Environmental Studies Program: Ongoing Study

Field	Study Information
Title	High Resolution Modeling of the Gulf of Mexico (NT-20-05)
Administered by	Office of Environmental Programs
BOEM Contact(s)	Jeff Ji (jeff.ji@boem.gov)
Procurement Type(s)	Cooperative Agreement
Conducting Organization(s)	Florida State University
Total BOEM Cost	$490,000
Performance Period	FY 2020–2022
Final Report Due	September, 2024
Date Revised	October 5, 2023
Problem	High resolution currents in the Gulf of Mexico (GOM) are needed to conduct oil spill risk analysis (OSRA). The accuracy of the current information, in terms of spatial and time resolution, is critical for the accuracy of the OSRA model results. Understanding the importance of ocean model resolution is also pertinent to analyzing the hydrodynamic and environmental processes in the GOM.
Intervention	This study will be conducted using the existing Hybrid Coordinate Ocean Model (HYCOM). The latest information on bathymetry, river inflows, satellite data, and meteorological fields will be incorporated into the HYCOM. The model grid will have a 1/100°-resolution in the GOM.
Comparison	Perform a 20-year data-assimilative hindcast using a 1/100°-resolution HYCOM configuration of the GOM with accurate bathymetry and enhanced vertical resolution compared to the presently available 1/25°-resolution HYCOM hindcast.
Outcome	The output of this study will be directly used in the BOEM OSRA applications. The improved currents will enhance the accuracy of OSRA model results and help us understand the impact of spatial resolution on the performance of OSRA model.
Context	Gulf of Mexico and Caribbean Sea

BOEM Information Need(s): BOEM needs better and more accurate information on currents and eddy activities in the GOM (BOEM, 2014). Results from this study will expand BOEM's ability to assess oil spill risks in the GOM and improve its ability to estimate oil spill trajectories.

Background: Circulation in the GOM is dominated by the Loop Current (LC) and by Loop Current eddies (LCEs) that form at irregular multi-month intervals by separation from the LC. Comparatively small cyclonic eddies (CEs) are thought to have a controlling influence on the LCE, including its separation from the LC. Because the CEs are so dynamic and short-lived, lasting only a few weeks, they have proved a challenge to observe and to numerically simulate. The spatial scale of these eddies can be 20 km or

less. With such small spatial scale, it is essential to have an ocean model that has sufficient spatial resolution to describe the LC and LCEs with confidence.

Accurate representation of the ocean dynamics in ocean models advecting the oil particles is crucial for simulating of the oil trajectories, since location of mesoscale features largely determines local surface oil transport. This is also important for understanding ecological connectivity, adaptability, and changes of critical deep communities that are commonly found in regions with substantial small-scale topographic variability.

Objectives:

1. Enhance the HYCOM with a high grid resolution of 1/100o. The numerical schemes of the model should also be carefully examined to ensure that the high resolution and the schemes are consistent with each other. Statistical tools should be used for model verification and validation.
2. Examine interactions of the vertical circulation with the sub-surface hydrography and horizontal circulation fields. The goal is to provide information on the potential lateral displacement and sub-surface transport of oil released at depth.
3. Perform a 20-year simulation using a 1/100°-resolution HYCOM configuration of the GOM with accurate bathymetry and enhanced vertical resolution compared to the presently available 1/25°-resolution HYCOM hindcast.
4. Deliver the 20-year HYCOM model results to BOEM for OSRA applications in the GOM.
    a. Hourly surface currents and 3-hourly (or less) sub-surface currents.
    b. Domain estimated to cover GOM and eastward through the Caribbean.

Methods: HYCOM (Chassignet et al., 2007; Chassignet and Srinivasan, 2015) was developed to improve the vertical coordinate scheme of earlier models. HYCOM is a primitive equation, general circulation model with vertical coordinates that remain isopycnic in the open, stratified ocean. This study will address the need for a new data assimilative ocean model that simulates characteristics of the deep Gulf consistent with new understanding gained from recent BOEM observational studies. The model would also provide a predictive tool to assess transport and impacts of oil spills throughout the Gulf from the surface to the seafloor.

Specific Research Question(s):

1. What are the potential impacts of different model grid resolutions to the simulation of eddies and other dynamic processes in the GOM?
2. How can the subsurface information from this high-resolution modeling be used in BOEM's oil spill risk analysis?
3. Over the simulation period of 20 years, will the fine resolution HYCOM (up to 1/1000) always be sufficient to resolve the eddy and eddy shedding processes in the GOM?

Current Status: The study is in its third year. The contract was modified to have 1-year extension, so that additional 2 years of simulation can be finished without extra costs to BOEM. The results of the originally required 20-year simulation has already been delivered to BOEM. The COR is currently working closely with the PIs of FSU on this cooperative agreement.

Publications Completed: None

Affiliated WWW Sites: None

References:

Ko DS, Wang D-P. 2014. Intra-Americas Sea Nowcast/Forecast System ocean reanalysis to support improvement of oil-spill risk analysis in the Gulf of Mexico by multi-model approach. Herndon (VA): U.S. Department of the Interior, Bureau of Ocean Energy Management. 65 p. Report No.: OCS Study BOEM 2014-1003.

Chassignet EP, Hurlburt HE, Smedstad OM, Halliwell GR, Hogan PJ, Wallcraft AJ, Baraille R, Bleck R. 2007. The HYCOM (Hybrid Coordinate Ocean Model) data assimilative system. J. Mar. Syst. 65:60–83.

Chassignet EP, Srinivasan A. 2015. Data assimilative hindcast for the Gulf of Mexico. Sterling (VA): U.S. Department of the Interior, Bureau of Ocean Energy Management. 46 p. Report No.: OCS Study BOEM 2015-035.