Environmental Studies Program: Ongoing Study

Title	Forecasted Ecosystem Conditions in Gulf of Mexico OCS Habitats Using Coupled Modeling and Climate Scenarios (GM-16-08)
Administered by	GOM OCS Region
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Procurement Type(s)	Inter-agency Agreement
Conducting Organization(s)	The Naval Research Laboratory
Total BOEM Cost	$350,000
Performance Period	FY 2016–2022
Final Report Due	August 2022
Date Revised	July 27, 2021
PICOC Summary	
Problem	BOEM requires information on both current and future spatio-temporal variability in ecosystem productivity and habitats to address impacts of the offshore oil and gas industry; however, there is a lack of objective analysis to determine baselines and predict cumulative impacts making problematic to writing NEPA analyses.
Intervention	The study will provide advanced modeling forecasts, at GOM regional scale and 50-year prediction, to determine baseline first and then generate a realistic future impact and cumulative analysis. It includes analyses on habitats of special interest to BOEM such as the Flower Garden Banks and marine mammal habitat in Mississippi and DeSoto Canyons.
Comparison	Uncertainty on future climate conditions is a critical issue in working with climate modeling and the associated environmental impact predictions. An objective analysis is imperative to define baselines and subsequently achieve reasonable cumulative analysis. The proposed objective analysis will combine the most advanced ecosystem models, well-documented climate future scenarios, and supercomputing resources to significantly improve previous numerical results in the GOM region.
Outcome	The overarching goal is to simulate through model hindcasts and forecasts how ecosystem conditions vary at detailed spatio-temporal scales in the GOM.
Context	Gulf of Mexico, all BOEM planning areas.

BOEM Information Need(s): BOEM requires information on both current and future spatio-temporal variability in ecosystem productivity and related higher-trophic habitat to address the potential impacts of the offshore oil and gas industry in the GOM over the muli-decadal lifetime of leases. This predictive need is identified in the OCSLA for understanding the cumulative impacts of multiple stressors on OCS ecosystems, as well as informing environmental sensitivity analyses for planning areas. The study will provide broad-scale forecasts for the GOM and may also analyze habitats of special interest to BOEM, such as the Flower Garden Banks and marine mammal habitat in Mississippi and De Soto Canyons. This study will inform NEPA analyses and Gulf long-term monitoring studies related to current and future variability in habitat and prey.

Background: Coupled biological-physical ocean modeling provides a powerful tool for forecasting of ecosystem conditions on both regional and global scales, augmenting more limited observational data. These types of coupled models are now 4-dimensional in space and time and are inherently interdisciplinary, incorporating aspects of physical forcing (e.g., ocean currents, winds, and solar radiation), chemical concentrations (e.g., carbon, nitrogen, and phosphorus), and biological components (e.g., bacteria, phytoplankton, and zooplankton). Coupled ocean modeling can help answer a variety of questions about the functioning of the marine ecosystem and habitat variability, including providing estimates of organic matter fluxes (e.g., primary and secondary productivity) at highly resolved spatial and temporal scales. In particular, the new generation of climate-based, ocean ecosystem models allow for forecasts of ocean habitat under a variety of greenhouse gas emission scenarios.

Only recently has the state-of-the-art in Gulf ecosystem modeling evolved from smaller regional scales to larger Gulf-wide domains. It is these Gulf-wide models that are required to address BOEM-permitted activities, with relevance to the large footprint of the oil and gas industry and its potential impacts on key-prey and/or far-ranging biological species of interest, including plankton, cetaceans, and seabirds. Key processes in the Gulf which impact distributions of these species can be captured by coupled models, including areas of upwelling, convergence, eddy activity, and riverine inputs. Model output can help fill gaps in our understanding of the climatology and future conditions of these and other Gulf oceanographic conditions and how they impact Gulf habitat.

Objectives: The overarching goal of this 5-year study is to simulate through model hindcasts and forecasts how ecosystem conditions vary at detailed spatio-temporal scales in the GOM. The specific objectives to be addressed include:

- Determining statistical variability to-date in Gulf-wide productivity and higher-trophic habitat.
- Forecasting ecosystem conditions in BOEM planning areas through 2050–2100 and identifying relative sensitivities between planning areas to future climate-based change.
- Providing higher-resolution information on past and future habitat variability in select smaller regions of special interest to BOEM.

Methods: This study will be performed through an Inter-Agency Agreement (IAA) with the Naval Research Laboratory (NRL), leveraging initial funding provided by the National Aeronautics and Space Administration (NASA) and other agencies. The objectives of this study will be met through validation and implementation of NRL's coupled bio-physical model which covers the entire GOM. The model incorporates a well-vetted, data-assimilating ocean circulation model for the Gulf, biological components, including phytoplankton and zooplankton grazers, as well as linkages with nutrients, dissolved gases, and detrital pools. The coupled model will be validated using historical Gulf datasets of physical, chemical, and biological observations; there is no new field component to this study. Sensitivity analyses will be run on the validated model to determine how sources of uncertainty can be apportioned to different model inputs. The validated model will be run in both hindcast and forecast mode over a multi-year time frame to explore seasonal and interannual variability in ecosystem dynamics (e.g., nutrient fluxes, patterns of productivity, and organic matter sedimentation). Climate scenarios from the Intergovernmental Panel on Climate Change (IPCC) will be utilized in model forecast mode to project potential impacts on Gulf habitat. Spatial and temporal variability in modeled habitat will be analyzed for BOEM planning areas in the Gulf, and at higher-resolution (using model nests) for habitat of special interest, including Flower Garden Banks and continental-slope regions that provide cetacean and pelagic seabird habitat, such as in De Soto Canyon, the Mississippi Canyon/Delta region,

and/or along the Rio Grande slope. The impacts of areas of upwelling, convergence, eddy activity, and river plume dynamics on biological productivity will be analyzed, including the role of episodic and climatic events, such as storm activity and variable Mississippi River discharge.

Specific Research Question(s): 1) Based on state-of-the-science models what would be the most realistic climatological conditions in a horizon of 50 years in the GOM? 2) Based on historical runs of these models and observational data, what would be the most reasonable ecosystem baselines for future cumulative analyses? 3) What is the uncertainty associated with future predictions based on current state of the science models?

Current Status: During year 2020, both the PI and COR had communications, discussions of quarterly reports and progress made on future modeling scenarios, statistical data analysis of results. During 2021, a no-cost modification was submitted, extending the period of performance (POP). The POP is currently extended to August 30, 2022. A peer-review publication is in progress. The project is on schedule.

Publications Completed: Peer-review publication in progress, target submission 4th quarter 2021.

Affiliated WWW Sites: https://www7330.nrlssc.navy.mil/derada/GOMCLIM/

References: NA