# Sensing the marine nitrogen cycle: development of a high-resolution autonomous sampler to capture microbial ecosystem services

Dr Julie Robidart, Dr Phyllis Lam, Keith Davidson (SAMS)

**Rationale:**
Microbes fuel the Earth's biogeochemical cycles and influence global climate, they provide feedstock for fisheries and aquaculture, yet are also responsible for environmental and economic damage e.g. through pathogenesis, harmful blooms, and eutrophication. However, current understanding does not enable us to accurately model their abundances, response patterns, or ecosystem functions, due to our inability to observe microbes over the correct spatial and temporal scales.

This project seeks to develop an autonomous, agile, miniaturized, transformative technology to collect and preserve microbes, their RNA, DNA and proteins in >1000 discrete microbial samples from aquatic environments with a wide range of potential applications including: pathogen and pollution tracking; bloom dynamics studies; diversity and resilience to environmental change. This sampler will have deployment longevity, platform flexibility and a modular design, allowing future integration to form the front end and archiving system for a miniaturized autonomous biological sensor. Test deployments will capture the dynamics of nitrogen-fixing microbes, whose "blooms and busts" have been detected in sediment traps but so far escaped recurrent *in situ* detection: perhaps amongst the most elusive phenomena in ocean biogeochemistry. The resultant data will have unprecedented spatiotemporal resolution that is much needed in any meaningful ecosystem modelling for future global changes.

**Methodology:**
The PhD project will involve the development of molecular biological assays targeting nitrogen- and carbon-cycling microbes, the optimization of DNA, RNA and protein sampling instrumentation with OTEG molecular biologists and engineers, and testing of hardware for long-term deployments (Stage 1). In Stage 2, there will be a proof-of-concept testing of the optimised molecular analytical planktonic sampler (MAPS) technology in the field, along the Atlantic Meridional Transect, on which MAPS sampling will be compared with conventional methods of sampling to address two major research questions:

*1) What drives the distributions and activities of $N_2$-fixing ecotypes?*

Field-testing will determine the environmental context of distributions and activities surrounding blooms, with unprecedented resolution, for further testing by experimentation. *2) Is the dependent ecosystem the same for each ecotype?*

The same sample set will reveal networked metabolic pathways in the ecosystem based on $N_2$ fixation, by measuring the activities of fixed-N-dependent physiologies within the metatranscriptome. The timing of peak activities of $N_2$ fixation relative to peak activities of dependent organisms will be repeatable and predictable day after day.

**Training:**

The NEXUSS CDT provides state-of-the-art, highly experiential training in the application and development of cutting-edge Smart and Autonomous Observing Systems for the environmental sciences, alongside comprehensive personal and professional development. There will be extensive opportunities for students to expand their multi-disciplinary outlook through interactions with a wide network of academic, research and industrial / government / policy partners. The student will be registered at the University of Southampton and hosted at the National Oceanography Centre, Southampton. Specific training will include:

Knowledge of mechanical, fluidic and optical platform engineering and optimization will result from instrumentation optimization and application in the student's role as part of an experienced and highly skilled engineering team. The PhD student will be trained in gathering and analysing metagenomic and metatranscriptomic sequence data, designing molecular probes, and optimising and implementing nucleic acid detection methodologies using the Environmental Genomics Facility and Class II Molecular Biological Laboratory at NOCS. The teamwork skills involved to achieve advanced engineering goals will be attractive to future employers. Personnel trained in this breadth of techniques are uncommon and therefore sought after by a variety of scientific fields (biotechnology, medicine, engineering and oceanography).

**Eligibility & Funding Details:**

**Minimum Academic Eligibility Criteria:**

BSc/MSci 2:1

and/or Masters (MSc or MRes) at Merit/Distinction level (>60%).

and/or evidence of significant relevant professional experience equivalent to Masters level.

**Funding:**

Each NEXUSS CDT project comes with a fully funded studentship for UK students and EU students who meet the RCUK eligibility criteria.

To be eligible for a full award (stipend and fees):

A student must have:

Settled status in the UK, meaning they have no restrictions on how long they can stay

and

Been 'ordinarily resident' in the UK for 3 years prior to the start of the grant. This means they must have been normally residing in the UK (apart from temporary or occasional absences)

and

Not been residing in the UK wholly or mainly for the purpose of full-time education. (This does not apply to UK or EU nationals)

**Applying:**

Potential PhD students are requested to apply using the University of Southampton postgraduate application form.

For information on the application process and documents required please click here then return back to this page to apply.

To apply for this project click Apply to NEXUSS CDT.

You are encouraged to contact potential supervisors by email to discuss project-specific aspects of the proposed research at an early stage. General enquiries should be directed to the NEXUSS Team using the contact form link below.

nexuss@soton.ac.uk

## Background Reading:

1. Shilova, I. N. *et al.* A microarray for assessing transcription from pelagic marine microbial taxa. *The ISME journal* **8**, 1476-1491 (2014).
2. Zehr, J. P., Robidart, J. C. & Scholin, C. A. Marine microoganisms, biogeochemical cycles, and global climate change. *Microbe Magazine*, 169-175 (2011).