Climate change and harmful algal growth using laboratory experiments, satellite remote sensing and biogeochemical modelling

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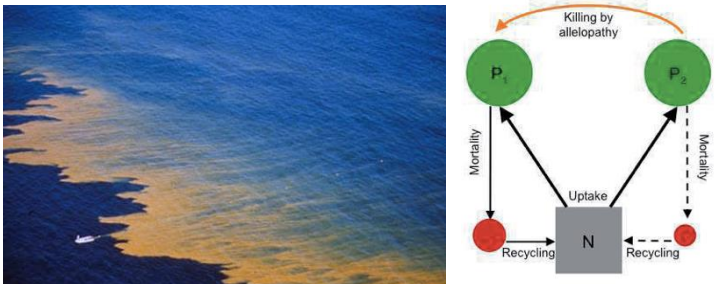
Marine harmful algae cause huge economic and ecological damage through the production of toxins and removal of oxygen from marine waters, affecting the marine wildlife and commercial aquaculture. Current models for prediction of harmful algal population dynamics are not sufficient due to lack of data on species-level interaction and their physiological responses to changing environment, but bloom prediction is particularly important with climate change. Species-interaction models suggest that allelochemical or toxin producing algae are important for the diversity of the primary producers and grazers, and for regulating the dynamics of lower-trophic interaction [1-2, see Fig below]. But the representation of certain keystone harmful algae species, such as those that produce toxin or allelochemicals are not explicit within the advanced ocean biogeochemical models. So, it is essential that the dynamics of these species are included in the biogeochemical models, and the wider impact of toxin production is explored across marine ecosystems [3-4]. This interdisciplinary project between the UoR, Cefas and the Marine Biological Association (MBA) aims to improve understanding of marine harmful algal dynamics by (1) using historic and current plankton data, (2) employing laboratory culture, toxin and DNA analysis and (3) mathematical modelling.



Left panel: Illustration of a harmful algal bloom scenario, which alters the colour of ocean and damages the ecosystem. Right panel: Inter-species competition dynamics is mediated by chemicals released by harmful algae (Fig from [1]).

The student will

(1) perform controlled laboratory culture experiments with a list of key harmful algae species found in the UK waters, and determine their toxicity in different growth conditions (year 1)
(2) measure harmful algae patterns in the English Channel ecosystem regions around the UK using a 60-year archive of plankton samples and satellite remote sensing (year 1,2)
(3) build dynamic interaction models among harmful-bloom forming and non-harmful phytoplankton and calibrate the models based on data from laboratory experiments (year 2,3),
(4) advance an ocean biogeochemical model [5] by incorporating the calibrated species-interaction model components (year 3)

This project will be useful for coastal management of harmful algae, and impact the studies and management of marine economic resources e.g. fish, and help predicting water clarity and food safety.

Training opportunities:

The project is multidisciplinary, it involves laboratory experiments, ecological modelling, statistical methods, and biological oceanography. Training will be given on building mathematical models, parameter estimation, model simulation, as well as laboratory culture of algae, water chemistry, analysis of bio-toxin, DNA analysis. The student will benefit from in house training on remote sensing and ecological modelling from experts in Department of Geography and Environmental Science within UoR. The student will learn mathematical modelling and software packages for simulation and visualization of biogeochemical models; coding in python, FORTRAN and MATLAB. The student will further benefit from the multi-disciplinary training on molecular genetics at MBA and marine biotoxin analysis.

Student profile:

This project will be suitable for students with a degree in physics, mathematics or a closely related environmental or physical science. We will provide training on modelling and computer programming and laboratory experiments to motivated candidates as needed.

Funding particulars:

This project includes CASE co-sponsorship from Cefas.

References: (optional)

1. Roy (2015) Importance of allelopathy as peudo-mixotrophy for the dynamics and diversity of phytoplankton. In: Biodiversity in Ecosystems - Linking Structure and Function. INTECH, 17-28.
2. Felpeto, Roy & Vasconcelos (2018) Allelopathy prevents competitive exclusion and promotes phytoplankton biodiversity. Oikos, 127 (1), 85-98.
3. Stern et al., (2018) Molecular analyses of protists in long-term observation programmes—current status and future perspectives, Journal of Plankton Research 40 (5), 519-536.
4. Turner et al. (2019) Toxic algae silence physiological responses to multiple climate drivers in a tropical marine food chain. Frontiers in Physiology 10 (373), 1-11
5. Anugerahanti, Roy & Haines (2018) A perturbed biogeochemistry model ensemble evaluated against in situ and satellite observations, Biogeosciences, 15, 6685-6711.

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