Preparing ocean governance for species on the move: Policy must anticipate conflict over geographic shifts

OVERLINE

Preparing ocean governance for species on the move

Policy must anticipate conflict over geographic shifts

By Malin L. Pinsky[1*], Gabriel Reygondeau[2], Richard Caddell[3,4], Juliano Palacios-Abrantes[2], Jessica Spijkers[5,6], and William W. L. Cheung[2]

The ocean is a critical source of nutrition for billions of people, with potential to yield further food, profits, and employment in the future (*1*). But fisheries face a serious new challenge as climate change drives the ocean to conditions not experienced historically. Local, national, regional, and international fisheries are substantially underprepared for geographic shifts in marine animals driven by climate change over the coming decades. Fish and other animals have already shifted into new territory at a rate averaging 70 km decade^{-1} (*2*), and these shifts are expected to continue or accelerate (*3*). We show here that many species will likely shift across national and other political boundaries in the coming decades, creating the potential for conflict over newly shared resources.

A shifting fish stock aggravates existing fisheries challenges because it contravenes the "clear boundaries" principle for sustainable governance of common pool resources, eroding incentives for conservation when new free riders, having no agreed-upon responsibilities for shared conservation and management, gain access to a resource (*4, 5*). Stock shifts can incentivize regional overharvesting as actors scramble to exploit a perceived disappearing resource. A stock that upon moving straddles national boundaries may find itself in "double jeopardy," exposed to unsustainable competitive harvesting (*5*). Governance challenges posed by shifting marine animal distributions have been recognized in certain cases, but the scope and magnitude of this problem has remained unclear and there have been few efforts to address the issues.

[1]*Dept. of Ecology, Evolution, and Natural Resources, Rutgers University, New Brunswick, NJ, USA.* [2]*Institute for the Oceans and Fisheries, University of British Columbia, Vancouver, BC, Canada.* [3]*Netherlands Institute for the Law of the Sea, Utrecht University, Utrecht, Netherlands.* [4]*School of Law and Politics, Cardiff University, UK.* [5]*Stockholm Resilience Center, Stockholm University, Stockholm, Sweden.* [6]*Australian Research Council Centre of Excellence for Coral Reef Studies, James Cook University, Queensland, Australia. *Email: malin.pinsky@rutgers.edu*

Shifting fishes already cause conflict

International law recognizes that cooperation is necessary for management of shared stocks, yet fisheries disputes remain commonplace, and are a leading cause of militarized disputes between democratic states in the post-WWII period (*6*). The so-called 'mackerel war' erupted in 2007 when the northeast Atlantic Mackerel stock (*Scomber scombrus*)—a fishery then managed by the European Union, Norway, and Faroe Islands—shifted into Iceland's Exclusive Economic Zone (EEZ) (*7*). Conflict arose over appropriate allocations among the actors, compounded by disagreement about the drivers and therefore the expected duration of the shift. In the absence of cooperation, the mackerel stock became increasingly overfished (*7*).

Shifting species have caused conflict even between countries that historically cooperate closely. During a period of warmer-than-average regional ocean temperatures in the 1980s and 1990s, United States catches of Pacific salmon (*Oncorhynchus* spp.) increased more than ten-fold and included increased interceptions of Canadian-bound salmon (*5*). Canadian fisheries retaliated by targeting salmon migrating to spawn in the U.S. Six years of rancorous disagreement passed before a new joint management agreement was concluded.

Shifting species distributions also present internal challenges for nations. Blueline tilefish (*Caulolatilus microps*) were historically caught and managed south of the Virginia-North Carolina border, U.S. When tilefish appeared further north, a fishery exploited the stock for nearly a decade without regulation. This situation only changed in 2015 with emergency rules from the National Marine Fisheries Service.

These cases exemplify a general pattern: existing fisheries management and governance is largely predicated on population geographies that remain broadly static through time. Challenges emerge when stock distributions become less predictable and are compounded when states act unilaterally to exploit the resultant windfall.

The magnitude of future challenges

The oceans have already absorbed 93% of the heat from anthropogenic climate change (*8*), and if future species geographic shifts exceed historical variation, adjustment to existing ocean governance will be needed. Alternatively, future geographic shifts could be sufficiently limited to retain stocks primarily under the jurisdiction of those countries currently managing them. The extent to which future shifts in species distributions will generate newly shared fish stocks and increase the potential for conflict, however, has not been clear.

We therefore projected future shifts in the distribution of 892 commercially important marine fish and invertebrates in relation to the world's 268 EEZs (see Supplementary Materials). Instead of precisely forecasting future changes, the projections help delineate plausible scenarios that illustrate the extent of future challenges. Comparing 1950-2014 against 2090-2100, we found that many of the world's EEZs are likely to receive one to five new, climate-driven transboundary stocks by the end of the century (Fig. 1A). Up to ten new stocks

were projected for some EEZs in east Asia, a region where new transboundary stocks could exacerbate maritime relations already complicated by disputed territories, overlapping EEZ claims, and illegal fishing.

The number of EEZs with new transboundary stocks was expected to reach 46±8 (±standard error) or 60±4 by 2060 (57±4 or 85±22 by 2080) under strong mitigation (Representative Concentration Pathway [RCP] 2.6) or business-as-usual (RCP 8.5) greenhouse gas emissions scenarios, respectively (Fig. 1B). Limiting greenhouse gas emissions would therefore reduce the potential for new fisheries conflicts. In total, new transboundary stocks were projected to be present in 23% (RCP 2.6) to 35% (RCP 8.5) of global EEZs by 2100 (Fig. 1A and 1B). In the tropics, fisheries will likely move out but not in, a process that creates additional food security concerns.

Most countries were projected to receive 1-30% of their potential fisheries catch from new stocks by 2100, but percentages were higher in temperate regions (e.g., Australia or countries around the Baltic and Bering Seas) and highest in shared Antarctic fishing grounds (92%). We note that past conflicts over even a single species with low catch volumes have been substantial.

MAJORS GAPS IN GOVERNANCE

The current legal framework for the international regulation of fisheries does not directly account for fluctuating or changing distributions. The primary source of international obligations for the governance of global fisheries resources remains the 1982 UN Convention on the Law of the Sea (UNCLOS) which entered into force in 1994. Under UNCLOS, states must ensure that fisheries in their EEZs are not endangered by overexploitation; hence national regulations for fishing could provide a basis for far-sighted management of shifting stocks.

For "straddling stocks" occurring in two or more EEZs, or within an EEZ and the high seas, UNCLOS obliges states to cooperate to establish necessary conservation and management measures. In 1995, the fisheries regime of UNCLOS was buttressed by the UN Fish Stocks Agreement (UNFSA), which specifically applies to straddling and highly migratory stocks and entered into force in 2001. The UNFSA reinforced national obligations to cooperate and to apply a precautionary approach to fisheries. Notwithstanding its constructive influence on international fisheries law, the UNFSA has not focused attention upon stocks that shift to occupy territory beyond the areas they have occupied historically.

Regional fisheries management organizations (RFMOs) remain the primary vehicle through which fish stocks that straddle multiple EEZs are managed. Many RFMOs address single species such as tuna or salmon, however, and an influx of additional species lies beyond their individual remits. Despite recent progress, fish stocks in large parts of the global oceans are weakly managed —a trend that may be exacerbated by shifting distributions. Few bodies have established a clear position on the elaboration of regulations for new fisheries, a loophole that often allows newly fished stocks to be heavily exploited before meaningful standards are developed (*9*). Moreover, there has been little to no cooperation between RFMOs on the potential for future shared stocks, and limited interactions with other regional ocean regulators or global treaties. Concerns also remain over the limited application of ecosystem-based management principles by RFMOs, including limited consideration of impacts on species not directly managed by the RFMOs.

Attempts to resolve conflicts judicially are largely untested, although shifting stocks could prompt judicial consideration in the future (legal processes in the mackerel dispute were discontinued). International courts and tribunals have been receptive to calls for more responsible stewardship of fish stocks and have adopted far-sighted allocation practices in individual cases. Nevertheless, they have historically accorded little consideration to environmental factors (climate or otherwise) in territorial disputes, and shifting stocks have not played an overt role in boundary decisions. Likewise, international law does not facilitate the adjustment of national jurisdictional boundaries in response to changing ocean conditions. Finally, judicial decisions do not always resolve conflicts: China refused to participate in recent arbitration concerning the South China Sea, rendering fisheries relations vulnerable to unilateral actions around stock shifts in this region.

Governance solutions for shifting fish

Past conflicts, the projected widespread emergence of new transboundary stocks, and the gaps in current governance frameworks all suggest that substantial new approaches are needed to forestall future conflict. The first step is for management authorities to plan ahead for cooperative management, which demands an emphasis on acquiring reliable projections of species shifts and associated uncertainties. Negotiations over shared stocks are easier with mutually-agreed facts, which can be facilitated by data from multilateral or independent scientific bodies, including the Intergovernmental Panel on Climate Change (IPCC). All projections should be interpreted cautiously, however, given the potential for thresholds and surprises in ecological systems. These inherent uncertainties complicate localized evaluations of the costs and benefits of cooperation (*10, 11*).

For RFMOs, performance reviews provide an established process for consideration of species shifts, although success depends on capacity and a culture of critical reflection. Data-sharing with other bodies is also vital. The Commission for the Conservation of Antarctic Marine Living Resources (CCAMLR) has been exemplary in this regard and has established collaborative arrangements with neighboring RFMOs to monitor the movement of stocks across regulatory frontiers. CCAMLR has also forged arrangements with other sectoral regulators to consider the prospective ecological footprint of a moving fishing industry.

Cooperation must then extend beyond data-sharing to inform genuinely collaborative management. For example, to meet their responsibilities under UNCLOS and UNFSA, RFMOs must accept the prospect of shared oversight and agree on regulatory responsibilities for species with an increasing presence in neighboring areas. Overlapping stocks have already generated tensions, such as between the Northwest Atlantic Fisheries Organization (NAFO) and the North East Atlantic Fisheries Commission (NEAFC) in the 1990s until shared responsibilities were implemented. CCAMLR has taken

a different and more constructive approach to cooperation, in part by imposing greater precautionary oversight of new fisheries, including for tuna displaced by ocean warming (*9*). Data-sharing and collaborative management can inform vital regulatory approaches such as area-based management and no-take zones to reduce pressure on shifting stocks.

Prevailing management mentalities also remain a fundamental challenge, notably the perception that one party "wins" and the other "loses" when a stock shifts geographically, an asymmetry that can undermine cooperation (*12*). Game theory provides lessons for incentivizing cooperation, including broadening the scope of negotiations to include non-fish resources (*5*). Broader negotiations, however, risk reducing fisheries to a bargaining chip, as suggested by the Brexit negotiations wherein fisheries access may be increasingly leveraged against other political and economic priorities. In the case of the U.S.-Canada Pacific Salmon Treaty, however, contributions to a conservation fund helped stabilize relations, creating an alternative avenue for compensation often termed a "side payment" (*13*). Similar approaches are illustrated by Norway and Russia's swaps of fisheries access within EEZs to balance shifts in shared stocks, an important example of flexibility in co-managing Arctic resources. Trading herring, blue whiting, or other fishery access to help resolve the Icelandic mackerel dispute has also been suggested (*14*). The utility of side-payments suggests that new bilateral or multilateral agreements concerning shifting fisheries will be more effective if negotiated at political levels above simply fisheries management. Presently, however, multilateral processes generally focus on discrete issues to help secure support. For instance, it is being actively debated whether fisheries should be included in United Nations negotiations on marine biodiversity beyond national jurisdiction (BBNJ), despite this process expressly seeking integration across governance sectors.

Compounding this proprietorial approach are concerns that access to current and prospective RFMOs is restricted to those with a "real interest" in the stock, with participatory rights zealously guarded by current constituents (*14, 15*). The North Atlantic RFMOs—which are facing geographic shifts in a number of important fisheries—are currently closed to new members (*9, 15*). Many existing fisheries are based on principles of zonal attachment and relative stability, wherein national allocations of fish catch are based upon historical patterns of presence in each country and geographic area. A first step towards more adaptable fisheries would be objective and regularly updated allocations of catch or effort to reflect changes in stock distributions. An intriguing, alternative approach would be to develop fisheries permits that are tradeable across political boundaries, as considered to some extent by the International Commission for the Conservation of Atlantic Tunas (ICCAT) and by NAFO (*15*). Regions with disputed maritime boundaries will remain especially prone to conflict, and shifting stocks may require additional consideration in the boundary delimitation process or bespoke arrangements between states over contested resources.

Climate-driven shifts in marine species distributions represent a growing governance issue affecting states in all regions of the world. An alternative future of widespread non-cooperative management over new transboundary stocks risks extensive overfishing, decline in global food and livelihood provisioning from the ocean, fractured international relationships, and political conflicts that could spill over into other, non-fishery areas of international politics. However, the challenges can also be mitigated through far-sighted governance strategies. With adaptable agreements between states, we have hope that ocean fisheries can continue to provide the myriad nutritional, livelihood, and economic opportunities relied upon by billions of people around the world.

REFERENCES AND NOTES:

1. C. J. Costello *et al.*, *P Natl Acad Sci USA* **113**, 5125 (2016). doi:10.1073/pnas.1520420113
2. E. S. Poloczanska *et al.*, *Nature Climate Change* **3**, 919 (2013). doi:10.1038/nclimate1958
3. W. W. L. Cheung, G. Reygondeau, T. L. Frölicher, *Science* **354**, 1591 (2016). doi:10.1126/science.aag2331
4. E. Ostrom, J. Burger, C. B. Field, R. B. Norgaard, D. Policansky, *Science* **284**, 278 (1999). doi:10.1126/science.284.5412.278
5. K. A. Miller, G. R. Munro, U. R. Sumaila, W. W. L. Cheung, Governing Marine Fisheries in a Changing Climate: A Game-Theoretic Perspective. *Canadian Journal of Agricultural Economics/Revue canadienne d'agroeconomie* **61**, 309 (2013). doi:10.1111/cjag.12011
6. S. M. Mitchell, B. C. Prins, *Int. Stud. Q.* **43**, **169** (1999). doi:10.1111/0020-8833.00115
7. J. Spijkers, W. J. Boonstra, *Regional Environmental Change* **17**, 1835 (2017). doi:10.1007/s10113-017-1150-4
8. M. Rhein *et al.*, in *Climate Change 2013: The Physical Science Basis. Contribution of Working Group I to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change*, T. F. Stocker *et al.*, Eds. (Cambridge University Press, Cambridge, 2013), pp. 255-316.
9. R. Caddell, *Int. J. Mar. Coast. Law* **33**, 199 (2018). doi:10.1163/15718085-13310013
10. K. Miller *et al.*, *Prog. Oceanogr.* **87**, 338 (2010). doi:10.1016/j.pocean.2010.09.014
11. S. Polasky, S. R. Carpenter, C. Folke, B. Keeler, *Trends Ecol. Evol.* **26**, 398 (2011). doi:10.1016/j.tree.2011.04.007
12. G. R. Munro, *The Canadian Journal of Economics* **12**, 355 (1979).
13. K. A. Miller, G. R. Munro, *Mar. Resour. Econ.* **19**, 367 (2004).
14. P. Ørebech, *Int. J. Mar. Coast. Law* **28**, 343 (2013). doi:10.1163/15718085-12341276
15. A. Serdy, *The New Entrants Problem in International Law*. (Cambridge University Press, Cambridge, UK, 2015).

Acknowledgments:
We thank C. Payne and K. Miller for helpful comments and discussions on this manuscript. Funding: This is a contribution to the Nippon Foundation—University of British Columbia Nereus Program and we acknowledge support from it. We also acknowledge support from National Science Foundation OCE-1426891 and DEB-1616821, New Jersey Sea Grant R/6410-0011, an Alfred P. Sloan Research Fellowship, the NOAA Coastal and Ocean Climate Applications program, and the project "Green Growth Based on Marine Resources: Ecological and Socio-Economic Constraints (GreenMAR)" funded by Nordforsk #61582. Author contributions: *Conceptualization*, M.L.P; *Data curation*, G.R., J.P.A.; *Formal analysis*, G.R., J.P.A.; *Funding acquisition*, W.W.L.C., M.L.P.; *Methodology*, G.R., M.L.P., W.W.L.C.; *Supervision*, M.L.P., W.W.L.C.; *Visualization*, G.R.; *Writing – original draft*, M.L.P., J.S., W.W.L.C., G.R., R.C.; *Writing – review & editing*, M.L.P., J.S., W.W.L.C., G.R., R.C. Data and materials availability: See Supplementary Materials.

List of Supplementary Materials:
Materials and Methods

10.1126/science.aat2360

Fig. 1. (A) Exclusive Economic Zones (EEZs) projected to contain one or more new fishery stocks by 2100, compared to the distribution of fish stocks in 1950-2014. Projections represent an ensemble average across three earth system models under the high greenhouse gas emissions scenario (RCP 8.5). (B) The number of EEZs with new transboundary stocks increased approximately linearly with increases in global temperature. The extent of warming and number of EEZs were greater under a high greenhouse gas emissions scenario (RCP 8.5, red), and lower under a low emissions scenario (RCP 2.6, blue). Thin lines are projections from each of three earth system models. Thick lines represent the average across models. See supplementary materials for details.