MASTS Coastal Zone Forum Grant – Final Report

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Genetic connectivity of *Modiolus modiolus* biogenic reefs: The Role of Marine Protected Areas

Background:

Biogenic reef structures such as those formed by *Modiolus modiolus* are species rich benthic habitats of high nature conservation importance and also of high functional and societal benefit. Such reef structures are features of Marine Protected Areas and are priorities for further conservation measures. Biogenic structures are prominent in a wide range of statutory and policy drivers including OSPAR, the Habitats and Species Directive and the Marine Strategy Framework Directive. In order to fulfil the high priorities set by the drivers, a robust evidence base regarding the ecological requirements and constraints for *M. modiolus* habitats is required. Additionally, the medium to long term value of spatial management measures for these habitats is not currently well understood in the context of changing environmental conditions.

Project overview:

Recent development of microsatellite markers by Heriot-Watt University has enabled researchers to determine genetic connectivity and diversity of *M. modiolus* populations across the species' distribution including the southern limit of the range (Wales) as far north as Orkney and including Isle of Man, Northern Ireland, and western Scotland populations. Such information will be instrumental in advising management of *M. modiolus* particularly in light of recent marine spatial planning developments and is also of further value for conservation and restoration of these habitats.

Marine Protected Areas (MPAs) for Scotland were recently announced and include a number of Shetland sites where well-documented *M. modiolus* sites are located. It is of management interest to determine the role that the Shetland MPA sites might play in the larger UK network and in potentially connecting UK *M. modiolus* populations to mainland Europe populations (e.g. Norway). Such information would strengthen the evidence for the benefits of MPAs to the wider marine environment. With this in mind, the main of objective of this work was to determine genetic connectivity and diversity (via microsatellite screening) of a *Modiolus modiolus* biogenic reef situated within a designated conservation area (Shetland MPA) including determining the role of the site in context of network of *M. modiolus* reefs across UK and Europe (Norway site). Genetic analyses of the sites will provide useful baseline data for the site so that in future we might determine how the protection of marine areas might influence the future genetic diversity of a site against the backdrop of climatic change impacts.

Links to MASTS Biodiversity Forum aims:

This work is strongly aligned with the MASTS theme: Marine Biodiversity, Function and Services aim to link "diversity, distribution in space and time, and resilience of marine organisms". Research will provide key information regarding how these "hotspots of biodiversity" are connected across the marine landscape, and will be critical in determining the value of Marine Protected Areas to conservation efforts. Furthermore, it will provide important information regarding the adaptive ability (via analyses of genetic diversity) of *M.*

modiolus under climate changed induced stress conditions such as ocean warming and hypoxia.

Results and future work:

Results suggest moderate levels of genetic connectivity between three sites analysed from Shetland, including one inside the Haskosay Sound Marine Protected Area, compared with other populations with comparable levels of genetic diversity across all UK sites. Unfortunately, we were unable to analyse the samples from Norway at this time but samples are available and this work is prioritised for the near future. Results from this work will complement recent PhD work regarding *M. modiolus*' vulnerability under climate change conditions (Mackenzie, 2017) and may also aid in informing restoration efforts for *M. modiolus* sites via identification of "genetically compatible" sources of individuals for transplantation to previously damaged sites.

Future work will continue to examine the genetic connectivity and diversity of additional *M. modiolus* reef sites across the European and pan-Atlantic range (including populations in Norway, the Faroes, Iceland and Atlantic Canada) of the species to improve understanding of the nature of the *M. modiolus* network. Results will also feed into larval dispersal modelling for Scottish *M. modiolus* populations, currently in progress, and thus contribute to a greater understanding of the role of MPA sites in acting as larval sink or source populations. Also, results may complement any genomic investigation in the species ability to use genetic mechanisms (e.g. upregulation of heat shock proteins) to mount a response, which cumulatively would be a valuable contribution to current understanding of the species' (or specific populations') sensitivity to climate change conditions.

Output:

Research paper to be submitted by December 2017:

Management implications of modelled larval dispersal and measured gene flow in *Modiolus modiolus* beds across UK populations, including Marine Protected Areas.
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Target journal PlosOne