A.8: Securing Sustainable Seas: Near Real-Time Monitoring and Prediction of Global Fishing Fleet Behavior

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TARGET 14.4.1

Effectively regulate harvesting and end overfishing, illegal, unreported and unregulated fishing and destructive fishing practices and implement science-based management plans, in order to restore fish stocks in the shortest time feasible, at least to levels that can produce maximum sustainable yield.
Issue: Sustainable Seas
Illegal Maritime Activities

Catching what you’re not supposed to
Issue: Sustainable Seas
Illegal Maritime Activities

Fishing where you’re not meant to i.e. MPAs
Geopolitical tension can arise from international fishery disputes. In particular, the expansion and militarization of the Chinese fishing fleet.
Issue: Sustainable Seas
Illegal Maritime Activities

Indian Navy Seizes Drugs Worth $400 Million From Fishing Boat
The Challenge is that…

… illegal activities are difficult to detect

Vessel transshipment event seen from space

Vessels night lights reveal fishing activities (Black Marble)

AIS data track the majority of the world’s vessels

Vessels transmit their location via the Automated Identification System (AIS)
Solutions

**Counting** vs **Modeling**

Suspicious grouping of fishing vessels in the Indian Ocean seen from their night lights

Disparity with the number of vessels in the area as seen from AIS data
Solutions
Counting vs **Modeling**

- Observable fishing vessels (AIS, night lights)
- Hidden vessels committing illegal activities
- Hidden living marine resources
- Observable biophysical environment (SST, Chl-a, Lagrangian Coherent Structures…etc)
Solution 1: Fishing on Fronts
(Random or not? Fred Castruccio, NCAR)

Lagrangian Coherent Structures (fronts) and fishing

Random or not?

Watson et al. 2018

Hennessey et al. in prep
Solution 2: Oceanographic Drivers of Fishing
(Scale Dependence!)

\[ y = f(x, z... \) \]
\[ y = \text{fishing} \]
\[ x = \text{SST} \]
\[ z = \text{Chl-a} \]
\[ ... \]
\[ f(\cdot) \text{ is a neural network} \]

MODIS derived SST, Chl-a

Oceanographic predictors of fishing at various time and spatial scales

Done regionally for large pelagic species; now we’re doing this globally for the ocean’s top predator (fishing). Martin et al. in prep

Scales et al. 2016
Solution 3: Drivers of Illegal Fishing

Ocean conditions predict when vessels cross borders

NASA seascapes data combined with AIS and Machine Learning can predict when Chinese vessels are likely to enter the Argentine EEZ

Woodill et al. 2021

<table>
<thead>
<tr>
<th>TABLE 3</th>
<th>Summary of main results</th>
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</thead>
<tbody>
<tr>
<td></td>
<td>Random forest</td>
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<tr>
<td></td>
<td>All variables</td>
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<tr>
<td>F-1 score</td>
<td>(1)</td>
</tr>
<tr>
<td>2012</td>
<td>69%</td>
</tr>
</tbody>
</table>

Good level of accuracy
Solution 3: Seascape Economics

“What gets measured gets managed”

NASA seascapes (M. Kavanaugh)

Ecosystem-based management and the wealth of ecosystems

Seong Do Yun, Barbara Hutniczak, Joshua K. Abbott, and Eli P. Fenichel
+ See all authors and affiliations

PNAS June 20, 2017 114 (25) 6539-6544; first published June 6, 2017; https://doi.org/10.1073/pnas.1617666114

Edited by Partha Sarathi Dasgupta, University of Cambridge, Cambridge, United Kingdom, and approved May 11, 2017 (received for review October 24, 2016)

Eli Fenichel’s framework for quantifying the economic value of natural assets.

“Managing fisheries is managing people”
Ray Hilborn, 2007
Solution 4: Who Harvests Where? (And who gets along with who?)

The Cod Wars, when Iceland and the UK came into armed conflict over fish.
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The Cod Wars, when Iceland and the UK came into armed conflict over fish.

Which nations rub shoulders when fishing?

Fishing fleet Shannon diversity

Nomura et al. In prep
Solutions: Complex Systems
(Spatial anomaly detection)

This is an agent-based model of fishing vessels reacting to a nearby illegal activity.

Watson & Woodill in review

GLOBAL FISHING WATCH
What do we know now?
(That we didn’t know before)

• We have learned that certain oceanographic features such as fronts drive spatial patterns of fishing at small spatial scales

• We have learned about the scale-dependence of fishing on oceanographic drivers

• We have learned that oceanographic seascapes can predict illegal fishing, specifically incursions into EEZs, and we can quantify the economic value of whole seascapes

• We have learned who rubs shoulders with who on the high seas, and how this might change in the future.

• We learned how to anticipate illegal maritime activities from the anomalous response of observable vessels.
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NASA funded A.8 project: U.S. Patent Application No. 63/027,651
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