

## **A High-Resolution Physical-Biological Study of the Northeast U.S. Shelf: Past Variability and Future Change**

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### **Abstract**

The ecosystem services of the northeast US region (e.g., fisheries, energy, tourism, recreation, health, etc.) are particularly vulnerable to climate change by virtue of their location at the confluence of the (cold) Labrador Current and the (warm) Gulf Stream, and a local rate of sea level rise predicted to exceed the global mean. Changes in climate will cause shifts in the location of the temperature fronts, water mass and associated biogeographic boundaries, ground and surface water distribution, directly affecting the ecosystem's structure and the associated resources (e.g., species' distributions). Understanding and quantitative projection of credible future scenarios will require sustained observations of the natural system as well as a modeling framework that represents the numerous oceanic components, the feedbacks between them, *and resolves the scales important to variability within each sub-system*. In this project we propose to study past variability and potential future changes of the Northeast U.S. (NEUS) shelf physics, biogeochemistry, and lower trophic level productivity by combining a high-resolution regional physical-biological model with global Climate and Earth System simulations.

Specifically, we will use a high-resolution coupled physical-biogeochemical model for the NEUS shelf to address questions and build capacity for understanding and predicting climate-ecosystem interactions. This system will be based on an existing coupled implementation of the Regional Ocean Modeling System (ROMS) and NOAA/GFDL's Carbon, Ocean Biogeochemistry and Lower Trophics (COBALT) biogeochemical model. First, we will implement and execute a data assimilative physical 30 year hindcast simulation using a newly developed Ensemble Kalman Filter (EnKF) for ROMS. This simulation will provide improved retrospective estimates of key physical ocean variables and their uncertainties that will be analyzed to understand the drivers of past observed hydrographic fluctuations; Second, we will develop a methodology for high-resolution seasonal predictions of ocean physics using ROMS, the EnKF and global seasonal forecasts developed at GFDL. Third, we will carry out a small ensemble downscaled physical-biological projections forced by output from selected CMIP5 Earth System Models and analyze results to assess how previously unresolved local-scale processes may significantly alter, or reverse large-scale projected changes.

The work proposed here directly addresses the funding opportunity priority research area of *Development and application of high-resolution, coupled, regional climate ocean-ecosystem models to provide past and future projections for improving our understanding of climate impacts on fish stock*. The components of this proposal will also support and augment other proposed efforts (e.g., Nye, Saba, Munroe, Wahle, Cohen, and others) and through these synergies directly link to work on higher trophic levels in the NEUS shelf. It brings together an academic and two NOAA scientists and leverages several ongoing efforts. The strengths and limitations of these systems, revealed through the analysis within this proposal and the applications it supports, are essential to ensuring the utility of a regional climate downscaling framework for marine resource applications. While a full transfer of "research to operations" is beyond the scope of this work, the three components form foundational pieces for a sustainable regional downscaling framework for the Northeast Fisheries Science center.