Modelling Predictions of Seabed Vulnerability to Climate-Crisis-Driven Changes over North Western European shelf

ECOWind

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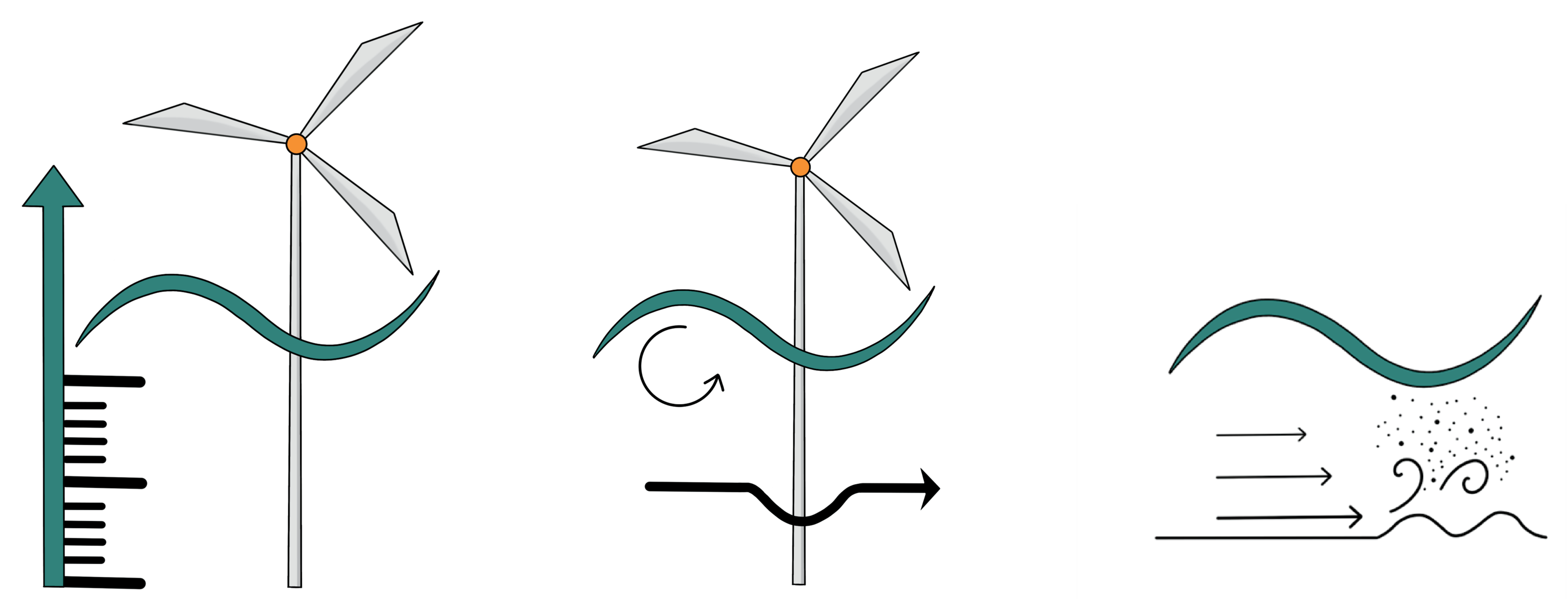
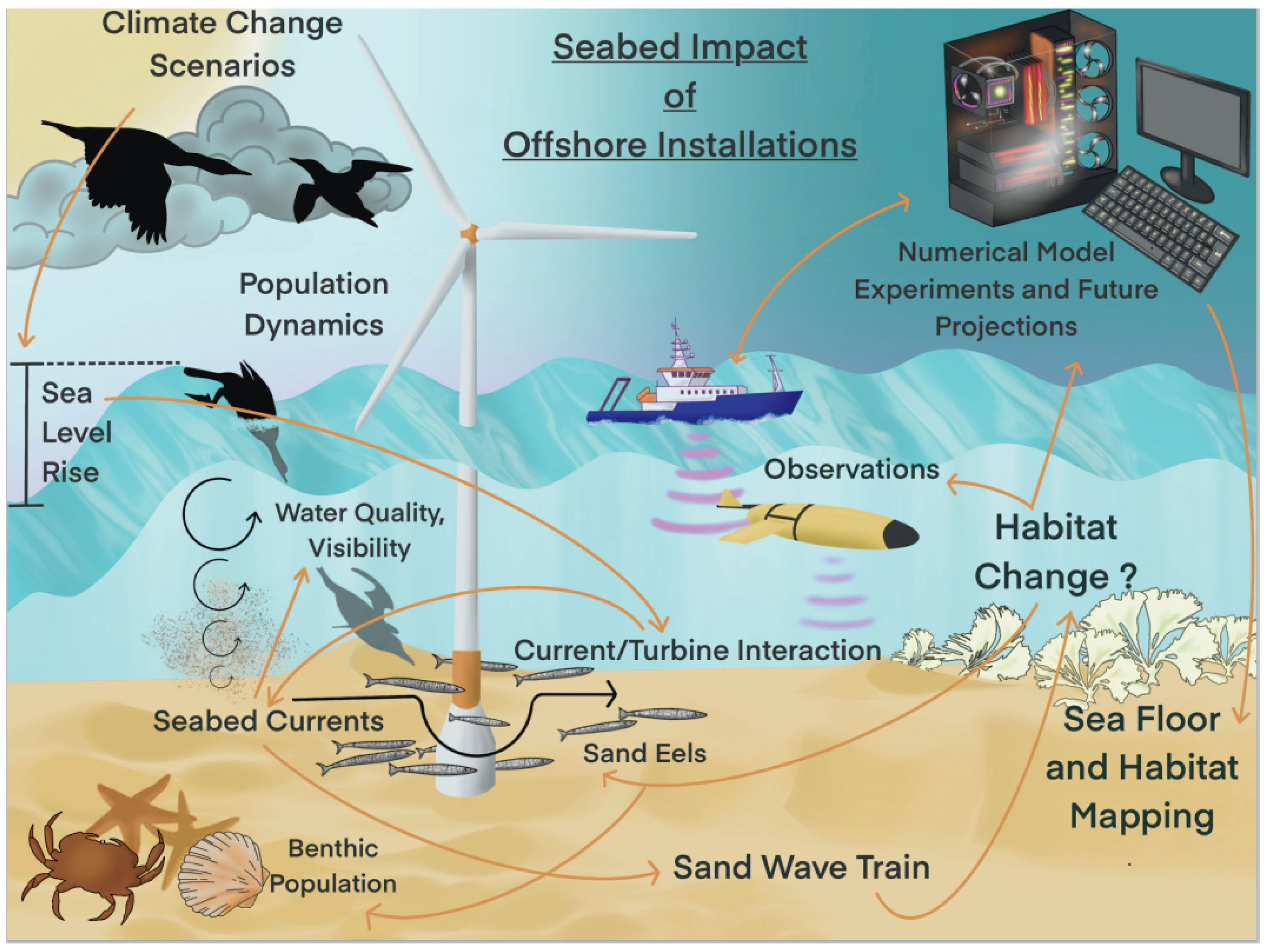
Aims and Objectives.

Understand the combined impacts of climate change and OWFs resulting in accelerated ecologically relevant seafloor change. How will future climate driven changes to wind, waves, tides and sea-level combine to influence flow and thus bed stress across the UK continental shelf? How will changing hydrodynamic forces around OWFs combine with those due to the climate crisis to drive seabed change the Eastern Irish Sea?





What physical processes impact the seabed?

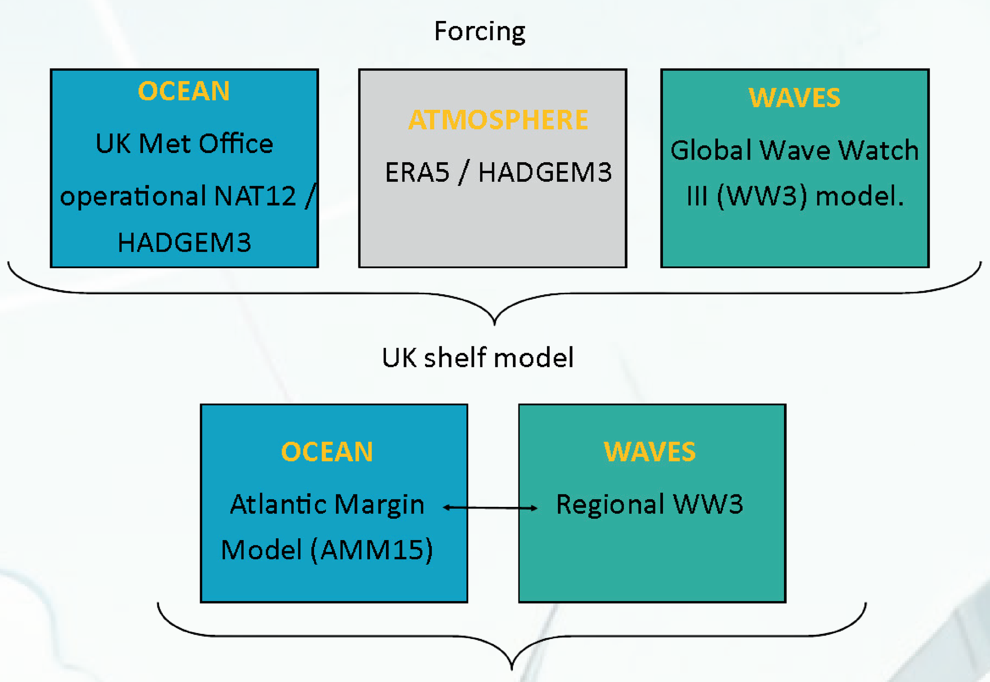
Regular tides and periodic storms generate waves and currents which exert stress at the seabed.

The tides are predictable, and can generate stresses around 3 Nm^2

Waves caused by storms are hard to predict, as they depend on passing weather events, how ever they can exert stresses of 10 Nm^2

These natural processes may change in the future due to climate change

The stresses may also change around OWF, where monopiles, cables, or anchors are present at the seabed



Current bottom friction (τ_c) estimated as per Soulsby and Clarke (2005), as function of the water density (ρ), barotropic current velocity (Ubar) and the drag coefficient (Cd) defined in the NEMO model based on roughness length (z0) and the Von Karman constant (k).

$$\tau_c = \frac{\rho C_d U_{bar}^2}{2} \qquad C_d = \left(\frac{\kappa}{\log(0.5e^t/z_0)}\right)^2$$

Wave induced bed stress (τ_w) estimated through wave orbital velocity as a function of near bottom rms velocity (Uw) as per Aldridge et al. (2014) and Soulsby (2006), as well as the water density (ρ) and the friction factor (f_w) based on the roughness length (z0) set as constant 3.0×10-3.

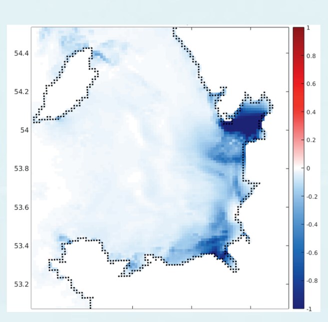
$$\tau_w = \frac{\rho f_w U_w^2}{2} \qquad Uw = \sqrt{2}\, U_{rms}$$

Total bed stress mean (τ_m) and maximum (τ_{max}) values estimated from combined currents and wave bottom orbital velocities, and the angle between current direction and wave travel direction (Φ).

$$\tau_m = \tau_c \left\{1 + 1.2\left(\frac{\tau_w}{\tau_c + \tau_w}\right)^{3.2}\right\}$$

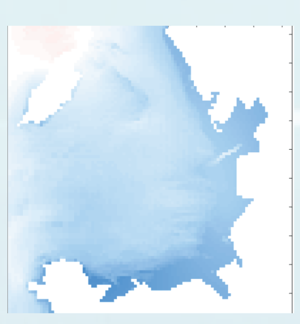
$$\tau_{max} = [\tau_{m+}\, \tau_w \cos(\Phi)^2 + \tau_w \sin(\Phi)]^{1/2}$$

Regions of interest



Predicted reduction in tidal current stresses due to Sea-level rise in the Eastern Irish Sea

Predicted reduction in wave exposure due to climate change in the Eastern Irish Sea



What has the biggest impact at the seabed?

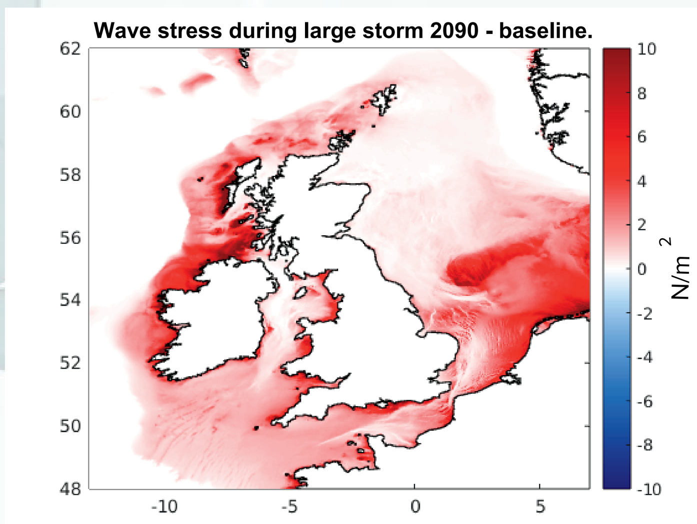
We demonstrate that while future sea level rise will lead to constant and predictable changes in seabed stress and related sediment mobilization, these changes are small compared to the impact of transient events, such as winter storms.

Results show the potential magnitude and range of changes that can be expected in the future, as well as the significance of extreme events. The majority of these future changes will be dominated by wave activity.

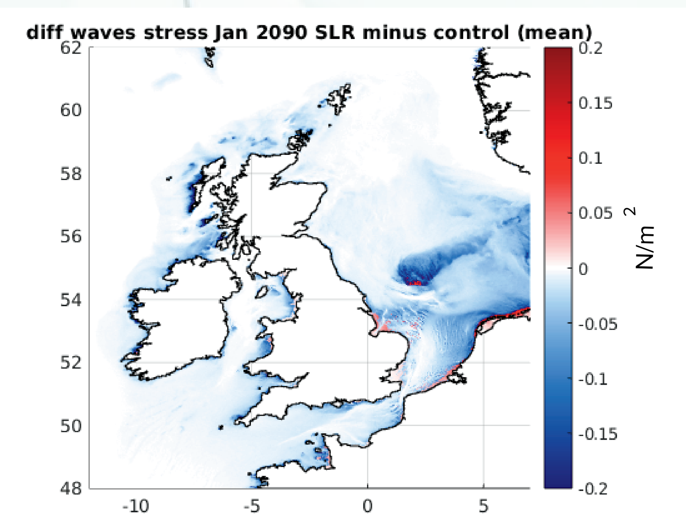
As climate change reduces mobility of the seabed, the impacts of OWF may be felt more strongly as a consequence. However these impacts will be site specific, and strongly controlled by seabed type.

It's the storm waves!

Individual storms can generate wave stresses 3 times bigger than the regular tides



Larger wave stresses experienced in extreme future storm



Change in present day wave bed stress: storm minus calm

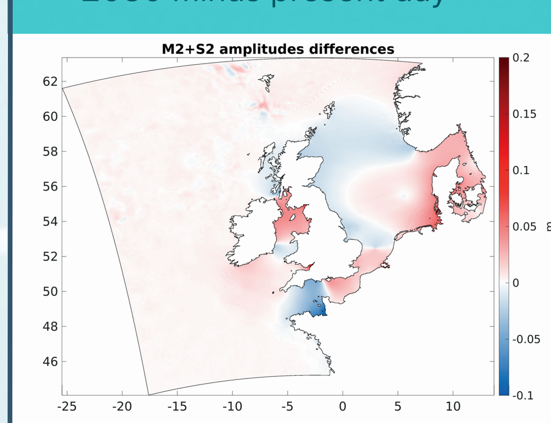
How will this change in future?

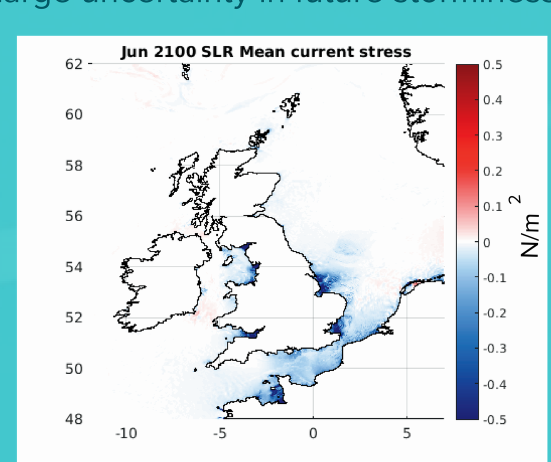
Process	Changes	Confidence	Magnitudes of change
Tides	Rising sea-levels around UK alter tides & sea-bed currents. Decouples currents from seabed, reduces stress (more in shallow water & estuaries).	SLR definite, rates uncertain (emissions scenarios). Tides linked to SLR; mechanisms clear, response confident.	Stress redistribution from SLR: water level increase dominates over changing tides. Spring/neap tides > climate impacts. Monthly seabed stress variation > climate change impacts.
Storms	Possible changes in storminess: overall stilling, but rarer severe storms. SLR decouples storm impacts from seabed, reduces stresses (more in shallow water).	Small impacts from climate-change with large uncertainty.	Little change in storm severity mid-century in Irish Sea; stronger storms end-century. Wave-induced seabed stress range (calm to storm) > individual storm impact changes.

Natural variability or climate change?

Large uncertainty in future storminess

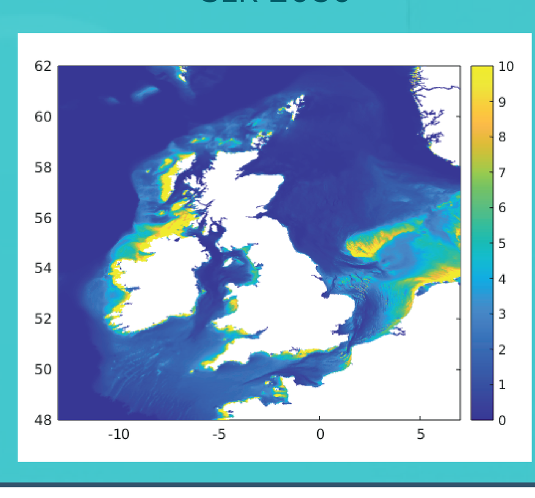
Change in tidal range: sea-level 2050 minus present day





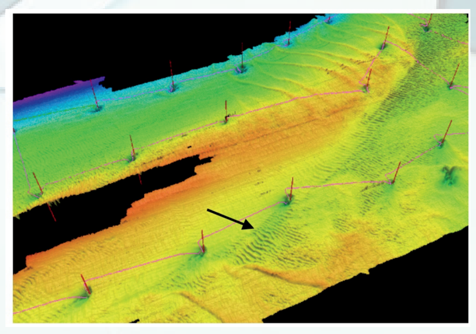
Change in mean current bed stress: sea-level 2100 minus present day

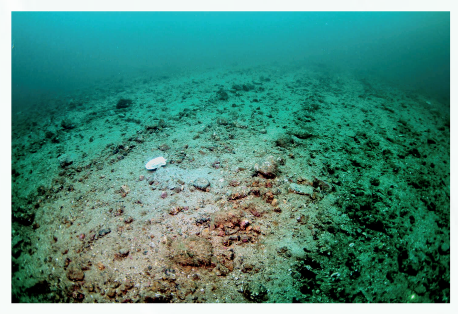
Maximum wave stress: SLR 2050



Why does this matter for offshore structures?

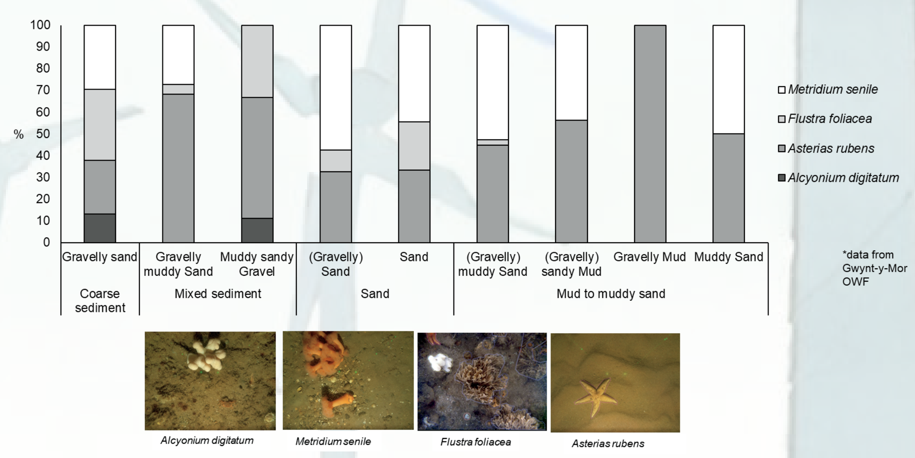
Scour and wakes behind monopiles can change local current and seabed stresses. How big are these seabed impacts compared to natural variability due to tides and storms? What about compared to bottom trawling or aggregate extraction?

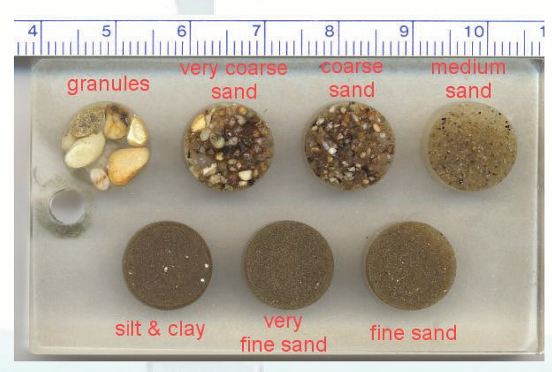




How does seabed type influence habitat?

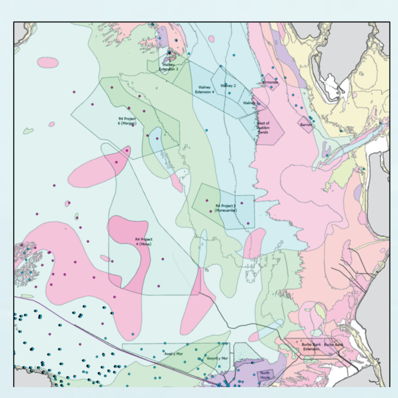
Seabed composition datasets were gathered to combine with bed stresses for sediment mobility maps, illustrating how coarse sediment could be mobilized in the future.

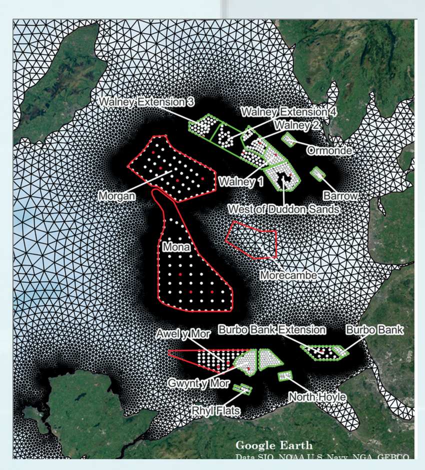




local impacts

Distribution of habitat types across study area





TELEMAC model grid and OWF lease areas: existing (green) and proposed (red)

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