PROJECT TITLE: Improving future predictions in ocean nitrogen fixation

DTP Research Theme(s): Living World, Changing Planet
Lead Institution:
Lead Supervisor: Fanny Monteiro, University of Bristol, School of Geographical Sciences
Co-Supervisor: Patricia Sanchez-Baracaldo, University of Bristol, School of Geographical Sciences
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Project keywords: Ocean, Nitrogen cycle, Machine Learning, Climate models

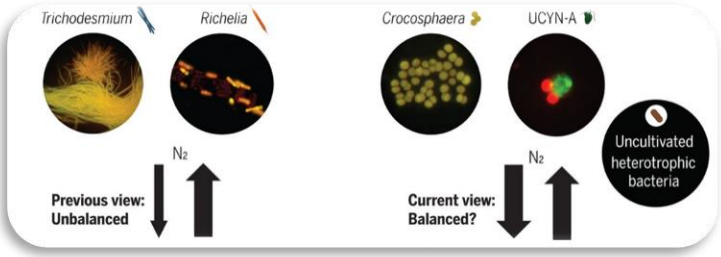

Figure 1: Main types of ocean nitrogen fixers (adapted from Zehr and Capone, 2020) showing that recently found nitrogen fixers might change our understanding.

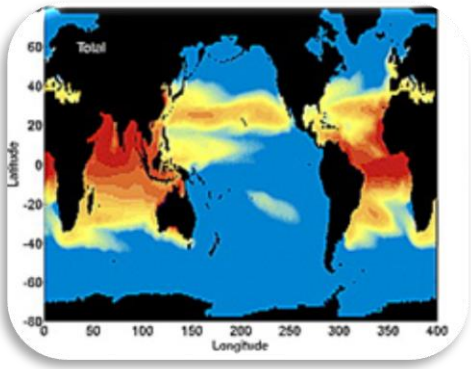

Figure 2: Global distribution of nitrogen fixation from the Darwin-MIT model (Monteiro et al., 2010)

Project Background

Nitrogen is one of the most limiting nutrients in the ocean, regulating life and carbon storage (Zehr and Capone, 2020). Nitrogen is primarily added to the ocean via nitrogen fixation, a biological process where bacteria utilise the abundant dinitrogen gas (N_2) to grow. This process gives nitrogen fixers an advantage in low-nutrient environments, where commonly used nitrogen forms (nitrate or ammonium) are limited. Despite its importance for the Earth System, climate models struggle to adequately represent nitrogen fixation, causing large discrepancies in future climate predictions (Bopp et al., 2023). The reasons are that 1) N_2 fixation observations are too patchy to constrain the models (Tang et al., 2019) and 2) models fail to capture the diversity of nitrogen fixers (Figure 1).

Project Aims and Methods

This PhD project aims to improve the observations in nitrogen fixation and their representation in climate models to reduce uncertainties in our future climate predictions. To do that, the student will first compile observations of the diverse nitrogen fixers and predict better global distributions using advanced machine learning approaches to fill the gaps in observations while quantifying uncertainties. The student will then improve the representation of the diverse nitrogen fixers in the state-of-the-art global ocean ecosystem model Darwin-MIT model (Monteiro et al., 2010; Dutkiewicz et al., 2020) validated with the observations. Depending on the student's interest, they will then have the possibility to run these models for future prediction and/or paleoclimate.

Candidate requirements

We seek a highly motivated and independent candidate interested in an interdisciplinary understanding of marine biology, ocean chemistry and climate. Candidates should have a degree in one of the following topics: Oceanography, Biology, Earth Sciences, Environmental Sciences, Geography, Chemistry, Geophysics, Physics or Mathematics. *We welcome and encourage student applications from under-represented groups. We value a diverse research environment.*

Project partner

Our project partner Dr Robidart from NOC (Southampton) will provide expertise on marine nitrogen fixers' observations, including merging different observation types and estimating their uncertainties. The student will visit NOC every 4 months in the first year to discuss ideas and design some aspects of the project, as well as interacting with the NOC marine research community, with the possibility for the student to perform data analysis or to go at sea in years 2 and 3, depending on the student's interest.

Training

Overall, the student will receive specialist training in computer model programming, AI and data analysis. The student will learn how to use and develop models of different complexity (from machine learning, ecosystem to Earth system models). Dr Monteiro will supply modelling support on nitrogen cycling and future/paleoclimate and AI applications to marine ecosystems. Prof. Sanchez-Baracaldo will provide expertise on differencing the diverse nitrogen-fixing bacteria using molecular tools. Dr Follet will provide expertise in modelling the different nitrogen fixer types. The student will develop expertise in marine ecology, ocean biogeochemistry and climate (future climate change and paleoclimate).

Background reading and references

Bopp et al. (2022). Diazotrophy as a key driver of the response of marine net primary productivity to climate change. *Biogeosciences*, *19*(17), 4267-4285.
Dutkiewicz, S., Cermeno, P., Jahn, O., Follows, M. J., Hickman, A. E., Taniguchi, D. A., & Ward, B. A. (2020). Dimensions of marine phytoplankton diversity. *Biogeosciences*, *17*(3), 609-634.
Monteiro et al. (2010). Distribution of diverse nitrogen fixers in the global ocean. *Global Biogeochemical Cycles*, *24*(3).
Tang, W., Li, Z., & Cassar, N. (2019). Machine learning estimates of global marine nitrogen fixation. *Journal of Geophysical Research: Biogeosciences*, *124*(3), 717-730.
Zehr, J. P., & Capone, D. G. (2020). Changing perspectives in marine nitrogen fixation. *Science*, *368*(6492), eaay9514.

Useful links

http://www.bristol.ac.uk/geography/courses/postgraduate/
https://www.bristol.ac.uk/people/person/Fanny-Monteiro-125e87b4-41ce-4afb-9fb4-48e2677c52c9/
https://research-information.bris.ac.uk/en/persons/patricia-sanchez-baracaldo
https://noc.ac.uk/n/Julie+Robidart
https://www.liverpool.ac.uk/environmental-sciences/staff/chris-follett/

Bristol NERC GW4+ DTP Prospectus:
http://www.bristol.ac.uk/study/postgraduate/2024/sci/phd-great-western-four-doctoral-training-partnership-nerc/

How to apply to the University of Bristol:
http://www.bristol.ac.uk/study/postgraduate/apply/
Please note: If you wish to apply for more than one project please contact the Bristol NERC GW4+ DTP Administrator to find out the process for doing this**.**

The application deadline is Tuesday 9 January 2024 at 2359 GMT. Interviews will take place from 26 February to 8 March 2024.

For more information about the NERC GW4+ Doctoral Training Partnership please visit https://www.nercgw4plus.ac.uk.

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