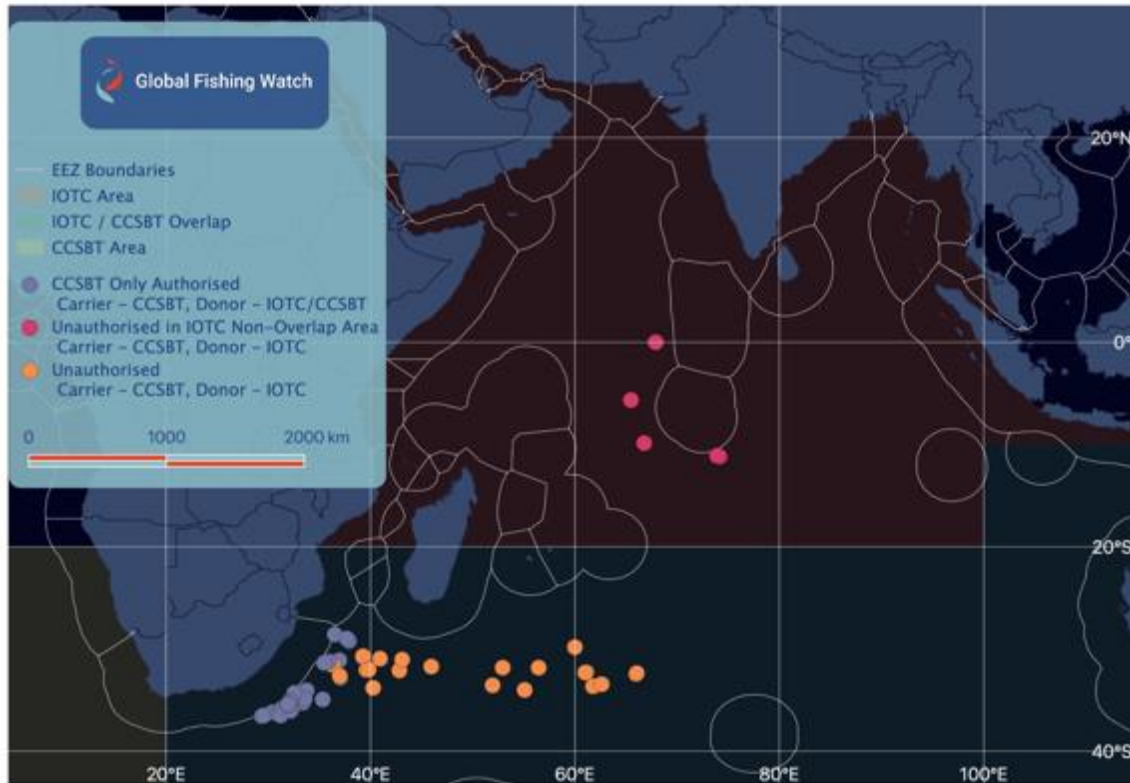

Figure 12 - Encounters Impacted by Vessel CCSBT Authorisation in IOTC Convention Area

Overlaying AIS-derived unauthorised encounters with transshipments as reported in the IOTC 2017 ROP report (figure 13) shows a clear correlation with the main transshipment areas. It also suggests some of the unauthorised encounters observed by Taiwanese vessels are, in fact, authorised as the authors suggest in Section 5.11. The process to overlay the two datasets, however, uses georeferencing of the IOTC image and is not accurate enough to make any firm determination on specific transshipment events shown on the chartlet.

Figure 13 - Map showing the AIS derived encounters where the authorisation could not be confirmed by non-Taiwanese carriers (yellow circles) and Taiwanese carriers (blue circles) overlaid on a map produced by IOTC showing transshipment locations during 2017 (red circles, MRAG, and CapFish 2018).

7 Temporal Distribution of Encounters

Understanding the spatial temporal activity of vessel encounters can give information on the pattern of life of tuna transshipment in the Indian Ocean and help to target scarce enforcement resources when deployed to investigate anomalous transshipment vessel activity at-sea.

There appeared to be a seasonal trend in encounters in the IOTC Convention Area during 2017 (Figure 14).

1. There was a strong peak in encounters during the months of May to July with the majority of transshipments at this time in the southern Indian Ocean at the peak of the longline southern bluefin and albacore fisheries in this zone (Kaplan 2014).

2. There is a peak in encounters in the south west Indian ocean close to the South Africa EEZ during months June through to November which corresponds with the peak longline catches of yellowfin tuna, bigeye tuna and in the southern area southern bluefin tuna (Kaplan 2014).

3. Observed encounters in the central Indian Ocean region between the equator and 20 degrees south in 2017 mostly occurring between months September and March. This activity relates to the peak longline fishery for yellowfin tuna and big eye tuna in that region (Kaplan 2014).
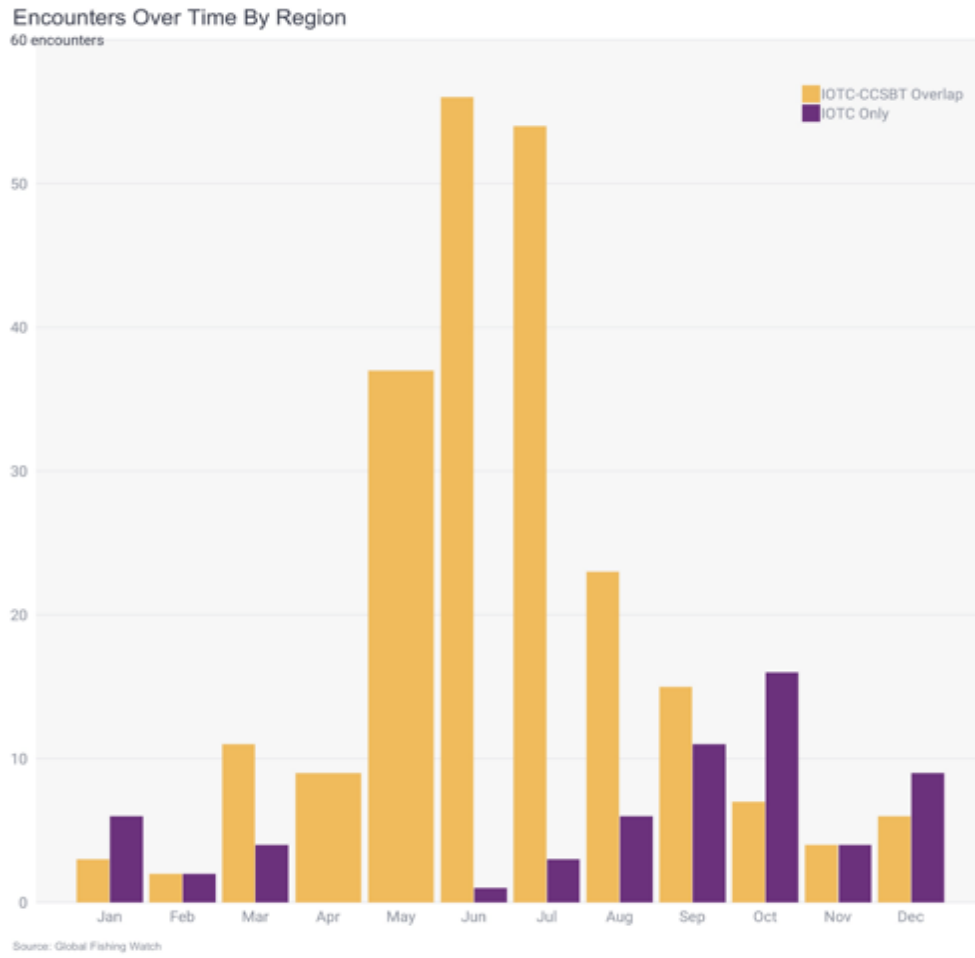
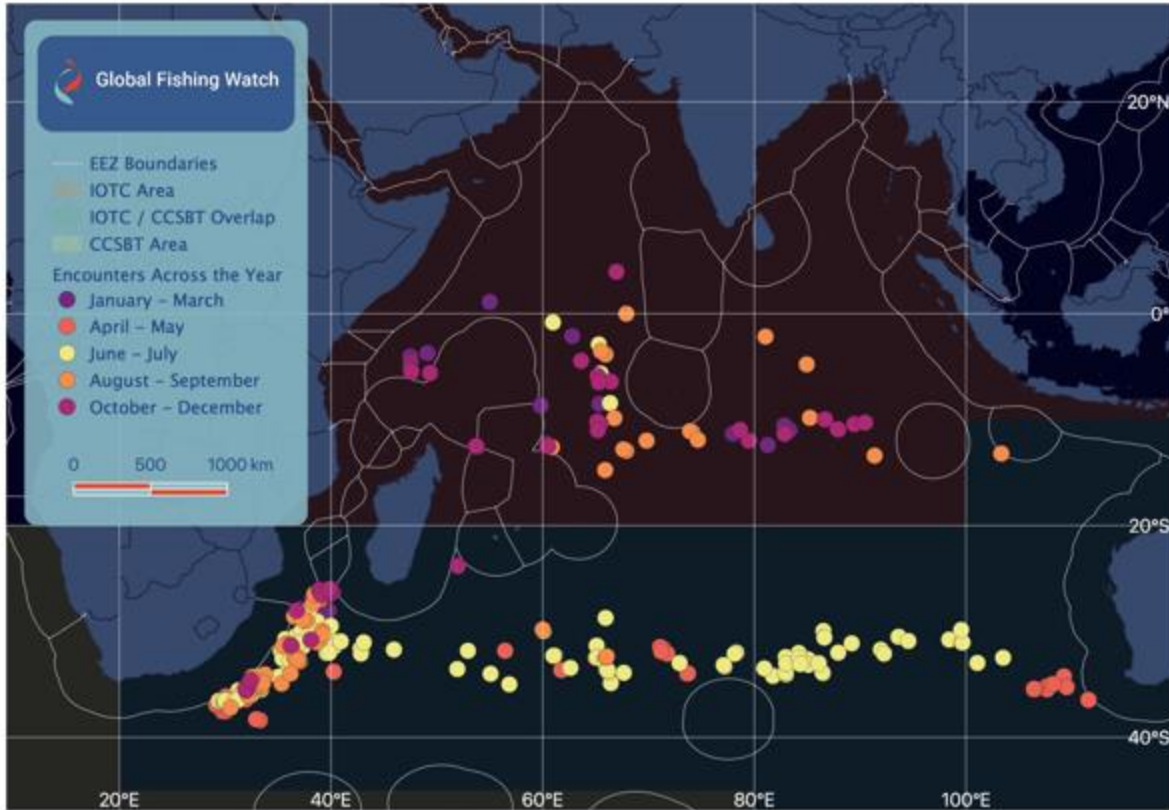*Figure 14 - Count of Encounters Across 2017 by Convention Area Region*

Figure 15 - Encounters Across 2017 within the IOTC Convention Area

8   Port Visits by Carriers after Encounters

The study examined the ports visited by carriers after encounters with donor vessels as these port visits may indicate the ports where tuna is often unloaded, and consequently represent important port locations to monitor and regulate the landing of fish product. The complete port data, including event and vessel information details is included in the annex of this report (available in Annex 2-0290-0578).

Port Louis, Mauritius was the most visited port with 111 visits. Singapore had the second most visits in 2017 (96), followed by Kaohsiung City, Taiwan (42), and Cape Town, South Africa (32). All other ports had less than five identified visits for all of 2017 (Figure 16).

Figure 16 - Port Visits by Carriers after Encounters with Donor Vessels

The study further examined how the visited ports may be affected by carrier and donor vessel authorisations (Figure 17) and/or flag State (Figure 18 and 19). This analysis showed the authorisation of a vessel did not generally appear to impact the visited port of a carrier after an encounter. However, Kaohsiung City, had the highest number of visits by carriers where no authorisation was found, followed by Singapore and Port Louis. Carriers that had encountered CCSBT authorised vessels only visited Port Louis and Singapore. Carriers with unconfirmed authorisations (Taiwan Carriers) had the largest number of visits in Kaohsiung City and Port Louis.
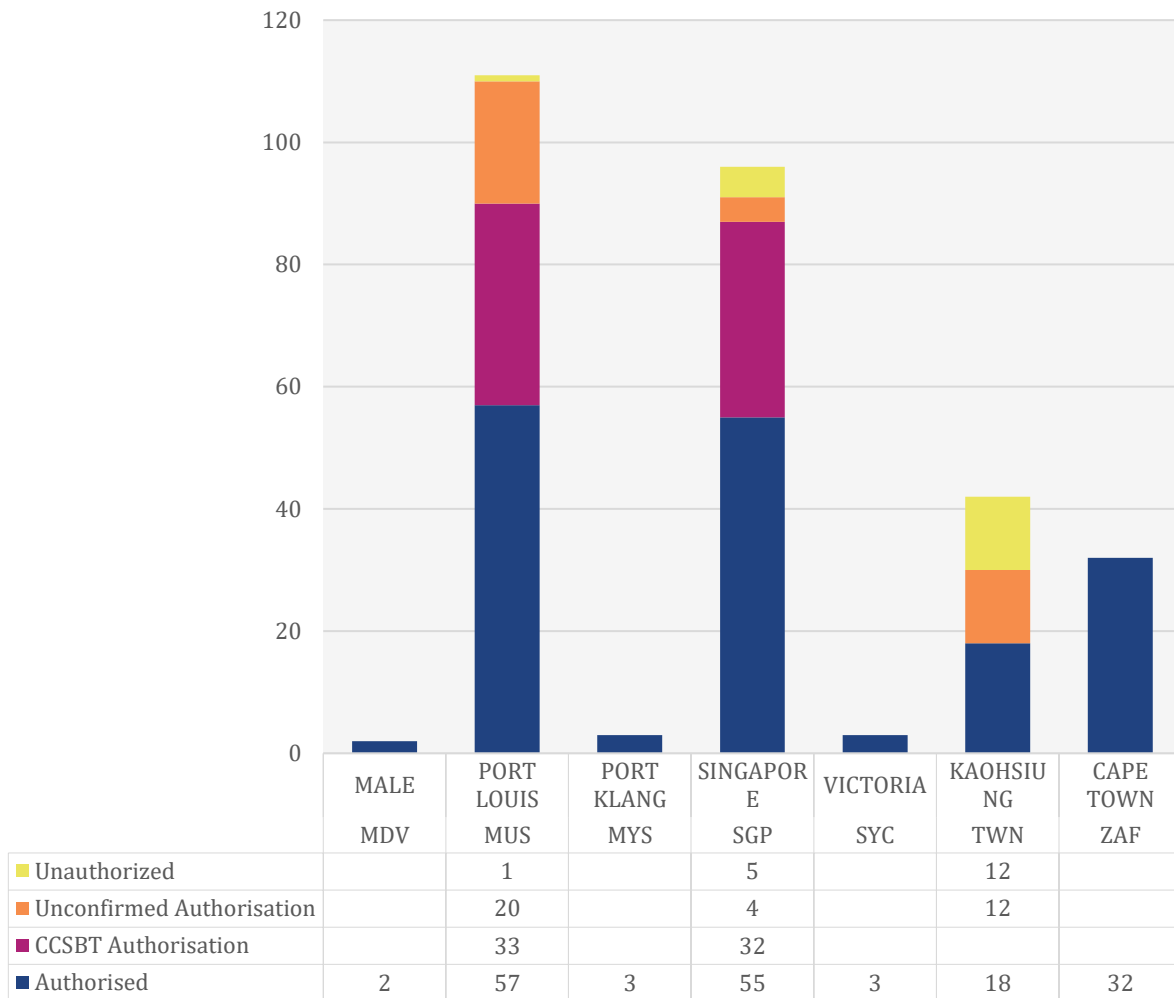
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	MALE	PORT LOUIS	PORT KLANG	SINGAPORE	VICTORIA	KAOHSIUNG	CAPE TOWN
	MDV	MUS	MYS	SGP	SYC	TWN	ZAF
■ Unauthorized		1		5		12	
■ Unconfirmed Authorisation		20		4		12	
■ CCSBT Authorisation		33		32			
■ Authorised	2	57	3	55	3	18	32

Figure 17 - Port Visits by Carriers by Vessel Authorisation

The majority of port visits after encounters where the carrier was unauthorised was to countries that have not ratified the Port State Measures Agreement (PSMA). The only PSMA ports visited by a carrier following an encounter where no authorisation could be found was Port Louis. Singapore and Taiwan are also non CPC countries so are unlikely to have access to IOTCs e-PSM application which is designed to electronically share information between CPC flag states, vessel operators and port states.
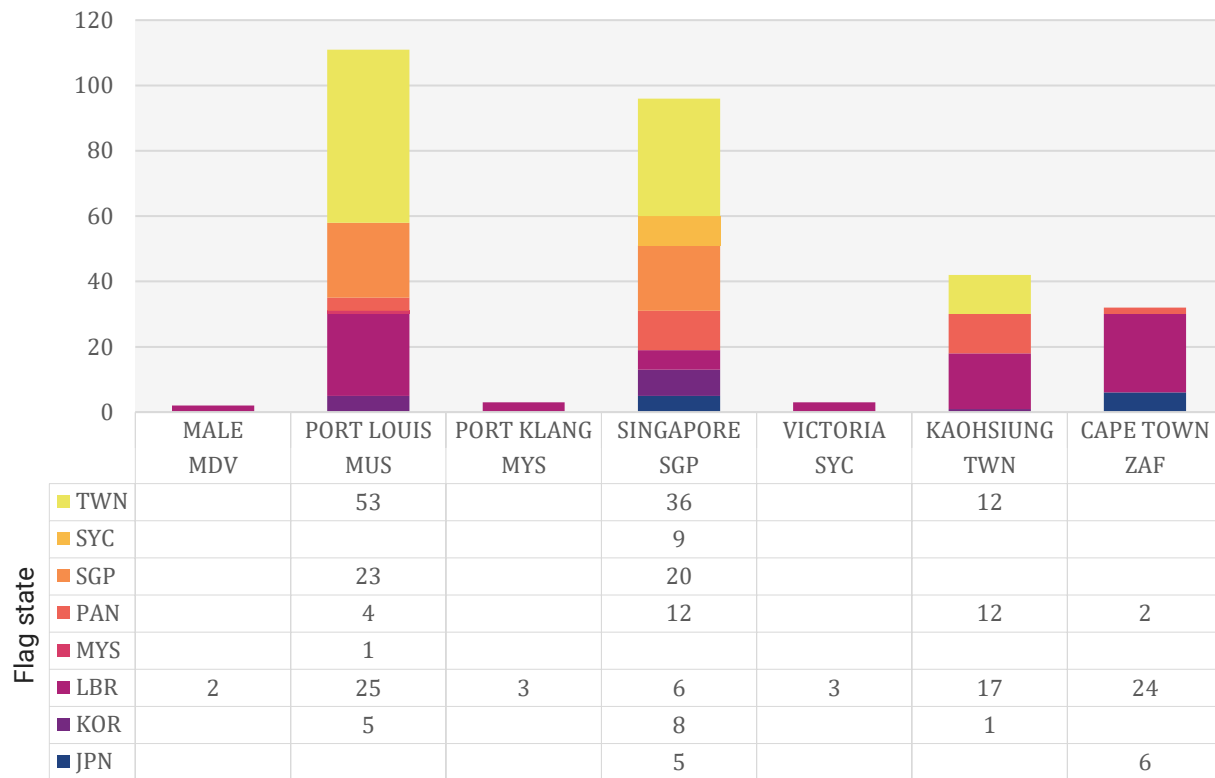
Flag state	MALE MDV	PORT LOUIS MUS	PORT KLANG MYS	SINGAPORE SGP	VICTORIA SYC	KAOHSIUNG TWN	CAPE TOWN ZAF
TWN		53		36		12	
SYC				9			
SGP		23		20			
PAN		4		12		12	2
MYS		1					
LBR	2	25	3	6	3	17	24
KOR		5		8		1	
JPN				5			6

Figure 18 - Ports Visits by Carriers by Donor Flag State and Authorisation

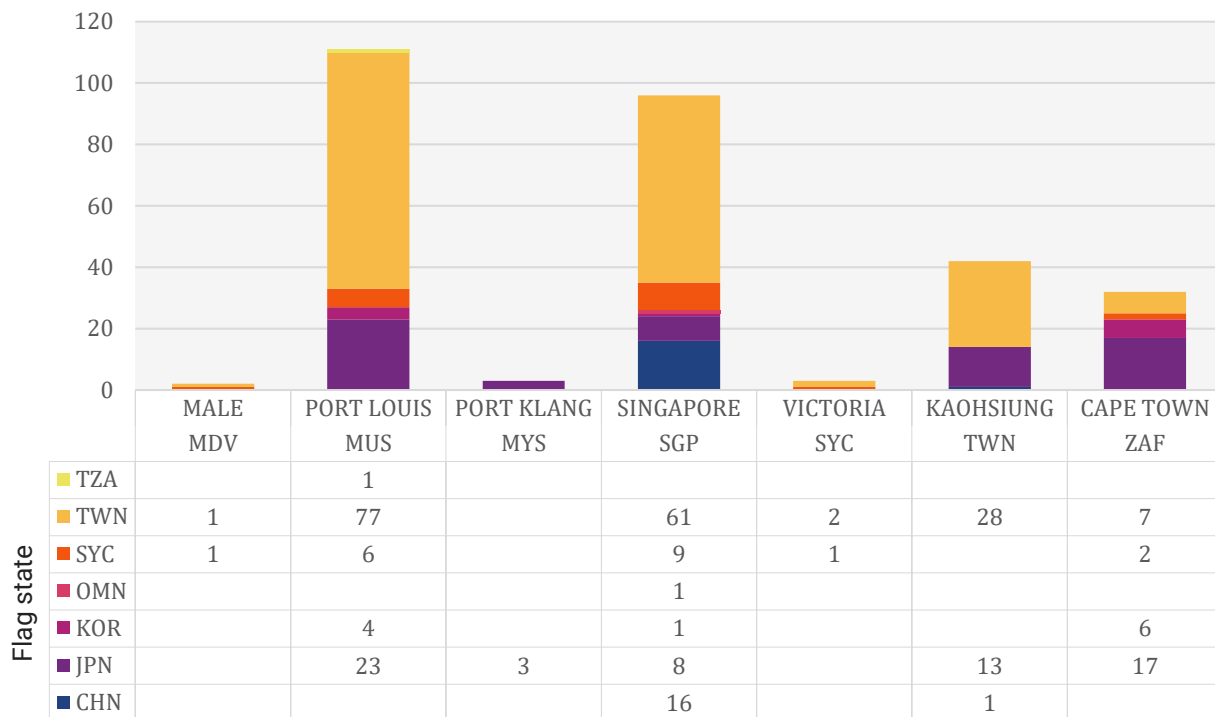| Flag state	MALE MDV	PORT LOUIS MUS	PORT KLANG MYS	SINGAPORE SGP	VICTORIA SYC	KAOHSIUNG TWN	CAPE TOWN ZAF
TZA		1					
TWN	1	77		61	2	28	7
SYC	1	6		9	1		2
OMN				1			
KOR		4		1			6
JPN		23	3	8		13	17
CHN				16		1	

Figure 19 - Ports Visits by Carriers by Carrier Flag State and Authorisation

9   Loitering Activity by Carrier Vessels

In addition to identifying carrier-donor vessel encounters, the authors examined loitering events to more fully understand possible transshipment activity in the IOTC Convention Area. Unlike the majority of longline fishing vessels operating in the Indian Ocean, fish carriers over 300GT in size on international voyages are required to use AIS. These differing international requirements create a situation where carrier vessel activity is more comprehensively observed on AIS as compared to the tracks of donor fishing vessels. If only the carrier in an encounter was using AIS, then the carrier would appear to have had a loitering event. The criteria used for a carrier vessel to be considered 'loitering' includes remaining at least 20 nautical miles from shore and operating at speeds less than two knots for at least four hours. These characteristics allow a carrier's movements to be consistently long enough to be possibly be interacting with a donor vessel (Miller et al. 2018) (See Methods).

Vessels can loiter at-sea for a number of reasons, transshipments are only one of them. Other reasons include awaiting permission to enter an EEZ or port, or simply awaiting new orders from the vessel's owner or charterer. Observing loitering events via AIS does not fully guarantee a transshipment involving the transfer of fish product occurred; it does however, provide preliminary indications in vessel behaviour that can help fishery managers further understand risks associated with unauthorised transshipments and better inform them when making management decisions.

By comparing reported transshipments to loitering events, policy makers can build a clearer understanding of the fleet dynamics and behaviour of carrier vessels operating in the IOTC region.

9.1   Loitering Events Count and Trends

The authors identified a total of 734 loitering events[7] to have occurred in IOTC Convention Area in 2017. Of these 734 loitering events 609 were by carriers either authorised by IOTC or CCSBT. The location of these loitering events is consistent with the location of both authorised and unauthorised vessel encounters (Figure 20).

A total of 39 loitering events were identified to have taken place by 13 different carrier vessels unauthorised by either IOTC or CCSBT. A review of the patterns of these loitering events and their locations appear to illustrate a significant risk exists that at-sea

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[7] All available loitering data can be found in Annex 3-0579-1315.

transshipments took place in 2017 outside of either the IOTC or CCSBT transshipment regulation framework.

The loitering events by unauthorised carrier vessels did not appear to occur in the central southern Indian Ocean region. Instead, the majority occurred on the high seas close to the maritime boundary lines of the EEZs belonging to South Africa, Madagascar, Seychelles, Mauritius, Maldives, and Indonesia (Figure 21). The loitering events in both the north and south-eastern IOTC Convention Area tend to be of short duration (few greater than 24 hours and none greater than 48 hours). Throughout the rest of the IOTC Convention Area, the duration of the loitering events varies (Figure 21).

Similar to the encounters involving unauthorised carrier vessels, most of the loitering events involving unauthorised carrier vessels appear to be conducted by Panamanian-flagged carriers with the addition of several Chinese and Russian-flagged carrier vessels (Figure 21).

- Two unauthorised Chinese carriers[8] were observed carrying out 7 loitering events in the IOTC Area of Competence in 2017. The loitering events by these unauthorised Chinese-flagged carriers all took place between eight and 48 hours in duration and only occurred in the northeast portion of the IOTC Convention Area, including a single eight-hour loitering event on the high seas outside the EEZ of Timor-Leste.

- A total of 10 Panamanian carriers without IOTC or CCSBT authorisation were observed on AIS carrying out 31 loitering events in the IOTC area of competence in 2017. The events occurred in the southwest Indian Ocean and also in the northeast Indian Ocean between Maldives and Indonesia. The loitering events of these vessels were often seen in sequence, similar to the typical behaviour of a carrier vessel carrying out authorised tr;ansshipments.

- There was one loitering event by an unauthorised IOTC carrier flagged to Russia. This event lasted 24 hours and occurred on the high seas close to the Indonesian EEZ. One single loitering event is difficult to determine if an encounter occurred or if any fish were transshipped.

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[8] One unauthorised Chinese vessel observed loitering in IOTC in February 2017, Fu Yuan Yu Leng 999 was arrested in Galapagos in August 2017 as an IUU vessel for illegal transport of shark and shark fins (GFW, 2017)

- There were three Taiwanese-flagged carriers with unconfirmed authorisation that had 86 loitering events in IOTC waters in 2017. These events occurred in the north and southwest Indian Ocean. As previously outlined in the sections related to vessel encounters, the authorisations of these vessels could not be fully confirmed for 2017 due to the lack of public availability of Taiwan flagged carrier vessel authorisation lists prior to December 2017.
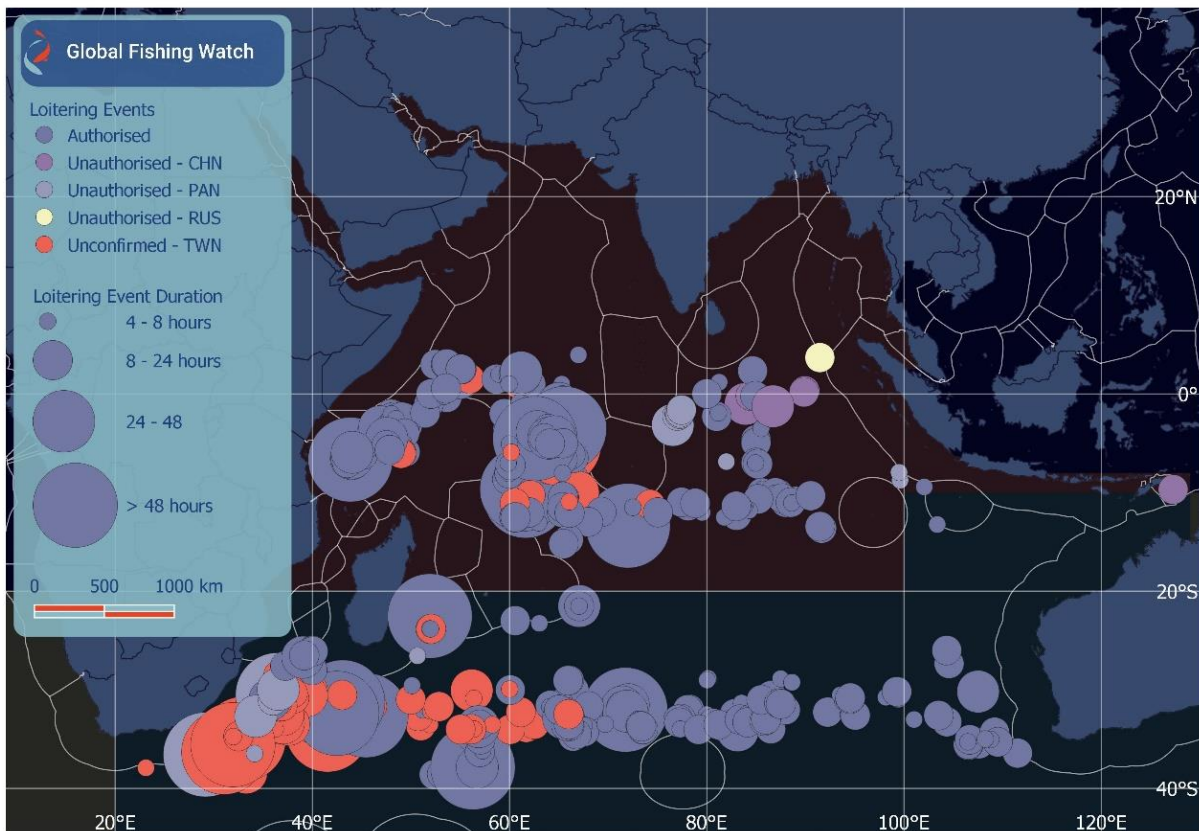

Figure 20 - Loitering events within the IOTC Convention Area by Authorisation and Duration
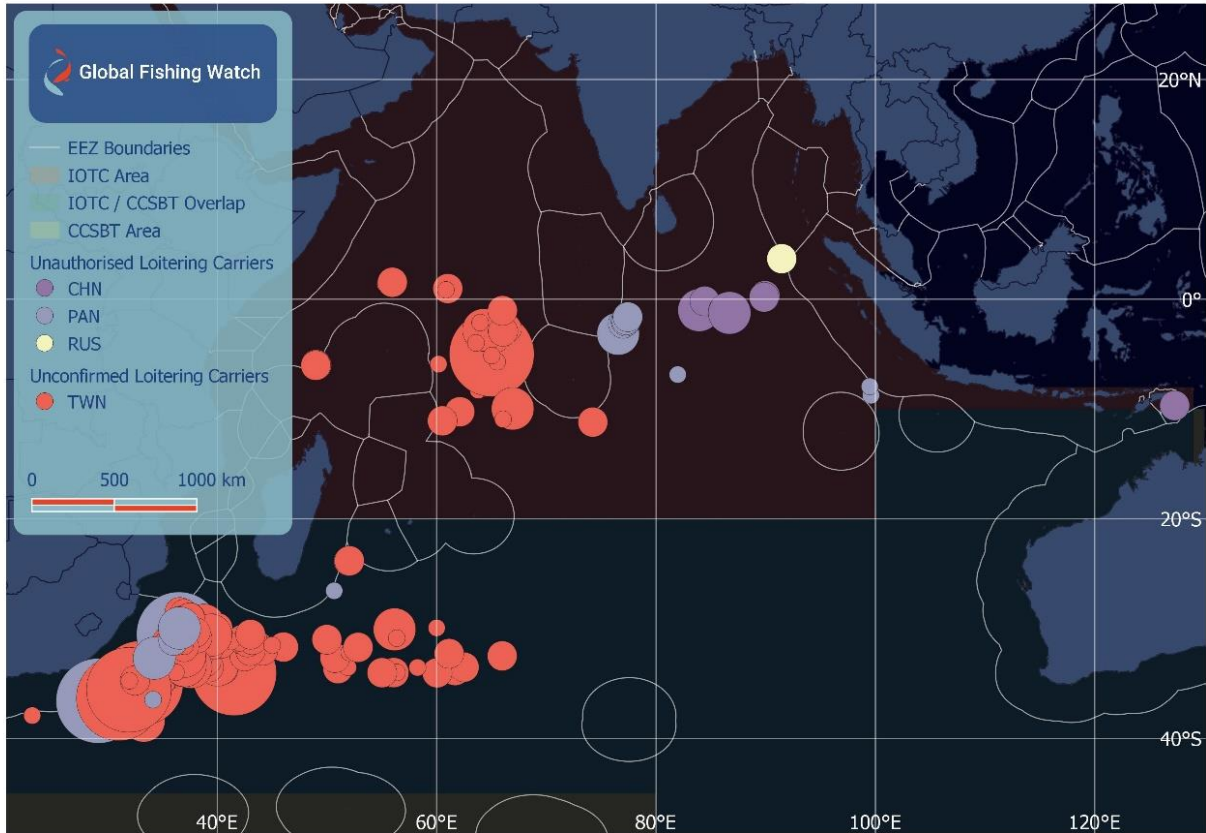
Figure 21 - Loitering events within the IOTC Convention Area by Carriers with unconfirmed authorisations (Taiwan) and possible missing authorisations (China, Panama, Russia)

The distribution of loitering events by authorised and unauthorised carrier vessels by vessel flag is similar to the distribution for encounter events. For example, Liberia has the most loitering events by authorised carriers (Table 2 and Figure 20) as well as the most encounters by authorised carriers (Figure 3).

The largest number of loitering events conducted by carriers where no authorisation was found are Panamanian-flagged carriers, similar to their distribution of encounters by unauthorised Panamanian carriers (Table 2 and Figure 7).

The addition of unauthorised Chinese and Russian carriers with loitering events but no encounter events suggests that if encounters were occurring the vessels meeting them were not using AIS.

Table 2 - Count of Loitering Events by Carrier Flag and Authorisation

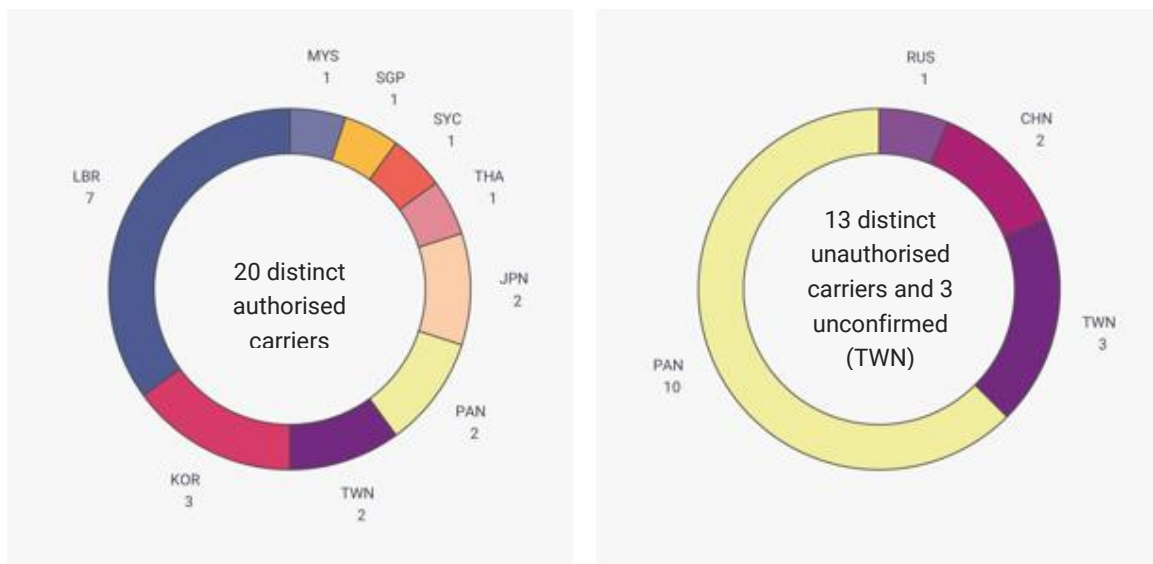| Carrier Flag	Authorisation	Count
LBR	Authorised	186
TWN	Authorised	134
SGP	Authorised	85
PAN	Authorised	71
KOR	Authorised	64
SYC	Authorised	35
MYS	Authorised	22
JPN	Authorised	10
THA	Authorised	2
RUS	Unauthorised	1
TWN	Unconfirmed authorisation	86
PAN	Unauthorised	31
CHN	Unauthorised	7

Figure 22 - Distinct Carriers in Loitering Events by Authorisation

Overlaying the AIS derived loitering events with the IOTC reported transshipments from the ROP report shows clear correlation between the two. This suggests that loitering events represent a good indication of where transshipments may have occurred. What stands out when the two data sources are overlaid are the locations of the loitering events by unauthorised carriers. There is a large group in the southwest Indian Ocean that are in the same general area as a concentration of reported transshipments. There are also a number of loitering events that do not match any reported transshipments, indicating that there may well be transshipments occurring in the main tuna fishing areas that are not being reported and therefore occur outside of IOTC's transshipment regulatory framework. The process to overlay the two datasets uses georeferencing of the IOTC image and is not accurate enough to make any determination on specific transshipment events shown on the chartlet. However, it does show a clear correlation between the two data sets, and provides insight into the potential methodology for comparing AIS with reported transshipment data in an effort to better uncover and identify anomalies.

Figure 23 - Map showing the AIS derived loitering events by vessels authorised to transship (yellow circles) and vessels not authorised to transship (blue circles) overlaid on a map produced by IOTC showing transshipment locations during 2017 (red circles, MRAG, and CapFish 2018).

Global Fishing Watch

9.2   Loitering Events Temporal Analysis

The distribution of loitering events over time is very similar to encounters over time (Figure 25 and Figure 15). There is a primary peak of encounters in June and July, followed by a secondary peak in October (Figure 24).

The seasonal peak did seem to be driven by loitering events that occurred within the overlap of the IOTC and CCSBT Convention Area waters, with an increase in loitering events in the IOTC-only Convention Area and decrease in the waters of the IOTC and CCSBT overlap during the secondary peak of events in October. These observed seasonal trends coincide with the albacore and southern bluefin tuna fisheries peaking in the southern Indian Ocean to May to July and the yellowfin and big eye tuna longline fisheries peaking in the central Indian Ocean later in September to March (Kaplan 2014).
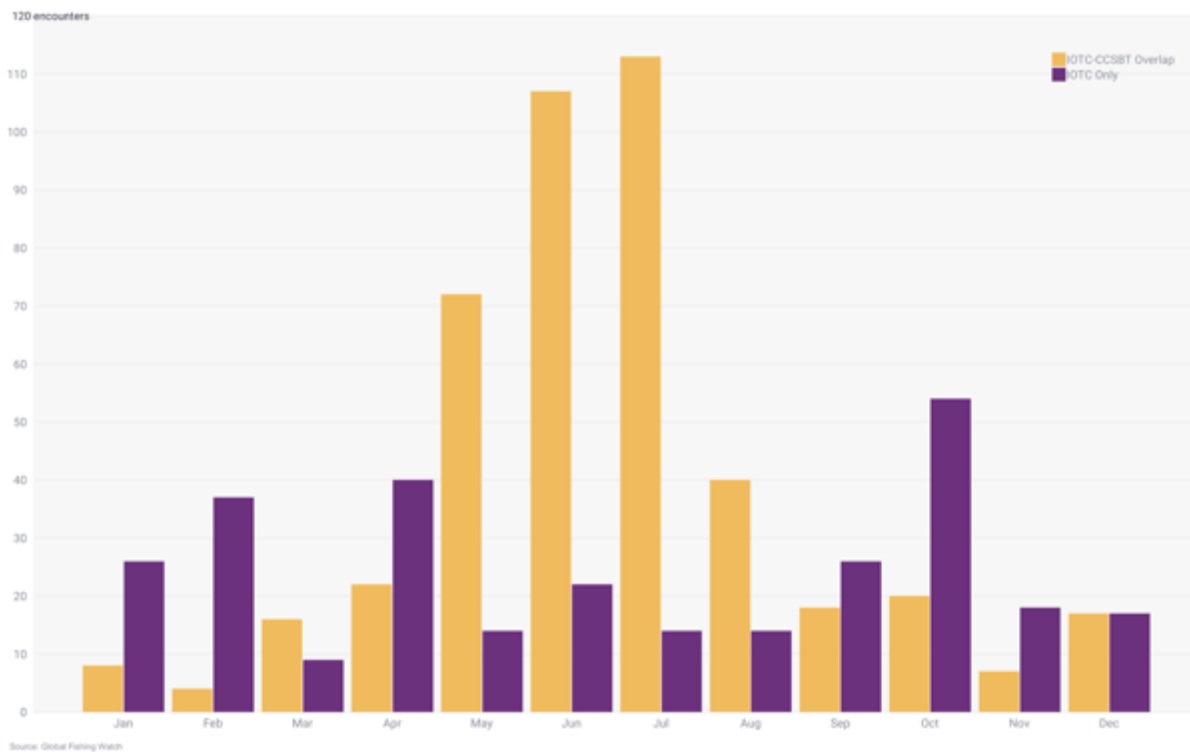

Figure 24 - Count of Loitering Events Across 2017 by Convention Area Region
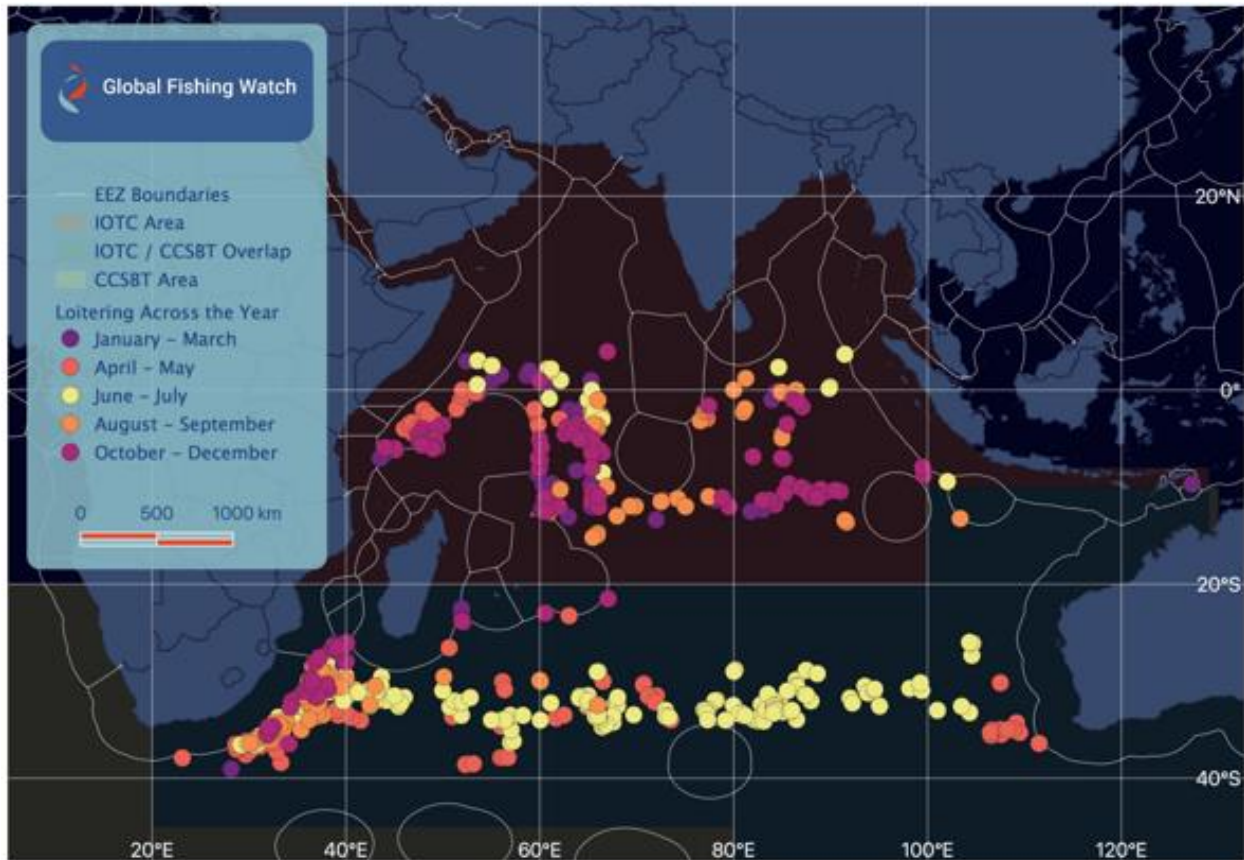
Figure 25 - Loitering Events Across 2017 within the IOTC Convention Area

9.3   Port Visits by Carriers after Loitering Events

Similar to the top ports visited by carriers after donor encounters, Port Louis, Mauritius had the most visits by carriers after a loitering event (283) followed closely by Singapore (226) (Figure 26). In fact, the top four most visited ports were identical for carriers after both encounters and loitering events (Figure 16 and Figure 26) (See Annex 4-1316-2049 for the full dataset). However, there was a wider range of ports visited by carriers after loitering events than after donor encounters (Figure 26).
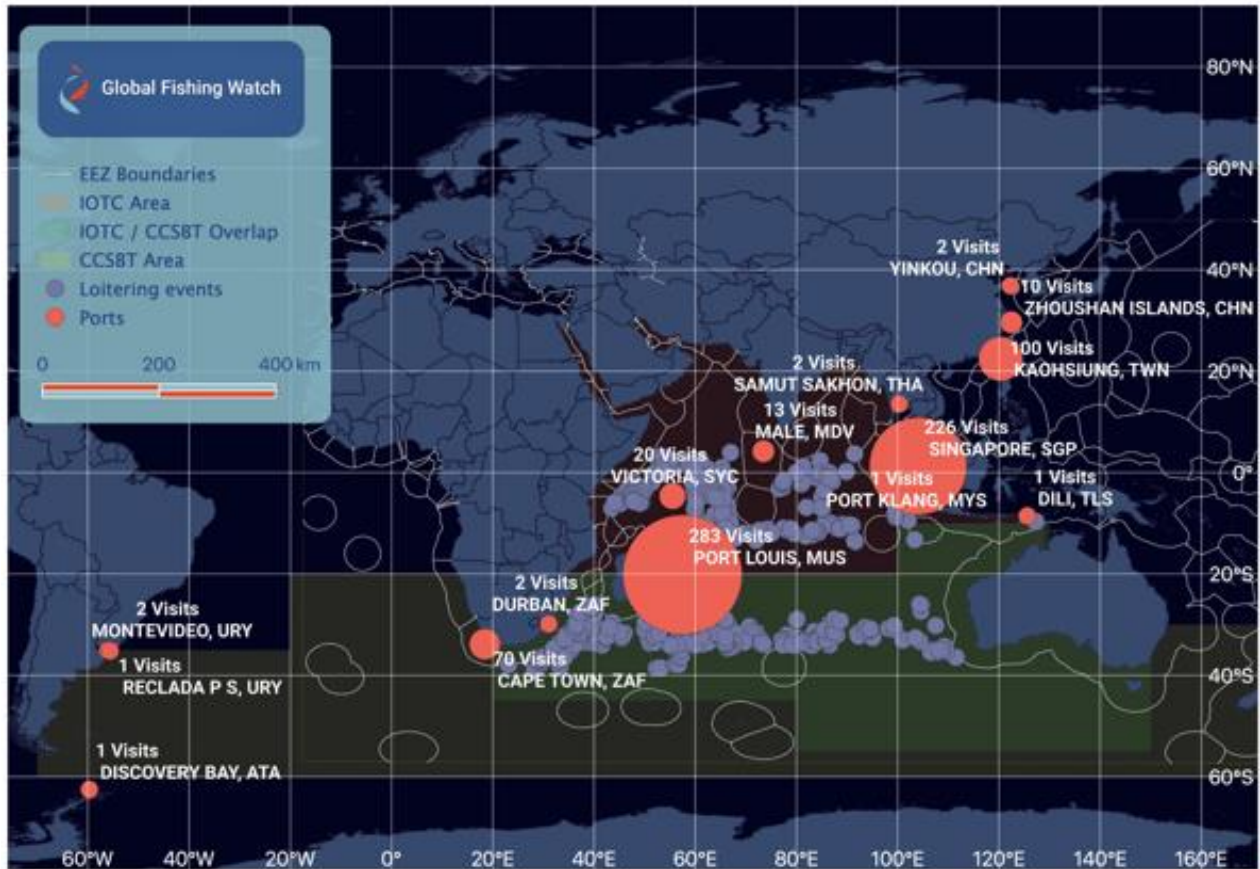
Figure 26 - Port Visits by Carriers after Loitering Events

The authorisation category of carriers that exhibited loitering behaviour did not appear to largely affect the visited port (Figure 27). However, the port of Kaohsiung City, Taiwan followed by Singapore had the highest number of unauthorised carrier visits after loitering events in the same pattern exhibited by unauthorised carriers after encounters (Figure 28 and Figure 16). Victoria, Seychelles and Cape Town, South Africa also had a high number of visits by unauthorised carriers after loitering events (Figure 28). Carriers transshipping in port with IOTC authorised donor vessels do not need to be authorised by IOTC; however, they must be always authorised by IOTC when transshipping on the high seas.
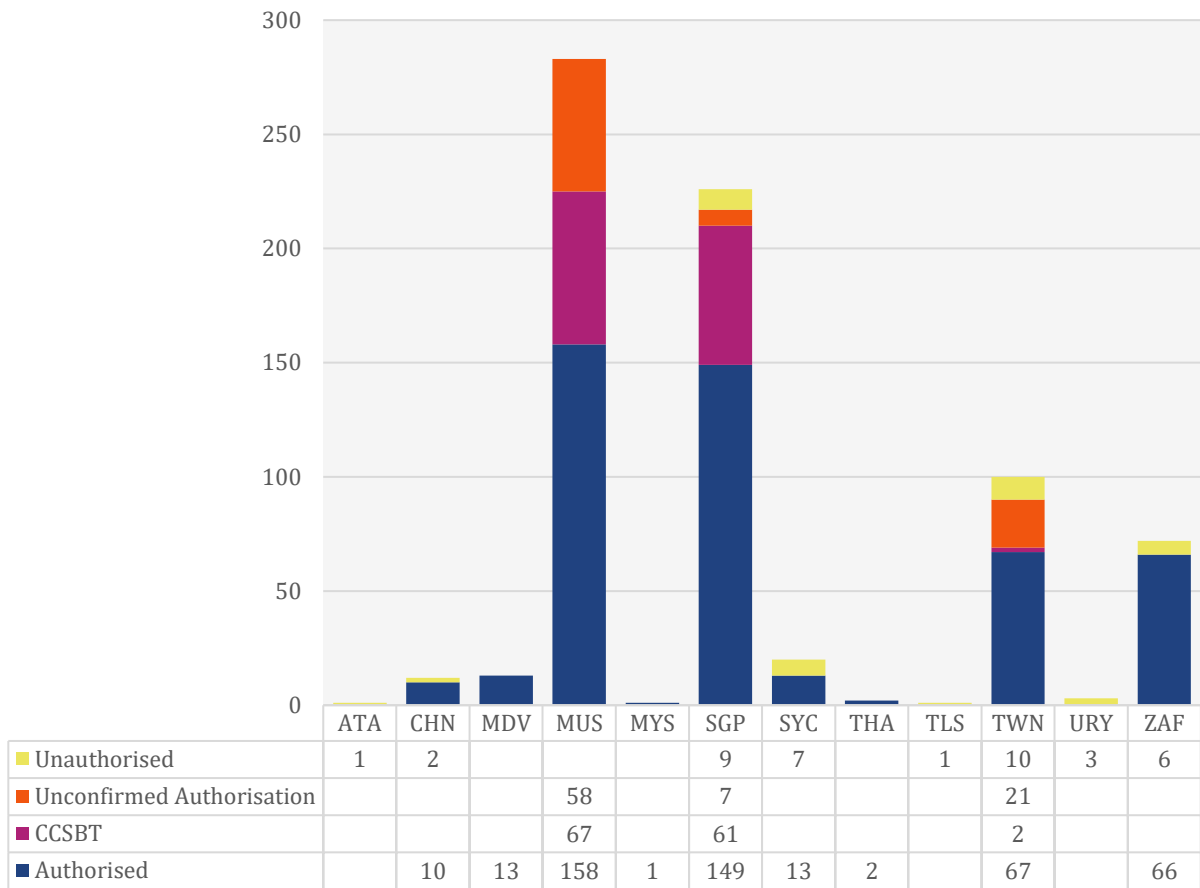
	ATA	CHN	MDV	MUS	MYS	SGP	SYC	THA	TLS	TWN	URY	ZAF
Unauthorised	1	2				9	7		1	10	3	6
Unconfirmed Authorisation				58		7				21		
CCSBT				67		61				2		
Authorised		10	13	158	1	149	13	2		67		66

Figure 27 - Port visits after Loitering Events by Carrier Authorisation

When carriers flagged to Taiwan are removed from the list of carriers with unconfirmed authorisations, the remaining Panamanian, Chinese, and Russian-flagged carriers observed with loitering events inside the IOTC area made 23 visits to ports that are not a party to the Port State Measures Agreement (PSMA). A further 16 visits were made to ports whose country was a party to the PSMA. The non-PSMA ports included Taiwan, China and Singapore. The countries that were a party to PSMA that unauthorised carrier vessels visited after loitering events in IOTC included Seychelles, Uruguay and South Africa.

10   Encounters between Fishing Vessels

It may be of interest to identify patterns and trends in encounters between two fishing vessels within the IOTC Convention Area. Per IOTC Resolution 18-06, on establishing a programme for transshipment by large scale fishing vessels within the IOTC Convention Area, "No at-sea transshipment of tuna and tuna-like species and sharks by fishing vessels other than LSTLVs shall be allowed" (IOTC 2018). Through AIS analysis the authors identified possible encounters between two donor vessels. These encounters may indicate transshipment between both vessels which, per Resolution 18-06, is not expressly allowed. Conversely, these encounters could indicate a larger transshipment event occurring with a carrier vessel not broadcasting on AIS.

The study identified 33 encounters between two fishing vessels (see Annex 5-2050-2085 for the full dataset). The location of donor-donor encounters follows the same patterns as the previously identified encounters and loitering events (Figure 29). Similar to identified encounters between carrier and donor vessels, the majority of donor-donor encounters were conducted by Taiwanese flagged vessels (Figure 30). Other prominent fleets in donor-donor encounters include, Spain, China, Malaysia, and Portugal (Figure 31). A majority of donor-donor encounters are between fishing vessels of the same flag State (Figure 30). The encounters between fishing vessels of different flag States are between Portugal and Spain flagged fishing vessels, and Taiwan and Malaysia, Seychelles, and Tanzania flagged vessels (Figure 31).
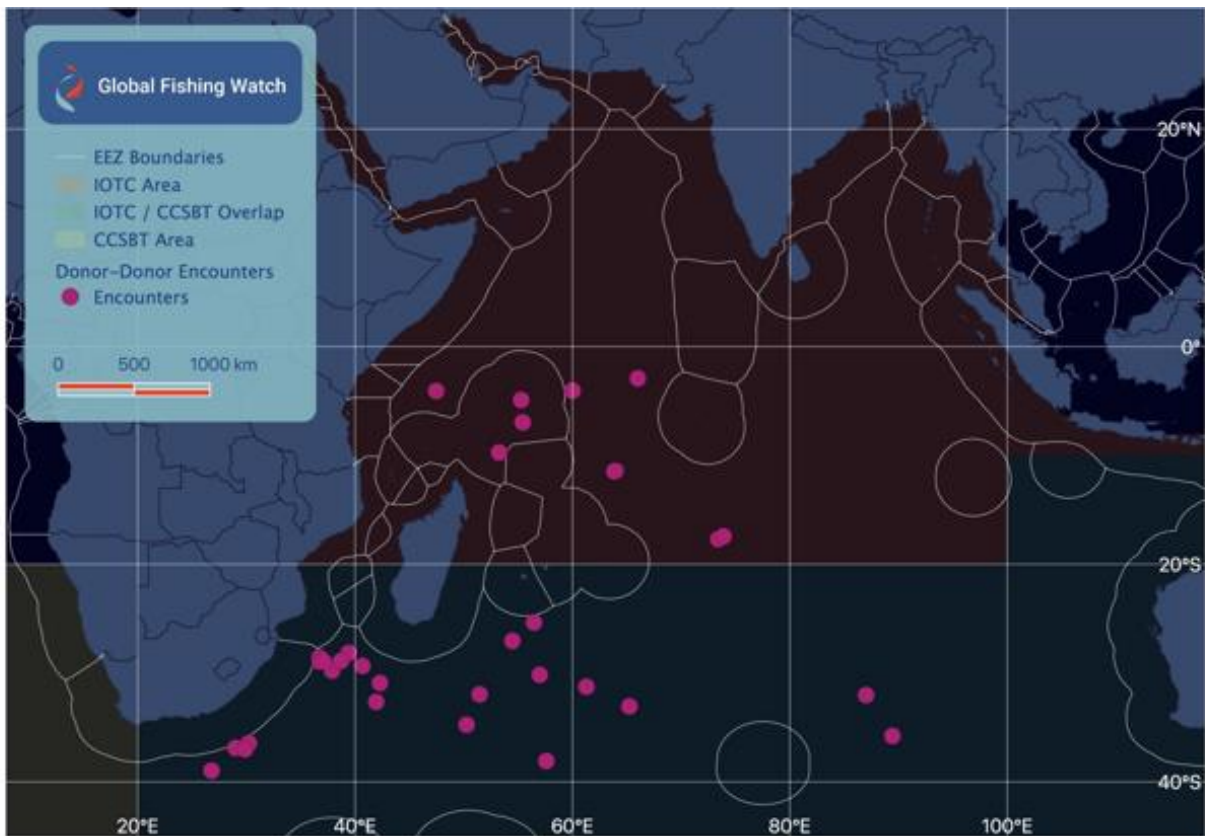
Figure 28 - Encounters between two Donor Vessels within the IOTC Convention Area
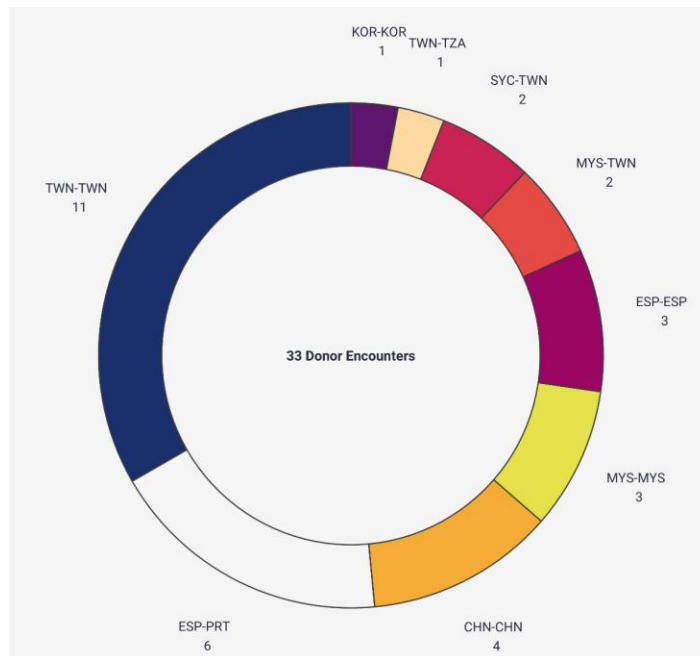

Figure 29 - Composition of Donor-Donor Encounters by Authorisation and Flag State
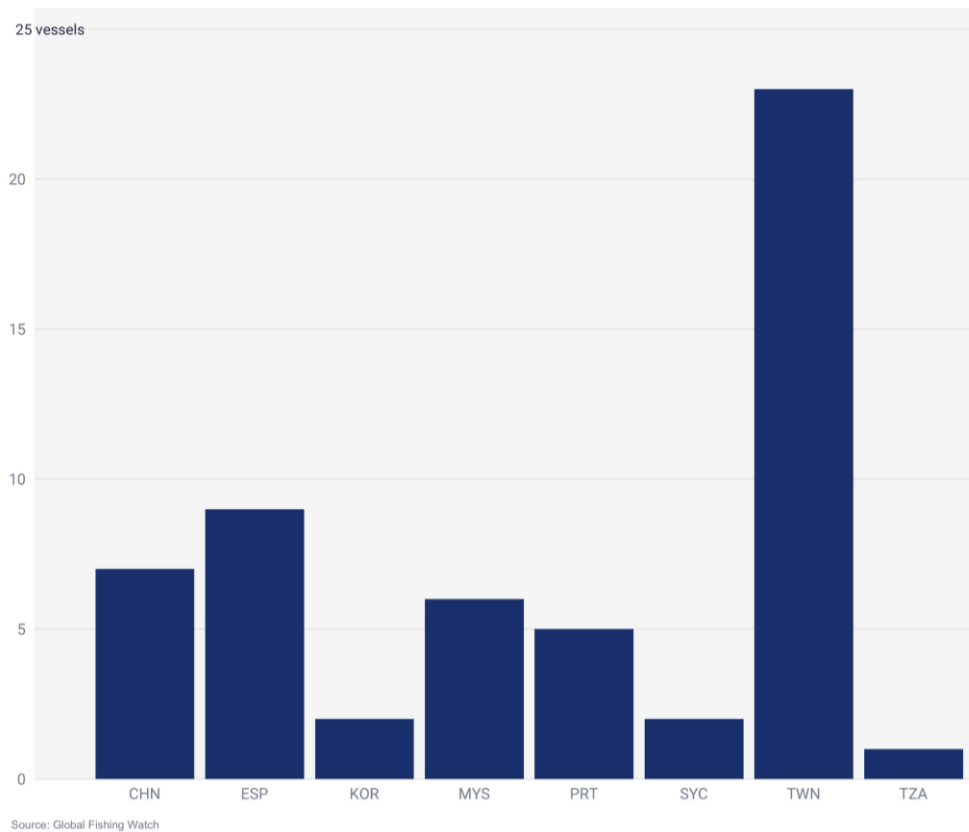
Figure 30 - Count of Distinct Donors by Flag State and Authorisation

The specific donor vessels identified in donor-donor encounters may indicate fleets of vessels operating together (see Annex 5-2050-2085 for vessel information). This information, in conjunction with the loitering and carrier-donor encounter events (also available in Annex 5-2050-2085) is useful to comprehend which fleets may need to be monitored and inspected more closely, or how tuna species are being harvested spatially and temporally throughout the IOTC Convention Area.

11   Data Caveats

The analysis presented in this report relies on commercially available AIS data and publicly available information. Therefore, the AIS data is limited by those vessels that transmit AIS data and do so by providing accurate vessel identity information. Low satellite coverage or high-density areas can also limit AIS data usefulness, although the IOTC Convention Area has relatively strong Class-A AIS coverage (See Kroodsma et al. 2018). However, AIS data tends to be sparser and more limited for vessels equipped with

a Class-B AIS device (Kroodsma et al. 2018), and many of the longline vessels in the IOTC region use Class-B AIS transponders. Class-B AIS reception is quite poor in the northern half of the Indian Ocean basin. AIS device class often depends on flag State regulations, vessel length, and vessel purpose. Because of the limitations of AIS data, lack of complete and accurate public vessel databases and registries, and limitations of modelling estimations, the encounter and loitering data are represented as accurate as possible, but should be considered restrained estimates based on these limitations (see Miller et al. 2018 for further discussion).

12   Key Findings

A review and analysis of AIS data for the Indian Ocean identified a total of 13 carrier vessels that operated inside the IOTC area of competence in 2017 in areas specific to tuna fisheries which did not match any carrier vessels listed on the IOTC or CCSBT vessel authorisation lists.

These 13 carrier vessels were observed loitering at-sea a total of 40 times. Some of the carrier vessels only had one loitering event such as the single Russian-flagged carrier observed on AIS. A single loitering event may be related to an activity other than transshipment and in cases such as this, it is difficult to confirm whether transshipment activity actually occurred. Conversely, a number of unauthorised carrier vessels were observed making multiple loitering events inside areas highly targeted and fished by tuna longline vessels. This behaviour suggests these unauthorised carriers were more likely to be actively transshipping as the patterns compared consistently with typical transshipping activity. These included the unauthorised Panamanian and Chinese-flagged carrier vessels. Two of the unauthorised Panamanian carriers were also observed encountering 17 different authorised tuna longline vessels also broadcasting on AIS. Repeated encounters where both carrier and donor vessels were broadcasting on AIS suggests the vessels involved were actively transshipping inside the IOTC area of competence outside the IOTC transshipment regulatory framework. One authorised carrier had an encounter with a Seychelles-flagged longline vessel which appeared to not be authorised by IOTC in 2017. This encounter occurred outside the Seychelles EEZ and should require proper authorisation. Seychelles maritime or fisheries authorities may wish to further investigate and evaluate this event.

The authorisation status of Taiwanese-flagged carriers posed a unique problem for the study as Taiwan is not a member of IOTC but cooperatively participates with the IOTC

Secretariat and CPCs. This results in Taiwan publishing their own authorised vessel lists on its own website. Unfortunately, their historical authorised carrier list did not cover the whole of calendar year 2017. The study identified seven Taiwanese carriers operating in IOTC but could not confirm the exact authorisation status of the vessels.

Through AIS analysis, this study identified a total of 289 encounter events that can be audited by the IOTC Secretariat or flag State authorities by crosschecking with official authorisation lists, transshipment reports and VMS tracks to determine if they involved transshipments at-sea involving IOTC-managed species that did not follow the authorisation and monitoring procedures of the current *IOTC Resolution 2018-06 on Establishing a Programme for Transshipment by Large-Scale Fishing Vessels.*

This study found several key findings and patterns that relate to specific policy areas in the control of transshipment activity in the IOTC Convention Area:

- There appeared to be a difference in the number of observed transshipments reported by the ROP during 2017 (MRAG and CapFish 2018) versus authorised encounters identified on AIS in this study. A lack of AIS usage by vessels involved in encounters can lead to differences in the number of possible transshipment events. AIS use by fishing vessels in the Indian Ocean is known to be relatively low and is linked to inconsistent national regulatory frameworks around the use of AIS as well as the piracy threat in the northwest Indian Ocean.

- No large tuna purse seine vessels were observed on AIS encountering a carrier at-sea; however, due to piracy issues these vessels tend to not use AIS outside of port, making monitoring them with AIS ineffective. For this reason, this study has focused specifically on transshipment compliance of longline vessels, however, the same techniques investigating carrier loitering events can be used alongside purse seine VMS data and provide an additional tool to identify any possible non-compliance with the IOTC transshipment regulation.

- The majority of carrier vessels identified in the IOTC Secretariat Compliance and observer programme service provider reports (see MRAG and CapFish 2018, IOTC Secretariat 2018a, and IOTC Secretariat 2018c) were not seen to encounter donor vessels operating on AIS. This highlights the fact that many authorised donor vessels do not use AIS. If this lack of AIS usage is extrapolated further, it may also provide a preliminary indication there may exist longline vessels without proper authorisation actively operating in IOTC waters which may not be transponding on

both VMS and AIS. However, the level to which this may occur would require further investigation.

- The overlapping regulatory framework between IOTC and CCSBT creates a challenging environment to understand under which authorisation a vessel is operating without access to all the relevant transshipment declaration data and catch reporting. It is intended that this study highlight the risks associated with the overlapping jurisdictions and promote stronger data sharing and cooperation between RFMO Secretariats and relevant flag State authorities. The data also provides an example of how the two RFMOs can benefit from AIS analysis to complement their current VMS picture of fishing activity occurring in their respective areas of competence. By working closely together and supplementing VMS with AIS data in this manner, it is hoped the results will provide greater transparency as to the activity of transshipment occurring at-sea and reduce the ability for vessels to hide non-compliant activity in the opaque management of overlapping jurisdictional areas.

- As Taiwan is not able to be a party to the IOTC treaty, it is difficult to fully address Taiwan's carriers activity without access to the historical authorised vessel records. For instance, the vessel registry information of Taiwanese-flagged vessels is not presented on the public IOTC vessel database, but Taiwan's Fishery Agency does provide their own database, which is a different format than the IOTC database and provides very little historical vessel information.

- Unauthorised Panamanian-flagged carriers had a high number of encounters and loitering events compared to other flag States. Panama is a non-CPC of IOTC, so closer engagement with Panama by the IOTC Secretariat to support monitoring and reporting of their vessels' activities is highly encouraged. Without the sharing of VMS data, integrated AIS monitoring, and robust port state controls, it is very difficult for flag States to control the activities of their vessels in waters beyond their own national jurisdiction which may interact with other foreign-flagged vessels while at-sea.

- There is a consistent pattern of ports that unauthorised carriers are visiting after having encounters within the IOTC Convention Area (two Panamanian-flagged carriers). The only ports visited were Singapore and Kaohsiung City, Taiwan. Neither Singapore nor Taiwan are IOTC contracting parties nor are they party to the PSMA. Unauthorised carriers observed with loitering events inside the IOTC area made 23 visits to ports in countries not party to the PSMA and 16 visits to

ports in countries party to the PSMA. As such, further work to strengthen CPC port controls in line with IOTC Resolution 16-11 on Port State Measures should be considered. Likewise, the Commission may wish to engage those non-CPC port States not party to the PSMA where these carriers made port visits to advocate for adequate inspections to be made on carrier vessels which had indications of activity in IOTC waters that may have been noncompliant without evidence of proper authorisation.

- The study found 33 cases where longline fishing vessels met at-sea. These often occurred between two vessels of the same flag; however, a number of examples can also be seen between vessels of different flags. In these cases, flag State authorities are unlikely to "see" the event occurring without the benefit of VMS data-sharing, which is nearly non-existent between IOTC CPCs. The identification of this activity occurring suggests that the circumstances of the encounters may warrant further investigation by the appropriate flag State authorities to determine whether they involved the transfer of fish product. If so, CPCs may wish to consider strengthening IOTC regulations to either clearly prohibit this type of activity or ensure when it occurs, proper reporting and documentation protocols are explicitly required.

13   Conclusion

Detailed analysis of AIS data related to transshipment activity within an RFMO area can provide valuable insight into fishing activity, including transshipment patterns, and can help to identify potential gaps or loopholes in the regulations and their implementation. AIS data can also provide an additional source of information for management authorities to review alongside existing transshipment declarations, VMS and authorisation data. This can ultimately help build a more complete picture of activities occurring at-sea and identity noncompliant activity that may be conducted outside of existing transshipment regulations and associated with IUU fishing. By building a more complete picture of transshipment activity, policy makers can focus on strengthening regulations specific to what is happening on the water, far from the reach of management and inspection authorities.

This study identified risks in transshipment activity in the IOTC region by unauthorised carriers flagged to both CPC and non-CPC countries. This activity exploits gaps in the current IOTC transshipment regulatory framework and MCS structure. Preventing transshipments linked to IUU fishing activity in the future will rely on the review of the

transshipment regulations around the authorisation of carrier vessels flagged to non-CPC countries, adoption of a centralised VMS system with robust data-sharing arrangements amongst relevant authorities and consideration of mandating AIS usage as a complimentary remote monitoring tool. It is recommended that the current data-sharing MoU with CCSBT be strengthened to specifically include the sharing of all transshipment related data and consideration of the use of AIS to supplement VMS for remote vessel monitoring and analysis.

Port state control has been identified as a potential weakness in detecting IUU fishing activity. Vessels unauthorised to transship in IOTC waters should be closely inspected on port arrival if their current voyage activity involved possible operations in IOTC waters. This is especially valid where the port is located in a country of an IOTC CPC and the country is party to the PSMA. Regardless, IOTC CPCs should be conducting port inspections consistent with the requirements of IOTC Resolution 16-11 on Port State Measures which is consistent with the PSMA. These vessels should be denied entry if persistent unauthorised transshipments inside IOTC are identified. Non-CPC States not party to the PSMA that receive carriers in their ports that have been identified to have transshipment related activity in IOTC waters should also be engaged to seek further cooperation to strengthen port controls related to these vessels. Encouraging these non-CPC port States to become a party to PSMA and implement effective port State measures involves many direct and indirect advantages for IOTC CPCs. These include improving the gathering, verification and exchange of information that not only lead to more accurate assessments of fish stocks, but also strengthens the monitoring of both national and international waters. The PSMA also creates a framework for information-sharing and collaboration where regional implementation of the PSMA can facilitate enforcement efforts across jurisdictions and makes it less economical for illegal operators to land illicit catch sourced from IOTC waters.

It is thought that synthesis of AIS data with authorisation data to the extent presented in this report is not common practice by any RFMO Compliance Committees. AIS data can provide an immense source of knowledge and insight into patterns of possible transshipment behaviour within the IOTC Convention Area by vessel type, flag State, authorisation, port visits, and across space and time. GFW intends to help the IOTC Secretariat and Commission facilitate more efficient and effective remote monitoring of vessels operating in the IOTC Convention Area by highlighting these patterns of activity and providing CPC authorities access to AIS data linked to possible transshipment events in near real time. By sharing this type of information in near real time, it allows

investigations to start sooner after anomalous events are first observed, increasing the likelihood of successful interventions by flag, coastal, or port State authorities.

A secondary intention of this study is to allow the RFMO and flag State authorities to use the historic AIS-based information to provide an initial starting point further investigate anomalies and possible unauthorised activity.

Incorporating AIS into compliance monitoring by IOTC could be further strengthened by Commission members agreeing to mandate use of AIS by its member countries' vessels when they operate in the IOTC Convention Area to supplement VMS requirements. The Piracy High Risk Area designated in the northwest of the Indian Ocean does provide an issue for vessels broadcasting their AIS position, however, the current advice (BAP5 2018) is that AIS is left on when inside the zone but it remains the master's decision. The southern and eastern Indian Ocean is also not currently affected by the piracy issue and mandating AIS in these regions would strengthen the monitoring of the IOTC Commission Area.

This study also highlights the value of improving the accuracy and depth of public availability of vessel registry information and transshipment authorisation data, the combined usage of both VMS and AIS data and the exchange of this information between IOTC and CCSBT and relevant flag, coastal and port State authorities. This shift towards data transparency in tuna fisheries in the IOTC Convention Area would lead to a more complete understanding of transshipment activity and stronger controls against IUU fishing. Improved transparency for data related to transshipments in the Indian Ocean would also provide an opportunity for interested parties such as port State inspectors, fish buyers, insurance companies, and investors to easily quantify the risks posed to them by possible IUU fishing activity within the IOTC Convention Area.

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Annex 2: Detailed Methodology

AIS Description

In 2002, an agreement under the International Maritime Organisation (IMO) International Convention for the Safety of Life at sea (SOLAS) made a new requirement aimed at improving safety at sea: to avoid collisions between vessels, all vessels on international voyages larger than 300 gross tons had to carry and operate an Automatic Identification System (AIS) device (IMO 2002). Although the use of AIS is not globally mandated for fishing vessels, many national governments have mandated vessels that fall outside the IMO regulation to use AIS. Each year, more than 300,000 unique AIS devices broadcast the location of a vessel along with other information, including identity, course and speed. Ground stations and satellites pick up this information, meaning a ship's movements can be followed even in the most remote parts of the ocean.

AIS Based Data Methods

GFW uses publicly broadcasted AIS data to estimate vessel information and vessel activity, including encounters and loitering events. Vessel encounters are defined when two vessels are within 500 meters of each other for at least 2 hours and traveling at < 2 knots, while at least 10 km from a coastal anchorage (Miller et al. 2018). Whereas, vessel loitering is when a carrier vessel travelled at speeds of < 2 knots for at least 4 h, while at least 20 nautical miles from shore (Miller et al. 2018). Loitering events may indicate a possible encounter for which data is lacking for the second vessel, possibly due to lack of AIS transmission, poor satellite coverage, or the size of the second vessel (Interpol 2014, Miller et al. 2018). Due to the unknown nature of encounter and loitering events close to shore we limited the analysis to events on the high seas.

The carrier and fishing vessels analysed in this report were chosen based on the GFW database of fishing and carrier vessels. The fishing database is defined in Kroodsma et al. (2018), and includes fishing vessels based on registry database information or as defined by a convolutional neural network (see Kroodsma et al. 2018). Fishing vessels capable of fishing tuna were defined by the GFW vessel classification using known registry information in combination with a convolutional neural network used to estimate vessel class (network described in Kroodsma et al. 2018). Any squid-jiggers and trawlers were removed from analysis. If a fishing class was not identified through the GFW algorithm, a review of vessel tracks and web search using all available vessel identifiers,

including vessel name, Maritime Mobile Service Identity (MMSI), flag State, callsign, and IMO unique identifier were used to assess vessel class. The remaining fishing vessels were all identified as longliners. The carrier database is defined in Miller et al. (2018) and was curated using International Telecommunications Union and major Regional Fisheries Management Organisations (RFMO), vessel movement patterns based on AIS, a convolutional neural network used to estimate vessel class (see Kroodsma et al. 2018) and the International Maritime Organisation (IMO) unique identifier.

In addition, the study examined port visits by carriers after encounters or loitering events. GFW defines ports as any 0.5-kilometer grid cell with 20 or more unique vessels stationary for greater than 12 hours. A port visit includes the port entry and exit of a vessel if the vessel stops. A vessel "enters" port when it is within 3 kilometres of a GFW-defined port. A vessel has 'stopped' when it has entered port and slowed to a speed of 0.2 knots and has started movement again when it moves over 0.5 knots. A vessel "exits" port when it is at least 4 kilometres away from the previously entered port.