Institution: University of Cambridge

Unit of Assessment: 14

Title of case study:
Natural Coastal Protection and Risk Reduction by Intertidal Wetlands

Period when the underpinning research was undertaken:
2000 – 2020

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:
Prof Tom Spencer (TS) Dr Iris Möller (IM)	Professor University Lecturer, College Lecturer Deputy Director, Cambridge Coastal Research Unit	01.01.1989 - present 01.10.2014 – 30.09.2019 2000-2014 2000-2019

Period when the claimed impact occurred: 1 August 2013 to 31 July 2020

Is this case study continued from a case study submitted in 2014? No

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

World-leading research from the Cambridge Coastal Research Unit on coastal wetlands has substantially changed awareness, attitudes, policy and practice within governments and organisations concerned with flood and coastal erosion risk management and hazard mitigation. The provision of unequivocal evidence for the cost-savings and benefits achieved through using coastal wetlands as 'natural buffers' to dissipate incident wave energy has led to key national and international policy shifts. The research has influenced decisions to ensure the protection of natural habitats and coastal communities in the UK, Europe, and the USA, and underpinned fundamental change in the way that the community of coastal stakeholders now thinks about coastal wetlands and their benefits to society.

2. Underpinning research (indicative maximum 500 words)

In 2017 the UK Climate Change Risk Assessment (CCRA2) identified 'Flooding and coastal change risks to communities, businesses and infrastructure' as the highest priority for inter-related climate change risk for the UK, both now and in the future. This was based on magnitude of risk and because of the need for additional, co-ordinated steps to be taken towards risk reduction within the next five years.

However, protecting lives, livelihoods and infrastructure at the coast with fixed, 'hard engineered' defences alone is expensive and ultimately not sustainable with rising sea levels and increases in storminess. Even a modest sea level rise of 0.5 m by 2100 is projected to make 1,000 km (20%) of all coastal defences in England vulnerable to failure. This risk will be even higher if the protective natural environments seaward of such structures are allowed to deteriorate [**S1**].

The Cambridge Coastal Research Unit (CCRU) is internationally recognised for developing the evidence base that demonstrates the protective function of vegetated foreshores by dissipating storm wave energy and maintaining the stability of intertidal sediments seaward of defences [**R1**]. Research has provided a scientific underpinning for the policy of 'Managed Realignment' - widely adopted in developed economies - which looks to set back the shoreline and create new habitat area. This strategy removes long-term financial commitments to maintain defences and restores natural environments and processes.

Since 2000, the Unit's field campaigns in Essex estuaries and Morecambe Bay (NERC CBESS, NERC BLUECoast) and across the European Union (EU FP7 FAST) have provided evidence for the degree to which wave energy is reduced when saltmarshes are inundated during high tides/storms. The research has shown how this process varies with water depth, wave height, vegetation, marsh surface topography, and the nature of the unvegetated mudflat or transition to saltmarsh [**R2**] [**R3**]. Salt marshes are found close to high water and often front important infrastructure, such as sea walls or flood embankments. Their buffering function markedly reduces maintenance and building costs of such structures.

In two true-to-scale experiments in the world's longest wave flume (GWK flume, Hannover 2013, 2018; EU Hydralab IV, EU hydralab+, NERC RESIST-UK) research demonstrated that, even during extreme storms, wave heights were lowered by 15-20% when only a 40m-wide salt marsh buffer zone was present, with 60% of this effect due to the presence of plants on the surface and the remainder due to a remarkably stable platform built naturally by the vegetation and surface sediment deposition [**R1**] [**R4**].

Research has also involved incorporating the results from field monitoring and large-scale experimentation into coastal models which contain metrics of the natural coastal protection function [EU FP7 RISC-KIT]; [**R5**] and, as in Foreshore Assessment using Space Technology (FAST), incorporate visualisation tools of the impact of natural coastal protection to aid non-specialist coastal managers, in coastal wetland settings around the world [**R6**].

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

All research outputs marked with * have been subject to a rigorous peer-review process. Reference R6 was reviewed through the UNISDR (United Nations International Strategy for Disaster Reduction) Secretariat.

R1. ***Möller** I, Kudella M, Rupprecht F, **Spencer** T, Paul M, van Wesenbeeck BK, Wolters G, Jensen K, Bouma TJ, Miranda-Lange M, Schimmels S 2014 Wave attenuation over coastal salt marshes under storm surge conditions. *Nature Geoscience*, **7**, 727–731 [doi: 10.1038/ngeo2251]

R2. ***Möller** I 2006 Quantifying saltmarsh vegetation and its effect on wave height dissipation: results from a UK East coast saltmarsh. *Journal of Estuarine, Coastal, and Shelf Sciences*, **69**, 337-351 [doi:10.1016/j.ecss.2006.05.003]

R3. ***Möller** I, **Spencer** T 2002 Wave dissipation over macro-tidal saltmarshes: Effects of marsh edge typology and vegetation change. *Journal of Coastal Res.*, **SI 36**, 506-521 [doi: 10.2112/1551-5036-36.sp1.506]

R4. *Rupprecht F, **Möller I**, Paul, M, Kudella M, **Spencer T**, van Wesenbeeck BK, Wolters G, Jensen K, Bouma TJ, Miranda-Lange M, Schimmels S 2017 Vegetation-wave interactions in salt marshes under storm surge conditions. *Ecological Engineering,* 100, 301-315 [doi: 10.1016/j.ecoleng.2016.12.030]

R5.* Christie EK, **Spencer T**, Owen D, McIvor AL, **Moeller I**, Viavattene C 2018 Regional coastal flood risk assessment for a tidally dominant, natural coastal setting: North Norfolk, southern North Sea. *Coastal Engineering,* **134**, 177-190 [10.1016/j.coastaleng.2017.05.003]

R6. UNISDR Scientific and Technical Advisory Group Case Studies – 2014 Recognising Natural Coastal Protection and Risk Reduction by Intertidal Wetlands [www.preventionweb.net/files/workspace/7935_**spencernaturalcoastprotection**.pdf]

Grants

- Response of Ecologically-mediated Shallow Intertidal Shores and their Transitions to extreme hydrodynamic forcing in UK settings (RESIST-UK), NERC Standard Grant, 01.04.2018-31.01.2021 (IM PI to 9/2019, TS PI from 10/2019, £582,105); EU H2020 Hydralab+ 2018 (IM PI, £179,000 (in kind, flume use)); EU Hydralab IV, 2011-2013 (IM PI, £70.000).
- Valuing the contribution which COASTal habitats make to human health and WEllBeing (CoastWEB) NERC, 01.08.2016- 31.07.2019 (IM PI, £25,731)

- BLUECoast: Coastal morphology: coastal sediment budgets and their role in coastal recovery, NERC (Highlight Topic), 01.01.2016-31.01.2022 (TS PI, £238,566)
- Stemming the rising tide: the protective role of saltmarshes, EU FP7 IEF, 01.01.2015-31.12.2016 (TS PI, £257,696)
- Foreshore Assessment using Space Technology (FAST), EU FP7, 01.01.2014-31.12.2017 (IM PI, £389,426)
- Resilience Increasing Strategies for Coasts – toolkit (RISC-KIT), EU FP7, 01.11.13-31.12.2017 (TS PI, £175,619)
- A hierarchical approach to the examination of the relationship between biodiversity and ecosystem service flows across coastal margins (CBESS), NERC Biodiversity & Ecosystem Service Sustainability (BESS), 01.04.2012-31.03.2016 (TS PI, £245,415)

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

Research by the CCRU has played an important part in the broad international movement towards cultivating natural flood defences in the response to climate change. It has provided robust scientific evidence to international and national assessments of the efficacy of natural flood defences and input into cost benefit analysis used by policy authorities to make decisions to invest in flood defences. Researchers have worked directly with coastal stakeholders in the UK, including Natural England, The National Trust and RSPB, in order to incorporate the benefits of coastal wetlands into their thinking and planning.

Providing scientific evidence to policy makers on the efficacy of natural flood defences

The impacts of flooding and coastal change in the UK are already significant (direct economic damages of GBP260 million per year) and are expected to increase as a result of climate and demographic change. By the 2080s, up to 1.5 million properties, and 1.1 million people, in England will be at significant risk of annual coastal flooding [**S1**]. Research by the unit [**R1**][**R3**] has demonstrated how the vegetated marsh platform reduces wave heights and the scale of artificial defences needed on the sea-facing side of artificial defences. '[*W]ith this demonstration of the efficacy of natural coastal protection – as evidenced by the use of the headline Cambridge metric of up to 50% of wave energy attenuated in the first 10-20 m of vegetated saltmarsh, the CCRA2 Evidence Report of 2016 cited the NEA* [National Ecosystem Assessment] *estimate that this wave buffering function could create capital savings in sea-defence costs GBP3.1 - GBP33.2 billion'* [**S2**] Head of Adaptation, Committee on Climate Change. With this estimate, the research has enabled policy authorities to quantify the benefit of natural coastal protection, both in its effectiveness in reducing wave height incidence and in reducing the need for investment in artificial defences, now and in the future. Around half of England's sea defences benefit from this 'buffering' effect. [**S2**]

Over a sustained period, the research has helped UK policy makers recognise the societal benefits (monetary and non-monetary) of coastal habitats in coastal protection schemes. In the current REF period this includes the February 2019 National Planning Policy Framework (HMG Ministry of Housing, Communities & Local Government) which refers to the importance of 'using opportunities provided by new development to reduce the causes and impacts of flooding (where appropriate through the use of natural flood management techniques)', defined as 'managing flood and coastal erosion risk by protecting, restoring and emulating the natural 'regulating' function of catchments, rivers, floodplains and coasts' [**S3**, pages 46 and 69].

In 2017 the UK Environment Agency published a guidance document 'Working with Natural Processes', for coastal managers. The report referenced recent field and laboratory work from Cambridge research [including **R1**, **R3**] which has demonstrated that saltmarshes can reduce wave heights under higher wave and water level conditions (for example, water depths of up to 2m and wave heights up to 0.9m), although they are most effective at low to intermediate water depths (<1.1m)' [**S4**]. '*This evidence base has been very important in helping us develop and publish our Natural Flood Management evidence base, which is helping us to mainstream more natural approaches to flood and coastal erosion risk management.*' [**S4**] Principal Scientists, Flood & Coastal Risk Management Research, Environment Agency.

Natural England, the government advisor on the natural environment, have used the research to help grow and disseminate the environmental evidence body relating to natural coastal protection, in particular the role of saltmarshes both in general advice and in site-specific cases. *"Natural England's 'Evidence summary' for Land Use (2015) stresses the value of work presented in Möller (2006)* [**R2**] *that shows coastal management needs to take account of the ecosystem values of saltmarsh"*. Cambridge researchers regularly collaborate with Natural England coastal specialists to produce 'report cards' on climate change biodiversity impacts, which are shared widely. Senior Environmental Specialist, Coastal Habitats, Natural England.[**S5**]

Environmental benefits through significant increases in restored and re-created natural coastal wetlands have recently taken place through the actions of multiple nature conservation organisations within and beyond the UK and CCRU's evidence has helped achieve this on the ground. Cambridge researchers are embedded in advising on growing the number and increasing the individual size of such sites and have worked with the National Trust, UK Wildlife Trusts and San Francisco Estuary Institute (SFEI) to support this development. For organisations such as the RSPB this means providing scientific support for its advocacy of natural coastal protection and securing improvements to government coastal management policies. *"I can confidently say that research by the Cambridge Coastal Research Unit (CCRU) has provided the critical scientific underpinning for RSPB positions on natural coastal protection and coastal habitat restoration, allowing us to advocate for and secure improvements to government coastal management policies. This helps in advocacy of the benefits of our managed realignment coastal habitat work at sites such as Titchwell, Wallasea Island and Medmerry*". [**S6**] Head of People Conservation Science, RSPB. Researchers worked with the RSPB to develop a practitioner-facing toolkit *(*the Toolkit for Ecosystem Service Site-based Assessment or TESSA*),* which has been downloaded by over 2500 users worldwide. This work helped the RSPB directly on its own scientific appraisal of the benefits of its restored salt marsh site at Hesketh OutMarsh in Lancashire [**S6**].

Research has helped The National Trust, the UK's largest private landowner, to develop and assess strategies for natural capital benefit in relation to its coastal areas, which represent one fifth of the coastline of England, Wales and Northern Ireland. 60 per cent of the coastline is at risk of erosion and flooding in the current century. With broader climate change and sea level rise the Trust is required to assess the risks and apply measures that facilitate effective management through adaptation. CCRU research has been used to inform the Trust's policy position, develop strategy, and implement projects for societal benefit in relation to coastal protection, particularly recognising the need for long-term thinking on predicting coastal futures. Its policy of 'coastal adaptation' draws on the approach of conservation and enhancement in the context of projected sea level rise, which has fed into regional management plans. The Trust now has 80 coastal adaptation strategies in place at 'hotspots' (at immediate impact from sea level rise and climate change impacts) across England, Wales and Northern Ireland, which cover 100 km of coast in the East of England. Research was used to undertake wave and tide monitoring at Blackwater Estuary Essex which enabled the Trust to obtain a DEFRA grant to support natural flood management. [**S7**].

From 2017, the team have worked closely with the DEFRA Marine Pioneer and local stakeholders to develop robust metrics to quantify the benefits, or 'environmental gain', from a natural capital approach at specific sites. In the Deben Estuary, Suffolk, where the ecosystem service value is GBP5 – 8.5k per hectare, the team established quantifiable, spatially-variable benefits of erosion prevention and sea defence from a fringe of saltmarsh of varying width in front of estuarine margin defences. This allowed decision-makers to see where investment in marsh restoration might have greatest effect in terms of flood and erosion risk mitigation. [**S8**] The methodology was then extended more widely as part of a regional plan. A consortium of public authorities including New Anglia Local Enterprise Partnership, Suffolk County Council and Norfolk County Council are currently planning a joint, regional environment strategy for the East Anglian region, to complement existing economic planning frameworks. [**S9**]

From the Head of Evidence, Marine Management Organisation (MMO), a national public body charged with regulation and planning of marine activities in the seas around England, '… *this was a model of how good science can be translated into impactful environmental advice. We are now developing a series of 'lessons' from the Marine Pioneers on how to fundamentally embed consideration of nature's importance in decision making at all levels.'* [**S8**]

From the Suffolk Marine Pioneer Project Manager, *'the role of the University of Cambridge was absolutely critical in ensuring not only the success of the local programme but also the delivery of a meaningful methodology upwards, both regionally and to the level of informing national policy debates… the outputs were both easily grasped and highly visual, allowing non-specialists to see where investment in marsh restoration might have its greatest effect for flood and erosion risk mitigation … As a consequence of increased awareness of the natural capital approach and greater knowledge of its application in government policy, several organisations have commenced planning processes informed by natural capital.* ' [**S9**].

The benefits of natural coastal defences have been pursued by the team within a wider programme of education and communication aimed at building international awareness of the value of coastal ecosystems. Cambridge research has reached out to global audiences via online tools, webinars, news and other broadcasts, youtube (including 'best video' at Earth Photo 2019 competition) and social media [**S10**].

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

[**S1**] Reports of the Committee on Climate Change (https://www.theccc.org.uk/wp-content/uploads/2018/10/Managing-the-coast-in-a-changing-climate-October-2018-1.pdf; https://www.theccc.org.uk/wp-content/uploads/2016/07/UK-CCRA-2017-Chapter-3-Natural-environment-and-natural-assets.pdf; https://www.theccc.org.uk/publication/managing-the-land-in-a-changing-climate/)
[**S2**] Testimonial from Head of Adaptation, Committee on Climate Change
[**S3**] National Policy Planning Framework https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/810197/NPPF_Feb_2019_revised.pdf
[**S4**] Testimonial from Principal Scientists, Flood & Coastal Risk Management Research, Environment Agency; https://www.gov.uk/government/publications/working-with-natural-processes-to-reduce-flood-risk; www.ccru.geog.cam.ac.uk/news/coastaloverview.pdf
[**S5**] Testimonial from Senior Environmental Specialist, Coastal Habitats, Natural England
[**S6**] Testimonial from Head of People Conservation Science, RSPB
[**S7**] Testimonial from Coastal Projects Manager, The National Trust
[**S8**] Testimonial from Head of Evidence, MMO and Marine Pioneer Programme Lead
[**S9**] Testimonial from Project Manager, Suffolk Marine Pioneer
[**S10**] Consolidated document showing reach from impact and outreach activities