Institution: Heriot-Watt University

Unit of Assessment: 7: Earth Systems and Environmental Sciences

Title of case study: Sustainable marine management implementation

1. Summary of the impact (indicative maximum 100 words)

Based on biogenic reef research at Heriot-Watt University (HWU), nine Marine Protected Areas (MPAs) have been designated and established in the Northeast Atlantic, Caribbean and Eastern Pacific, and a further six are under consideration. These MPAs represent 10% of the Caribbean Sea area, 6% of the UK's inshore Special Areas of Conservation (SAC) and 18% of the MPAs under consideration in Scotland. In addition, our ecological assessments of the biodiversity value and structure of biogenic habitats, and their sensitivities to widespread stressors, stakeholder conflict assessment and economic assessments have underpinned the objectives, management measures and assessment of MPAs, and other marine spatial planning initiatives, undertaken in the context of both the current marine environmental conditions and future climate change trajectories.

2. Underpinning research (indicative maximum 500 words)

For over 20 years, marine scientists at HWU's have been continuously discovering biogenic reefs formed by molluscs, polychaetes and corals whilst researching the distribution, biodiversity value and function of them (e.g. Moore *et al.,* 1998 [5]; **Roberts** *et al*. 2009 [6]). These habitat types have increasingly become the focus of protective spatial management measures as their biodiversity value has become better appreciated.

North Atlantic Research

HWU researchers have investigated reproductive biology, associated biodiversity and rates of reef regeneration by the flame shell *Limaria hians*. Similar work has been conducted by **Lyndon** and **Mair** with other colleagues on the horse mussel *Modiolus modiolus* and the fan worm *Serpula vermicularis* supported by Scottish Government funded projects totalling £312k. **Sanderson** joined HWU in 2010 when he developed this work further with **Mair** and **Porter** and other colleagues at HWU supported by a further three Scottish Government funded research projects totalling £163k. Reefs formed by flame shells (*Limaria hians*) and fan-worms (*Serpula vermicularis*) have been mapped during aforementioned projects, including the world's largest known flame shell bed. Horse mussel reef research dates back to annual environmental monitoring studies conducted in the late 1970s and 1980s by **Mair** and **Lyndon** investigating density, biodiversity and population structure whilst further projects have investigated biological health.

Caribbean and Eastern Pacific Research

With support from a £120k Defra Darwin Initiative project, **Mair** mapped habitats of conservation importance in the Colombian Caribbean (Mitchell *et al.* 2001 [4]). This was the first international research collaboration the Colombian government agency, Coralina, had undertaken. Subsequently, **Side** undertook research with EU INCO-DC (International Cooperation with Developing Countries) Framework support (£300k) in collaboration with Coralina and the Charles Darwin Research Foundation in the Galapagos Islands. The research by **Kerr** and **Side** integrated fisheries stock assessment, stakeholder conflict analysis and socio-economic assessments to underpin MPA designation (Seaflower biosphere reserve) and management in both Seaflower and Galapagos (Davos *et al*. 2007 [2]). **Mair** collaborated with researchers in the Smithsonian Tropical Research Institute and Darwin Initiative support (£220k) to map habitats and evaluate patterns of biodiversity in Las Perlas Archipelago including reef forming Sabellariidae (**Mair** *et al.* 2009 [3]).

Pressures on biogenic habitats

Biological impact studies on biogenic reefs (*Limaria*, *Serpula, Lophelia* & *Modiolus* spp.) showing the sensitivity of biogenic habitats to anthropogenic stressors have been developed in close collaboration with government agencies leading to impact before publication (e.g. Cook *et al*., 2013 [1]). Based on this understanding of impact, **Sanderson**, **Mair** and **Porter** with other HWU staff have ongoing research interests in indicators of Good Environmental Status (JNCC funded research project; £50k) and restorative potential though Esmee Fairbairn Foundation funding

(£89k). Research by **Porter** and **Sanderson** has used habitat modelling under IPCC scenarios to show the potential for the biogeographic range of protected habitats to change their distribution in relation to international MPA networks. Similarly, **Roberts** is leading work on calcifying biogenic habitats for the UK Ocean Acidification programme sponsored by NERC, Department of Environment and Climate Change, Defra and LWEC.

3. References to the research (indicative maximum of six references)

The references identified with * are the ones which best indicate the quality of the underpinning research.

[1] Cook, R. L., Fariñas-Franco, J., Gell, F., Holt, R., Holt, T., Lindenbaum, C., **Porter, J.S.,** Seed, R., Skates, L., Stringell, T. & **Sanderson, W.G.** 2013. The substantial first impact of bottom fishing on rare biodiversity hotspots: a dilemma for evidence-based conservation. PLoS ONE 8(8): e69904. doi:10.1371/journal.pone.0069904

[2]* Davos, C., Siavakara, K., Santorineou, A., **Side, J.,** Taylor, M., & Barriga, P. 2007. Zoning of marine protected areas: Conflicts and co-operation in the Galapagos and San Andres archipelagos. Ocean & Coastal Management 50 (3-4) 223-252. doi:10.1016/j.ocecoaman.2006.03.005

[3] **Mair, J.M.,** Sibaja-Cordero, J.A., Arroyo, M.F., Merino, D., Vargas, R., Guzman, H.M., & Benfield, S., 2009. Mapping benthic faunal communities in the shallow and deep sediments of Las Perlas Archipelago, Pacific Panama. Marine Pollution Bulletin, 58, 375-383. doi: 10.1016/j.marpolbul.2008.10.015

[4] Mitchell, A., Garcia, M., Mow-Robinson, J.M., Karpouzlie, E. & **Mair, J.** 2001. Marine mapping techniques using remotely sensing data in the archipelago of San Andrés, Providence and Santa Catalina (Colombia). Proceedings of the IX Latinamerican Congress on Marine Science (COLACMAR), San Andres, Colombia, September 17-29, 4 pages.

[5]* Moore C.G., Saunders G.R. & Harries D.B. 1998. The status and ecology of reefs of *Serpula vermicularis* L (Polychaeta: Serpulidae) in Scotland. Aquatic Conservation V8 pp645-656. DOI: 10.1002/(SICI)1099-0755(199809/10)8:5<645::AID-AQC295>3.0.CO;2-G

[6]* **Roberts, J.M.,** Davies, A.J., Henry, L-A., Duineveld, G.C.A., Lavaleye, M.S.S., Dodds, L.A., Maier, C., van Soest, R.W.M., Bergman, M.I.N., Huhnerbach, V., Huvenne, V., Sinclair, D., Watmough, T., Long, D., Green, S., van Haren, H. 2009. Mingulay reef complex: an interdisciplinary study of cold-water coral habitat, and biodiversity. Marine Ecology Progress Series 397: 139-151. DOI:10.3354/meps08112

4. Details of the impact (indicative maximum 750 words)

The UN Convention on Biological Diversity (CBD) establishes that 10% of coastal and marine environments should be conserved through protected areas by 2020, an ambition that is not yet even half realized. Across the North East Atlantic, Caribbean and Eastern Pacific, nine Marine Protected Areas (MPAs) have been designated based on HWU research and a further six are under consideration since the inception of the CBD at the 1992 Rio Earth Summit.

1. **Mair's** research with the Colombian government agency Coralina led (in combination with **Kerr** and **Side**) to the designation of the San Andres archipelago as a United Nations Man and Biosphere Seaflower Reserve in 2000 (Mitchell *et al*. 2001 [4]). At the United Nations Convention on Biological Diversity Conference in Nagoya, in October 2010, Coralina won the International Union for the Conservation of Nature's (IUCN) Countdown 2010 Biodiversity Award for the work in San Andres. A senior member of staff [S1] of Coralina, wrote: "*The management of the reserve has been challenging work ……. but…. based on good scientific information [inc work by Mair]. It was a great honour therefore to have our work recognised by …. Nagoya 2010…..*". Elsewhere, **Mair's** collaboration with the Smithsonian Tropical Research Institute (STRI) in Panama led directly to the protection of Las Perlas Archipelago as a marine Special Management Zone and underpinned subsequent management (Mair *et al*., 2009 [3]). A senior staff member at STRI [S2] expressed the Institute's "*gratitude to the Heriot-Watt*

University for ……the ground research work that allowed the Panamanian government to designate the Archipelago Las Perlas as a Special Management Zone…… should help in guiding science-based decisions…."

2. HWU researchers (Mair, Sanderson and Lyndon) have a track record of research on temperate biogenic structures that has led to the designation of European MPAs called SACs under the EU Habitats Directive. Before 2008, these have been designated at Loch Sunart, Loch Creran, Loch Duich Long and Alsh and Sullom Voe based on their work. Since 2008, the Isle of Man government have used work by Sanderson and Porter (Cook et al. 2013 [1]) as a core component to the permanent protection of 6 km2 of horse mussel (Modiolus modiolus) reef in the Irish Sea. "*This research* [Cook et al. 2013 [1]] *supported the permanent protection of the reef as part of the Ramsey Marine Nature Reserve, designated in October 2011*.", [S3]. In November 2012, the cold water corals of East Mingulay became part of another MPA of European importance (a candidate SAC) based on Robert's on-going biodiversity research (Roberts et al. 2009 [6]). Marine Scotland, [S4] confirm that "*the GIS data supplied by [HWU] for Marine Scotland Science's 2010 survey of the Mingulay Reef Complex was a key component in the design of our survey [and was] key to the process of re-defining the boundary for proposed East Mingulay Special Area of Conservation (SAC)*"

3. Based on a track record of 23 commissioned projects from Scottish Government's scientific and statutory conservation advisors, Scottish Natural Heritage and Marine Scotland Science continue to commission HWU to undertake research, survey and evaluate marine habitats as potential MPAs. Since 2008 research by Lyndon, Mair, Porter, Roberts and Sanderson (and other colleagues) has been key to policy implementation in the form of MPA proposals under the Marine (Scotland) Act (2010) in Blue Mull Sound, Wyre and Rousay Sounds, Noss Head, Southern Trench, Lochs Linnhe, Etive, Leven and Eil (www.scotland.gov.uk/marineconsultation). A senior marine advisor at Scottish Natural Heritage, [S5] confirms "*HWU involvement in survey, research and assessment ... has contributed to the designation and sustainable management of a number of Special Areas of Conservation (SAC)*".

4. Biogenic habitat research by **Mair**, **Porter**, **Sanderson** and **Roberts** has underpinned MPA policy within the North East Atlantic for 'threatened and/or declining species and habitats' under the Convention for the Protection of the Marine Environment of the North-East Atlantic (the OSPAR Convention). The research was widely assimilated in assessments published between 2008 and 2010 on the status and key threats for deep water sponge aggregations, horse mussel beds and cold water coral habitats. These assessments have led to an international policy to protect biogenic habitats as 'Priority Marine Habitats' in an MPA network across 15 North East Atlantic countries. For deep water sponge aggregations, their significance has been recognised globally through **Roberts'** work under the United Nations Environment Programme (Section 5: Hogg *et al*., 2010 [S6]) and these and other habitats have been identified in Ecologically or Biologically Significant Marine Areas (EBSMAs) beyond national jurisdictions in the North-East Atlantic through **Roberts'** work on the International Council for the Exploration of the Seas (Advice Drafting Group June 2013, Copenhagen).

5. Research to support sustainable development, especially protected areas, has been enhanced through a programme of outreach. MPA biogenic habitats have been widely promoted at three annual Dunbar Science Festivals (2011-13) by **Sanderson, Porter**, **Mair** and **Roberts** (each >3,000 visitors), the 2013 Orkney International Science Festival (**Sanderson, Porter**, **Mair**) and the Edinburgh Science Festival during National Science and Engineering Week in March-April 2013 (**Mair**, **Porter**, **Roberts**). **Roberts** integrated a school visit in the Outer Hebrides (Benbecula) into an MPA research cruise on RV James Cook in May 2012.

6. HWU has a strong track record of environmental indicator development under the Water Framework Directive (**Fernandes**). Research by **Lyndon**, **Mair**, **Porter Sanderson** and **Roberts** since 2008 has been widely cited in the development of the UKs biodiversity indicators of Good Environmental Status for biogenic structures under the EC Marine Strategy

Framework Directive (see section 5: Moffat *et al*. 2011 [S7]), an area where **Sanderson** provides on-going advice to the UK and EU (through DEFRA and OSPAR Benthic Expert Groups).

7. **Kerr** and **Side's** research in the Galapagos (e.g. Davos *et al*. 2007 [2]) provided baseline data (fisheries and socio-economic) for the establishment of the Seaflower biosphere reserve in San Andres and on-going fisheries management in the Galapagos Marine Reserve (GMR). Capacity building exchanges included training for Charles Darwin Research Station (CDRS) and Coralina (San Andres) [S2] research staff at ICIT. Additionally an ICIT PhD student (Alex Hearn) was in post as Co-ordinator of Fisheries Research at CDRS 2002-2008. **Kerr** was recently invited back to the Galapagos to present at a 2010 UNESCO workshop exploring socio-economic aspects of future management of the GMR.

Overall, the beneficiaries of HWUs sustained research into biogenic reef habitats are a number of government agencies, NGOs and communities involved in protected area management throughout Central America and North Western Europe. Sustainable protected area management can be highly socially valuable to communities and economies beyond conventional resource extraction because the ecosystem services of biogenic reefs can, for example, stabilise sediment, maintain water quality and sequester carbon as well as providing human food and recreation.

5. Sources to corroborate the impact (indicative maximum of 10 references)

[S1] A senior member of staff of Coralina and

[S2] A senior manager of the Smithsonian Tropical Research Institute

Will confirm the importance of HWU research to the management of San Andres and Las Perlas Archipelagos. [S2] Can also corroborate HWU's role in the development of research staff based in CDRS and San Andres.

[S3] Senior member of the Isle of Man Government's biodiversity team:

Will confirm the role of HWU research in the designation and management of Ramsey Marine Nature Reserve.

[S4] Marine Scotland Science:

Will confirm the importance of HWU research and analyses in establishing East Mingulay as a Special Area of Conservation.

[S5] Senior Member of Scottish Natural Heritage's marine team:

Will confirm HWU research contribution to the designation and sustainable management of Special Areas of Conservation (SAC) under the EC Habitats Directive since the 2008.

[S6] Hogg, M.M., Tendal, O.S., Conway, K.W., Pomponi, S.A., van Soest, R.W.M, Gutt, J., Krautter, M., Roberts, J.M. 2010. Deep-sea Sponge Grounds: Reservoirs of Biodiversity. UNEP-WCMC Biodiversity Series No. 32. UNEP-WCMC, Cambridge, UK.

[S7] Moffat, C., Aish, A., Hawkridge, J.M., Miles, H., Mitchell, P.I., McQuatters-Gollop, A., Frost, M., Greenstreet, S., Pinn, E., Proudfoot, R., Sanderson, W. G., & Tasker, M. L. 2011. Advice on United Kingdom biodiversity indicators and targets for the Marine Strategy Framework Directive. *Healthy and Biologically Diverse Seas Evidence Group Report to the Department for Environment, Food and Rural Affairs.*