MASTS Coastal Zone Forum Grant – Final Report

Clara Mackenzie, Heriot-Watt University

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Grant received in support of PhD Project:

Vulnerability of *Modiolus modiolus* reefs to climate change: from mechanisms to management strategies

Project overview:

The project aims to investigate the roles that environment and genetics play in shaping population responses to environmental stress tolerance in the horse mussel, *Modiolus modiolus*, so as to contribute to management of the species under current and future climate conditions. *M. modiolus* and associated biogenic-reef structures are currently threatened in all OSPAR regions and are prominent in a wide range of statutory and policy drivers including the Habitats Directive and the Marine Strategy Framework Directive. Scientific based investigations into the genetic connectivity, stress response, plasticity and adaptation (i.e. cumulatively, the vulnerability) of populations across their range will support development of a robust evidence base to inform ecosystem-based management and marine spatial planning.

Links to MASTS Coastal Zone Forum aims:

This project is strongly aligned with the MASTS Coastal Zone Forum's aim of addressing management needs for the coastal zone. The project recognises the critical need for linking current marine research and management objectives for priority habitats such as *M. modiolus* reefs. With this in mind, the project aims to provide a sound evidence base to inform management decisions for *M. modiolus* biogenic reef sites, particularly under the context of climate change. Key outputs for the project include management tools such as a vulnerability index and improved environmental envelope model for the species. Additionally, knowledge accumulated over the project may advise the design and implementation of MPAs. In supporting this project, MASTS will enable the development of vital management strategies, and thus contribute to the future survival of this ecologically valuable habitat.

Summary of work funded by grant:

The MASTS Coastal Zone Forum Student Grant funding application was made to support the following project objective:

- characterise the stress response (expressed as DNA, lipid and protein damage; antioxidant production; gene expression of antioxidants and heat shock proteins; and energetic shifts) of *M. modiolus* populations to abiotic changes under controlled conditions (including warming and/or hypoxia) in the laboratory.

Funds were obtained to support experimental work as part of an investigation of population-based sensitivities to climate change in the horse mussel, *Modiolus modiolus*. A range of lab consumables were purchased for measuring oxidative stress response in *M. modiolus* populations from northern and southern locations of the species' range under conditions of warming and/or hypoxia. Purchased items included biomarker kits for measuring oxidative damage (e.g. protein carbonylation) and antioxidants (e.g. catalase and superoxide dismutase (SOD)). Additionally, lab consumables were purchased for carrying out gene expression work (e.g. RNA extraction for examination of HSPs).

Animals from Orkney and Wales were held in warming conditions (10°C, 14°C, 18°C) for 28 days in a purpose built flow-through aquarium system (Figure 1). For the final week of the trial, 50% of animals within each temperature treatment were placed under hypoxic conditions (2 mg O_2 L^{-1}). Following exposure, gill tissues were dissected from all animals, flash frozen in liquid nitrogen and stored at -70°C until processing. Oxidative stress biomarker kits were then used to determine levels of protein carbonyl, SOD and catalase (Figure 2). Additionally, RNA

samples were extracted from tissues and frozen for future examination of gene expression under climate change conditions.

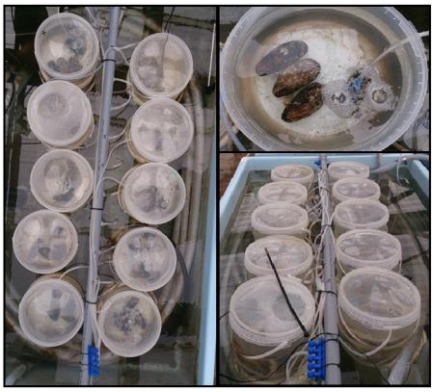

Figure 1. Experimental set-up for warming and hypoxia experiments. Image shows one temperature treatment consisting of 10 tanks receiving continuous supply of fresh seawater (at experimental temperature). Half of tanks received hypoxic water for final week of 28-day exposure.

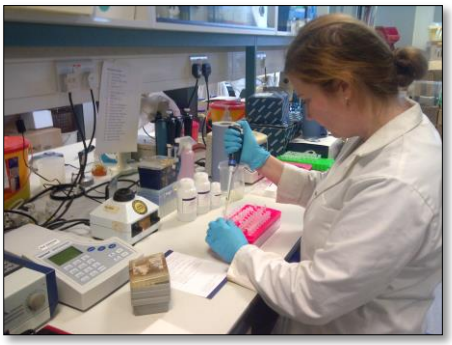

Figure 2. Oxidative stress was quantified via laboratory-based determination of oxidative damage and antioxidant production.

Preliminary results:

Results to date suggest that populations have varying abilities to mount responses to climate stressor conditions. Wales and Orkney populations showed distinct differences in their responses to warming and hypoxic conditions. For example, warming caused increases in both oxidative damage and production of antioxidants in the Wales populations with little additional effect of hypoxia. Conversely, temperature had little effect on oxidative damage in the Orkney population and under hypoxic conditions oxidative damage actually decreased as compared to baseline level. Results also suggest that other aspects of biology/physiology/ecology may need to be considered. This work is currently being written up for publication.

Future work:

Future work will look at other UK populations' responses to climate change stress so as to aid in identifying those populations that may be most vulnerable or resilient to climate change impacts. Additionally, investigation will have greater focus on changes in gene expression. Such information may contribute to marine spatial planning efforts and management requirements for this priority habitat (e.g. aid in determining most suitable MPAs). Results from this work will also be combined with parallel investigation of impacts to DNA (via Comet assay) and energy budgets (e.g. cellular energy allocation) to move towards a holistic understanding of the mechanisms behind responses to climate change stress. Additionally, results will be considered alongside population genetics information for the same populations so as to determine the role of genetic diversity and connectivity to vulnerability.