Foras na Mara
Marine Institute

# Cullen Scholarship: Hyperspectral Analysis of Blooms in Irish waTers (HABIT)

# (PhD Award)

## Background

Harmful algal blooms (HABs) in marine ecosystems pose a significant threat to biodiversity, marine wildlife, and aquaculture operations. These phytoplankton blooms can lead to severe disruptions in food chains, marine habitat destruction, and economic losses due to contamination of seafood and fish kills. Current monitoring techniques are often inadequate to predict HAB events in real time or on a large scale, highlighting the need for innovative approaches to improve early detection and monitoring. Remote Sensing combined with drone technology provides a promising solution to collect high-resolution spatial data of near surface marine waters, enabling the identification of some phytoplankton groups and enhanced tracking of some harmful species. The application of these technologies (drones coupled with hyperspectral sensors) can contribute to the development and enhancement of existing early warning systems, crucial for mitigating the impact of HABs on ecosystems and industries.

This proposed PhD project will investigate the potential of hyperspectral imaging using drones to improve how we monitor and manage harmful algal blooms, benefiting both the scientific community and Irish industries at risk from this type of marine hazard.

## Proposal

We propose a **structured four-year PhD** on a full-time basis to investigate the use of drone-based hyperspectral imaging to monitor high biomass phytoplankton blooms in surface waters that can potentially harm marine wildlife and aquaculture operations. The research will address the following specific questions: *How can hyperspectral drone data be used to detect and monitor harmful algal blooms in Irish waters, and what are the key spectral signatures that indicate the presence and severity of these blooms?*

The project will aim to:

- Develop a comprehensive fieldwork approach for collecting hyperspectral data on phytoplankton blooms in Irish waters.
- Analyse spectral signatures of different phytoplankton species, with a particular focus on those responsible for harmful blooms creating an optical library.
- Create an end-to-end operational system for monitoring HABs using hyperspectral sensors housed in an air drone, including field data collection, data processing, and the development of data products to visualise and interpret hyperspectral results. Where deemed suitable the data products developed will be used in combination with satellite remote sensing and ship based in-air hyperspectral sensors.

- Contribute to the existing Irish HAB early warning system (HAB bulletin) which provide alerts to aquaculture operations.
- Publish at least three peer-reviewed scientific articles detailing the methods, results, and applications of hyperspectral drone technology in HAB monitoring.

**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.

Support for the student will be provided from several groups within the Marine Institute (e.g. the MEFSS Phytoplankton team, the OCIS Ocean Oceanography & Ocean Climate team).

The scholar will be part of a team with expertise in remote sensing and will receive training on different detection methods already in use at the institute (e.g. the Irish Research Vessels *in-air* and *in-water* Hyperspectral systems; ocean colour Satellite Remote Sensing products). Expertise on HABs will be provided by the MEFS phytoplankton team who recently purchased a drone housed with a hyperspectral sensor.

This collaborative project has an international partner Ecosystems Oceanography Group at the Institute of Marine Sciences of Andalusia (ICMAN) of the Spanish National Research Council (CSIC), who will train the scholar in the operation of drone-based hyperspectral imaging systems and the analysis of hyperspectral data.

Training will include:

- Hands-on experience in drone operation, including flight planning, data acquisition, and safety protocols.
- Advanced techniques for processing hyperspectral imagery to detect and quantify phytoplankton blooms, with a focus on harmful algal species.
- Data analysis methodologies for extracting meaningful environmental indicators from hyperspectral data.

**Outcome**

The expected outcomes from the project will be:

- A fully operational drone-based system for the detection and monitoring of harmful algal blooms, from field data collection to visualisation of results.
- A set of robust spectral signatures and data processing methods for identifying high biomass phytoplankton blooms.
- The integration of this system into an Irish HAB bulletin, contributing to better-informed decisions in aquaculture operations and marine wildlife management.
- At least three peer-reviewed publications in leading journals on marine science, remote sensing, environmental monitoring, disseminating the methodologies and findings to the scientific community.

- That the methodologies (principles, tools and practices) and transferable framework developed in the project will be used in future national and international projects.
- A comprehensive framework for extending this approach to other regions and scales, with potential for use in global HAB monitoring programs.

The scholarship will enhance links between the Marine Institute and the Spanish National Research Council.

## Marine Institute Corporate Strategy 2023-2027

Under the strategic priority "Delivering impact through research and innovation" of the Marine Institute's corporate strategy Ocean Knowledge that Informs and Inspires, this research will address strategic initiative number 5 "Strengthen the Marine Institute's capability and capacity in strategically important research areas by enhancing our equipment and infrastructures, building our expertise, fostering strategic partnerships, and attracting and retaining talented researchers".

This PhD proposed research will strengthen the Marine Institute's capabilities across infrastructure (how to use a drone to monitor HABs), expertise (drone-based hyperspectral imaging analysis and interpretation), and strategic partnerships (cross institute collaborative research; strengthening ties with international partners in Spain), while also contributing to its long-term goal of maintaining excellence and leadership in marine research (Peer reviewed scientific publications; build capacity and expertise in the rapidly evolving field of drone-based remote sensing and hyperspectral imaging while supporting early career development of the PhD student). Transfer world-class knowledge and technical skills from CSIC (Spain) to the MI (Ireland), fostering internal expertise and strategic partnerships by providing the opportunity for future knowledge transfer to other researchers.

The proposed PhD project would directly contribute to the Marine Institute's strategic research areas, particularly in marine ecosystems, aquaculture, and environmental monitoring.

## Specific Requirements

The scholar should have a primary degree in 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).

**Marine Institute Co-Supervisor**


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