Project Highlights:
- Climate change meets microbiology
- Unique opportunity to study environmentally relevant enzymes
- World-leading supervisory team in marine microbiology

Overview:
Phosphorus (P) is an essential element for all life. In marine ecosystems the availability of P plays a critical role in controlling primary production, which has major implications for global C cycling and the abundance of organisms throughout the food chain (1, 2). In several oceanic regions e.g. the North Atlantic Ocean and Mediterranean Sea, P levels are vanishingly low. In these regions organisms have adapted to chronic P limitation by reducing their cell and genome size (3, 4) but also by developing specific biochemical responses. These include the ability to acquire P from alternative sources e.g. organic phosphates (5) or to replace phospholipids with other non P containing lipids (6). The latter response, phospholipid remodelling does not occur in all organisms. Hence, cell lysis resulting from viral infection or sloppy grazing can also produce membrane fragments containing phospholipids (6). Very recently it has been shown that marine bacteria can also release lipid vesicles directly into the environment, perhaps to prevent phage attack by acting as decoys (7).

However, enzymes responsible for the degradation of the released lipids are not known. Similarly, key phosphatases involved in phospholipid recycling and organic phosphate cleavage remain to be characterised, both in phototrophic cyanobacteria (key primary producers) and heterotrophic bacteria (key nutrient recyclers).

Figure 1: Oligotrophic regions low in P proliferate across the world oceans in which Synechococcus cyanobacteria dominate marine primary production. This project will identify and characterise key enzymes missing in the marine P cycle and determine their metal ion requirements.

AIMS and METHODOLOGY:
The major aim of this PhD project is thus to biochemically characterise key enzymes involved in P recycling – organic P phosphatases, lipid phosphatases and extracellular phospholipases – and determine the metal dependency of these proteins. We will focus on enzymes in key phototrophic (Synechococcus, cyanobacteria) and heterotrophic (Roseobacter) groups so as to target both bacterial producers and consumers. This exciting project should not only identify key missing links in the marine P cycle but is also likely to identify key trace metals (e.g. zinc or iron [8]) that are required for enzyme function and that might co-limit primary production or recycling. We will use bioinformatic approaches to identify target enzymes and protein over-expression and subsequent structural analysis (NMR, ICP-OES) to define biochemical properties of specific enzymes. Once metal-dependency of specific enzymes is known, transcriptomics will be performed to assess the
regulation of the genes encoding these enzymes and identify any co-regulated networks.

Training and skills: This project will provide excellent training in marine microbiology, biochemistry and molecular biology using cutting edge biochemical and ‘omic approaches, in the context of a major biogeochemical cycle: the marine P cycle.

CENTA students will attend 45 days training throughout their PhD including a 10 day placement. In the first year, students will be trained as a single cohort on environmental science, research methods and core skills. Throughout the PhD, training will progress from core skills sets to master classes specific to the student's projects and themes.

Partners and collaboration (including CASE):

Prof Scanlan has >20 years expertise working with marine cyanobacteria from ecology to genomics, and especially defining nutrient acquisition mechanisms and the role of P in limiting marine production. The student will be assisted by the wide array of scientific expertise already available in the very active Scanlan research lab. In addition the project will greatly benefit from having Dr Yin Chen, a marine microbiologist with extensive molecular and biochemical expertise working with novel enzymes produced by bacterial heterotrophs, and Dr Claudia Blindauer, an inorganic chemist with specific expertise in the structure and function of metal-binding proteins, as co-supervisors on the project.

Possible timeline:

Years 1 and 2: Bioinformatic identification and biochemical characterisation of organic P phosphatases, extracellular phospholipases and intracellular lipid phosphatases. Years 2 and 3: Structural characterisation of specific enzymes, especially those shown to require a specific metal ion for activity, and subsequent transcriptomic analysis to understand mechanisms of regulation.

Further reading:


(2) Scanlan, DJ and Wilson, WH (1999) Hydrobiologia 401: 149-175


Further details: APPLICANTS should possess a BSc or MSc in Microbiology/Biochemistry with a particular interest in analytical and molecular techniques. Informal enquiries can be made to Prof Dave Scanlan (d.j.scanlan@warwick.ac.uk). Further details of research in the supervisors labs can be obtained from http://www2.warwick.ac.uk/fac/sci/lifesci/people/dscanlan/, http://www2.warwick.ac.uk/fac/sci/lifesci/people/ychen/ and http://www2.warwick.ac.uk/fac/sci/chemistry/research/blindauer/blindauergroup.