A brief history of Scottish blue carbon science and the Scottish Blue Carbon Forum: Where next ?

Austin, W.E.N.[1], W.R. Turrell and C. Tilbrook

1 School of Geography & Sustainable Development, University of St Andrews - wena@st-andrews.ac.uk

2 Marine Scotland Science

3 NatureScot

Before the term "blue carbon" was coined by Nellerman et al. in 2009[1], there had already been significant studies of related topics in Scotland. The geology of our shelf sea sediments and seabed habitats had been extensively mapped in the 1970s and 80s, partly in support of the growing offshore oil and gas industry. Through the 1990s and 2000s, carbon, as a principal building block of life, had been tracked and quantified as it flows through marine ecosystems, and there had been significant studies of the carbonate cycle of our shelf seas. However, with the growing realisation of the impact of CO_2-induced climate change and the imperative to stop the increase of this greenhouse gas in the atmosphere at the turn of the millennium, the understanding of the flux and storage of carbon in marine habitats took on a new urgency.

"Blue carbon" science in Scotland has undergone a similar evolution as that globally, moving from basic descriptive inventories of carbon stores, to studies of sequestration rates and processes, studies of threats and pressures and their impacts, studies of restoration and protection measures, and investigations of the potential use of "blue carbon" habitats in an emerging carbon trading market.

A notable first inventory of Scottish blue carbon across all marine habitats was published by Mike Burrows and co-authors in 2014[2], commissioned by NatureScot (then SNH). In 2018, the Scottish Blue Carbon Forum (SBCF) was formed in collaboration with the Scottish Government, to coordinate blue carbon science in Scotland. Since then specific areas of focus of Scottish research have been sea loch carbon stores (e.g., detailed inventories of sea loch carbon stocks by Craig Smeaton and the lead author here [BA] from 2016 onwards[3]), saltmarshes (from a first national habitat survey published in 2016 by Haynes[4] and NatureScot, to a recent complex assessment of carbon stocks and sequestration rates by the St Andrews team[5]), and seabed sedimentary carbon stores (from simple stock assessments using national seabed geological records through to a recent assessment of the vulnerability of seabed carbon to bottom trawling by Kirsty Black and co-authors[6]).

The threat to seabed blue carbon from fishing recently made global media headlines following the publication of a paper in Nature by Enric Sala and co-workers in 2021[7], and the fallout from this work is still reverberating around blue carbon science. Alongside the headline-grabbing papers, Scottish scientists have made great efforts to explain blue carbon science to policy makers, stakeholders and the public through a series of events, publications and infographics (e.g., the SPiCE review, SBCF infographics). A major international conference was hosted alongside COP26 by Marine Scotland and the SBCF, which aimed to move blue carbon science forward to studies "beyond the inventory". Additionally the SBCF has recently launched an International Policy Challenge to further bring together policy makers and blue carbon scientists and the SBCF has become a member of the IPBC and is now leading on the UN Decade Programme for Blue Carbon (GO-BC) to support the UN SDGs.

Today blue carbon scientific focus is moving on to providing the evidence to include saltmarshes in the UK greenhouse gas inventory; providing advice for the development of Highly Protected Marine Areas that consider the protection of blue carbon; developing a full understanding of the impact of bottom trawling on carbon stores; and developing the science needed to protect and restore all fragile coastal blue carbon habitats with a better holistic understanding of all the ecosystem services they provide.

References

1 - Nellemann, C. et al. (2009). Blue carbon: the role of healthy oceans in binding carbon: a rapid response assessment. United Nations Environment Programme.
2 - Burrows, M.T. et al. (2014). Assessment of carbon budgets and potential blue carbon stores in Scotland's coastal and marine environment. Scottish Natural Heritage Commissioned Report No. 761.
3 - Smeaton, C. et al. (2021) Carbon Burial in the Mid-Latitude Fjords of Scotland. Marine Geology 441, 106618.
4 - Haynes, T.A., (2016) Scottish saltmarsh survey national report. Scottish Natural Heritage Commissioned Report No. 786.
5 - Miller, L.C. et al. (in press) Carbon accumulation and storage across contrasting saltmarshes of Scotland.
6 - Black, K.E. et al. (2022). Assessing the potential vulnerability of sedimentary carbon stores to bottom trawling disturbance within the UK EEZ. Frontiers in Marine Science 9.
7 - Sala, et al. (2021). Protecting the global ocean for biodiversity, food and climate. Nature.

Trial to Validate Environmental DNA (eDNA) as a Survey Method for Fish Ecology Assessment around Offshore Wind Farms

Michelle Elliott[1], Stephanie Dickens[2], Samuel Stanton[3] and Edward Wort[4]

[1] *Natural Power Consultants – michelle@naturalpower.com*
[2] *Natural Power Consultants - stephanied@naturalpower.com*
[3] *NatureMetrics – samuel.stanton@naturemetrics.co.uk*
[4] *NatureMetrics – edward.wort@naturemetrics.co.uk*

Ambitious UK Government targets to reach 50GW of operating offshore wind capacity by 2030, is increasing the pressure on the offshore wind farm industry. There is also a move towards demonstrating Biodiversity Net Gain (BNG) and Net Positive Impact (NPI) from marine development activities (Natural England, 2022). These pressures increase the demand for robust and scalable environmental data collection. However, many conventional environmental surveys still rely on costly and time-consuming capture-based techniques (Maiello *et al*. 2022). This is creating a supply chain bottleneck which can result in consenting and development delays. Furthermore, as a greater number of Offshore Wind Farms (OWFs) are being sited in deeper water, it can become more difficult to conduct the required environmental monitoring using existing methods.

Environmental DNA (eDNA) metabarcoding is a technique which can potentially provide an innovative solution to overcome these challenges. All living things leave traces of DNA in the environment (such as mucus, scales, and faeces from fish as they swim in the water column). Water samples for eDNA analysis can be taken without specialized staff using a non-intrusive hand-held device from a wide range of vessels, and from previously inaccessible locations, such as within turbine arrays. Once collected, eDNA can be amplified and sequenced to identify unique genetic sequences. The sequences are then compared to genetic reference databases through a process called bioinformatics to identify species and generate information on the biodiversity of the area sampled.

Natural Power is leading a research project at Blyth Offshore Demonstrator, part funded by the Offshore Wind Growth Partnership (OWGP) and in partnership with EDF Renewables and NatureMetrics. The study will compare data from eDNA sampling with fish catch data from otter trawl surveys conducted simultaneously, as well as with historic data from the site. The main aim of the study is to produce a method for fish ecology eDNA surveys around commercial sites; demonstrating that the technique provides equivalent if not better fish ecological data than the traditional method. Initial results show it also provides data on marine mammals, seabirds, and invertebrates. Should the eDNA methodology be accepted as a viable alternative it would likely lead to a reduction in development costs, delays, survey personnel and environmental impacts. It also has the potential to support ecological targets through the provision of high-quality biodiversity data to assist informed marine planning decisions at both project and regional level.

The first two of four planned surveys are complete, with initial data showing good overlap in the fish species identified, and with 70% more species from the eDNA samples, including fish, invertebrates, seabirds, and marine mammals. The formal results of this study will be published in 2023, however the initial results indicate the potentially important role eDNA may play in future environmental assessment.

References

Maiello, G., Talarico, L., Carpentieri, P., De Angelis, F., et al. (2022). Little samplers, big fleet: eDNA metabarcoding from commercial trawlers enhances ocean monitoring. Fisheries Research. 249. 0165-7836. 10.1016/j.fishres.2022.106259.

Natural England (2022). Marine net gain – leaving the marine environment in better state. URL: https://naturalengland.blog.gov.uk/2022/06/07/marine-net-gain-leaving-the-marine-environment-in-better-state/

Scotland's changing coastal environment: how time series support the Blue Economy Vision

E. Bresnan, B. Berx, L. Brown, P. Diaz, D. Eerkes-Medrano, A. Gallego, M. Geldart, F. Gibb, J. Hindson, M. Machairopoulou, K. McIntosh, T. Regnier, H. Smith, K. Smith, L. Webster, S. Wells

Marine Scotland Science, Marine Laboratory, 375 Victoria Road, Aberdeen, AB11 9DB – Eileen.Bresnan@gov.scot

The Scottish Coastal Observatory (SCObs) has been measuring environmental and biological variables at multiple locations around the Scottish Coast for over 25 years. A combination of temperature, salinity, nutrients, carbonate chemistry, dissolved oxygen, pigments, and plankton communities are collected weekly at selected sites. Two metocean buoys have recently been added to the programme, collecting high frequency meteorological, physical and chemical data which is available in near real time. SCObs data are used to fulfil the Scottish Government's statutory reporting requirement for the Marine Scotland Act (2010), the UK Marine Strategy and the Oslo/Paris Commission (OSPAR) status assessments. SCObs is providing evidence that the physical and chemical properties, and plankton communities of Scottish coastal waters are changing. These changes which have the potential to impact industries that are part of the Blue Economy include; i) a change in the diversity and abundance of plankton life forms with the potential to impact food webs, ii) a decreasing trend in salinity coincident with a catastrophic decline in zooplankton abundance observed at the Loch Ewe site, iii) an increase in the abundance of the shellfish toxin producing diatom *Pseudo-nitzschia* observed in Scalloway, increasing the risk of shellfish harvesting closures, iv) a mismatch between the timing of zooplankton and fish larvae potentially influencing recruitment, and v) dissolution of the shells of shellfish larvae associated with carbonate chemistry. The SCObs dataset also highlights the regional variability of Scotland's coastal environment and how this can impact local marine industries. The conditions of Scotland's marine waters are predicted to change over the coming decades due to multiple pressures such as climate change, ocean acidification and natural variability over yearly to multi-decadal time scales. Time series such as SCObs which identify environmental changes that can impact sustainable use of the marine environment provide important support to the Blue Economy Vision.

Acknowledgements

The Scottish Coastal Observatory is funded by the Scottish Government's schedule of service 20465/ST05a.

The SCObs programme relies on a number of dedicated citizen scientists, volunteers, contractors and Marine Scotland Science staff, to collect water samples and lower instruments in the sea each week in all weathers. Their input is gratefully acknowledged; Millport: Field Studies Council, Mallaig: Hugh Cameron, Loch Maddy: John Macdonald, Loch Ewe: Loch Ewe Shellfish, Scapa: Orkney Islands Harbour Council, Scalloway: North Atlantic Fisheries College, Fair Isle: David Parnaby, Cromarty: Robert Bashford, Stonehaven: The Stonehaven Sampling Team, St. Abbs: St Abbs Marine Station, St. Kilda: National Trust for Scotland.