Biological ensemble modeling to evaluate potential futures of living marine resources - DTU Orbit (16/12/2018)

**Biological ensemble modeling to evaluate potential futures of living marine resources**

Natural resource management requires approaches to understand and handle sources of uncertainty in future responses of complex systems to human activities. Here we present one such approach, the "biological ensemble modeling approach," using the Eastern Baltic cod (Gadus morhua callarias) as an example. The core of the approach is to expose an ensemble of models with different ecological assumptions to climate forcing, using multiple realizations of each climate scenario. We simulated the long-term response of cod to future fishing and climate change in seven ecological models ranging from single-species to food web models. These models were analyzed using the "biological ensemble modeling approach" by which we (1) identified a key ecological mechanism explaining the differences in simulated cod responses between models, (2) disentangled the uncertainty caused by differences in ecological model assumptions from the statistical uncertainty of future climate, and (3) identified results common for the whole model ensemble. Species interactions greatly influenced the simulated response of cod to fishing and climate, as well as the degree to which the statistical uncertainty of climate trajectories carried through to uncertainty of cod responses. Models ignoring the feedback from prey on cod showed large interannual fluctuations in cod dynamics and were more sensitive to the underlying uncertainty of climate forcing than models accounting for such stabilizing predator–prey feedbacks. Yet in all models, intense fishing prevented recovery, and climate change further decreased the cod population. Our study demonstrates how the biological ensemble modeling approach makes it possible to evaluate the relative importance of different sources of uncertainty in future species responses, as well as to seek scientific conclusions and sustainable management solutions robust to uncertainty of food web processes in the face of climate change

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