Fisheries Network Analysis

DSAN 6400: Network Analytics

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1 Abstract

A "teaser" paragraphs summarizing the work (see below for more detail). * The work isn't finished so this can just be an initial draft * An abstract is a 150 to 250-word paragraph that provides readers with a quick overview of your essay or report and its organization. It should express your thesis (or central idea) and your key points; it should also suggest any implications or applications of the research you discuss in the paper. * The function of an abstract is to describe, not to evaluate or defend, the paper. * The abstract should begin with a brief but precise statement of the problem or issue, followed by a description of the research method and design, the major findings, and the conclusions reached.

1.1 Keywords

Fisheries; Illegal, Unreported, and Unregulated Fisheries; IUU Fishing; IUUF; Network Analysis; Western and Central Fisheries Commission; WCPFC; RFMO; fishing vessel registry

2 Introduction

- Summary of the topic, why it is important, why the reader should continue, what work has been done in the past by other research groups, what are the "different points of views"/interpretations in the literature, what are you exploring, what questions are you trying to address, what are your goals and hypothesis, etc

Over 90 million tons of seafood is fished from our oceans every year("Commercial Fishing. Global Fishing Watch" 2024), collected by the nearly 3 million fishing boats scattered across the globe. (Poortvliet 2024) With the immense amount of fishing, there is also a distinct need for regulation of fishing activities to maintain the fish stocks for future generations. Many individual countries and regions have adopted conservative fishing practices and fish stock tracking for decades, but many countries and nefarious actors do not abide by these rules, causing increased global concern for Illegal, Unreported, and Unregulated (IUU) fishing.

This protein supply chain is unique in that there are a multitude of players across the fisheries enterprise at all different levels of procurement and production *in addition to* a complicated lattice of regulatory bodies that are meant to govern this sector. Unlike domestic agriculture or meat production, commercial fishing conduct hundreds if not thousands of miles from those running the operations and those government bodies overseeing the process.

With that in mind, this paper will be utilizing Network Analysis to parse out the complicated relationships within the fisheries enterprise.

Insert more here

2.1 Background

Certain fisheries, especially those which cross over multiple regions and jurisdictions are governed by Regional Fisheries Management Organizations, or RFMOs. RFMOs are bodies that set regulations for fisheries and are responsible for holding their registered fishing vessels accountable for following the regulations sent forth. RFMOs have designated regions and species within their field of management; Figure 1 is a map of the five tuna RFMOs[1] that are responsible for managing fisheries covering 91 percent of the world's oceans.("What Is a Regional Fishery Management Organization. Pew" 2012)

For the purposes of this paper, we will be scoping the analysis to the RFMO responsible for the Western Pacific, the **Western and Central Pacific Fisheries Commission (WCPFC)**. In order for vessels to fish for highly migratory species of fish (i.e. all types of tuna, marlin, etc.) in the Western and Central Pacific, they must be registered with WCPFC and follow their regulations. The WCPFC Convention Area covers over 12 million square nautical miles, or 20% of the Earth's oceans (Figure 2).

[1]Tuna is considered one of the most valuable fisheries in the world and all the tuna species are pelagic, ocean-going fish and considered highly migratory, making them a prime target for RFMOs.

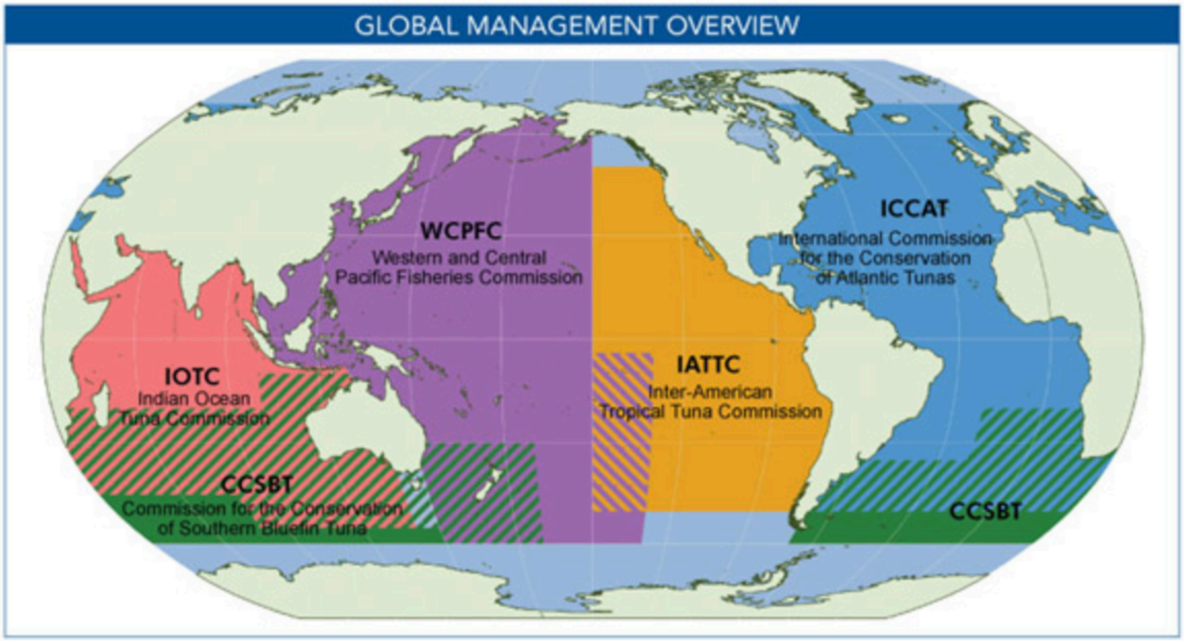

Figure 1: Global overview of tuna managing Regional Fisheries Management Organizations.

There are currently over 3,000 vessels registered under the WCPFC, with the most prominent flag states[2] of China, Japan, Chinese Taipei (Taiwan), and the Philippines.("WCPFC RFV" n.d.) The WCPFC regulates when, where, what, and how these vessels are allowed to fish, but only on the High Seas outside any other country's Exclusive Economic Zone (EEZ)[3]. In order for a vessel to be registered with WCPFC, they must also be flagged[4] in a country at that is a member of the WCPFC[5].

[2]Flag State, or Flag State Jurisdiction, is defined as: "A State may exercise jurisdiction over a vessel that is registered with the State and flying its flag. This exercise of jurisdiction is based on the internationally recognized principle that a State may regulate the conduct of its nationals even when those nationals are acting outside of the State's territory."(National Oceanic and Atmospheric Administration 2024)

[3]Exclusive Economic Zone (EEZ): "A coastal State has sovereign rights to the management of natural resources and other economic activities within its EEZ. It does not have sovereignty within its EEZ, so foreign vessels possess the same non-economic rights within a State's EEZ as on the high seas." (National Oceanic and Atmospheric Administration 2024) The EEZ extends from the country's baseline to 200NM (or when meeting another country's EEZ).

[4]Flag State, or Flag State Jurisdiction, is defined as: "A State may exercise jurisdiction over a vessel that is registered with the State and flying its flag. This exercise of jurisdiction is based on the internationally recognized principle that a State may regulate the conduct of its nationals even when those nationals are acting outside of the State's territory."(National Oceanic and Atmospheric Administration 2024)

[5]WCPFC Commission Members: Members - Australia, China, Canada, Cook Islands, European Union, Federated States of Micronesia, Fiji, France, Indonesia, Japan, Kiribati, Republic of Korea, Republic of Marshall Islands, Nauru, New Zealand, Niue, Palau, Papua New Guinea, Philippines, Samoa, Solomon Islands, Chinese Taipei, Tonga, Tuvalu, United States of America, Vanuatu. Participating Territories - American Samoa, Commonwealth of the Northern Mariana Islands, French Polynesia, Guam, New Caledonia, Tokelau, Wallis and Futuna. Cooperating Non-member(s) - The Bahamas, Curacao, Ecuador, El Salvador, Liberia, Panama,

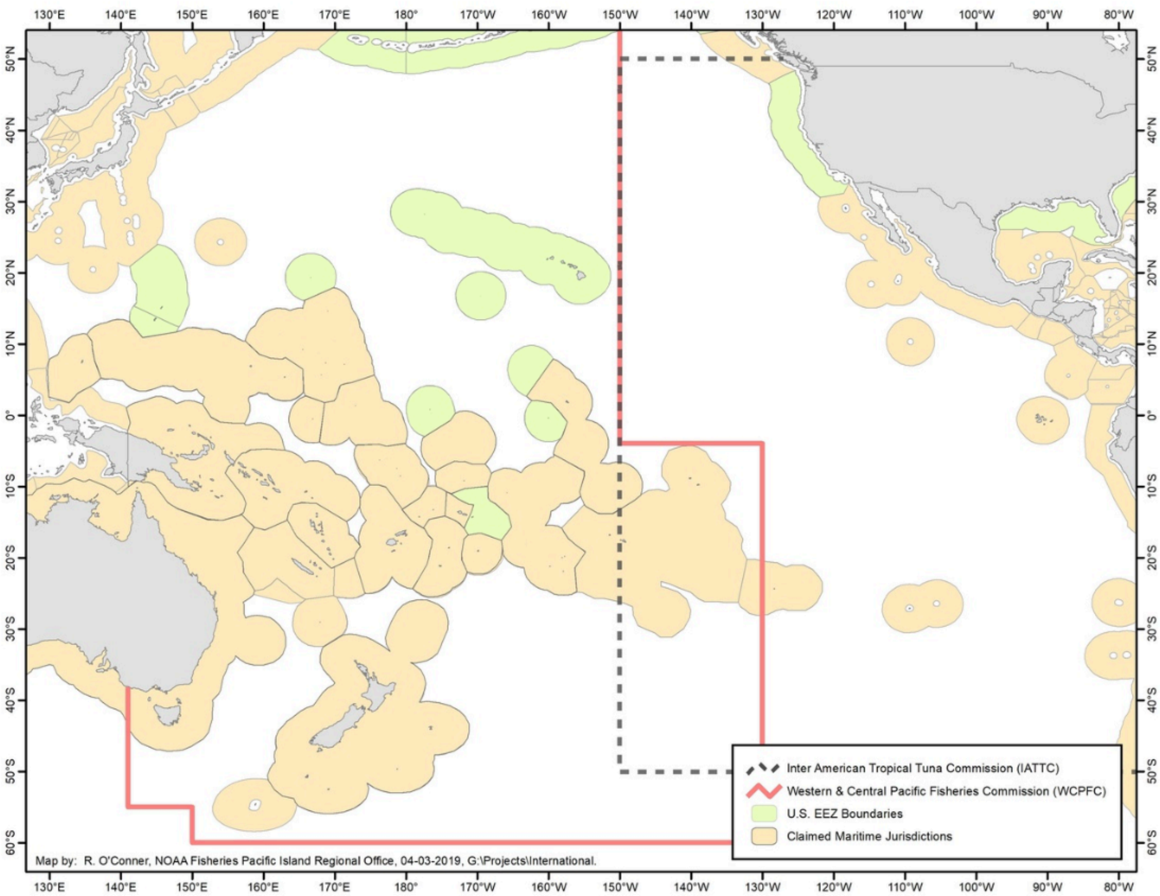

Figure 2: The WCPFC Convention Area spans the Pacific Ocean from roughly 141°E to 150°W.

With 26 member states and over 3,000 vessels, along with large of number of owners, operators, and corporations, the web of associations within the fisheries sector for just this RFMO is vast.

Struggling on how to bring it back

Using publicly available data on ship registration and associated information, we hope to examine the files for relationships that might flag potential concerns or insight into the fishing practices of this area of the globe.

2.2 Previous Work

Much previous research has used network analysis to examine fishing practices. Given the highly complex and layered relationships that can occur between different entities or information (e.g. in Dell'Apa et al. (2013) the authors used SNA to analyze trade flows of spiny dogfish, revealing how global trade relationships impact regional conservation outcomes and suggesting that trade regulations could promote sustainability) that otherwise would be extremely hard to model simultaneously and understand.

Network analsis can be used to relate information like 'vehicle' (in this case, ship), such as the 2018 paper Ford, Bergseth, and Wilcox (2018) where the authors utilized Social Network Analysis (SNA) to identify key ships within the fishing industry in the Indian Ocean. The researchers utilized AIS data to infer relationships for vessel who operated in close proximity and found that Reefer (Refrigerated Cargo Vessels) and Bunkering (Fuel Resupply Ships) play a key role in the vessel network as identified by their eigenvector centrality. Another paper Mulvaney et al. (2015) utilized survey data to establish connections between players in the Great Lake's local fisheries network. The paper discussed heavily their methodology constraints with the survey, but also concluded that the fisheries network included many informal and formal relationships, with the informal relationships forming a significant portion of the edges.

Again and again, the layered relationship between complex variables in the oceanic and fishery world shows that different forms of these tools are highly effecitve. Varlamis et al. (2021) go through an interesting deep dive on the utilization of AIS to create vessel traffic networks. While this paper may not ultimately be helpful for overfishing, these types of visualization and aggregation of data in a relationship format that can be analyzed is incredibly powerful.

Similarly in terms of applications that may not have merit in this initial data study, Marín and Berkes (2010) examined co-management networks in Chilean small-scale fisheries, finding that power was highly centralized in government institutions, with limited cooperation among fisher associations, and recommending policy changes for more participatory governance - something that is far beyond classic data analysis and using qualitative data to reveal relationships.

Thailand, Vietnam.

The qualtitative element is important to remember for future work post quantitaive analysis, e.g. for intervation - Dell'Apa et al. (2014) expanded on previous work to explore how stakeholder networks influence fishery management policies for spiny dogfish, showing the importance of network structures in shaping effective governance.

These interventions can help us to not just implement policy, but to 'live-manage' its implementation in such a complex ecosystem.

A critical component of Nogueira et al. (2023) analysis of fisheries in the Azores was converting time-series catch data into network structures. Their time sensitive identification of key species associations and critical fishing nodes relevant for sustainable management strategies show extreme promise not just for analysis and results, but for recommendations and a far more effective way to achieve our goal; which is to ultimately sustain healthy fish populations and protein sources for the future inhabitants of the planet.

The previous work of many authors, Nogueira et al. (2025) included, is applying complex network analysis and metrics to fisheries data - whether in Nogueira et al. (2025) from the Azores Islands, which focused on uncovering structural patterns in the ecosystem and offering insights for sustainable policy and marine resource management, or whether in the social dynamics that can help facilitate a different form of management.

3 Data Source

WCPFC Registry of Fishing Vessels (RFV)

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