Visual Analytics for Uncovering Illegal Fishing Networks

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Introduction

Illegal, unreported, and unregulated (IUU) fishing poses a significant threat to marine ecosystems worldwide. It leads to depletion of fish stocks, ecological imbalances, and negatively impacts livelihoods of small-scale coastal fishing communities. The WWF estimates that IUU equates to about $10-23.5 billion in value of losses. It is thus imperative to detect and stop entities involved in IUU fishing.

Tactics to Evade Detection

Entities often use a variety of methods to avoid detection, making it challenging for authorities to identify them:

1. **Transshipment**: Moving the catch between vessels at sea or at port.
2. **Data Manipulation**: Species, amounts caught, & locations may be misreported.
3. **Vessel Identity Fraud**: A vessel may use more than 1 identity, or the identity of another vessel, resulting in multiple vessels with the same identity.

Objective

Identify influential companies potentially involved in illegal fishing practices through visualisation

Dataset

34,552 nodes:
Companies that originated/ received shipments
5,464,092 edges:
From shipper to receiver

Data Wrangling

The data was cleaned and filtered to only include shipments related to live fishes. Missing fields for Value of Goods were generated based on educated approximations. Finally, the data was aggregated by shipment frequency, total weight, and value of goods for each source and target pair.

Red Flags

Based on the dataset, entities will be identified using 2 red flags: (1) Sudden changes in shipment frequency, & (2) Abnormal shipment values over years

Approach

Pre-filtered 4 entity bundles

Three bundles were generated based on top centrality measures: (1) In-degree, the importers, (2) out-degree, the exporters, & (3) betweenness, the intermediaries. The 4th bundle comprised entities which met thresholds for the red flags.

Identify temporal patterns

Visualise the temporal patterns of the 4 bundles & their trade routes

Identify IUU fishing companies

The networks and shipment details of the red-flagged companies will be identified through various visualisations

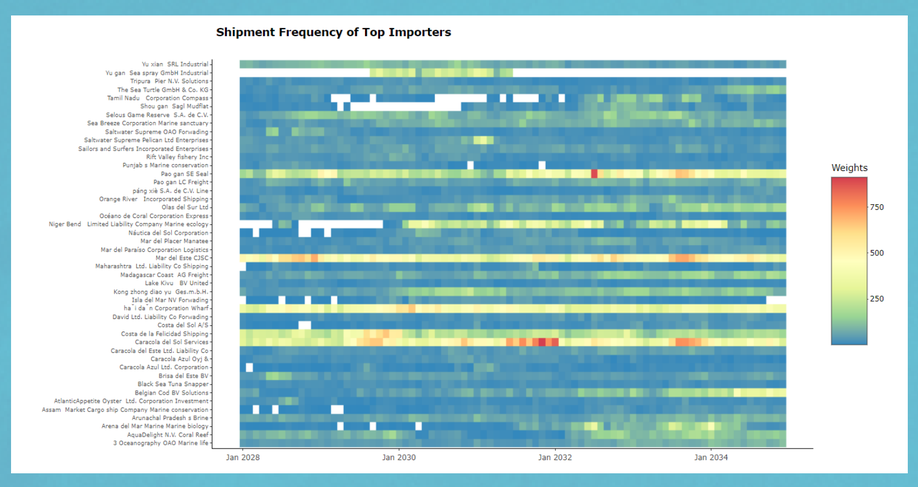
R Packages

Shiny App:
shiny, shinywidgets
Data/network:
tidyverse, jsonlite, tidygraph, ggraph, igraph, visNetwork, lubridate, DT

Results

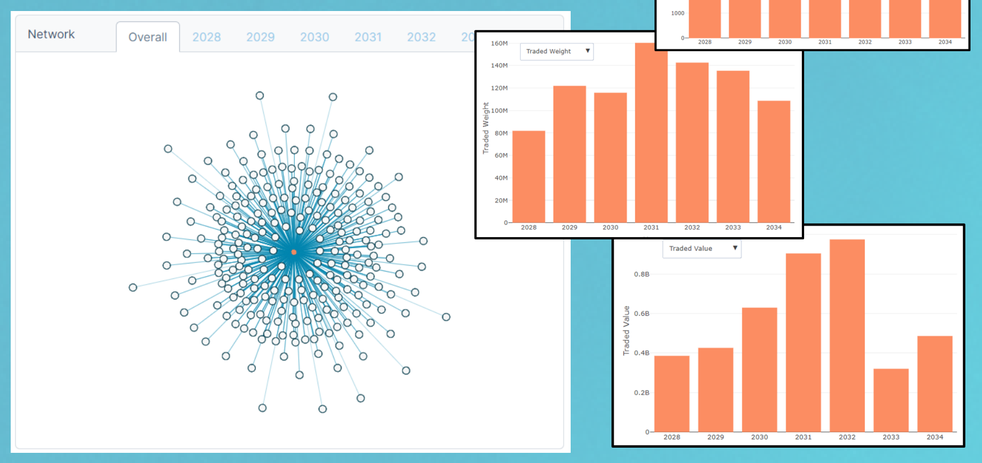
① Explore Shipment Frequency (Months)

Users can filter between importers, exporters & intermediaries to generate heatmaps of shipment patterns. Ideally, they will note which companies had the most shipments and sudden changes in shipment patterns.



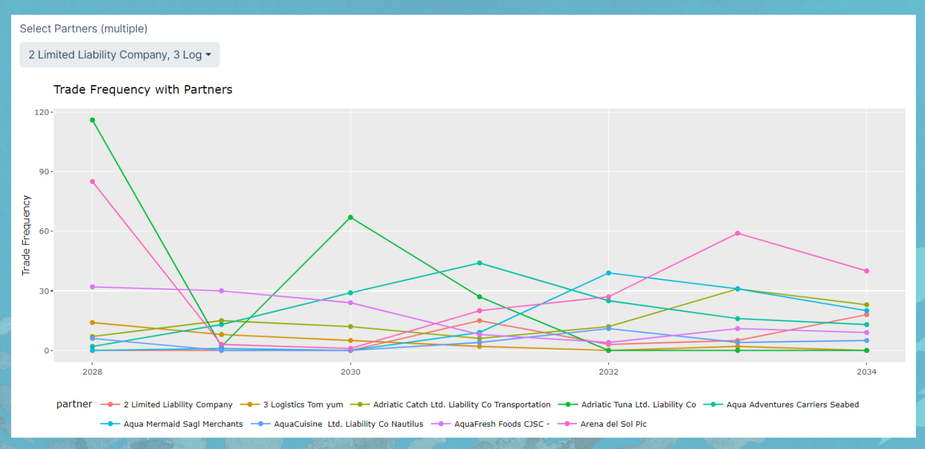
② Investigate Shipping Networks of Entities

Users can select a company of interest to view its network graph & a bar chart of its shipment details (total frequency, weight, & value). Based on this information, users can try to spot companies with red flags.



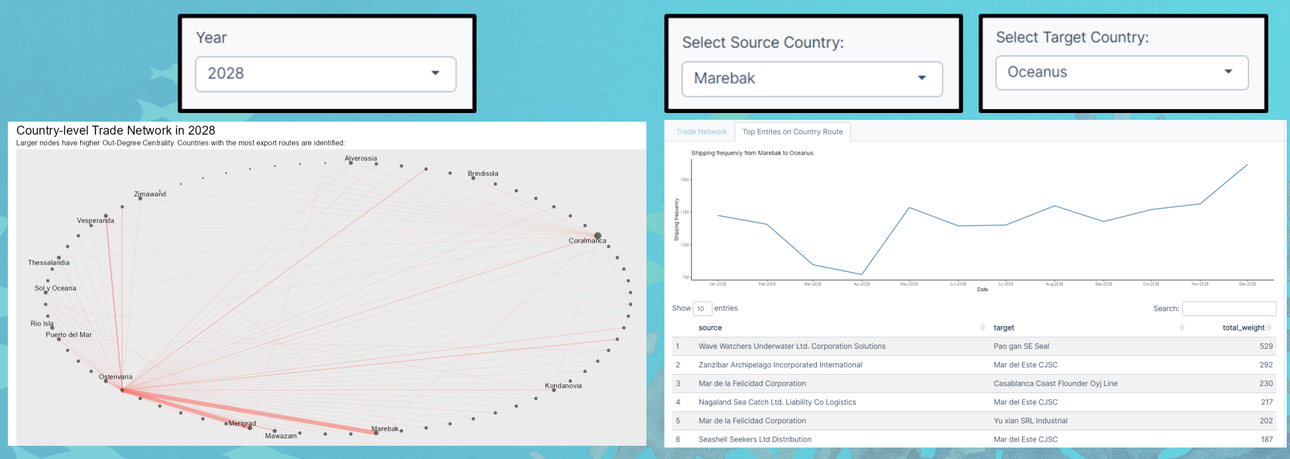
③ Investigate Trade Patterns of Entities

For the company selected in 2, the user can generate a line chart of the its trade frequency with partners over the years. Multiple partners can be selected concurrently. From the line charts, users can assess what the various business relationship patterns are, and detect anomalies (if any).



④ Explore Country-Level Trade Networks

The user can first generate a circular line graph for a certain year. Countries with bigger nodes represent higher number of routes, while thicker lines indicate higher shipment frequency. In the second tab, users can choose from the top 5 shipping routes to view the top 10 companies which ply the route, and ideally be able to narrow down the red-flagged companies.



Future Work

Advanced interactive visualisation techniques such as animated graphs may provide more immersive ways to explore the data. Further, incorporating machine learning algorithms may help to automatically identify anomalies in the data, and thus improve detection of IUU fishing.