The effects of offshore wind farms at a regional scale

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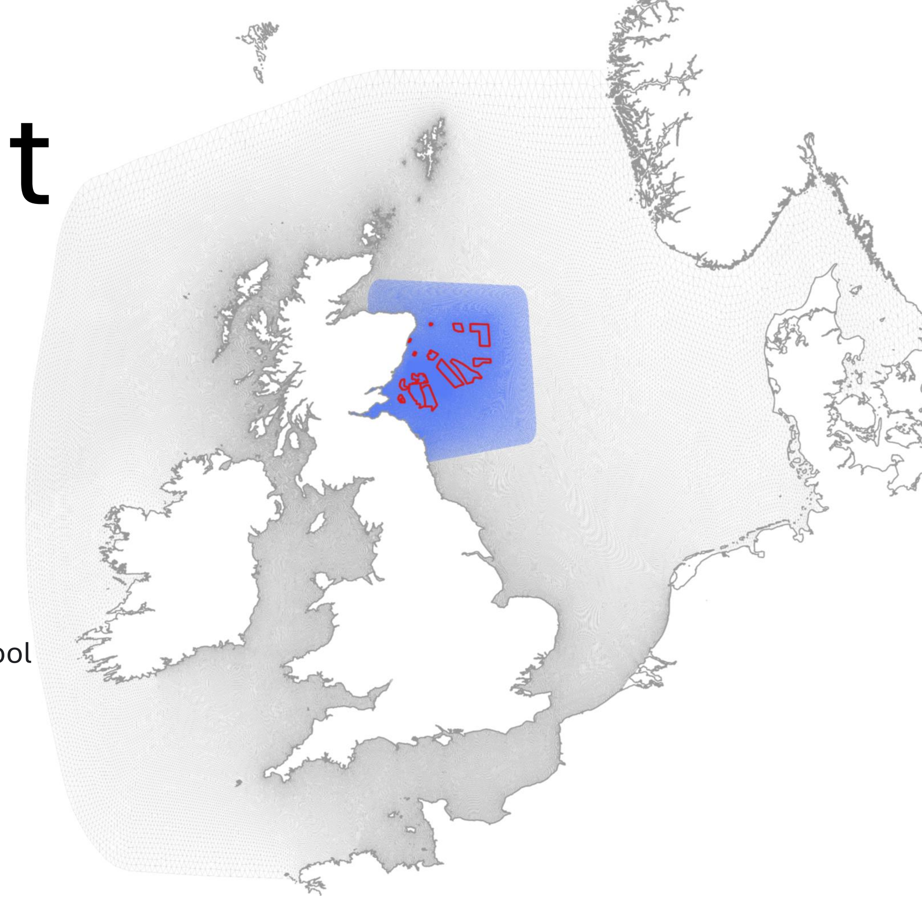
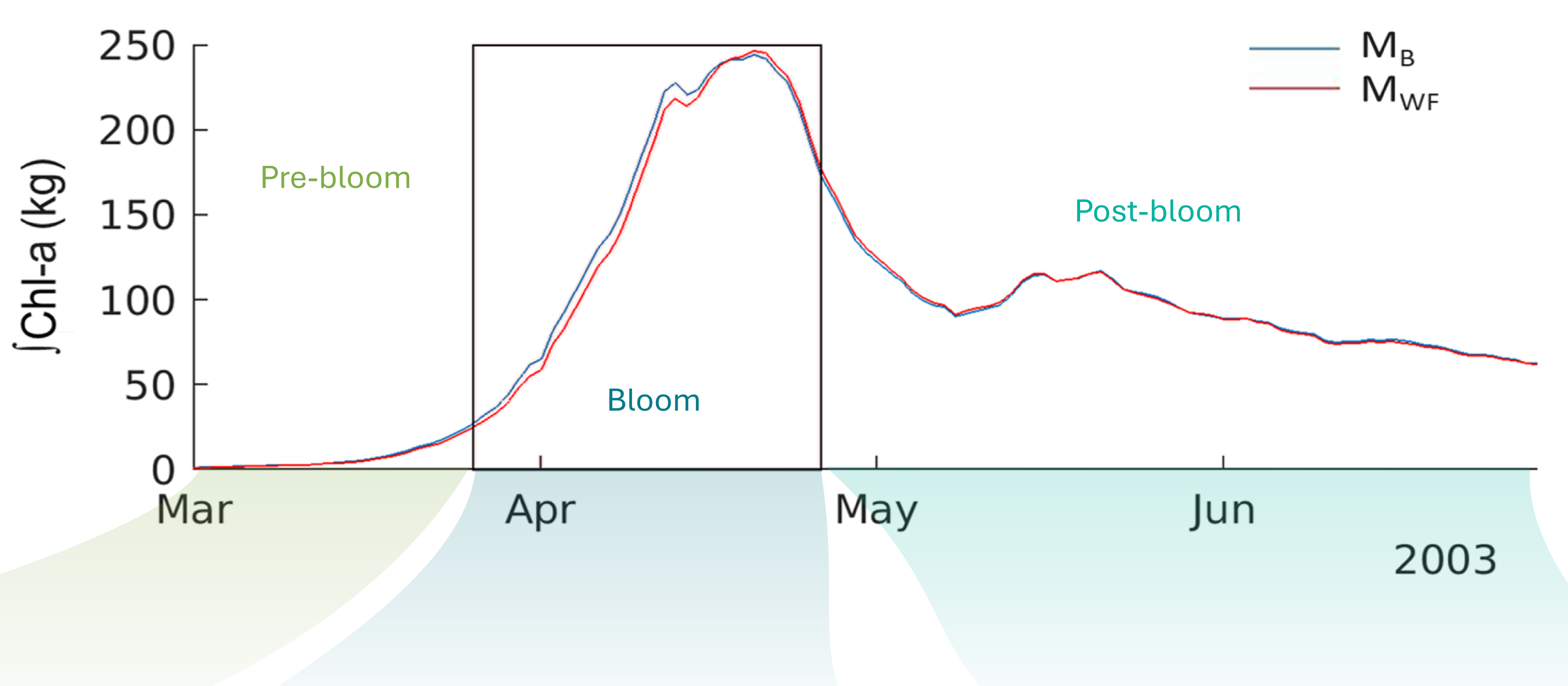


Context

Large offshore wind farms (OWFs) will affect the physics and biology of shelf seas, altering mixing, stratification, sediment resuspension and food availability[a].

Given the diversity of structures and marine environments[b], the interplay between habitats and turbines creates a wide range of scenarios that can be explored using oceanographic models. Here we explore the potential impacts of OWF wind wakes.

Modelled physics and chlorophyll-a (Chl-a) in scenarios with (M_{WF}) and without (M_B) OWFs.

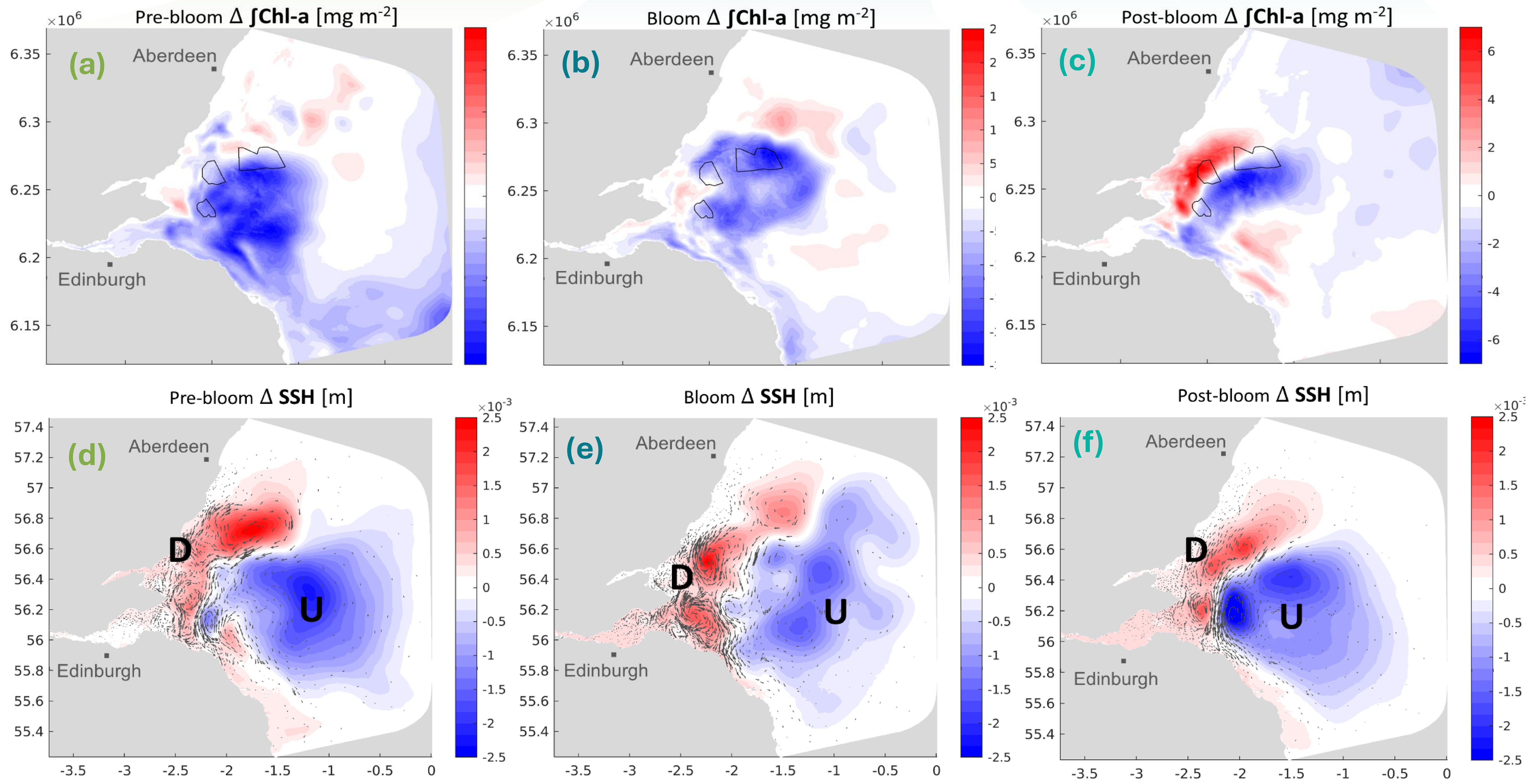


How

The effects of three OWFs on abiotic and biotic processes were modelled using the Finite Volume Community Ocean Model (FVCOM) coupled with the European Regional Sea Model (ERSEM) in the north-west North Sea. The undisturbed scenario (M_B) was validated to *in situ* data and compared to the scenario including OWF wind wakes[c] (M_{WF}) .

Changes:

$$\Delta = M_{WF} - M_B$$

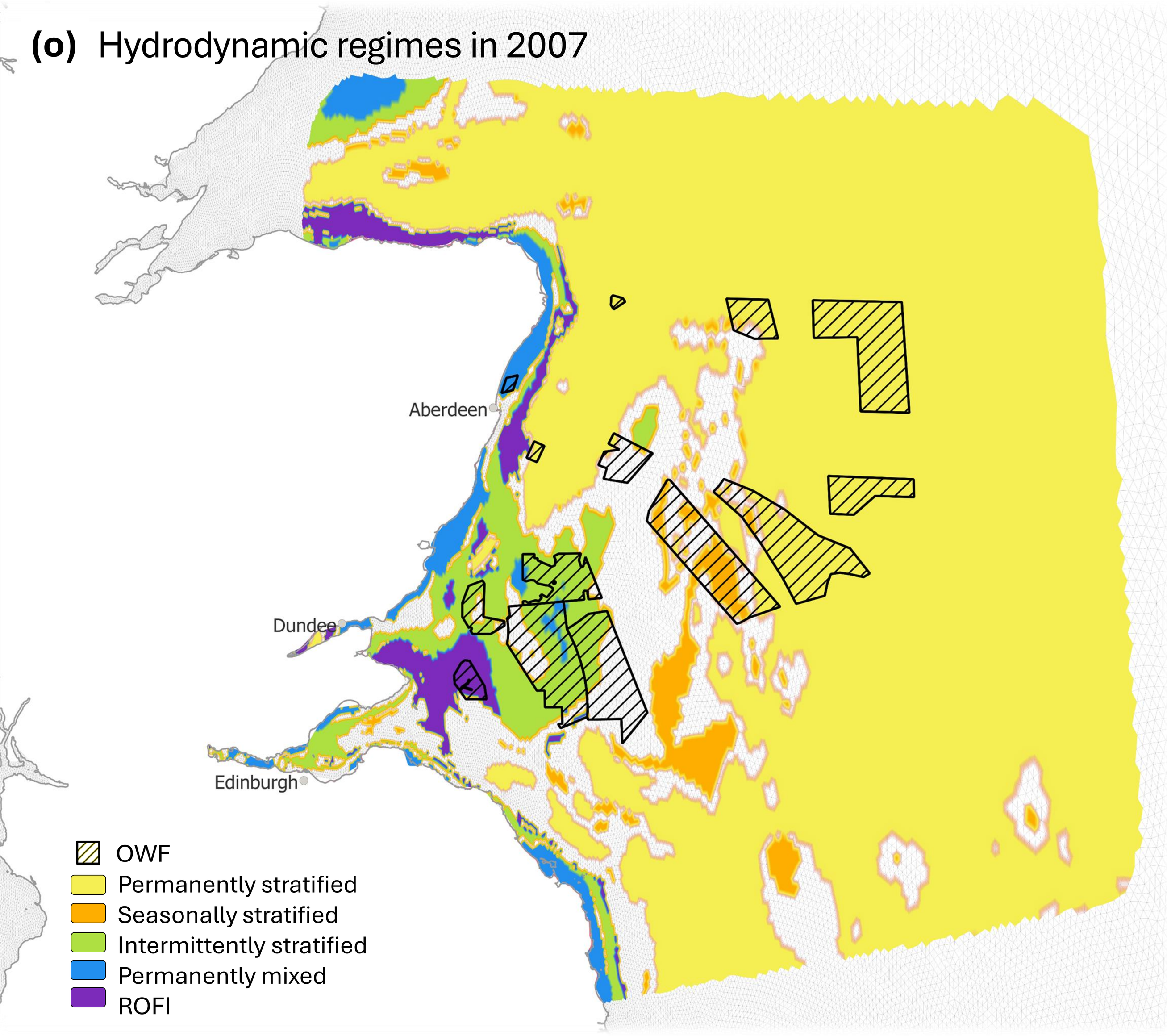


Changes in Chl-a overall decreased across the region, although local increases occurred during three phenological periods: pre-bloom, bloom and post-bloom

Changes in sea surface height (SSH) exhibit an upwelling (U) and downwelling (D) dipole near the wind farm.

- Spatial patterns of decreasing and increasing Chl-a (Figure a-c) were observed at different phenological periods, suggesting that the potential effects on the ecosystem are complex and vary through time and across regions/habitats.
- Positive and negative variations in Chl-a did not linearly correlate to their distance from OWFs, and large variations were identified close to (1-2 km) and far (90 km) from OWFs.
- Specifically, mis-timed blooms could have impacts early in the season whereas, spatially, changes in Chl-a may play a significant role in driving the distribution of food resources during less productive periods (post-bloom).
- OWF wind wakes originated dipoles of sea surface height (Figure d-f), temperature and salinity. These physical changes ultimately affected the stratification strength of the region.

(o) Hydrodynamic regimes in 2007

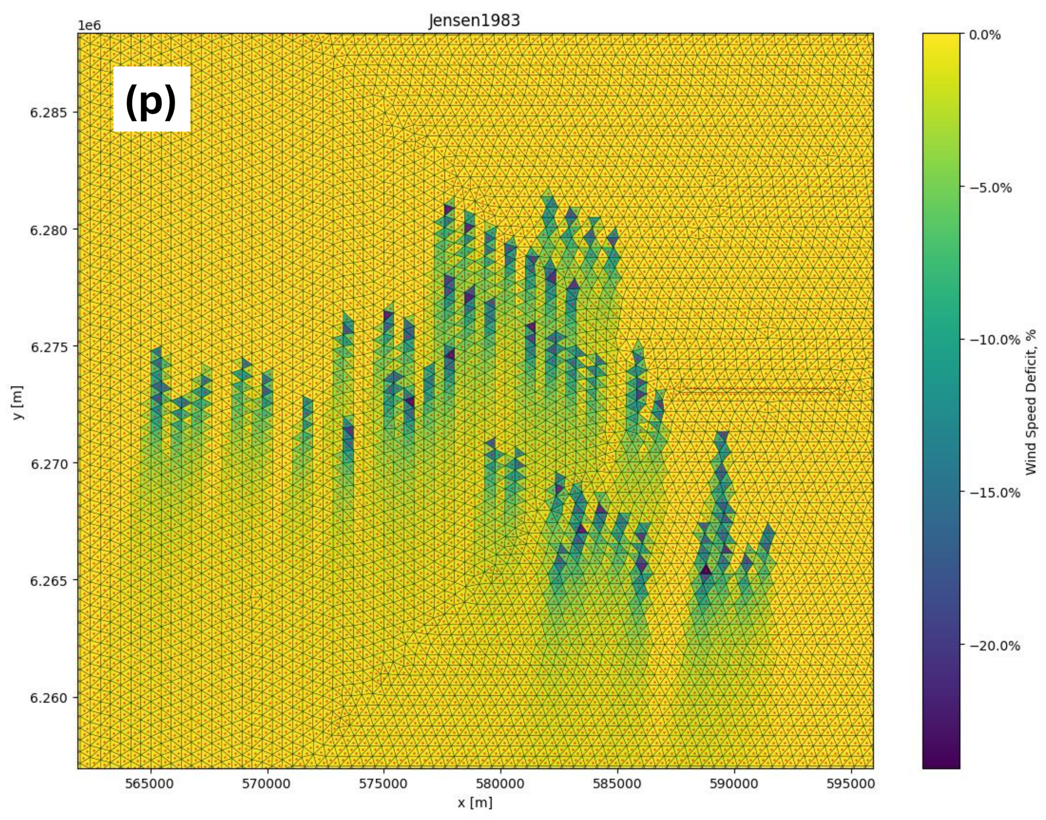


What is next?

Representing multiple OWFs by improving the parametrisation of their effects, such as wind wake at the turbine scale (Figure p) and turbine foundations (see poster from William Macdonald), and under climate change (see poster from Jennifer Jardine).

Investigate long-term effects (10 years) to understand trends and resiliencies within different habitats or hydrodynamic regimes (Figure o).

Investigate variations in plankton phenology, quantity and quality over 10 years at a regional scale, identifying wheatear changes in temperature and salinity may favour some groups of species than others at specific habitats or hydrodynamic regimes.



With courtesy of Dr Diego Araya Araya, University of Manchester

[a] Daewel, U., Akhtar, N., Christiansen, N., and Schrum, C. (2022). Offshore wind farms are projected to impact primary production and bottom water deoxygenation in the North Sea, Commun. Earth Environ., 3, 1–8, https://doi.org/10.1038/s43247-022-00625-0.
[b] van Leeuwen, S. van, Tett, P., Mills, D., and Molen, J. van der (2015). Stratified and nonstratified areas in the North Sea: Long-term variability and biological and policy implications, J. Geophys. Res. Oceans, 120, 4670–4686, https://doi.org/10.1002/2014JC010485.
[c] Christiansen, N., Daewel, U., Djath, B., and Schrum, C. (2022). Emergence of Large-Scale Hydrodynamic Structures Due to Atmospheric Offshore Wind Farm Wakes, Front. Mar. Sci., 9, 818501, https://doi.org/10.3389/fmars.2022.818501.