Geological data incorporation into an opportunities model for Irish offshore wind energy to inform engineering considerations and habitat change potential

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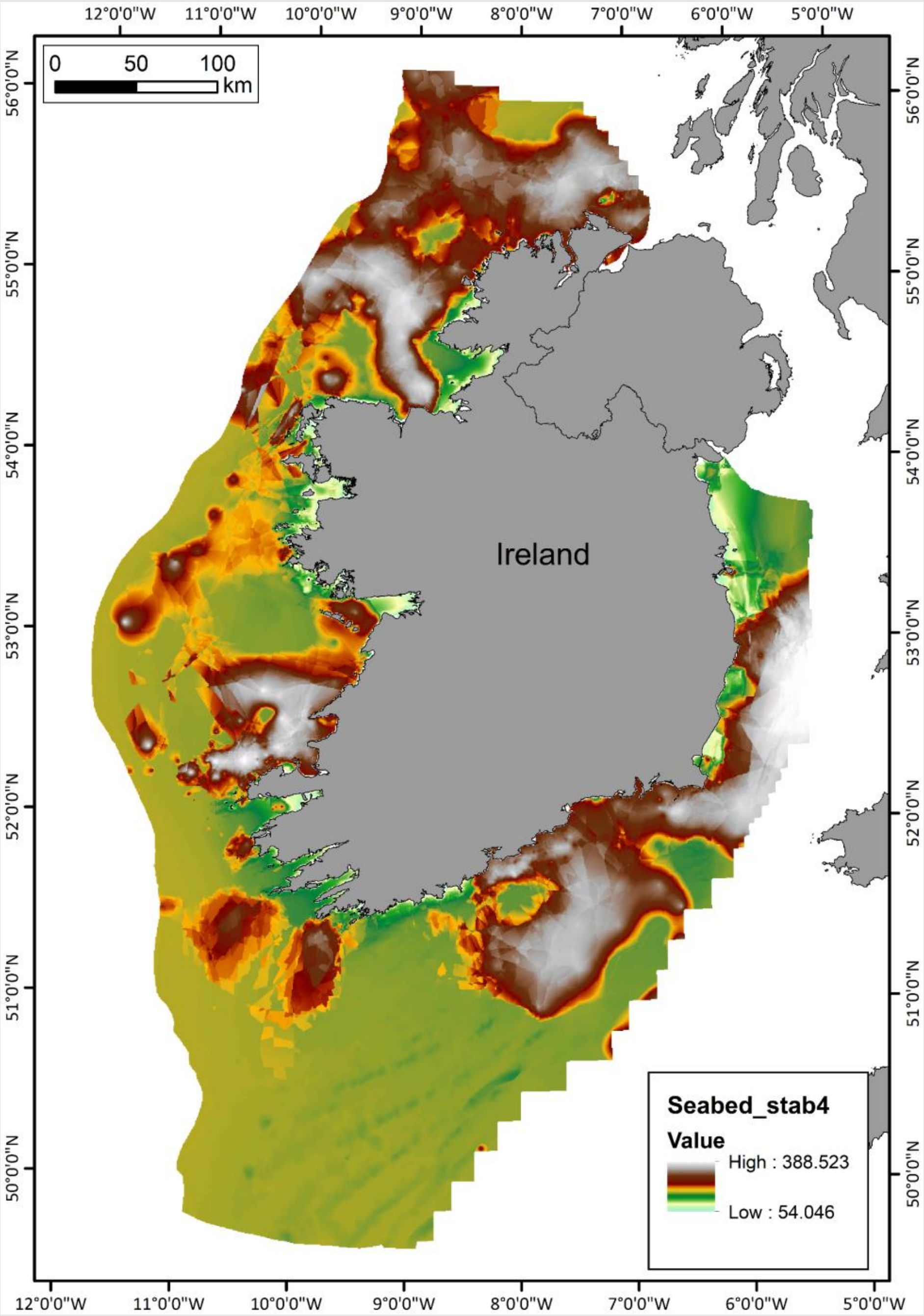
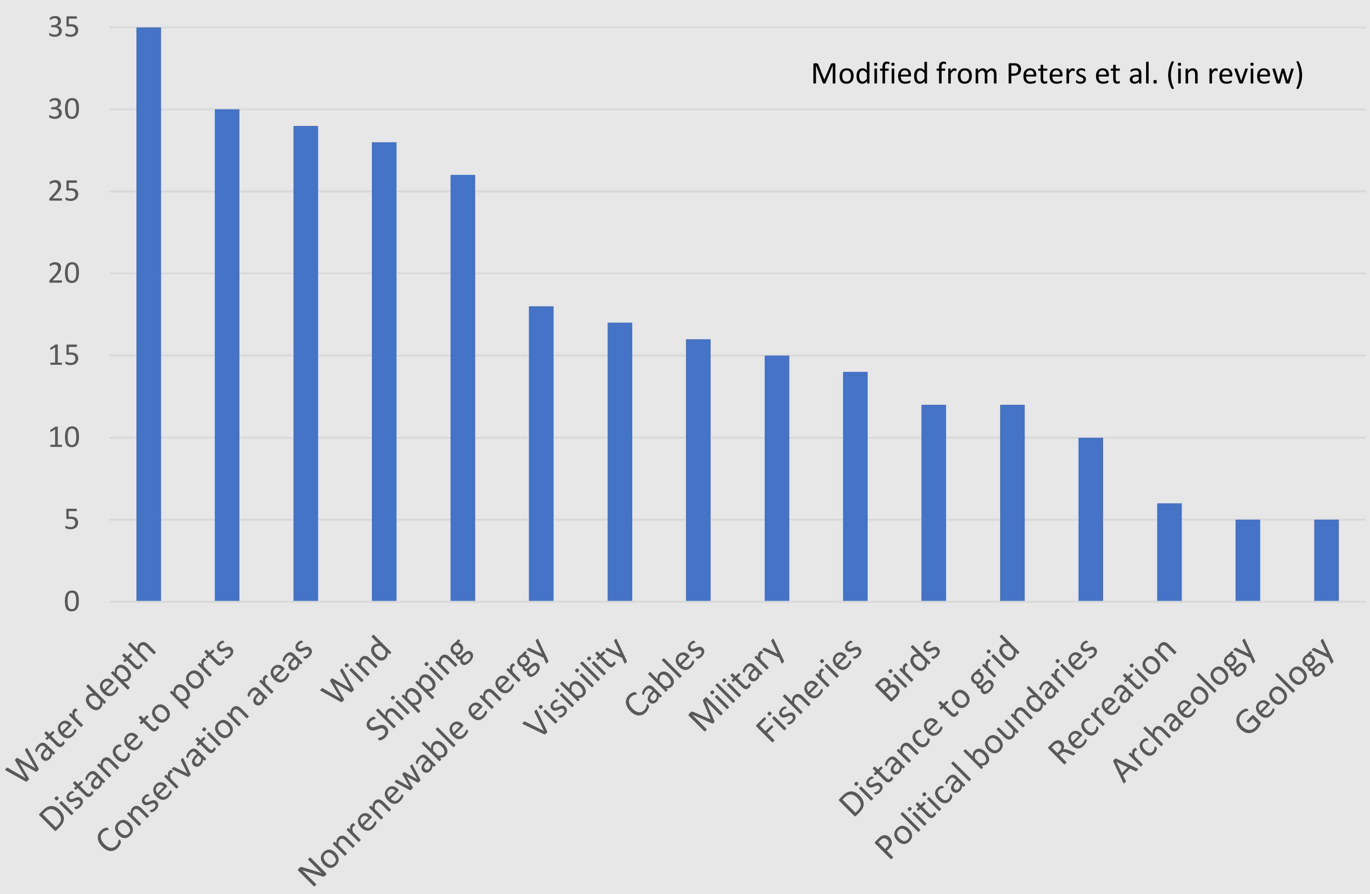
Summary: Sediment grabs and cores were used with multibeam echosounder data as a basis for a dataset to model the probability of seabed sediment mobilisation specifically for incorporation in models for offshore wind development. This presentation has been optimised for online sharing by adding text.



Background: Geology is important but underused

Background

- Chart shows the most common GIS parameters used to assess offshore wind developments
  - Systematic review of 2,668 results
- Geology is 15th despite influencing:
  - Foundation design
  - Cable routes
  - Scour protection
  - Local habitats
- Probable cause of uncommon use:
  - Typically less compiled
  - Seldom rasterised
  - Require more interpretation

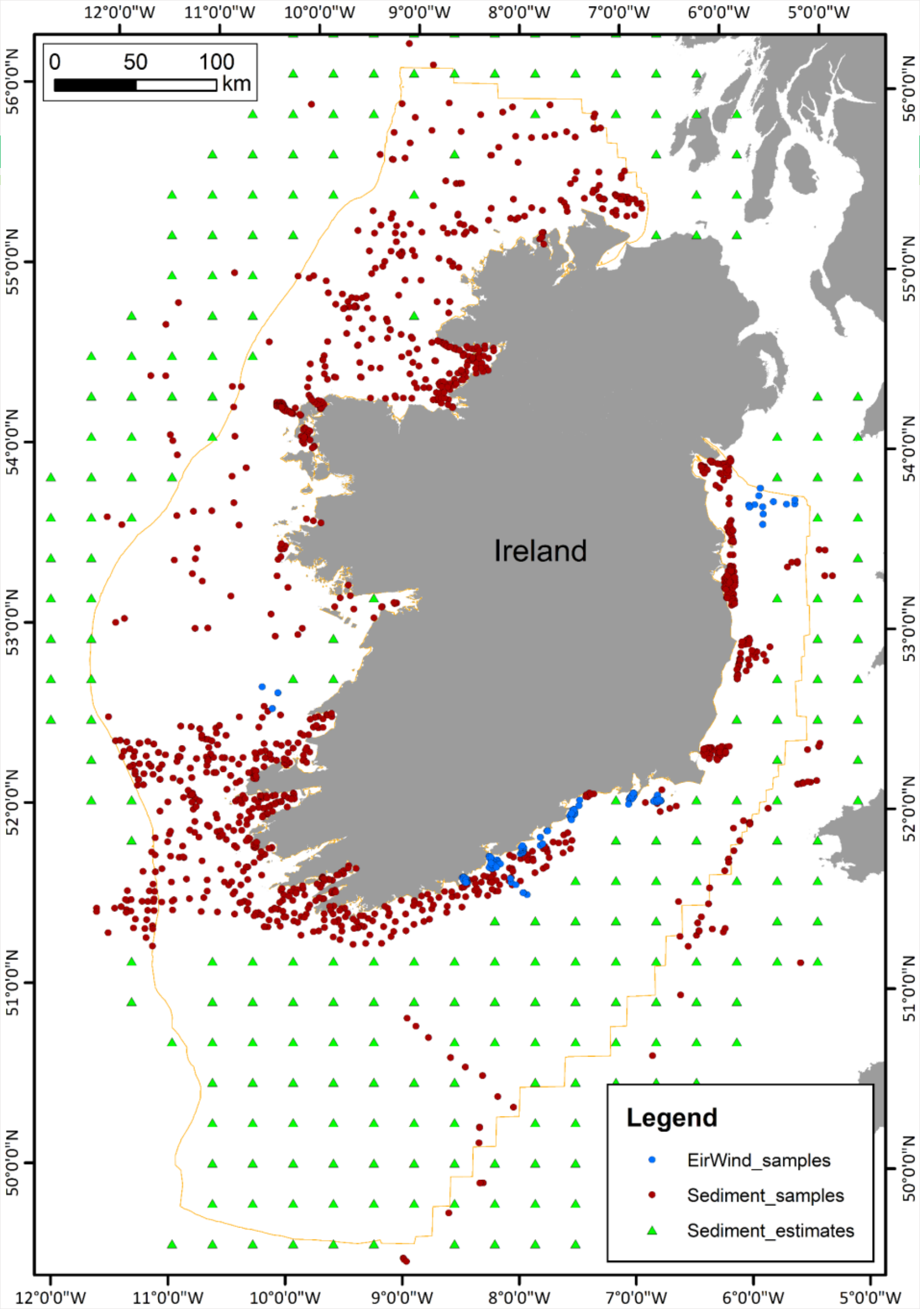


Notes for online sharing: A systematic review and meta-analysis (Peters et al. in review) reveals geological research to be poorly utilised in offshore wind research despite its importance to several aspects of planning. Here we present research attempting to provide insights to the seabed at regional scales for preliminary investigations.

Data mining & collection

Data Preparation

- Geological data mining
  - Marine Institute (INFOMAR)
  - Quaternary geology studies
- Geological data collection
  - Targeted areas based on potential utility to OWE development and data gaps
  - 187 grab and vibrocore samples
- Data estimates
  - 25-m grid
  - Grid boxes with ≥2 sediment samples were not estimated

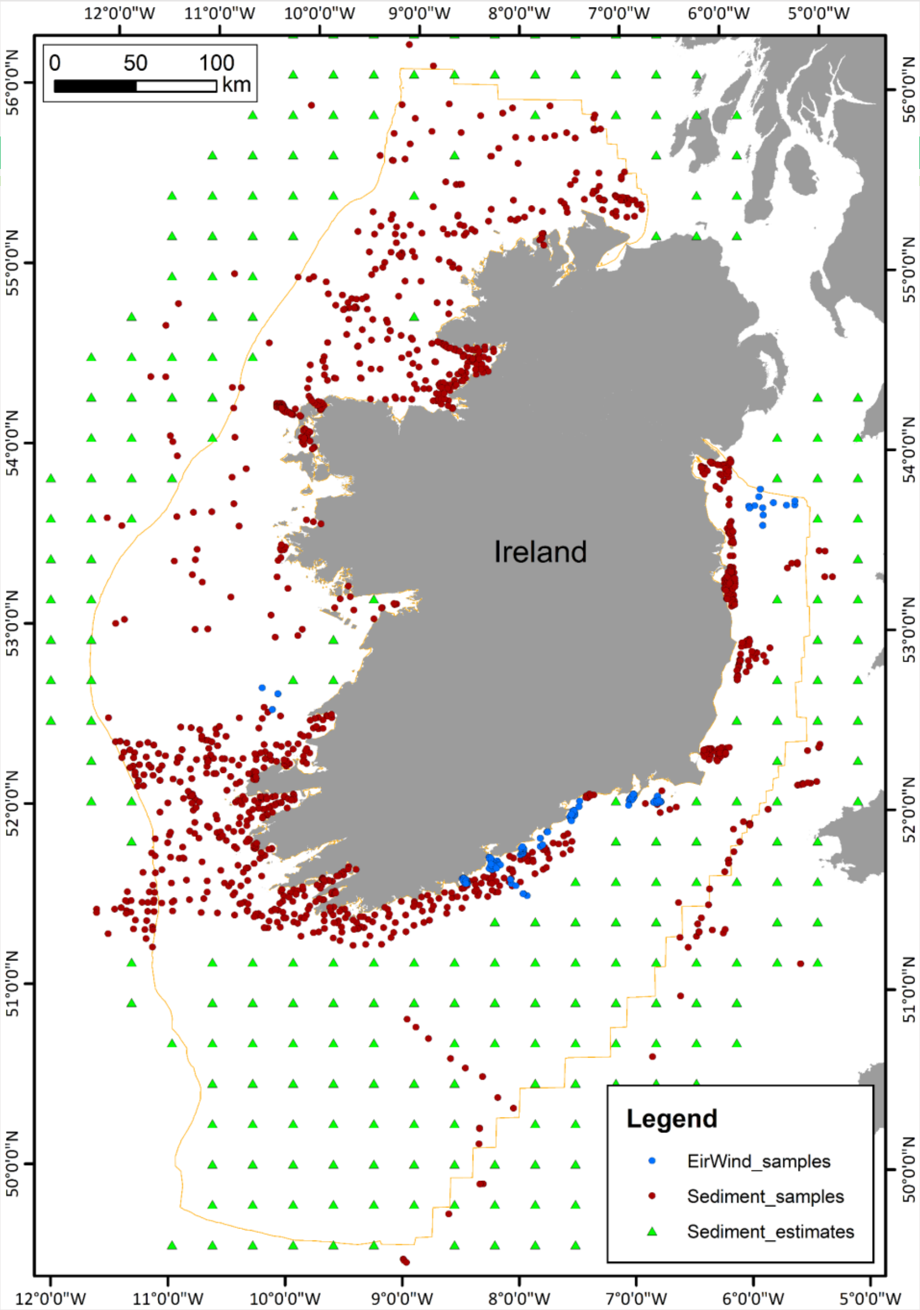


Notes for online sharing: Total of 1,586 sediment samples and 278 estimates (N = 1,864). Thirteen published articles and Marine Institute surveys were used to generate most data points. Estimates are based on EMODnet models, backscatter, and bathymetry and were not made unless at least two of these were available at the point to be estimated.

Geological data coding

Data Preparation

- For all **data points** and estimates:
  - Descriptions were standardised
  - A modified 7-point Folk scale was interpreted
  - Likely critical bed shear stress and angles of repose were assigned to each point



Notes for online sharing: Estimates were generally made to improve predictions in the south and to extend point coverage outside of the study area (yellow line on map) to improve the interpolations by reducing "edging."

Geological data coding

Data Preparation

- For all data points and estimates:
  - Descriptions were standardised
  - A modified 7-point Folk scale was interpreted
  - Likely critical bed shear stress (τ_c) and angles of repose were assigned to each point
- **Values** were coded for use in GIS models:
  - Folk-7 (1 – 7, highest = coarsest)
  - Critical shear (1 – 5)
  - Angle of repose (1 – 5)

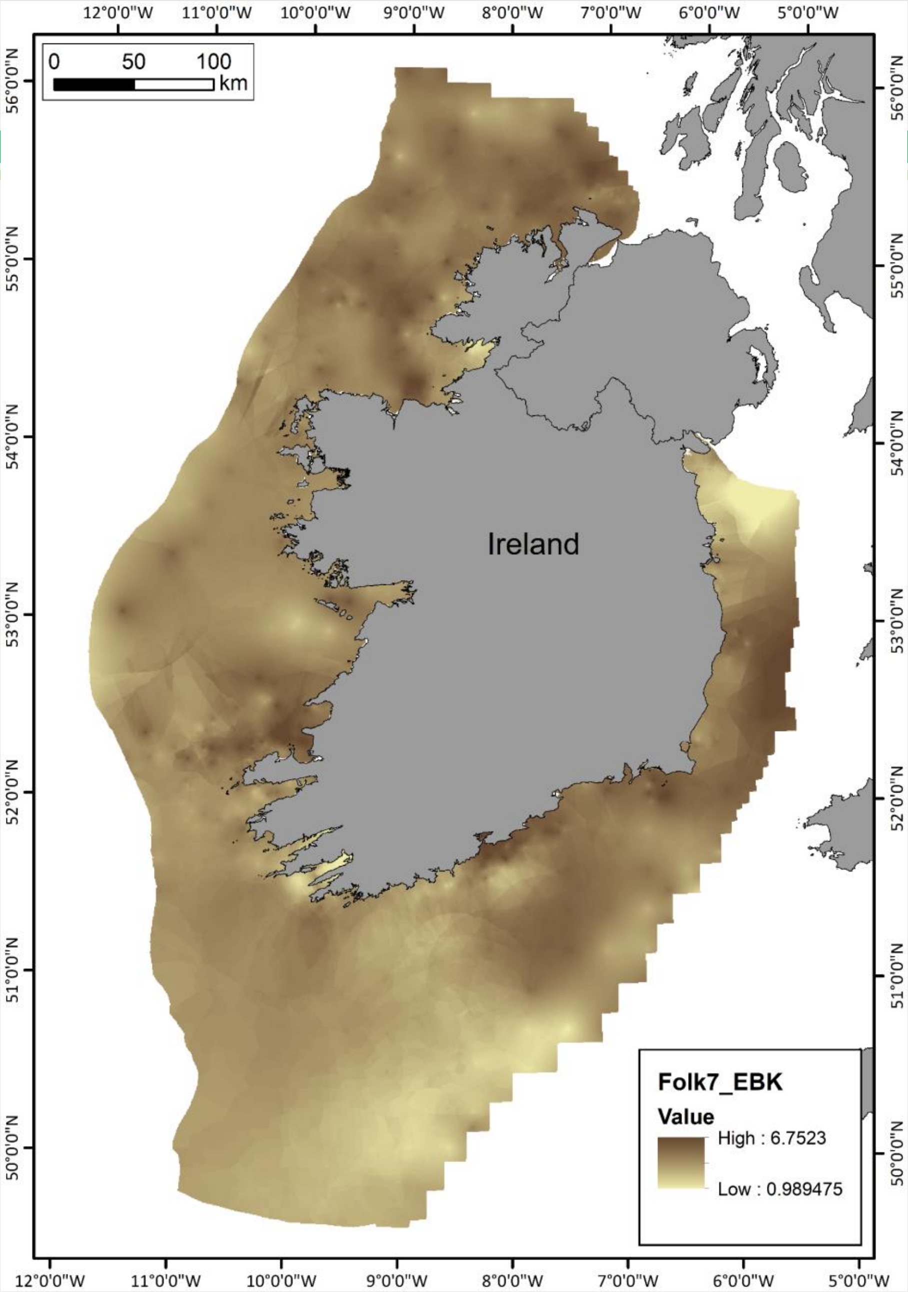
Generalised sediment type	Folk code	Mean τ_c from literature	τ_c code	Angle of repose code
mud	1	0.0616	1	1
stiff mud	1	na	3	4
sandy mud	2	0.08675	1	1
muddy sand	3	0.1485	2	1
sand	4	0.22475	3	1
mixed sediment	5	4.00875	4	3
coarse sediment	6	22.61667	5	3
rock and boulders	7	125.2	5	5

Notes for online sharing: Industry and academic resources were consulted for deriving generalised critical shear stress and angle of repose values based on sediment descriptions and the modified 7-point Folk scale. Mixed and consolidated sediments were given relatively higher values because they are less likely to be mobile.

Data interpolation

- Coded, modified 7-point Folk scale
    - Higher values (darker colours) = harder/coarser seabed
- Critical bed shear stress
    - Higher values = more likely to be stable
- Angle of repose
    - Higher values = higher angle of repose (more stable)

- All interpolations done using Empirical Bayesian Kriging, which incorporates a semivariogram estimation

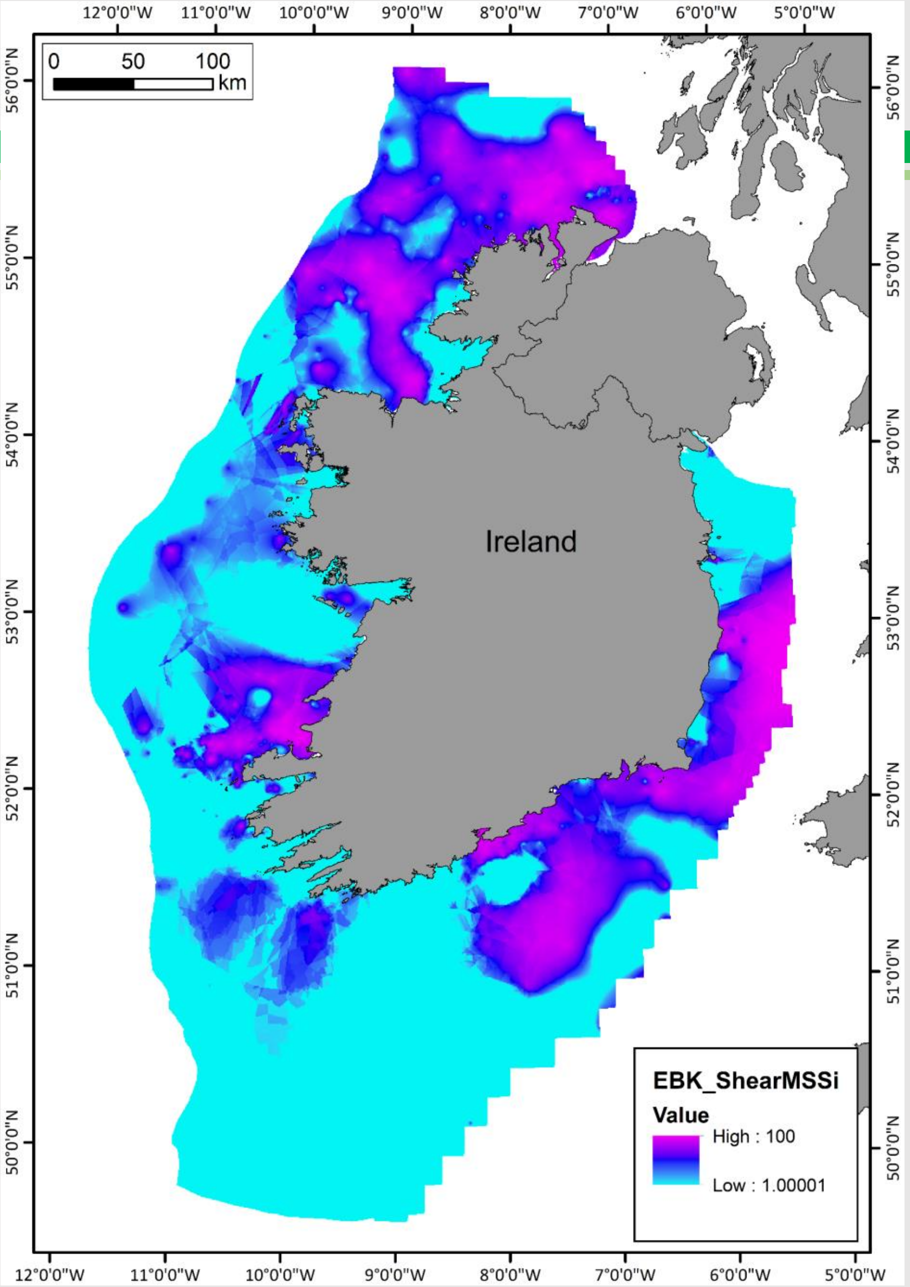


Notes for online sharing: Higher values were assigned to coarser Folk-7 values to simplify coding for shear stress and angle of repose. All interpolations were assessed using leave-one-out cross-validation and later rescaled to range from 1 – 100.

Data Treatment

Data interpolation

- Coded, modified 7-point Folk scale
  - Higher values = harder/coarser seabed
- Critical bed shear stress
  - Higher values (purple) = more likely to be stable
- Angle of repose
  - Higher values = higher angle of repose (more stable)



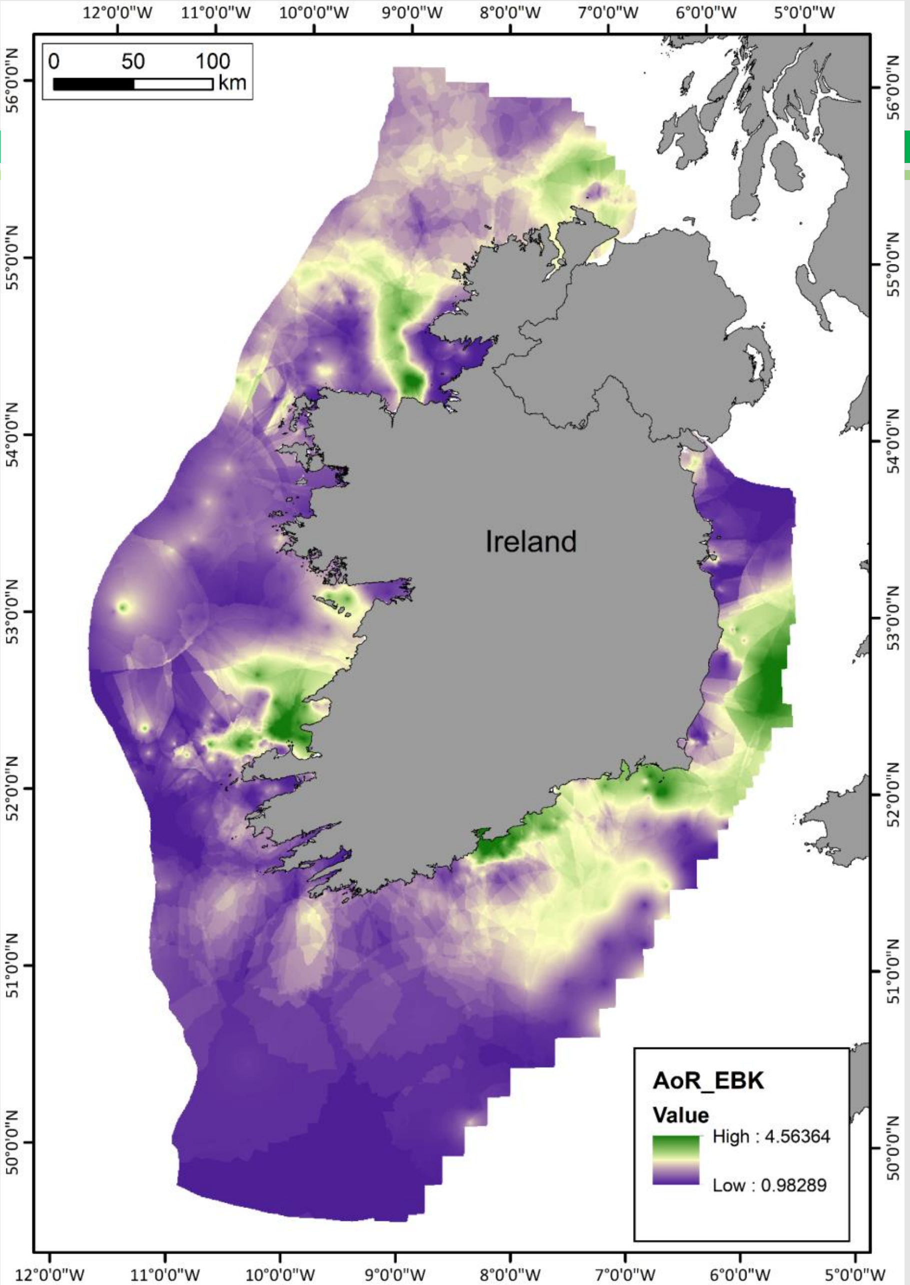
Data Treatment

Notes for online sharing: For all modelled parameters, higher values were assigned to more likely stable conditions based on geological data. All interpolations were assessed using leave-one-out cross-validation and later rescaled to range from 1 – 100.

Data interpolation

- Coded, modified 7-point Folk scale
  - Higher values = harder/coarser seabed
- Critical bed shear stress
  - Higher values = more likely to be stable
- Angle of repose
  - Higher values (green) = higher angle of repose (more stable)

Data Treatment



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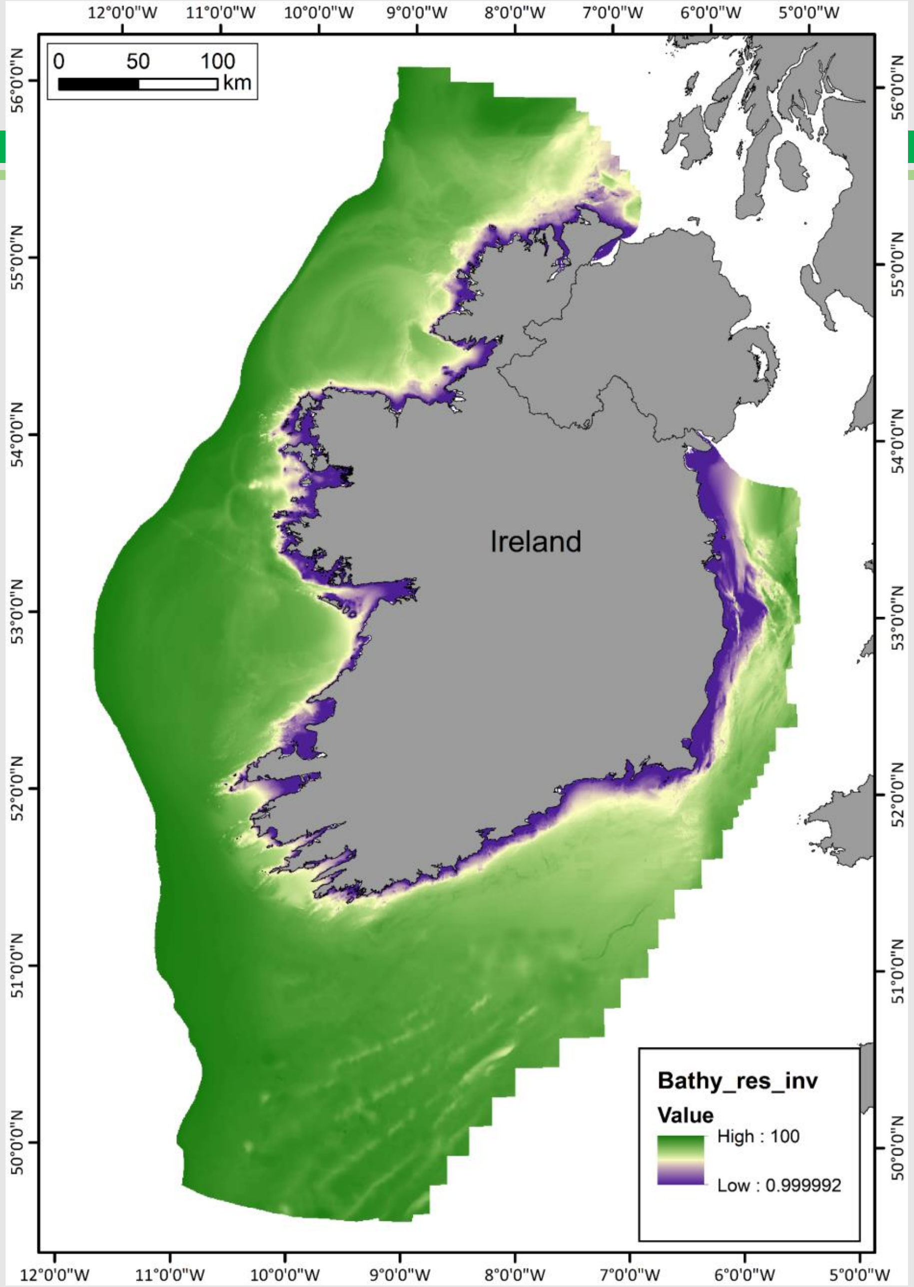
Geomorphology metrics

Data Treatment

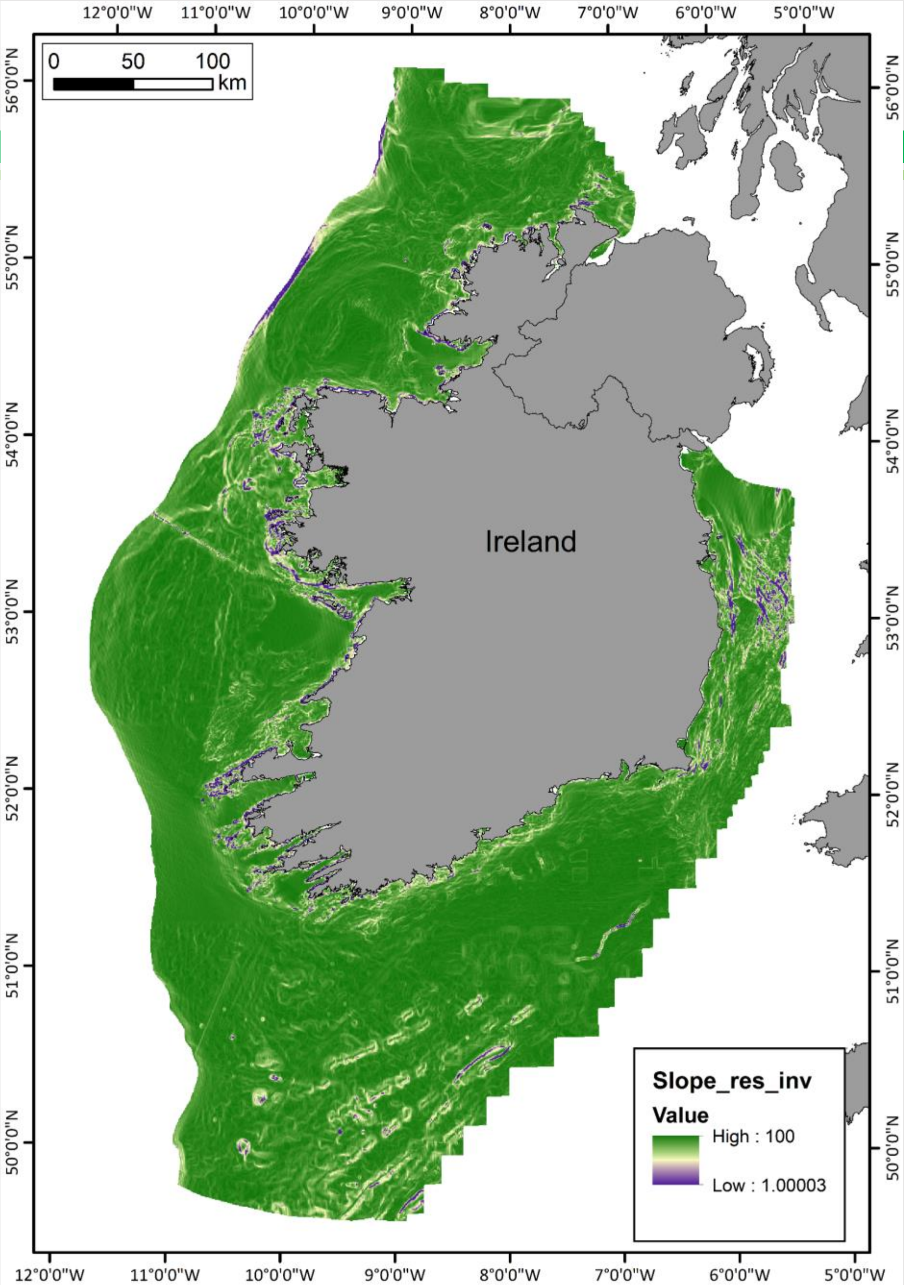
- Simplified bathymetry
  - Rescaled to generalise the likelihood of increased current and wave activity at shallower depths
  - Inverted so that high values (green) = less wave and current (higher likely stability)
- Slope
  - Calculated as a function of a moving 3-by-3 pixel neighbourhood

Notes for online sharing: Bathymetry rescaled using an exponential function (ESRI) to prioritise shallow depths. Values were inverted using map algebra.



Geomorphology metrics

- Simplified bathymetry
  - Rescaled to generalise the likelihood of increased current and wave activity at shallower depths
  - Inverted so that high values = less wave and current (higher likely stability)
- Slope
  - Calculated as a function of a moving 3-by-3 pixel neighbourhood
  - Rescaled using exponential function to prioritise high slopes
  - Inverted so that high values (green) = less slope (higher likely stability)

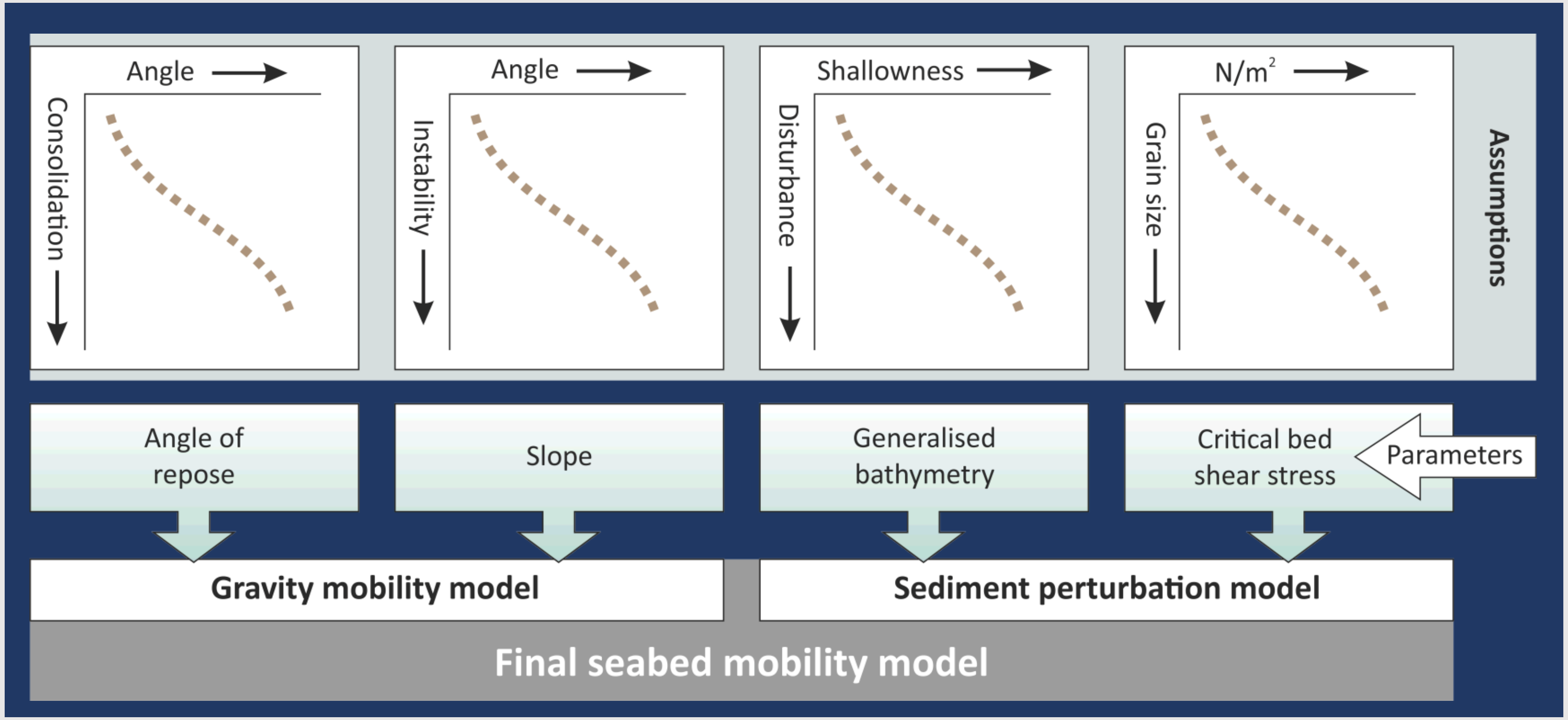


Notes for online sharing: Slope calculated from unaltered (~100-m resolution) EMODnet bathymetric data using Oregon State University's Benthic Terrain Modeler application (Walbridge et al., 2018).

Data Treatment

Seabed modelling summary and initial outputs

- Sediment perturbation model
  - Map algebra combining estimated critical bed shear stress and generalised bathymetry data
- Gravity mobility model
  - Map algebra combining slope and estimated angle of repose data

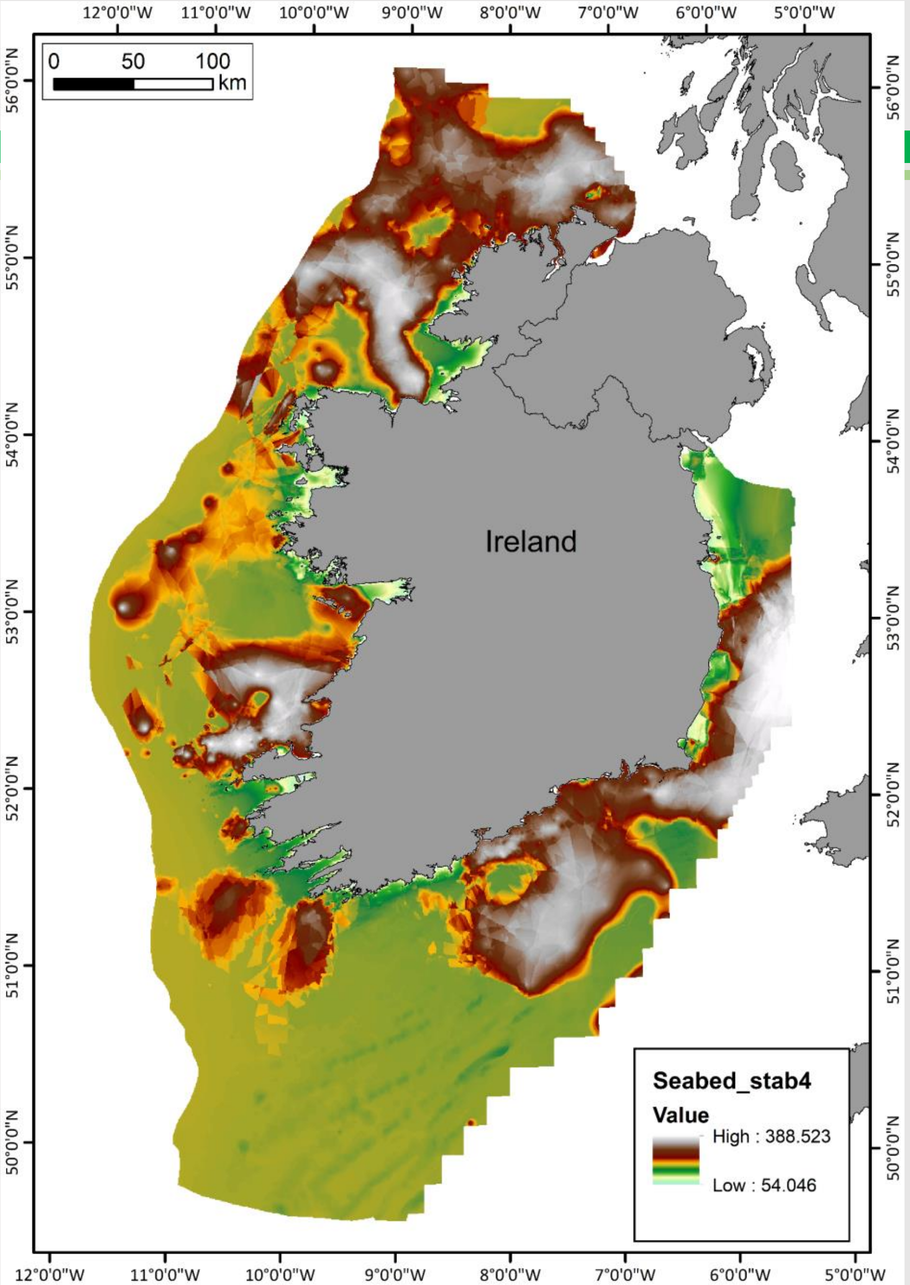


Results

Notes for online sharing: General workflow summarised as: (1) establish and code assumptions based on sediment properties; (2) build initial rasters (which are models themselves) to use as model parameters; (3) sum parameter values to create overall seabed stability probability model.

Seabed modelling final output

- Sediment perturbation probability
  - Map algebra combining estimated critical bed shear stress and generalised bathymetry data
- Gravity mobility probability
  - Map algebra combining slope and estimated angle of repose data
- Combined seabed stability prediction model
  - Higher values generally correspond to:
    1. Coarse material
    2. Consolidated material
    3. Low slopes
    4. Deep waters (also typically correlates to distance from shore)



Notes for online sharing: Combined seabed model created from the sum of all new rasters; high values suggest the most stable areas that will likely require the fewest mitigation efforts based on bathymetry and sedimentary data.

Results

Thank You

Science Foundation Ireland For what's next
EirWind
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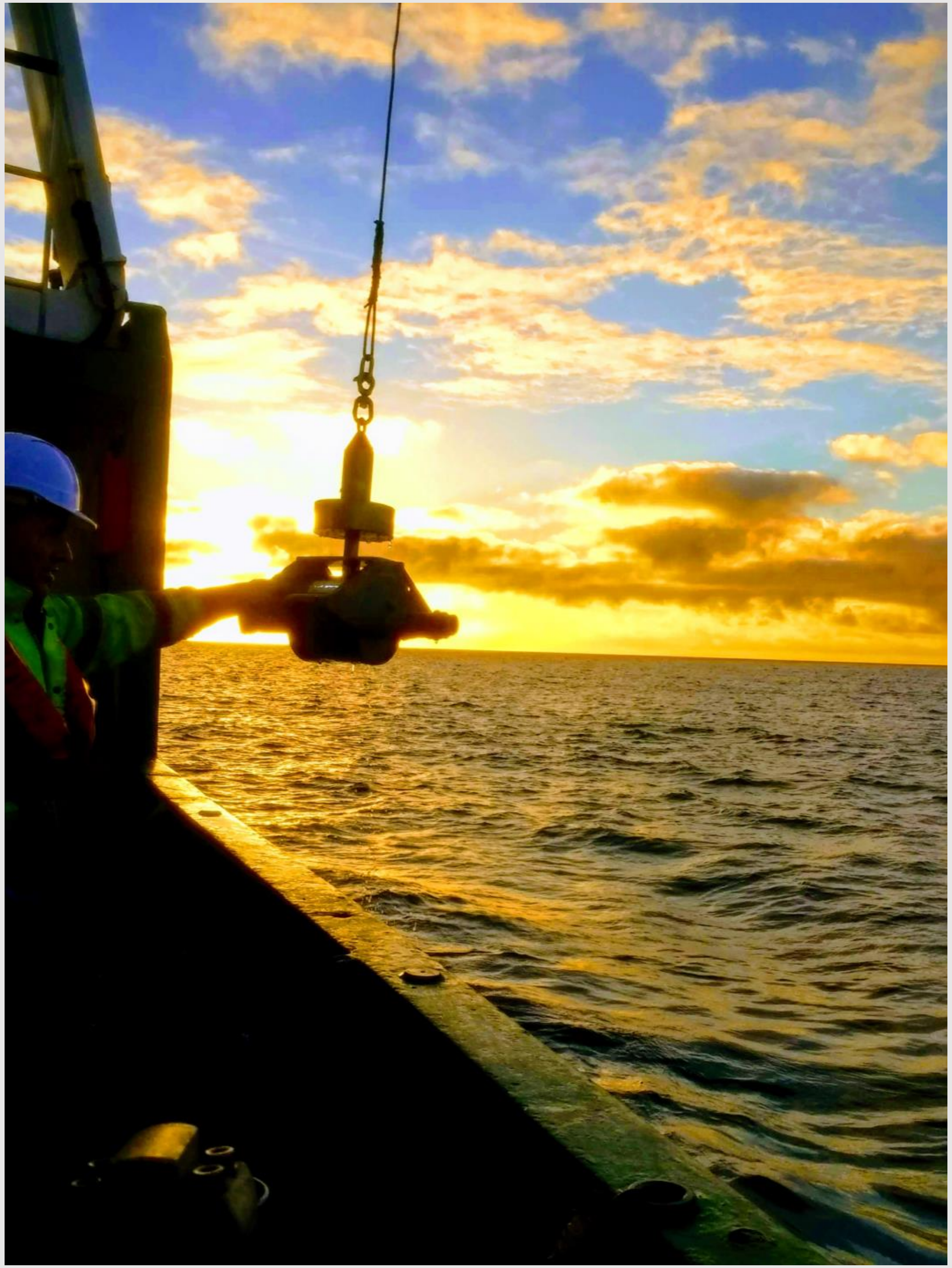

Acknowledgements

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- Funding
    - **<u>EirWind</u>**: This study was conducted as part of the EirWind Project (https://www.marei.ie/eirwind/#tab-id-6), which has received funding from the following industry partners: Brookfield Renewable Ireland, DP Energy Ireland, EDP Renewables, Electricity Supply Board, Enerco Energy, ENGIE, Equinor ASA, Simply Blue Energy, SSE Renewables, and Statkraft Ireland; Science Foundation Ireland (SFI) under Grant No 12/RC/2302; and University College Cork, Ireland.
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