Publishable Summary Report for Marie Sklodowska-Curie Career Integration Grant (CIG)

Project: DISCOSAT project (PCIG12-GA-2012-333143), October 2013 - October 2017

Researcher: Simon Ussher (University of Plymouth, UK)

1. Introduction

Phytoplankton are microscopic algae that are the main contributors to photosynthesis in the sunlit ocean layer, which covers an area of about 71% of the Earth's surface. Certain dissolved metals (e.g. iron, manganese, cobalt, lead) play important roles either as vital nutrients sustaining phytoplankton growth or by reducing growth when these elements exceed toxic concentrations. One of the ways that these '*trace'* metals enter the ocean ecosystem is via natural and man-made atmospheric particles (aerosols) that settle into the ocean surface, the zone most populated by marine plants and organisms.

DISCOSAT (Determining the Impact of Seawater Chemistry On the Solubility of Atmospheric Trace metals) aimed to discover if global changes to the physics and chemistry of surface seawater (e.g. via increasing temperature, ocean acidification, dissolved gases) will affect the quantity of trace elements that dissolve from the aerosols. This was an important undertaking as major changes of this kind could lead to ecosystem changes in vast regions of the ocean, favouring the survival of certain marine plants and animals.

2. The work carried out to achieve the project's objectives

The work of the CIG Fellow (Dr Simon Ussher) has focussed on intensive sampling of atmospheric aerosols over a period of 4 years (Objective 1). This was conducted at sampling sites around the North Atlantic Ocean (Bermuda, Ireland and South West England). The UK site is a new site, where long-term aerosol sampling was started by the fellow, as a result of this project. These atmospheric sites receive winds containing atmospheric particles, representative of those falling into the ocean. This has allowed a comparison of the trace metal concentrations of aerosols and their solubility, in the east and west regions of the North Atlantic Ocean (Objective 2).

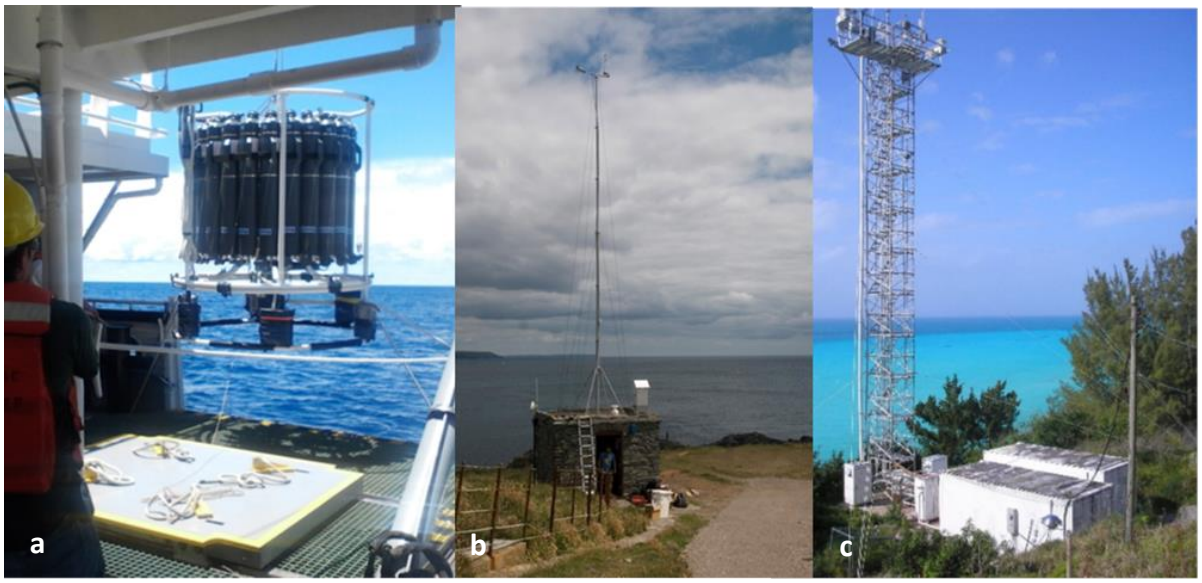

Figure 1. DISCOSAT Sampling Sites (a) Sargasso Sea seawater (b) Penlee Point Atmospheric Observatory (UK) and (c) Tudor Hill Atmospheric Observatory (Bermuda)

Once the aerosol and North Atlantic surface seawater samples were analysed, they were mixed together under controlled condition to allow the Researcher to conduct 1-month simulation experiments to observe how the trace metals dissolved, depending on the conditions of the seawater (Objectives 3-5).

The project involved training in state-of-the-art sampling, processing and analytical techniques. Highlights included the development and use of mass spectrometry techniques that allow the separation of trace metals from seawater leaches prior to analysis and allow very sensitive detection of concentrations down to parts per trillion concentrations (i.e. 1 g in 1,000,000 tonnes of seawater).

3. Overview of results, conclusions

The results have shown that for all elements (Fe, Mn, Pb, Cu, Co), the impacts of changing conditions should not be a major risk to the ecology of the ocean. Regardless of the pH, oxygen and temperature extremes, the dissolving time of the metals in seawaters was generally low (i.e. less than 10 minutes) and no significant changes to the quantities of the metals dissolving have been observed that would affect marine phytoplankton. However, the work did reveal that major changes are evident depending on: whether the aerosols are man-made (e.g. soot, ash) or natural (e.g. fine weathered dust), the global weather patterns (e.g. wind directions, pressure systems) and whether there are metal binding organic molecules (ligands) in the ocean that stabilise the dissolved metals in seawater.

4. Overview of research and socio-economic impacts of the project

The Fellow, Dr Ussher, has benefitted from the project by establishing his air-sea biogeochemistry research agenda at the University of Plymouth within the Biogeochemistry Research Centre (BGC) and inheriting clean room laboratory space as well as continuation and establishing of collaborative links with the Bermuda Institute of Ocean Sciences and Plymouth Marine Laboratory. The project resulted in the direct training of 3 PhD students (UK and EC funded), attendance of the fellow and students at 8 scientific conferences/meetings and facilitated visits to Bermuda, Ireland and local sampling sites for fieldwork. Major scientific papers on the topic of marine trace elements have already been published.

The target groups that could benefit from the results from this project include global climate/ecosystem modellers and marine policy makers; including the International Maritime Organisation regulation of ship emissions and the Marine Strategy Framework Directive requirements to achieve Good Environmental Status in the oceans. Individual government environmental departments with concern over the impacts of air quality and emissions would also benefit from the knowledge obtained from the project. In particular, data from the long-term monitoring at Penlee Point started during this project will be of benefit to the UK's Department of Environment, Food and Rural Affairs who maintain air monitoring sites and data around the country.

Relevant contact details

Dr. Simon Ussher (Associate Professor of Marine and Analytical Chemistry)

School of Geography, Earth and Environmental Sciences, Portland Square, University of Plymouth

Plymouth PL4 8AA t: + 44 (0) 1752 584578 e: sussher@plymouth.ac.uk