MASTS Postdoctoral and Early Career Researcher Exchange (PECRE) Fellowship Final Report

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Enhancing the ecological outcomes of artificial coastal defences

Background

Globally, the majority of artificial coastal defences have not been optimised to achieve or facilitate ecological functions and the wider ecosystem services for society that they could provide. Yet, these are achievable goals that could benefit coastal ecosystems via designs that co-enhance coastal protection and local biodiversity. Results from my doctoral research have shown that it is possible to increase biodiversity on coastal structures using concrete tiles moulded with complex designs. However, it is still unknown whether these designs would have a similarly positive effect on seawalls and rock armour structures in temperate systems. In collaboration with Dr. Naylor, one of my experimental tile designs is now being trialled in Scotland, along with various other designs, as part of a larger (UK-wide) eco-engineering project. One of the aims of this fellowship was to participate in the field collection, monitoring and analysis of the settlement data on these tiles, to better understand and improve the scientific outcomes of my work on the ecological enhancement of seawalls. Another fundamental objective was to gain experience in advanced microscopy techniques (at the ISSAC facility) for analysing the biotic-rock/concrete interactions at the surface and near-subsurface to characterise, understand and determine whether biodeteriorative processes are operating on the experimental tiles used in Singapore. Understanding the surface features as well as the geochemistry of different substrates is critical for future ecological engineering projects as they can regulate and facilitate colonisation by bacteria and other marine organisms. This PECRE fellowship has not only enabled me to learn and perform these techniques, but more crucially do so in an institution with a strong research background in geographical and earth sciences. Having the geological/bio-geomorphological perspective is important, not only as it is an area that is often overlooked in current seawall research, but also for improving our understanding of bioprotection and biodeteriotation effects of organisms. Such information, which can be used for improving asset resilience to weather-related deterioration, is also desired by industry for widespread application.

Interactions with the MASTS community

During this fellowship, I was an active member of the research community at the School of Geographical and Earth Sciences, and the Imaging Spectroscopy And Analysis Centre (ISAAC) at the University of Glasgow. I interacted with faculty, graduate students, and other fellows, and gave a departmental seminar (ERSG seminar series) as well as participated in a 45-minute pre-seminar Athena Swan coffee session. I also gave seminars at the Scottish Association for Marine Science (SAMS), hosted by Prof. Michael Burrows, and at the Scottish Oceans Institute, University of St Andrews, hosted by Prof. David Paterson. The talk I gave at the University of St Andrews was also webcasted so that other members of the MASTS community could view it. Towards the end of my month-long exchange, I also attended the 6th MASTS Annual Science Meeting (ASM) at the Technology & Innovation Centre in

Glasgow, and gave an oral presentation in the general science session. Partaking the MASTS conference helped me to connect with the MASTS community and gain a broader and deeper understanding of marine science research in Scotland.

Completed and expected outputs

Laboratory work — To analyse my concrete samples from Singapore, I was trained and supported by micro-analyst Peter Chung at the ISAAC facility to perform several analytical techniques including: Scanning Electron Microscopy (SEM), 3D-SEM, Electron Backscatter Diffraction (EBSD) and Energy-dispersive X-ray spectroscopy (EDS) mapping and point analysis. These skills (including the numerous ways of sample preparation) allowed me to characterise (at the micron-scale) the morphology, mineralogical composition, and chemistry of inorganic and organic materials of my samples—an approach that has never been undertaken in tropical seawall research. Data acquired revealed several unexpected and interesting features that were unique to a tropical context and inspired the development of new research ideas. Results of these analyses are expected to lead to a publication. As mentioned earlier, these insights would not have been possible without the geomorphological expertise provided by Dr Larissa Naylor and the ISAAC facility at the host institution.

Fieldwork — The PECRE fellowship also enabled me to visit two field sites in Scotland where my tile designs had been deployed: Blackness (Blackness Bay, Firth of Forth) and Saltcoats (west coast of North Ayrshire, Firth of Clyde). In addition to the data collection and monitoring work conducted on these fieldtrips, first-hand field observations also enabled deeper discussions about the potential similarities and differences between tiles deployed in the UK and those in Singapore. I also helped Dr. Naylor's PhD student, Mairi MacArthur, with analysing these preliminary data, which she shared at the MASTS conference.

Added value — While I was at the ISAAC facility I assisted Dr. Naylor with the analysis of several concrete samples prepared in resin blocks under the SEM to gather more evidence of the potential bioprotective role played by barnacles on fine-scale weathering processes leading to concrete deterioration. I used previously established methods for quantifying features of deterioration in samples with varying levels of barnacle bioprotection. This will contribute towards a manuscript she is currently preparing on the bioprotective role of barnacle colonisation against mechanical weathering processes on temperate coastal defences, enabling me to gain a second publication from my MASTS PECRE fellowship work.

Future plans enabled by PECRE

Seawall research is set to continue in Singapore. I am an integral part of a 2 million pound, 4.5-year, project to increase biodiversity on tropical seawalls led by Dr. Peter Todd at the National University of Singapore. The project will examine why seawalls support low biodiversity, how can existing seawalls be manipulated to enhance biodiversity and how new seawalls can be designed to support high levels of native biodiversity. As the majority of this research will be conducted locally in Singapore, i.e. in an equatorial low water energy environment, there is great potential to conduct comparative experiments in Scotland (a temperate high water energy environment) to identify the generality of results and test the global applicability of our solutions. I plan to continue collaborations with Scottish coastal and marine scientists through the networks I have established during my exchange, and that the insights and findings gained will lead to sustained interactions and future grant proposals.

Award size and expenditures

Total award: £3950 (plus £325 due to currency fluctuations that occurred between incurring my expenses and being reimbursed).