Field	Study Information
Title	Developing a Next-generation 3D Oil Spill Model to Better Serve BOEM's Mission (NT-26-01)
Administered by	Office of Environmental Programs
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Procurement Type(s)	Contract, Cooperative Agreement
Conducting Organization(s)	TBD
Total BOEM Cost	TBD
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Final Report Due	TBD
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Problem	BOEM needs a transparent, efficient, and legally defensible oil spill risk assessment tool to enhance decision-making in response to the increasing oil and gas lease sales in the Outer Continental Shelf (OCS). The current Oil Spill Risk Analysis (OSRA) model requires extensive time to implement, lacks some oil spill dynamics, and has no public facing visualization interface for ease of understanding.
Intervention	This study aims to adapt the community-based, open-source, state-of-the-art, 3D oil spill model OpenDrift to calculate oil spill metrics for use in BOEM's environmental assessments and to develop a public facing interface for understanding and visualization of model results.
Comparison	OpenDrift is an integrated oil spill transport and fate model that can simulate both 2D and a more complicated 3D oil spill, such as Deepwater Horizon incident in the Gulf of America.
Outcome	This study will deliver the following: 1) a modern, well-documented 3D oil spill model code that BOEM modeling experts can run independently for oil spill risk assessment; 2) a web portal for calculating the 3D oil spill trajectories that incorporates various oil spill weathering processes that can be easily used and understood by those who are not oil spill modelers; and 3) long-term (≥10 years) probability maps for oil spill trajectories in regions of interests, along with a public facing visualization tool for these results.
Context	Gulf of America, Cook Inlet, and other potential OCS leasing areas

BOEM Information Need(s): The Outer Continental Shelf Lands Act (43 U.S.C. § 1331 et seq.) mandates that the Secretary of the Interior administers energy and mineral resources in an environmentally responsible manner. The current OSRA model is a crucial tool for BOEM in estimating oil spill risks to environmental and social resources related to potential oil and gas lease sales, exploration, and development on the OCS. The OSRA model produces oil spill metrics in support of decision-making for oil and gas leasing, exploration, and development on the OCS and information for oil spill response plans. However, the current OSRA model requires extensive time to implement, lacks some oil spill

dynamics, and has no public facing visualization interface for ease of understanding (Kaufman et al. 2024). These limitations highlight the need for a more efficient and modernized 3D oil spill risk assessment tool for BOEM's environmental assessments and decision-making processes in OCS oil and gas exploration and development.

To support the current administration's Executive Order (EO) 14154, titled "Unleashing American Energy," along with Executive Order 14213, which creates the National Energy Dominance Council, and Secretary Order (SO) 3417, addressing the National Energy Emergency, as well as Secretary Order 3418—also focused on "Unleashing American Energy"—which promotes energy exploration and production on federal lands and waters, including the Outer Continental Shelf (OCS), BOEM expects an increase in oil and gas lease sales. Therefore, it is crucial to develop a highly effective spill risk assessment tool to meet these forthcoming needs. This study will develop a 3D oil spill model that can simulate both surface and subsurface oil spill releases and have a user interface for easier usage and understanding. Adapting an open-source model such as OpenDrift will enhance BOEM's environmental assessments and decision-making processes in OCS oil and gas exploration and development.

Background: OpenDrift was developed by the Norwegian Meteorological Institute (Dagestad et al. 2018) and has demonstrated to be able to realistically simulate incidents such as Deepwater Horizon oil spill (Hole et al. 2019). OpenDrift was identified as one of two highly regarded open-source models widely used in the scientific community, based on a comprehensive review of eighteen state-of-the-art oil spill models that includes both open-source and proprietary models (Keramea et al. 2021). OpenDrift includes all major oil spill weathering processes: spreading, advection, diffusion, evaporation, emulsification, and dispersion. It utilizes a 3D module to simulate vertical mixing due to oceanic waves and currents, as well as the resurfacing of oil due to buoyancy. The model also integrates oil properties from the ADIOS oil database (Lehr et al. 2002), developed by the National Oceanic and Atmospheric Administration (NOAA), ensuring accurate representation of oil behavior. Unlike traditional operational oil spill models that typically focus on short-term predictions (a few days), OpenDrift has been successfully used to generate 30-year probability maps for oil spill trajectories in the Barents Sea, providing potential environmental and social-economic risk assessment (Pavlov et al, 2022).

Currently, the NOAA Offshore Technology Transition office is funding a three-year project (September 2023 - August 2026) in the Cook Inlet, titled "Marine Particle Tracking and Visualization Tools for Coastal Incident Response, Maritime Domain Awareness, and Research Applications." This project uses OpenDrift code set for trajectory simulation. BOEM is a member of the Project Technical Committee (PTC) for this initiative and could leverage insights and experiences gained from this project.

Objective(s):

- Develop a modern oil spill risk assessment tool to calculate oil spill metrics for use in BOEM's environmental assessments using an open source, well-established 3D oil spill model OpenDrift.
- Develop a web portal to calculate 3D oil spill trajectories that include oil spill dynamics for oil spill response planning and non-specialists.
- Develop a visualization tool to archive and display the probabilities generated from long-term (>10 years) simulation using best available meteorological, oceanographic and sea ice data.

In additional to code development, a user manual documenting these tools is required.

Methods: This study will develop a model framework that simulates stochastic oil spill trajectories and calculates oil spill metrics using an open source operational, 3D oil spill model OpenDrift. The model will be capable of simulating oil weathering processes and coupled to meteorological, oceanographic and wave models. Oil spill metrics based on the model output will be developed along with appropriate visualizations.

This study will simulate a real oil spill scenario, such as the Deepwater Horizon incident in the Gulf of America, to validate the model with observations. The simulation of the oil spill scenario will consider factors such as spill volume and oil characteristics, and it will quantify oil contamination by calculating the distribution of oil mass across the surface area, i.e., oil thickness, or other appropriate metrics. This will help assess the oil spill impact on ecological and socio-economic resources that are sensitive to varying thresholds of oil thickness, ranging from barely visible sheens to slicks that could endanger birds and other marine species (Galagan et al. 2018). Additionally, the study will create a graphical user interface (GUI) for the scenario simulation, allowing for the adjustment of input parameters to illustrate the effects of current, wind, wave, and various weathering processes on oil spill trajectories.

This research will use the latest 10-year output from a high-resolution ocean model in the Gulf of America, specifically the Hybrid Coordinate Ocean Model (HYCOM) 1/100° model reanalysis (available at https://www.hycom.org/dataserver/gom/gom-reanalysis), along with wind data, to simulate oil spill trajectories from potential leasing areas in the Gulf of America. The analysis will primarily focus on 2D surface oil releases for stochastic oil spill trajectory simulations, as the 3D effects on the water column are difficult to assess due to the rapid spatial and temporal variability of contamination.

Oil spill trajectories will be modeled by inputting a shapefile that represents geospatial locations identical to the hypothetical launch areas or by initializing from a set of launch points within the designated area. Spill trajectories will be simulated daily or over longer intervals throughout the 10-year period, with trajectories tracked for up to 30 days or as deemed appropriate based on the oil spill volume and characteristics. Seasonal and annual distributions of spill probability will be derived from this analysis by tabulating the contacts of trajectories launched over the 10-year period to the grid cells in the model domain and dividing the contacts by the total number of trajectories launched. A 10-year probability map of trajectory will be created based on various leasing scenarios. Probability statistics of contamination, based on the oil thickness threshold, will be archived, allowing for post-processing to evaluate the impacts on individual ecological and socio-economic resources.

The study will adopt a phased approach, beginning with trajectory simulations that do not consider oil volume or characteristics, using one year of data to demonstrate the concept and robustness of the calculations, as well as the post-processing capabilities for generating spill probability related to individual resources. Oil spill volume and characteristics will be incorporated into the analysis in subsequent phases.

Specific Research Question(s):

1. How do the oil spill weathering processes affect trajectories when simulated with high-resolution meteorological, hydrodynamic, and wave data, along with oil types pertinent to specific regions of interest?
2. How do oil spills originating from the potential leasing area affect the environmental resources, including those spills at-depth?

3. What is the most efficient approach to initiate hypothetical oil spill trajectories, rather than using launch points that span the entire planning area?

Current Status: N/A

Publications Completed: N/A

Affiliated WWW Sites: Web site for OpenDrift model: https://opendrift.github.io/.

References:

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