**Importing seafood, exporting overfishing: are high governance countries outsourcing their fisheries overexploitation?**

**Abstract**

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**Keywords:** trade, fisheries, seafood, overfishing, governance, leakage, telecoupling

**1. Introduction**

Seafood is one of the world’s most highly traded food commodities exceeding the trade value of sugar, maize, coffee, rice, and cocoa combined (Asche *et al.* 2015). Furthermore, demand for seafood is growing with the global seafood supply increasing by 3.2% annually from 1961-2013, more than double the rate of human population growth (FAO 2016). Developed countries remain both the largest importers and exporters in the global seafood trade, but seafood exports are the primary source of export earnings for many developing countries, which are rapidly increasing their fisheries production and seafood exports (FAO 2016). Fisheries development can confer diverse bioeconomic benefits including increased profitability through increased prices (citation?), reduced environmental impacts via increased efficiency (citation?), and promotion and financing of environmental protections (citation?). However, increasing production and trade can also promote overexploitation (Pace and Gephart 2016).

A particularly complex effect of increasing trade is the creation of “telecouplings” (Liu *et al.* 2013), in which marine ecosystems can become vulnerable to distant actors. For example, if a country enacts a policy to reduce the catch of a depleted resource without a concomitant decrease in domestic demand for the products provided by that resource, the fishing and potential overexploitation of the resource will shift to foreign waters. Negative environmental impacts manifesting in external jurisdictions, referred to as “leakages”, occur through four pathways (Barrett 2003): (1) *conservation leakage* occurs when domestic measures to conserve resources result in negative environmental impacts from an increase in foreign production to meet persistent domestic demand; (2) *production leakage* arises when regulations on domestic producers results in a transfer of production effort to foreign producers; (3) *consumption leakage* results when domestic demand exceeds domestic supply and requires input from foreign producers; and (4) *trade leakage* occurs when an import ban from particular industries causes a redirection in the flow of trade to other consumer markets. Through these pathways, it is theorized that consumer countries with strong environmental oversight can threaten ecosystems in producing countries with weaker oversight (citations?).

Although leakages resulting from land use policies have been well documented (Murray *et al.* 2004; Wear and Murray 2004; Mayer *et al.* 2005; Meyfroidt and Lambin 2009; Meyfroidt *et al.* 2010; Kastner *et al.* 2011), leakages resulting from marine fisheries management have received much less attention. Helvey et al. (2017) recently elevated the profile of leakages in marine systems using U.S. fisheries management as a case study. U.S. fisheries are among the best managed fisheries in the world (Ricard *et al.* 2012) yet 90% of seafood consumed in the U.S. is imported (NOAA 2018), largely from countries with weaker fisheries regulations (e.g., China, Thailand, Canada, Indonesia, Vietnam, Ecuador; Hilborn and Melnychuk 2015; NOAA 2018). This discrepancy has resulted in only a handful of documented leakages. For example, regulations to reduce bycatch of sea turtles in the West Coast and Hawaiian swordfish fisheries have resulted in increased imports of swordfish from countries with less stringent bycatch policies (primarily Ecuador and Panama) and have actually increased net sea turtle bycatch (Sarmiento 2006; Rausser *et al.* 2009; Chan and Pan 2012). There are few other examples of policy-induced fisheries leakages (Helvey *et al.* 2017) and all of these examples use increasing catch, a weak measure of negative fisheries impact (Pauly *et al.* 2013), to describe the leakage. A comprehensive analysis of leakages in global marine fisheries using stock status as the measure ecological impact is needed to understand the true extent and magnitude of marine leakages globally.

Although it has been theorized that seafood consumption by high governance, developed countries can drive the overexploitation of fisheries resources in low governance, developing countries (Smith *et al.* 2010), empirically evaluating this theory has proved difficult. While satellite monitoring of deforestation enables rigorous, global-scale analyses for leakages in forest systems (citations?), monitoring the status of global marine fisheries is more difficult. Traditional fisheries stock assessment requires large amounts of data (Hilborn and Walters 1992) that are expensive to collect and are absent in most regions of the world (Ricard *et al.* 2012; Costello *et al.* 2012). Two recent studies attempt to circumvent these data limitations by using data-poor estimates of stock status to describe the impact of international trade on global fisheries status (Eisenbarth 2018; Erhardt 2018). Unfortunately, the data-poor assessment method (Kleisner *et al.* 2013) used in both papers has been shown to generate essentially random estimates of stock status (Branch *et al.* 2011; Carruthers *et al.* 2012) compromising the utility of these studies. However, recent advancements in catch-only stock assessment methods (i.e., methods that only require catch data to estimate stock status; Free et al. in review) have enabled the estimation of status estimates than can be reliably used in global-scale analyses (Free et al. in prep).

In this study, we use global bilateral trade data and global fisheries stock status estimates from a new superensemble model (Free et al. in prep) to evaluate the impact of the seafood trade on fisheries stock status. First, we ask whether increasing trade in seafood promotes overexploitation of marine fisheries and whether this relationship varies based on fisheries governance capacity. Second, we ask whether the overexploitation of fisheries in low governance countries is driven by increasing exports to high governance countries. Collectively, these questions seek to determine (1) whether trade is a stabilizing or destabilizing force for marine ecosystems and (2) whether the environmentally conscious actions of high governance consuming nations like the U.S. and Australia have negative impacts on the ecosystems of low governance producing nations.

**2. Methods**

*2.1 Stock status*

Insert text describing the stocks used in the analysis (FAO area-country-species triples) and describing the methods used to estimate time series of stock status (B/BMSY).

I’m hoping to publish my ensemble model and associated stock status estimates before our paper is submitted in which case we’ll have an established method and dataset to reference.

*2.2 Trade data*

Insert text describing the bilateral trade data and the harmonization of the trade data to match the stock status data (or vice versa, whichever we do).

*2.3 Governance capacity*

Insert text describing the governance indicators used to delineate low, medium, and high governance countries.

Presently, we’re only using the *rule of law* indicator but I think we should switch to using the same composite indicator as Smith et al. (2010 *Science*) which combines four indicators: *rule of law, control of corruption, governmental effectiveness,* and *regulatory quality*. This gives us a reference for our choice of indicator! I think we should also see how well this correlates with Mora et al. (2009)’s country level fisheries management effectiveness indicators.

*2.4 Data analysis*

Insert text about regression analysis and other analyses.

Figure showing proportion of seafood imported versus used in country arranged (a) alphabetically, (b) by governance indicator, (c) by GDP?

**3. Results**

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**4. Discussion**

Ideas for discussion points

Please insert your ideas about things to discuss in the discussion!

Discuss the fact that our analysis leakages between countries and that there could be additional leakages happening within countries that also require attention. Reference the (Cunningham *et al.*) example where a catch share program instituted for New England fisheries resulted in increased catch in neighboring Mid-Atlantic fisheries.

Helvey et al. (2017) propose the following six solutions for reducing the leakage of ecological impact by U.S. fisheries management and I think we could apply/refine/expand these solutions in our discussion of solutions for reducing leakage by all high governance countries:

1. Increase awareness of U.S. fisheries
2. Develop U.S. domestic aquaculture to complement capture fisheries
3. Support sustainable fishing practices in other nations
4. Multilateral cooperation
5. Recognize the externalities of management decisions
6. Treat wild capture and aquaculture fisheries as part of the food system

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