Case study: Characterizing Illegal, Unreported and Unregulated (IUU) fishing and resource conflict in coupled human-natural marine systems using global Automatic Information System (AIS) vessel data

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Topics:

Building a global geospatial data center for marine traffic, fisheries, and climate;
"Big data" analytical techniques for improving accuracy and reducing geospatial uncertainty in monitoring Illegal, Unreported and Unregulated (IUU) fishing; and
Modeling risk of marine resource conflict under future climate scenarios.

Background:

The oceans are a key source of food and income, and medium of transport for over a billion people worldwide. Potential risks of large-scale conflict exist in numerous highly contested marine regions including the South China Sea, the Central American Caribbean and Pacific, and the North Atlantic. The often-ignored cause is data scarcity that undercuts geopolitical decision-making over **oceans as a space for competing territorial claims to resources**. Disputes over territorial control of marine resources have had regional destabilizing effects in the past. For example, the Cod Wars in the 1950s and 70s between the UK and Iceland were initiated by verbal disputes between individual fishermen of these different states. Over a short period of time, these individual disputes cascaded into heightened political tension and eventually armed conflict, with destabilizing effect on NATO's Cold War strategy. A potentially greater shock to international peace and stability is emerging contemporaneously around fishing disputes, and more specifically -- Illegal, Unreported and Unregulated (IUU) fishing.

On an hourly basis, tens of thousands of ocean going vessels are transmitting their location data to an Automatic Information System (AIS). AIS data clearinghouses passively record spatiotemporally adjusted data from ships, paired with other identifier information such as ships' nationality, size and cargo. These data can be used to monitor the activities of discrete fishing vessels. At global scales, over long periods of time, AIS data can be used to map the spatial concentrations and distribution of IUU fishing, and understand marine-system resource exploitation and international competition for fisheries.

Fig. 1. Sample locations of AIS broadcasting container ships at midnight on 20 July 2012 (shipmap.org).

As fishing stocks respond to climate change, their spatial and seasonal distribution will likely change in expected ways, however governance institutions

mediating access to fisheries do not, exacerbating conflicts around changing fishing grounds. AIS data can be used to anticipate hotspots and trajectories of scarcity and conflict.

We aim to train a cohort of graduate students to compile and manage AIS databases, and learn and develop analytical models based around AIS data. Training will include "big data" analytical techniques, such as: 1) flow anomaly detection, 2) network analysis, 3) "spoofing" detection, 4) Bayesian geostatistics, 5) trajectory analysis, 6) marine and coastal "big data" fusion, 7) equation free modeling, 8) satellite image analysis, and 9) real-time "big data" streaming, geovisualization (including virtual reality display), and analytics. Using the research-publication model developed by Van Den Hoek, we will team-teach a sequence of special topics Geography 572/599/699 courses on the application of these techniques to AIS data to address resource competition around IUU fishing.

Existing Data:
We will rely on Automated Identification System (AIS) data, which provide real-time data on the location, size, telemetry, nationality and cargo of the majority of maritime vessels. These AIS data have been used to identify IUU fishing previously, but only for isolated events. There remains a critical challenge, which we will address, to use these data for a *global* and *automated* assessment of IUU fishing in short- and long-terms, at multiple spatial scales.

Challenges include AIS's incomplete coverage of global vessel traffic, and incomplete data for a given vessel through time. To meet these challenges, we will identify and monitor anomalously low and high volumes of traffic, and anomalous human interference with the continuous operation of the AIS transponder. Finally, we will estimate error and improve accuracy of AIS–based analysis with targeted marine vessel detection analyses using very high resolution (VHR) images (2-3m) from Planet Labs' Dove satellites. Comparing locations derived from AIS and satellite data will give us a comprehensive and entirely new understanding of the spatial behavior of maritime vessels, both fishing and flows of licit and illicit resources. To better understand the competing territorial claims on marine resource access, we will synthesize global data on the location of valuable fish stocks, fishing activity and shipping lanes. The spatial distribution of fish stocks globally will be identified using the Seas Around Us project data and the RAM Legacy database.

Data needs:
An AIShub data logger is currently installed at Yaquina Head, where it is relaying data to a CEOAS server, providing access to the global AIShub database. There are multiple low-cost pathways to a full, global database, which we will pursue if successful. In addition we will deploy low-cost AIS receivers in specific coastal locations of interest (e.g. Central America) to supplement the global database.

Synergies:
Graduate training, analysis and data visualization will be supported by CEOAS' GAZE Facility in Ag Strand Hall Rm 361. If successful, we will equip GAZE with an AIS data center to meet university-wide needs around data access, analysis and visualization (see: carto.ceoas.oregonstate.edu). Please refer to preliminary visualizations here: jakobzhao.gitbooks.io/web-mapping/content/lec/lec26/ais/).

This NRT, if successful, will enable us to integrate interdisciplinary training of graduate students into concurrent research plans for AIS data. This proposal leverages a series of planned efforts to fund research on marine conflict, location "spoofing," illegal fishing, and illicit drug trafficking, including a Minerva Program proposal ($2.6 million to be requested this Spring).