

Institution: Heriot-Watt University		
Unit of Assessment: B07 Earth Systems and Environmental Sciences		
Title of case study: Marine Ecosystem Services Restoration & Management		
Period when the underpinning research was undertaken: 2015 – present		
Details of staff conducting the underpinning research from the submitting unit:		
Name(s):	Role(s) (e.g. job title):	Period(s) employed by submitting HEI:
William Sanderson	Reader / Associate Professor	2010 – present
James Mair	Professor	1979 – 2017 (emeritus since)
Dan Harries	Assistant Professor	2004 – present
Joanne Porter	Associate Professor	2009 – present
Colin Moore	Associate Professor	1980 – 2008 (hon. staff since)
Alastair Lyndon	Associate Professor	1995 – present
Theodor Henry	Professor	2013 – present
Andrew Want	Research Associate	2017 – present
David Woolf	Reader	2013 – present
Mike Bell	Research Fellow	2008 – present
Kate Johnson	Assistant Professor	2012 – present
Lauren McWhinnie	Assistant Professor	2020 – present
Teresa Fernandes	Professor	2012 – present
Sandy Kerr	Associate Professor	1993 – present
Period when the claimed impact occurred: 2015 – Dec 2020		
Is this case study continued from a case study submitted in 2014? Y		
1. Summary of the impact Heriot-Watt University research into critically important biogenic habitats and the ecosystem services they provide continues to shape policy and management objectives in international maritime spatial planning initiatives. This research has led to significant economic and policy impacts by: providing exemplars of marine habitat restoration inspiring international proliferation of similar initiatives; working with nature in a widely publicized novel corporate partnership; shaping government policies and plans to promote sustainable practices through marine management and stimulated the growth of new oyster restoration supply chains for the NE Atlantic from the economically fragile Scottish Highlands.		
2. Underpinning research Heriot-Watt University (HWU) has built a 25-year legacy of research focused on biogenic reef ecosystems, enabling us to understand their sensitivity, and the goods and services they provide (e.g. Cook <i>et al.</i> , 2013; Davos <i>et al.</i> , 2007; Mair <i>et al.</i> , 2009; Mitchell <i>et al.</i> , 2001; Moore <i>et al.</i> , 1998; Roberts <i>et al.</i> , 2009). HWU researchers Harries, Mair, Moore, Porter, Lyndon, and Sanderson have greatly improved the understanding of these declining habitats of high conservation importance, many of which are subject to legal protection, in relation to: biodiversity, reproductive biology, regeneration processes and spatial and temporal variation in flame shell <i>Limaria hians</i> , horse mussel <i>Modiolus modiolus</i> , fan worm <i>Serpula vermicularis</i> and		

oyster *Ostrea edulis* reefs. The largest known and most biodiverse examples of these biogenic reefs were protected through conservation legislation as a result of HWU research, and global first continuous time-series studies (starting with Mair in the 1970s) now provide essential baselines against which environmental change and human impacts are assessed.

Slow-growth and recovery-rates and sporadic recruitment of reef building fauna require active intervention to reverse declines in their status. Esmee Fairbairn (GBP90,000) funded research by Harries and Sanderson devised highly effective restorative techniques that enhanced recruitment and survival of *Serpula vermicularis* reefs (Cook *et al*, 2021). Similarly, since 2014, Sanderson has led the Dornoch Environmental Enhancement Project (DEEP) with Mair, Harries, Henry and Porter (total GBP739,000: The Glenmorangie Company) that first demonstrated that the native oyster (*Ostrea edulis*) historically occurred in the coastal NE of Scotland, secondly, that environmental conditions remain suitable for oyster survival, and thirdly, that oyster restoration is feasible across the NE Atlantic MPA network [3.1]. Restoration of extirpated shellfish reefs in Europe with oyster 'seeding' on added shell cultch was initiated in the Dornoch Firth MPA and successfully achieved through an understanding that *Ostrea edulis* larvae are gregarious and settle in response to cues that are indicative of their adult habitat [3.2].

High levels of genetic connectivity are evident from Porter's research on shellfish beds within and outside MPAs across seascapes [3.3] and has revealed the importance of understanding 'source' and 'sink' dynamics within a changing climate context, and thereby inform more effective spatial management and targeted restoration efforts. The understanding of connectivity in oyster restoration is dependent upon a full understanding of larval behaviour [3.4] and is a pre-requisite to inform effective restoration strategies for extirpated species such as in the DEEP project.

Research has demonstrated the Natural Capital value of biogenic reef habitats for local ecosystem services, e.g. nursery functions provided for commercially important species such as whelk and queen scallops as demonstrated by Sanderson, Mair and Porter [3.5]. Sanderson, Mair, Porter and Harries have extended this Ecosystem Services management rationale; quantifying the importance of these habitat types are Blue Carbon Stores [3.6]. The declaration of the Climate Emergency by the Scottish Government, has prioritised the sustainable management of carbon stores in protected areas and Sanderson has quantified the enhanced deposition of carbon-rich sediments to the seafloor by shellfish beds is increased by a factor of 3 [3.6] (Lee *et al*. 2020). The world's first regional audit of blue carbon by Porter and Want quantified that 9,190 tonnes C km⁻² occurs on the seabed in Orkney, originating in biogenic habitats or sediments derived from them, and vastly exceeding the carbon stores of terrestrial habitats.

3. References to the research

[3.1] Farinas-Franco, JM, Pearce, B, Mair, JM, Harries, DB, MacPherson, RC, Porter, JS, Reimer, PJ & Sanderson, WG 2018, 'Missing native oyster (*Ostrea edulis* L.) beds in a European Marine Protected Area: Should there be widespread restorative management?', *Biological Conservation*, vol. 221, pp. 293–311. <https://doi.org/10.1016/j.biocon.2018.03.010>

[3.2] Rodriguez Perez, A, James, M, Donnan, DW, Henry, TB, Møller, L & Sanderson, W 2019, 'Conservation and restoration of a keystone species: Understanding the settlement preferences of the European oyster (*Ostrea edulis*)', *Marine Pollution Bulletin*, vol. 138, pp. 312–321. <https://doi.org/10.1016/j.marpolbul.2018.11.032>

[3.3] Gormley, KSG, Mackenzie, CL, Robins, P, Coscia, I, Cassidy, A, James, J, Hull, A, Pierny, S, Sanderson, W & Porter, J 2015, 'Connectivity and dispersal patterns of protected biogenic reefs: Implications for the conservation of *Modiolus modiolus* (L.) in the Irish Sea', *PLoS ONE*, vol. 10, no. 12, e0143337. <https://doi.org/10.1371/journal.pone.0143337>

[3.4] Rodriguez Perez, A, Sanderson, W, Møller, LF, Henry, TB & James, M 2020, 'Return to sender: The influence of larval behaviour on the distribution and settlement of the European oyster *Ostrea edulis*', *Aquatic Conservation: Marine and Freshwater Ecosystems*, vol. 30, no. 11, pp. 2116-2132. <https://doi.org/10.1002/aqc.3429>

[3.5] Kent, F, Mair, JM, Newton, J, Lindenbaum, C, Porter, J & Sanderson, W 2017, 'Commercially important species associated with horse mussel (*Modiolus modiolus*) biogenic reefs: a priority habitat for nature conservation and fisheries benefits', *Marine Pollution Bulletin*, vol. 118, no. 1-2, pp. 71-78. <https://doi.org/10.1016/j.marpolbul.2017.02.051>

[3.6] Kent, F, Last, KS, Harries, DB & Sanderson, W 2017, 'In situ biodeposition measurements on a *Modiolus modiolus* (horse mussel) reef show enhanced sedimentation and provide insights into ecosystem services', *Estuarine, Coastal and Shelf Science*, vol. 184, pp. 151-157. <https://doi.org/10.1016/j.ecss.2016.11.014>

4. Details of the impact

In REF 2014 HWU research was shown to be instrumental in global marine spatial planning initiatives, particularly those focused on biogenic habitats, including the designation and management of Marine Protected Areas (MPAs) in Panama, Colombia, Galápagos and Europe. HWU research has since expanded our expertise providing underpinning evidence to support conservation policy implementation and management of protected biogenic reef habitats, and their Ecosystem Services (ES), across North East Atlantic Europe.

The Dornoch Environmental Enhancement Project (DEEP: Sanderson, Mair, Harries, Henry and Porter) is a collaboration between HWU, The Glenmorangie Company and the Marine Conservation Society. The business interest is in the mitigation of organic discharges into the adjacent marine environment by exploiting the remediative biofiltration (ES) of oyster reefs which concomitantly increases biodiversity through the provision of oyster reef structure and function [5.1]. Good environmental stewardship has added brand value [5.1, 5.2]. DEEP has pioneered, demonstrated and enhanced [3.1, 3.2, 3.4] restoration of the historically widespread native oyster; demonstrating that restoration can be accomplished across the European Atlantic MPA network [3.1]. Press coverage measured as 'Opportunity to See' has reached 1,000,000 to 865,000,000 people in years 2016 to 2020 [5.1, 5.2].

Research [3.1] has contributed directly to the development of UK Environment Agency and UK Department of the Environment Fisheries & Rural Affairs agenda 2025, restoring UK coastal marine habitats. The UK Environment Agency stated that they used the approach taken by the HWU partnership in Scotland as inspiration for a new Environment Agency initiative; Restoring Meadow, Marsh and Reef (ReMeMaRe) and in 2019 organised for the first time in the UK a successful international conference on estuarine and coastal habitat restoration: Restoring Estuarine and Coastal Habitats (REACH). This was widely attended including Ministers and Chairs of government bodies. The initiative is now sponsored by the Defra Group which includes JNCC, the Marine Management Organisation, Natural England and Cefas as well as the Crown Estate and Inshore Fisheries Conservation Authorities. It has led to the development of the first

UK and Ireland Oyster Restoration manual (now a model for seagrass, saltmarsh and beneficial use of dredged material manuals), the first oyster biosecurity workshop hosted by the Native Oyster Restoration Alliance at HW in January 2019, the development of oyster restoration potential maps for England, and; has culminated in a multi-million bid to Defra and HMT under the 4 year strategic review for additional funds for restoration of not only oysters, but seagrass and saltmarsh too [5.3].

Senior Estuary and Coast Planning Manager at the UK Environment Agency [5.3] said it *"....proved to be a defining moment for the future of marine environmental protection and recovery in the UK ..."*, and has, *"demonstrated ... how practical intervention could actually help to restore habitats that have been lost"*, and, *"all of this inspired by Heriot-Watt and Dr Sanderson's work in the Dornoch Firth"*. [5.3]

Furthermore, the work is cited by an increasing number of community-based restoration projects and SMEs as inspiration and proof of concept:

- *"As a result, we have secured funding from the National Lottery GBP225,000 to establish Scotland's first community-led native oyster restoration project at Craignish..."*, Project Coordinator, Seawilding. [5.4]
- *"Involved in DEEP...[we]...have created a spin-out company called The Native Oyster & Shellfish Company Ltd."*, NOSCO Ltd. [5.5].

The unique DEEP business collaboration with one of the world's leading whisky distillers has revolutionised the approach taken to marine conservation and restoration and recognised in multiple awards^{1,2,3,4,5}, including the Guardian Award for University Business Collaboration. It also provides a marine exemplar of 'working with nature' to remediate human impacts. Together, DEEP partners have developed a restoration pathway with global applicability in temperate systems that has helped inspire and inform other marine restoration projects across Europe [5.7], not least through the hosting of the Native Oyster Restoration Alliance conference in 2019 (155 participants; 15 countries). The DEEP business collaboration is already bringing about a range of benefits including:

- The development and increase in oyster reef habitat in the Dornoch Firth [5.1]
- Biofiltration by the oyster reef with associated water quality benefits [5.1]
- Benefiting the rural economy and the native oyster supply chain, evaluated by an independent Scottish government report as having the potential to create up to 50 FTE jobs and GBP3,000,000 GVA in fragile rural communities [5.6].

Sanderson has presented the research in partnership with Glenmorangie's Directors of CSR and Operations, in diverse settings from the local communities and at international events. The science underlying the project has shaped the whisky industry's approach to CSR; reaching tens of thousands of members of the public on whisky tours, festivals and open days and generating media coverage worth an advertising equivalent of >GBP15,000,000 [5.1, 5.2]. The project has inspired stakeholders across many countries (5.1, 5.2), elevating the reputation of partners and forging a new frontier in restoration at the start of the 2021 UN Decade on Ecosystem Restoration.

Sanderson, Mair, Harries, and Porter's ecosystem services (ES) research has demonstrated the habitat provisioning value of biogenic shellfish habitats for commercial species [3.5] and has become a key driver of enhanced protection by Scottish Government such that policy and management advice for Scottish Priority Marine Features now delivers enhanced protection from

fishing impacts [5.8]. Furthermore, there is mounting evidence of significant ES value in the carbon stores generated through biogenic habitats [3.6] (Sanderson, Mair, Harries). As part of the Scottish Government's objective to lead the world in adopting evidence-based policies to mitigate climate change, Porter and Want's audit of blue carbon resources for Orkney is the most comprehensive regional audit of blue carbon anywhere in the world. Porter, Woolf, Bell, Johnson, McWhinnie, Kerr and Fernandes subsequently undertook a review of the Orkney State of Environment Assessment [5.9; see e.g. p75-76] where blue carbon, pressures and sensitivity data have been incorporated as a basis for the statutory Orkney Marine Spatial Plan (a regional extension of the Scottish State of Environment Plan).

Awards:

¹[VIBES Awards 2017 \(winner of Hydro Nation Award\)](#)

²[Walpole British Luxury Awards 2017 \(winner of 'Luxury With a Heart'\)](#)

³[RSPB Nature of Scotland Awards 2017 \(winner of Corporate Award\)](#)

⁴<https://www.theguardian.com/education/gallery/2019/apr/11/the-guardian-university-awards-2019-the-winners>

⁵[Brave New World Foundation Lighthouse Award 2020](#)

5. Sources to corroborate the impact

[5.1] Letter from Glenmorangie confirming the impacts of DEEP.

[5.2] DEEP Project Evaluation Report 2016 – 2020, Webber Shandwick - report outreach metric for media coverage.

[5.3] Letter from UK Environment Agency confirming policy impacts.

[5.4] Letter from Project Coordinator, Seawilding.

[5.5] NOSCO Ltd acknowledgement of spin-out in response to DEEP project: NOSCO Ltd -Our Story – A Beginning: <https://scottishshellfishcompany.com/pages/our-native-story>

[5.6] Scottish government report (Allen 2019), *Towards an Economic Value of Native Oyster Restoration in Scotland: Provisioning, Regulating and Cultural Ecosystem Services* (see ii. Acknowledgments, p35).

[5.7] Native Oyster Restoration Alliance (Europe) Guidance (multiple contributions to Biosecurity / Restoration handbooks and Declaration) <https://nora-europe.eu/nora-publications/>

[5.8] Scottish Government improvements to protection to Priority Marine Features outside of the Marine Protected Area network (<https://consult.gov.scot/marine-scotland/priority-marine-features/>). Especially see review document on horse mussel beds with HWU references throughout (inc. HWU Ecosystem Services references).

[5.9] Orkney Islands Council, 'Orkney Islands Marine Region: State of the Environment Assessment', 2020 (see 235pp - see especially pages 75-76).