MASTS Small Grants (2015 Round)

Investigation into the effects of hypoxia on oxidative stress response in the horse mussel, *Modiolus modiolus* (Final Report)

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Grant received in support of PhD Project:
Vulnerability of *Modiolus modiolus* reefs to climate change: from mechanisms to management

Project overview:
Increases in temperature alter the physical, chemical and biological characteristics of seawater. Of particular concern is the reduction of seawater oxygen concentrations that occur due to the fact that oxygen becomes less soluble with increasing temperature (Keeling & Garcia, 2002). There is evidence that oxygen concentrations in the thermoclines of most ocean basins have decreased since the 1970s, likely driven by reduced rates of water renewal (Bindoff et al., 2007). Moreover, current climate change projections to the end of this century predict a four to seven percent decline in dissolved oxygen in the oceans (Matear et al., 2007). The number of coastal sites where hypoxia has been reported has increased substantially over the past 25 years and future increases are expected in response to the combined effected of coastal eutrophication and global warming (Vaquer-Sunyer & Duarte, 2008).

This PhD project aimed to characterise the stress response of *M. modiolus* (horse mussel) to climate change stressors including temperature and hypoxia, and at both species and population levels. This application was made in support of hypoxia experimental work. Examination of the effects of hypoxia will further contribute to determining the potential vulnerability of horse mussels to climate change, and will key to informing management objectives for this priority marine habitat.

Relevance to MASTS:
Project work was carried out at two MASTS partner institutes: Heriot-Watt University and St. Abbs Marine Station. Equipment purchased for the work will contribute to the development of St Abbs Marine Station facility and is available to other projects. The project is aligned with the MASTS research theme: *Biodiversity, Function and Services* (particularly the theme's central aspect of *"resilience of marine organisms"*) and the Scottish Government's Strategic Research Theme (2011-2016), *Environmental Change (Local Responses to Global Change), Theme 1 - Scotland's environmental assets, biodiversity and ecosystem services are identified and valued to inform decision making*. It is also contributes to MASTS goals: "to enhance scientific excellence in marine research through communication, collaboration and co-ordination within the Scottish marine research community", "to support a healthier environment as a result of better informed policies to manage human activity based on the best available scientific knowledge (BASK)", and "to provide experience and training to the next generation of marine researchers and opinion makers through the MASTS graduate school and related bespoke events".

Summary of work funded by grant:

The aims of the work supported by this grant were:
1. To examine hypoxia tolerance levels in the horse mussel;
2. To examine the effects of hypoxia on oxidative stress response in the horse mussel;
3. To determine population-based differences in responses to hypoxia

Funds provided by MASTS contributed toward the build of a hypoxia flow-through aquarium system at St. Abbs Marine Station specifically via purchase of a dissolved oxygen probe, mixing tanks and pumps.

Results:

Due to time constraints, the experimental schedule for this work was limited and only preliminary testing was able to be carried out. A prototype hypoxia aquarium system was constructed but needs further testing before it is suitable for robust experimental investigation. However, preliminary investigation of hypoxic limits across several *M. modiolus* populations suggests that hypoxic limits may vary, potentially due to varying historic conditions (e.g. loch-based populations vs current swept populations). Further, results also show that hypoxic conditions may lead to oxidative stress in *M. modiolus* but further investigation is needed. Nonetheless, these preliminary results highlight the importance of considering multi-stressor conditions particularly in coastal populations where coinciding changes in temperature and oxygen content (as well as other physical conditions) are predicted under future climate change conditions.

Future work:

Future work aims to continue examination of the impact of multi-stressor conditions to *M. modiolus* including the impact of longer-term exposure to coinciding warming and hypoxia conditions.

Outputs arising from work:

This work contributed to successful PhD completion and defence by the applicant (Mackenzie, 2017). The applicant also plans to submit an article regarding the impacts of climate change to oxidative stress in *M. modiolus* (which results from this work may contribute towards) for publication in a peer-reviewed journal.

References:

Bindoff, N.L., Willebrand, J., Artale, V., Cazenave, A. *et al.* (2007) Observations: Oceanic Climate Change and Sea Level. In: *Climate Change 2007: The Physical Science Basis. Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change* [Solomon, S., D. Qin, M. Manning, Z. Chen, M. Marquis, K.B. Averyt, M. Tignor and H.L. Miller (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA.

Keeling, R.F. & Garcia, H.E. (2002) The change in oceanic O_2 inventory associated with recent global warming. *PNAS* **99**, 7848-7853.

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Vaquer-Sunyer, R. & Duarte, C.M. (2008) Thresholds of hypoxia for marine biodiversity. *PNAS* **105**, 15452-15457.