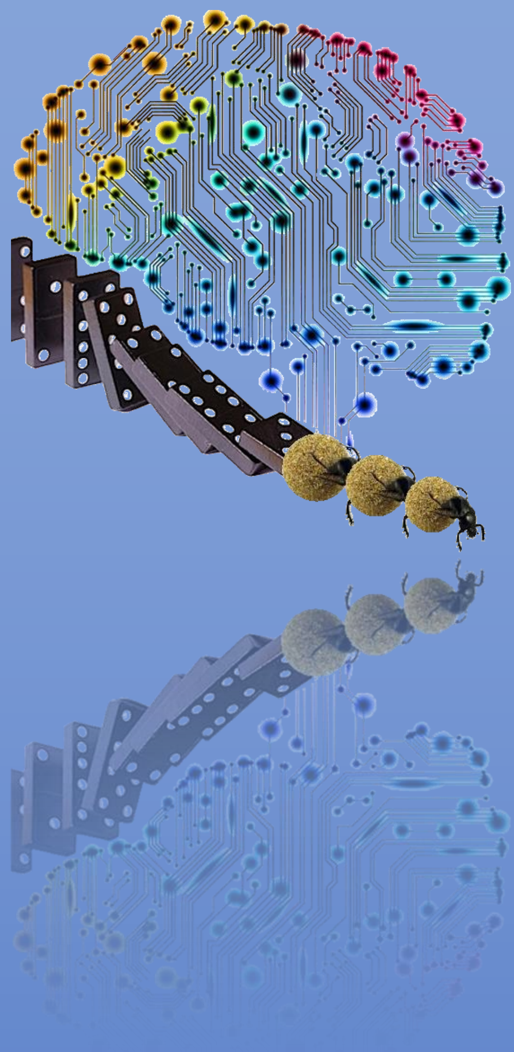

Domino effects of cumulative bias and erroneous data in fisheries big-data mapping models

A case study: The Global Fishing Watch 2012-2016 view of transhipments

A fact-checking, analysis & preliminary findings report by:

FISH SPEKTRUM

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Abstract:

Cumulative-biases in fisheries big-data mapping models have a domino effect that inevitably culminates in independent innovative and worthy technological projects failing to deliver the scientific rigour that is expected of them.

Worse still, they open up such projects to the charge that the over or under-reporting in their findings and the lack of rigour in their statistical analysis is down to politically biased vigilantism, skewed more towards media environmental activism rather than a true reflection of the situation at sea.

Moving from public-facing awareness-raising tools to credible independent Monitoring Control & Surveillance (MCS) systems that help bring rogue fishing industry to order, such is the challenge facing the independent fisheries MCS intelligence community.

Madrid –Spain, May 16th 2017

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List of abbreviations

AIS	Automatic Identification System
ANN	Artificial Neural Network
AOR-E	Atlantic Ocean Region East
AOR-W	Atlantic Ocean Region West
BIOT	British Indian Ocean Territory
BOF	China's Bureau of Fisheries
CAS	Community Alert System
CCAMLR	Convention for the Conservation of Antarctic Marine Living Resources
CCG	China Coast Guard
CCSBT	Commission for the Conservation of Southern Bluefin Tuna
CLAV	Consolidated List of Authorized Vessels
CMS	China Marine Surveillance
COFI	FAO Committee on Fisheries
COG	Course over ground
CPCs	Contracting Parties, Cooperating non-Contracting Parties, Entities or Fishing Entities
CPUE	Catch per Unit Effort
CSIRO	Commonwealth Scientific and Industrial Research Organisation
EEZ	Exclusive Economic Zone
EFCA	European Fisheries Control Agency
EJF	Environmental Justice Foundation
EPIRB	Emergency Position Indicating Radio Beacon
EU CFR	Community Fishing Fleet Register
FAO	Food and Agriculture Organisation of the United Nations
FFA	Pacific Islands Forum Fisheries Agency
FLEC	China's Fisheries Law Enforcement Command
FOC	Flag of Convenience
GFW	Global Fishing Watch
GMDSS	Global Maritime Distress and Safety System
GRT	Gross Registered Tons
GT	Gross tonnage
HF	High Frequency (radio)
Hp	Horsepower
HSVAR	High Seas Fishing Vessel Authorisation Record
IATTC	Inter-American Tropical Tuna Commission
ICCAT	International Commission for the Conservation of Atlantic Tuna
IRCS	International Radio Call Sign
IMO	International Maritime Organisation
IOR	Indian Ocean Region
IOTC	Indian Ocean Tuna Commission
IPOA	International Plan of Action
ISM	International Safety Management
ITQ	Individual Transferable Quota
ITU	International Telecommunications Union
IUU	Illegal, Unreported and Unregulated (fishing activity)
JRC	Joint Research Centre
kW	Kilowatts
LOA	Length Overall (of the ship)
LSA	Life-saving Appliance
LSTLV	Large Scale Tuna Longline Vessel
MBDF	China's Maritime Border Defence Force

MCS	Monitoring, Control and Surveillance
MEFS	China's Marine Environmental Forecast Service
MF	Medium Frequency (radio)
MMSI	Maritime Mobile Service Identity
MoU	Memorandum of Understanding
MSA	China's Maritime Safety Administration
NGO	Non Governmental Organization
NPFC	North Pacific Fisheries Commission
OECD	Organisation for Economic Cooperation and Development
PD	Probability of Detection
PFD	Personal Flotation Device
PLAN	China People's Liberation Army Navy
POR	Pacific Ocean Region
Ps	Pferdestärke
PSMA	Agreement on Port State Measures to Prevent, Deter and Eliminate IUU Fishing
PST	Personal Survival Techniques
RFMO	Regional Fisheries Management Organisation
ROP	Regional Observer Programme
SART	Search and Rescue Transponder
SCRS	Standing Committee on Research and Statistics
SICA	Sistema de la Integración Centroamericana
SIF	Stop Illegal Fishing
SOA	China's State Oceanographic Administration
SOG	Speed over ground
SOLAS	International Convention for the Safety of Life at Sea, 1974
SOW	Speed over water
SPRFMO	South Pacific Regional Fisheries Management Organisation
UNCLOS	United Nations Convention on Law of the Sea, 1982
UNODC	United Nations Office for Drugs and Crime
UVI	Unique vessel identifier
VHF	Very High Frequency (radio)
VMS	Vessel Monitoring System
WCPFC	Western and Central Pacific Fisheries Commission
Wp	Waypoint
WUVI	Worldwide Unique Vessel Identifier
WWF	World Wide Fund for Nature

Introduction

One of the major problems to achieve an optimal management of global fishing activity has been the lack of a **Worldwide Unique Vessel Identifier (WUVI) database** that allows for proper fisheries compliance scrutiny as well as scientifically accurate spatio-temporal mappings of fishing presence, effort and footprint.

So far, public, private, national, multilateral and NGOs initiatives –most of them under the US sponsored *Safe Ocean Network* umbrella[i]– such as the *Oceana-DiCaprio Foundation-Google-SkyTruth* sponsored "*Global Fishing Watch*"[1], have solely relied on data contained in self-created combined vessel lists from:

- Likely fishing vessels (those identifying themselves as fishing in a number of **passive** AIS mapping WebPages such as *MarineTraffic, Vesseltracker, VesselFinder, MariTrace, Shipxy.com, MyShipTracking* or *FleetMoon*)
- Known fishing vessels from a combined set of registry sources such as CLAV (combined tuna RFMOs), CCAMLR, ITU, FFA and the EU CFR registry

Such projects have tried, to match fishing vessel registration identifiers (Name, IRCS, IMO, and National Registration Number-NRN) to their alleged AIS MMSI numbers.

In our opinion, and as will be proven in this preliminary report, such an endeavour has yielded a large number of erroneous ship identification references.

In the case of the *Global Fishing Watch* (GFW) platform, a repository for versioning three different categories of generated fishing vessel lists is available for download[2].

We downloaded the full *vessel lists master repository* on November 14th 2016 and January 5th 2017.

This *vessel lists master repository* contains three categories of vessel lists, described by the GFW as:

- *"Likely fishing lists-lists generated from a query of vessels identifying themselves as fishing in the shiptype_text field in the vessel identity messages in the type 5 and type 24 AIS messages. Details of the query can be found in Benthos #397. In the next round we will filter out some additional "unknown" vessel types and probably drop the threshold to include some vessels that almost always identify themselves as fishing. Likelyfishing_2014.csv - Vessels which always identified themselves as fishing throughout 2014.*
- *Known fishing lists - list based on public fishing registry records[3]:*

RFMOs

SPRFMO	*CCSBT*
CCAMLR	*CLAV*
WCPFC	*FFA*

[1] http://globalfishingwatch.org/

[2] at: https://github.com/GlobalFishingWatch/vessel-lists

[3] Most known fishing vessels are also on the likely fishing list. The likely fishing vessel lists used were based on a less restrictive filter for total number of positions so new combined lists should be updated here with the new threshold for likely fishing vessels.

The lists here should be replaced as we apply the new standard for selecting likely fishing vessels, improved matching methods that were not applied to lists other than 2015, and pull data from a larger set of available public registries.

IATTC	*SICA*
ICCAT	*CTMFA*
IOTC	*NPFC*

National Registries

Russia	*EU*
Peru	*USA (FCC database)*
Canada	*Norway*
Alaska (ADFG)	*Iceland*

UN Agencies

FAO	*ITU*

- *Combined fishing lists - Lists produced by combining likely and known fishing lists and then removing sets of known non-fishing vessels (fish-carriers, fishspotting helicopters, research vessels) along with short MMSI's (less than 5 digits) and MMSI's that will likely have a large number of spoofing vessels (111111111). See Benthos #397. Combinedfishing_2014.csv - from Likelyfishing_2014 and the FFA, CLAV, and CCAMLR registries as described in Benthos #397. Combinedfishing_2013.csv - from an identical query to that used for the Likelyfishing_2014 list but using a 2013 date range. The same registry sources were added in, see Benthos #370. It is difficult to get registry data from previous years, 2014 records were added to this list."*

Combined fishing lists[4] for 2012 to 2016 from the Global Fishing Watch[5] (GFW) were crosschecked against **FishSpektrum´s Krakken V.8.2. WUVI database** and the following results were obtained:

- The total number of GFW vessel references identified by an AIS MMSI number for the period 2012 to 2016, **not corresponding to an active fishing vessel** (Those are vessels radio-electronically posing as commercial fishing vessels while having a different naval/maritime activity) amounted to **23.731 (31,38%)**.

[4] Lists produced by combining likely and known fishing lists and then removing sets of known non-fishing vessels (fish carriers, fish-spotting helicopters, research vessels) along with short MMSI's (less than 5 digits) and MMSI's that will likely have a large number of spoofing vessels (111111111). See Benthos #397. Combinedfishing_2014.csv - from Likelyfishing_2014 and the FFA, CLAV, and CCAMLR registries as described in Benthos #397. Combinedfishing_2013.csv - from an identical query to that used for the Likelyfishing_2014 list but using a 2013 date range. The same registry sources were added in, see Benthos #370. It is difficult to get registry data from previous years, 2014 records were added to this list.

[5] "Global Fishing Watch uses data about a vessel's identity, type, location, speed, direction and more that is broadcast using the Automatic Identification System (AIS) and collected via satellites and terrestrial receivers. AIS was developed for safety/collision-avoidance. Global Fishing Watch analyses AIS data collected from vessels that our research has identified as known or possible commercial fishing vessels, and applies a fishing detection algorithm to determine "apparent fishing activity" based on changes in vessel speed and direction. The algorithm classifies each AIS broadcast data point for these vessels as either apparently fishing or not fishing and shows the former on the Global Fishing Watch fishing activity heat map. AIS data as broadcast may vary in completeness, accuracy and quality. Also, data collection by satellite or terrestrial receivers may introduce errors through missing or inaccurate data. Global Fishing Watch's fishing detection algorithm is a best effort mathematically to identify "apparent fishing activity." As a result, it is possible that some fishing activity is not identified as such by Global Fishing Watch; conversely, Global Fishing Watch may show apparent fishing activity where fishing is not actually taking place. For these reasons, Global Fishing Watch qualifies designations of vessel fishing activity, including synonyms of the term "fishing activity," such as "fishing" or "fishing effort," as "apparent" rather than certain. Any/all Global Fishing Watch information about "apparent fishing activity" should be considered an estimate and must be relied upon solely at your own risk. Global Fishing Watch is taking steps to make sure fishing activity designations are as accurate as possible. Global Fishing Watch fishing detection algorithms are developed and tested using actual fishing event data collected by observers, combined with expert analysis of vessel movement data resulting in the manual classification of thousands of known fishing events. Global Fishing Watch also collaborates extensively with academic researchers through our research program to share fishing activity classification data and automated classification techniques".

9.435 of such subset of vessels, again according to GFW, experience substantial AIS MMSI ID spoofing[6] and therefore are to be *quarantined* until their Id is clearly defined.

- The total number of GFW vessel references identified by an AIS MMSI number, indeed **corresponding to an active fishing vessel** for the period 2012 to 2016, therefore amounted to **51.891 (68,62%)**.

The **Krakken V.8.2. WUVI database** used at **FishSpektrum** contains **1.697.327** historic references[7] for a total of **779.823** fishing vessels and fish-carrier vessels from **184** fishing nations. (Statistics for its 2017 **V.9.0.** version will be available on June 1st 2017 on our website). Over **300.000** of such vessels are or have been active on AIS during the period 2009-2016.

Krakken V.8.2. WUVI database also provides comprehensive characterizations of such vessels by way of **128** specific fields of information per vessel reference. Such data taxonomy is fully standardized by way of a nomenclative reference system.

It includes updated and detailed information on sanitary conditions for those vessels authorized by different national/multilateral food safety authorities/agencies to export their catches to foreign specific markets.

Furthermore, the GFW has produced a separate list of "*reefer*" vessels claiming that they have "*identified and tracked an estimated **90** percent of the world's refrigerated cargo ships (reefers)*".

Based on such reefer list, the *Global Fishing Watch*[8] (GFW) has recently published (February 2017) a report titled: **THE GLOBAL VIEW OF TRANSHIPMENT (Preliminary findings)**

The report is co-signed by David Kroodsma[9], Research Program Director; Nathan Miller[10], Data Scientist and Aaron Roan[11], Data Scientist.

The report was presented at the Economist World Ocean Summit 2007[12] in Indonesia by Brian Sullivan, Google's lead for Global Fishing Watch[13]

The report sponsored by the Walton Family Foundation, also enjoyed Google's in-kind computing platforms and guidance. The five-year global AIS dataset was provided by ORBCOMM.

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[6] By ID spoofing, GFW means two or more vessels that are using the same MMSI at the same time. All the messages for an MMSI are grouped into sets of tracks that are contiguous spatially and temporally. Each continuous track has a unique seg_id field added. Some tracks contain invalid lat/lon (like 91, 181) and are put into a special 'BAD' segment. GFW's test for spoofing is fairly naive - they simple compute the extent of each segment in time, add them all up, and compare that to the extent of time that the vessel is active. If the segment time is longer than the active time, then GFW infers that some of the segments must overlap, and this is the indication of ID spoofing.

[7] **214.504** EU flagged fishing vessels for **989.958** historic references for such vessels. **532.146** non EU flagged fishing vessels for **671.152** historic references for such vessels.

[8] http://globalfishingwatch.org/

[9] http://www.huffingtonpost.com/author/david-kroodsma

[10] https://www.linkedin.com/in/nathan-miller-07b636102

[11] https://www.linkedin.com/in/aaronroan

[12] http://www.economist.com/events-conferences/asia/ocean-summit-2017

[13] https://www.youtube.com/watch?v=LVXbP9H38DY

The authors of the GFW report affirm that "*Transhipment at sea, the offloading of catch from a fishing vessel to a refrigerated cargo vessel far from port, obscures the actual source of the catch and is a significant pathway for illegally caught fish to enter the legitimate seafood market.*

Occurring out of sight and over the horizon, the practice enables other nefarious activity, ranging from smuggling to human trafficking. Increasing the transparency of transhipment could improve fisheries management and reduce human rights abuses".

They furthermore state that: "*To address this gap in transparency, SkyTruth and Global Fishing Watch analysed over* ***21*** *billion positional Automatic Information System (AIS) messages from ocean-going vessels between 2012 and 2016, and we identified and tracked an estimated 90 percent of the world's refrigerated cargo ships (reefers)*".

A repository containing three csv files are also published along with such report:

- **Potential_Transshipments_20170222.csv**
- **Likely_Transshipments_20170222.csv**
- **Refrigerated_Cargo_Vessel_List_2017022.csv**

We downloaded the pdf report as well as all three annexed csv files.

Such files are available as annexes to this report.

The following contains the preliminary findings of a fact-checking exercise carried out by FishSpektrum's fisheries data analysts.

Preliminary technical specifications on fish-transhipments-at-sea

Identifying illegal unregulated and unreported fish-transhipments[14] at sea continues to be one of the fundamental hurdles in combating illegal, unregulated and unreported (IUU) fishing.

Picture 1: Tuna transhipment from a Philippines flagged longliner to a sashimi grade tuna reefer vessel. ©Jiri Rezac / Greenpeace

According to the authors of the GFW report on transhipments "*a transhipment is an event that occurs when two vessels meet to exchange cargo (e.g., supplies, fish, personnel). In principle, transhipments benefit fishing fleets because vessels are able to offload catch at sea and continue fishing. This can consolidate fuel costs within a fleet and move product to market more quickly. Transhipments often involve the use of refrigerated cargo vessels, also known as reefers, which collect the harvest of multiple fishing vessels and deliver it into port. Reefers may also carry supplies and personnel from a distant home port to fishing vessels at sea*".

It is our view that such a succinct descriptive definition fails to address the various complexities inherent to such type of activity.

Furthermore and as will be seen below, it may be inferred that some of the mistakes detected in the GFW report on transhipments are partially due to the latter.

This is why we choose to narrow-on some preliminary technical specifications on fish transhipment.

Fishing vessels will unload their catch either in-port, or at-sea to a transhipment vessel.

Transhipments in port are arranged on an ad-hoc basis and will typically occur once the freezing-hold/s or the brine-well/s of the fishing vessel are full.

At-sea transhipments are typically arranged between the two parties some time ahead of the actual event and may occur before the fishing vessel has completely filled its freezing-hold/s or brine well/s.

[14] Fish-transhipment-at-sea (fresh or frozen) consists of the offloading of the catch from one or several fishing vessels to a refrigerated cargo vessel, in high-seas.

Quantities transferred will therefore depend upon the fullness of the fishing vessel's freezing hold/s or brine well/s.[15] [16]

A variety of frozen fishery products are transhipped at sea. According to the UK P&I Club, the main types, in approximately descending order of frequency are as follows:

> ***Whole, gilled and/or gutted, or dressed fish individually frozen:*** *Tuna intended for canning is a typical example.*
>
> ***Whole, gutted, or dressed fish in blocks:*** *This is a common form of presentation for small and medium-sized fish intended for further processing. Blocks are rarely more than 10cm thick or more than 50kg in weight. Common sizes are 25 and 50kg. Blocks are either unwrapped or wrapped in plastic film and are sometimes packed in strapped cartons.*
>
> ***Fillets of fish frozen in blocks:*** *Fillets of fish are often frozen into geometrically shaped blocks. Blocks are usually wrapped in plastic film and packed into inner display packs. The display packs are then commonly packed in outer cartons.*
>
> ***Fillets of fish, individually frozen:*** *These are fillets frozen as separate pieces, and perhaps then coated with batter, or batter and breadcrumbs. Fillets are either placed in packages for retail sale or loosely packed in plastic bags. Small display packs are packed in outer cartons while loosely packed fillets may be packed in bags within outer cartons.*
>
> ***Cephalopods, frozen in blocks or as packaged products:*** *These include squid, cuttlefish and octopus. Both processed and unprocessed products are typically frozen in blocks weighing 10 or 25kg. Blocks are occasionally individually packaged, but more usually are overwrapped in plastic with several blocks being packed together in a single outer carton.*
>
> ***Crustacean shellfish, frozen in blocks or as packaged products:*** *These include lobster, crayfish, shrimp and crab. Smaller crustaceans and crustacean meats are often frozen in blocks weighing up to 1kg. Blocks are packed individually in cartons or over-wrapped in plastic film and then packed into outer cartons.*
>
> ***Crustacean shellfish, individually frozen:*** *Large crustacea, for example lobsters and crayfish are individually frozen, whole or as tails, wrapped and packed in cartons.*

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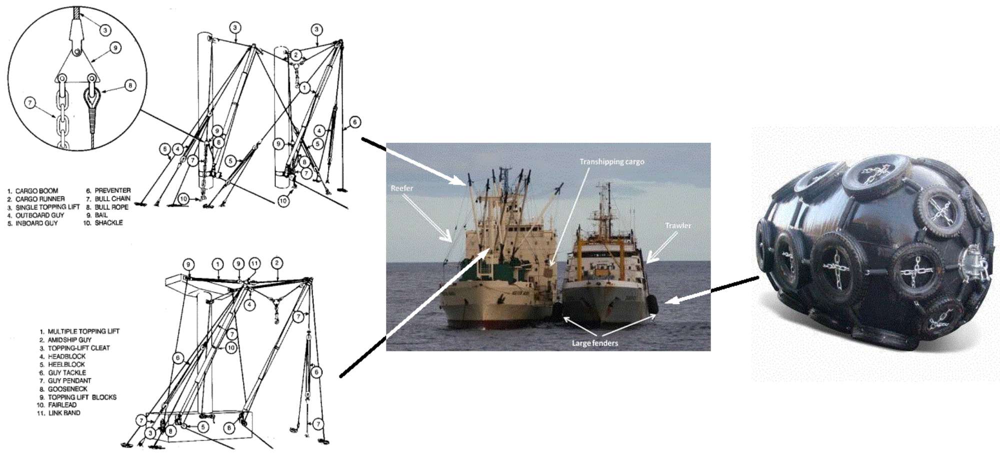
[15] In a pilot study, where tuna RFMO observers validated catches on board three transhipment vessels, quantities varied from 42-53 tonnes per transhipment. Assuming that each fish weighed around 40kg, then approximately 1.000 fish were transferred during these transhipments.

[16] Examples of freezing methods onboard fishing vessels: **Brine freezing of individual fish**: Brine freezing is used for larger, whole fish like salmon and tuna. The technique is used almost exclusively onboard fishing vessels, particularly tuna-catchers. The fishing vessel is fitted with one or more insulated tanks containing refrigeration coils. Before fishing starts, these tanks are filled with sea water, which is then cooled to around 0ºC. As fish are caught, they are dropped into the tanks. When a tank is full, salt is added to lower the freezing point of the brine and the temperature is lowered so that the fish freeze. The temperature that can be achieved depends on the concentration of the brine – the minimum, when the brine is saturated, is about -21ºC. In practice, fishing vessels aim for a solution giving a temperature of around -12ºC. Once the fish are frozen, the brine is drained from the tank and the fish are held in dry condition with the refrigeration system on.

Freezing of blocks: Small products, including small fish, fish fillets, squid, octopus and shrimps, are often frozen in blocks. The product is laid in trays and frozen, either in a tunnel through which cold air is passed or between pairs of hollow plates through which refrigerant is circulated. The frozen block is knocked out of the tray, protected by some form of over-wrapping and perhaps packed into cartons.



Picture 2: Typical onboard deck cargo handling booms and fenders typically used by reefer vessels transhipping fish at sea

Fish transhipping at sea means that:

- Both ships –the carrier and the fishing vessel- must be (sea-weather permitting) at an almost standstill and moored side-to-side during transhipment operations.
- The reefer (Refrigerated fish-carrier) must have specific on-board means of preservation for frozen fish.[17]

  With the exception of sashimi-grade tuna reefer vessels, refrigerated holds are designed as cold stores to maintain the temperature of already frozen products; they do not have the refrigeration capacity to freeze products at the required rate.

  Sashimi-grade tuna reefers may be equipped with blast-freezing tunnels. In such case, transhipped fresh tunas are generally gilled & gutted, dressed, loined or further processed into *saku*-blocks onboard such reefer vessels.
- The reefer vessel must be equipped with proper on-board deck cargo handling booms and protective fenders such as the *Yokohama-type* fender shown in Picture 2. In our opinion, such type of deck cargo handling gear is essential in order for the receiving reefer vessels to effectively and safely tranship into their refrigerated or freezer-holds, the catch from fishing vessels or other fish-carriers for that matter, as illustrated in Pictures 1, 2 & 3.

Physical damage affecting the processability or merchantability of fish product can occur during the freezing process, storage and distribution practices before transfer onboard the reefer vessel, as well as by the manner of handling, loading, stowage and carriage onboard either of both vessels, before, during and after the product is finally stored onboard the reefer vessel.

In the event of the two vessels being secured alongside each other, transhipment operations for a given consignment of fish may take place using a sling, a cargo net or a pallet self-balancing fork. Fish is first winched out from the freezer-hold or brine-well to the deck of the fishing vessel. Fish may then be winched across to the transhipment vessel attached to a sling, in a cargo net or if boxed in palletized cartons, onto a pallet self-balancing fork.

[17] When a fish product is cooled in a freezer its temperature drops rapidly to about -1ºC, when ice begins to form. However, not all the water in the fish turns to ice at this point. As more heat is extracted, more ice forms, but the temperature of the product drops only slowly until about -3ºC.

This period, when the product temperature changes very gradually, is known as the 'thermal arrest period'.

It is important for the quality of the frozen product that the thermal arrest period is as short as possible, preferably less than two hours. This rate of cooling can only be achieved in equipment designed for the purpose – merely placing fish in a cold store will not achieve a sufficiently high freezing rate.

Guide ropes from the sling, the cargo net or the pallet self-balancing fork must be manned from both vessels to prevent unnecessary swinging and to guide the fish-cargo down onto the reefer's deck and from there into its refrigerated or freezer-holds for final stowage. Frozen products at low temperatures are often brittle and prone to damage by rough handling. Tails are easily broken off whole fish and blocks can be shattered or chipped.

Individually frozen fish can be severely indented where they lie across each other, and tend to take up the shapes of the surfaces they are pressed against – ridged floor plates or edges of structures in the hold. In an extreme case, a stack of fish can be compressed together into a solid mass, with almost no spaces between the fish. Blocks of products are squeezed, flattened and distorted and will extrude into gaps between cartons, they can also be indented by floor plates or pallet boards.[18]

This is why good sea-weather conditions become a key factor taken into consideration by both parties when arranging some time ahead a given transhipment and why the transhipment event may occur before the fishing vessel has completely filled its freezing hold/s or brine well/s.

In the case of tuna transhipments and due to the high value of the product, great care is taken to avoid damage to the fish during transhipment procedures. Sea-weather conditions in this particular case are decisive for both parties before engaging in any given transhipment event. Furthermore, tuna transhipments often take place in potentially hot climates. When considering climatic conditions, temperature, humidity and the rate of air flow are also taken into consideration: The heat transfer rate from warm air to frozen tuna is determined by the equation $\mathbf{Q = h}\boldsymbol{A}\ \mathbf{(}\boldsymbol{Tf\text{-}Ts}\mathbf{)}$ [19] *As a result humid, fast moving air will have a much greater warming effect on the cargo than dry still air at the same temperature. Such conditions are common in the tropics at sea.*[20]

Picture 3: Tuna transhipment from a purseiner to a reefer vessel. ©Mike A. McCoy, Gillett, Preston & Associates Inc – Regulation of transhipment by the Western & Central Pacific Fisheries Commission: Issues & considerations for FFA member countries.

[18] Source: UK P&I Club.

[19] Where: Q is the rate of heat transfer; h is the heat transfer coefficient; *A is the surface area of material; Tƒ is the temperature of the air and Ts* is the temperature of the surface.

[20] Source: Refrigerated transport of frozen tuna ; by: Ian Goulding – Megapesca Ltda Portugal.

GFW database of the World's reefer vessels

As stated before, the authors of the GFW report assert that they have "*identified and tracked an estimated **90** percent of the world's refrigerated cargo ships (reefers)*".

They claim that their database of reefers was compiled from the following sources:

> *"Refrigerated cargo vessels, fish-carriers, and fish tender vessels were identified using vessel lists from the International Telecommunications Union and major Regional Fisheries Management Organizations (RFMO).*
>
> *If a vessel participated in multiple encounters with fishing vessels, we conducted a web search and reviewed RFMO registries using information from the vessel's AIS to determine if the vessel was a reefer.*
>
> *Additional reefers were found by investigating documentation on registry websites and other online resources and determining alternate identities that we were able to match in our database.*
>
> *A vessel classification neural network, developed by Global Fishing Watch to predict vessel types based on movement patterns, was used to identify possible reefers.*

They furthermore claim that "*vessels that were identified as likely reefers by this neural network were manually reviewed through web searches and RFMO registries. After developing the list, we verified vessel information using reputable online sources: the IHS shipping databases, MarineTraffic, ShipSpotting, VesselFinder, and FleetMon. Our database of reefers is now available through globalfishingwatch.org".*

Finally the authors of the GFW report conclude that they have "*identified a total of **794** reefers"* and that *"according to the US Central Intelligence Agency World Factbook, **882** refrigerated cargo vessels were active worldwide in 2010. Assuming that the number of reefers has not significantly increased or decreased since 2010, **our dataset includes about 90 percent of the world's reefer vessels.** Some industry analysis suggests the number of reefers is decreasing, meaning that this 90 percent figure is a conservative estimate".*

We thus downloaded the GFW report attached file: ***Refrigerated Cargo Vessel List 2017022.csv*** and crosschecked its ship data with that contained in our **Krakken V.8.2. UVI fishing and fish-carrier vessel database**, only to find out for the time-being, the following *basket of apples and oranges*:

1. The GFW ***Refrigerated Cargo Vessel List 2017022.csv*** contains **1.132** vessel historic references for **794** alleged reefer vessels active during the period 2012-2016.

2. Out of the **794** GFW alleged reefer vessels contained in file ***Refrigerated_Cargo_Vessel_List_2017022.csv***

    a. Fourteen (**14**) of such vessels references do not include the vessel's name, its flag, its IRCS and/or its IMO number. Such AIS MMSI numbers were checked only to find out *high-noise*[21], *peak* and/or *mirror-effect* recurrences. AIS MMSI discarded numbers (They do not pertain to active fish-carrier reefer vessels) are:

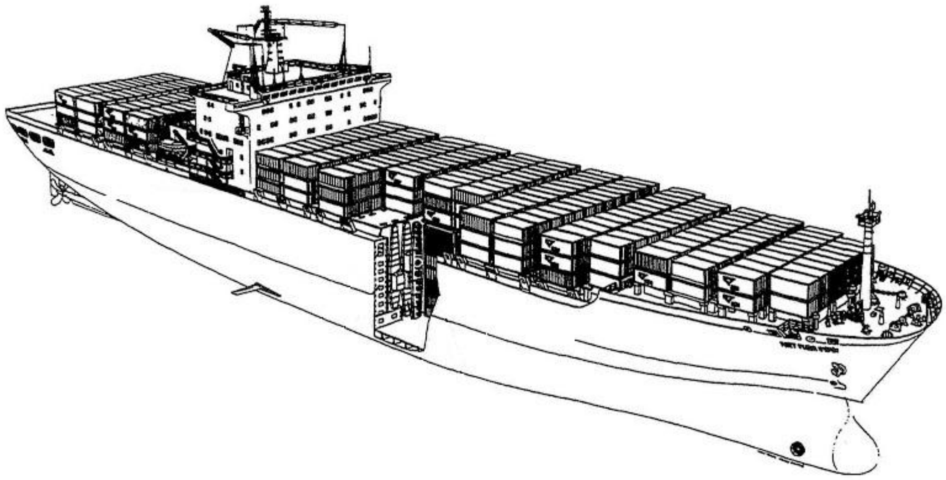
310746848	273332291	412699340
371118580	273332299	416064900
548401400	273332326	432661000
224500000	273851400	667003111
249889000	351219000	

b. Twenty eight (**28**) of such vessels have been laid-up, decommissioned or lost;

c. Six (**6**) of such vessels are general cargo or cargo/container reefer vessels, incapable of transhipping fish at sea and furthermore have been decommissioned or lost;

d. Sixteen (**16**) of such vessels are frozen-fish-carriers but incapable of transhipment at sea; (Such vessels are only equipped with cranes suited for at-port cargo loading and offloading)

e. One hundred and forty (**140**) of such vessels are cargo/container reefer vessels that may or may not carry containerized frozen fish but are incapable of transhipping fish at sea. Picture 4 is self-explanatory;



Picture 4: Typical layout of a cargo/container reefer vessel. ©Types of ships: Shipbuilding Picture Dictionary forshipbuilding.com

f. Twelve (**12**) of such vessels are fruit reefer vessel;

g. Eight (**8**) of such vessels are not reefer vessels but bulk carriers, tankers or dry cargo ships;

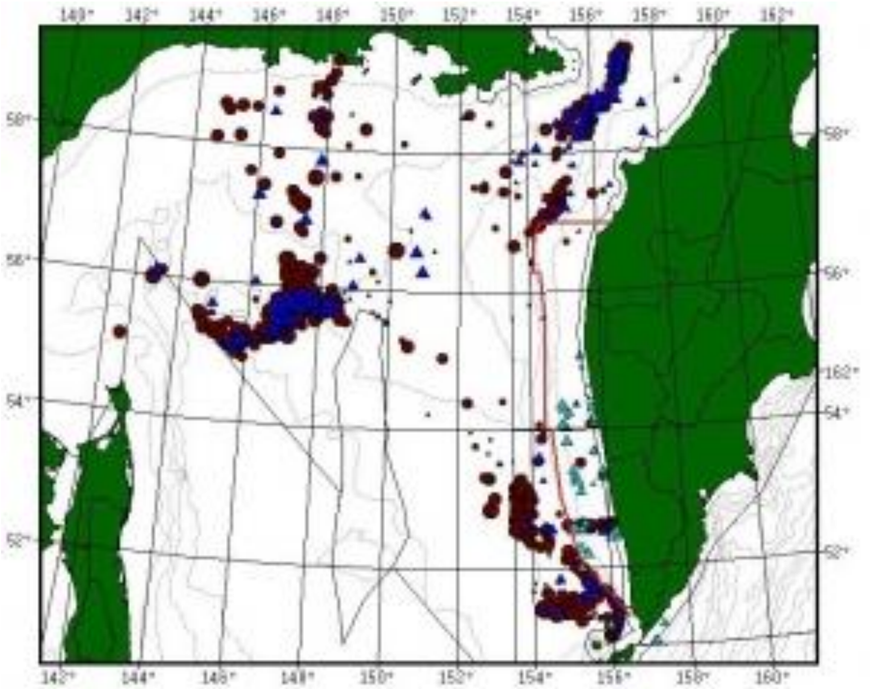
h. Forty one (**41**) of such vessels are not reefer vessels but general cargo vessels;

i. One (**1**) of such vessels is not a reefer vessel but a recreational luxury yacht;

[21] Spoofing in GFW terms

j. Eighteen (**18**) of such vessels are not reefer vessels but fish factories or processing vessels;

k. Twenty one (**21**) of such vessels are not reefer vessels but fisheries tender vessels, specifically used in salmon/groundfish fisheries in the North-western American waters and in the King-Crab, walleye pollock (An MSC certified fishery since 2013[22]), mesopelagic fishes, squid and groundfish fisheries (among others) inside Russia's Fareast Sea of Okhotsk[23];[24] (See Picture 5)



Picture 5: Results of the Sea of Okhotsk Pollock fishery in 2016: Source: KamchatNIRO[25]

l. Twenty two (**22**) of such vessels are not reefer vessels but active fishing vessels engaged in fisheries ranging from salmon to crab and tuna;

A total of **327** vessels (**41,18%**) therefore cannot be considered as active fish-carrier vessels capable of fish-transhipping at sea, the latter bringing GFW's ***Refrigerated_Cargo_Vessel_List_2017022*** down to **467** vessels that would likely qualify as potential targets for transhipment activity analysis.

The entire list of discarded vessels can be found at pdf file ANNEXE. (Pictures of such vessels confirming reasons for discard are provided) Such file can be downloaded at www.fishspektrum.com.

By way of comparison, the **Krakken V.8.2. WUVI database** contains **11.127** vessel historic references of fish-carrier vessels of all kinds, corresponding to:

[22] https://www.msc.org/newsroom/news/russia-sea-of-okhotsk-pollock-fishery-is-msc-certified

[23] https://www.bloomberg.com/news/articles/2014-06-19/illegal-king-crab-fishing-off-russia-valued-at-700-million-a-year

[24] http://rbth.com/science_and_tech/2015/11/30/the-secrets-of-rusias-sea-of-okhotsk-nearly-500-species-discovered_546029

[25] http://www.russianpollock.com/information/news/results-of-the-sea-of-okhotsk-pollock-fishery-in-2016-view-of-kamchatniro-specialists-/

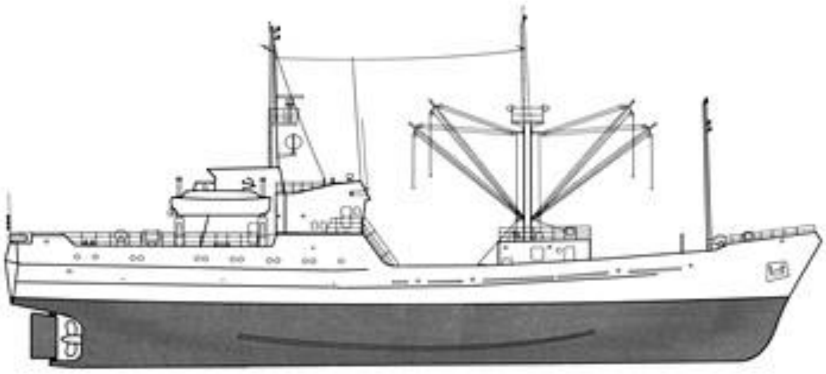
732 vessels defined as frozen, refrigerated or live fish-carriers, reefer vessels (capable or not of fish-transhipment-at-sea) or fish RSW well-vessels, that are currently no longer active because they have been laid-up, scrapped, lost, sunk or decommissioned;

2 vessels that were previously small scale fish-carriers and were transformed into purseiner fishing vessels;

4.367 currently active vessels, defined as frozen, refrigerated or live fish-carriers, reefer vessels (capable or not of fish-transhipment-at-sea) or fish RSW well-vessels (**2.523** historic references for **1.527** ships are identified by AIS MMSI number) and the subdivision of which follows:

i. **2.392** small scale fish-carriers capable of fish-transhipment-at-sea;

These include among others, original small scale built fish-carriers, namely the Russian active fleet; as well as former Japanese-type longliners equipped with on-board freezing holds. (See following pictures 6 and 7)



Picture 6: Typical layout of a "Raduzhnyy" type small-scale refrigerated fish-carrier project 1350. In total 100 units were built from 1974 to 1996 at Khabarovsk shipyard. Vessels of this type are built in a hull of "Vasiliy Yakovenko" type fishing freezer trawler. Source: http://soviet-trawler.narod.ru/pages/ussr/tr_raduzhnyy.html

Picture 7: Typical Japanese-type small scale fish-carrier. ©marinko-MarineTraffic.com.

ii. **35** refrigerated seawater (RSW) fish-carriers capable of fish-transhipment-at-sea;

Picture 8: Typical Norwegian-type small scale RSW fish-carrier. ©Dag Remoy-MarineTraffic.com.

iii. **1.783** large-scale reefer vessels capable of fish-transhipment-at-sea and known to be engaged in fish trade;

Picture 9: Typical reefer vessel capable of fish-transhipment-at-sea. ©marinko-MarineTraffic.com.

iv. **16** frozen-fish-carriers incapable of fish-transhipment-at-sea;

Picture 10: Typical frozen-fish-carrier incapable of fish-transhipment-at-sea. ©Kristian-Markus Pedersen-Marine Traffic.com.

v. **141** cargo container vessels known for transporting containerized frozen fish.

Picture 11: Typical cargo container vessel known for transporting containerized frozen fish. Source: Icelandic reefer shipping line Eimskip (http://theloadstar.co.uk/coolstar/eimskip-follows-fish-new-markets-nets-strong-third-quarter-results/)

False transhipments and omission of officially recorded transhipments

False transhipments

AIS MMSI numbers pertaining to all of GFW's **327** itemized vessels as non-capable of transhipping fish at sea were identified and subsequently extracted.

The number of such AIS MMSI numbers for such vessels amounted to **414** including those AIS MMSI numbers that were previously discarded in 2.a.

Some of such vessels were indeed reflagged during the period 2012-2016 which explains the change in their AIS MMSI identification.

We then crosschecked such **414** AIS MMSI numbers with data contained in files

- **Potential_Transshipments_20170222.csv**
- **Likely_Transshipments_20170222.csv**

The combined number of waypoints contained in both files amounted to **91.555** corresponding to:

> **86.490** of such waypoints corresponded to alleged *potential* transhipments.
>
> **5.065** waypoints corresponded to alleged *likely* transhipments.

16.798 (**19,42%**) waypoints for *potential* transhipments and **364** (**7,19%**) waypoints for *likely* transhipments, all corresponding to the **327** vessels we identified as incapable of transferring fish at sea, were therefore discarded as **<u>false transhipments</u>**, because clearly and undoubtedly corresponding to innocent passage events[26]

Finally and though with little impact on our overall analysis, it is worth pointing-out that file ***Refrigerated_Cargo_Vessel_List_2017022.csv***, contains numerous instances of outdated or erroneous International Radio Call Signs (IRCS) and/or MMSI data.

194 instances where vessels are using International Radio Call Signs (IRCS) which are not those issued by their flag state as indicated for the purposes of the fishing licence, were so far detected and duly identified.

Omission of officially recorded transhipments

As part of a consulting contract with the **Overseas Development Institute** (ODI), related to fish transhipments in Western Africa during 2013[27], FishSpektrum identified among others, nine (**9**) reefer vessels, operative during that year in the Central and South Atlantic Ocean, under ICCAT supervision and therefore with ROP ICCAT observers on board.

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[26] According to Article 19 (2) of UNCLOS

[27] The full report can be downloaded at: https://www.odi.org/publications/10459-western-africas-missing-fish-impacts-illegal-unreported-and-unregulated-fishing-and-under-reporting

Those on-board ROP observers' reports to ICCAT contain voluminous and precise longitude, latitude and time-stamp data for all at-sea transhipments of tuna and/or species under ICCAT's management jurisdiction, those reefer vessels were engaged-in during 2013.

We hence plotted all such waypoints (Wps) pertaining to **380** ICCAT recorded transhipments and over-layered them onto reefer vessel tracks obtained from their respective AIS (ter+sat) MMSI signals during that year.

The aim of such exercise was to ascertain de degree of reliability of AIS MMSI (ter+sat) signalling data for those vessels and therefore retro-validate both our AIS tracking methodology reliability, as well as that of the information contained in such ICCAT ROP reports.

For all nine reefer vessels, ICCAT ROP observer report/s transhipment Wps overlay with reefer AIS MMSI tracks, coincidence level was equal or exceeded **95%** as can be seen in following Figures 1 to 9.

In other words, waypoints pertaining to at-sea recorded transhipments by those nine (**9**) reefer vessels, coincided both spatially and temporally with AIS MMSI (ter+sat) tracks' timestamps for those same nine ships, thus validating both our methodology and ICCAT ROP observer reports' data.

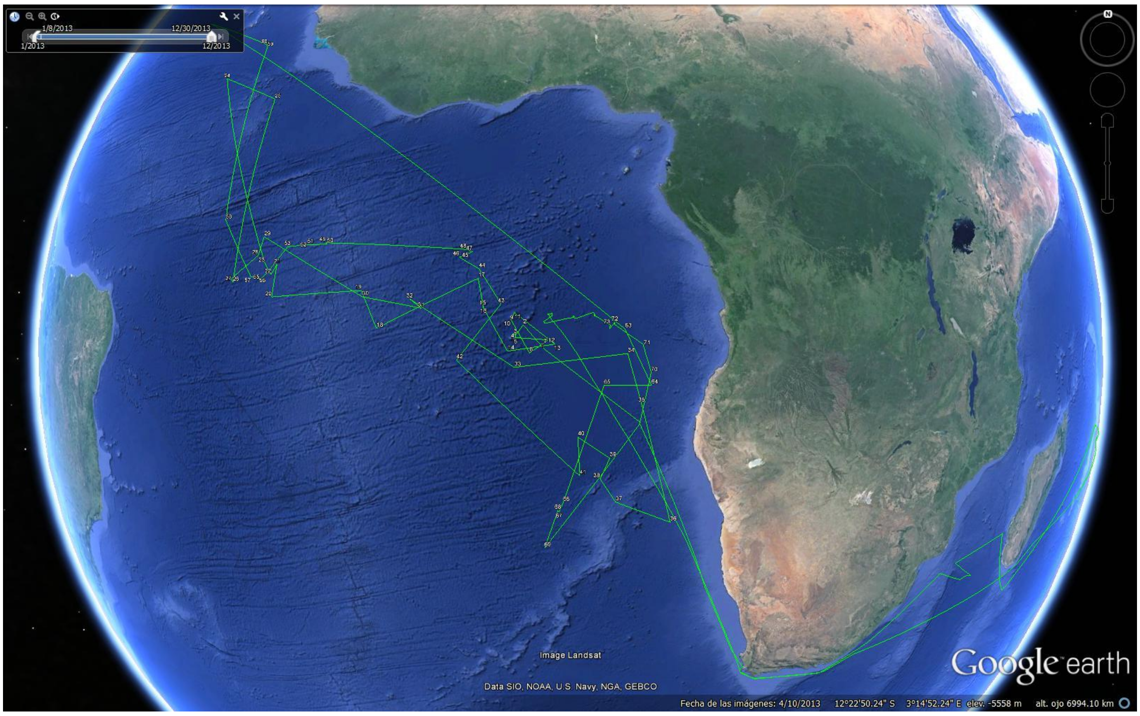

Figure 1: Overlay crosscheck & AIS data validation for vessel: TAISEI MARU NO.15 - AT000VUT00019 - IMO: 8710728 - ICCAT ROP Report/s Nº: (xxxxx) ICCAT ROP observer report/s Wps overlay with reefer AIS tracks coincidence level: ≤ 95%. Source: FishSpektrum

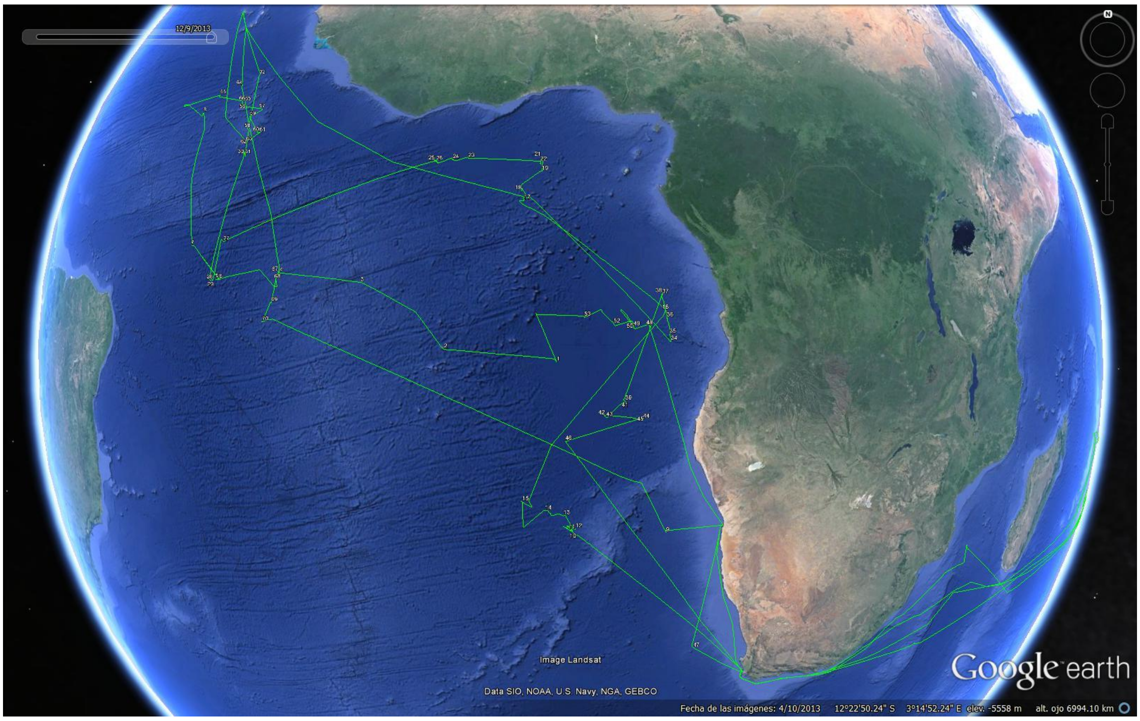

Figure 2: Overlay crosscheck & AIS data validation for vessel: TAISEI MARU NO.24 - AT000JPN00571 - IMO: 9086758 – ICCAT ROP Report/s Nº: (xxxxx) ICCAT ROP observer report/s Wps overlay with reefer AIS tracks coincidence level: ≤ 95%. Source: FishSpektrum

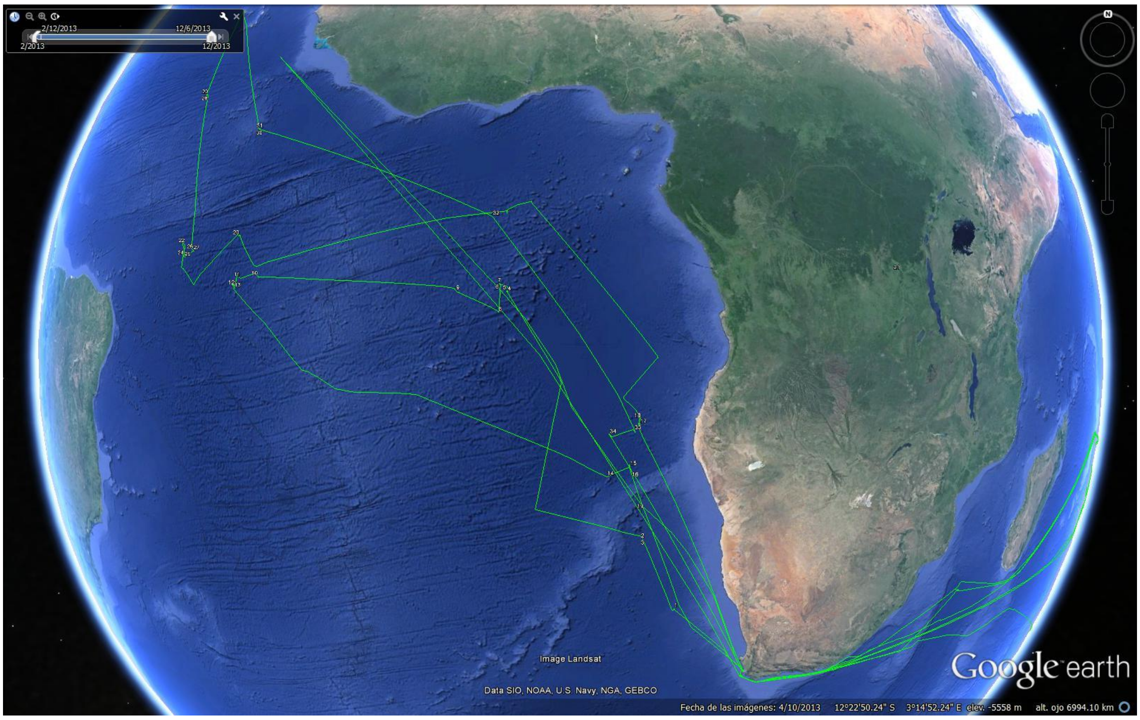

Figure 3: Overlay crosscheck & AIS data validation for vessel: FUTAGAMI - AT000JPN00572 - IMO: 9105293 – ICCAT ROP Report/s Nº: (xxxxx) ICCAT ROP observer report/s Wps overlay with reefer AIS tracks coincidence level: ≤ 95%. Source: FishSpektrum

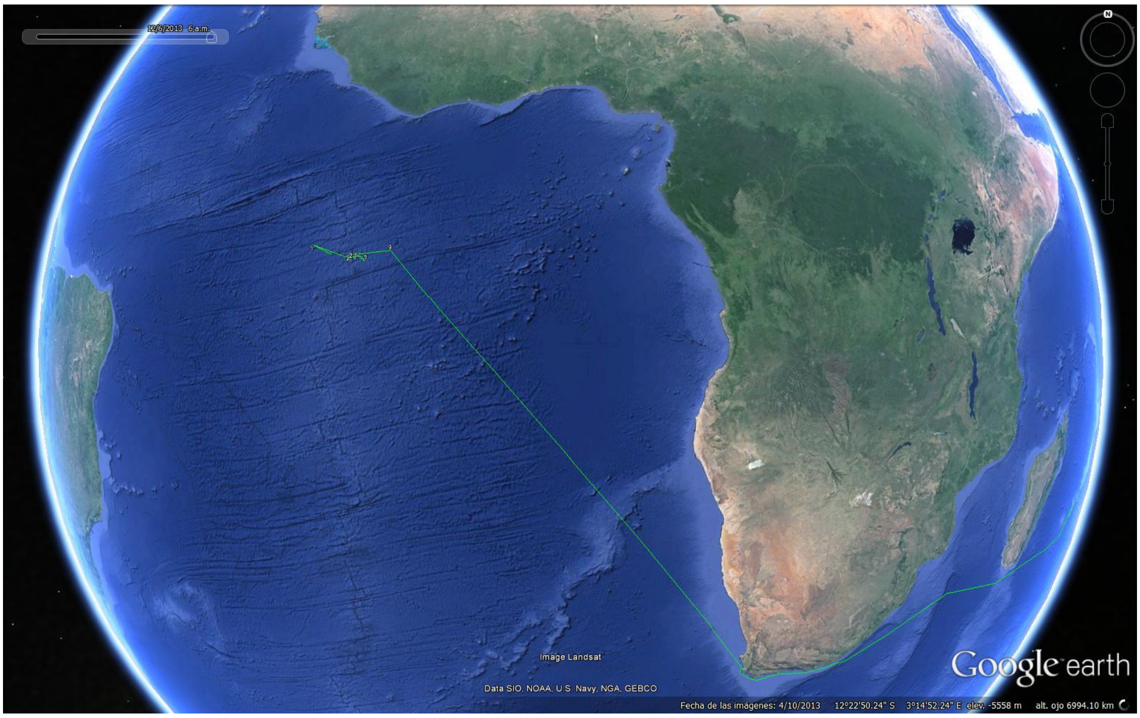

Figure 4: Overlay crosscheck & AIS data validation for vessel: HARIMA 2 - AT000JPN00587 - IMO: 9133317 – ICCAT ROP Report/s Nº: (xxxxx) ICCAT ROP observer report/s Wps overlay with reefer AIS tracks coincidence level: ≤ 95%. Source: FishSpektrum

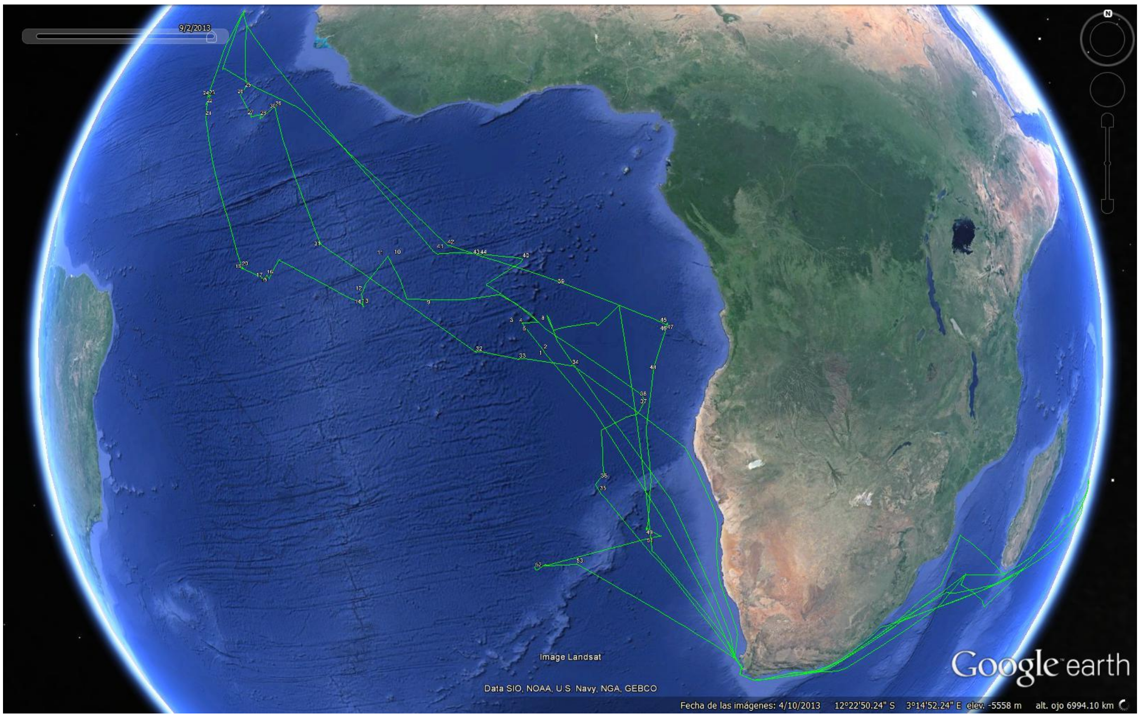

Figure 5: Overlay crosscheck & AIS data validation for vessel: SHIN FUJI - AT000JPN00576 - IMO: 9140281 – ICCAT ROP Report/s Nº: (xxxxx) ICCAT ROP observer report/s Wps overlay with reefer AIS tracks coincidence level: ≤ 95%. Source: FishSpektrum

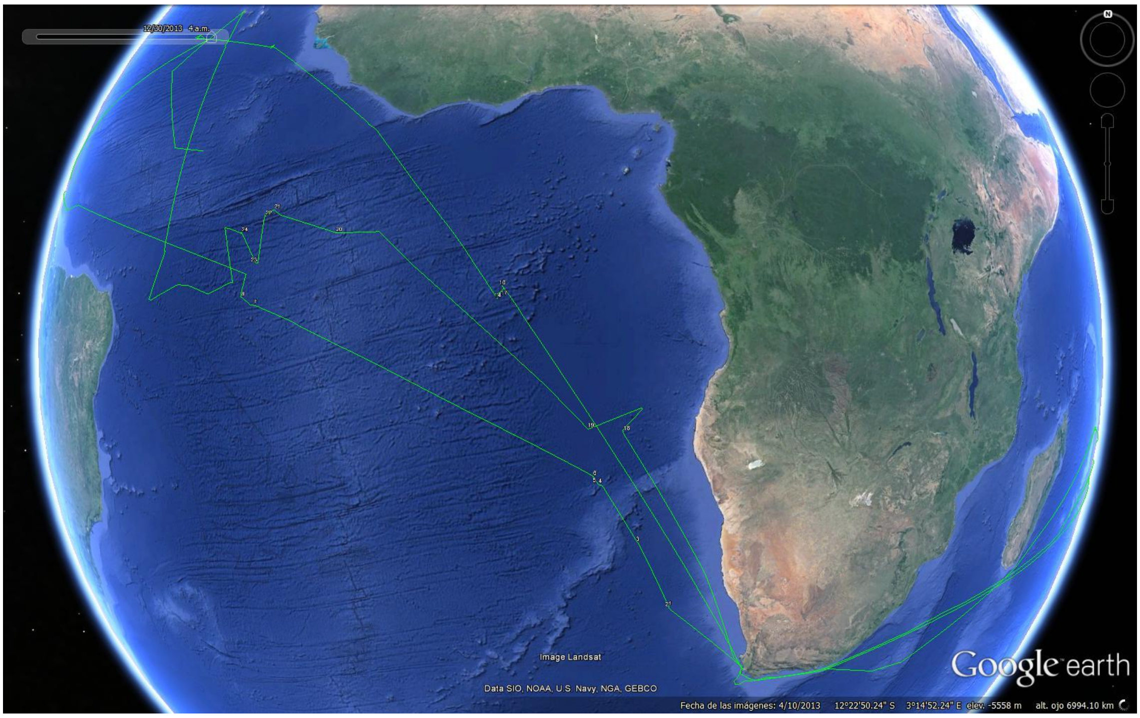

Figure 6: Overlay crosscheck & AIS data validation for vessel: HARU - AT000JPN00588 - IMO: 9241932 – ICCAT ROP Report/s Nº: (xxxxx) ICCAT ROP observer report/s Wps overlay with reefer AIS tracks coincidence level: ≤ 95%. Source: FishSpektrum

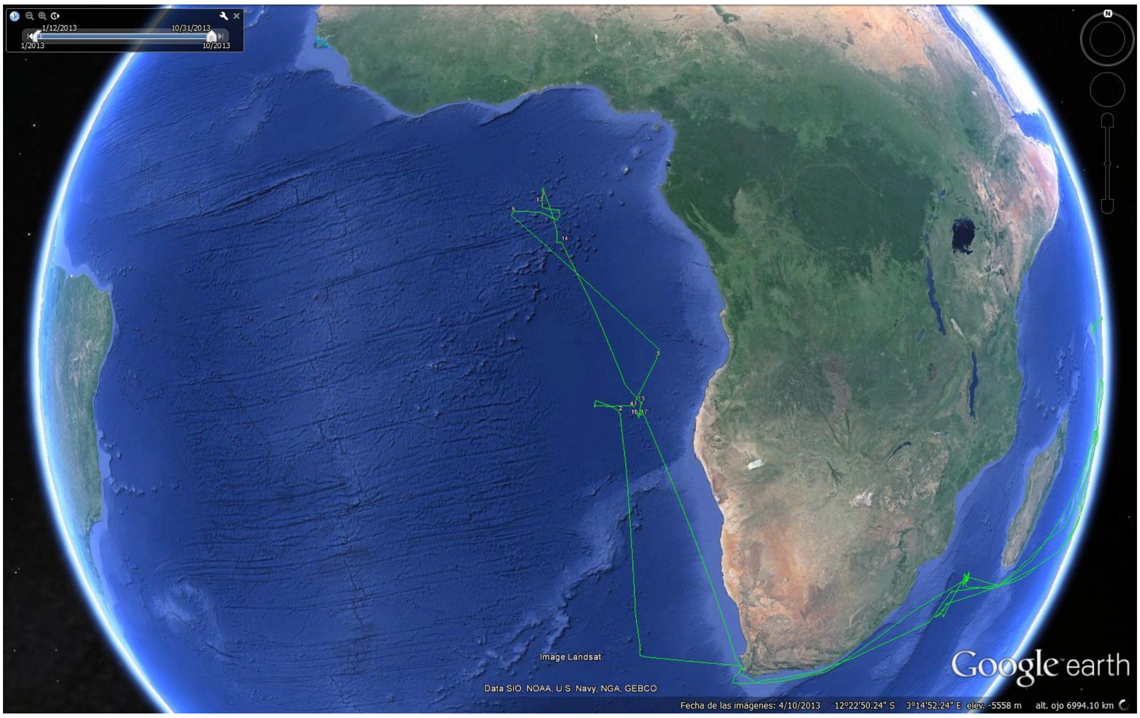

Figure 7: Overlay crosscheck & AIS data validation for vessel: GENTA MARU - AT000VUT00014 - IMO: 9620384 – ICCAT ROP Report/s Nº: (xxxxx) ICCAT ROP observer report/s Wps overlay with reefer AIS tracks coincidence level: ≤ 95%. Source: FishSpektrum

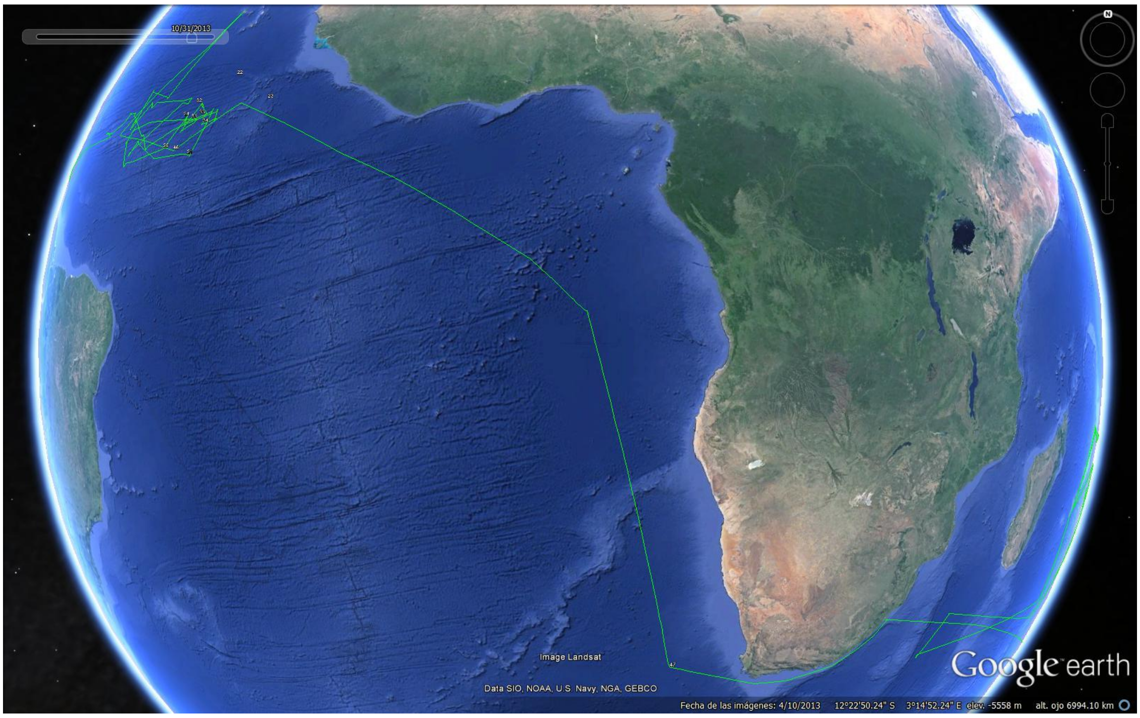

Figure 8: Overlay crosscheck & AIS data validation for vessel: IBUKI - AT000VUT00015 - IMO: 9666481 – ICCAT ROP Report/s Nº: (xxxxx) ICCAT ROP observer report/s Wps overlay with reefer AIS tracks coincidence level: ≤ 95%. Source: FishSpektrum

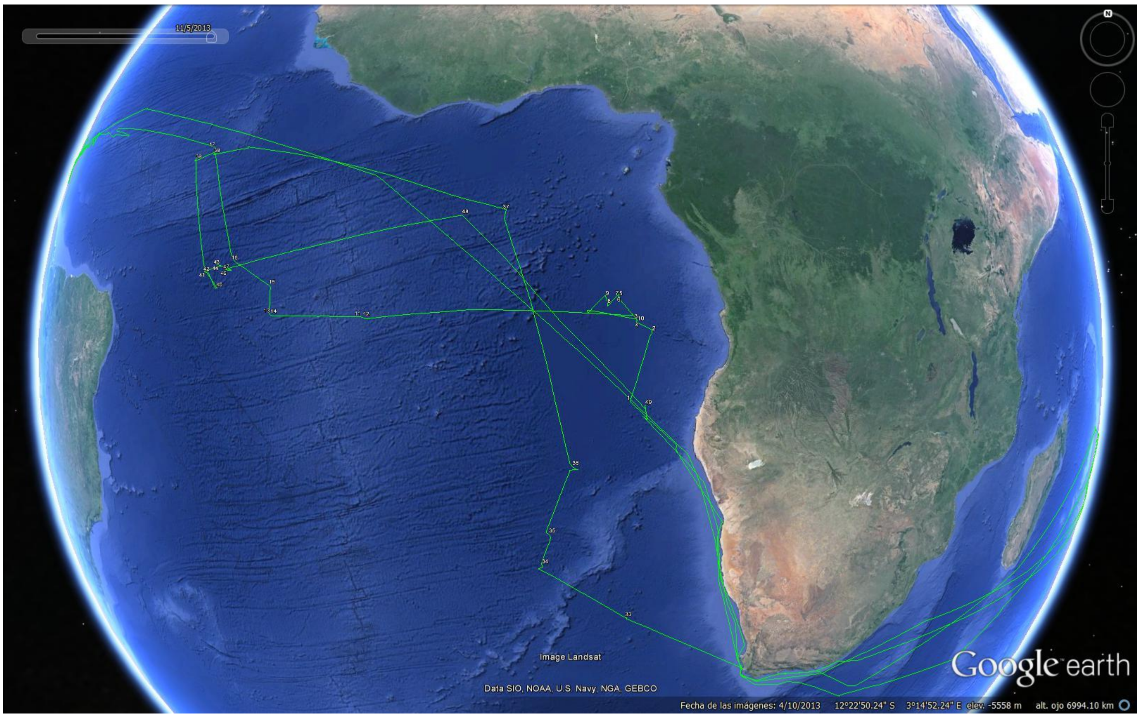

Figure 9: Overlay crosscheck & AIS data validation for vessel: CHIKUMA - AT000VUT00018 - IMO: 9666493 – ICCAT ROP Report/s Nº: (xxxxx) ICCAT ROP observer report/s Wps overlay with reefer AIS tracks coincidence level: ≤ 95%. Source: FishSpektrum

Most of such officially recorded transhipments are plotted as potential transhipments in GFW's core map of *Global footprint of transhipments for the period 2012-2016* (See Figure 16) Oddly enough very few of such instances are plotted as *likely* transhipments.

Most of such officially recorded transhipments, simply do not appear in subsequent maps such as the one publish by the NGO Oceana[28] (See Figure 18)

The same may be inferred for on-board ROP observers' reports for other RFMOs during the period 2012-2016[29].

This much will be confirmed at a later stage and for the purpose of a final report adjacent to this preliminary one.

Notwithstanding the authors of the GFW report state that they analyzed "*known observer-reported transhipments from the Indian Ocean Tuna Commission (IOTC; **5.874** transhipments between 2009 and 2015).*

Through their analysis, they "*identified reefers that exhibited similar patterns of moving less than 2 knots for longer than 8 hours. Distinctive C-shaped tracks and abrupt shifts in course following a period of slow speeds characterized most transhipment events.*

Following these metrics, (they) *analyzed **117** million reefer positions from 2012 - 2016 and identified **86.490** events where a refrigerated cargo vessel exhibited these behaviours, which* (they) *identify as "potential transhipments*."

The latter begs the question as to why did the authors of the GFW report not include a third transhipment identification type repository into their mapping model; that is "*know recorded transhipments*" based on "*ground-truth*" sources of information? (Those officially recorded by the IOTC between 2012 and 2015)

Furthermore, why such recorded transhipments by the IOTC between 2012 and 2015, didn't even make it into the **5.065** waypoint repository corresponding to GFW's alleged *likely* transhipments?

Should they have done so, the authors of the GFW report would have ascertained the degree of effectiveness and reliability of the algorithm developed to detect possible transhipment events and therefore retro-validate that of the information contained in such IOTC reports.

Notwithstanding it is worth noting that if "*ground-truth*" sources such as RFMOs observer reports on transhipments had been included, this would have potentially skewed the distribution of "*likely*" transhipment events based on availability of information (ie. in ocean areas where information on observed/recorded transhipments is not publically available or was not made available to GFW, the number of likely transhipment events would be relatively under-recorded).

Though we believe there is no reason not to include "*ground-truth*" sourced data on transhipments, doing so could well exacerbate a "*geo-political bias*" issue discussed herein-under.

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[28] Map taken of Oceana's latest report: "No More Hiding at Sea: Transhipping Exposed (February 22, 2017) Authors: Lacey Malarky and Beth Lowell.

[29] See A Survey of Tuna Transhipment in Pacific Island Countries: Opportunities for Increasing Benefits and Improving Monitoring, Mike A. McCoy, July, 2012.

Discussion

Overall, GFW's report on transhipments suffers, among others, from four fundamental cumulative-bias flaws which we have chosen to schematically itemize and briefly discuss herein:

- The "geo-political" bias
- The "AIS (sat) bottleneck problem" bias
- The biases due to misconceptions and misconstrued definitions
- The biases due to false, erroneous or inexistent data input, faulty pattern recognition, data classification and learning process

Further discussion on GFW's report on transhipments will be made available after its full analysis process is completed.

The "geo-political" bias

One of the most salient biases that lurks GFW's report on transhipments, pertains to the poor coverage of its alleged reefer vessel database, especially in terms of vessel flagging. The authors of the GFW report claim that they have "*identified and tracked an estimated **90** percent of the world's refrigerated cargo ships (reefers)*".

This much is simply false, as demonstrated before in this preliminary fact-checking report. (See pages 13 to 18)

Some fleets of fish-carrier vessels, for example the Ecuadorian fleet of small-scale fish-carriers, active in the Eastern Central Pacific Ocean, are simply disregarded in GFW's ***Refrigerated_Cargo_Vessel_List_2017022.csv***.

The same may be said with reference to fish-carriers operative in African, Indonesian and Philippine waters, as shown in next Figures 10 & 11 and Picture 12.

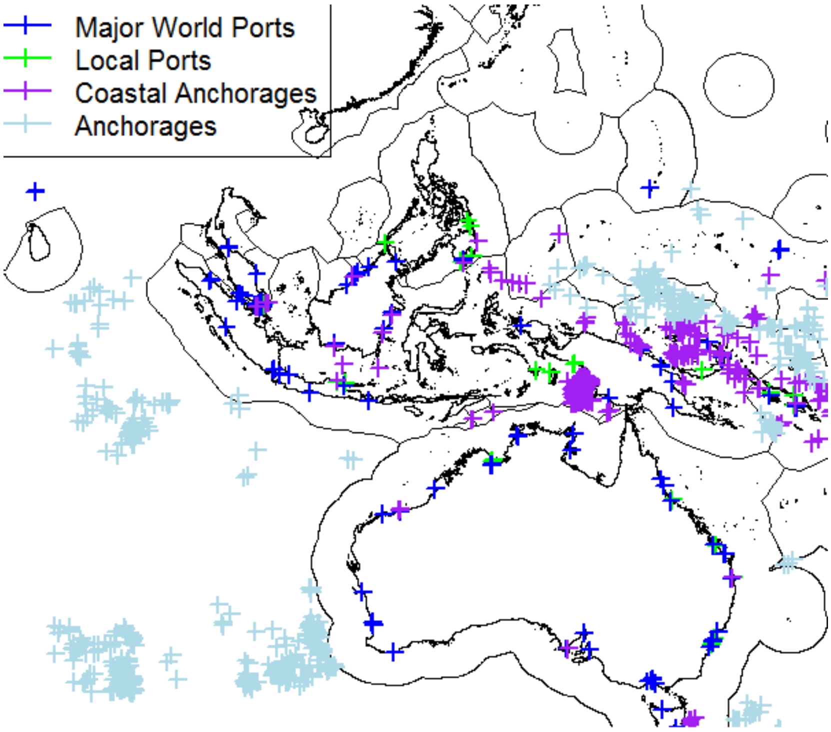

Figure 10: Identifying Transhipment using AIS. Map of Indonesian and surrounding waters major, local ports and anchorages. Source: CSIRO Monitoring, Control & Surveillance Analytics.[30]

[30] CSIRO Monitoring, Control & Surveillance Analytics is exploring the use of both spatial statistics and statistical clustering methods to identify vessels behaving anomalously, using data from the Indonesian

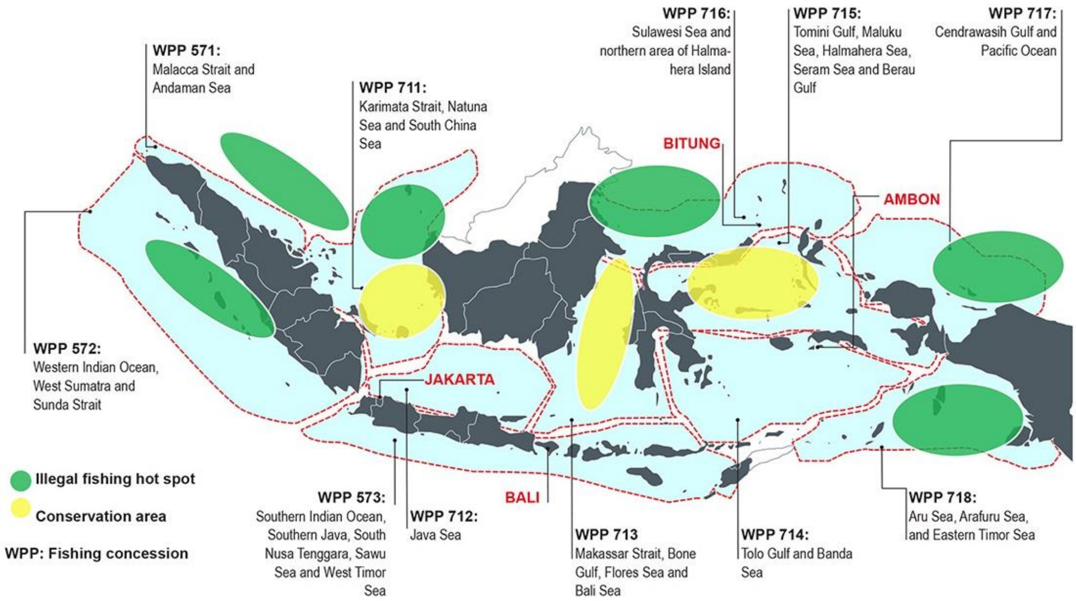

Figure 11: Map of fishing concessions and illegal fishing hotspots inside Indonesian waters. Source: Maritime Affairs and Fisheries Ministry of Indonesia.[31]

Picture 12: Philippines flagged purseiner GENEVIVA, during support operations with a typical fisheries tender vessel. Source: Greenpeace; http://www.greenpeace.org/seasia/ph/News/greenpeace-philippine-blog/a-day-in-the-life-of-geneviva/blog/43144/

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economic exclusion zone (EEZ) and surrounding waters. They have used AIS data to identify anchorages and ports, to record individual histories of proximity to land and EEZ boundaries and behaviour around or within the EEZ, and to provide both direct and derived track summary information of individual vessels.

Several, well-known IUU transhipment hot-spots are evident in Figure 10: particularly several coastal anchorages in the area known as the Dog's leg – on the EEZ boundary of Indonesia and Papua New Guinea, North-West of the Cape York Peninsula of Australia. Also evident are several anchorages identified as local ports, particularly at Poumako port in Papua, which was identified in late 2015 as the home port of several illegal Chinese fishing vessels. Anchorages identified as local ports were cross-checked with an online Indonesian register of fishing ports which indicated several anchorages in this class were close to registered local ports, indicating the ability to potentially detect registered and unregistered fish landing zones and at-sea transhipment zones.

[31] http://www.thejakartapost.com/longform/2016/10/04/collateral-damage-in-war-against-poachers.html

As stated previously, the GFW ***Refrigerated Cargo Vessel List 2017022.csv*** only contains **467** vessels that would indeed qualify as potential targets for transhipment activity analysis.

By way of comparison, the **Krakken V.8.2. WUVI database** used by FishSpektrum, contains **4.210** currently active vessels that definitively do qualify as potential targets for transhipment activity analysis.

Such a poor coverage level, not only has a direct consequence as to the scientific pertinence of GFW's *global footprint of transhipments* map for the period 2012-2016; it indeed yields a "*geo-political*" bias as to coverage and mapping of transhipments by nationality of vessels involved as well as by transhipment geographical areas.

Such issue could become highly controversial. Fishing nations and/or vessel operators for which GFW's AIS MMSI signal coverage seems to be *acceptable*, may rightfully reject GFW's mapping production as a whole, because of an "*arbitrary*" level of coverage for a number of flags and fishing grounds. (See Figure 20)

The "AIS (sat) bottleneck problem" bias

The authors of the GFW report state that their five-year (2012.2016) global AIS dataset was provided by US low Earth orbit communications satellites company ORBCOMM.

This would suggest that the entirety of the **21B** analyzed AIS MMSI positions were exclusively received via satellite since ORBCOMM does not operate a network of terrestrial AIS receiving antennas. According to GFW developers half of all AIS MMSI signals served by ORBCOMM are indeed terrestrially picked-up. It is unclear to us how that subset of terrestrial AIS MMSI data was obtained by ORBCOMM and then over-layered in avoidance of "*double-spotting*" with that of satellite AIS MMSI data.

"The majority of power of signal transmitted from ship borne 12W-power AIS transmitters located within the maximum signal coverage area may be received with the sufficient margin of power of signal by the LEO satellite, but the space-based AIS system generally suffers from the insufficient CIR (carrier to co-channel interference ratio) of signal received since around 95% pairs of message simultaneously received by satellites may not be correctly decoded. The insufficient CIR of signal received is the bottleneck for the high message detection probability.

From orbit, an AIS satellite can "see" a circle of about 3,000 miles in diameter – an area of more than 7 millions square miles.

Whenever there are more than about 1,000 ships anywhere in that field of view, the probability of detecting the vessel drops significantly.

The very best and most expensive satellites can pick up about 85% of ships in a crowded tracking area (Gulf of Mexico, certain parts of the Mediterranean, Indonesian waters, etc.) with about 5,000 ships in the field of view.

Most satellites, regardless of the operator, detect closer to 15% on a single pass.

This means that between 15% and 85% of ships will be missed on each pass.

Additional satellite passes occur sometime later and pick up that percentage again.

Statistically, after many passes, nearly all transmitting ships will be detected.

Only after each detection does a dot appear on the user's map display. The effect is that when a user looks at a screen and sees thousands of dots (or hundreds in a zoomed view), those dots represent the most recently reported and detected position of the ship.

On average, the positions shown will be many hours old but with a huge spread of times than can range from a few minutes to several days.

Each ship must be checked manually to see not only the position but also the time of that position and an estimate of its current position must be made". [32].

[32] Taken from: Detection probability analysis of space-based AIS signal by using geometrical model by Yuli Chen and from The Time Spread Problem with Satellite AIS by: MAERO Space.

The issue here, is of extreme importance since one of the often ignored factors with satellite received AIS MMSI signals concerns what is known as the *Probability of Detection* (PD) of a satellite or the *AIS(sat) bottleneck problem*, as we at FishSpektrum call it.

In all fairness, the authors of the GFW report do address such issues but fail to propose mitigating measures.

At FishSpektrum we believe that one of the methods to minimize potential biases related to incomplete AIS (sat) detection is to blend-supplement such data with that obtained from AIS signals received via terrestrial antennas -AIS (ter)- during the same studied period and maritime area. This is particularly true for coastal and near coastal fishing grounds AIS analysis.

Terrestrial AIS coverage has its own merits and shortcomings but the mixing of both (sat) and (ter) adds robustness to the exercise and lowers bias levels due to deficient vessel detection, especially in those areas of dense maritime traffic.

The biases due to misconceptions and misconstrued definitions

The bias due to misconceptions

It is important to note at this point in time that the Global Fishing Watch platform and GFW's report on transhipments, are mapping what we at FishSpektrum define as **density of received itemized AIS MMSI signals**. (See Figure 15)

Other AIS MMSI signal providers such as exactEarth/exactTrax™, LuxSpace, Catapult/ Eyes on the Seas, ORBCOMM or MarineTraffic also produce such density maps as shown in Figures 12a-b & 13a-b.

The concept of **density of received itemized AIS MMSI signals** or the "*birds of a feather flock together*" concept as we also call it at FishSpektrum, has nothing to do with the following four important concepts:

Fishing presence
Fishing-effort / fishing-intensity
Fishing footprint
Transhipment footprint

The "fishing activity heat map" misconception

- In order to properly map **fishing presence** (That is fishing vessels regardless of whether they are fishing or just cruising-steaming) AIS MMSI received signals must be plotted and rendered taking into account at least the following standardized items:
  - Type of fishing vessel (Longliner, purseiner, trawler, gillnetter dredger...)
  - Vessels' length and width (m)
  - Tonnage (GRT or GT)
  - Summer deadweight (Mt)

  In other words, transoceanic purse-seiners and artisanal fishing vessels will be *dotted* differently (based on a size, texture and/or colour scale) as for the end user to clearly distinguish the significance of one mapped dot from another. It is our understanding that this is definitively not the case at GFW map portal.

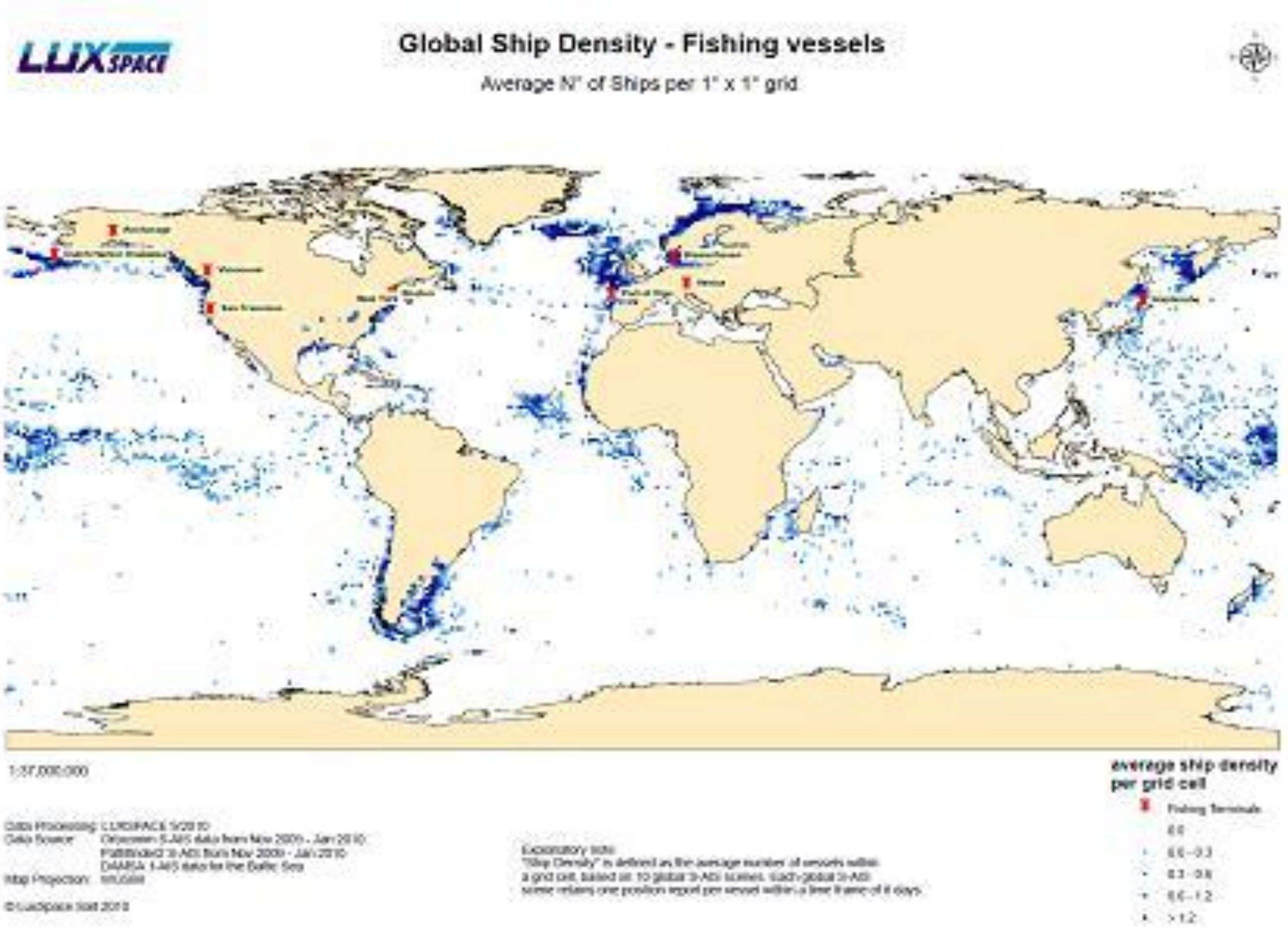


Figure 12a. LuxSpace fishing vessels AIS MMSI global density map

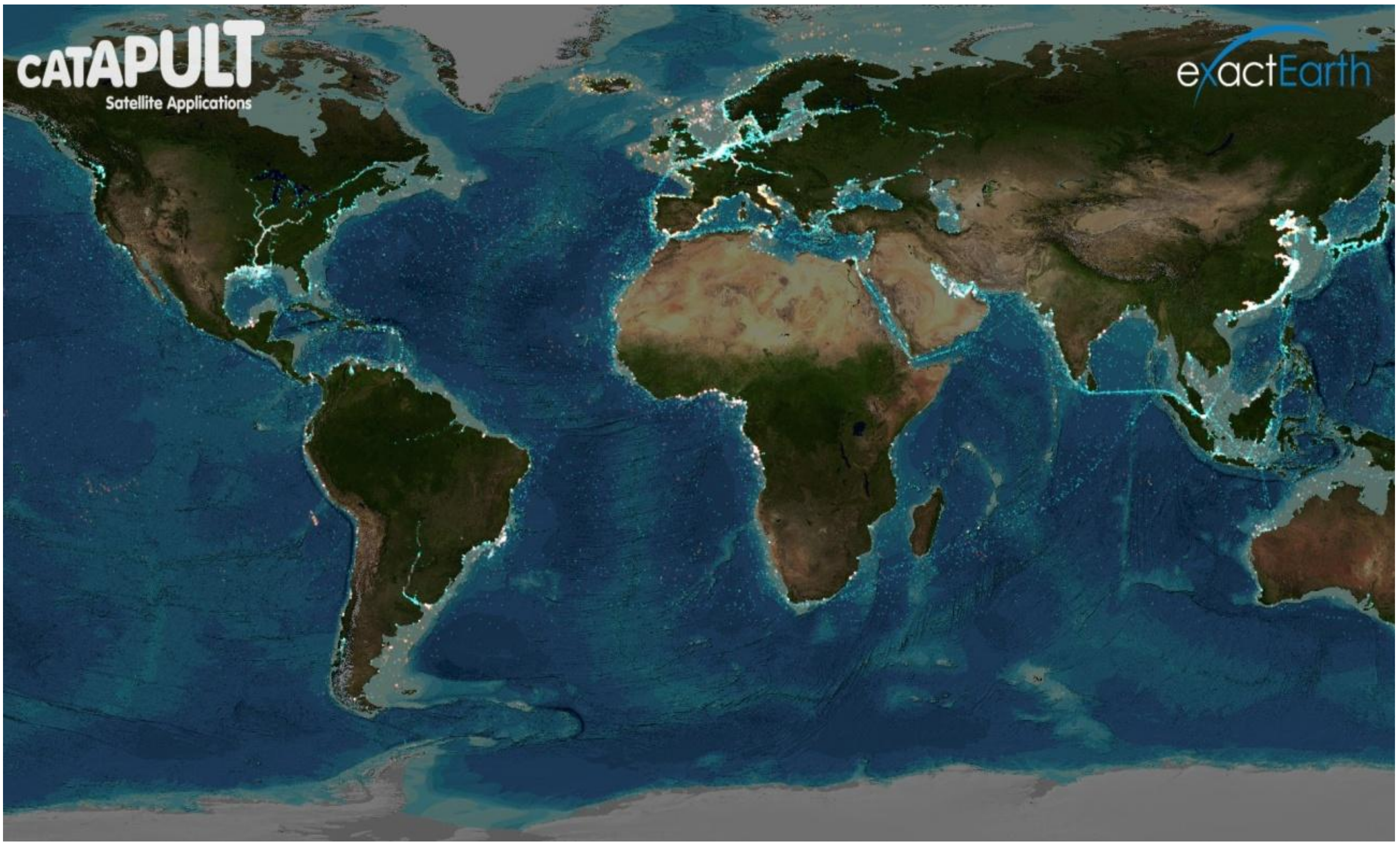


Figure 12b. Catapult/Eyes on the Seas' live global display of vessel activity overlaid with ocean seabed data. Photo credit Pew

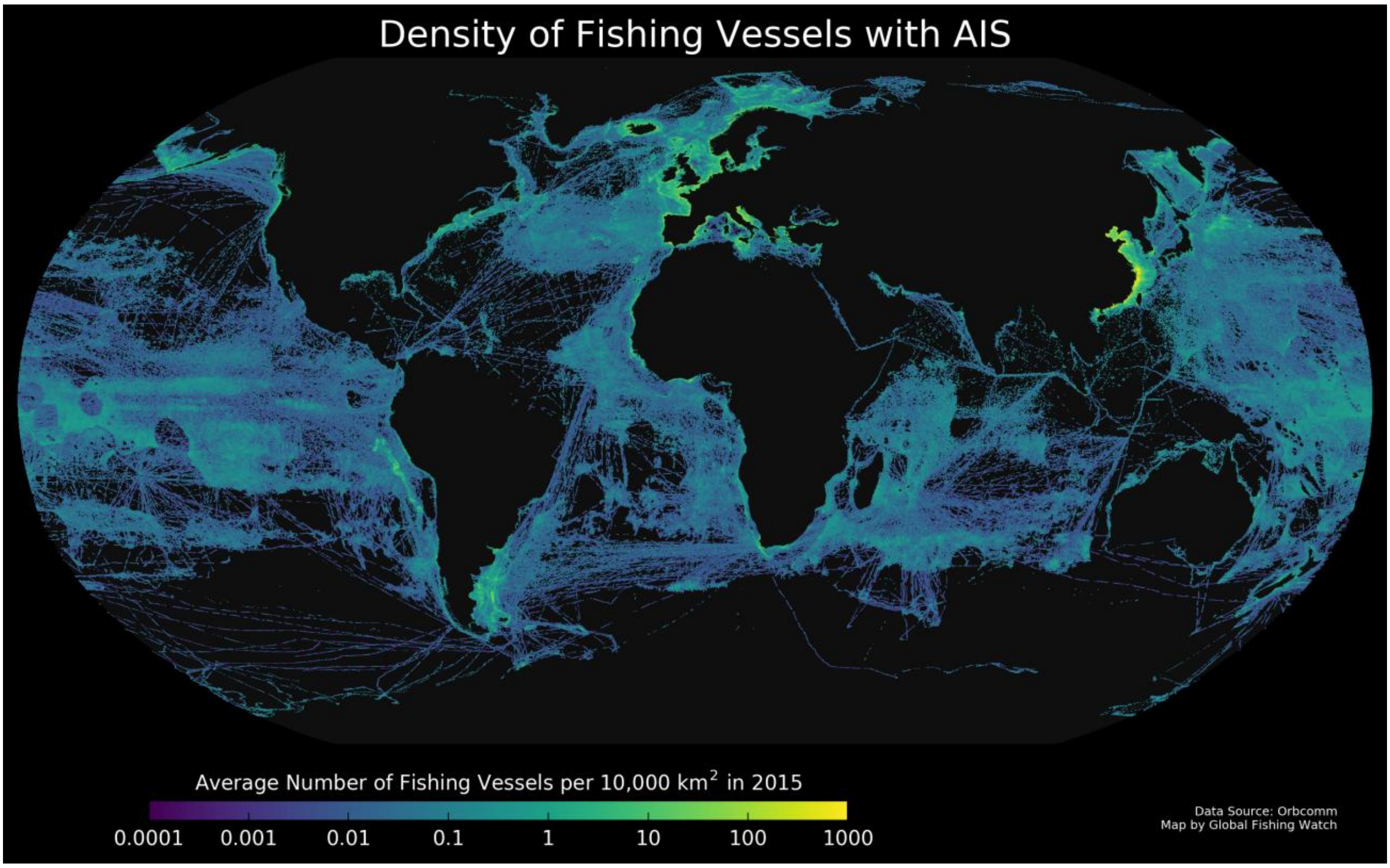


Figure 13a: ORBCOMM's global average number of fishing vessels 2015 map.

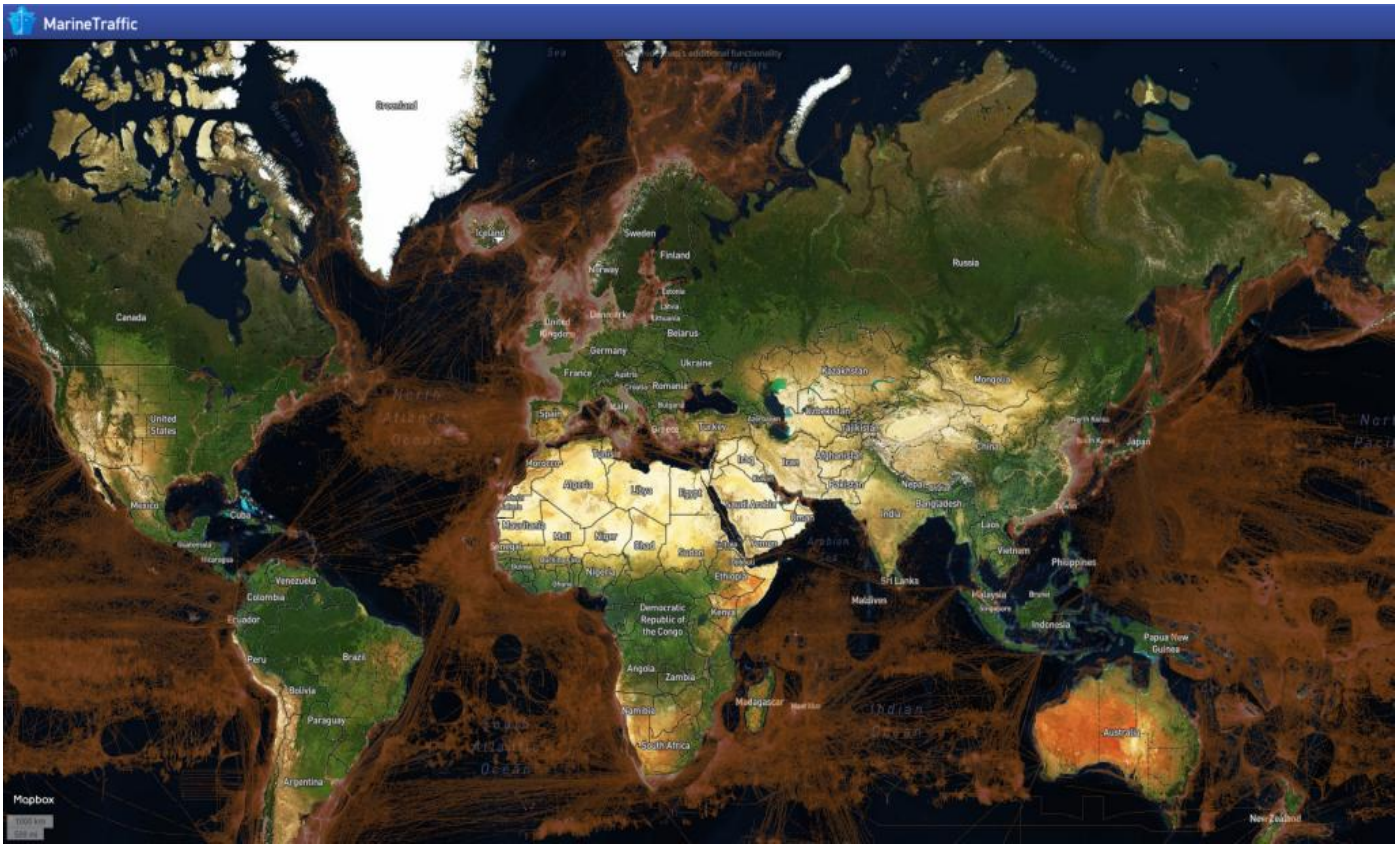


Figure 13b: MarineTraffic's global fishing vessel density 2016 map.

- Furthermore, in order to properly map **fishing-effort / fishing-intensity**, fishing presence mapped AIS MMSI received signals must be further filtered.

  Cruising-steaming signals must be discarded by way of pertinent speed over ground (SOG) filters per type of fishing vessel.

  Moreover, speed over ground (SOG) filtered fishing presence AIS MMSI received signals must be itemized by pertinent depth and landing filters as well as by fishing ground filters and then must be re-plotted and rendered taking into account the following standardized items:

  - Installed main engine power
  - Type of fishing gear used at the time of the AIS MMSI message reception. (Ex. If a trawler is using a mid-water or a bottom otter trawl net)
  - Time laps between beginning and end of fishing vessel's effective fishing activity.

  This much will allow to further refine input by way of calculation of theoretical catch per unit efforts (CPUE) based on daily, fishing-trip or number of hours/engine; per vessel type and size, target species and used fishing gears.

  In other words, an industrial commercial fishing vessel may well yield a smoother fishing-effort visualization than that of a smaller fishing vessel. Again fishing-effort is to be *rendered* differently (based on a size, texture and/or colour scale) as for the end user to clearly distinguish the significance of one mapped series of dots from another. It is our understanding that this is again, definitively not the case at GFW map portal.

- In order to properly map **fishing footprint**, fishing effort/fishing intensity mapped AIS MMSI received signals, must be again plotted and rendered taking into account the following standardized items:

  - Seabed/seafloor sediment data (For bottom trawling)
  - Seabed/seafloor taxa data (For bottom trawling)
  - Type of fishing ground (targeted species, unwanted catches, discards)
  - Fishing quotas and/or ITQs
  - Port catch offloading data

So far and to the best of our knowledge, only the European JRC has developed a tool - Mapping Fishing Activities (MFA)- that provides detailed maps of high intensity fisheries areas based on AIS tracking data for EU flagged fishing vessels above 15m LOAs inside European waters.

The MFA includes several layers of geographical information and a high-resolution map of fishing intensity covering all EU waters. Information on the position of vessels in relation to areas of high fishing intensity and in the surrounding of ports is aggregated into a dependency index which represents the gravitation of coastal communities towards specific fishing grounds and other ports. (See Figure 14)

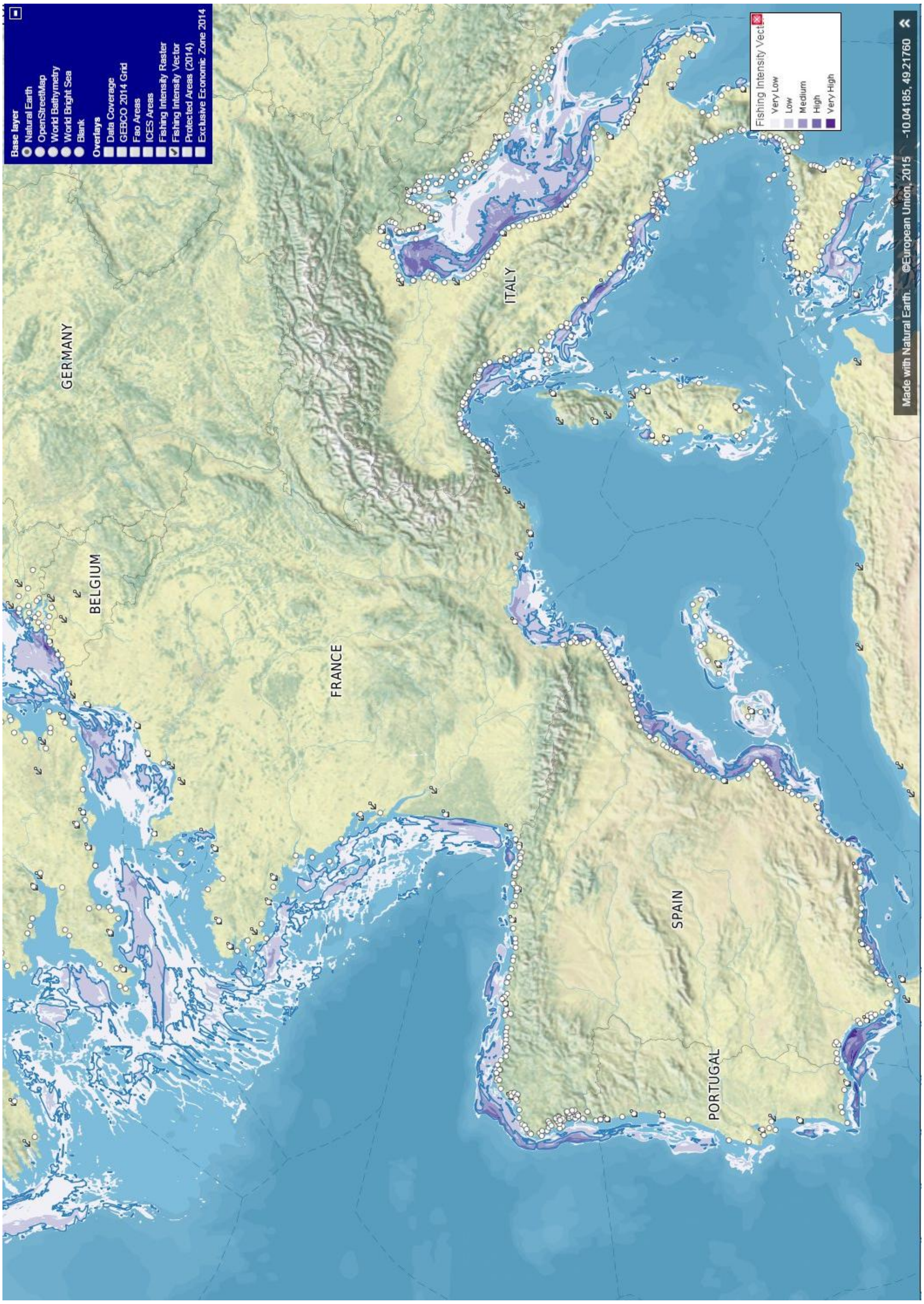


Figure 14: EU-JRC AIS-based map for fishing intensity inside EU waters during 2014 and 2015.

Likewise, it is important to note that the authors of the GFW report on transhipments are **only mapping density of received AIS MMSI signals they have chosen to itemize as *likely* or *potential* transhipments**, this regardless of fish-carrier vessels' types and freezing / refrigerated cargo capacities. (See Figure 16)

In our opinion, this is clearly the most salient misconception contained in their report.

Such misconception coupled with what in our opinion is clearly a misconstrued definition as to what is a *likely* and a *potential* transhipment; has in our view a snowballing effect of erroneous transhipment event identifications.

The authors of the GFW report indeed choose to present such erroneous transhipment event identifications *as proxy for transhipments of fish at sea.*

In other words, *likely* or *potential* transhipments are plotted and rendered by GFW using the same size, texture and colour, regardless of whether such visualizations pertain to large reefer vessels or to small scale fish-carriers, therefore in total contradiction with the notion of "*footprint*" itself.

This creates a bias that turns the whole GFW mapping exercise simply into an unbelievable proposal. For the record the title of GFW's report core map is: "*Global **Footprint** of Transhipments 2012-2016*".

Though the methodology section in the GFW's report makes clear some of such limitations (Though also significantly misses some - see ref. smaller reefer vessels, legal frameworks...), indeed one of the major issues with the GFW report pertains not as much to the limitations in its methodology, but as to the presentation of such limitations in its findings, particularly as to the use of titles and wording on graphs and maps.

This is the opinion of a number of fisheries scientists we have approached on the matter for the purpose of this preliminary fact-checking report, and indeed our own opinion.

Certainly, in order to properly map the global footprint of fish transhipments, selected AIS MMSI signals itemized as *likely* or *potential* transhipments should have been scaled plotted and rendered taking into account the following "*nice-to-have*" standardized specifications and criteria, among others[33]:

- Type of fish-carrier vessel
- Vessels' length and width
- Tonnage
- Summer deadweight
- Fish-holds maximum capacity (in metric tons) or fish-holds volume

[33] Some of such data will only be available where the fishing vessel is also transmitting.

- Vessel's daily freezing capacity
- Time laps between beginning and end of vessel's effective transhipping activity
- Type of fishing vessel transhipping its catch
- IHP (kW) of fishing vessel transhipping its catch
- "Fishing gear selectivity", "selective fishing", and "selection of fish" criteria[34] of fishing vessel transhipping its catch
- Fish species being transhipped and status of such fish species stocks[35]

In other words, transhipment activity by transoceanic reefer vessels and coastal small-scale fish-carriers should have been *dotted* differently (based on a size, texture and colour scale) as for the end user to clearly distinguish the pertinence and significance of one mapped *likely* or *potential* transhipment dot from others.

In fact, a particular transhipment by a transoceanic reefer vessel may well have yielded a much *smoother* transhipment-footprint visualization than that of a small-scale fish-carrier. (See Figure 17. *Typical Fish-carrier transhipment/s event/s, footprint analysis flux diagram*)

Furthermore, fish transhipments should be analysed taking into account the type of fishery at stake by way of spatio-temporal plug-in filters.

In other words, King Crab, Anchovy, Pollock or Tuna fisheries (just to mention a few) are four different worlds altogether.

Treating their alleged related transhipment activities on a same criterion basis is in our view yet another methodological *brouhaha*.

In time, such rendering may be refined, by *plugging* into the set of analysis and mapping algorithms, local sea-weather histograms of currents, wind, waves and sea surface temperature (SST) using cloud-free Advanced Microwave Scanning Radiometer for the Earth Observing System (AMSR-E) or high-frequency radar data repositories used for monitoring ocean conditions as well as surveillance.

This much could enrich the analysis, looking for other drivers of reefer vessels' abnormal track behaviour, currently itemized by GFW as being *likely* or *potentially* engaged in fish transhipment activity; when in fact could well correspond to innocent loitering events in avoidance, for example, of anchoring fees or lay-time excess demurrage.

[34] https://www.ices.dk/news-and-events/Blogs/Inotherwords/Lists/Posts/Post.aspx?ID=32

[35] Good Environmental Status (GES) fishing mortality (F) and reproductive capacity (SSB)

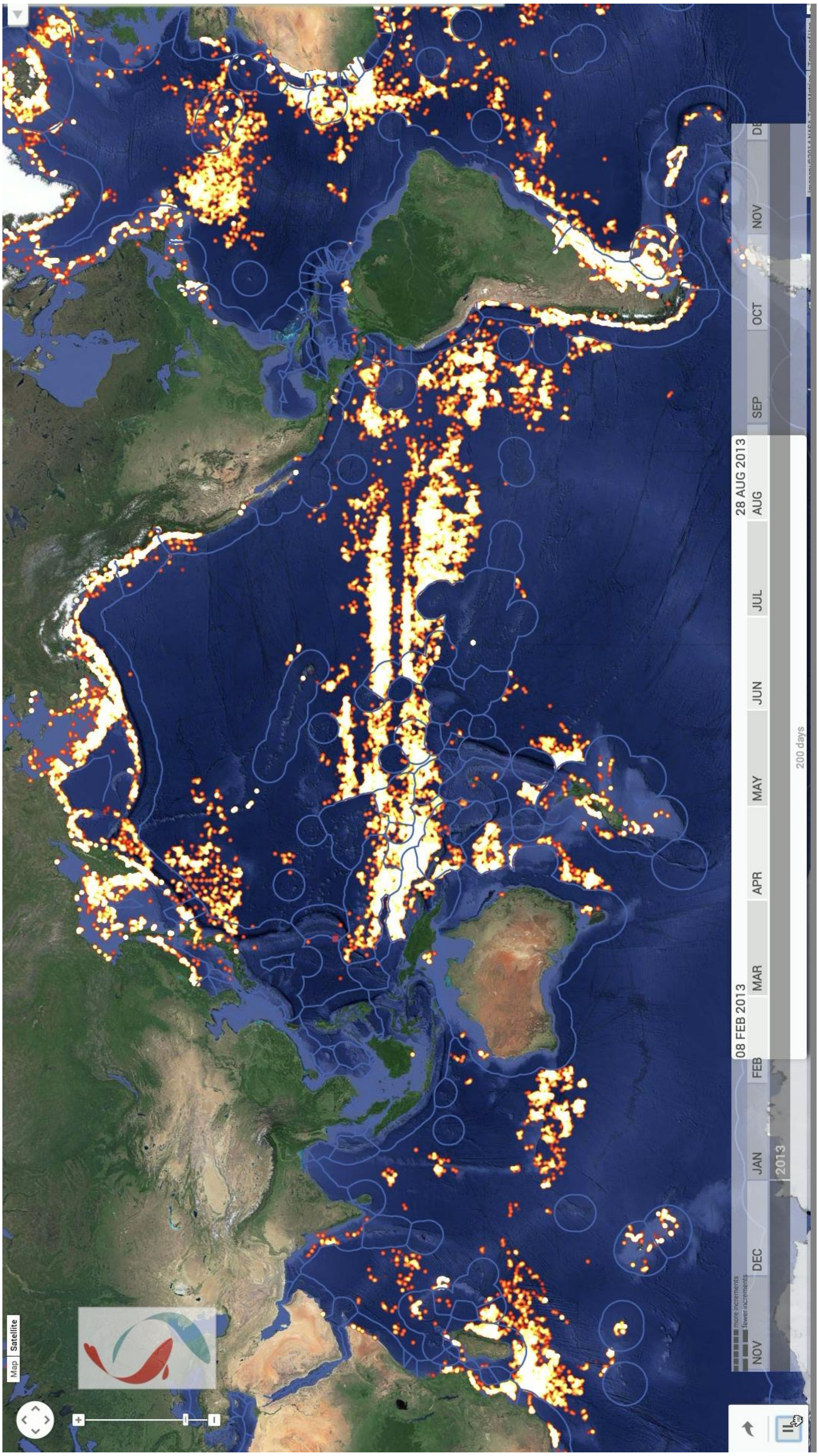


Figure 15: GFW's global multi-year fishing activity heat map.

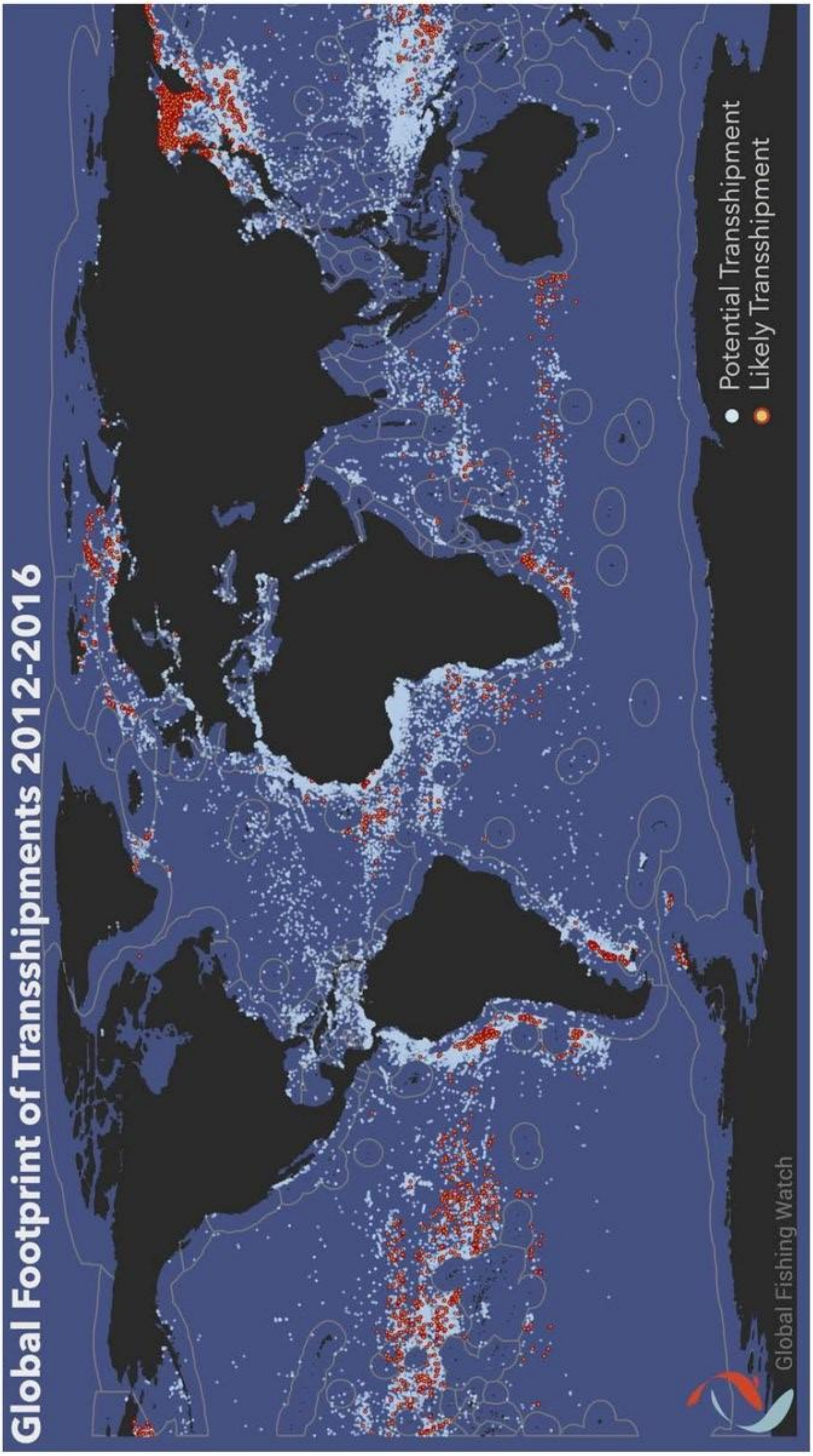


Figure 16: GFW's global map of transhipments based on reefer encounters and reefer rendezvous behaviour.

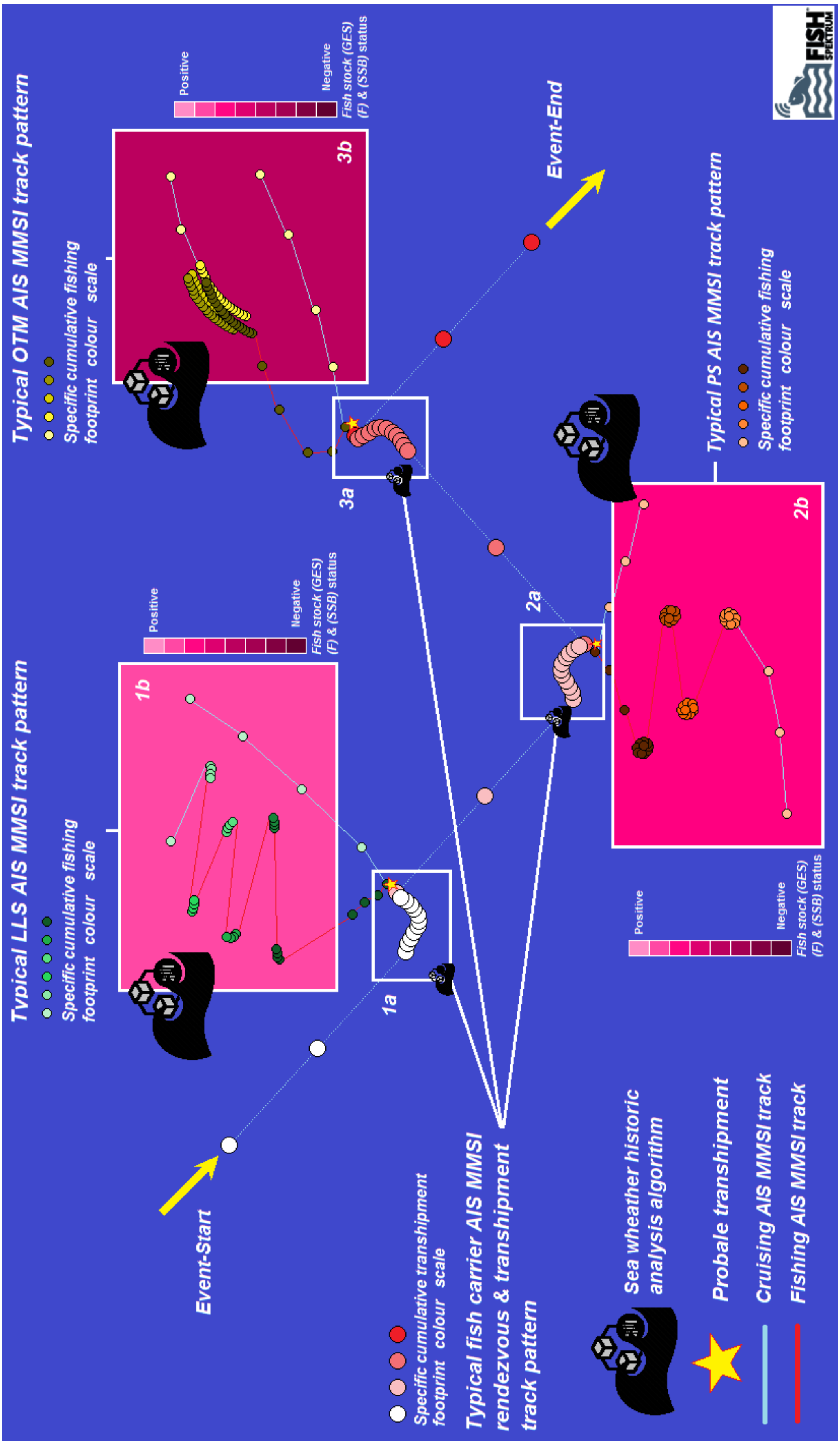


Figure 17: Theoretical fish-carrier transhipment/s event/s, footprint analysis flux diagram

The bias due to misconstrued definitions

The authors of the GFW report state that "*for this report, we call an event where a reefer encounters a fishing vessel a "likely transhipment" and an event where a reefer exhibits rendezvous behaviour a "potential transhipment."*

Furthermore, the authors of the GFW report furthermore state that "*to identify likely transhipment events, we identified all interactions between two vessels which remained within **500** meters of each other for longer than **3** hours while travelling at less than **2** knots.*

These parameters balance the need to detect vessel pairs in close proximity for extended periods of time while recognizing that satellite coverage and inconsistent AIS transmission rates may limit our ability to identify long periods in which vessels are in immediate contact (see data caveats below).

*We filtered our results to include only events where one of the vessels was a refrigerated cargo vessel and the other a fishing vessel. This left us with **5.065** encounters between reefers and fishing vessels, or "likely transhipments," from 2012 through 2016*".

They also assert that "*not all of these rendezvous events are transhipments of fish.*

Some may represent transfers of fuel or cargo, and others may be the reefer simply waiting until it is scheduled to travel to its next location.

Future research will estimate the fraction of these loitering events that are transhipments of fish. For this report, we present these events as a proxy for transhipment of fish at sea, recognizing that it is not a one-to-one relationship".

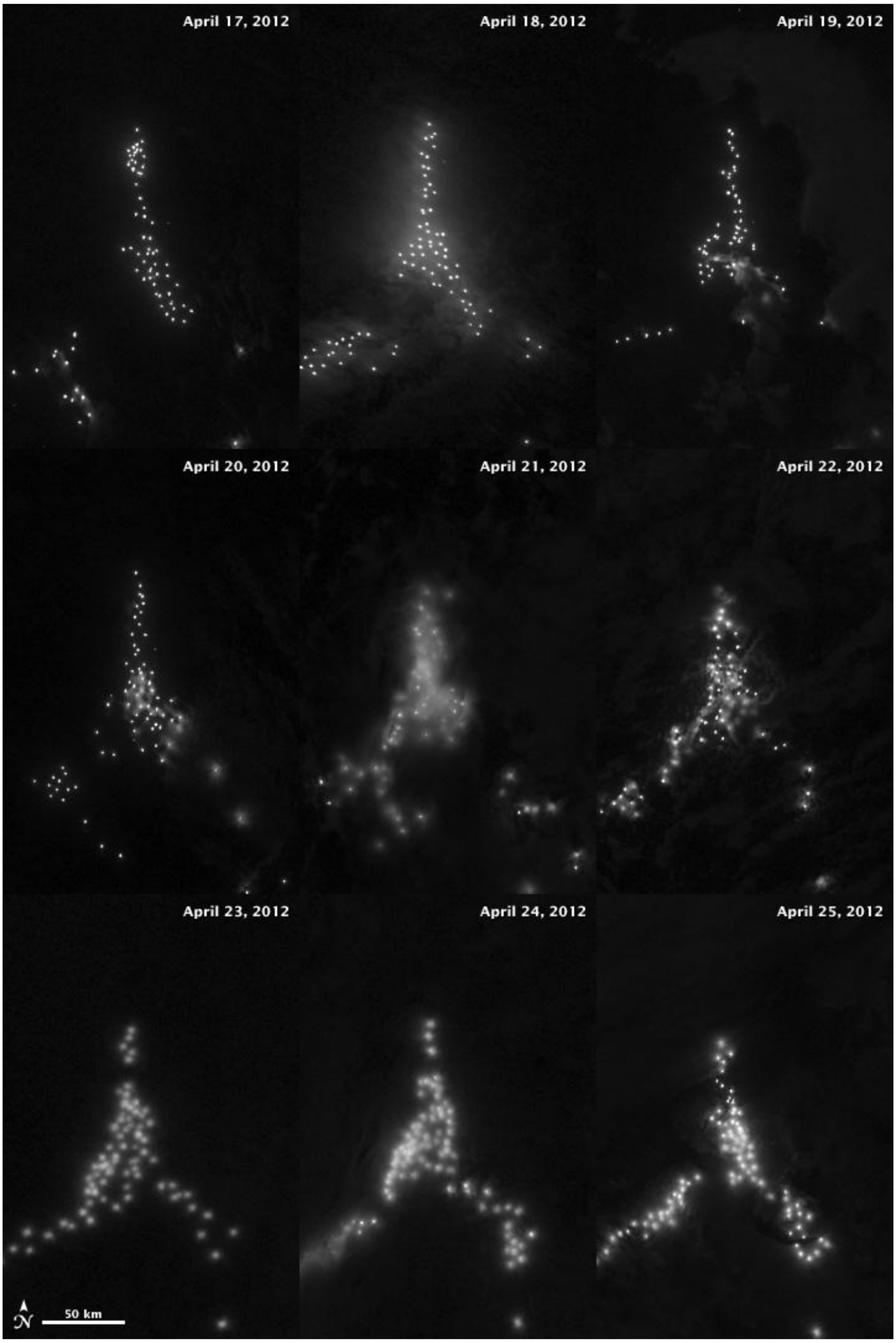
Again and as stated before, both ships involved in a fish transhipment operation –the carrier and the fishing vessel- must be (sea-weather permitting) at an almost standstill and moored side-to-side during such transhipment operations. (See Pictures 1, 2 & 3)

In other words no fish transhipment activity can take place in rough seas, moreover when both ships are separated by more than **20**m, this is of course unless GFW is capable of explaining to the inadvertent reader how two vessels separated by as much as **500**m can tranship fish at sea.

Moreover, the authors of the GFW report fail to understand that a given fishing ground may be *over-crowded* on a seasonal basis and that entire fishing fleet clusters may indeed be in the close vicinity of *loitering* fish-carriers during several days/weeks without a single transhipment having taken place; a common practice in squid jigging fisheries, for example and as shown in Picture 13.

To argue that ≥**500**m/**3**h+ vicinity events automatically translate into *likely transhipment events* is unfounded and denotes a certain degree of ignorance in common fisheries' practices.

To further infer that an *outbreak* of such false-transhipment events are to be characterized and mapped (hot-to-cold rendering) as a statistically significant transhipment regional "*hotspot*" is a cavalier mathematical recreation. (See Figure 18)



Picture 13: Example of a crowded fishing ground. Over the course of nine nights, squid jiggers shift positions while hugging the borders of the EEZs of Argentina and the Falkland Islands. (Map by NASA Earth Observatory, using VIIRS day-night band data from Suomi NPP.)[36] [37] *50km scale can be found in the left-bottom corner of the picture.*

[36] https://earthobservatory.nasa.gov/Features/Malvinas/?src=features-hp&eocn=home&eoci=feature

[37] Squid boat fleets use high-powered lamps to attract squid to the surface. The boats typically cluster in groups that follow schools of fishes from one night to the next. Sometimes the orientations of the clusters they form are tied in a benign way to natural features such as sea-surface boundaries that help form productive waters.

In AIS MMSI terms, for a **probable** fish transhipment operation to take place, this means that:

- AIS MMSI recorded time-stamp data for both vessels must be the same or almost the same (a 1 to 3 minutes gap can be allowed. See **The "AIS (sat) bottleneck problem" bias**)
- AIS MMSI recorded longitude and latitude position data for both vessels must be almost the same (A **≈0,01** nautical mile gap, corresponding to the approximate sum of both vessels' half-beams, must be allowed)
- AIS MMSI recorded course over ground (COG) for both vessels must be the same.
- AIS MMSI recorded gyro course (heading) for both vessels must be the same or the almost exact opposite, depending on whether both transhipping vessels moored side by side are bow against bow or bow against stern.
- AIS MMSI recorded speed over ground (SOG) data for both vessels ideally must be zero or close to zero knots[38]. If the above criteria are met and both vessels' SOGs are equal but higher than 0,1 knot, it could be inferred that both ships are being dragged by a same sea current and/or wind, while their respective speed over water (SOW) remains equal to zero knots.

In turn, this does not mean that all detected cases, in which all previously listed criteria are given, automatically correspond to fish-transhipment activity.

These could well correspond to other operations such as refuelling, transferring of fish-bait/supplies from one ship to another, permutation of crew or an emergency evacuation, among other type of events.

The authors of the GFW report have chosen not to specifically define what a **probable** fish transhipment would look like in AIS MMSI signal terms.

They have further rejected the idea of adding a third transhipment identification type repository: **know recorded transhipments**.

They could have obviously done so.

As others in the independent fisheries MCS/compliance intelligence community, GFW has access to RFMO data repositories pertaining to on-board ROP observer reports on transhipments at sea.

GFW has nevertheless chosen a loose descriptive around the notions of *likelihood* and *potentiality* that in our view, gives way to a snowballing effect that aggrandizes their findings and further biases their final conclusions.

As will be seen herein-under; such snowballing aggrandizing effect cannot be exclusively circumscribed or attributed to *loitering events* automatically being translated into *proxy for likely or potential transhipments of fish at sea.*

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[38] No vessel speed over ground data (SOG) can be found in the **Potential Transhipments csv** file or in **the Likely Transhipments csv** file.

As stated, both ships involved in a fish transhipment operation –the carrier and the fishing vessel- must be at an almost standstill (Speed over water (SOW) ≈ 0 knots) and moored side-to-side during such transhipment operations. (See Pictures 1 2 & 3)

AIS MMSI recorded speed over ground (SOG) data is therefore an important piece of information in order to identify **probable** transhipment operations as will be explained herein-under.

The biases due to false, erroneous or inexistent data input, faulty pattern recognition, data classification and learning process

As stated before, the authors of the GFW report assert that: *"A vessel classification neural network, developed by Global Fishing Watch to predict vessel types based on movement patterns, was used to identify possible reefers. Vessels that were identified as likely reefers by this neural network"...* detected vessels *"were manually reviewed through web searches and RFMO registries".*

Furthermore, they assert that: "*After developing the list,* -of reefer vessels- they *verified vessel information using reputable online sources: the IHS shipping databases, MarineTraffic, ShipSpotting, VesselFinder, and FleetMon*".

Should this have indeed been the case, some of the reckless flaws previously described (See pages 13 to 18) **may well have been avoided.**

Both assertions furthermore beg the question as to the intrinsic validity of GFW's ANN[39] configuration criterion for AIS MMSI track pattern recognition, data classification and learning process.

Indeed, GFW's *neural network* and the authors of the report for that matter have neglected a relevant basic consideration: **Cargo/container reefer vessels simply do not tranship fish at sea**; this is in spite of the fact that **140** of such vessels were itemized by GFW's ANN as *likely* and/or *potentially* involved in at-sea fish transhipment activity, when all of such cases should have been discarded or at least catalogued as "*innocent passage*"[40] events right from the very beginning.

The same may be said about the **12** fruit reefer vessels, the **8** bulk carriers, tankers or dry cargo ships, the **41** general cargo vessels, the recreational luxury yacht, the **21** fisheries tender vessels and the **22** active fishing vessels, the authors of the GFW report have included into their ANN *tutti-frutti melting-pot*.

But as if this was not enough, the authors of the GFW report affirm that "*in 2016, more than **300.000** vessels broadcasted an AIS signal, of which about **80.000** were fishing vessels, and a few hundred were refrigerated cargo vessels*".

No mention to GFW's ANN pattern recognition and fishing detection algorithms is made here by the authors of the GFW report. The source that would substantiate such a statement remains to be known.

Moreover, such a statement simply defies credulity and *bona-fides*; furthermore could be interpreted as a hasty *cover-up* for the very poor quality of not only GFW's ***Refrigerated Cargo Vessel List 2017022.csv*** but also that of GFW's ***vessel lists master repository*** of fishing vessels as described in pages 13 to 18 of this fact-checking preliminary report.

For the record, the total number of real fishing vessel references identified as active fishing vessel for the period 2012 to 2016, in GFW's ***vessel-lists-master repository***, only amounts to **51.891**.

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[39] Artificial Neural Network

[40] According to Article 19 (2) of UNCLOS

By way of comparison the **Krakken WUVI database** used at **FishSpektrum** contains **1.697.327** historic references[41] for a total of **779.823** fishing vessels and fish-carrier vessels from **184** fishing nations, in its 2016 V.8.2. version[42]. Contrary to GWF, **Krakken WUVI database** identifies each vessel by primary and secondary fishing gear among other characteristics.

In other words, the authors of the GFW report would have left-out of their equation most of the active global fishing fleet that indeed broadcasted AIS MMSI signals during the period 2012 to 2016. This much will be confirmed in full detail at a later stage and for the purpose of a final report adjacent to this first fact-checking, analysis & preliminary findings report.

Finally, neither GFW's *Fishing Vessel Lists Master Repository, nor* GFW's *Refrigerated Cargo Vessel List,* contain basic comprehensive characterization of such vessels by way of specific fields of information per vessel reference. These would be among others.

- Type of fishing vessel or fish-carrier vessel,
- Vessels' length and width,
- Tonnage (GRT, GT, Other),
- Summer deadweight (Mt),
- Installed main engine power (Hp, Ps or kW),
- Type of primary and secondary fishing gears,
- Fish-holds maximum capacity (in metric tons) or fish-holds volume (m^3 or ft^3),
- Vessel's daily freezing capacity (Mt/day).

Such data-taxonomy should be fully standardized by way of a nomenclative reference system in order for mapping and scaled rendering to be fully consistent, as described in previous paragraphs.

To the best of our knowledge this is not the case with GFW's mapping platform, thus incapable to serve on-line fisheries footprint, "*heat*" or "*hotspot*" mappings of any sort.

On the other hand, GFW developers may be solely relying on incomplete, unreliable and unstandardized vessel characterization data, contained in received AIS MMSI signals and/or in registry repositories such as for example CLAV (combined tuna RFMOs) or the International Telecommunications Union (ITU)

In our opinion, AIS MMSI signals and both registry repositories have so far revealed a high degree of data unreliability[43] regarding ships' identification and technical specifications.

Should the latter be the case, all of their alleged footprint or "*hotspot*" mapping exercises to date (fishing and transhipment included) would have again peddled highly biased and erroneous visualizations.

Should the latter not be the case, as everything seems to indicate, we let the inadvertent reader imagine the kind of overall bias such cumulated data-vacuum may have caused to Oceana-GFW's lucubrations on *global patterns and trends*, *vessel identities* and *port analysis*. (Pages 8 to 14 of their report on transhipments)

[41] 214.504 EU flagged fishing vessels for 989.958 historic references for such vessels. 532.146 non EU flagged fishing vessels for 671.152 historic references for such vessels.

[42] Statistics for the 2017 version Krakken V.9.0. WUVI database will be available on June 1st 2017 on our website: www.fishspektrum.com

[43] An analysis report on the latter is currently being redacted by FishSpektrum's fisheries data analysts and should be published later this year.

Conclusions

It is said that *God is in the detail* though in the case of GFW's latest report on transhipments and Oceana's subsequent opuscule "*No More Hiding at Sea*", it is truly the *devil that haunts the well*.

It is our opinion that the general high-level of scientific uncertainty that criss-crosses its assumptions and postulations, contrives GFW's report on transhipments into an artefact in which most inputs that feed their mapping model, are erroneous, overestimated or simply irrelevant, while others are underestimated or simply absent.

The authors of such report, notwithstanding a self-exculpatory disclaimer[44], fail to state who their scientific peer-reviewers were prior to publication; that is if it was indeed reviewed by an independent panel at all.

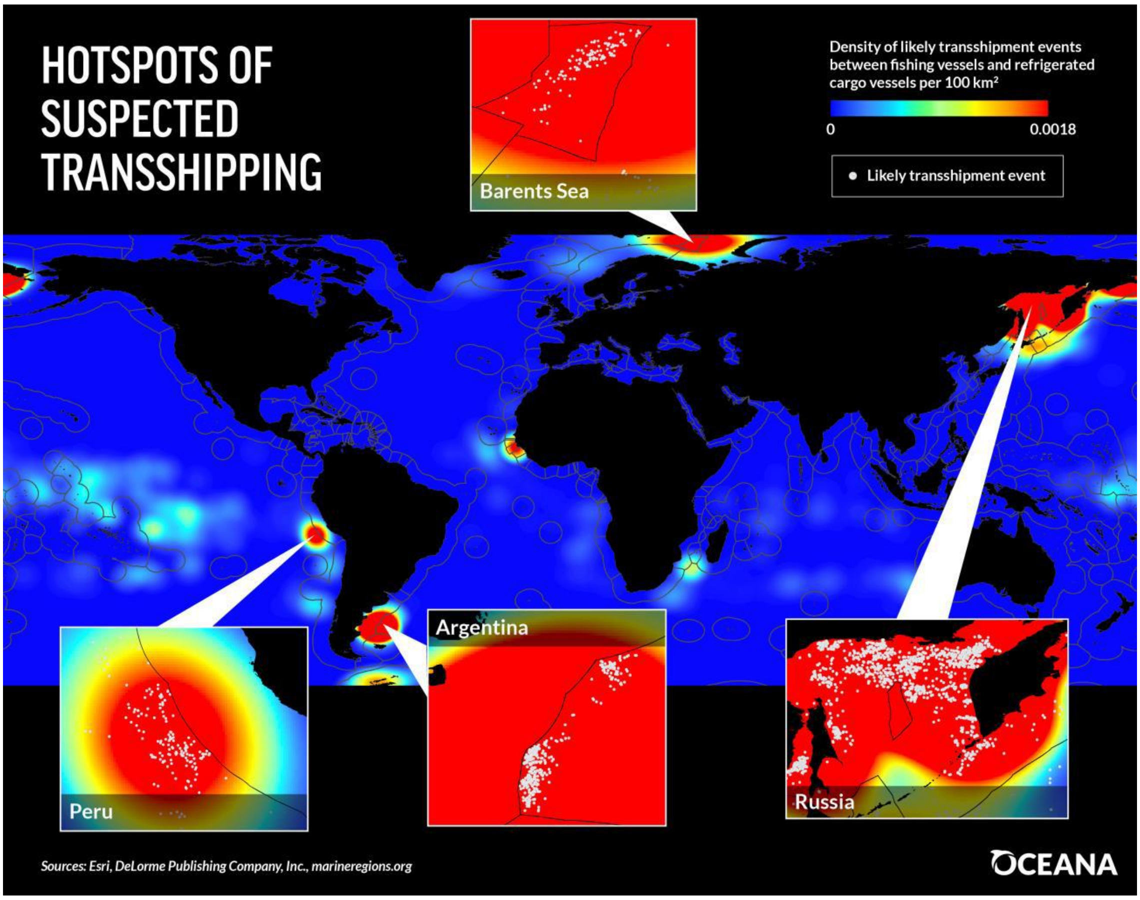

Figure 18: Example on how GFW flawed transhipment mapping retro-feeds NGO literature. Map taken of Oceana's latest report: "No More Hiding at Sea: Transhipping Exposed (February 22, 2017) Authors: Lacey Malarky and Beth Lowell. Astonishingly, no hotspot mapping for South-western African, Indonesian or Indian Ocean waters have been indicated.

44 "*I acknowledge and understand that Global Fishing Watch analyzes Automatic Identification System (AIS) data collected from vessels that our research has identified as known or possible commercial fishing vessels, and applies a fishing detection algorithm to determine "apparent fishing activity" based on changes in vessel speed and direction. As AIS data varies in completeness, accuracy and quality, it is possible that some fishing activity is not identified as such by Global Fishing Watch; conversely, Global Fishing Watch may show apparent fishing activity where fishing is not actually taking place. For these reasons, Global Fishing Watch qualifies all designations of vessel fishing activity, including synonyms of the term "fishing activity," such as "fishing" or "fishing effort," as "apparent," rather than certain. Any/all Global Fishing Watch information about "apparent fishing activity" should be considered an estimate and must be relied upon solely at my own risk*".

Its web dissemination in the flesh and the much webinar-workshop-media trumpeting[45] [46] [47] around such "*a godsend to ocean conservation"* has been nothing short of bemusing for some of us in the fisheries independent MCS[48]/Governance intelligence community.

GFW's report scientific credibility aside and on a more philosophical tone, it is our view that its general argumentation rationale is *spiced-up* by a "*guilt-by-statistical-association*" hallmark approach that upholds what is known as the "*prosecutor's fallacy*", a very specific way of inferring the suspect's guilt by way of argumentative sleights of hand.

A good example of the latter can be found in GFW's report at page 8: Map: *Regions with more IUU have more suspected transhipments*.

The authors conclude that "*in general, we find that regions with a higher percent of IUU fishing have more potential and likely transhipment events.*

The correlation between suspected transhipments and the percentage of catch suspected to be IUU for each FAO region, as based on Agnew et al. 2000, is decent (R^2=0.32), especially if we account for the following outliers..."

In our opinion, observations that are well outside of the expected range of values in a study should deserve a more in-depth analysis than that proposed by the authors of the GFW report (for example in the case of FAO Region 61: East Russia/Japan).

Alternatively such observations should be discarded from the core data set altogether.

Moreover it is our opinion that belief or label propagation in graphs of artificially-generated guilt innuendos such as "*likely*", "*potential*", "*suspected*" "*heat-map*" or "*hotspot*" is hazardous, no matter how fancy the used probabilistic graphical model is.

Figure 19: Zoom-in on GFW's global map of transhipments based on reefer encounters and reefer rendezvous behaviour (Period 2012-2016), for European Union EEZ waters under EU EFCA fisheries surveillance.

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[45] http://www.huffingtonpost.com/andrew-sharpless/oceana-unveils-global-fis_b_12030462.html

[46] http://www.huffingtonpost.com/entry/58cbe005e4b0537abd956fbc

[47] http://blog.waltonfamilyfoundation.org/2017/april/how-big-data-is-helping-in-battle-against-illegal-fishing

[48] Fisheries monitoring, control and surveillance

A good example of the later is shown in Figure 19 where we have chosen to zoom-in on GFW's global map of transhipments based on reefer encounters and reefer rendezvous behaviour (Period 2012-2016), for European Union EEZ waters under EU EFCA fisheries surveillance.

According to GFW, the inadvertent reader should be left to believe that at-sea fish transhipment activity could have possibly taken place at locations such as the English Channel, all across the Strait of Gibraltar, all around the Dutch and Danish coasts, not to mention throughout the Mediterranean Sea.

Such a proposal is simply preposterous given the fact EU waters may well be the most policed waters in the world: Fishing vessels are systematically inspected in cases of suspicion or findings of non compliance with conservation and management rules (i.e. sightings, notification under the Community Alert System (CAS), or identification for IUU fishing).

Furthermore, all transhipment operations between third country fishing vessels and EU fishing vessels may only take place in designated ports in EU Member States.

Fishing vessels flying the flag of an EU Member State shall not be authorised to tranship at sea catches from third country fishing vessels outside EU waters unless the fishing vessels are registered as carrier vessels under the auspice of a RFMO.

Moreover and according to ICCAT regulations, transhipment at sea operations of BlueFin Tuna in the eastern Atlantic and Mediterranean Sea is strictly prohibited.

"*Most managers believe their organization's investment and project execution decisions are rational and based on informed choice. In reality, bias frequently leads to poor decision-making, creating a domino effect that culminates in failed projects*".[49]

In this particular case, such type of exercise not only generates precious little light but undermines what in our opinion still is a valid, legitimate and necessary objective: **A global unified platform to fight overfishing and IUU fishing activity.**

This is why the funders and the authors of this report should be urged to reconsider, recant and practise some degree of scientific responsibility in future publications[50].

Notwithstanding, the Global Fishing Watch is still a highly innovative and worthy project put together by a renown coalition of conservationists and funders who genuinely want to end overfishing and the IUU crisis in the world's oceans.

But there is a danger that the use of erroneous data, flawed databases and ignorance of fisheries common practices, will only serve to move us further away from that admirable goal.

Regional fisheries management organisations (RFMOs)**,** industry and governments are able to identify the issues and flaws within GFW's report and databases as a whole.

They indeed operate much sophisticated MCS real-time fisheries analysis platforms[51] such as and among many others:

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[49] Michael Krigsman for Beyond IT Failure (June 24, 2010)

[50] While a meta-analysis will yield a mathematically accurate synthesis of the studies included in the analysis, if these studies are a biased sample of all relevant studies, then the mean effect computed by the meta-analysis will reflect this bias. Several lines of evidence show that studies that report relatively high effect sizes are more likely to be published than studies that report lower effect sizes. Since published studies are more likely to find their way into a meta-analysis, any bias in the literature is likely to be reflected in the meta-analysis as well. This issue is generally known as publication bias. (Introduction to Meta-Analysis. Michael Borenstein, L. V. Hedges, J. P. T. Higgins and H. R. Rothstein © 2009 John Wiley & Sons, Ltd. ISBN: 978-0-470-05724-7)

[51] United Nations General Assembly, "Agreement for the Implementation of the Provisions of the United Nations Convention on the Law of the Sea of 10 December 1982 Relating to the Conservation and Management of Straddling Fish Stocks and Highly Migratory Fish Stocks" (1995), http://www.un.org/depts/los/convention_agreements/texts/fish_stocks_agreement/CONF164_37.htm.

- The EU JRC[52]-EMSA Copernicus[53] - European Fisheries Control Agency (EFCA)[54], in our opinion the most advanced in the World;
- The US Navy's TOPSIDE[55] and the US Coast Guard Computer-Assisted Maritime Threat Evaluation System (CAMTES)[56]
- The FFA Regional Fisheries Surveillance Centre[57];
- China's Marine Surveillance platform that integrates under the umbrella of the People's Liberation Army Navy (PLAN) the following maritime agencies:
    - the State Oceanographic Administration (SOA),
    - the Marine Environmental Forecast Service (MEFS),
    - the Bureau of Fisheries (BOF),
    - the Fisheries Law Enforcement Command (FLEC),
    - the Maritime Border Defence Force (MBDF),
    - China Marine Surveillance (CMS),

Article 18.3(e) requires "recording and timely reporting of vessel position, catch of target and non-target species, fishing effort and other relevant fisheries data in accordance with sub-regional, regional and global standards for collection of such data. Article 18.3(g)(iii) mandates flag States to conduct monitoring, control, and surveillance of their vessels by, inter alia, "the development and implementation of vessel monitoring systems [VMS], including, as appropriate, satellite transmitter systems, in accordance with any national programs and those which have been sub-regionally, regionally or globally agreed among the States concerned." Annex I provides standard requirements for the collection and provision of data, including on vessel positioning and fishing activity.

[52] https://bluehub.jrc.ec.europa.eu/webgis_fish/

[53] The Copernicus Security Service supports EU policy by providing information in response to Europe's security challenges. It improves crisis prevention, preparedness and response in three key areas: maritime surveillance (implemented by EMSA), border surveillance, and support to EU External Action.

[54] http://www.efca.europa.eu/

[55] The US Navy's TOPSIDE data fusion system provides a comprehensive common operating picture of the maritime environment to support real-time decision making and situational awareness. System development was guided by the US Office of Naval Research. An evolving set of tools allows the same interface to be used to examine historical data to identify patterns and trends and to conduct statistical analyses. TOPSIDE integrates complex maritime system details and displays them in an intuitive way to greatly simplify the users' understanding of the operational environment.

To assist decision makers, TOPSIDE information is displayed on a time axis that shows a record of all previous system actions. Some of the information provided by TOPSIDE includes global AIS, VMS, and weather data, including ocean model forecasts (Navy Coastal Ocean Model) with ocean currents. Thus, in addition to being used for identifying and tracking potential illegal activities, TOPSIDE information is useful for search and rescue operations. TOPSIDE can integrate and fuse commercially available satellite imagery.

[56] CAMTES fills a gap in unclassified maritime domain awareness (MDA) systems architecture: It adds context to the "dots on the screen." The U.S. Naval Forces Europe-Africa / U.S. 6th Fleet (C6F) operations and intelligence watches and cells routinely use CAMTES as one of the data sources to research vessels.

They can easily research the background and history of a vessel including its owners, flags, ports of call, track history, and infractions. CAMTES also allows analysts to use geographic tripwires (vessels entering a defined area) and other filters to quickly find vessels which may be of interest.

They have used CAMTES to research vessels of interest for a number of reasons including those suspected of illicit transport or other law breaking, embargo breaking, and those that have been pirated.

European states have also successfully used it for similar purposes. It is also part of C6F's MDA engagement and training for its African partners.

They can use it to research vessels that are bound for their ports or are, for example, fishing in their exclusive economic zones. Whereas CAMTES compliments C6F's classified data sets, CAMTES is the only source of this type of information for these partners.

[57] It integrates the ongoing flow of FFA VMS, WCPFC VMS, and AIS data into a fused, coherent display that is assessed against each member nation's fishing license list, the WCPFC IUU and vessel of interest lists, individual fishing vessel log entries, flag-state catch and effort reports, and member nation boarding reports to generate the Regional Surveillance Picture (RSP).

- the China Coast Guard (CCG),
- the Maritime Safety Administration (MSA).

Not only could Oceana-GFW lose credibility in the political/media sphere where it mostly seems to operate; such state of affairs could ricochet and potentially damage that of other reputable **private/independent** fisheries monitoring, control & surveillance (MCS) initiatives, most of them already in existence well before the September 2016 launch of GFW[58]. Such (MCS) initiatives are:

- **Trygg Mat Tracking (TMT)**[59] that provides "*national fisheries authorities and international organisations with expert fisheries intelligence analysis, in support of enforcement actions and broader improvements in fisheries governance*."

- **Catapult-Pew Charitable Trusts** backed "***Eyes on the Seas***"[60] in the waters of Chile, Palau, Pitcairn Islands and the UK Overseas Territories;

- **OceanMind** that "*operates as a division of the Satellite Applications Catapult, a non-profit UK government innovation and technology initiative*".[61]

- **FISH-i Africa** formed in 2012 with the aim to improve cooperation, information and intelligence sharing in order to take enforcement actions against illegal fishing operators inside Comoros, Kenya, Madagascar, Mauritius, Mozambique, Seychelles, Somalia and Tanzanian waters.[62]

- **WildAid** and **Conservation International** which have achieved an important milestone in real-time monitoring of Ecuador's marine environment with the installation of a long-range surveillance camera and radio-based monitoring software (AIS) on Isla de la Plata.

- The **Environmental Justice Foundation (EJF) Fisheries Information Network (FIN)** & **Fisheries Transparency Initiative (FiTI)**, active in West Africa (Sierra Leone, Liberia, Ghana and Cote d'Ivoire) where it operates Community Surveillance projects (investigations, community monitoring) to gather data and evidence on potential illegal activities and report IUU fishing activities to decision makers nationally and across the globe.

- The **WWF-Navama-Technology for nature TransparentSea.org** initiative[63]

- **FishSpektrum**[64] that provides **Krakken V.8.2. WUVI database**, the World's largest and most complete Unique Vessel Identifier database, containing **1.697.327** historic references for a total of **779.823** fishing vessels and fish-carrier vessels from **184** fishing nations.

  Krakken V.8.2. WUVI database provides comprehensive characterizations of such vessels by way of **128** specific fields of information per vessel reference.

[58] The very first time AIS MMSI signals were ever used to independently monitor fisheries activity, dates to May-July 2009 when a Greenpeace team along with FishSpektrum personnel monitored the entire Turkish Bluefin Tuna fishing fleet operative inside their EEZ, from a self-built and operated terrestrial antenna station in Southern Cyprus.

[59] https://www.tm-tracking.org/

[60] http://www.pewtrusts.org/en/multimedia/video/2015/project-eyes-on-the-seas
[61] http://www.oceanmind.global/

[62] https://www.fish-i-africa.org/

[63] http://navama.com/ ; http://transparentsea.org/?lang=en
[64] www.fishspektrum.com

Such data taxonomy is fully standardized by way of a nomenclative reference system, therefore allowing for fully consistent footprint mapping and scaled rendering of fishing activities as well as for their optimal management and proper compliance scrutiny.

Worse still, credibility issues may well open up Oceana-GFW to the charge that the over-reporting or under-reporting in its findings and the lack of rigour in its statistical analysis is down to politically biased vigilantism.

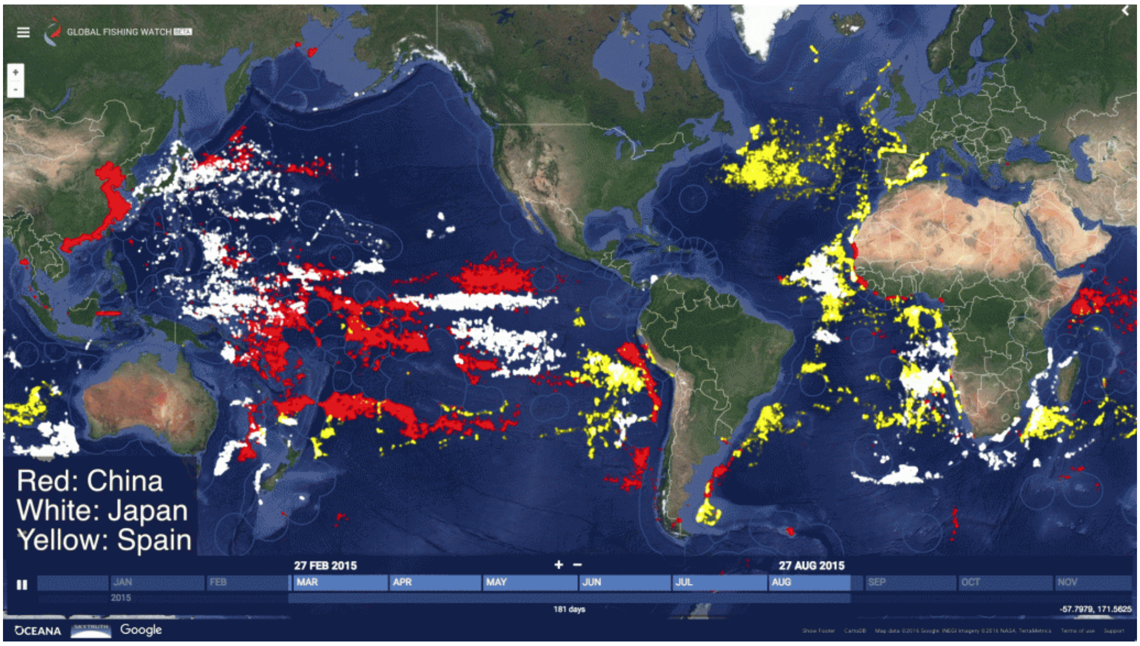

Figure 20: Poor coverage level and poor data quality, not only has a direct consequence as to the scientific pertinence of GFW's global footprint maps; it indeed yields a "geo-political" bias as to coverage and mapping by nationality of vessels involved as well as by geographical areas. Such issue could become highly controversial as fishing nations and/or vessel operators for which GFW's AIS MMSI signal coverage seems to be acceptable, may rightfully reject GFW's mapping production as a whole, solely based on an "arbitrary" level of coverage for a number of flags and fishing grounds.

The charge that the report is skewed more towards activism rather than a true reflection of the situation at sea could be labelled at the authors of the study by either vessels that have been materially misstated as reefer vessels transhipping fish at sea and by those sections of the industry that want to continue to flout the rules.

It is our understanding that NGOs such as Oceana scrupulously adhere to honest reporting and respect for the science in everything else they do.

This is why we have written this preliminary report. We as an organisation, like Oceana and the other GFW partners are truly committed to stopping the worst practices of the fishing industry.

Satellite technology offers the best opportunity in a generation to increase independent control of the international fishing industry and the oceans they and we depend on, but only if the technology is backed-up by accurate data, duly-processed fact-checking and expert knowledge on fisheries.

Global Fishing Watch must now move from a public-facing awareness-raising tool to a credible detection and mapping system that has the scientific rigour to help bring rogue fishing industry to order and manage a sustainable future for fish and fishermen across global oceans.

Competing interests: The author declares that no competing interests exist.

List of pictures and figures

End notes

[i] *The Safe Ocean Network, an initiative U.S. Secretary of State John Kerry first announced at the second Our Ocean Conference in 2015, seeks to build a global community to strengthen all aspects of the fight against illegal fishing including detection, enforcement, and prosecution.*

Illegal fishing is a worldwide problem estimated to cost the global fishing industry billions, possibly tens of billions, of dollars a year. It undermines sustainable fisheries management and degrades global environmental, food, and economic security. Organizations and individuals engaged in illegal fishing may be involved in other illicit activity and transnational crime ranging from human rights abuses and tax evasion to weapons and drug trafficking.

The Safe Ocean Network is focused on increasing collaboration between countries and organizations combating illegal fishing around the world. Sharing knowledge and technology is vital to understanding what resources are committed and preventing duplication of efforts in the global fight against illegal fishing. Sharing information and data is essential to catch illegal fishers as they move from the waters of one country to another and over the high seas, transfer fish between boats, and offload illegally caught fish around the world.

The world agreed as part of the Sustainable Development Goals to a target of ending overfishing, illegal, unreported and unregulated fishing and destructive fishing by 2020. Ultimately, the Safe Ocean Network will contribute to achieving this goal.

The Safe Ocean Network has brought together 46 governments and organizations to share knowledge and better coordinate to combat illegal fishing around the world. More than 40 counter illegal fishing projects worth over $82 million are affiliated with the Safe Ocean Network. Partners include: Australia, Bahamas, Bangladesh, Cabo Verde, Canada, Chile, Costa Rica, the European Union, France, Gabon, Ghana, Indonesia, Italy, Japan, the Netherlands, New Zealand, Norway, Palau, Panama, Philippines, Portugal, Senegal, Seychelles, Spain, the United Kingdom, the United States of America, Vanuatu, the Centre for Advanced Defence Studies, the Consortium for Ocean Leadership, the Environmental Law Institute, the International Monitoring, Control and Surveillance Network, the International Seafood Sustainability Foundation, INTERPOL, mFish, Monterey Bay Aquarium, National Geographic Society, Oceana, Oceans 5, Pew Charitable Trusts, Secure Fisheries, Skytruth, the Stimson Centre, UN Office on Drugs and Crime, UN Food and Agriculture Organization, Vulcan, and World Wildlife Fund. More information about Safe Ocean Network projects can be found below.

Oceana, SkyTruth and Google are partnering to make Global Fishing Watch -- a big data technology platform that leverages satellite data to create the first global view of commercial fishing -- available to the public for free. A number of organizations announced support for Global Fishing Watch.

Paul Allen's Vulcan announced $3.7 million to develop a satellite image analysis system to aid the detection of illegal fishing activity. The program will provide the enforcement community with greater insight into vessels that may be engaging in illegal fishing.

The Pew Charitable Trusts and Satellite Applications Catapult will continue to support Project Eyes on the Seas, a technology platform that combines satellite monitoring and imagery data with other information such as fishing vessel databases and oceanographic data, to help authorities detect suspicious fishing activity. The system can synthesize and analyze multiple layers of data in near real time to monitor and identify suspicious vessels around the globe and alert authorities to investigate and take action.

The International Monitoring, Control, and Surveillance Network is developing a centralized data base of vetted qualified monitoring, control, and surveillance (MCS) experts available to national authorities and international institutions for consultancy and capacity-building projects in the field of fisheries MCS.

The World Wildlife Fund announced DETECT IT: Fish, a web-based tool, which uses big data analytics to identify, compare, and analyze trade discrepancies and irregularities in global fish trade data to help discover and investigate IUU activities. DETECT IT: Fish holds the potential to reduce IUU by 50% by 2020, when utilized with other effective tools and policies. DETECT IT: Fish was one of the winners in the 2016 Hewlett Packard Enterprise's competition, Living Progress Challenge.

The Stimson Centre and Pristine Seas – National Geographic announced the launched of their new website "Secure Our Oceans" at secureoceans.org which for the first time provides policy makers with a comprehensive and neutral catalogue of technologies that can be used to combat illegal fishing and aims to match countries needs with detection and enforcement technology products.

INTERPOL's Project SCALE supports international investigations and the prosecution of criminals involved in illegal fishing and associated crime. This is done through cooperation between clusters of law enforcement agencies from various jurisdictions, as well as by collaborating with international partners. Project SCALE has created coherent international law enforcement connectivity for meaningful collaboration, planning and direction towards achieving professional investigative responses worldwide. The project's focus on illegal fishing activities and associated criminality, including fraud, avoidance of *taxes, handling of stolen goods, corruption, money laundering, document falsification, and human trafficking, etc., have enabled a holistic analysis and approach in tackling criminal supply chains.*

The Environmental Law Institute and National Geographic announced $86,000 for a Model Fisheries Law project to identify regulatory approaches that nations can take to develop or enhance their legal frameworks to provide effective authority for Marine Protected Area (MPA) enforcement and compliance.

The NGO Centre for Advanced Defence Studies (C4ADS), in partnership with the private firm Windward, is working to map and investigate the beneficial ownership, logistical, and financial networks of IUU vessels and their associated companies using advanced data analytics developed for the national security community.

The United Kingdom announced the establishment of Ocean Innovation Hubs in the UK Overseas Territories that have Marine Protected Areas. Building on the collaborative approach the UK and US are taking in the British Indian Ocean Territory, we will enable countries to work together to test new approaches to combating illegal fishing.

The FISH-i Africa Task Force enables authorities to identify and act against large-scale illegal fishing. The aim is to build a robust and effective mechanism to catalyze enforcement actions and secure an end to illegal fishing in the Western Indian Ocean. The Task Force countries of Comoros, Kenya, Madagascar, Mauritius, Mozambique, Seychelles, Somalia and the United Republic of Tanzania form the core of FISH-i Africa. The coordinating team is led by Stop Illegal Fishing, supported by The Pew Charitable Trusts and advised by Nordenfeldske Development Services, Trygg Mat Tracking, the Indian Ocean Tuna Commission, the Indian Ocean Commission, and other experts.

The European Union announced a $470,000 modernization project to update the European Fisheries Control Agency application to provide EU Member States the ability for worldwide vessel tracking, as well as a commitment that EU Naval Forces operating in the Indian Ocean will collect information about fishing activity in Somali waters whenever possible and submit data to the Indian Ocean Tuna Commission to facilitate prosecutions.

The International Seafood Sustainability Foundation, announced $600,000 over two years to support the use of electronic monitoring, electronic reporting, and a ProActive Vessel Register to enable sustainable fisheries management and market transparency. Efforts are focused in Ghana, Federated States of Micronesia, Cook Islands, Fiji, Republic of the Marshall Islands, Solomon Islands, New Zealand, Tonga, Samoa and Indonesia, and supported by Areas Beyond National Jurisdiction Tuna Project, World Wildlife Fund, the Global Environment Facility, the UN Food and Agriculture Organization, the Pacific Islands Forum Fisheries Agency, the Western and Central Pacific Fisheries Commission, and the Secretariat of the Pacific Community.

The Monterey Bay Aquarium announced $340,000 over the next 2 years in initiatives to address IUU fishing activities in the Asia – Pacific region, including a new partnership with USAID and continued support from the David and Lucile Packard Foundation. Projects will improve the environmental and social performance of fisheries and aquaculture operations through strengthened traceability, new partnerships and incentives to access to the North American market.

The mFish initiative will enable small scale and artisanal fishermen with mobile technology services and applications to report illegal fishing activities. Applications and services will initially be available in Indonesia with plans to expand availability to Malaysia then across south, south-east Asia, Africa and Latin America. Reports of illegal fishing activity will be shared with relevant government authorities for follow up.

New Zealand announced that it will undertake high seas fisheries patrols of the South Pacific Longline Tuna Fishery in 2017. New Zealand will also institute a pilot project to undertake genetic testing of tuna both in New Zealand ports and on high seas fisheries patrols to detect misreporting of fish species that takes place amongst commercial tuna longline vessels operating in the southern albacore fishery.

Oceans 5, the Smithsonian Institution, Wildlife Conservation Society, and Centre for Marine Studies announced a $1.3 million MesoAmerican Reef Initiative to implement electronic licensing, vessel tracking, and catch documentation systems in Belize and Honduras.

Chile announced the establishment of the Nazca Desventuradas Marine Park around the San Félix and San Ambrosio Islands as a hub for the testing of detection technologies to monitor illegal fishing activity in the park.

The United States and Canada announced a nine-month pilot project to probe the extent to which certain prohibited fish species are available for sale.

Italy announced the entry into force of their new legislative framework to regulate swordfish fisheries in the Mediterranean. The new rules – in the framework of the European Common Fishery Policy - significantly reduce the number of Italian vessels authorized to target swordfish; introduce mandatory notification requirements for all vessels; and, forbid possession of certain fishing equipment aboard vessels targeting swordfish in order to prevent the illegal use of such equipment.

The Netherlands announced $1 million for the development of a device called a "black box" that can be installed on fishing boats to continuously monitor and track vessels and provide opportunities to improve compliance with fisheries regulations.
Spain announced $7.8 million over four years to maintain and improve an Integrated Control System to ensure sustainable fisheries management by controlling and monitoring vessels, imports of fishery products and individuals and companies associated with the Spanish fishing sector.

The United States announced $2 million to support a number of Safe Ocean Network projects, including: $900,000 for Port State Measures Agreement (PSMA) Capacity Building in Central and South America; $300,000 for maritime enforcement training in the Pacific, South East Asia and Bay of Bengal to be delivered predominantly by U.S. Coast Guard personnel; $300,000 to the UN Office of Drugs and Crime (UNODC) to support fisheries investigations and prosecutions in the Western Indian Ocean; and $500,000 for a data mining project that would target the known bad actors and develop risk profiles to identify other vessels that may be illegally fishing.

The United States will continue to support SeaVision, an unclassified, internet-based maritime information sharing and visualization tool that combines vessel location information from the Maritime Safety and Security Information System (MSSIS) as well as commercial data feeds in near-real time

The United States announced a suite of USAID activities worth an anticipated $55 million over five years to combat illegal fishing and promote sustainable fishing in Indonesia, the Philippines, and West Africa. Activities include: strengthening of law enforcement and fisheries management capacity in Indonesia, including through technical assistance to Indonesia's National IUU Task Force; enhancing environmental law enforcement, and working with communities to reduce illegal fishing and wildlife trafficking in the Philippines; and capacity building for law enforcement officials in Ghana and the West Africa region.

The United States announced a set of programs to combat illegal fishing worth $2.9 million over 5 years to support law enforcement training and capacity building in Indonesia, the Philippines and West Africa.

The United States announced a new suite of programs worth $2.846 million to tackle the root causes of forced labour in the fishing and seafood sector in Indonesia and Thailand.

The United States announced $143,000 for a coordinated effort by NASA, the U.S. National Oceanic and Atmospheric Administration (NOAA) Centre for Atmospheric Sciences, the Namibian Ministry of Fisheries and Marine Resources, and the North-West University of South Africa to test improved methods of using data from the Suomi-National Polar-orbiting Partnership (S-NPP) satellite for illegal fishing detection. The satellite uses a technology called the Visible Infrared Imaging Radiometer Suite (VIIRS) to identify vessels that may be illegally fishing at night through the use of light detection.

The United States announced $574,00 over two years to develop a fishing boat detection service for Asia and the Pacific using low light imaging data collected by the Visible Infrared Imaging Radiometer Suite (VIIRS), a space based sensor. At the request of fishery agencies, the U.S. National Oceanic and Atmospheric Administration (NOAA) supplies near-real time alerts for VIIRS boat detections in 86 marine protected areas in Indonesia and areas closed to commercial fishing in the Philippines. The VIIRS instrument is capable of detecting lights present at the earth's surface, including from fishing boats that use lights to attract catch at night and may be illegally fishing.

The Oceania Maritime Security Initiative (OMSI) is a Secretary of Defence program using Department of Defence (DOD) vessels transiting the Western and Central Pacific region to increase the Coast Guard's maritime domain awareness, ultimately supporting its maritime law enforcement operations in Oceania. Coast Guard law enforcement detachments embark aboard transiting US Navy vessels, joined by local law enforcement authority shipriders, enabling fisheries enforcement boardings.

The U.S. Coast Guard is pursuing new shiprider agreements with Vanuatu and Fiji and maritime law enforcement training in the Pacific, Bay of Bengal, and the Philippines.

Beginning in September 2016, the U.S. Maritime Domain Awareness Executive Steering Committee will launch a crowd-sourcing competition in conjunction with the White House's Open Government initiative, with competitors vying to develop an algorithm capable of assisting countries to better identify and respond to illegal, unregulated, and unreported fishing. This Challenge, facilitated by NASA's Centre of Excellence for Collaborative Innovation and run on the TopCoder platform, is an effort to promote the goals of the Safe Ocean effort.

The 3rd annual Fishackathon, a weekend coding contest was held on April 22-24, 2016. It included several challenges encouraging the development of tools to assist fishermen and enforcement officers in combating illegal fishing. All entries, including the winning submissions, are available online at Fishackathon.com.

Source: https://m.state.gov/md261988.htm