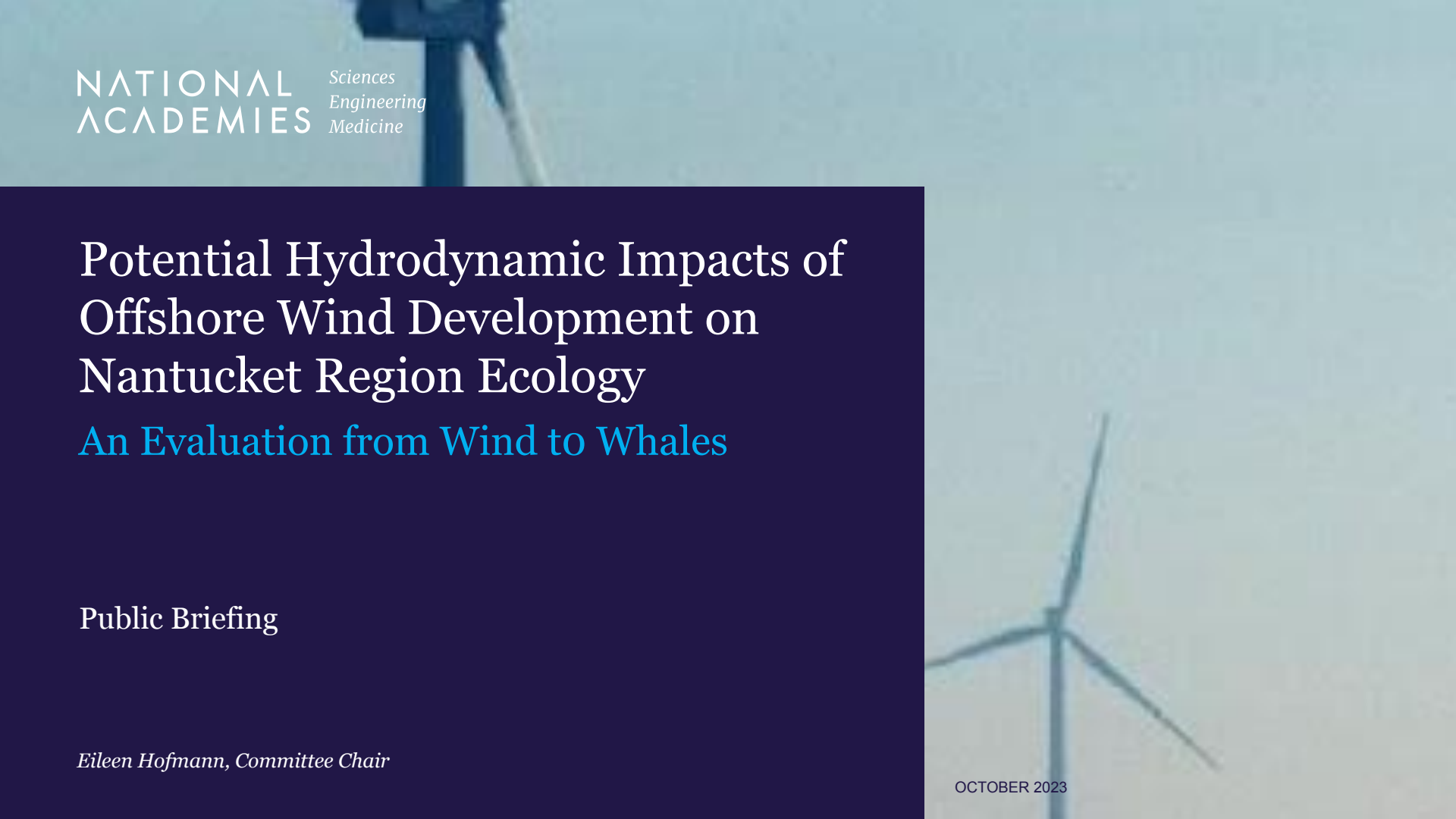

NATIONAL ACADEMIES
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Medicine

Potential Hydrodynamic Impacts of Offshore Wind Development on Nantucket Region Ecology

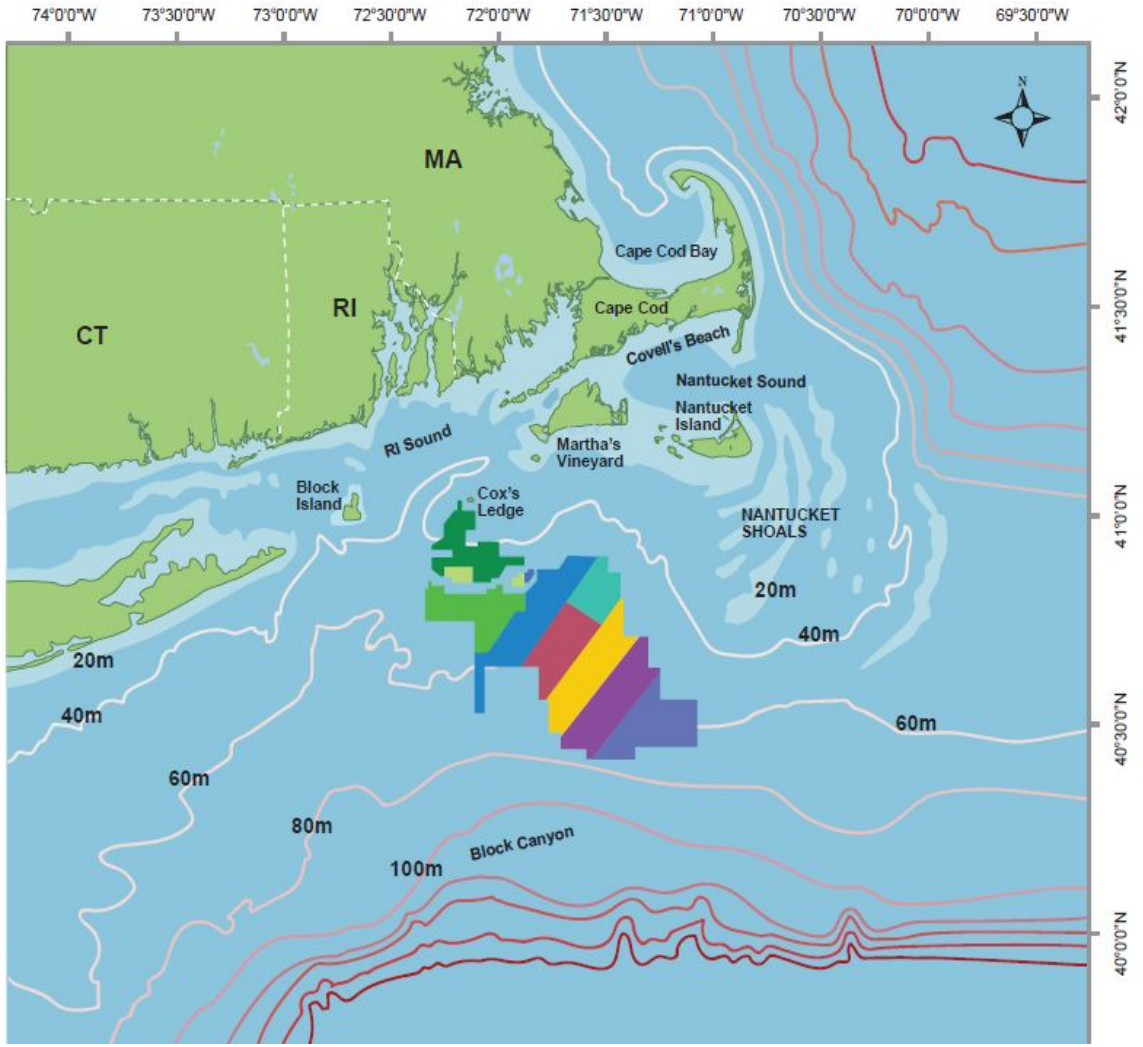
An Evaluation from Wind to Whales

Public Briefing

Eileen Hofmann, Committee Chair

OCTOBER 2023

Nantucket Shoals Region Offshore Wind Development



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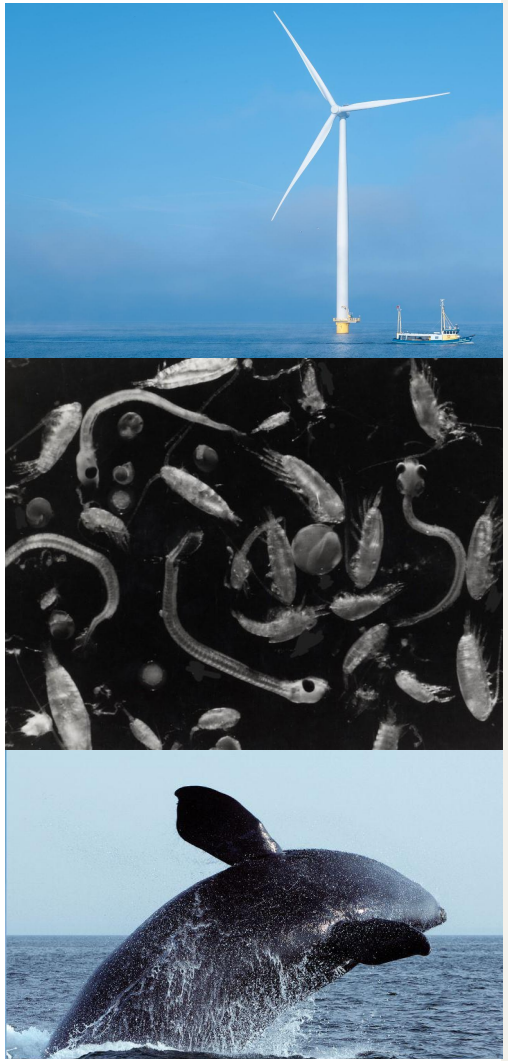
Statement of Task

- Conduct a literature review covering the state of the science on the effects of offshore wind turbine structures at local to regional scales on hydrodynamic process and the scale of change related to natural variability.
- Based on the literature review and public information gathering sessions:
    - Comment on the ability to estimate the extent of perturbations (distance and magnitude) caused by WTG installation and operation, to the oceanographic regime. This will include potential changes to ecosystem dynamics, specifically for assessing whether these facilities could substantially affect North Atlantic right whale prey availability near Nantucket Shoals.
    - Evaluate the applicability of models used by the Bureau of Ocean Energy Management in EIS analysis or studies in conjunction with US Atlantic Wind Energy Areas to the Nantucket Shoals region.
    - Suggest approaches for assessing the hydrodynamic impacts of WTGs.

Committee

- **Eileen Hofmann**, *Chair*, Old Dominion University
- **Jeffrey Carpenter,** Helmholtz-Zentrum Hereon
- **Qin Jim Chen,** Northeastern University
- **Josh Kohut,** Rutgers University
- **Richard Merrick,** NOAA Fisheries (retired)
- **Erin Meyer-Gutbrod**, University of South Carolina
- **Douglas Nowacek,** Duke University
- **Kaustubha Raghukumar,** Integral Consulting Inc
- **Nicholas Record,** Bigelow Laboratory



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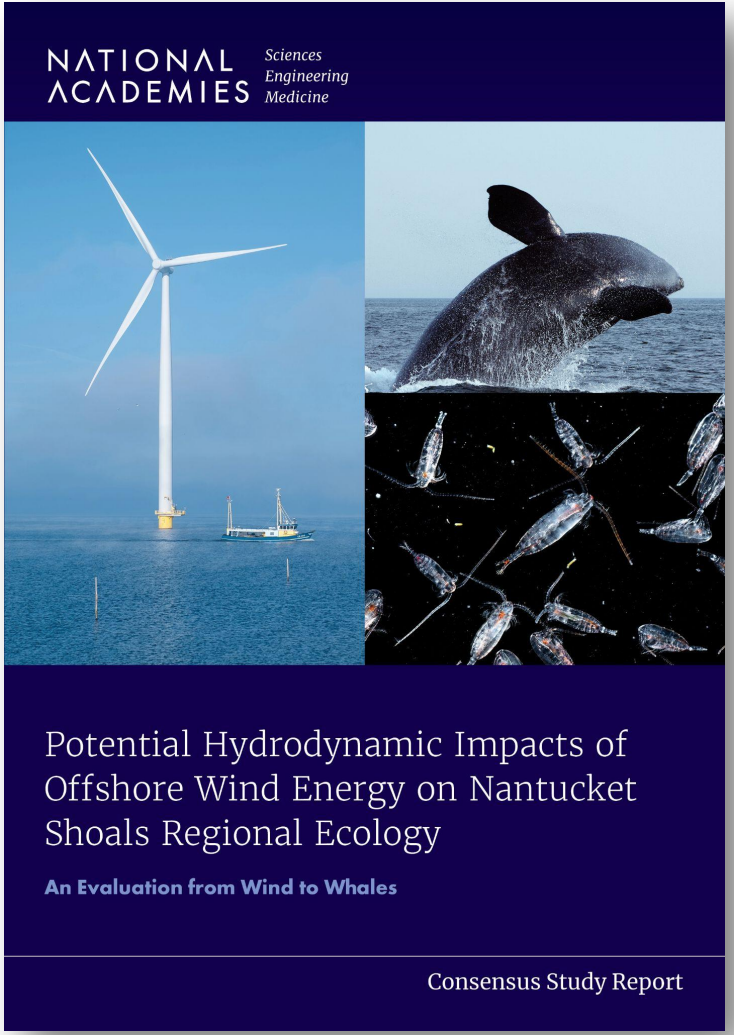
Study Overview

- 1-year contract:
  March 01, 2023 – February 28, 2024
- Sponsor: BOEM
- Committee of 9 volunteer experts
- Four 2-day meetings + chapter team meetings
  - Public workshop, information gathering
  - Deliberations and writing
- External peer review
- Deliverables:
  - Peer-reviewed consensus study….in 6 months!
  - 4-page highlights; 1 page summary
  - Conference & Meeting presentations

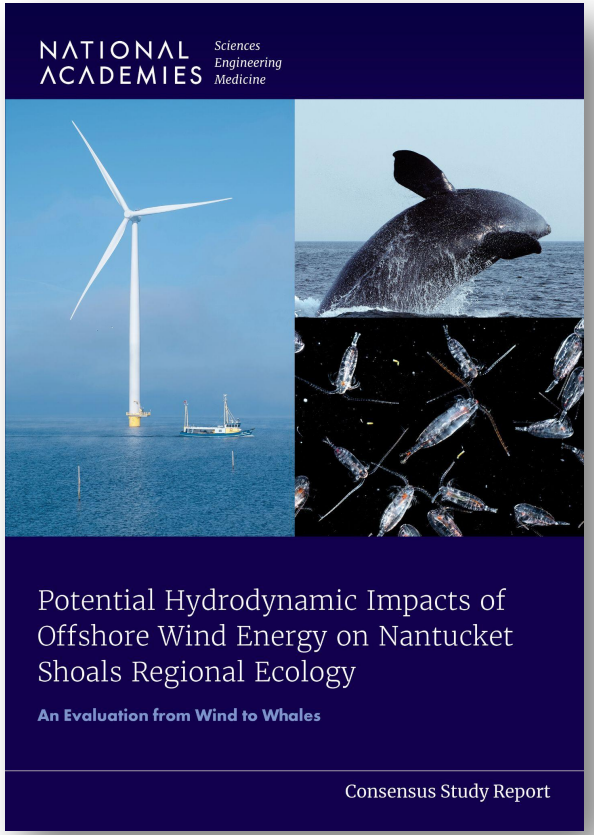


Summary of Conclusions

- The significant natural and anthropogenic variability in this dynamic oceanographic and ecological system suggests:
  - Perturbations in hydrodynamics due to wind farm development in the Nantucket Shoals region are likely to be difficult to isolate
  - Effects on the zooplankton are likely to be difficult to distinguish

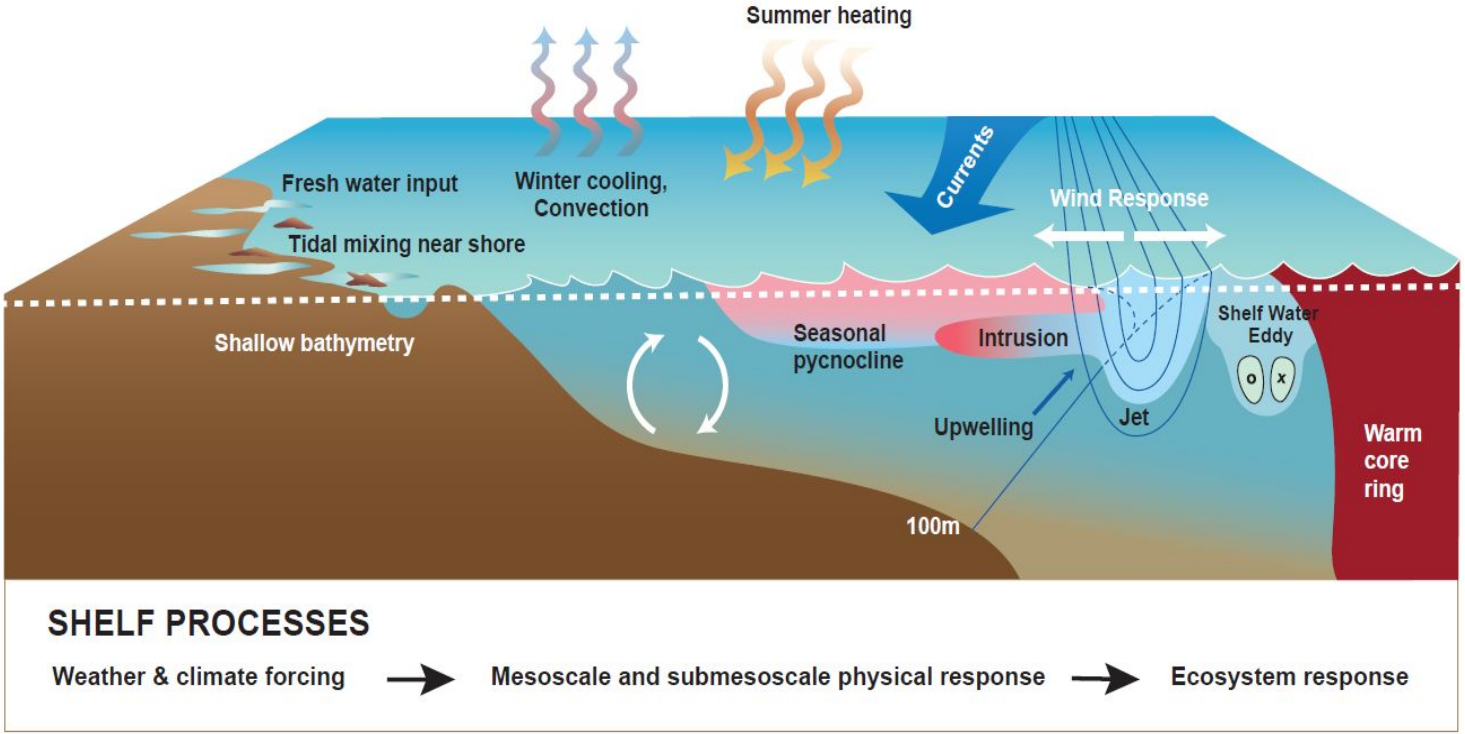
- Significant uncertainties exist in assessing the hydrodynamic impacts associated with:
  - Wind wake and ocean wake effects at local, farm, and regional scales for this region and with the wind farm design planned for the Nantucket Shoals region
  - Abundance and aggregation of zooplankton including right whale prey like *Calanus finmarchicus*, *Pseudocalanus* and *Centropages*
  - Current and future foraging patterns of North Atlantic right whales

Report Structure



1. Introduction
2. **Oceanographic Regime**
3. Hydrodynamic Impacts
4. Ecological Impacts

Physical Oceanography of the Nantucket Shoals Region

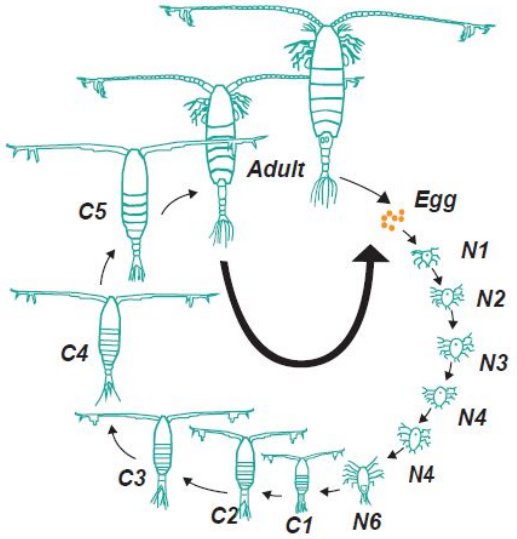


SOURCE: Adapted from Gawarkiewicz and Plueddemann, 2020

Biological Oceanography of the Nantucket Shoals Region

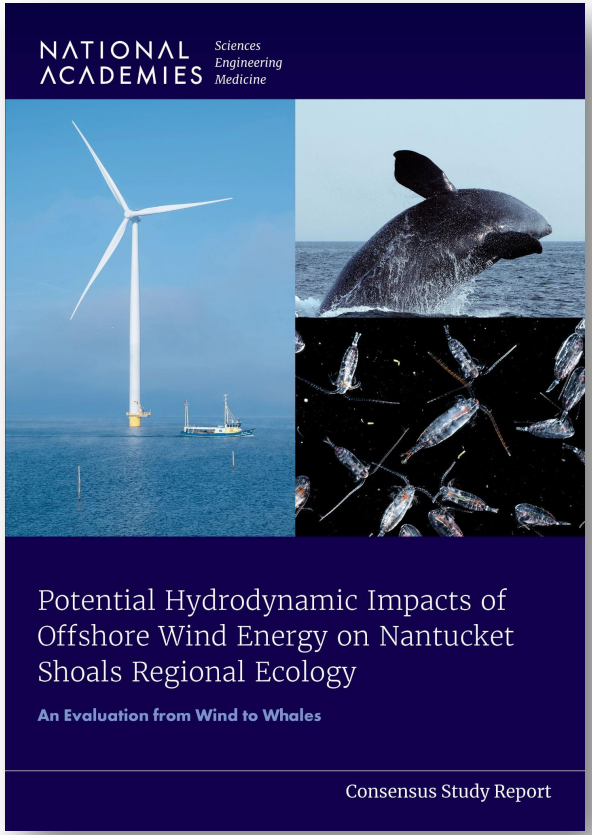
- Nantucket Shoals area is an important foraging regions for the North Atlantic right whale
- North Atlantic right whales migrate to the region to forage from winter to spring
- *Calanus finmarchicus* is a primary prey
- Habitat is changing as a result of climate change - particularly since ~2010

SOURCE: Dawn Witherington; NOAA



SOURCE: Adapted from Ji et al., 2017

Report Structure



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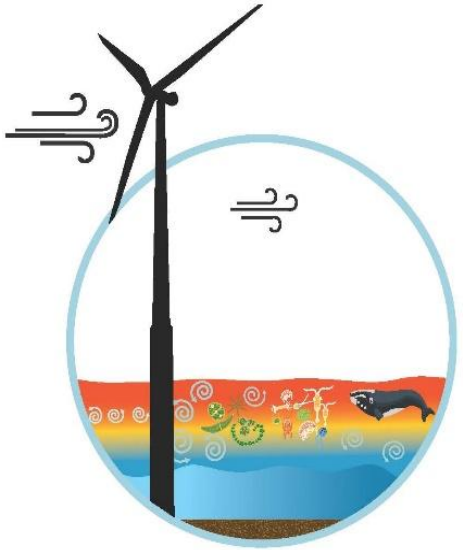
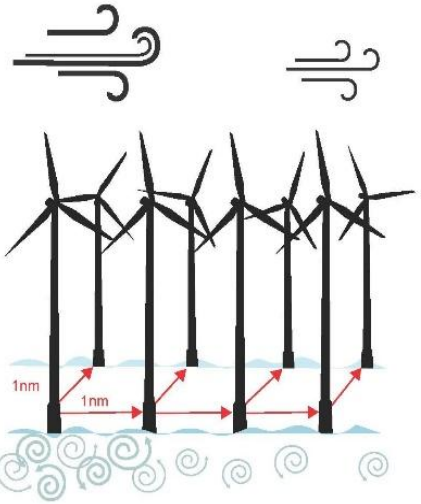
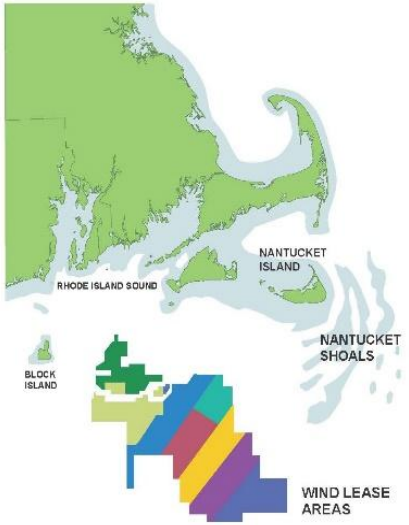
Scale of Effects



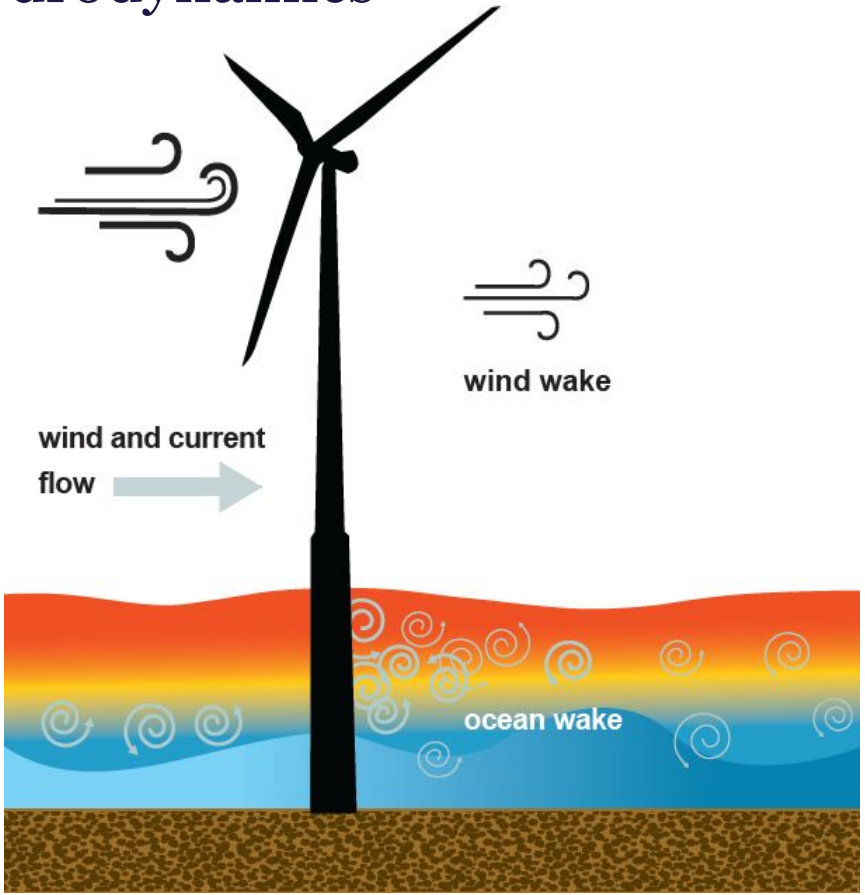




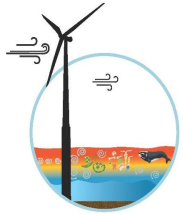
	TURBINE	WIND FARM	REGION
SPATIAL SCALE	~1m–1km	1km–100s km	> 100s km

Wind Turbine Effects on Hydrodynamics

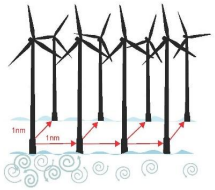
- Wind wake
  - Increased turbulence downwind of turbine
  - Decreased wind stress / effects on stratification
- Ocean wake
  - increased turbulence downflow of pile



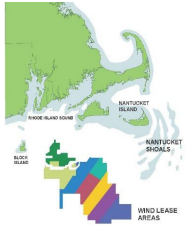
Ability to Estimate Perturbations



Turbine scale: few observations for verification of wake behavior.



Wind farm scale: changes in ocean current speeds, stratification, ocean surface wind speed, and deflection of the pycnocline.



Regional scale: difficult to quantify due to natural variability.

Applicability of Hydrodynamic Models to the Region

Scale of Effects	Resolution	Idealized	LES	Non-hydrostatic Models	RANS Models
Turbine O(1)m – O(1)km	Millimeters to meters	●	●	◖	◖
WEA O(1) km – O(10-100)km	Meters to 10s of meters	●	●	●	●
Region >O(100)km	10s-1000s of meters	●	●	●	●

LES - Large Eddy Simulation
RANS - Reynolds-averaged Navier-Stokes Models

- ● Only assess key processes at these scales
- ● Support predictions at specified resolution
- ◖ Some versions can support an unstructured grid
- ● Full range of process at these scales is constrained by computational capacity
- ◖ Can assess specific processes at these scales and requires parameterization

Recommendation 1: Hydrodynamic Observations

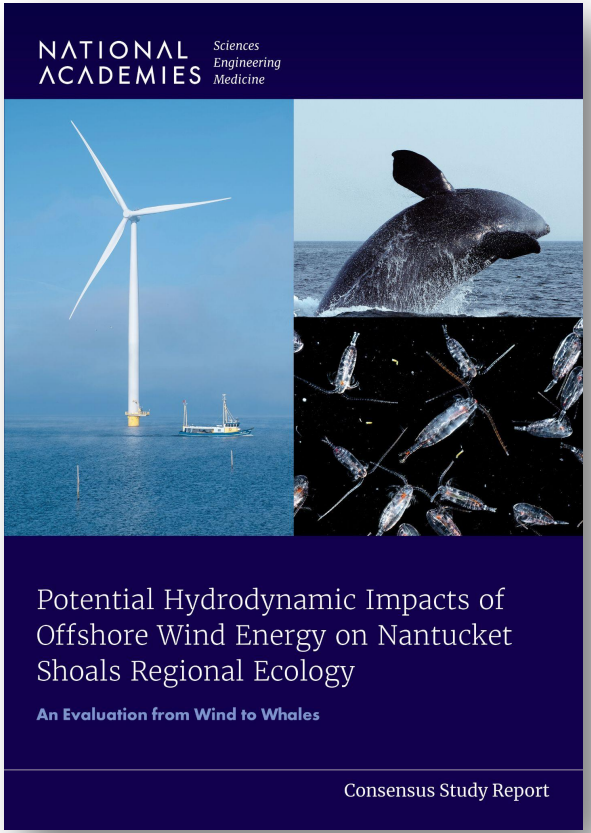
The Bureau of Ocean Energy Management, National Oceanic Atmospheric Administration, and others should promote, and where possible, require **observational studies** within wind farms during all phases of wind energy development—surveying, construction, operation, and decommissioning—that **target processes at the relevant turbine to wind farm scales to isolate, quantify, and characterize the hydrodynamic effects**. Studies at Block Island, Dominion, Vineyard Wind I, and South Fork should be considered as **case study sites** given their varying numbers of turbines, types of foundation, and sizes of turbine spacing.

Recommendation 2: Hydrodynamic Modeling

The Bureau of Ocean Energy Management, National Oceanic Atmospheric Administration, and others should **require model validation studies** to determine the capability and appropriateness of a particular model to simulate key baseline hydrodynamic processes relevant **at turbine, wind farm, and/or regional scales**. These studies should

- Evaluate the ability of the model to represent the physical complexity
- Evaluate the model sensitivity
- Quantify the uncertainty
- Evaluate model performance
- Make parameterizations, model configurations, and solutions publicly available

Report Structure



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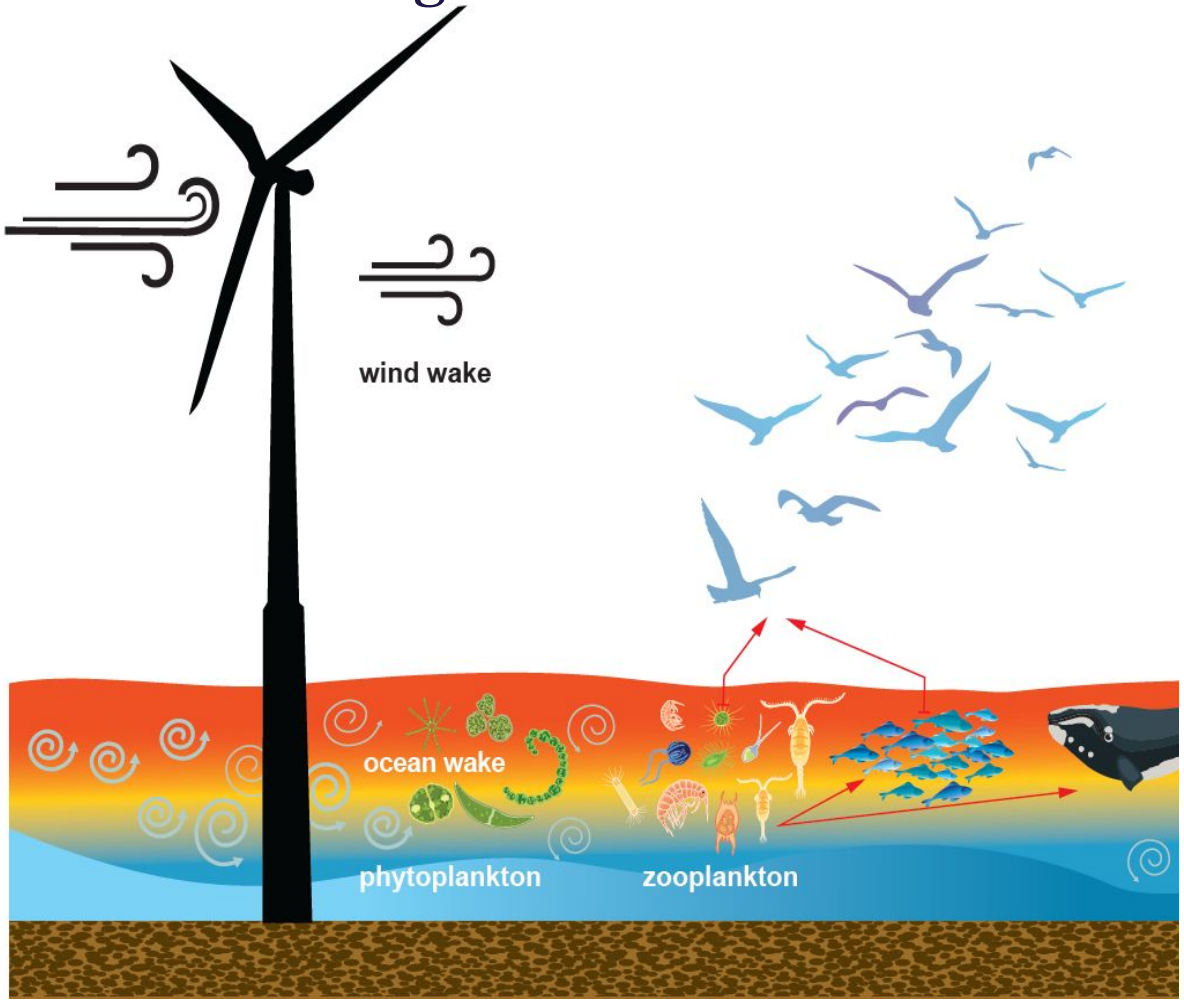
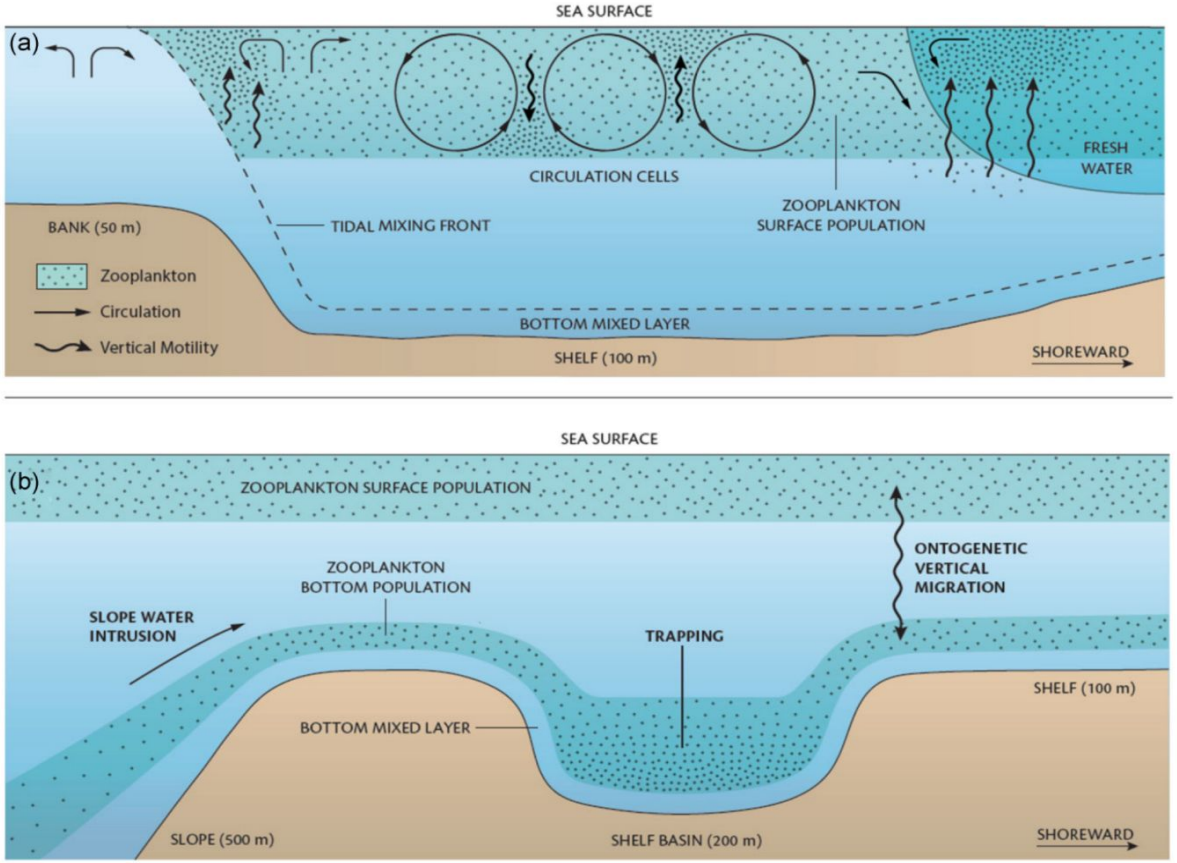
Ecological Effects



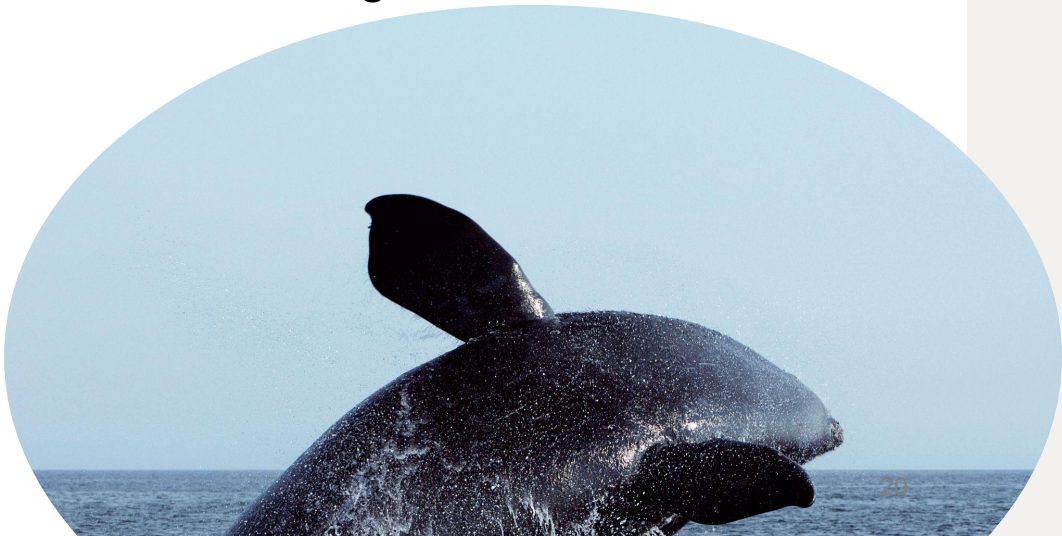
Hydrodynamic influences on Calanus



SOURCE: Sorochan, 2021

Effects on the Right Whale

- The hydrodynamic impacts on zooplankton are currently difficult to isolate
- There is a gap in understanding of foraging by North Atlantic right whales in the Nantucket Shoals region
- Studies concentrated at the wind farm scale do not adequately capture broad-scale right whale use of the Nantucket Shoals region
- Difficult to detect and/or predict



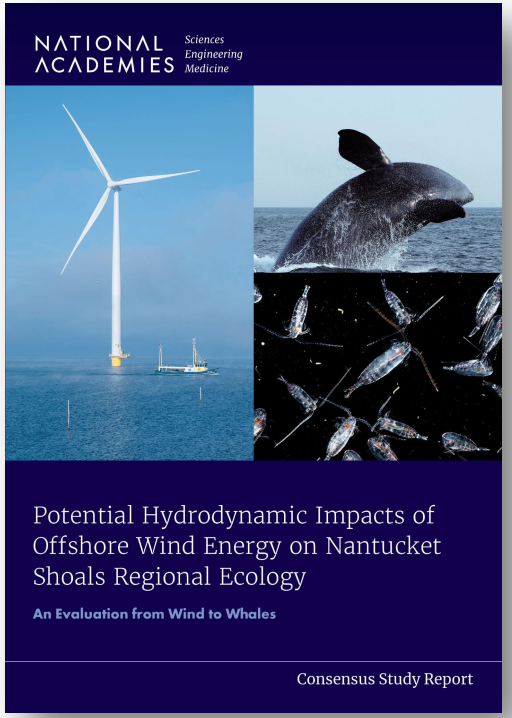
Recommendation 3: Oceanographic and Ecological Observations

The Bureau of Ocean Energy Management, National Oceanic Atmospheric Administration, and others should require the collection of **oceanographic and ecological observations** through a robust integrated monitoring program **before and during all phases of wind energy development**: surveying, construction, operation, and decommissioning. This is especially important as right whale use of the Nantucket Shoals region continues to evolve due to oceanographic changes and/or the activities and conditions relevant to offshore wind turbines.

Recommendation 4: Oceanographic and Ecological Modeling

The Bureau of Ocean Energy Management, National Oceanic Atmospheric Administration, and others should require **oceanographic and ecological modeling before and during all phases of wind energy development**: surveying, construction, operation, and decommissioning. This critical information will help guide regional policies that protect right whales and improve predictions of ecological impacts from wind development at other lease sites.

Key Takeaways



- Significant uncertainties exist in assessing:
  - hydrodynamic impacts at local, farm, and regional scales for this region and with the wind farm design planned for the Nantucket Shoals region
  - Abundance and aggregation of zooplankton and especially *Calanus finmarchicus*
  - Current and future foraging patterns of North Atlantic right whales
- The significant natural and anthropogenic variability suggests:
  - Perturbations in hydrodynamics due to wind farm development in the Nantucket Shoals region are likely to be difficult to isolate
  - Effects on the zooplankton are likely to be difficult to distinguish
- Responsible development, operation, and decommissioning of offshore wind in this region should include:
  - Coordinated regional programs designed to understand and identify hydrodynamic and ecological effects at the turbine and wind farm scales. Case studies at existing NE coast wind farm sites are a prime opportunity
  - Modeling studies that capture the physical and ecological complexity of the region.

Acknowledgements

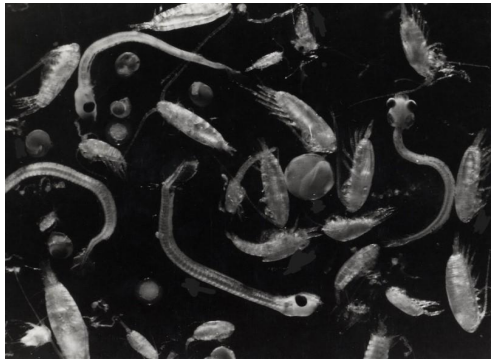
- Bureau of Ocean Energy Management
- Many volunteers who generously gave their time and expertise to enriching this effort:

  Cristina Archer (University of Delaware), Mary Boatman (BOEM), Yorick Broekema (Deltares), Göran Broström (University of Gothenburg), Changsheng Chen (University of Massachusetts Dartmouth), Ute Daewel (Helmholtz-Zentrum Hereon), Glen Gawarkiewicz (Woods Hole Oceanographic Institution), Sean Hayes (National Oceanic and Atmospheric Administration), Tom Johnson (Danish Hydraulic Institute), Seth Kaplan (Ocean Winds), Laura Morse (Invenergy), Ruth Perry (Shell Renewable and Energy Solutions), Andrew Pershing (Climate Central), Ole Petersen (Danish Hydraulic Institute), Jeffrey Runge (University of Maine), and Ariana Zampollo (University of Aberdeen)

- Peer Reviewers and Report Review Committee:
  Alan Hastings (NAS), University of California, Davis
  Anthony Kirincich, Woods Hole Oceanographic Institution
  Charles “Stormy” Mayo, Center for Coastal Studies
  Ruth Perry, Shell Renewables and Energy Solutions
  Jeffrey Runge, University of Maine
  Paul Thompson, University of Aberdeen
  Roger Wang, Rutgers University
  Richard Sears, Stanford University
  Katherine Freeman, Penn State University

Thank you!

Any questions?


To learn more about the study or process:

https://www.nationalacademies.org/our-work/evaluation-of-hydrodynamic-modeling-and-implications-for-offshore-wind-development-nantucket-shoals