Offshore Wind Impact on Oceanographic Processes: Middle Atlantic Shelf

Authors:
Nickitas Georgas, RPS, a Tetra Tech company
Dan Codiga, Tetra Tech
Emily Day, Tetra Tech
Lily Engel, Pacific Northwest National Lab
Lysel Garavelli, PNNL
Lenaig Hemery, PNNL
Mahmud Monim, Tetra Tech

Abstract ID: 35
Call:: MRC 2025 Technical Track – Call for Abstracts
What Theme Are You Submitting for?: Environmental and Ecosystem Considerations
Keywords: Delft3D, Environmental Impacts, Ichthyop, Offshore Wind, SWAN, Wind wake, circulation, larval connectivity, pyWake, stratification, waves

Offshore wind energy development along the U.S. North Atlantic shelf (North Carolina to New York) has raised stakeholder concerns about environmental impacts. This study evaluates potential changes to physical oceanography and larval transport from large-scale offshore wind farm installations using a coupled modeling system. We simulated three scenarios from February 2018 to January 2020: (1) baseline (no turbines), (2) partial buildout, and (3) complete buildout (8 fully occupied clusters). Wake effects from 15 MW turbines were modeled using PyWake, with wake-modified winds applied across the domain. These winds, combined with increased hydrodynamic drag near monopiles, forced SWAN and Delft3D-FM models.

Results show wind speed reductions exceeding 20% locally within turbine arrays and ~10% at their downwind edges, extending 100–200 km. Wave heights and bed shear stress are reduced primarily where wind is suppressed. Hydrodynamic changes are dominated by wind reductions rather than turbine-induced drag, leading to enhanced southward along-shelf currents, stronger stratification, and higher surface temperatures. Seasonal cold pool evolution remains largely unaffected.

A biophysical larval dispersal model (Ichthyop) evaluated impacts on Atlantic sea scallop, surfclam, and black sea bass. Under baseline conditions, larvae were transported predominantly southward with higher connectivity in northern areas. Wind farm-induced changes decreased northern retention and increased dispersal distances. Including vertical migration behavior increased connectivity, while temperature-dependent mortality reduced it.

Overall, the most ecologically relevant impacts stem from hydrodynamic alterations, especially temperature increases and stratification. These may influence larval dynamics and species distributions, potentially amplifying climate-driven northward shifts. Impacts on

sediment mobility and regional oceanography are modest relative to natural variability, with strongest effects localized within and near wind arrays.