

---

# **Global Fishing Watch**

## **Big Data, Research, and Analysis**

Resources for the Global Maritime Security Community

Tyler Clavelle and Gunther Errhalt

---

# Outline

- Data sources
- Methods
- Applications



Global Fishing Watch

# Data Sources



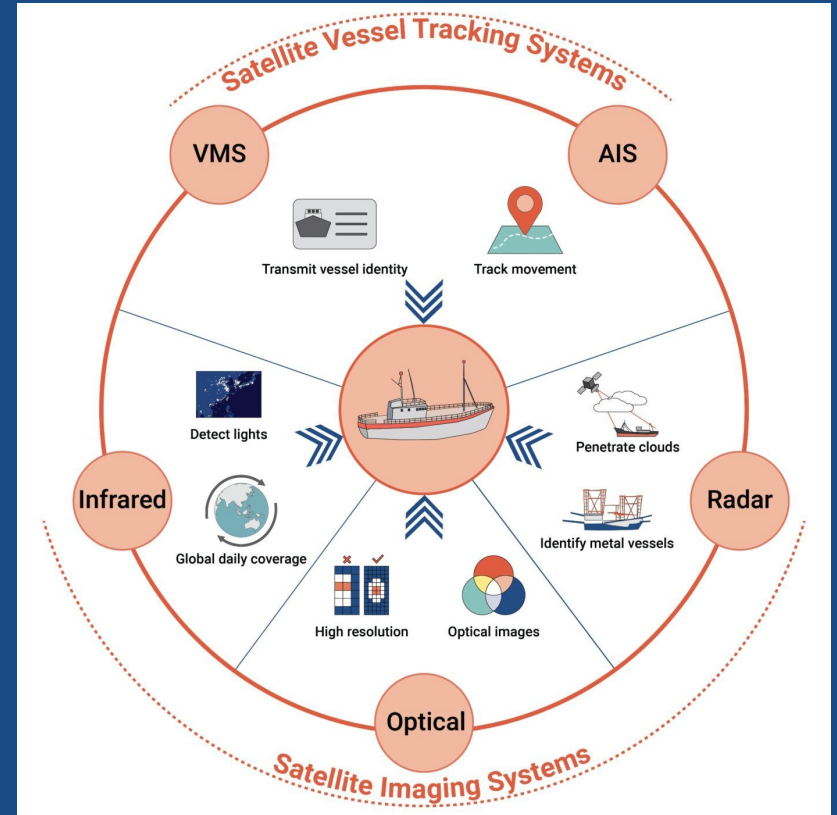
Global Fishing Watch

# Data fusion

Global Fishing Watch (GFW) fuses numerous data sources to detect, track, and identify vessels all over the world, every day

Vessel tracking systems provide data on fine-scale vessel movements, which we use to identify various fishing activities

Satellite imaging systems can help detect all vessels above a certain size and provide visual proof of activities



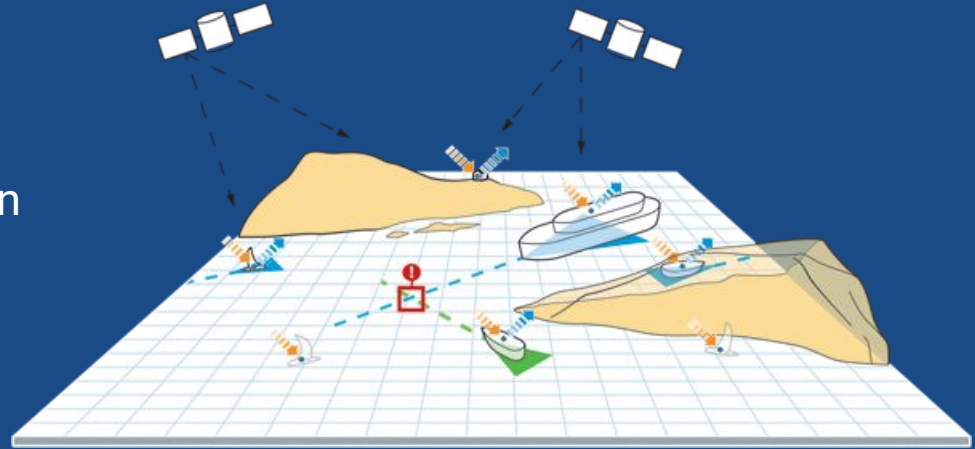
# Automated identification system (AIS)



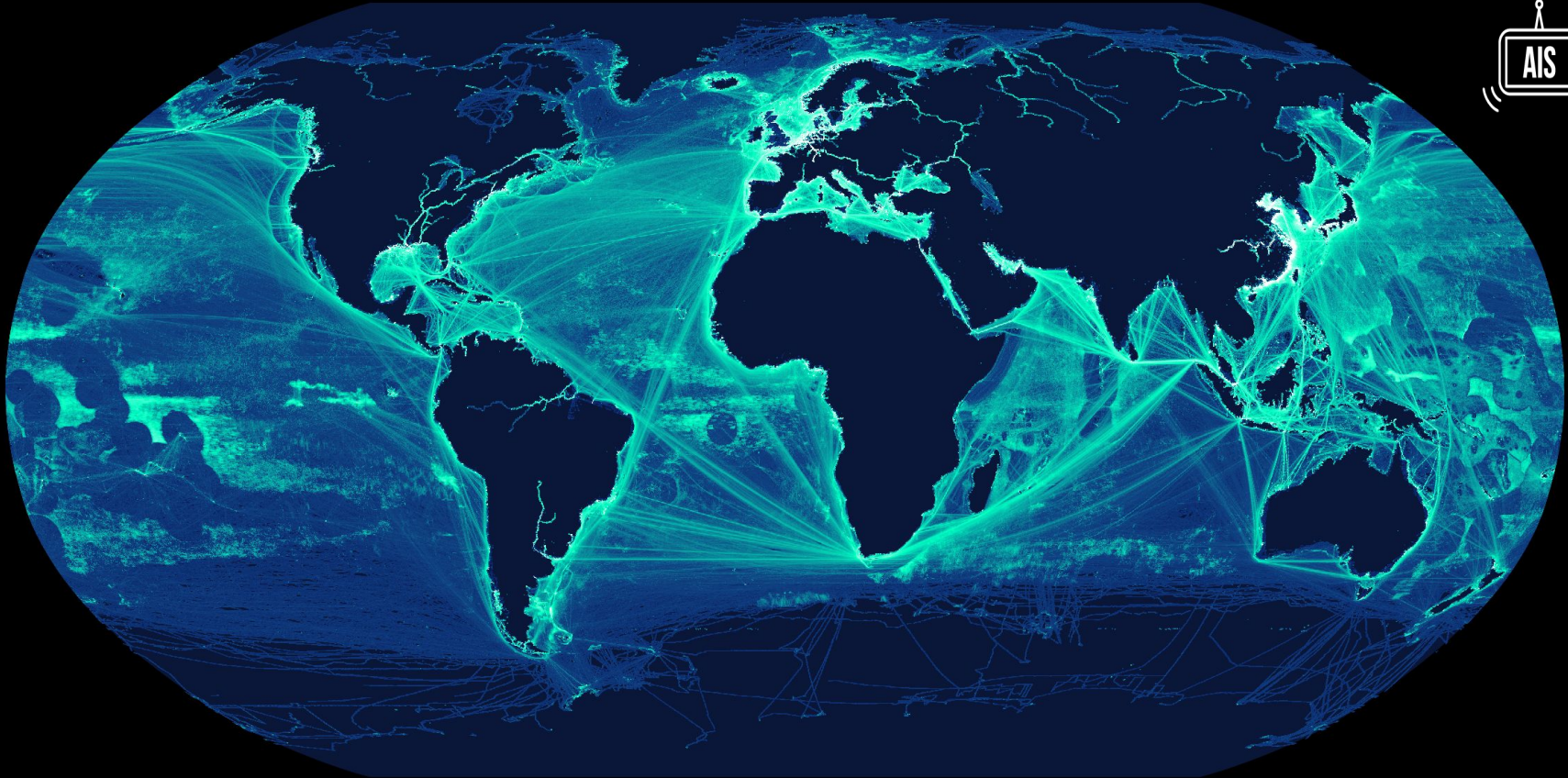
The automated identification system (AIS) is a vessel broadcast technology originally designed for ship-to-ship communication as a collision avoidance system.

AIS messages transmit a lot of information about a vessel, including identity, position, and speed, among others.

AIS messages are received by other ships and are picked up by both terrestrial and satellite receivers.



# Vessels with AIS, 2018



Hours of vessel presence per 100 km<sup>2</sup>



Global Fishing Watch

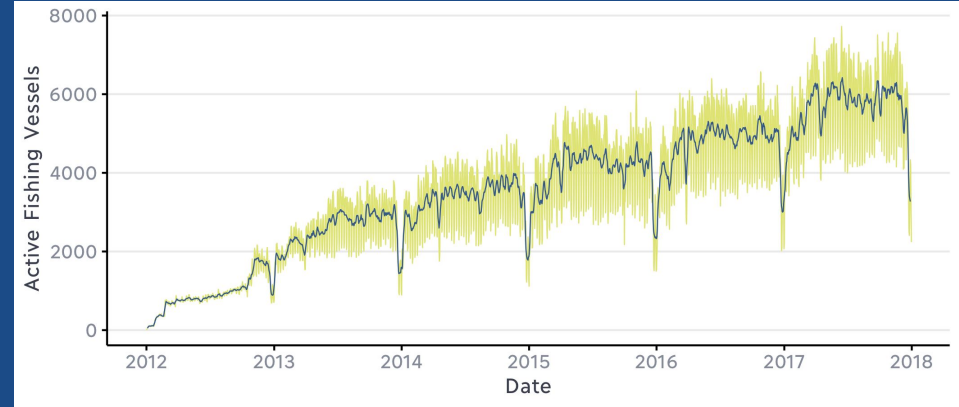
# AIS key considerations



AIS use is increasing over time

Most GFW AIS data (~75%) comes from terrestrial receivers

Every AIS device broadcasts a “unique” ID known as its Maritime Mobile Service Identity (MMSI)



The main types of AIS messages include position and identity messages. Identity messages do not include lat/lon, which can complicate analysis

Two main classes of AIS devices, A and B. Class A devices are stronger, ping more often, and are more expensive, which may explain why many fishing vessels use class B

# Fishing vessel coverage



AIS data includes only a small fraction (~70,000) of the world's estimated ~3 million fishing vessels.

Coverage is much higher for larger vessels, and vessels broadcasting AIS are predominantly from upper and upper-middle income countries.

The majority (~60%) of fishing vessels in AIS are Chinese vessels

Size Range	Estimated % Coverage
Less than 12 meters	< 0.4%
12-24 meters	14-19%
> 24 meters	52-85%



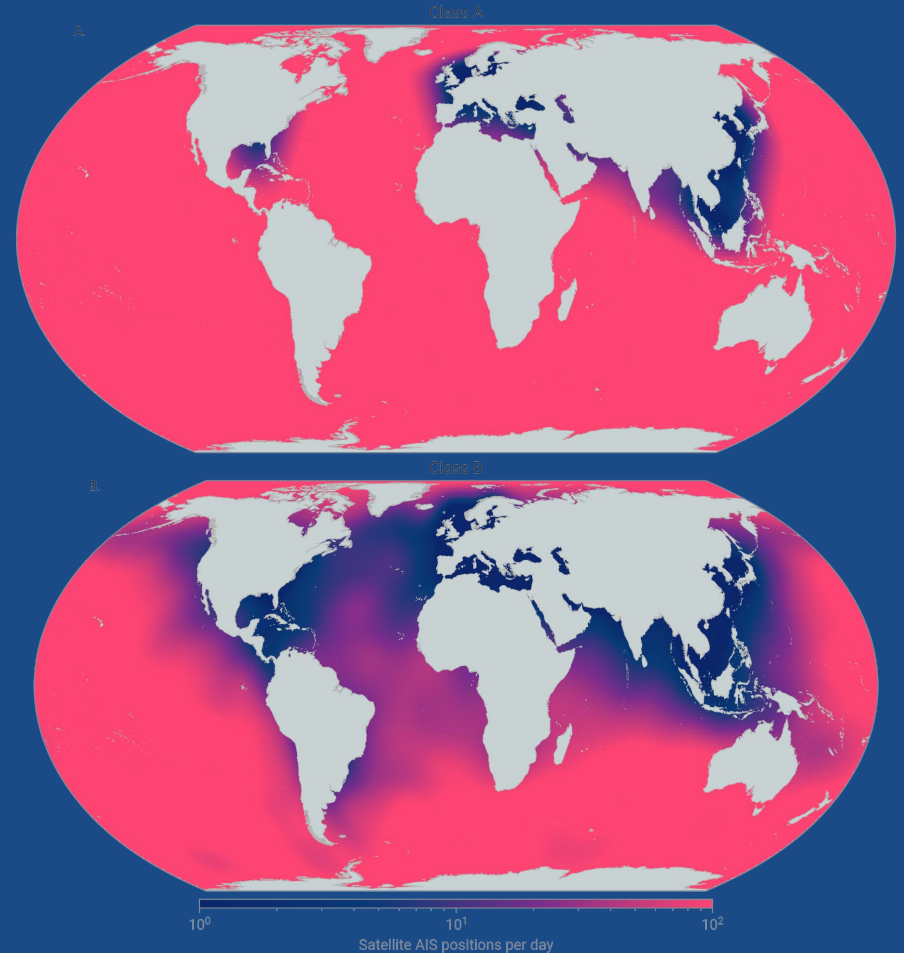
# Reception quality

Not every AIS message that is broadcast is recorded

Satellites must be overhead to receive signals, and terrestrial receivers only receive signals within line-of-sight

AIS messages can interfere with each other, preventing a receiver (mainly satellites) from recording them when many vessels are within range

Class A signals are stronger than class B and some AIS devices may be weaker than others



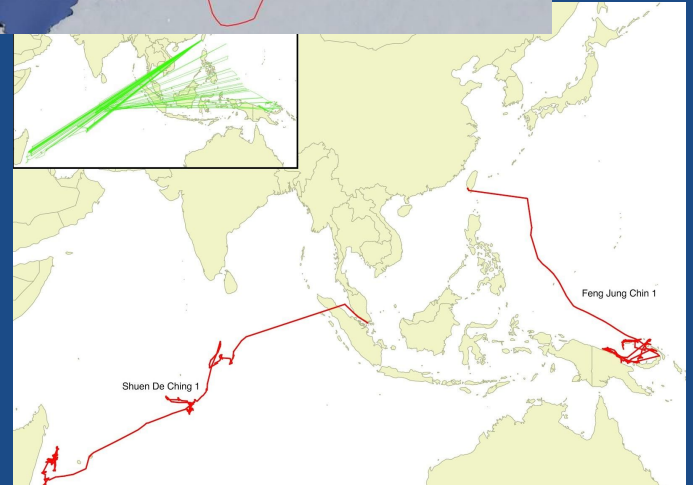
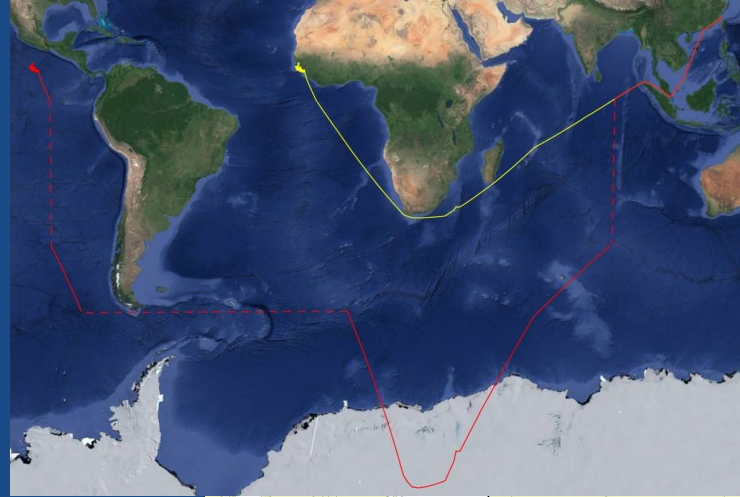
# Spoofing

“Spoofing” refers to when a vessel’s location and/or identity is obscured in its AIS messages.

Identity spoofing is when 2+ vessels simultaneously broadcast the same MMSI.

Location spoofing refers to when a vessel’s AIS positions are manipulated, obscuring their location (e.g. by adjusting lat/lon).

Correcting and/or separating these tracks can reveal suspicious activity, such as fishing in a foreign EEZ



# Vessel monitoring system

A fishing vessel monitoring system (VMS) is a private tool for the monitoring, control, and surveillance of fisheries activities by fisheries agencies.

Like AIS, a VMS comprises of a shipboard device that uses GPS to broadcast a vessel's location to satellite and/or terrestrial receivers.

VMS messages are usually broadcast at a fixed rate and relayed to a shore-based fishery monitoring center.

Countries often impose strict VMS use requirements and hefty penalties for violations

VMS data can complement AIS data in regions of poor AIS reception



13.5944, -114.6747

+

-

EN

LAYERS

Basemaps

Activity Layers

- Night Light Vessel Detections
- Fishing effort
- Indonesian VMS Fishing Activity
- Peruvian VMS Fishing Activity
- Panamanian International Fleet VMS Fishing Activity
- Chilean VMS Fishing Activity
- Vessel Encounters

Static Layers

ADD LAYERS

EDIT LAYERS



START 01 JAN 2021

Fishing hours

1 MONTH

END 25 JUN 2021

June

9.2708,  
-93.5536

+

-

↶

EN

🗺

LAYERS

Basemaps

Activity Layers

- Night Light Vessel Detections
- Fishing effort
- Indonesian VMS Fishing Activity
- Peruvian VMS Fishing Activity
- Panamanian International Fleet VMS Fishing Activity
- Chilean VMS Fishing Activity
- Vessel Encounters

Static Layers

ADD LAYERS EDIT LAYERS



# Methods



Global Fishing Watch

# Core datasets



## Fishing effort

Vessel-specific fishing activity identified from AIS/VMS data by GFW algorithms



## Vessel database

Comprehensive vessel information (MMSI, flag, gear type, length, authorizations, etc.) for all vessels listed on public vessel registries



## Port visits and voyages

Global database of anchorages visited by vessels broadcasting AIS and the voyages they make between ports



## Transshipment

Detection of potential transshipment events



## Non-transmitting vessels

Detection of vessels not broadcasting AIS or VMS using satellite imagery



Global Fishing Watch

# Fishing effort



GFW identifies *apparent* fishing activity in the AIS and VMS data.

We combine a comprehensive vessel database with two convolutional neural networks—a cutting edge form of machine learning model—to help us classify fishing vessels and predict when they are fishing based on their movements

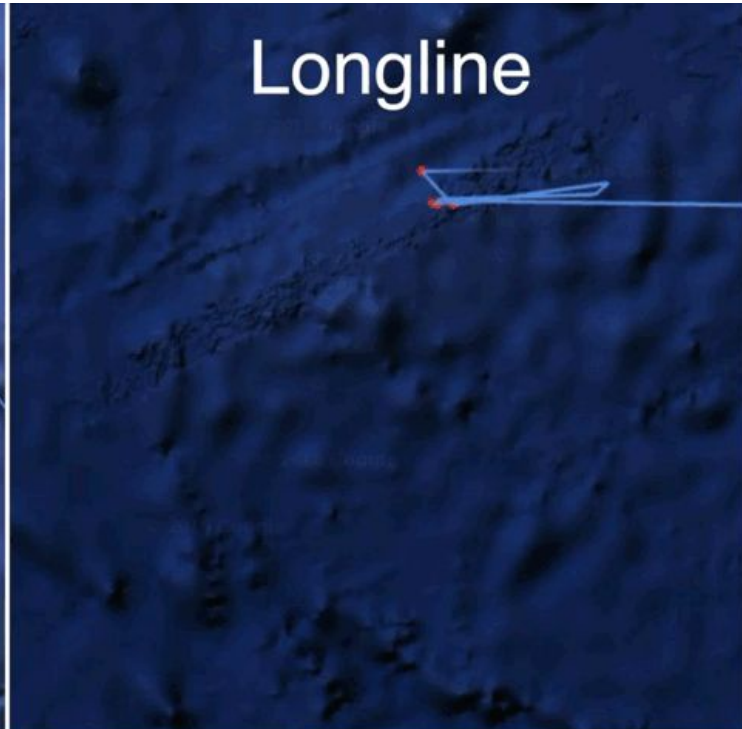
1. A vessel classification model looks at all the AIS positions for an MMSI and predicts the most likely vessel class (fishing or non-fishing) for that vessel
2. A fishing detection model gives every AIS position a fishing score from 0-1, with scores  $>0.5$  indicating fishing



# Trawl



# Longline

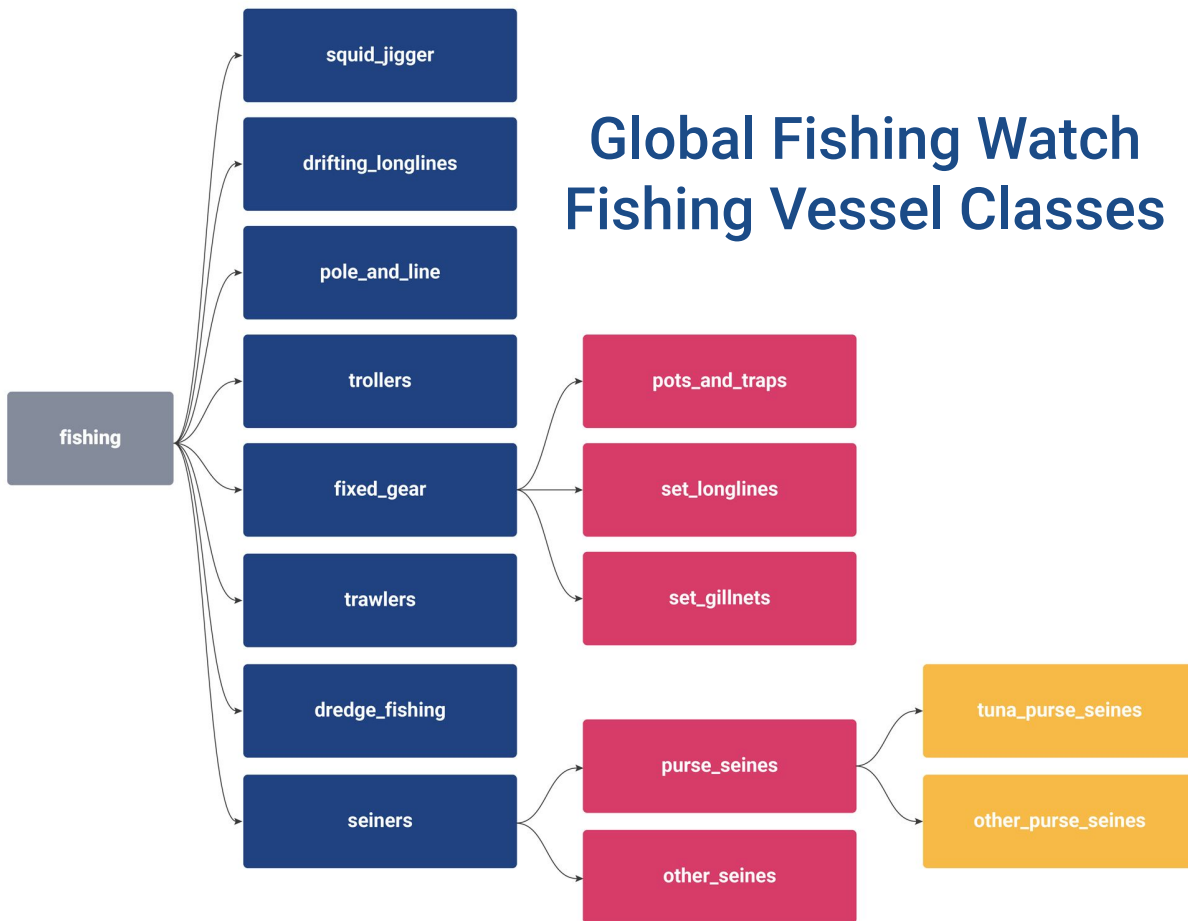


# Purse Seine

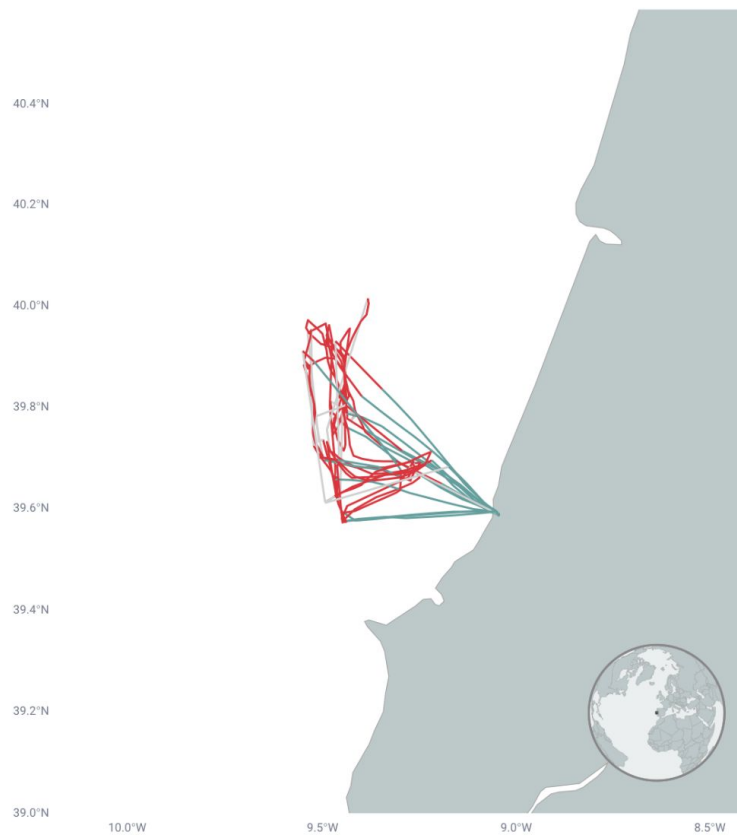




# Global Fishing Watch Fishing Vessel Classes



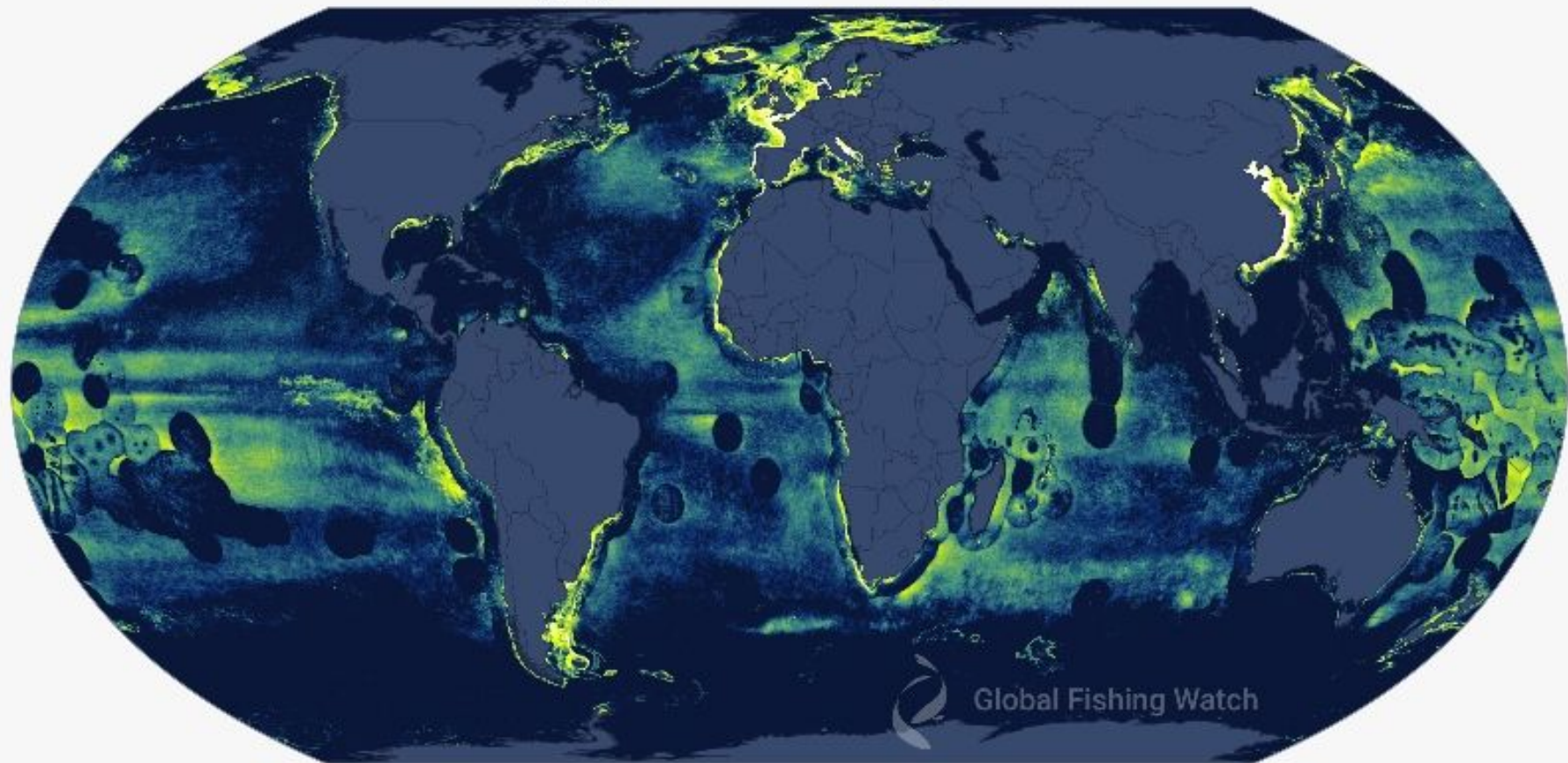
**VELLINO**  
263477000



— Steaming — Fishing



## Fishing by Vessels with AIS, 2012-2020



Global Fishing Watch

hours of fishing per km<sup>2</sup>

0.1 1.0 10.0 100.0

# Transshipment



Potential at-sea transshipment events between fishing vessels and refrigerated carrier vessels.

Encounter events occur when both the carrier and fishing vessels are observed on AIS within 500 meters of each other and travelling  $<2$  knots for at least two hours.

Loitering events occur when a carrier vessels is observed on AIS travelling  $<2$  knots for at least two hours, suggesting a transshipment event could've occurred with a fishing vessel not broadcasting on AIS.



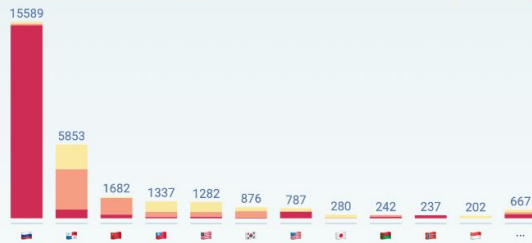
Credit: Francisco Blaha

ENCOUNTERS

LOITERING

Between Jan 1st 2017 and Apr 30th 2021, 723 carriers from 39 flag States had 29034 encounters .

Encounters by flag State of carrier



Authorized  
Partially authorized  
Unknown authorization

CARRIERS 723 | FLAGS 39 | PORTS 210

Victor Gavrilov	383
Vsevolod Sibirtsev	339
Bukhta Nagaeva	295
Lyra	267
Tambov	266
Zaliv Vostok	266
Kapitan Efremov	249
Piotr.Zhitnikov	245
Kapitan Teplyukov	236
Kamchatskiy Proliv	230
Pingtairongleng2	229
Vladivostok 2000	229
Full Kuo Shin	227



-14.7711 -95.0864



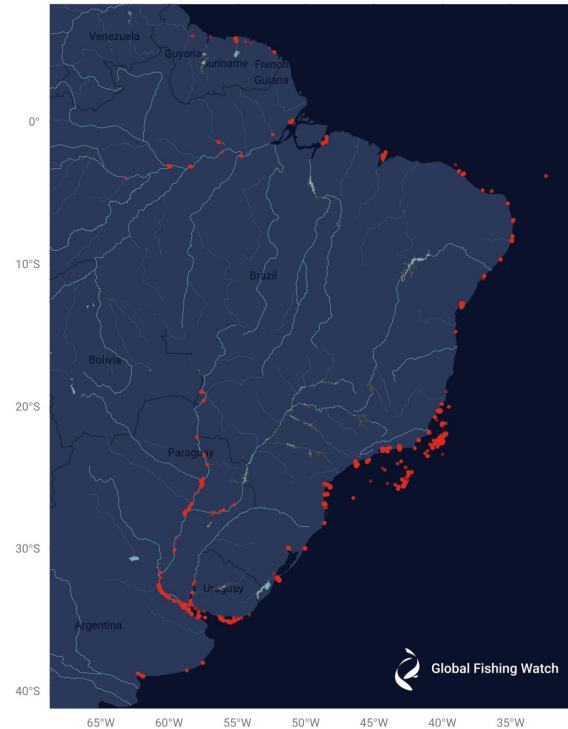
# Ports and voyages

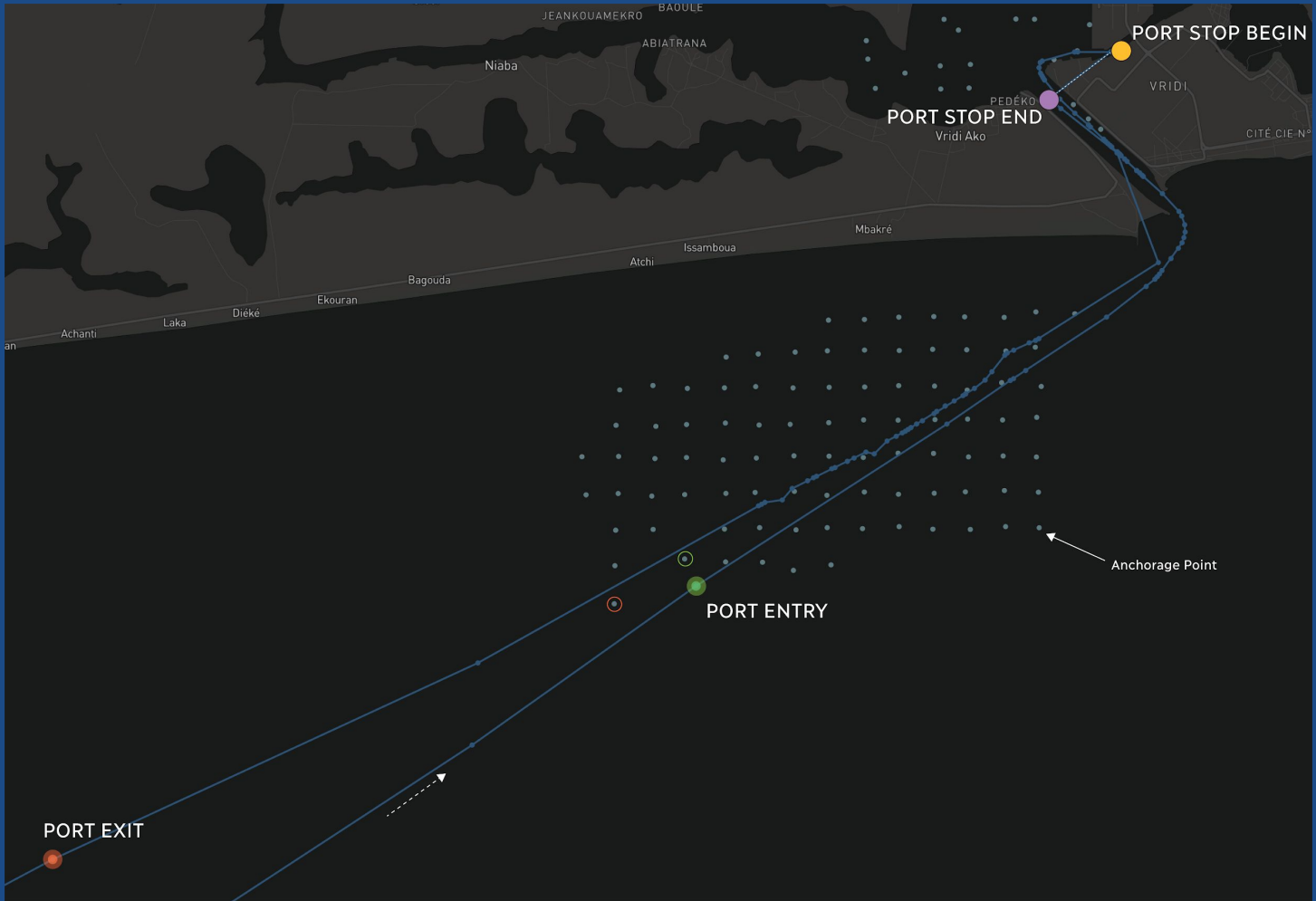
A global dataset of 166,000+ anchorage points grouped into ports and used to track port events and trips between port (voyages).

Anchorage points are identified by gridding the world into 0.5km cells and finding all cells where at least 20 individual vessels in the AIS data remained stationary for at least 12 hours.

Port events (entry/exit, stops, gaps) are identified using a rule-based algorithm that considers vessel speed and proximity to anchorage points.

Global Fishing Watch Anchorages Dataset  
Eastern South America







# Vessel registry database

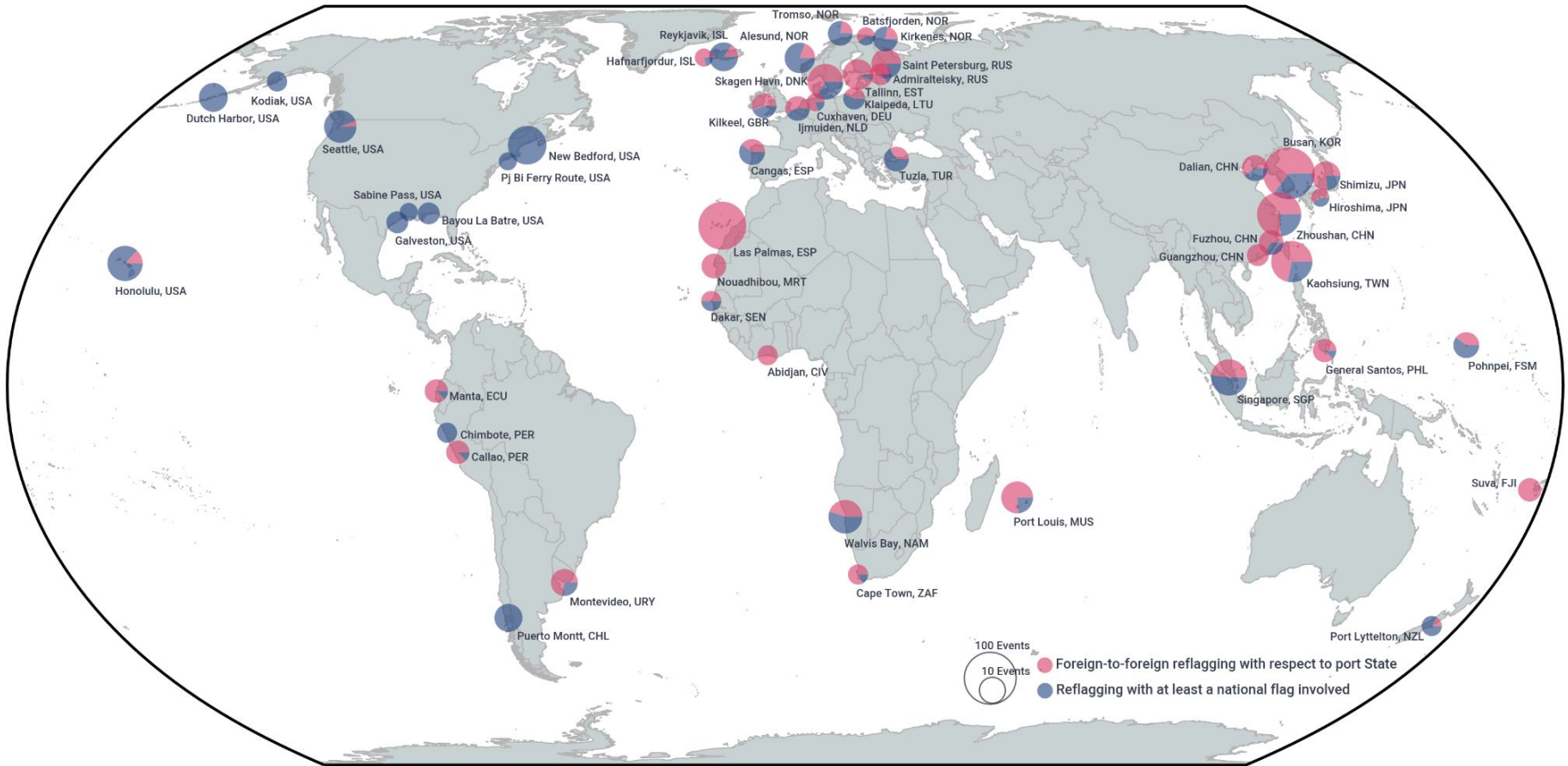


A comprehensive dataset of information sourced from public vessel registries and supplemented with AIS

- Vessel identity (ship name, callsign, IMO number)
- Characteristics (length, engine power, tonnage, crew size)
- AIS activity
- Authorizations (where it can operate)
- Ownership

Vessel identities from registries are matched to AIS data using multiple identity fields

## Top 50 ports in which vessels were reflagged (2012-2020)



# Dark targets



Vessel detections derived from global satellite imagery using various machine learning models.

- Synthetic aperture radar (SAR)
- Visible Infrared Imaging Radiometer Suite (VIIRS), aka “night lights”
- Optical imagery

Detections are matched to AIS when possible in order to determine vessel identity.

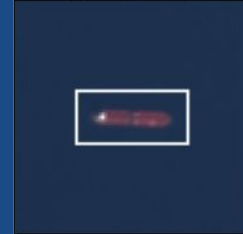
Vessel detections that cannot be matched are assumed to represent vessels that are not broadcasting AIS (the “dark fleet”).



0405 (1 130, 40 816)



0405 (1 291, 41 072)



0405 (1 213, 41 051)



# Datasets and Code



## DATASETS

### Bathymetry

Bathymetry layer from the General Bathymetric Chart of the Oceans (GEBCO) used to assign a depth for every AIS position message.

LAST UPDATE

03/24/2020

[SEE MORE](#)

### Distance from port in meters

At one kilometer resolution, the distance from port (in meters) of every point in the ocean.

LAST UPDATE

11/23/2020

[SEE MORE](#)

### Distance from shore in meters

At one kilometer resolution, the distance from shore (in meters) of every point in the ocean.

LAST UPDATE

03/20/2020

[SEE MORE](#)

### Miller et al. (2018). Identifying Global Patterns of Transshipment Behavior

Transshipment data from the 2018 publication in *Frontiers in Marine Science* by Global Fishing Watch Senior Data Scientist Nate Miller et al. titled

### Anonymized AIS training data

Anonymized AIS data with labeled fishing positions suitable for training machine learning solutions.

### Anchorage

Global database of anchorage locations where vessels congregate

# Research program

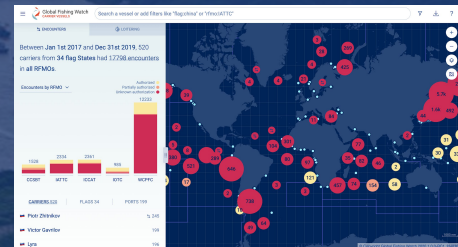
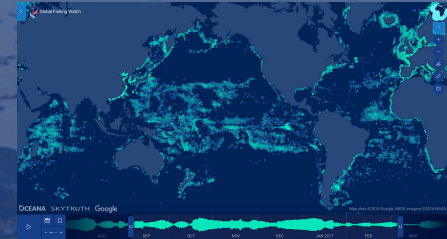
Idea or  
Prototype



Research  
Projects



Management  
Tools



# Case Study

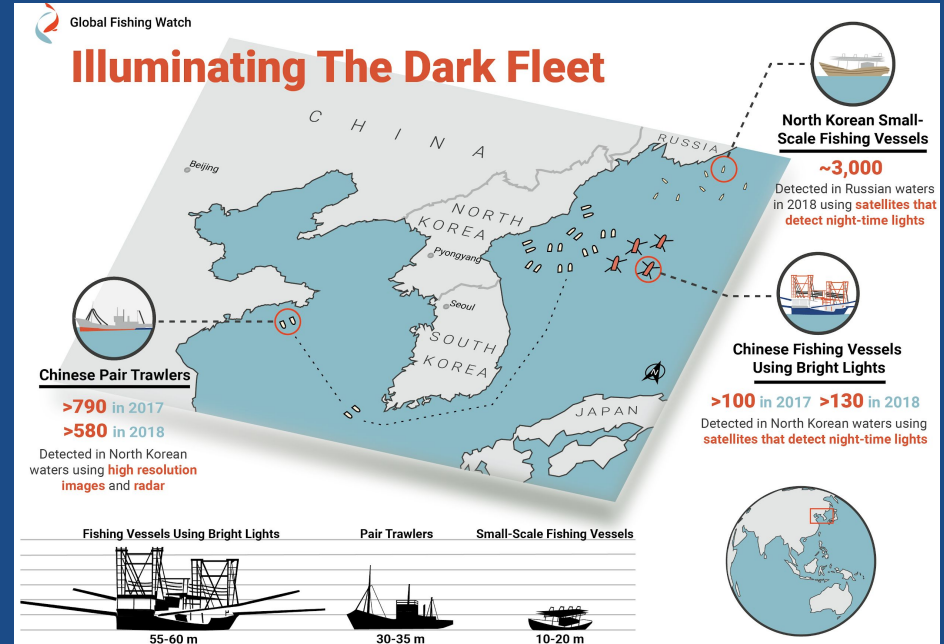
## Illuminating dark fishing fleets in North Korea

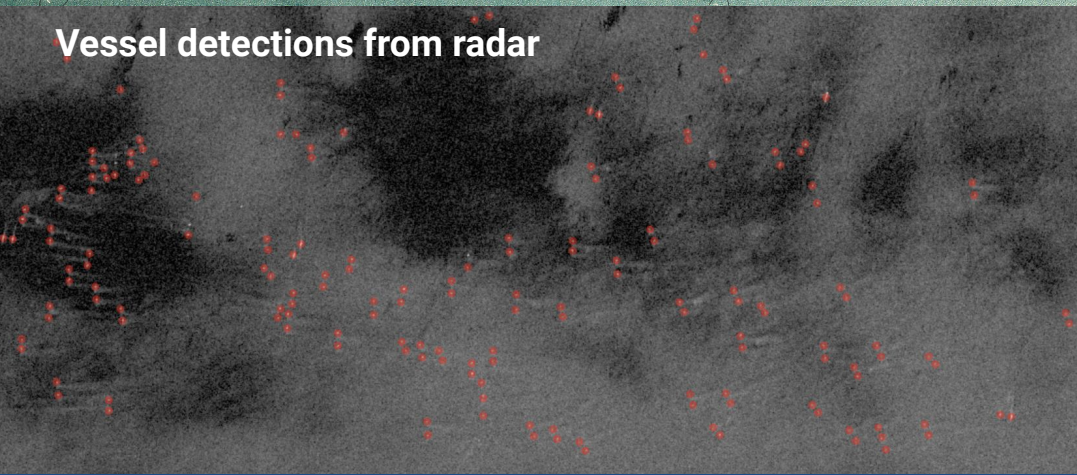
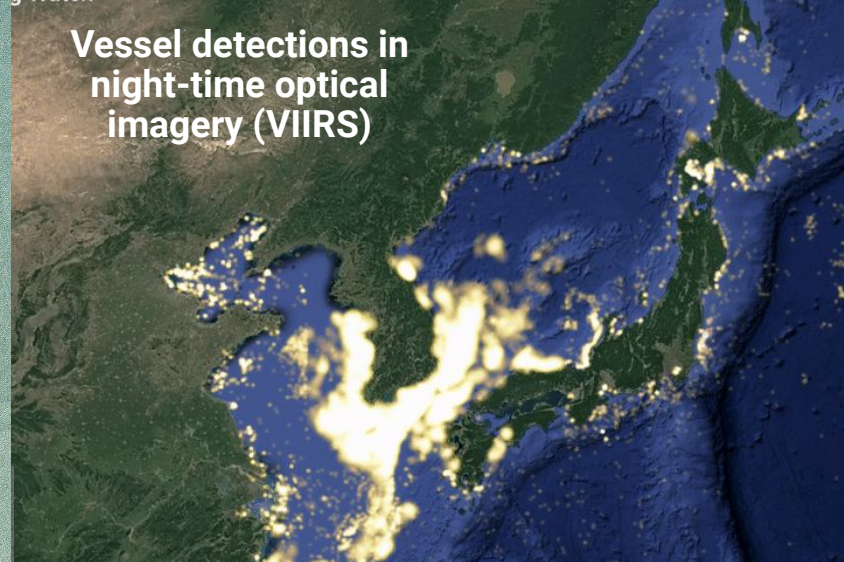
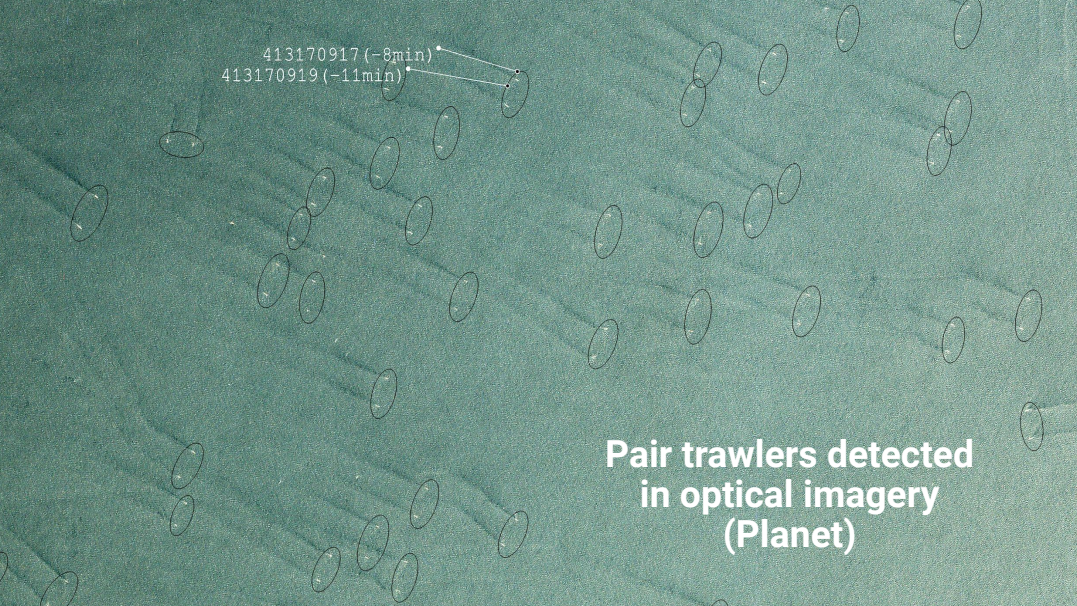
Alerted by South Korean authorities of suspicious activity by Chinese vessels.

Developed machine learning models to detect vessels in multiple satellite imagery datasets and matched detections to AIS.

Proved that a large fleet of Chinese vessels were operating in North Korean waters in violation of UN sanctions and Chinese domestic law.

Findings were published in a peer-reviewed scientific journal and received extensive media coverage.





# Applications



Global Fishing Watch



# Analysis Program

## Reports

- Vessel-of-interest analysis
- Dark target analysis (VIIRs, SAR, optical)
- IUU fleet analysis

## Assessments

- Transshipment operations
- Coastal State and port risk
- Flag State vessel monitoring

## Patrol Support

- Strategic, operational, and tactical

## Capacity Building

- Analysis training



Global Fishing Watch

# IUU Vessel Report: MV NIKA

Data to back investigation of illegal activity in Galapagos MPA

GFW data helped show transshipment involved in Chinese vessel caught carrying illegal sharks and shark fins

- Confiscation of the Chinese ship
- Arrest of its 20 crew
- Jail time for vessel operators
- \$6M fine

**\$6M**

Fine on Chinese  
Transshipment  
Vessel



Global Fishing Watch



---

**“Global Fishing Watch provided us with the much needed analysis about the movements of MV NIKA. GFW and INTERPOL have helped us to predict the movements and position of MV NIKA with their timely provided information and analysis. This type of information sharing and cooperation must be promoted for other countries to adopt.”**

**- Mas Achmad Santosa, former Coordinator of Special Advisors of the Indonesian Minister of Marine Affairs & Fisheries/Commander of Task Force 115.**

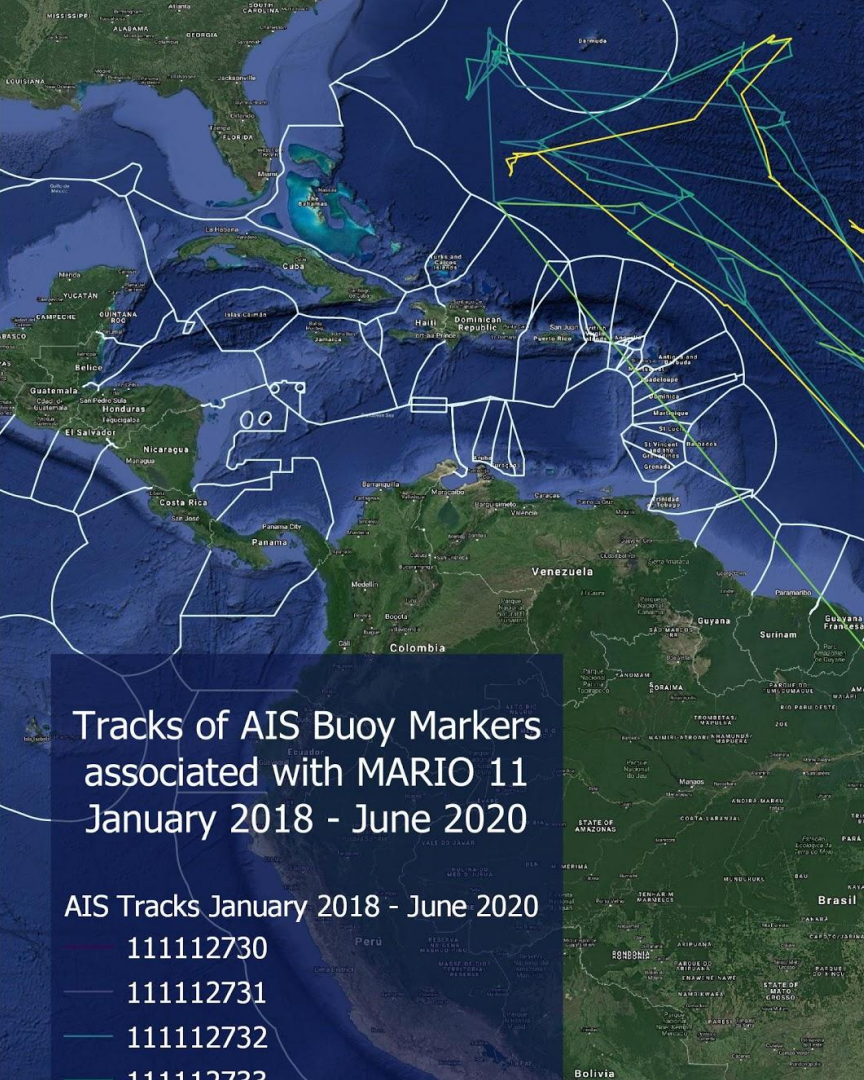


**Global Fishing Watch**

# Dark Target Analysis

Provided track analysis to partner organisation TMT for a 2020 report on IUU Longliner and Mini Reefer Operations in the Atlantic

Provide MIFC LANT with potential AIS targets to locate and track IUU vessels through their AIS fishing gear transponders



Tracks of AIS Buoy Markers  
associated with MARIO 11  
January 2018 - June 2020

AIS Tracks January 2018 - June 2020

111112730

111112731

111112732

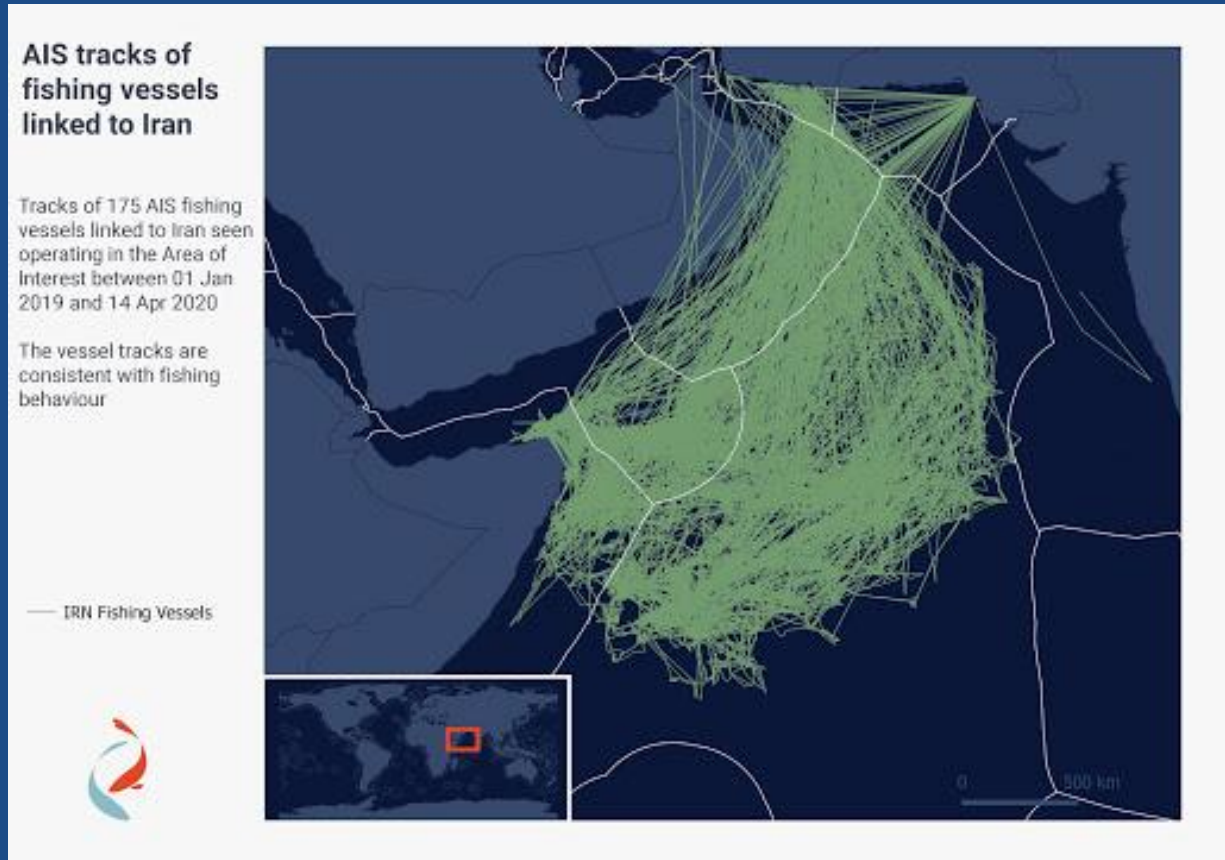
111112733



# Dark Target / IUU Fleet Somalia IUU Report

Analysis by GFW and Trygg Mat Tracking revealed **175 Iranian vessels** in Somali and Yemeni waters.

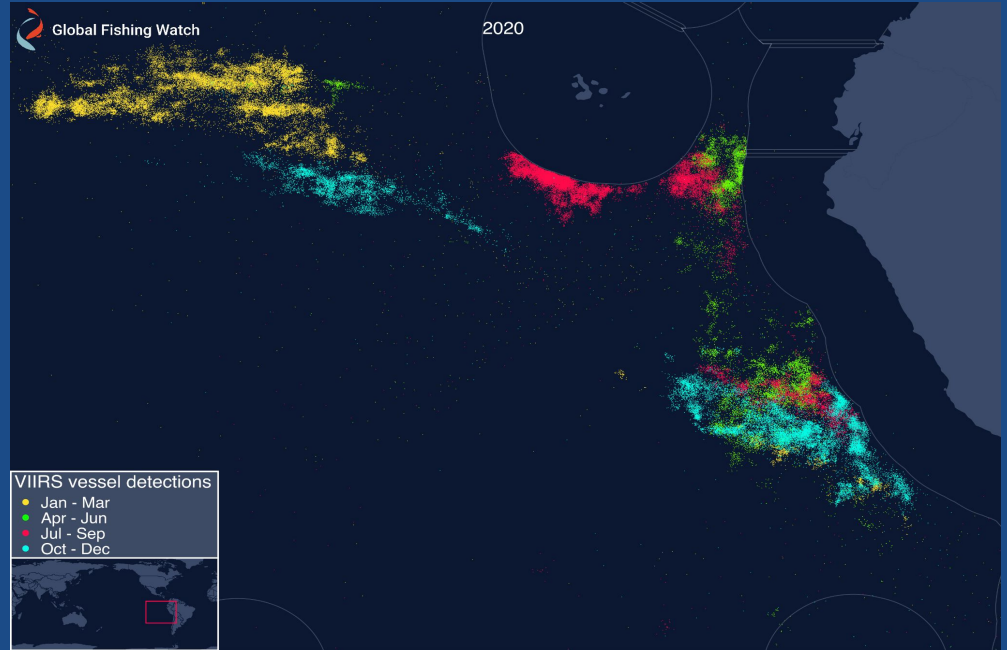
This represents one of the world's largest illegal fishing operations.



# Squid Fleet Report

Since last year, GFW has been monitoring the activity of the squid fleet in the Southeast Pacific Ocean

This report seeks to better understand and analyze the squid fleet activity in the region during 2020 by combining different sources of information (AIS, SAR, and VIIRS)



Global Fishing Watch

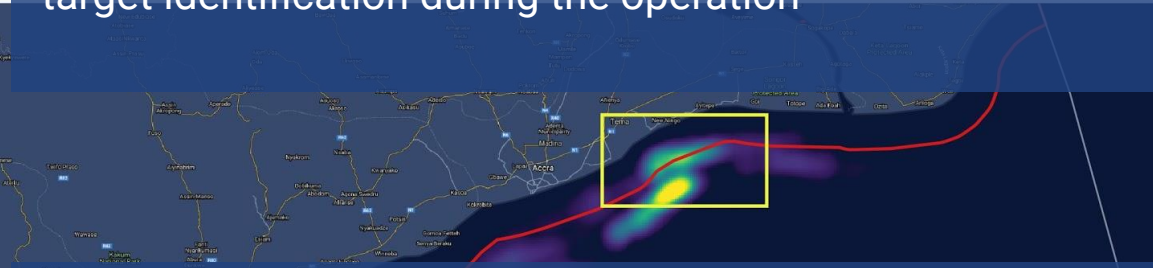
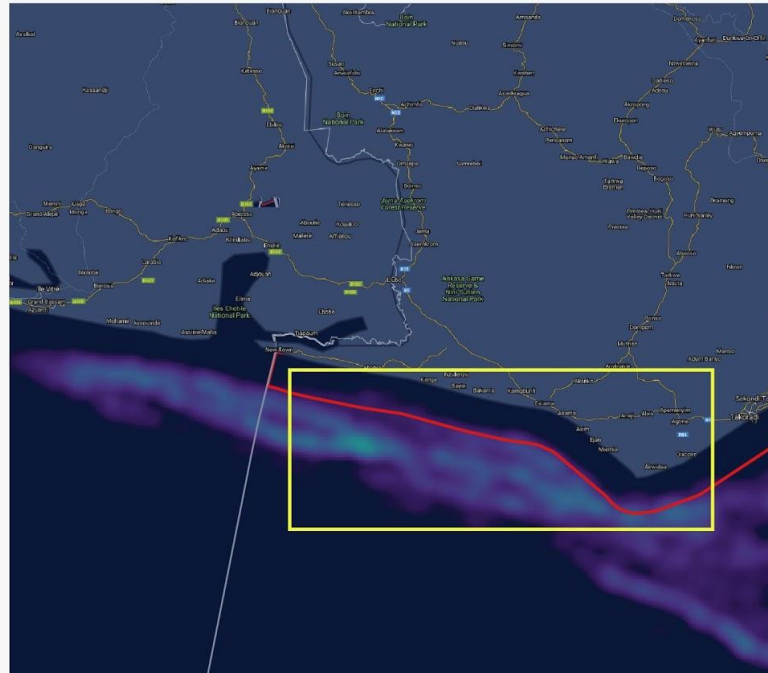


## Fishing effort by trawlers using AIS in the Ghana EEZ

# Fisheries Patrol Support

Ghana Navy supported by UNODC and TMT - August 2020

GFW provided pre-patrol analysis, SAR analysis and live target identification during the operation



The operation resulted in 5 ships arrested and 4 ships cautioned.

Built confidence to continue operations with further success



GFW support  
provided for  
2019 USCG  
patrol in the  
North Pacific





A map of the Pacific Ocean region, showing patrol routes and zones. The map is overlaid with a yellow grid. The zones are labeled Alpha, Bravo, Charlie, and Delta. A white line with yellow dots represents a patrol route. A red shaded area is visible in the Charlie zone. A black banner at the top contains the text 'APPROXIMATED FINAL PATROL'. A blue banner at the bottom contains the text 'THE 2019 PATROL PRODUCED A 344% INCREASE IN VESSEL BOARDINGS AND AN 867% INCREASE IN IDENTIFIED VIOLATIONS COMPARED TO 2018.'

# APPROXIMATED FINAL PATROL

THE 2019 PATROL PRODUCED A **344%** INCREASE IN VESSEL BOARDINGS AND AN **867%** INCREASE IN IDENTIFIED VIOLATIONS COMPARED TO 2018.



---

**“GFW’s platform provides a vital overlapping layer of intel, giving greater transparency on legitimate vessels and potential violators involved in IUU fishing. Whether you’re a large or small national state, to have access to near real-time data on fishing activity in or outside your waters is a very powerful tool. It sheds light on the problem, so that countries with restricted enforcement ability can focus their efforts efficiently on illegal fishing.”**

**Captain Adam B. Morrison, US Coast Guard**

# OP SOUTHERN CROSS

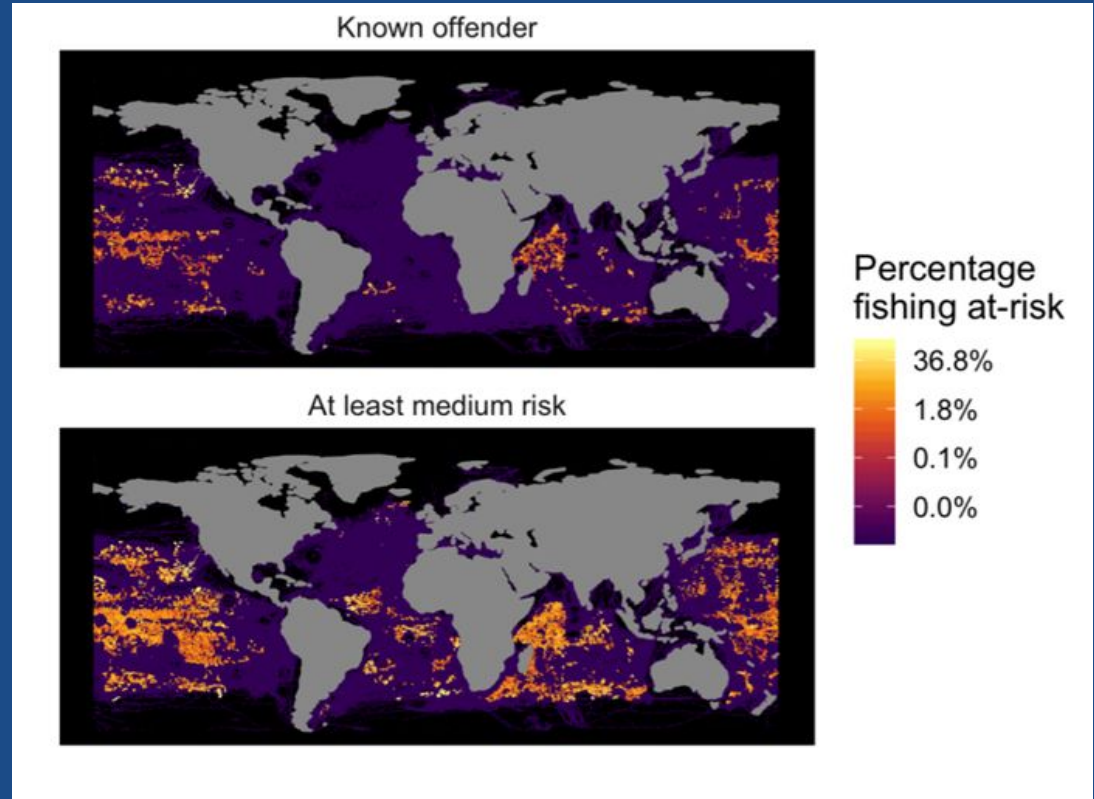


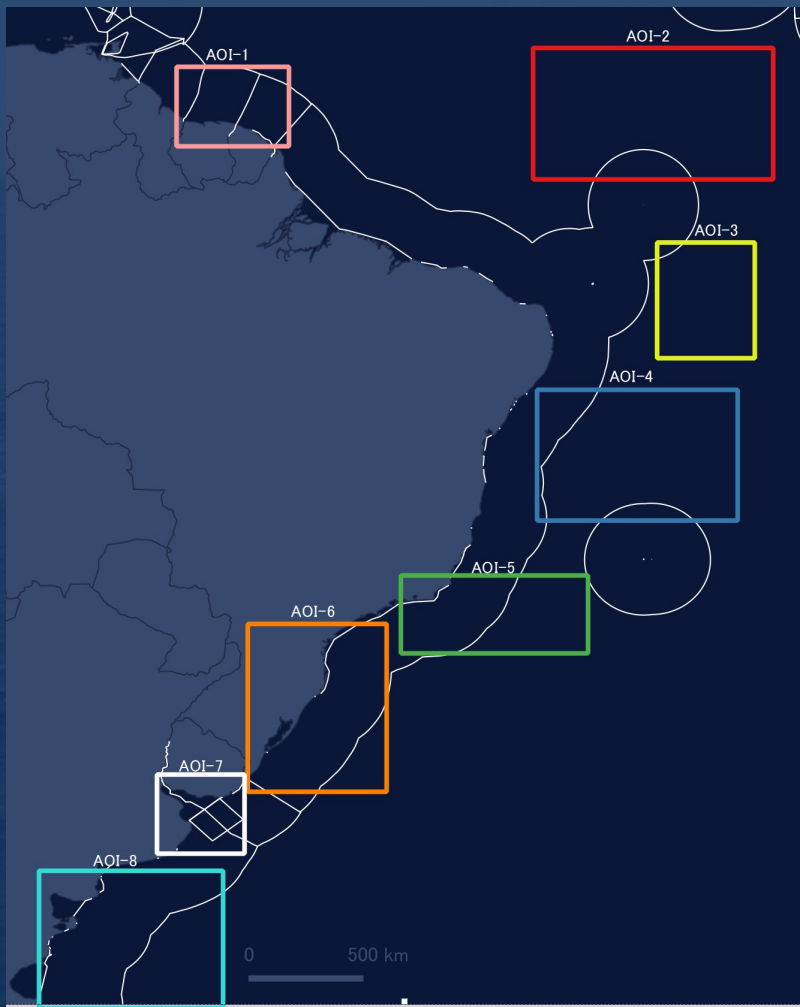
# Labor Risk Model

By comparing patterns of vessels with known labor-rights violations, we created a scoring algorithm to identify likeness between known IUU and other vessel's behaviors

These indicators include

- Time at sea
- Distance from ports or other vessels
- Hours of fishing a day
- Risky port usage etc

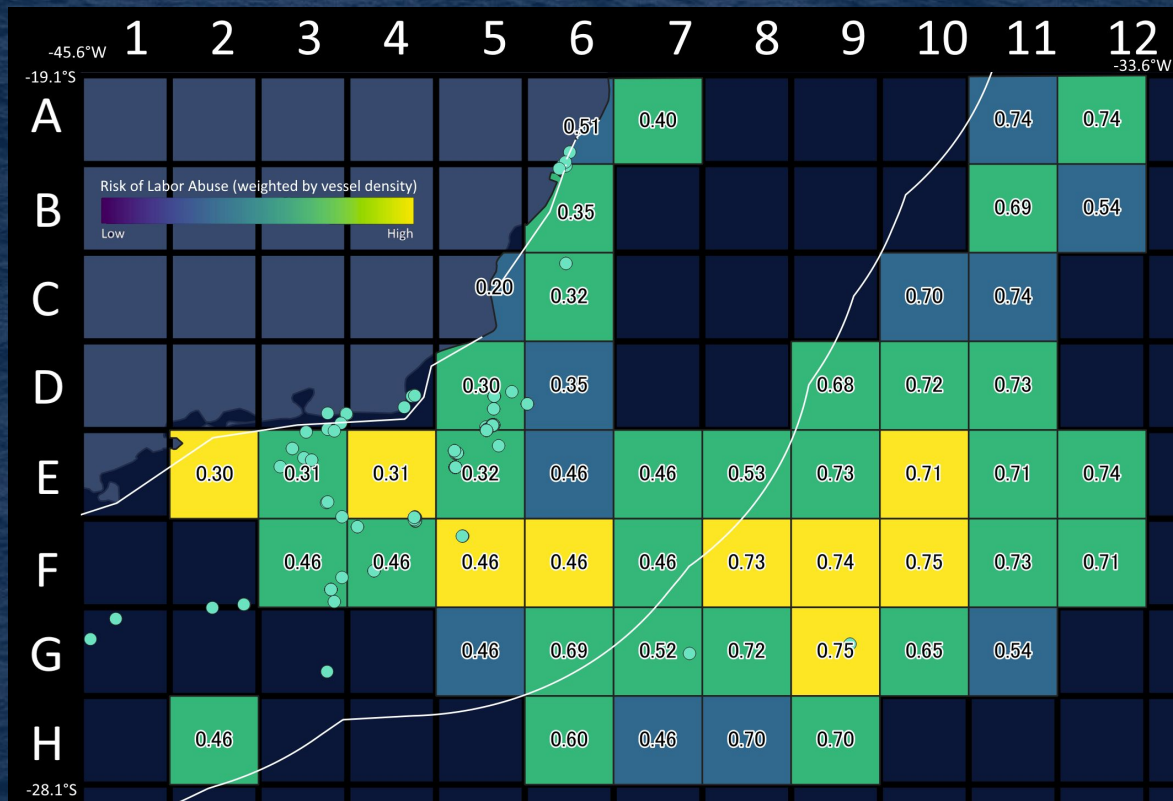




1. Identifying the patrol area

2. Locating historic areas of fishing weighted by labor risk score

3. Finding the historic areas of loitering and transshipment



Lastly, precise grids of each AOI are made with weighted scores colored based on vessel density with the average score of the vessels in that area overlaid. Thus, indicating the areas with the most vessels with the highest risk.

# AOI5

MMSI	Ship Name	Flag	Gear	Risk Score
416132600	YUH MAO NO106	TWN	Drifting longlines	0.7587337
416689000	YUH MAO NO.236	TWN	Drifting longlines	0.7540339
416117800	JIN MAO NO.101	TWN	Drifting longlines	0.7402814
416176800	MAO HONG NO.8	TWN	Drifting longlines	0.7354250
416044800	SHENG MAO NO.222	TWN	Drifting longlines	0.6973475
416180800	FU.MAO268	TWN	Drifting longlines	0.6967479
710017040	CARDOSOABRASIL	BRA	Drifting longlines	0.5363258
341038572	FRUTO DA FE	KNA	Drifting longlines	0.5141433
710096180	SAMBAQUI III	BRA	Drifting longlines	0.5132100
710537301	SEA MOBY DICK	BRA	Drifting longlines	0.4559550

# YUH MAO 102



UNCLASSIFIED

DIN MAO CO., LTD.

# YUH MAO 106

## YUH MAO NO106

032019ZFEB21 25°50.8'S / 035°52.7'W

MMSI – 416132600 / Callsign – BZGG

Actively Fishing / Pulling Catch Onboard

03 Radio Direction Finding Antennas

Longline Gear / Using AIS Buoys (2 found on PoleStar)

Longline > 40nm of gear, hauled in w/ marker buoys every 1000 yards.

Estimated 100+ Shark Fins / Tail Fins drying

Tuna and Marlin observed being landed

Over a dozen people visible on deck



CLASSIFIED



UN



YUN MAO OCEAN ENTERPRISE CO., LTD.

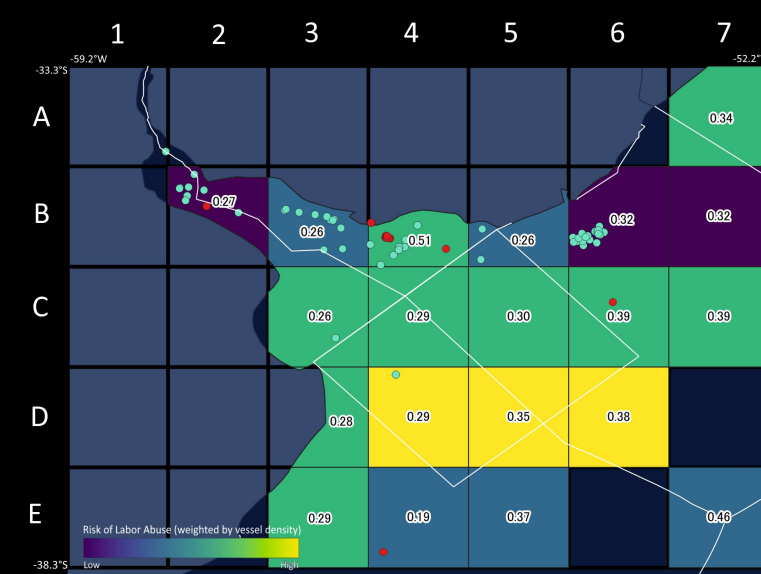
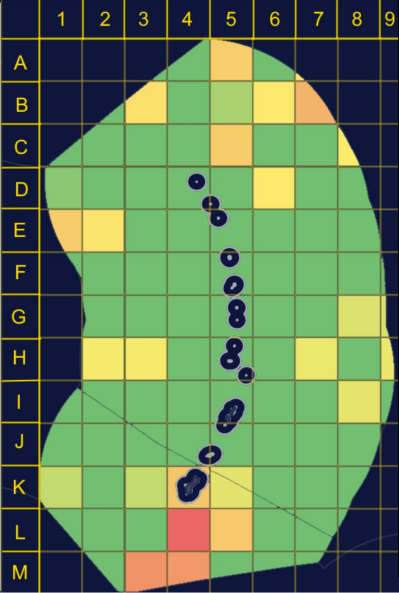
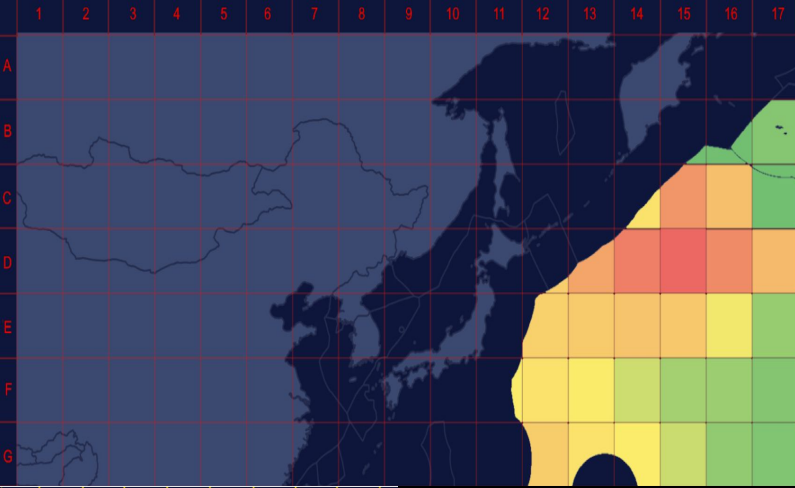


# Future Analysis Innovation...

GFW is prototyping new automated concepts for Fisheries Patrol Planning enabling both long-term strategic planning and near-real time support to operational assets.

This tool will leverage GFW's behavior models, vessel database, and other risk products to provide the user the ability generate outputs which highlight areas of greatest risk of IUU.

Similarly, GFW is developing other new products that enable different use-cases including Port State measures agreement and marine protected area management and monitoring.



**Thanks!**



Global Fishing Watch