


Section A		
Institution: University of St Andrews 		
Unit of Assessment: UoA 14: Geography and Environmental Studies		
Title of case study: Assessing Blue Carbon Resources: Ensuring Coastal Protection and Climate Change Mitigation through Scotland's natural carbon sinks		
Period when the underpinning research was undertaken: 2015 – 31 December 2020		
Details of staff conducting the underpinning research from the submitting unit:		
Name(s):	Role(s) (e.g. job title):	Period(s) employed by HEI:
William Austin Craig Smeaton	Professor Research fellow	01 September 1999 – present 01 December 2017 – present
Period when the claimed impact occurred: 2016 – 31 December 2020		
Is this case study continued from a case study submitted in 2014? N		
Section B		
1. Summary of the impact <p>Carbon management is a critical part of mitigating the climate crisis. To enable politicians to make effective decisions on the future of our planet, timely and accurate information on the potential of natural carbon sinks is essential. Until recently, the magnitude and role of carbon stored in marine sediments (so-called 'blue carbon') within the carbon cycle was not well understood; researchers from the School of Geography and Sustainable Development at the University of St Andrews have worked with international partners to expand blue carbon knowledge by, first, analysing sediment in fjordic sea lochs; and secondly, delivering national-scale marine carbon stock assessments for Scotland. These investigations have delivered understanding about the rates at which carbon is buried, the magnitude of the carbon stores, and quantified the role of the terrestrial environment in the development of coastal carbon stores. This research has influenced the way governments now undertake marine carbon auditing. In Scotland, changes to Scottish Climate Change policy have been enacted to incorporate this blue carbon research advice; private organizations have changed their long-term planning; and work with communities has helped them engage with these important areas as both unique habitats and vital carbon stores.</p>		
2. Underpinning research <p>In 2015/2016, Professor William Austin and Dr Craig Smeaton analysed sediment cores from Scottish sea lochs for carbon and discovered that these sediments stored blue carbon in significant amounts: just one sea loch can store around 27,000,000t of carbon [R1]. The analysis also demonstrated that these marine carbon stores capture a significant amount of 'lost' terrestrial carbon; this 'subsidy' – $42.0 \pm 10.1\%$ of the organic carbon is terrestrial in origin – thereby gives terrestrial carbon a 'second chance' of burial and storage in these unique coastal environments [R2]. These new quantitative estimates of carbon stored in coastal areas supported the hypothesis that fjords are important environments for the burial and long-term storage of carbon and therefore should be considered and treated as unique environments within the global carbon cycle [R1, R2].</p> <p>In 2017, this research was upscaled to deliver carbon assessments for all 110 Scottish sea lochs, at the same time as Scottish Natural Heritage commissioned the team to assess carbon storage in Scotland's Inshore Marine Protected Area Network (MPAs), in collaboration with the Scottish Association for Marine Science (SAMS). This was the first national assessment of its kind in the world, and showed that the amount of carbon that is stored within Scotland's inshore MPA network is equivalent to four years of Scotland's total greenhouse gas emissions: over 600,000,000t of carbon stored in the surface sediment of Scotland's fjordic sea lochs, accumulating at a rate of</p>		

31,000 to 40,000t per year [R3]. It also demonstrated that, compared to adjacent carbon stores including peatland, Scotland's mid-latitude fjords are significantly more effective as carbon stores than their terrestrial counterparts: Scottish marine stores of carbon are around 18 times larger than either Scottish peatland or forests [R4]. This demonstrates that fjords are important environments for the burial and long-term storage of carbon, offering new opportunities to policymakers to reconsider the protection and sustainable management of MPAs because of their role in climate change mitigation [R3].

The potential for blue carbon to be incorporated into natural capital accounting for Scotland was clear; but, before this could happen, further work had to be done to incorporate carbon stock uncertainties into the accounting process to bring it into line with IPCC protocols. To do this, the team pioneered a multi-tier approach to map the spatial heterogeneity of sedimentary carbon in mid-latitude fjords, research that enabled uncertainties to be incorporated into the carbon accounting process with methodological applications around the world [R5].

As a result, in 2018 the Scottish Government commissioned the team to deliver these innovative approaches and work with Professor Joanne Porter (Heriot Watt University) to make an audit of Orkney's blue carbon resources in its marine habitats [R6]. Prior to this, studies have generally focused on one habitat type, in isolation, whereas this study took the innovative step of combining all the known habitats into a single quantified collection in a defined location. The research identified and assembled relevant data and information on the distribution and extent of blue carbon habitats in Orkney, and assessed quality, quantity, scale and the nature of the carbon stores within these habitats [R6]; currently, the audit informs Orkney Islands Council's 'Orkney Marine Region State of the Environment Assessment'.

3. References to the research

R1-R3 and R5 are peer-reviewed papers published in highly regarded international journals. R4 and R6 are reports commissioned for Scottish Natural Heritage and the Scottish Government. All the work was supported by major peer-reviewed grants (GBP1,000,000 funding; please see additional contextual data section for further details).

R1: **Smeaton, C., Austin, W. E. N.**, Davies, A.L, Baltzer, A., Abell, R.E., and Howe, J.A. (2016); Substantial stores of sedimentary carbon held in mid-latitude fjords; In *Biogeosciences*. 13, 20, p. 5771-5787, DOI: <https://doi.org/10.5194/bg-13-5771-2016>

R2: **Smeaton, C. & Austin, W. E. N.**, (2017), Sources, sinks and subsidies: terrestrial carbon storage in mid-latitude fjords, In *Journal of Geophysical Research - Biogeosciences*. 122, 11, p. 2754-2768, DOI: <https://doi.org/10.1002/2017JG003952>

R3: Burrows, M., Hughes, D., **Austin, W. E. N., Smeaton, C.**, Hicks, N., Howe, J., Allen, C., Taylor, P. & Vare, L., (2017), Assessment of blue carbon resources in Scotland's Inshore Marine Protected Area Network: Commissioned Report No. 957, Inverness: Scottish Natural Heritage. 283 p., <https://www.nature.scot/snh-commissioned-report-957-assessment-blue-carbon-resources-scotlands-inshore-marine-protected-area>

R4: **Smeaton, C., Austin, W. E. N.**, Davies, A., Baltzer, A., Howe, J. A. & Baxter, J. M., (2017) , Scotland's forgotten carbon: a national assessment of mid-latitude fjord sedimentary carbon stocks, In *Biogeosciences*. 14, 24, p. 5663-5674, DOI: <https://doi.org/10.5194/bg-14-5663-2017>

R5: **Smeaton, C. & Austin, W. E. N.**, (2019), Where's the carbon: exploring the spatial heterogeneity of sedimentary carbon in mid-latitude fjord, In *Frontiers in Earth Sciences*. 7, 16 p., 00269, DOI: <https://doi.org/10.3389/feart.2019.00269>

R6: Porter, J., **Austin, W.**, Burrows, M., Clarke, D., Davies, G., Kamenos, N., Riegel, S., **Smeaton, C.**, Page, C. & Want, A., (2020), Blue carbon audit of Orkney waters, Marine Scotland. 96 p. (Scottish Marine and Freshwater Science Reports; vol. 11, no. 3), DOI: <https://doi.org/10.7489/12262-1>

4. Details of the impact

Over the past four years, the St Andrews team have initiated new research [R1, R2] and worked with partners across Scotland [R3, R6] to deliver nation-scale marine carbon stock assessments [R3, R4, R5]. Throughout, the St Andrews team have initiated and led all the work on sedimentary blue carbon; the research is visible on a global stage yet serves to underpin impact in Scotland. These investigations have increased understanding about the magnitude of the carbon stores within these environments and highlighted the role of the terrestrial environment in the development of coastal carbon stores. Nature-based solutions for climate change mitigation are of vital environmental, socio-economic, and political importance, and towards that goal, the research has (a) shaped Scottish Government policies and research agendas, (b) changed private organisations' roadmap policies and (c) helped to safeguard blue carbon for the future by disseminating knowledge.

- **Shaping government policy and research agendas**

This innovative work on assessing blue carbon has provided key scientific evidence to the Scottish Government, enabling them to understand the role and significance of carbon storage in the marine environment. Policy debate on climate change and the environment has been influenced specifically by this research, after the team provided information and assistance *"to officials and Ministers, both directly and indirectly, in gaining a deeper understanding of blue carbon and the issues surrounding it"* [S1], through research seminars, government briefing events, and partnership events. This work has had *"a significant role in the development of [the Scottish Government's] blue carbon policy agenda"* [S1].

In July 2017, the Cabinet Secretary for Environment, Climate Change and Land Reform made an announcement in the Scottish Parliament highlighting the Scottish Government's progress in tackling climate change and noting that it would *"support Marine Scotland to consider further opportunities to expand that valuable and remarkable research to better understand the role and significance of blue carbon"* [S2, p.19]. Marine Scotland have subsequently reported that the St Andrews team have had *"a significant role in the development of our blue carbon policy agenda"* [S1]; Scottish Government base this upon the *"understanding of the scientific evidence that points to the role and significance of blue carbon in our marine environment"* [S3]. In 2018, the Scottish Government was able to incorporate blue carbon storage, for the first time, into its 'Climate Change Plan: third report on proposals and policies 2018–2032 (RPP3)' [S4, pp.180-181].

As well as funding a number of research positions at St Andrews, Marine Scotland's Science Division also became actively engaged as a research partner (latterly contributing to research outputs) and, following the initial report [R3], *"through the access which we have provided to our fleet of research vessels"* [S3]. This work also led to the foundation of the Scottish Blue Carbon Forum in 2018, a nationwide body to coordinate research on the role of our oceans in sequestering carbon [S5].

This *"wealth of new scientific understanding"* [S3] of Scotland's blue carbon resources has attracted positive comment from Government, including public recognition of the work of the St Andrews team by Scotland's First Minister during her keynote speech at Scotland's International Marine Conference in 2019 [S6]. In March 2020, Austin led MSPs and their staff in a seminar and panel discussion on blue carbon, which demonstrated 'its importance in Scotland's marine environment' and *"improved understanding of this issue to MSPs and parliament staff that will inform ongoing scrutiny of Scottish Government policy on tackling climate change and protecting and enhancing Scotland's marine environment"* [S7]. The event led to a parliamentary motion with cross-party support to mark World Oceans Day in June 2020 which stated, *"That the Parliament...praises the ongoing work in the scientific community on blue carbon and its role in tackling climate change"* [S7].

This blue carbon research [R6] has also led to a change in practices affecting broader marine habitat assessment, now increasingly incorporating blue carbon assessments alongside

measures of biodiversity. The Scottish Government commissioned the team to undertake sedimentary carbon stock assessments, working alongside Professor Joanne Porter (Heriot Watt University), who was responsible for broad-scale habitat surveys, to assess Orkney's blue carbon stocks as part of Orkney's Marine Planning analysis [S8]. This was the first time that an audit of blue carbon had been included alongside habitat assessment and marine spatial planning, demonstrating that these environments are important for both blue carbon *and* biodiversity, a major environmental and political national milestone [S8].

- **Changes to private organisations' roadmap policies**

The scientific evidence for blue carbon potential has inspired The R&A, the world's most prestigious commercial golfing organisation, to develop opportunities for nature-based solutions to mitigate the impact of climate and coastal changes across the UK and Ireland; golf's value to the UK economy in 2019 was valued at GBP2,300,000,000 Gross Value Added and Full Time Equivalent employment was in excess of 50,000 [S9].

The blue carbon team advised The R&A on the development of their Golf Course Action Plan for Great Britain and Ireland 2030 (Coastal Change and its Impact on Golf Courses, GC2030). In particular, blue carbon research [R6] guided The R&A's Recommendations for Action, including incorporating soil carbon stock assessments and an assessment of golf courses' vulnerability to coastal erosion in the long-term sustainability planning. As a result, The R&A committed GBP250,000 to achieve its environmental objectives and are working with international engineering and project management consultancy Royal Haskoning DHV to apply this across their portfolio. The R&A have commented "*your recent collaboration with the Links Trust, St Andrews highlights how academic-industry partnerships can be developed to support the design of a cost-effective and minimally invasive programme of site investigation*" [S9].

- **Helping to safeguard Blue Carbon through disseminating knowledge**

The St Andrews team has also disseminated its research findings to a variety of audiences. In addition to the policy makers and businesses detailed above, the team have reached new audiences by working with ClimateXchange, Scotland's centre of expertise connecting climate change research and policy, to share their findings on carbon sequestration with members of the public through events and the production a short film, *Peat, soil and sea: Managing carbon in Scotland* [S5]. Early career researchers within the team also secured a knowledge exchange award from the RSGS, when they shared work they undertook aboard the research vessel *Scotia* in 2019 with new audiences via [Marine Scotland's blog](#) and social media channel [S10].

In addition to this, in December 2019 the team launched their [Blue Carbon Quest citizen science](#) initiative for primary school-age children, supported by the Scottish Minister for the Natural Environment. The project sees children working with scientists from the University of St Andrews and naturalists from the Scottish Wildlife Trust to collect soil samples from the Montrose Basin saltmarshes as part of an audit of these unique wetlands [S10], thereby actively engaging young people in scientific research to expand our knowledge of vital marine environments.

5. Sources to corroborate the impact

S1. The Scottish Government; letter from Policy Officer–Marine Scotland

S2. The Scottish Parliament meeting 13 June 2017 – official report, p. 19.

S3. Marine Scotland - Science– statement on St Andrews contribution to Scotland's blue carbon research impact agenda (letter from Head of Science).

S4. Climate Change Plan: third report on proposals and policies 2018-2032 (RPP3): <https://www.gov.scot/publications/scottish-governments-climate-change-plan-third-report-proposals-policies-2018/> (pp.180-181)

S5. Marine Scotland - Policy – launches the Scottish Blue Carbon Forum and funds a Blue Carbon research agenda with a major St Andrews contract awarded to deliver blue carbon research for Marine Scotland (letter from Marine Planning & Policy Unit).

S6. First Minister – opening speech at Scotland's First International Marine Conference on significance of St Andrews blue carbon work (2019, published speech):

<https://www.gov.scot/publications/scotlands-international-marine-conference-2019-first-ministers-speech/>

S7. Scottish Parliament Information Centre - letter to evidence a Parliamentary motion with cross-party support to recognize blue carbon's role in tackling climate change (letter from SPICe)

S8: Orkney Council Marine Planning statement: [https://www.orkney.gov.uk/Files/Planning/Development-and-Marine-Planning/2019 Miscellaneous/OIC Marine Planning Update June 19.pdf](https://www.orkney.gov.uk/Files/Planning/Development-and-Marine-Planning/2019%20Miscellaneous/OIC%20Marine%20Planning%20Update%20June%2019.pdf)

S9. R&A – letter to acknowledge policy advice on blue carbon that has shaped Golf Course 2030 – the industry roadmap for Great Britain & Ireland (published acknowledgment, letter from Director of Sustainability).

S10. Scottish Rural Network – Blue Carbon blog post