Bottom-up drivers of global patterns of demersal, forage, and pelagic fishes - DTU Orbit (30/09/2019)

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Large-scale spatial heterogeneity in fisheries production is predominantly controlled by the availability of zooplankton and benthic organisms, which have a complex relationship with primary production. To investigate how cross-ecosystem differences in these drivers determine fish assemblages and productivity, we constructed a spatially explicit mechanistic model of three fish functional types: forage, large pelagic, and demersal fishes. The model is based on allometric scaling principles, includes basic life cycle transitions, and has trophic interactions between the fishes and with their pelagic and benthic food resources. The model was applied to the global ocean, with plankton food web estimates and ocean conditions from a high-resolution earth system model. Further, a simple representation of fishing was included, and led to moderate matches with total, large pelagic, and demersal catches, including re-creation of observed variations in fish catch spanning two orders of magnitude. Our results highlight several ecologically meaningful model sensitivities. First, the latitudinal distribution of the total catch is modulated by the temperature dependence of metabolic rates, with increased sensitivity pushing fish toward the poles. Second, coexistence between forage and large pelagic fish in productive regions occurred when forage fish survival is promoted via both favorable metabolic allometry and enhanced predator avoidance in adult forage fish. Third, the prominence of demersal fish is highly sensitive to the efficiency of energy transfer to benthic invertebrates. Fourth, forage fish biomass is suppressed by strong top-down controls on temperate and subpolar shelves, where mixed assemblages of large pelagic and large demersals exerted high predation rates. Last, spatial differences in the dominance of large pelagics vs. demersals is strongly related to the ratio of pelagic zooplankton production to benthic production. We discuss the potential linkages between model misfits and unresolved processes including movement, spawning phenology, seabird and marine mammal predators, and socioeconomically driven fishing pressure. Ultimately, our model provides a new tool for understanding, quantifying, and predicting global fish biomass and yield, now and in a future dominated by climate change and improved fishing technology.

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