Large pelagic fish are most sensitive to climate change despite pelagification of ocean food webs

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Global climate change is expected to impact ocean ecosystems through increases in temperature, decreases in pH and oxygen, increased stratification, with subsequent declines in primary productivity. These impacts propagate through the food chain leading to amplified effects on secondary producers and higher trophic levels. Similarly, climate change may disproportionately affect different species, with impacts depending on their ecological niche. To investigate how global environmental change will alter fish assemblages and productivity, we used a spatially explicit mechanistic model of the three main fish functional types reflected in fisheries catches (FEISTY) coupled to an earth system model (GFDL-ESM2M) to make projections out to 2100. We additionally explored the sensitivity of projections to uncertainties in widely used metabolic allometries and their temperature dependence. When integrated globally, the biomass and production of all types of fish decreased under a high emissions scenario (RCP 8.5) compared to mean contemporary conditions. Projections also revealed strong increases in the ratio of pelagic zooplankton production to benthic production, a dominant driver of the abundance of large pelagic fish vs. demersal fish under historical conditions. Increases in this ratio led to a "pelagification" of ecosystems exemplified by shifts from benthic-based food webs towards pelagic-based ones. The resulting pelagic systems, however, were dominated by forage fish, as large pelagic fish suffered from increasing metabolic demands in a warming ocean and from declines in zooplankton productivity that were amplified at higher trophic levels. Patterns of relative change between functional types were robust to uncertainty in metabolic allometries and temperature dependence, though projections

of the large pelagic fish had the greatest uncertainty. The same accumulation of trophic impacts that underlies the amplification of productivity trends at higher trophic levels propagates to the projection spread, creating an acutely uncertain future for the ocean's largest predatory fish.