Study of Potential Wind Farm Impacts on Nantucket Shoals

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Introduction

This study evaluated the potential for an operational offshore wind farm to affect hydrodynamics in the Nantucket Shoals (NS) area of coastal southern New England. Altering hydrodynamics, such as seasonal water column stratification, might affect the distribution and density of zooplankton, particularly copepods (*Calanus finmarchicus*), which are the favored prey of the endangered North Atlantic right whale (NARW).

Methods

Data analysis and analytical models were used to assess whether and how much:

- the wake effect from turbine rotors might alter sea surface conditions
- turbine towers might alter mixing and circulation in local and regional waters.

Historical data and literature studies were used to quantify NARW foraging habits and *C. finmarchicus* distributions and density.

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Study made possible through funding by SouthCoast Wind

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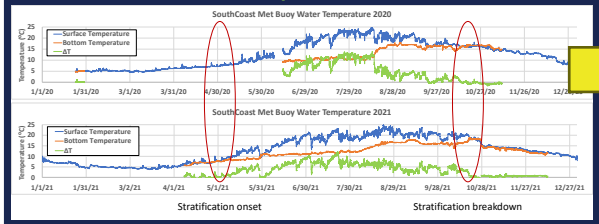
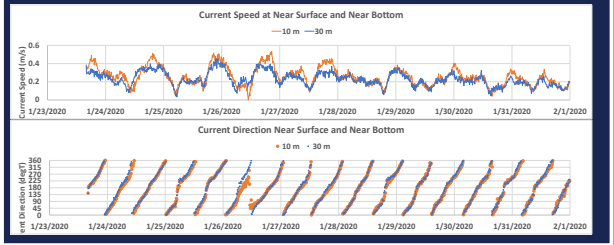
Surface & bottom temperature => Stratification



Current speed & direction => Copepods Aggregations

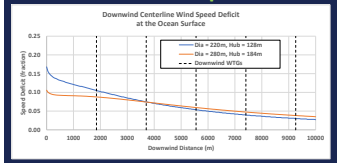


Results

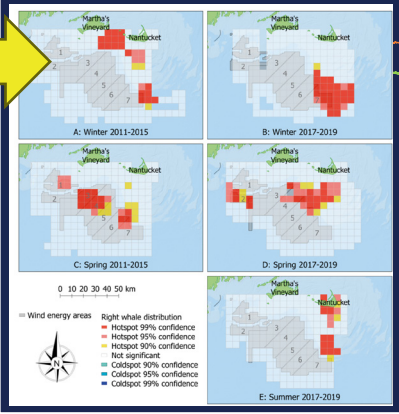
- With 1 nm (1,852 m) between turbines, cumulative effects are unlikely.
- Mixing disturbance would not reach tidal mixing front.

- Wake model[1] application predicted decreased surface wind speeds of 0.5 m/s, within local variability. Primary impacts aloft.
- Subsurface tower wake effects extend 11x tower diameter[2], <10% (185 m) of the distance between towers, others[3] suggest up to 50x D (800 m), i.e.<½ the distance.
- Mixing model[4] showed tower wake energy insufficient to break down stratification locally or over the WEA during summer season.

Sea surface wind speed deficit

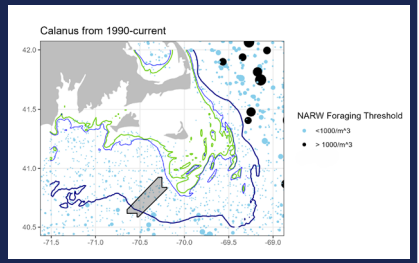


NARW Foraging Distribution

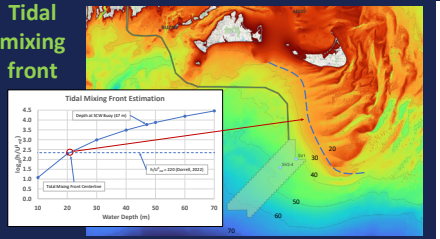


Complex bathymetry, water column stratification, and tidal front create *Calanus* aggregations where North Atlantic right whales can forage effectively. NARWs are observed during all times of the year with peak occurrences in winter and spring.

Calanus Distribution and Density

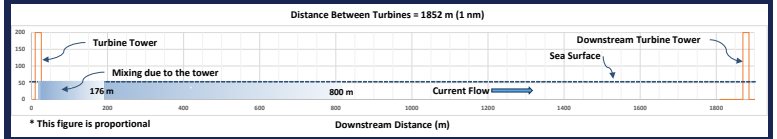


Tidal mixing front



Bathymetry combined with hydrodynamic modeling predict a tidal mixing front >10 km from the WEA.

Subsurface mixing from turbine tower



Conclusions

- Distance between adjacent turbines towers inhibits cumulative, region-wide effects.
- Strong stratification makes the area more resilient to tower wake mixing (than in the North Sea).
- Total anthropogenic mixing does not produce enough turbulent energy to collapse the stratification or reach the tidal mixing front, preserving these important copepod habitat features.
- No indication that turbines will affect regional current speed or direction, and thus the advection of copepods onto Nantucket Shoals.

This study suggests that the planned installation of the SouthCoast Wind Farm will not substantially impact the mechanisms governing the movement and concentration of the prey, nor the foraging behavior of the North Atlantic right whale.

1. Xie S and C. Archer. Self-similarity and turbulence characteristics of wind turbine wakes via large-eddy simulation. Wind Energy. 2015;18(10):1815-1838.
2. Miles, J., Martin, T., and Goddard, L., 2017. Current and wave effects around windfarm monopile foundations. Coastal Engineering 121, 167-178, Doi 10.106/j.coastaleng.2017.01.003
3. Dorrell RM, Lloyd CJ, Lincoln BJ, Rippeth TP, Taylor JR, Caulfield CCP, Sharples J, Polton JA, Scannell BD, Greaves DM, Hall RA and Simpson JH (2022) Anthropogenic Mixing in Seasonally Stratified Shelf Seas by Offshore Wind Farm Infrastructure. Front. Mar. Sci. 9:830927. doi: 10.3389/fmars.2022.830927
4. Carpenter, J.R., L. Merckelbach, U. Callies, S. Clark, L. Gaslikova, and B. Baschek. 2016. Potential impacts of offshore wind farms on North Sea stratification. PLoS ONE 11(8):e0160830, https://doi.org/10.1371/journal.pone.0160830.