Understanding the effects of dynamic interactions between changing ocean conditions and fishing effort on living marine resources

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Global climate change affects the physical and biogeochemical characteristics of the ocean including ocean temperature, stratification, oxygen content, salinity and net primary productivity. These changes in turn impacts on marine ecosystems and associated organisms, affecting their distribution and ecology, as well as dependent marine fisheries and communities. Socio-economic outcomes linked to climate-related shifts in the distribution and productivity of marine species can increase the vulnerability and risk of many coastal communities and countries. Indeed, previous studies suggest that changes in marine ecosystems are amplified through trophic webs, from primary production to upper trophic levels, both without fishing or under idealized fishing scenarios. However, much less is known about the degree to which accounting for dynamic human actions including targeted fisheries management measures and the economics of fishing effort and behavior might affect the sensitivity of marine ecosystems responses to climate perturbations in global models.

Here, we develop and apply a holistic approach for projecting impacts of climate change on global fish stocks and fisheries by linking a fishing effort dynamic model with a biological simulation model, the Dynamic Bioclimate Envelope Model (DBEM). Spatial and temporal changes in fishing effort are projected based on changes in catch and profitability of exploited species, while the DBEM projects changes in species distribution and abundance under given climate change and prior fishing effort. In the effort dynamic model, fishers are assumed to seek to maximize their profit under the constraints of management measures (e.g., harvest control rules), and a set of given economic factors such as seafood price, operating costs of fishing, and capital and depreciation costs for purchasing a new vessel and the depreciation cost of fishing vessels. We show that the effort dynamic model can broadly reproduce historical changes in fishing effort, and that projections of future catches can be substantially different if economic effort dynamics are considered, compared with previous studies with simple fishing effort assumptions. Using these model outputs, we examine whether, and to what degree, fishing may affect the vulnerability of fish stocks to changing ocean conditions. This study highlights the critical importance of including realistic fishing scenarios when attempting to understand and project climate change impacts on fisheries. Thus, research focusing on using scenarios and models to inform policy on marine ecosystems and fisheries needs to include fishing effort dynamics and it is suggested as a way to support the development and application of economic-based tools when seeking ocean-based climate solutions.

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