

# **Submarine evidence of ice-streaming and ice-sheet re-advance of the British Ice Sheet**

Heather Stewart

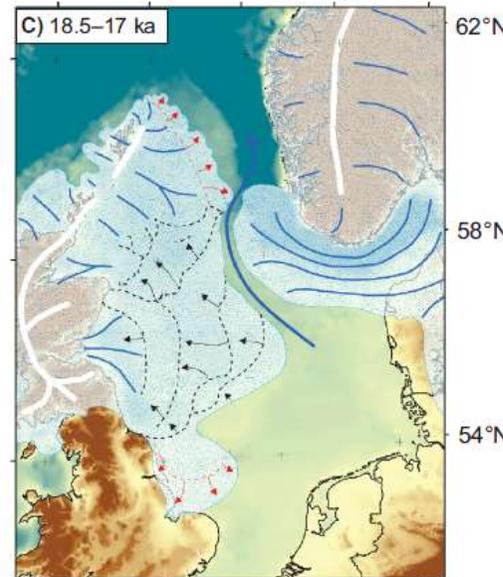
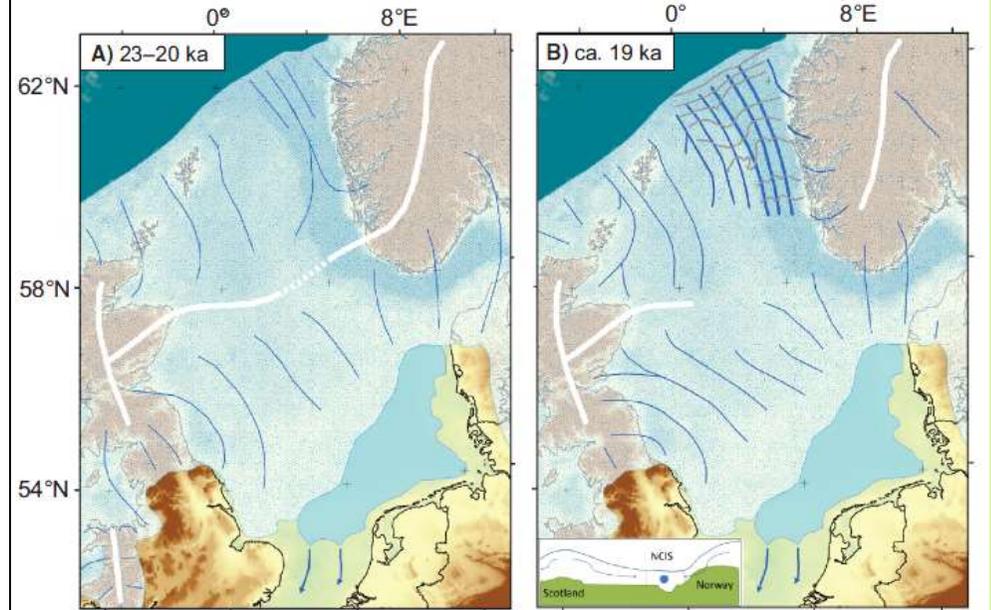
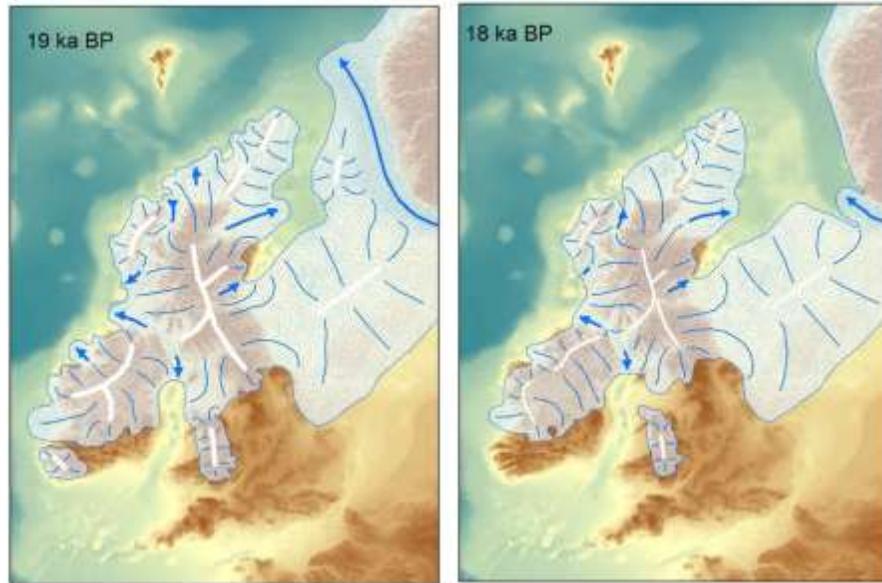
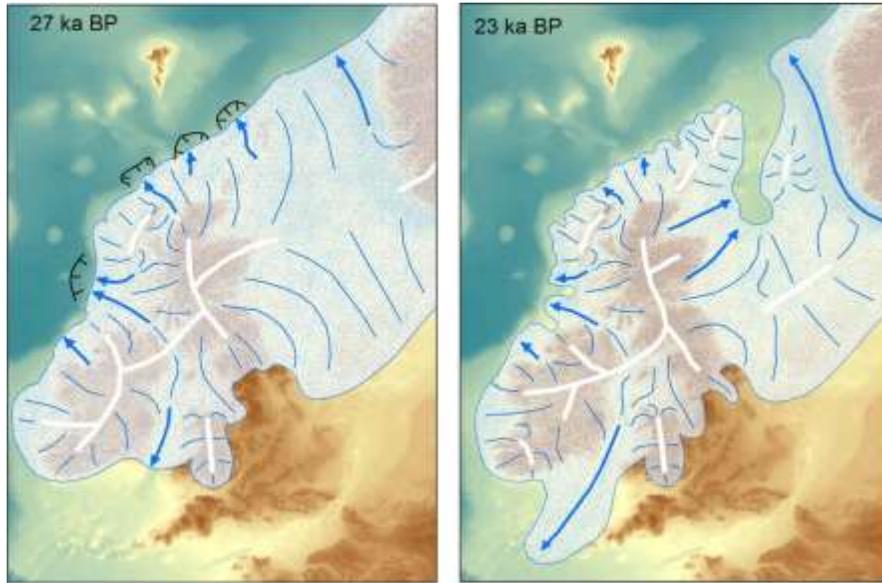
Tom Bradwell, Margaret A. Stewart & Colm Ó Cofaigh

# Research Aims

- To study the impact of glacial/interglacial cycles and ice streaming on the Quaternary landforms and sediments in the North Sea Basin.
  - Improved understanding of these marine sediments and their geomorphology will inform the distribution of sea-bed habitats, geohazards, resources, site selection for offshore renewables, and climate change.
- The investigation of palaeo-ice sheet beds is critical to the assessment of recent and future changes in contemporary ice sheets and for understanding the controls that influence their behaviour.
  - An improved understanding of the past cycles of glaciation, timing and extent, has far reaching implications for better understanding global climate change and ice-sheet behaviour.

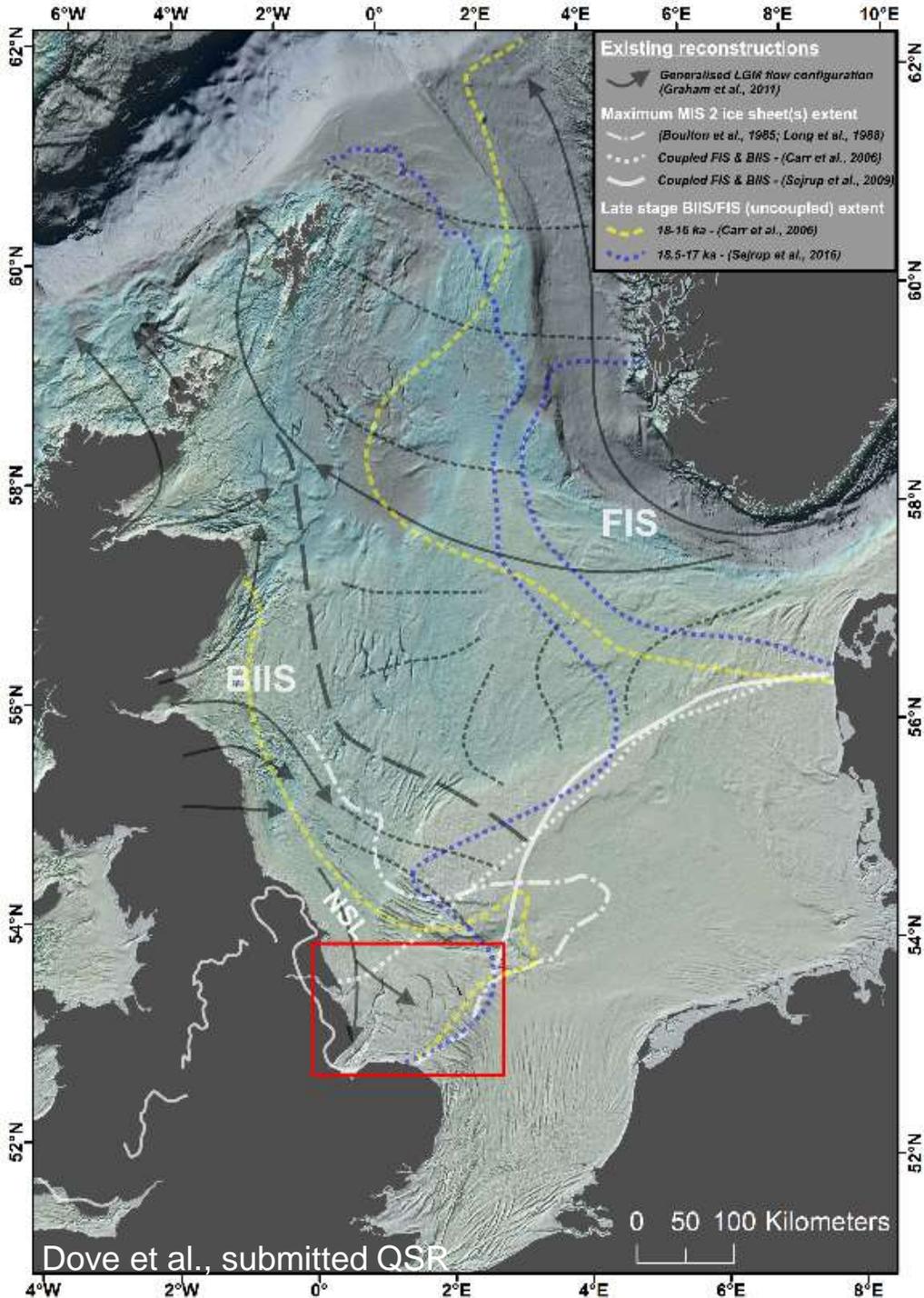


# Glaciation of the North Sea Basin



*Ice sheet models  
for British Isles  
(Last Glacial  
Maximum)*

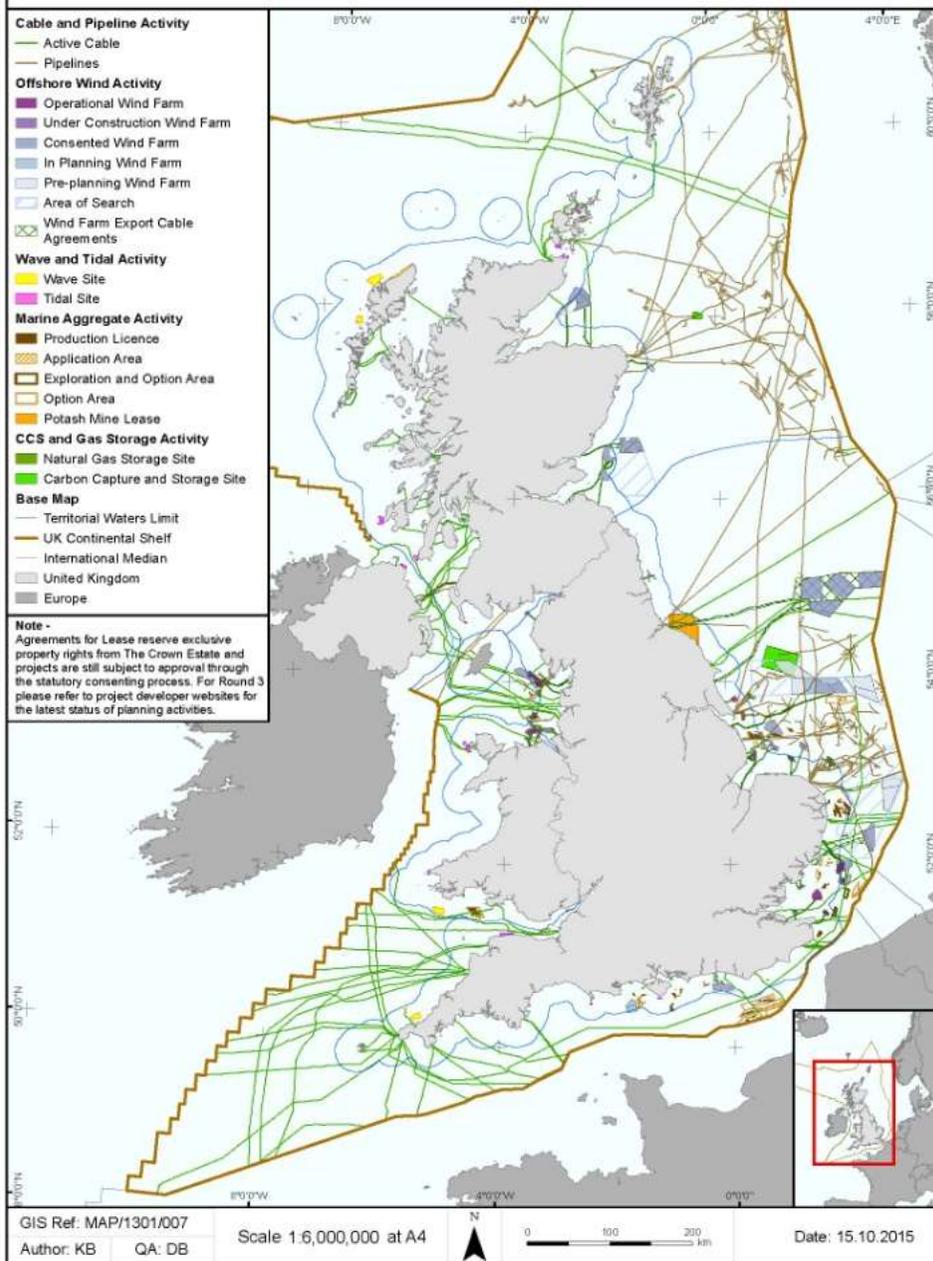




- Modelling studies demonstrated that the BISS was:
  - Dynamic
  - Drained by a number of ice streams
  - Associated with shifts in ice flow direction
- In North Sea Basin the BISS was:
  - Coalescent with Scandinavian ice
  - Drained by large, fast-flowing ice streams in north-eastern Scotland and southwards down east coast England



# The Crown Estate Offshore Activity (UK)

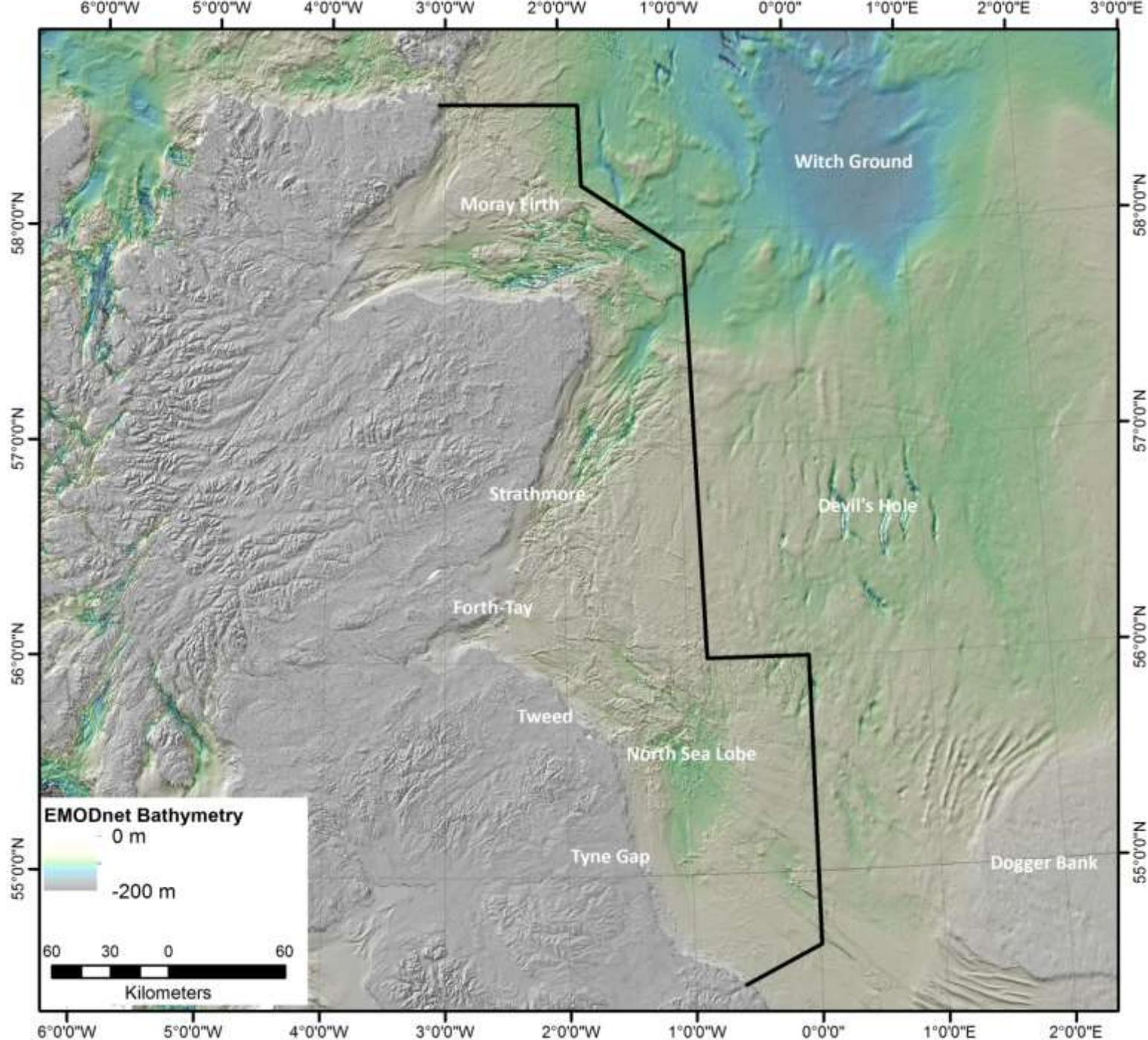


# Why?

- **Aggregates and Minerals**
- **Biology**
  - Habitat mapping and Marine Protected Areas
- **Commercial**
  - Offshore Renewables
  - Oil and Gas infrastructure
  - Carbon Capture and Storage
- **Geohazards**
  - Shallow gas
  - Coastal erosion
- **Marine Archaeology**
  - Paleolandscapes
  - Wrecks
- **Political**
  - Law of the Sea
- **Scientific**
  - Climate History and active environmental dynamics

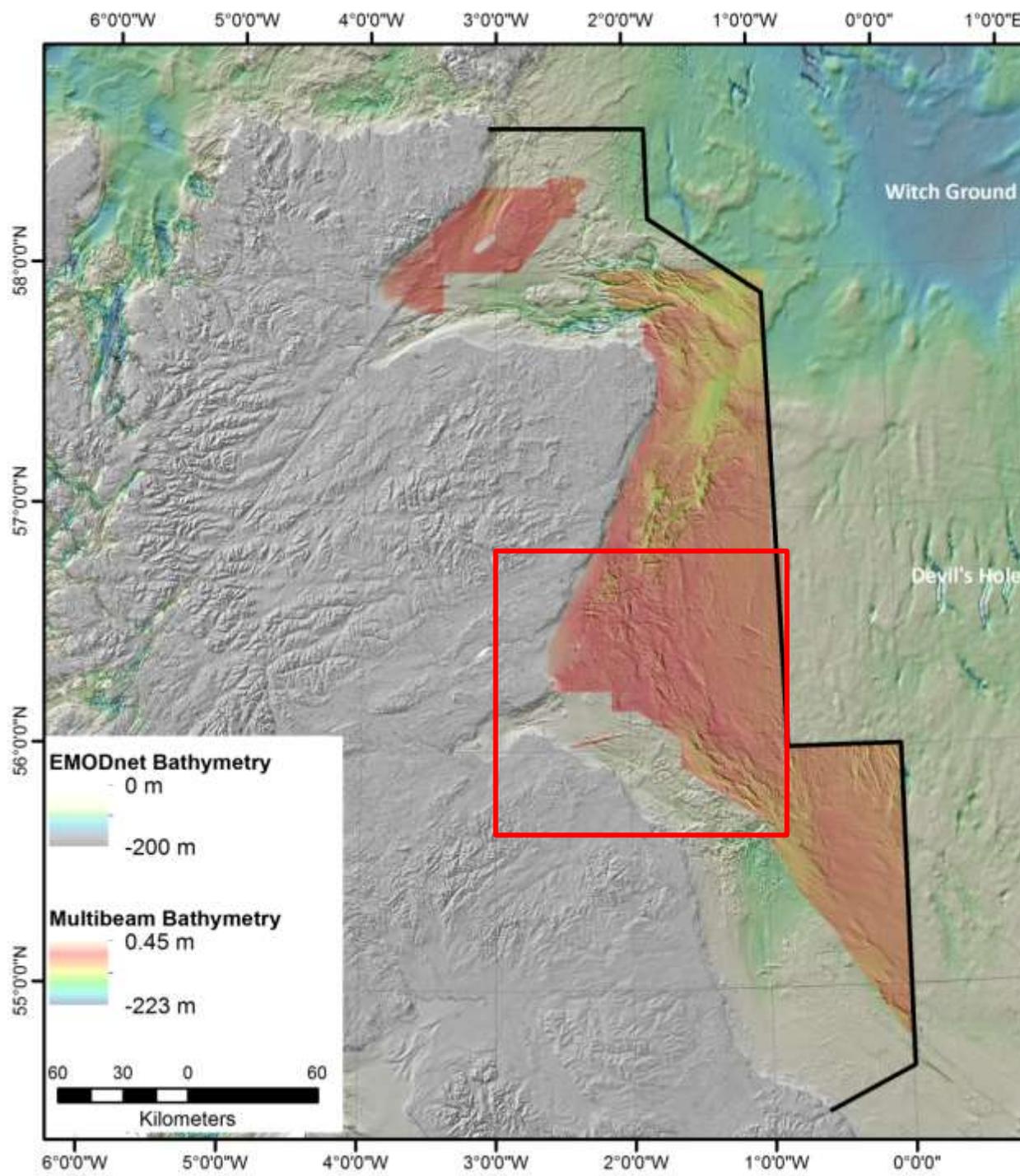


# Study Area



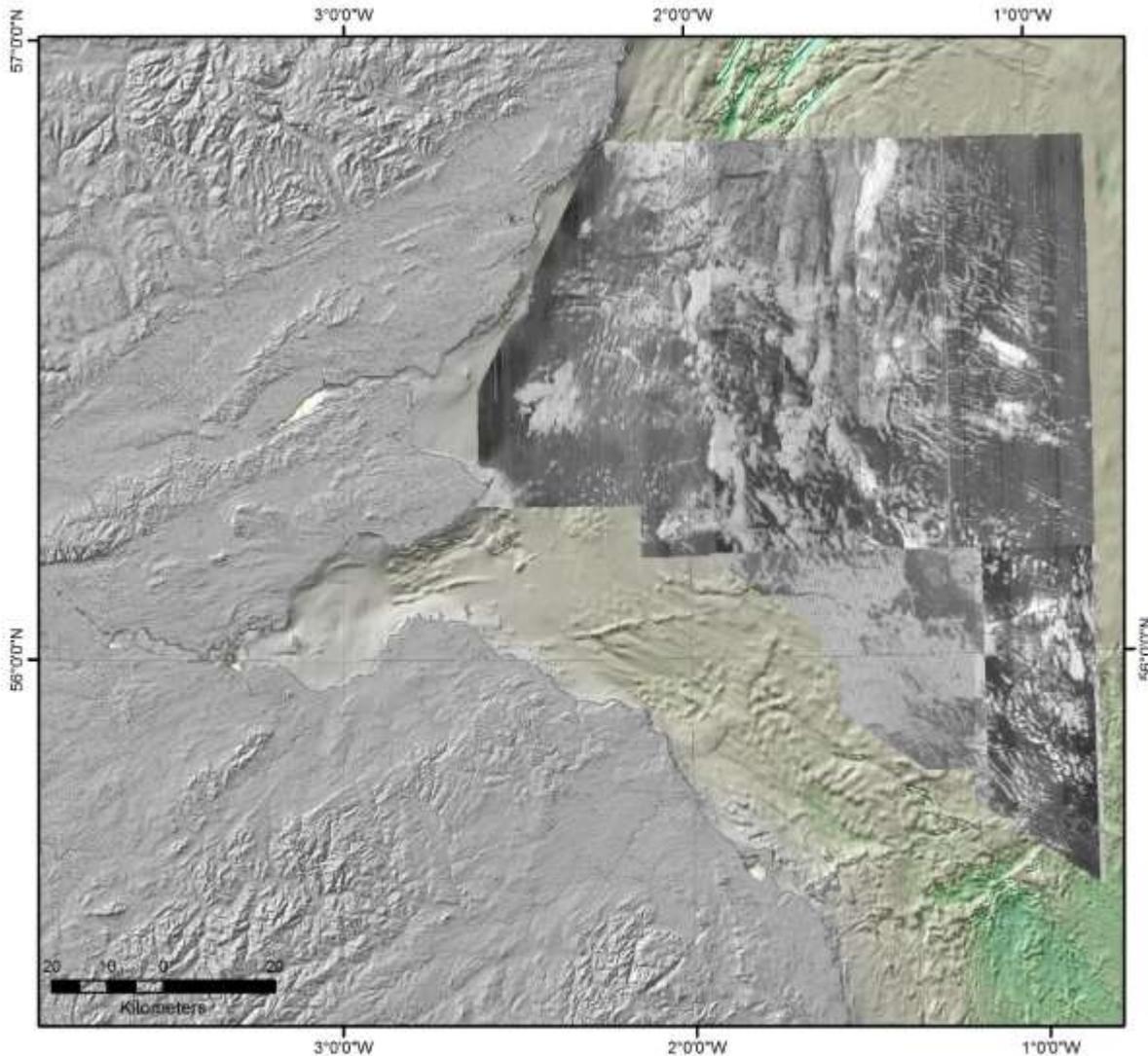
General bathymetry: EMODnet ([www.emodnet-hydrography.eu](http://www.emodnet-hydrography.eu))  
Onshore DTM: NextMap Britain elevation dataset (Intermap Technologies)





- Bathymetry data:
  - Multibeam echosounder
  - Best resolution single beam

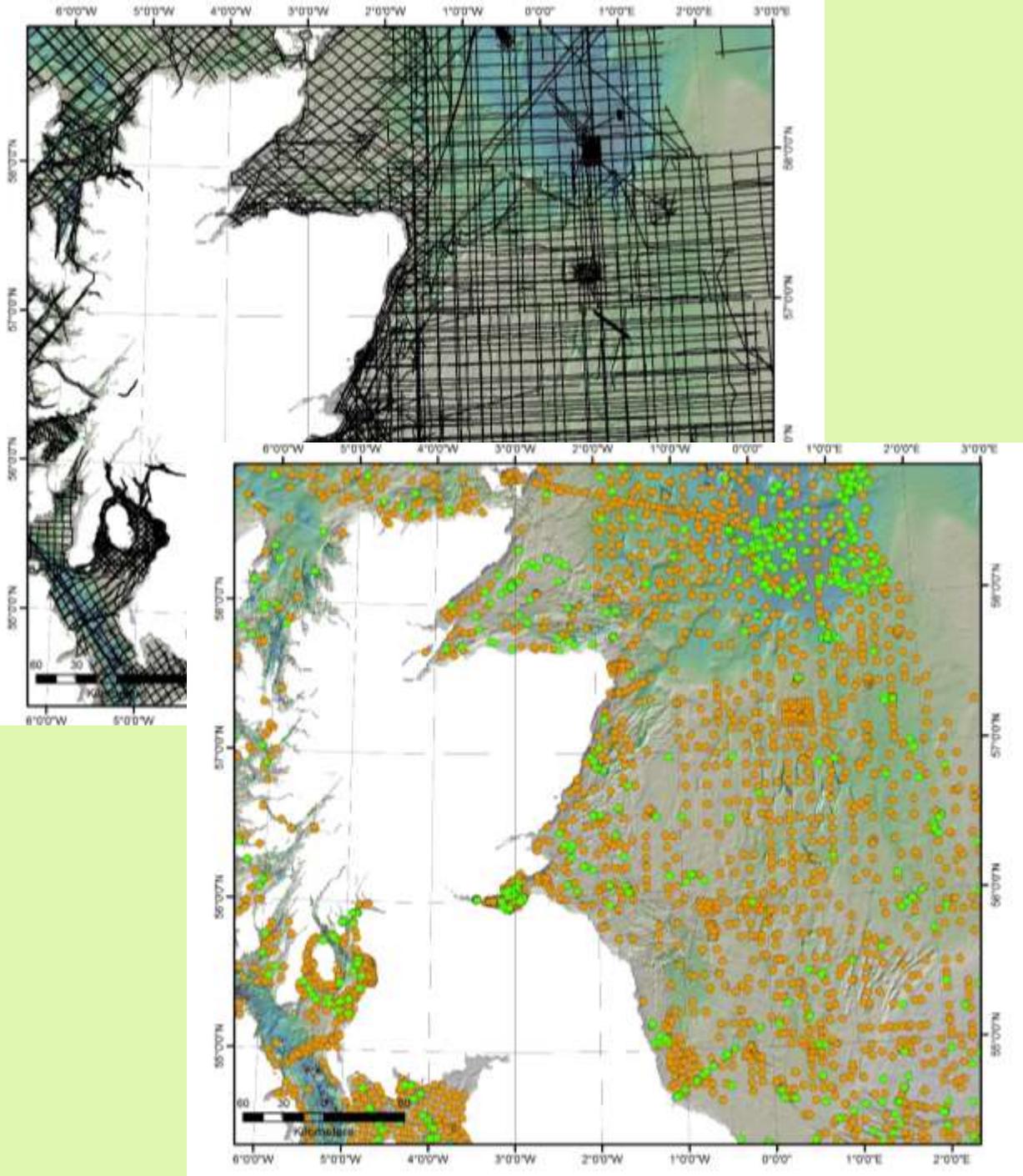




- Bathymetry data:
  - Multibeam echosounder
  - Best resolution single beam
- Backscatter intensity data:
  - Processed using FM Geocoder
  - Gridded at a variety of resolutions
  - Not 100% coverage over study area

Note: multibeam echosounder data susceptible to degradation (equipment setup, poor weather, and increasing water depths) even for systems with an operational window within the expected water depths to be encountered.





- Bathymetry data:
  - Multibeam echosounder
  - Best resolution single beam
- Backscatter intensity data:
  - Processed using FM Geocoder
  - Gridded at a variety of resolutions
  - Not 100% coverage over study area
- Sub-bottom data
- Offshore samples



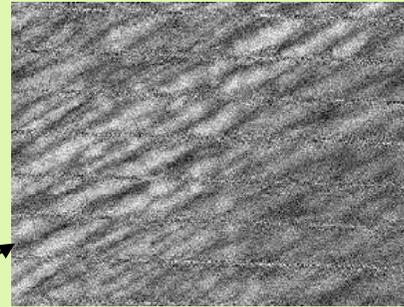
# Methodology

- Derived layers generated from bathymetry data:
  - Rugosity, slope, bathymetric positioning index and aspect.
- Backscatter intensity data:
  - used to determine sea bed substrate and where possible landform interpretation.
- Combination of expert judgement and semi-automated techniques.
- Incorporation of sub-bottom data and sample data.
  - Review and update with stratigraphy where possible and reconcile this with geomorphological evidence from high-resolution sea floor imagery.

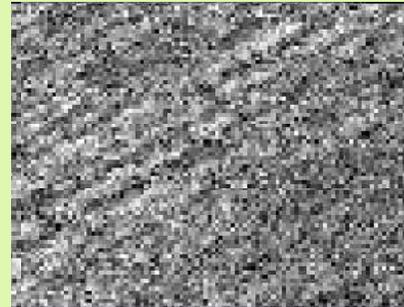


# Semi-automated Classification

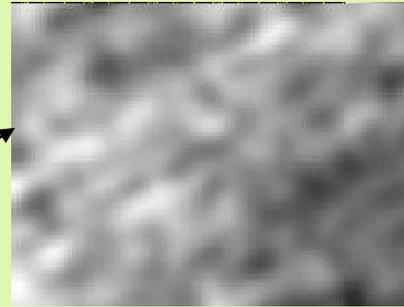
Backscatter mosaic generalisation / smoothing prior to auto-classification routine



Original image



Resample to 20 m



FocalStats back to 3 m



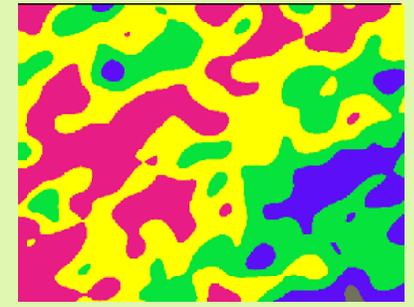
FocalStats \*10

Focal Statistics to populate new 3m grid (3x3 neighbourhood mean)

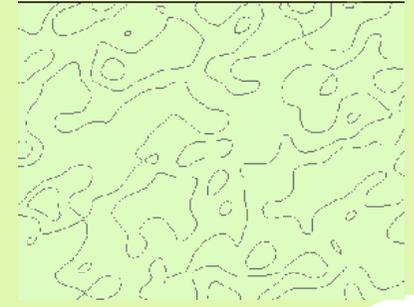
Iso cluster (migrating means technique) used as input for maximum likelihood classification routine



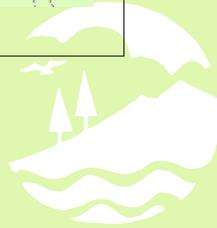
Result of FocalStats/generalising



Iso cluster tool



Raster to polygon



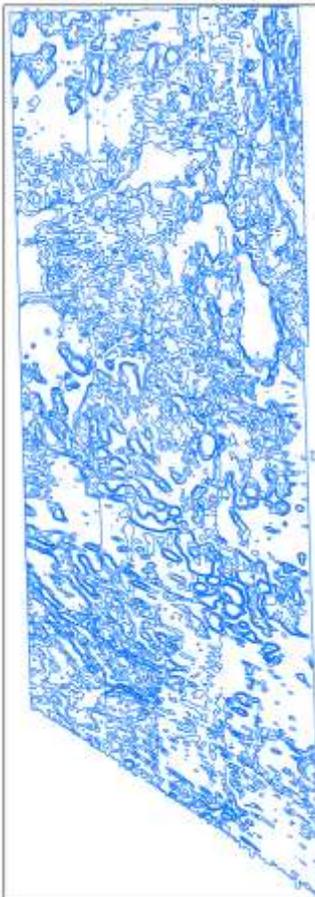
# Semi-automated Classification



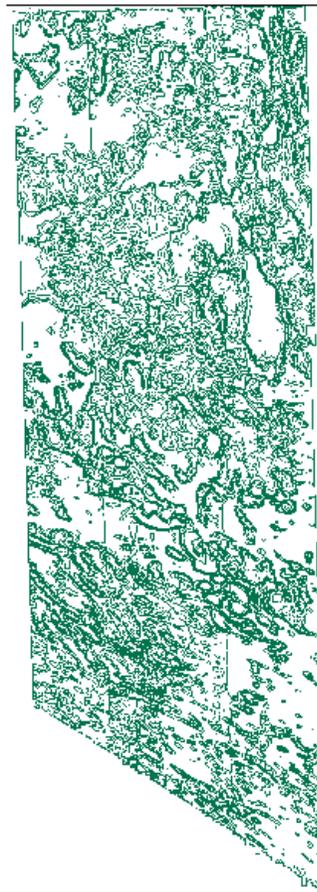
2m resolution



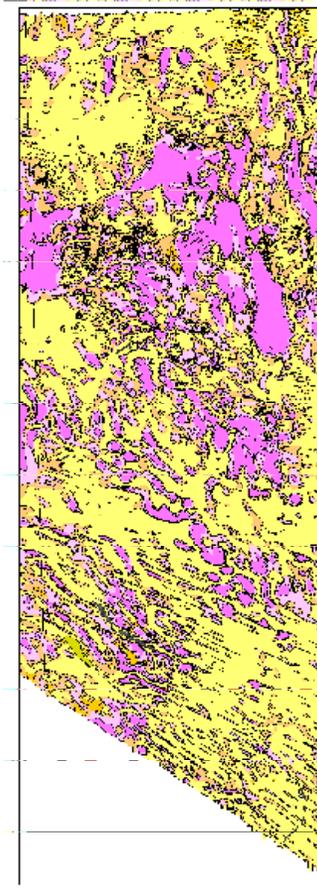
4 classes



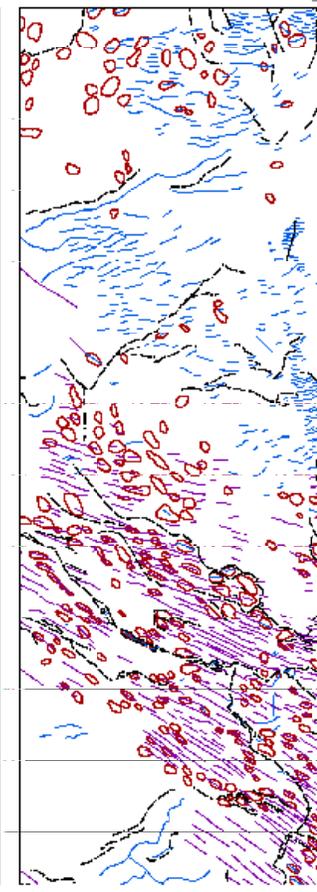
5 classes



6 classes



Seabed  
sediments

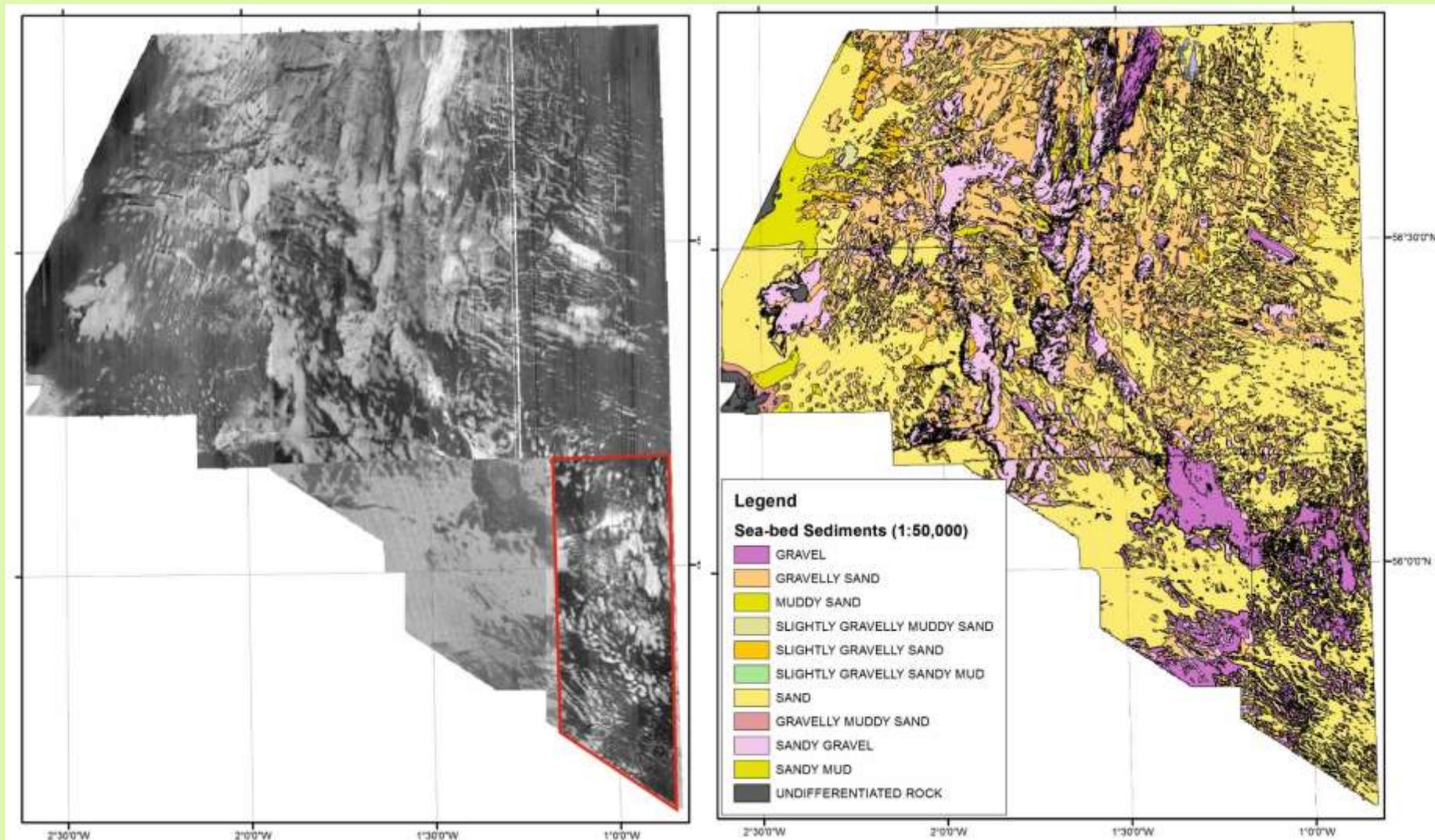


Glacial  
landforms

Combination of expert judgement and semi-automated techniques



# Interpretations: sea-bed sediments

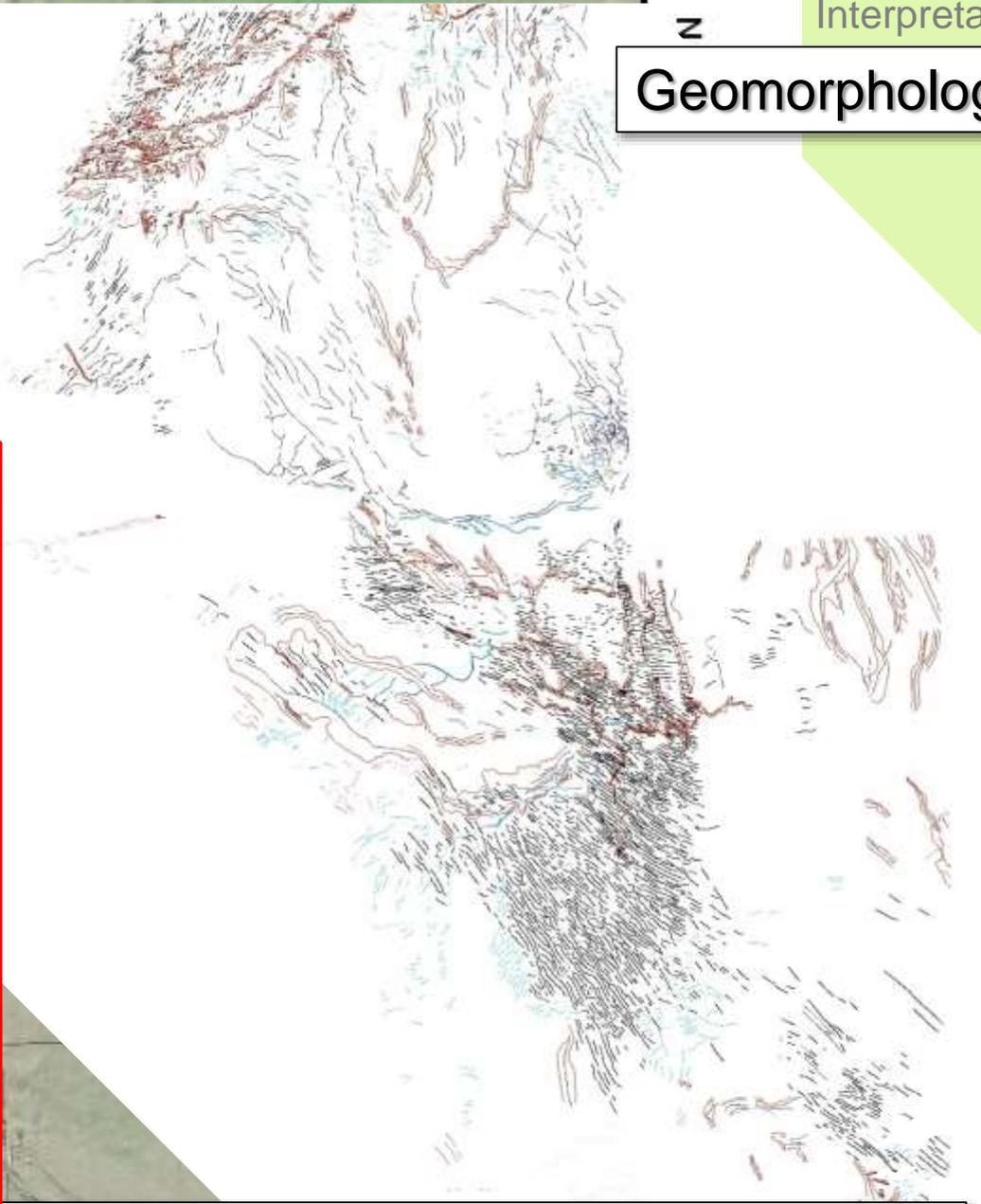
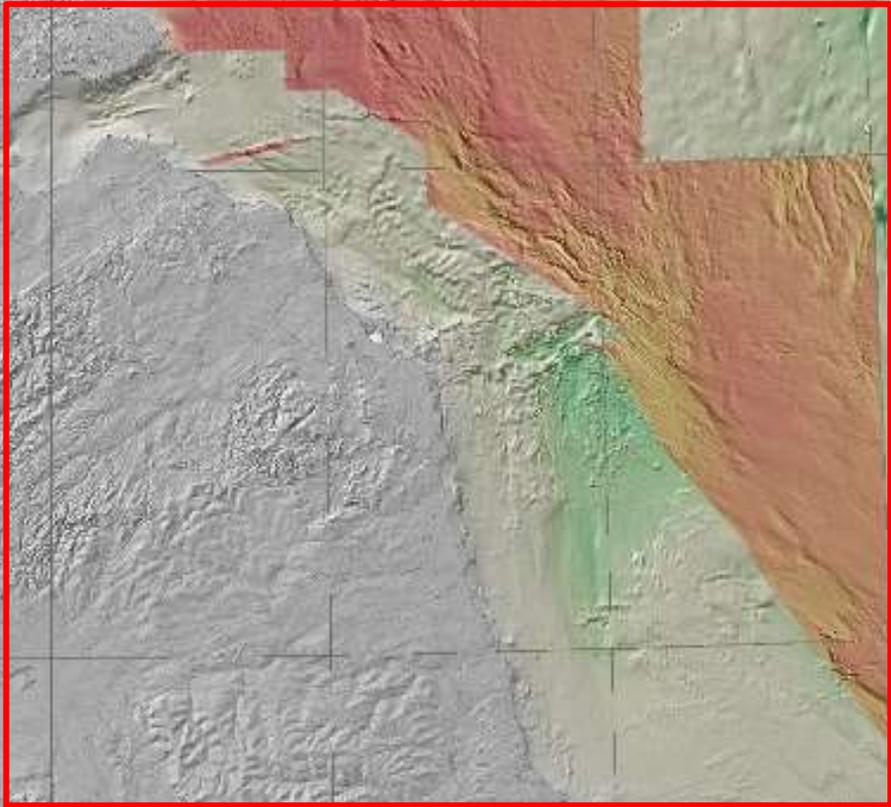


Combination of expert judgement and semi-automated techniques

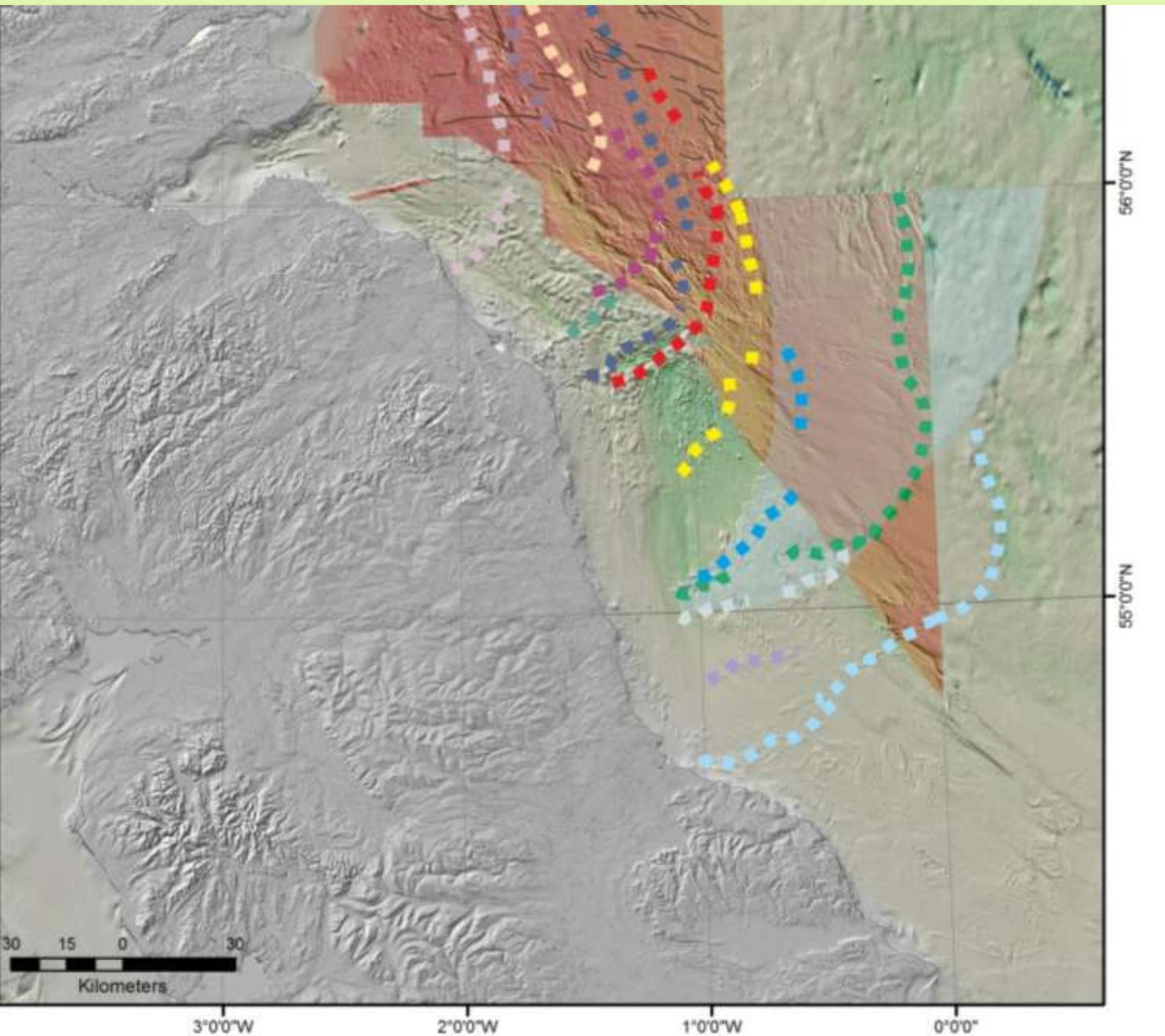
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Interpretation

# Geomorphology



Combination of expert judgement and semi-automated techniques



## Overview

Pervasive  
MSGL and  
drumlin  
signature.

Large  
expanses of  
glacigenic  
deposits.

Overprinting of  
earlier moraine  
deposits.



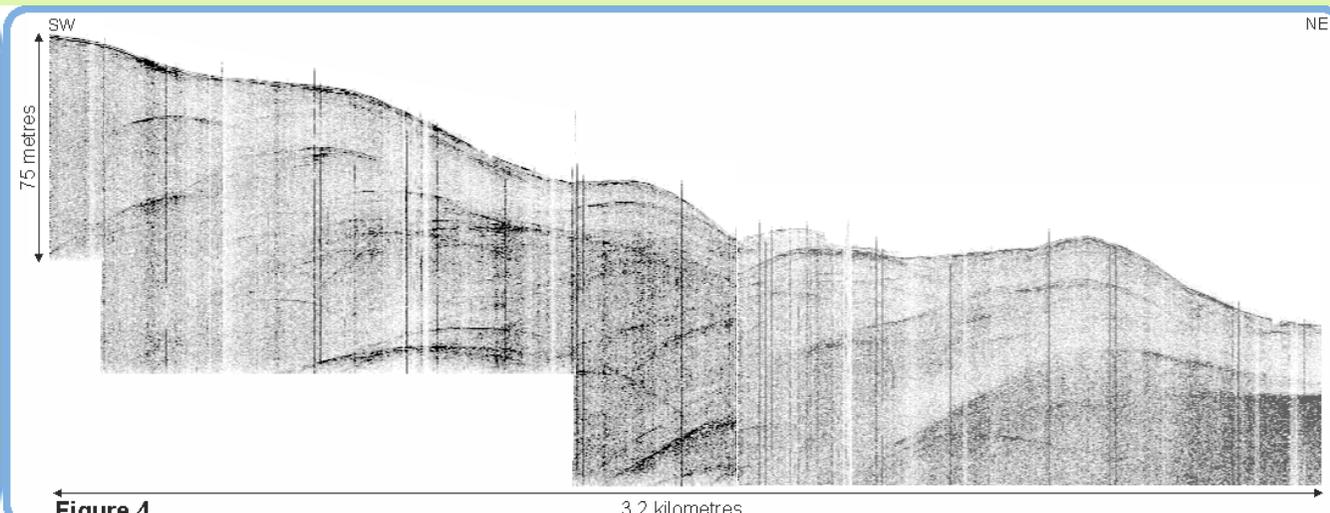
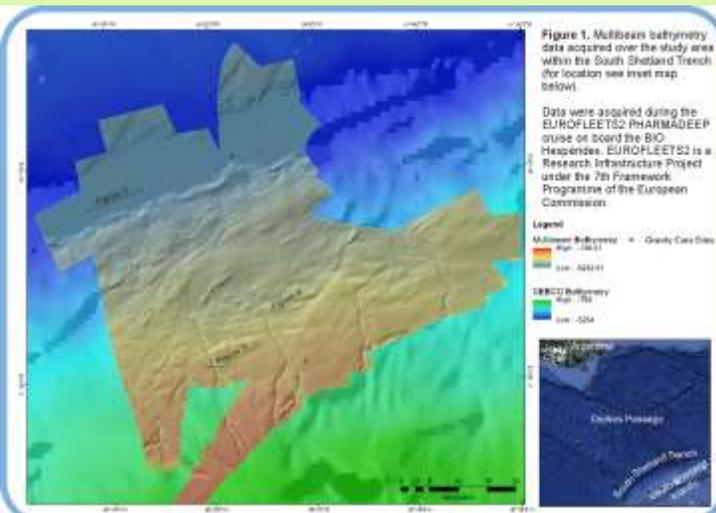
# Summary

- Best-resolution **bathymetry data** has helped to unravel ice sheet dynamics offshore eastern UK.
- Combination of **expert judgement** and **semi-automated** techniques in use.
- Interpreted seabed geomorphology indicates North Sea Lobe **fed** by ice stream from **Forth-Tay** catchment.
- Moraines of various scales and grounding zone wedges indicate **complex advance, recession** and **re-advance** of the North Sea Lobe during Last Glacial Maximum.



# Next Steps

- First two papers *should* be submitted shortly (North Sea Lobe).
- Expand geomorphological interpretation over entire study area (including QC).
- How does this fit with what is known onshore?
- Look at ice-sheet reconstructions for the western North Sea Basin that best fits the available geological data.
- Incorporate sub-bottom and core data.
- South Shetland Trench (sub-Antarctic) dataset acquired.



# Acknowledgements

- Data providers:



- Thanks to D.J.A. Evans, D.H. Roberts (Durham University) and D. Dove (BGS) for active discussions on this project.
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- My supervisors: Tom Bradwell (Stirling University), Margaret Stewart (BGS) and Colm Ó Cofaigh (Durham University).
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