Cullen Scholarship: Measuring the Impact of Rockall Trough Circulation on Celtic Climate (PhD Award)

Background

The poleward transport of heat in the North Atlantic Current (NAC) is a critical component of the global climate system and has been termed "Europe's Central Heating System". The Rockall Trough (RT, Fig. 1), a ~200 km wide channel in the eastern subpolar North Atlantic, serves as a key NAC pathway (Fraser et al. 2022, Daly et al. 2024). The NAC is an integral component of the Atlantic meridional overturning circulation (AMOC) at subpolar latitudes, with recent results indicating that the RT branch plays a primary role in AMOC variability (Fu et al.). Furthermore, the release of heat from the NAC into the atmosphere has been shown to be the biggest ocean-atmosphere buoyancy exchange signal in the subpolar gyre (Jones et al. 2023). Since the west coasts of Ireland and Scotland sit immediately east of the RT branch of the NAC (Fig. 1), we might presume that their weather and climate is particularly sensitive to changes in heat delivered by the NAC. However, we currently lack the observational insights needed to understand this relationship at a regional scale. Against a backdrop of destabilising Atlantic circulation patterns, a robust, observation-based understanding of this mechanism is urgently required to improve climate predictions for Ireland and Scotland.

There is a longstanding effort to monitor circulation and hydrography in the RT, exploiting this natural bottleneck in North Atlantic circulation. Since 2014, transports across the Extended Ellett Line (EEL) have been continuously monitored using a dynamic height mooring array (Fig 1.) deployed as part of the larger OSNAP (Overturning in the Subpolar North Atlantic) programme (Fraser et al. 2022). In addition, regular hydrographic surveys on both the southern RT (SRT) and EEL sections have been running for decades (Daly et al. 2024). Each of these cross-sections of the NAC can be used to calculate the ocean heat flux through the RT. Used in combination, the SRT and EEL datasets therefore provide a unique opportunity to directly measure the horizontal convergence of ocean heat in the RT. It is this heat convergence which sustains net heat delivery to the atmosphere and onto the shelf, effectively providing a constraint on the marine and atmospheric

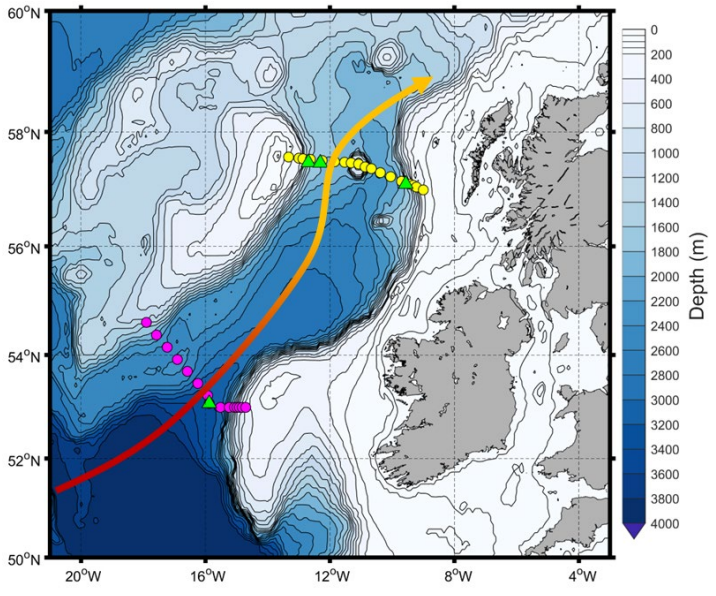

Figure 1: Bathymetric map of the Rockall Trough showing Southern Rockall Trough (magenta) and Extended Ellett Line (yellow) observing stations, and longstanding moored observing platforms (green triangles). Red arrow denotes the North Atlantic Current pathway with fading colour symbolising heat loss to the atmosphere.

heat supplied to Ireland and Scotland from the Atlantic. To date, however, there have been no studies focused explicitly on measuring heat convergence in the NAC.

Proposal

We propose **a structured four-year PhD** on a full-time basis. This PhD project will use the extensive range of ocean observing systems in the northeast Atlantic, centred around the SRT and EEL datasets, to provide observational estimates of the convergence of ocean heat in the Rockall Trough and to quantify the influence on atmospheric and coastal marine conditions in western Ireland and Scotland. Ship-based and mooring data will be supplemented with satellite and Argo float data to construct a comprehensive heat transport product for each section, employing innovative data analysis and gridding techniques pioneered by Jones et al. (2023). In addition, the student will utilise regional ocean simulations and atmospheric reanalyses to further unpick the causal relationships between ocean heat delivery, atmospheric heat content, and terrestrial weather and climate in Scotland and Ireland, over timescales ranging from days to decades.

The project will address the following research questions:

1. Does ocean heat convergence in the RT drive variability in ocean-to-atmosphere heat flux?
2. Does ocean-to-atmosphere heat delivery over the RT have a measurable impact on weather and climate in Ireland and Scotland?
3. Are these mechanisms governed by processes in the ocean or in the atmosphere, and over what timescales?

Further research questions will be formulated and tackled over the course of the project, as the student becomes increasingly self-directed.

Location of Scholar and Training Provided at the Marine Institute

The scholar will be based for circa 50% of their time over the four years at the Marine Institute HQ Rinville, Galway.

The project will be mainly desk-based involving extensive training in MATLAB and/or python. There will be opportunities to develop skills in remote glider piloting and to participate in field campaigns to the RT on both the Irish and UK research vessels.

Key methodologies, for which the scholar will be trained are:

- Rockall Trough observations and derived circulation patterns (e.g. Fraser et al., 2022; Daly et al., 2024).
- Budget analysis for volume (e.g. Fraser et al. 2024) and heat (e.g. Desbruyères et al., 2021).
- Regional ocean and coupled ocean-atmosphere simulations (e.g. Graham et al. 2018).
- Ocean atmosphere fluxes from reanalysis projects (e.g. ECMWF ERA5).
- Open ocean-shelf exchanges: collaboration with NERC CANARI and ODISSEA programmes.

Outcome

The eastern North Atlantic plays a crucial role for the mild climate prevailing across Ireland, the UK and Europe and enables the European shelf to support thriving ecosystems and blue economies (McCarthy et al., 2023). This project will, for the first time, provide a budget analysis of climate-relevant fluxes from the Rockall Trough to the atmosphere and onto the shelf. Not only will the project improve our understanding of these crucial metrics, but —through dedicated outreach activities— will also communicate their implications to the communities most affected.

The project will also contribute to the development of improved regional climate predictions, one of the current global challenges, through gathering ocean observations and contributing to our understanding of important climate relevant fluxes.

Marine Institute Corporate Strategy 2023-2027

The table below summarises which strategic priority areas of the Marine Institute's corporate strategy Ocean Knowledge that Informs and Inspires (headings in table), and associated strategic initiatives (numbers in table) that this project will address.

Advice and services	Climate and biodiversity	Research and innovation	Blue Economy
4,6,8	1,5,6	1,5,6	6

This project will strengthen emerging areas of research by adding expertise in open ocean–shelf interaction to current Marine Institute/OCIS capabilities, bridging the gap between open ocean circulation and coastal and atmospheric conditions. It will reinforce the Marine Institute's position in international research through links with the Scottish Association for Marine Science (SAMS) and multi-national collaborations in the OSNAP/ODISSEA programmes.

Specific Requirements

The scholar should have a primary degree in a relevant scientific or technical subject (marine science, physical oceanography, physics, ocean sciences, mathematics, IT or civil engineering).

Financial Details

Scholarships will be up to €34,000 per annum (maximum funding PhD of €136,000 over four years). This amount comprises a maintenance award of €25,000 to the student as well as payment of fees to the host higher education institution (HEI). The maximum fees payable to the HEI will be €6,000 per annum. The scholarship award also includes a budget of up to €3,000 per annum for eligible research

costs (travel & subsistence, publication costs, consumables and other costs, such as minor kit purchase e.g. camera) for the sole use of the student and are payable on a reimbursement basis direct to the host institution where the postgraduate student (scholar) is registered. There are no overheads payable on the scholarship.

Publication costs are intended to cover publications on which the scholar is listed as first author and are published under Open Access.

Scholars can also supplement this funding by applying to the Marine Institute's Networking & Marine Research Communication Awards annual call.

In addition, the cost of a laptop will be covered by the Marine Institute (purchased via the Research Funding Office).

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