Protecting the South West through improved coastal hazard forecasting

sweep Impact Summary

The SWEEP OWWL model is delivering more accurate, site-specific coastal hazard forecasts for the South West. The team worked closely with the Environment Agency (EA) to ensure the improved forecasts have real-world application -helping to protect the environment and properties, save lives, and facilitate cost-savings for marine and coastal businesses.

Porthleven during a storm

Daily coastal flood forecasting to **626** Twitter followers and **150** email subscribers, **34** EA flood warning officers and **29** local authorities

Informed EA real-time coastal forecasting plans (£20m) within their **£140m** national coastal forecasting strategy

Providing operational efficiencies to marine business in Lyme Bay

Ways of Working

Innovative Knowledge Provision — Effective Collaboration — Capacity Building — Tailored Decision Support

sweep OWWL Operational Wave & Water Level Model

Why it mattered?

The detrimental economic and societal impacts of coastal flooding along the South West's 1014km of highly indented coastline is exacerbated by increasing demands on coastal use, and the threat of climate change and rising sea levels. Better forecasting can potentially saves lives, protect the environment and property, and help marine businesses and flood-response organisations to operate more efficiently.

Coastal flooding is normally considered to be the result of high tides and storm surge, but in the South West an important additional factor is 'wave run-up'. This occurs where large waves hit coastal structures or beaches. The Operational Wave and Water Level Model (OWWL) brought all these factors together (See Storm Emma Case study).

> *"Good forecasting is the most cost effective way to safeguard communities at the coast and, ultimately, save lives."*
>
> **Nick Ely, Environment Agency Coastal Modelling & Forecasting Manager**

Previous forecasting models did not include wave-run up and only predicted offshore wave conditions at coarse resolutions. Whilst useful for area-wide application, these predictions are less useful at the local, site-specific level, and where breaking inshore waves create the greatest damage. There was a need to develop more accurate and localised forecasting.

What we did

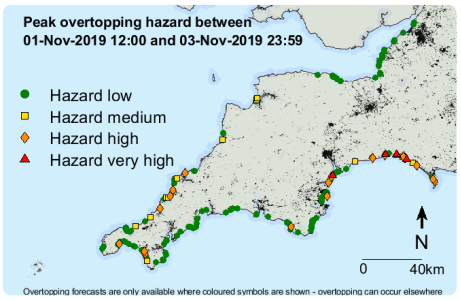
In March 2017, Prof. Gerd Masselink, Dr Kit Stokes, and Dr Tim Poate from the University of Plymouth's Coastal Processes Research Group began working closely with the EA and Met Office to a develop a storm impact model - OWWL - to improve coastal flooding and other coastal hazard forecasting in the South West and, for the first time, include wave run-up.

The first version of OWWL was finalised in October 2018 and predicts storm impacts around the South West coastline at a resolution of 1 km. It is delivered daily via the Channel Coastal Observatory (CCO) website, Twitter, and through tailored alert emails providing site-specific, 'three-day advance' forecasts of coastal overtopping and flooding hazards.

It currently has 70 subscribers, including 19 local EA flood managers who have now used it to inform their decisionmaking over the winter since 2018.

Working with Offshore Shellfish Ltd (OSF), the UK's largest offshore, rope-cultured mussel farm, the SWEEP team developed bespoke OWWL sea-condition forecasts for Lyme Bay.

It is expected that the daily forecasts will support more effective decision-making for the OSF operations team about when to go to sea, and which activities can be undertaken on any given day, for example. Plans are in place to monitor further impacts over winter (2020/21).



Impacts & benefits delivered

Health & Wellbeing

Improving health and wellbeing: Nick Ely, EA's Coastal Modelling & Forecasting Manager, confirmed OWWL *"has been instrumental in helping us to make more informed decisions on issuing warnings to the public"* and will *"safeguard not only the health and wellbeing of coastal communities during storms, but also the wellbeing of our flood response staff around the southwest coast."*

The development of OWWL has:

Attitudinal/Capacity

Influenced an attitudinal shift at the EA around the importance of having an overtopping tool as part of their national forecasting srategy;

Policy & Legislation

Informed a national-level strategic review of the EA's coastal forecasting strategy, and led to £140m of Defra funding with £20m ear-marked for future, enhanced real-time coastal forecasting plans;

Organisational Function

Influenced EA operational practises: South West local flood warning officers use the daily live OWWL wave overtopping forecast t more accurately predict coastal flooding and more effectively target resources;

Economic

Delivered cost savings to the EA through accelerated improvements in forecasting capabilities and more effective resource targeting.

Organisational Function

Early results indicate that OWWL forecasts have delivered operational efficiencies to Offshore Shellfish Ltd. through being able to make better decisions about when to go to sea, and what activities can be achieved on a particular day.

> *"Prior to having the SWEEP-OWWL forecast we would have had a much wider response, a more reactionary response, or perhaps even not have responded at some of the key locations for wave overtopping"*
>
> **Nick Ely, Environment Agency Coastal Modelling & Forecasting Manager**

> *"This improvement in resource targeting [as a result of the OWWL model] will have saved the EA thousands of pounds during each of the six largest storms over the last two winters by being able to be more targeted in our working, and reducing unnecessary trips and deployments.."*
>
> **Nick Ely, Environment Agency Coastal Modelling & Forecasting Manager**

Chesil beach during a storm

Looking to the future

Demand for further applications of the SWEEP-OWWL model is growing and the team are currently developing a number of new projects:

- Delivering a bespoke OWWL model for South Wales with Natural Resources Wales and Welsh Coastal Monitoring.
- Developing a beach hazard forecast for Crantock, North Cornwall with the RNLI, National Trust, and Duchy of Cornwall.
- Initial collaboration with potential partners to develop a hydrodynamic forecasting service for the Isles of Scilly.
- Working with the Marine Energy Test Area (META) in Pembrokeshire, Wales to provide bespoke forecasts for marine renewable energy developers.

The team will continue to collaborate with the EA - following the initial success of the OWWL overtopping and coastal flooding forecast, and with Offshore Shellfish - tracking the operational benefits of their use of the bespoke Lyme Bay forecasts over the winter (2020/21).

Underpinning NERC Science

- NERC Strategic Highlght Topics grant: Physical and biological dynamic coastal processes and their role in coastal recovery (BLUE-coast) (consortium grant led by Liverpool NOC) - NE/N015525/1
- NERC Urgency grant: Impact of sequences of extreme storms during 2013/14 winter on South West coast of England - NE/M004996/1
- EPSCR grant: New understanding and prediction of storm impacts on gravel beaches (NUPSIG) - EP/H040056/1

About SWEEP

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For more information contact sweep@exeter.ac.uk

UKRI Natural Environment Research Council

Protecting the South Wales coastline - extending the impact of OWWL

sweep
Impact Summary

Drawing on the success of the first SWEEP Operational Wave and Water Level (OWWL) model developed for the Environment Agency, SWEEP's team - **Professor Gerd Masellink, Dr Tim Poate and Dr Kit Stokes from the University of Plymouth's Coastal Processes Research Group** - have developed a suite of additional bespoke, localised OWWL models for a variety of wider partners. The following impact summaries highlight the benefits being delivered, both for the public and private sector.

£300k new funding secured
2 jobs and contracts for **>5** survey companies

80 people and organisations benefiting from increased coastal forecasting capacity

Fast-tracked stakeholder engagement work by more than **>6** months

Ways of Working

Innovative Knowledge Provision — **Effective Collaboration** — **Capacity Building** — **Tailored Decision Support**

Why it mattered?

Overtopping and coastal flooding is a significant problem along the South Wales coast with an estimated 44,000 dwellings being at risk of coastal flooding.

Natural Resources Wales (NRW) is responsible for flood risk management in Wales, supported by key organisations such as the Welsh Coastal Monitoring Centre (WCMC).

WCMC is developing a strategic approach to coastal monitoring as part of the National Strategy for Flood and Coastal Erosion Risk Management (FCERM). It aims to identify the most vulnerable coastline locations, and strengthen management strategies through more robust risk based-decision making, underpinned by greater scientific evidence.

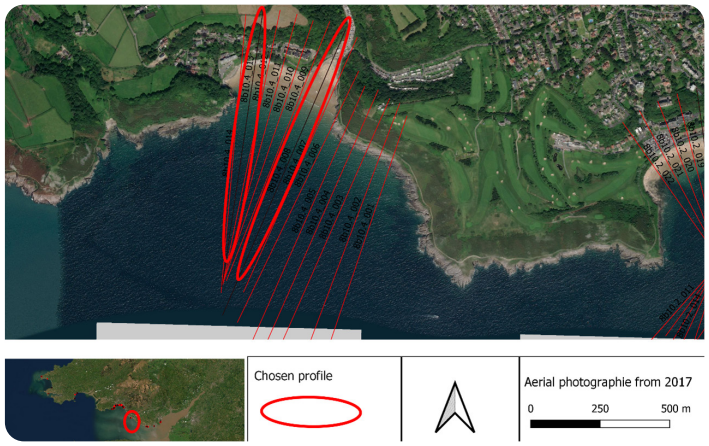
WCMC approached SWEEP to develop a bespoke Operational Wave and Water Level (OWWL) model for the South Wales coastline, taking advantage of the new topographic data available to them and the innovative OWWL science.

What we did

Working in close collaboration with WCMC, and wider beneficiaries such as NRW and local South Wales coastal authorities, the SWEEP team collated a new database of 30 coastal profiles, topographic data and sea-defence information for South Wales. This was used to feed a new bespoke version of the OWWL model that automatically generated daily wave overtopping forecasts for different areas along the South Wales coastline.

Alongside project partners, the team disseminated information and access to the OWWL model and forecasts, delivering direct training and support in their use, before monitoring and evaluating the usefulness, uptake and impact through partner interviews and feedback.

Caswell, Wales



Impacts & benefits delivered

Knowledge/Capacity

Delivered innovative knowledge and capacity: SWEEP's freely available forecasts deliver accurate 5-day in advance wave and water level data for the South Wales coastline, at a greater precision (1 km resolution) than previously available. Training, and awareness raising, has been delivered for more than 80 beneficiaries, resulting in more collaborative and effective ways of working in relation to tackling coastal flooding management.

Attitudinal/Capacity

Influenced attitudes and perceptions with key beneficiaries:

- **Welsh Coastal Monitoring Centre (WCMC)** – building consensus for more specific, localised coastal hazard forecasting, as well as a more joined-up national forecasting approach for Wales.
- **Natural Resources Wales (NRW)** – stimulated new thinking about how cutting-edge science approaches such as OWWL could be used to strengthen national policies and practice for coastal flooding forecasting in Wales.
- **Coastal flood managers** – OWWL forecasts are now a key part of the 'go-to' best practice drawn on to improve decision making and mitigate the impact of coastal overtopping.

Organisational Function

Strengthened various aspects of WCMC's work e.g.:

- OWWL forms a key part of WCMC's suite of innovative science-based coastal monitoring tools, which has enabled the centre to demonstrate the value of its work and secure further funding.
- Enabled WCMC to better support coastal authorities with more localised, accurate forecasting data, leading to more effective coastal management decisions that enhance coastal safety, and reduce damage, disruption, and costs. See Vale of Glamorgan OWWL case study.
- New, stronger, regional and national networks of stakeholders working more collaboratively to tackle coastal hazards.
- Informing and strengthening the future direction of WCMC's work through better understanding and prioritisation of areas most at risk along the South Wales coastline.

Policy & Legislation

Natural Resources Wales recognise the value of OWWL and the opportunities SWEEP's forecasts provide for improvements in coastal flooding safety and cost-savings.

Financial & Economic

Contributed to WCMC successfully leveraging £300k over 5-years to extend its work, supporting 2 FTE jobs and employment contracts for more than 5 survey companies per year.

> *"Without SWEEP WCMC absolutely wouldn't have been able to offer local coastal authorities this brand new product and approach to accurately and timely deliver site specific local overtopping forecasts and alerts."*
>
> **Gwyn Nelson, Welsh Coastal Monitoring Centre Programme Manager**

> *"I use the SWEEP OWWL forecast frequently and find it valuable not only for corroborating other sources, but sometimes serving as the best early warning system for hazardous wave and water conditions. This will have a significant impact on improving preparedness for big flood events."*
>
> **John Buttivant, Chair of Severn Estuary Coastal Group**

Waves crashing at Caswell Bay Beach

> *"The collaboration with SWEEP and the extension of the OWWL model to South Wales was invaluable in helping WCMC showcase what the centre could do in terms of delivering added value around coastal flooding management data. We're delighted that this has contributed to funding success with our next five year phase."*
>
> **Gwyn Nelson, Programme Manager WCMCGroup**

> *"I believe the modelling approach taken by SWEEP OWWL would be considered to inform any future wholescale review of NRW's coastal forecasting model."*
>
> **Neil Counsell, Specialist Advisor, Flood forecasting NRW**

Coastline at Caswell, Wales

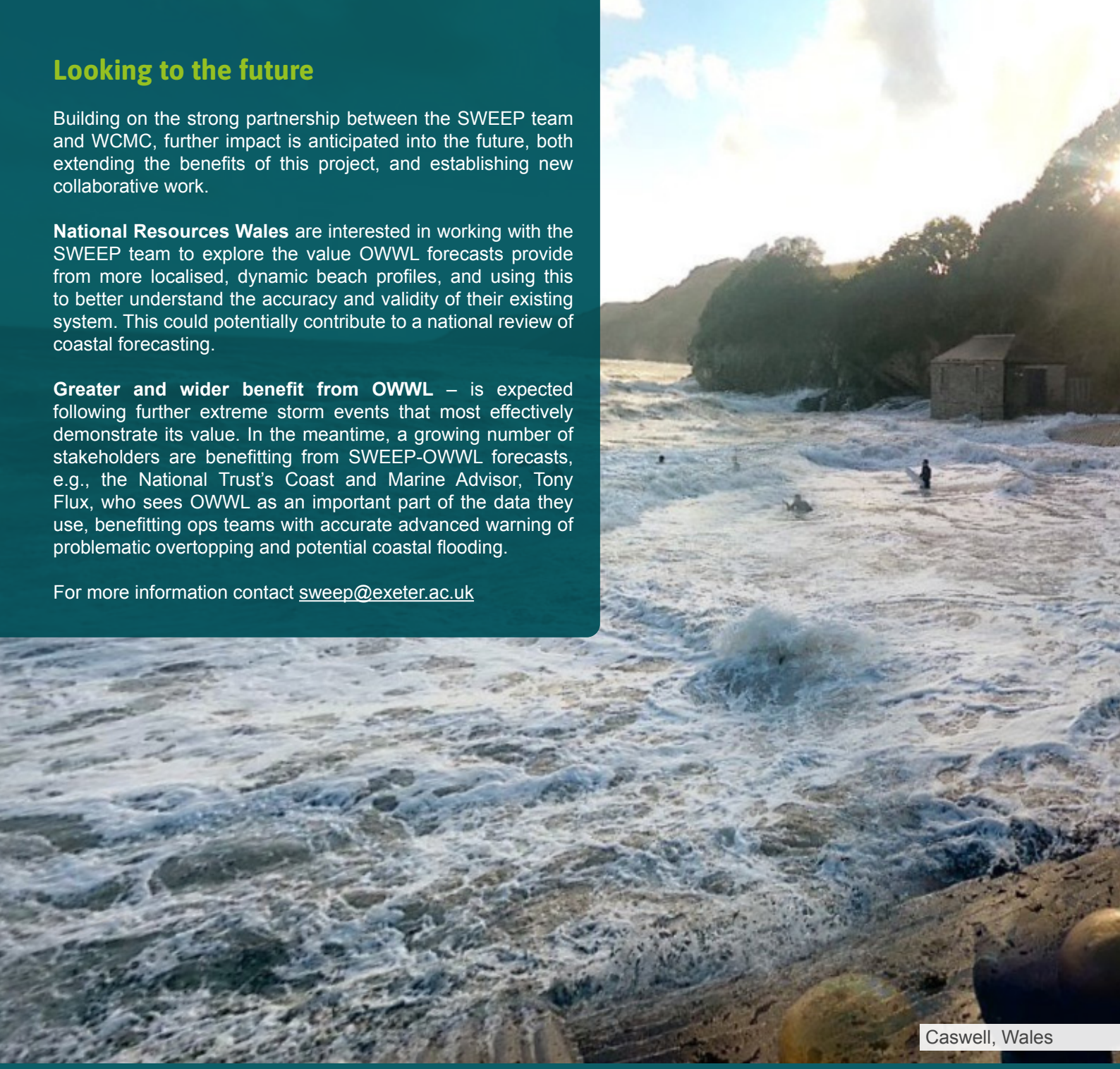
Looking to the future

Building on the strong partnership between the SWEEP team and WCMC, further impact is anticipated into the future, both extending the benefits of this project, and establishing new collaborative work.

National Resources Wales are interested in working with the SWEEP team to explore the value OWWL forecasts provide from more localised, dynamic beach profiles, and using this to better understand the accuracy and validity of their existing system. This could potentially contribute to a national review of coastal forecasting.

Greater and wider benefit from OWWL – is expected following further extreme storm events that most effectively demonstrate its value. In the meantime, a growing number of stakeholders are benefitting from SWEEP-OWWL forecasts, e.g., the National Trust's Coast and Marine Advisor, Tony Flux, who sees OWWL as an important part of the data they use, benefitting ops teams with accurate advanced warning of problematic overtopping and potential coastal flooding.

For more information contact sweep@exeter.ac.uk



Caswell, Wales

Organisation we worked with

WCMC
Wales Coastal Monitoring Centre

Underpinning NERC Science

- NE/N015525/1 - Physical and biological dynamic coastal processes and their role in coastal recovery (BLUE-coast)
- NE/M004996/1 - Impact of sequence of extreme storms during 2013/14 winter on South West coast of England
- EP/H040056/1 - New understanding and prediction of storm impacts on gravel beaches (NUPSIG)

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UKRI Natural Environment Research Council

Strengthening business decision making - OWWL forecasting for Offshore Shellfish Ltd., Lyme Bay, Devon

sweep

Impact Summary

Rope grown mussels

Drawing on the success of the first SWEEP Operational Wave and Water Level (OWWL) model developed for the Environment Agency, SWEEP's team - **Professor Gerd Masellink, Dr Tim Poate and Dr Kit Stokes from the University of Plymouth's Coastal Processes Research Group** - have developed a suite of additional bespoke, localised OWWL models for a variety of wider partners. The following impact summaries highlight the benefits being delivered, both for the public and private sector.

A bespoke **localised**, forecast for Lyme Bay delivering **finer resolution data** for decision making

Vital learning strengthening wider OWWL work, including **2** new projects

Ways of Working

Innovative Knowledge Provision — **Tailored Decision Support**

Why it mattered?

Offshore Shellfish Ltd (OSF) in Lyme Bay, Devon, is the UK's largest offshore rope cultured mussel farm. The production of mussels offers an environmentally-friendly, sustainable source of high-quality seafood that also contributes important natural capital services such as carbon capture and wildlife protection.

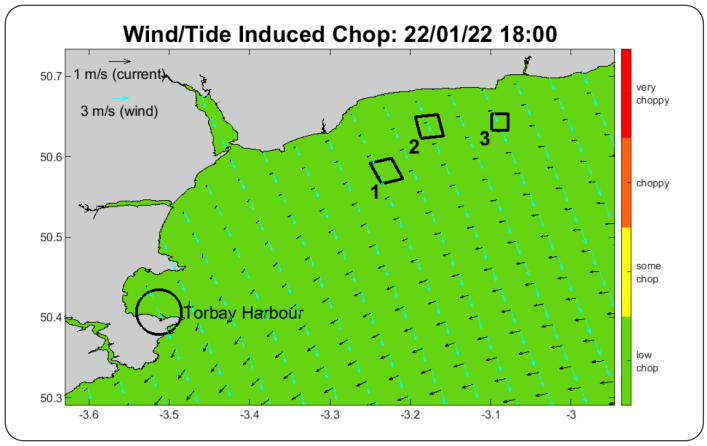
The mussel farms in Lyme Bay are frequently exposed to high wind and waves; conditions that limit the proximity of vessels alongside the suspended ropes of mussels that are easily dislodged. This can limit business operations, impacting on profit and loss, so accurately predicting these conditions is vital to making correct 'go/no-go' decisions for vessels heading out to the farm.

OSF approached SWEEP to develop a bespoke Operational Wave and Water Level (OWWL) model that provided more nuanced sea conditions, enabling better, more cost-efficient, operational decisions about whether to go to sea to harvest in rough sea conditions.

What we did

Working with John and George Holmyard, the Managing Director and Head of Operations at OSF, the SWEEP team developed:

- A bespoke version of the SWEEP OWWL model.
- Automated, bespoke, co-designed high-resolution (1 km) forecasts of sea conditions most problematic to OSF's operations.
- A monitoring system to evaluate the use and value of the forecasts.



Lyme Bay Mussel Farm, photo credit: Ross Brown

Impacts & benefits delivered

Various factors limited the immediate and direct impact of this project. A key factor was the unreliability of the Met Office data feeding the forecasts, which resulted in these arriving sporadically with OSF, reducing confidence in their use. A change in personnel at OSF, and external business issues, also impacted on levels of project engagement and impact.

Knowledge/Capacity

Delivery of a new, bespoke, co-created OWWL model: SWEEP forecasts arrived automatically with OSFs at 1km resolution (finer resolution than was available to OSF at the time), including forecast elements specifically important to them, e.g., wind and wave chop.

Application of lessons learnt, strengthening new projects: the key impact of this work has been the invaluable learning about the processes and resources required to effectively transfer this type of cutting-edge academic know-how into real-world solutions. This has strengthened the team's wider OWWL work in Plymouth Sound (with the Marine Institute) and East Pickard Bay, Pembrokeshire (with Bombora Wave Energy's Wave Energy Converter).

> *"When the OWWL model was available it was able to provide a finer detailed forecast and a map of the weather which was entirely down to SWEEP."*
>
> **George Holmyard, Head of Operations, OSF**

Lyme Bay Mussel Farm, photo credit: Ross Brown

Looking to the future

OSF are keen to continue collaborating with the SWEEP team to refine the OWWL forecasts and enable more consistent operational 'go'/'no-go' decisions on whether to go to sea for mussel harvest. It is anticipated this will result in more productive days at sea leading to increased sales, reduced costs from fewer wasted journeys, improved safety for workers and more accurate assessment of locations suitable for new offshore mussel farms.

Learning from this project has already strengthened other OWWL projects, demand for which, continues to increase. The OWWL model data feed has been switched to the more stable Copernicus Marine data (CMEMS) and improvements have been made to ensure more effective co-creation, delivery and embedding of localised OWWL forecasts within partner organisations.

> *"The forecasts provided by OWWL were a useful tool to check against existing forecasts. The forecast did prove to be more accurate than existing forecasts on several occasions but was not the deciding factor in going to sea. Had we had a long run of uninterrupted forecasts then we would have been more confident in using the forecast as the deciding tool."*
>
> **George Holmyard, Head of Operations, OSF**

Organisation we worked with

offshore shellfish ltd

Underpinning NERC Science

- NE/N015525/1 - Physical and biological dynamic coastal processes and their role in coastal recovery (BLUE-coast)
- NE/M004996/1 - Impact of sequence of extreme storms during 2013/14 winter on South West coast of England
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UKRI Natural Environment Research Council

Strengthening the wave energy sector - OWWL forecasting for Bombora Wave Energy, Pembrokeshire, Wales

sweep

Impact Summary

Drawing on the success of the first SWEEP Operational Wave and Water Level (OWWL) model developed for the Environment Agency, SWEEP's team - **Professor Gerd Masellink, Dr Tim Poate and Dr Kit Stokes from the University of Plymouth's Coastal Processes Research Group** - have developed a suite of additional bespoke, localised OWWL models for a variety of wider partners. The following impact summaries highlight the benefits being delivered, both for the public and private sector.

Contributing to the operational success of **£20m** wave energy convertor

5-days-in-advance localised wave forecasts enhancing decision-making

Informing delivery of anticipated **5%** of UK's 2050 installed wave energy target

Ways of Working

Innovative Knowledge Provision — **Tailored Decision Support**

Why it mattered?

With global electricity demand expected to double by 2050, and estimates that the sea will deliver 10% of this, Wave Energy Converters (WECs) are set to play a key role in helping to meet this demand. Despite the opportunities for a potential $141.1m market by 2027, progress with wave energy has been slow to date, partly due to poor survivability of wave technologies.

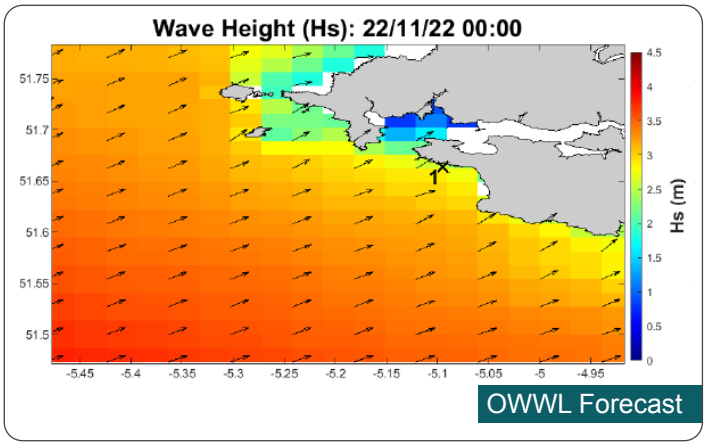
Bombora Wave Energy, is one of only a small number of companies still actively developing WECs. Since 2018 it has been constructing the world's first, full-scale flexible membrane style WEC in Pembrokeshire, Wales; the first WEC ever to be deployed in the SW of the UK. Achieving proof of concept, will lead to a significant breakthrough, and investment opportunity.

With four enormous flexible membranes, worth over £200k each, Bombora's WEC is susceptible to costly damage during high sea states, particularly with waves more than 4.5m in height. Bombora approached SWEEP to develop a version of their Operational Water and Wave Level (OWWL) model to generate bespoke forecast data for the deployment site, enabling more proactive and cost-effective operational decision making.

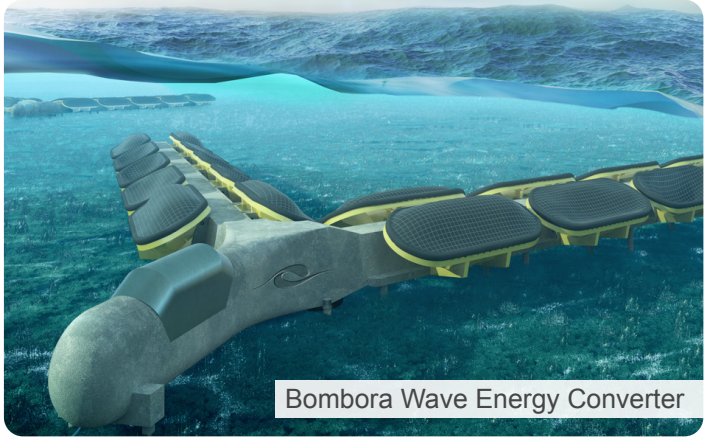
What we did

Working closely with Bombora Wave Power, the SWEEP team delivered:

- **A bespoke OWWL model** for Bombora's deployment site (East Pickford Bay, Freshwater, Pembrokeshire) driven by Copernicus Marine Environment Monitoring Service (CMEMS) data, operating independently in forecast mode and fully calibrated and validated.
- **Daily forecast reports** on hydrodynamic parameters in East Pickford Bay, generated and delivered automatically to Bombora and including wave height, wave power thresholds and alerts.



OWWL Forecast



Bombora Wave Energy Converter

Impacts & benefits delivered

Due to delays in Bombora's WEC deployment, much of the expected SWEEP impact has yet to be evidenced, but is still anticipated by our partner.

Knowledge/Capacity

New information, knowledge and capacity building: SWEEP's bespoke OWWL model is providing more site-specific, localised, higher spatial resolution forecasts for the deployment site than was previously available to Bombora. This data forms a key component of the approach to accurately and timely predict, and respond, to wave conditions in East Pickford Bay; critical for the WEC success.

Organisational function

Cost-savings on SWEEP vs an external consultant to produce these forecasts. SWEEP delivered additional value through the provision of ongoing data throughout the deployment period (as opposed to just specific weather windows) and ensuring this arrived in advance and was tailored to Bombora's needs.

Looking to the future

In anticipation of WEC deployment, our partner confirms they expect significant impact will be delivered over the next 6-12months (during 2023).

- **Strengthening decision making and planning** – using SWEEP's forecasts to strengthen planning particularly around:
  - WEC experiments - part of the commissioning process.
  - The WEC launch - as membranes are inflated.
  - The back-up process for WEC shut-down - either in the event of an automatic shut-down failure and/or as a precautionary action when large sea states are expected.
- **Financial and economic benefits** – material and repair costs-savings will be realised by minimising WEC membrane damage. Additionally, greater profits will be delivered by avoiding interruptions to WEC energy production: estimated to be 1 GW per hour, per year. Successful proof of concept is expected to unlock investor confidence in wave energy production machines such as Bombora's WEC, and through their ongoing involvement, SWEEP will contrite to the economic benefits associated with delivering the UK's 2050 target of 22 GW of installed wave energy capacity.
- **Extending benefits to other Bombora projects** – as well as to the wider wave energy industry – Peter Arnold, Head of Loads and Modelling, Bombora Wave Power told us *"SWEEP's approach of developing forecast outputs, fed from publically available CMEMS data and formatted in a way that's useful to a WEC developer, is of great value to the wave energy sector as a whole"*.

> *"SWEEP forecasts allow us to plan experiments on the WEC demonstrator in advance, and react more quickly when we need to shut down the machine in the event of live sea states; two factors key to the success of the project."*
>
> **Peter Arnold, Head of Loads and Modelling, Bombora Wave Power**

> *"The real benefit of SWEEP's work is the cost savings by helping to prevent wave damage to this £20m machine. We can't get that wrong - even if one membrane ruptures, we have to replace the cell module, and if all four membranes are lost, the project will have no value at all. So stopping damage in the first place is really key."*
>
> **Peter Arnold, Head of Loads and Modelling, Bombora Wave Power**

Organisation we worked with

bombora

Underpinning NERC Science

- NE/N015525/1 - Physical and biological dynamic coastal processes and their role in coastal recovery (BLUE-coast)
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Enhancing South African coastal management and beach safety through improved hazard forecasting

sweep

Impact Summary


South African Weather Service (SAWS)

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Ways of Working

What we did and its impacts

SWEEP's OWWL work directly provided the method and helped to secure Newton funding for this project, enabling the transfer of expertise on coastal forecasting applications to the South African Weather Service (SAWS). A version of SWEEP's Operational Wave and Water Level (OWWL) model was created for the Cape Town coastline to trial the use of an overtopping forecast that would improve forewarning of potentially hazardous storm events, and safeguard coastal communities. SAWS have coded the system into their operational routines and further monitoring will determine how forecasts are being used to support better decision making.

As part of this project, the SWEEP team also delivered a pilot rip current forecast system for Cape Town. Based on earlier NERC funded research on rip currents (2008-2013) under the 'Dynamics of Rips and Implications for Bather Safety' (DRIBS) project, this tool has been operationally implemented by SAWS and used by the National Sea Rescue Institute to generate public-facing rip warnings - see video.

The system has many parallels with the forecasting and hazard warning approach used by the SWEEP team in their 025 Crantock Beach hazard safety project.

> *"The project will most definitely help contribute to safer beaches in Cape Town specifically, and South Africa in general, once the rip forecast model has been validated and released."*
>
> **Andrew Ingram, Drowning Prevention Manager, National Sea Rescue Institute**

> *"This work has enabled South African researchers, scientists and organisations to expand their knowledge, skill and ability to better inform our communities regarding their beach safety. SAWS anticipates including the rip hazard warnings into daily forecasts for the Cape Town summer season and holiday periods and , over time, will expand to include as much as possible of the coastline around South Africa."*
>
> **Carla-Louise Ramjukadh, Scientist in charge of coastal forecasts, South African Weather Service**

Organisations we've worked with

South African Weather Service

CITY OF CAPE TOWN
ISIXEKO SASEKAPA
STAD KAAPSTAD

NATIONAL SEA RESCUE INSTITUTE

Underpinning NERC Science

- NE/N015525/1 - Physical and biological dynamic coastal processes and their role in coastal recovery (BLUE-coast)
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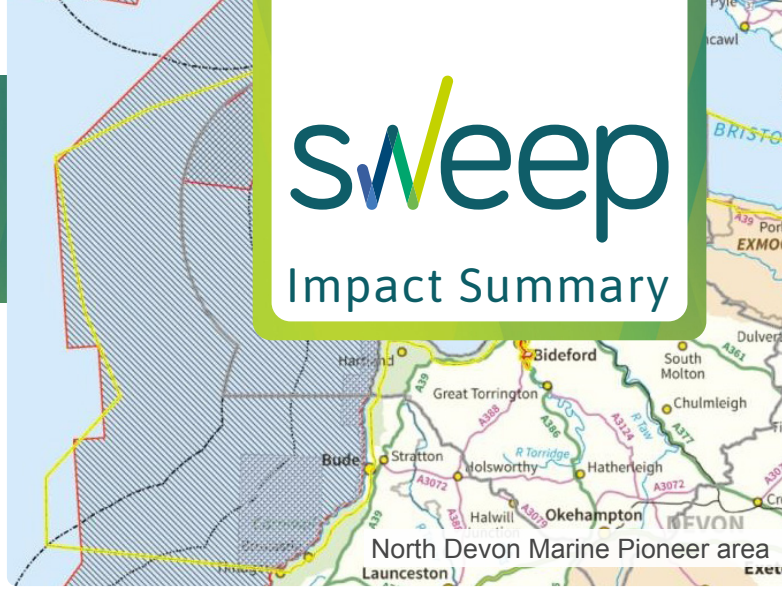
Strengthening the climate change science behind marine planning to deliver economic, social, and environmental benefits to the South West

sweep

Impact Summary

In Phase 1 of this project, SWEEP directly informed the UK government's approach to marine management through its role in delivering the North Devon, Marine Pioneer. Central among the wide range of stakeholders involved, the team provided the scientific underpin for the novel tools and approaches produced to test the natural capital approach for marine systems.



North Devon Marine Pioneer area

Collaborative engagement with **120** individuals and **60** marine organisations in the South West

Essential delivery partner in Defra's Pioneer programme as part of the 25YEP - the UK's **1st** Marine Natural Capital Plan

Provided scientific underpin for **12** innovative marine policies and approaches - including WWF's Blue Impact Fund

Ways of Working

Innovative Knowledge Provision → Effective Collaboration → Capacity Building → Tailored Decision Support → Natural Capital Valuation

Why it mattered?

The region's marine sector supports over 29,000 jobs and contributes direct impact Gross Value Added (GVA) of £1.4bn and aggregate GVA (including sector multipliers) of £3.6bn[1]. The marine environment influences the region's culture, shapes coastal communities and benefits human health and wellbeing. Marine habitats have the potential to mitigate climate change by storing carbon, supporting sustainable marine industries and underpinning a blue economy. However, this marine's natural capital, with a national estimated value of £211bn[2], is threatened by human activities, population growth and climate change.

The UK government's 25 Year Environment Plan aims to improve the environment by adopting a natural capital approach, encompassing a longer-term, more holistic approach than in previous policies. Four Pioneer Projects, including the North Devon Marine Pioneer, were established in 2016 to develop guidance around how a natural capital approach could be applied to a specific geographical area in order to best manage it for the benefit of the environment, economy and people. The Pioneer explored a range of management topics such as joining-up planning and delivery, exploring novel funding mechanisms and sharing lessons[3].

What we did

In 2017, Prof. Mel Austen along with Prof. Martin Attrill, Dr Sian Rees, Dr Matthew Ashley and Tom Mullier from the University of Plymouth's Marine Institute began work with key project partners (Detra, Marine Management Organisation, North Devon Biosphere Reserve, World Wildlife Fund, Natural England, Devon & Severn Inshore Fisheries and Conservation Authority and the Devon Local Nature Partnership) to support the delivery of the North Devon Marine Pioneer.

The SWEEP team co-developed three novel natural capital assessment tools and approaches:

1) Natural Capital Asset and Risk Register - a 'first of its kind tool' for the marine environment. The Natural Capital Asset and Risk Register was developed to document the extent and condition of natural capital assets, and stocks and flows of ecosystem services in the North Devon Marine Pioneer. It was used to identify threats to key natural capital assets and recommend optimal future management strategies. Development of this tool was preceded by the Geodatabase which consolidated existing economic, social and environmental data for the area to develop indicators for evaluating impact, natural capital, ecosystem services and benefits.

2) Innovative framework for integrating Natural Capital into Sustainability Appraisals. In direct response to stakeholder requests, the team developed a framework and guidance for incorporating the natural capital approach into Sustainability Appraisals - a legal requirement for planning authorities. They created a preliminary assessment for the North Devon Marine Natural Capital Plan and demonstrated that it could enhance methods for assessing impacts on natural capital assets and ecosystem services.

3) Options for application of a marine 'net gain' approach to planning. The 25YEP seeks to embed 'biodiversity net gain' within planning -a requirement that will feature in the forthcoming Environment Bill, but only for terrestrial developments. The team generated recommendations on how the 'net gain' principle could be applied to the marine environment for both biodiversity specifically, and natural capital and ecosystem services more widely.

1 The economic contribution of the UK Maritime Sector. Cebr report (Apr 22).
2 Marine accounts, natural capital, UK (2021)
3 MMO Guidance: Marine Pioneer project, updated 17 January 2019

Impacts & benefits delivered

Attitudinal/Capacity

Enhanced marine stakeholder engagement and changing perceptions: The team's approach to stakeholder engagement connected over 120 individuals from 60 organisations. building social capital between academics and stakeholders which, in turn, positively influenced attitudes towards using natural capital approaches to inform marine management decisions.

> *"SWEEP helped (us) to develop (our) perception and use of natural capital approaches and increased... consideration of social and economic data (in fisheries management)."*
>
> **James Stewart, Devon & Severn IFCA**

Policy & Legislation

Influenced marine policy and implementation nationally and in North Devon: SWEEP accelerated the delivery of the North Devon Marine Pioneer Programme and provided the underpinning evidence to many of its recommendations. This pioneering application of the natural capital approach in North Devon, underpinned by the Natural Capital Asset and Risk Register, is informing implementation of the UK government's 25YEP and decision-making in the North Devon Biosphere Reserve, a UNESCO World Heritage site.

> *"Without going on that journey with SWEEP and the decision-makers, I don't think we would have reached the point of thinking about having a Marine Natural Capital Plan."*
>
> **Aisling Lannin, Marine Management Organisation**

> *"SWEEP provided the gold-standard for how to create an ecological and socio-economic baseline for an MPA."*
>
> **Sarah Young, WWF**

Delivered innovation in Marine Protected Area (MPA) management and funding: Working alongside the WWF UK Seas Project - which seeks to improve management of MPAs - SWEEP directly contributed to development of the Compass tool, designed to assess the effectiveness of MPAs. Following successful application in North Devon, the Compass was rolled out for use in the UK and overseas. SWEEP also informed WWF's work on Sustainable Financing Mechanisms for MPAs which led to development of the Blue Impact Fund, a new approach seeking to catalyse investment in MPAs.

Strengthened inshore approaches to sustainable fisheries management: SWEEP's Asset and Risk Register provided robust scientific evidence to inform Devon and Severn IFCA activities and MMO licensing decisions. providing additional leverage to promote a more holistic ecosystem-based approach to marine decision making. It is anticipated that SWEEP outputs will also strengthen the North Devon 'Fisheries Research and Management Plan'. SWEEP's work also enabled the Isles of Scilly IFCA to trial a new approach to fisheries management, where decisions are based on a wider understanding of benefits from natural capital and impacts under different fisheries management scenarios.

Developed methods to incorporate natural capital into marine planning: SWEEP developed an innovative framework for incorporating a natural capital approach into Sustainability Appraisals bringing existing planning systems in line with government ambitions. Streamlined reporting within impact assessments ensures the natural capital of an area - at strategic and site levels - is properly valued and considered in planning decisions, and environmental improvement ambitions are realised.

Looking to the future

The SWEEP team continues this pioneering work by:

- Creating further opportunities for integrating marine natural capital into plans and policies;
- Piloting and refining the Sustainability Appraisal framework and expanding its use into marine Net Gain and environmental impact assessment;
- Supporting Cornwall Council to develop key performance indicators for marine natural capital;
- Developing options for Sustainable Fisheries and certification schemes;
- Exploring sustainable recreation futures linked to green/blue natural capital.

> *"...over coming years the UK intends to use a 'natural capital' approach as a tool to help us make key choices and long-term decisions.."*
>
> **25 Year Environment Plan, page 19**

Underpinning NERC Science

- NE/L003279/1 - Marine Ecosystems Research Programme

Other funding bodies

European Union (Framework Programme 7 and INTERREG), Natural England, Department for Environment, Food and Rual Affairs, Blue arine Foundation, World Wildlife Fund, Devon & Severn Inshore Fisheries & Conservation Authority, European Maritime & Fisheries Fund, and Marine Conservation Society

For more information contact sweep@exeter.ac.uk

About SWEEP

The South West Partnership for Environmental & Economical Prosperity (SWEEP) is a partnership between the University of Exeter, the University of Plymouth, and Plymouth Marine Laboratory. Funded by the Natural Environment Research Council and stakeholders together to solve key challenges faced by those working with our natural resources. **www.sweep.ac.uk**

UKRI Natural Environment Research Council

Enhancing seafood labelling schemes that support sustainable fishing practices

sweep

Impact Summary

Mevagissey Harbour, Cornwall

SWEEP's research has strengthened Cornwall Wildlife Trust's Cornwall Good Seafood Guide. This provides new opportunities for local fishermen in Cornwall and contributes to its vision of a more sustainable marine environment.

1 new Marine Advisor job supported by **£20k** leveraged funding

22 Cornish fishers interviews, and **335** consumer surveys

5 evidence-based recommendations being implemented by **Cornwall Wildlife Trust**

Ways of Working

- Innovative Knowledge Provision
- Effective Collaboration
- Capacity Building
- Tailored Decision Support

Why it mattered?

The seafood industry is worth almost £100m to the Cornish economy with more than £30m of fish landed every year in Newlyn alone. Seafood labels (or certification) schemes can play a key role in promoting more sustainable fishing practices, by allowing consumers to choose to purchase products that are produced more sustainably.

The increased demand for sustainable seafood can also translate into direct benefits for local fishermen e.g. providing access to new markets, reducing tariffs and decreasing price variability. But with labelling schemes increasing, it is important to understand when and under which conditions food labelling schemes provide benefits for its members. Administered by Cornwall Wildlife Trust (CWT), the Cornwall Good Seafood Guide (CGSG) is one such scheme. Keen to assess the effectiveness of the CGSG, CWT approached SWEEP to help.

Key goal

Evaluate the benefits for fishers from participating in the CGSG and recommend improvements to maximise these benefits and enhance the CGSG scheme.

Credit: Matt Slater, CWT

What we delivered

A bespoke report containing 5 key recommendations:

1. Improve the clarity of the scheme's remit.
2. Increase the visibility of CGSG labelled catch by implementing stamp/ stickers that can be used to label catch.
3. Boost internal and external communication.
4. Expand the number of engaged food businesses and fishers by building stronger relationships with Cornish fishing organisations.
5. Strengthen the CGSG network and create opportunities to foster connections and networking between members.

What we did

During 2019-2020, two key data collection mechanisms were employed. Firstly, Cornish fishers were interviewed to collect data about their fishing activities, and opinions regarding the CGSG and other labelling schemes. Fishers both participating and not participating in the scheme were interviewed and the data were analysed using thematic analysis.

Secondly, a survey aimed at seafood consumers was run over three weeks in January 2020 to understand public attitudes towards labelling schemes. The results fed into a report by Rose Regeneration, informing their evaluation of and recommendations for the CGSG.

> *"Getting the fisher's opinions from SWEEP was really helpful, especially as they could be completely honest with Océane as an independent academic. I don't think we would have had the same response if we'd conducted it ourselves."*
>
> **Cornwall Wildlife Trust**

Impacts & benefits delivered

Organisational Function

Underpinned a successful funding bid for £20k to appoint a part-time Fisheries Adviser to deliver the Wilder West Project. The Wilder West Project was established to deliver the recommendations of the SWEEP report. Since October 2021 Abby Masterson has been in this post at CWT, developing collaborative relationships with fishers in the Fal and Mevagissey area of Cornwall. She has also been promoting sustainable fishing practices through targeted workshops, discussions and collaborations.

CWT also have made changes to the CGSG based on the following additional recommendations from the SWEEP work.

- An online registration form had been created as a formal framework for fishers to sign up to the scheme, helping to create a stronger association and connection with the project. A further two fishermen have been signed up.
- Plans are in place to implement a stamp / sticker scheme that fishers can use to label their boxes.
- CGSG is receiving additional specialist support from CWT to realise the SWEEP recommendation to target more primary buyers and food businesses to join the scheme.
- Part-time fishers in the Falmouth estuary that do not have a satisfactory direct market have been identified for discussions around improved direct sales.

> *"The report was invaluable in helping us get the project accepted as a core piece of work within the Trust. It enabled us to go down that route of employing someone to take on a one-on-one advisory role. We're focussing on one area for now, as a kind of trial, but hopefully will roll out to a wider area over time."*
>
> **Cornwall Wildlife Trust**

> *Océane's consumer data was really useful, it gave us a perspective on the level of impact of the CGSG in terms of influencing behaviour. It enabled us to develop recommendations that they think in a more proactive way about the way their publication seeks to interact with the public and how further downstream it affects people's behaviours."*
>
> **Ivan Annibal, Rose Regeneration**

Looking to the future

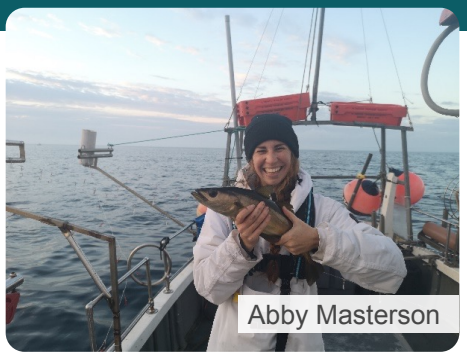
Further research is being explored to build on this work. Descriptive statistics have already been developed on the first set of data, but there is opportunity and value in conducting further analysis to inform the future development of fisheries management tools, including, but not limited to, the CGSG.

The public survey was live in January 2020, before COVID-19, Brexit and the rapid increase in the cost of living. It would be beneficial therefore, to repeat the process to draw before/after comparisons and understand if, and how, seafood consumption patterns have evolved following these major changes.

Wider application

As well as targeted local recommendations and impact, the report established three key criteria to inform other groups when deciding on the right scheme for a given fishery and its end market:

1. The economic, social, institutional, and environmental benefits retrieved by the fishermen need to exceed the burden of being part of it.
2. A minimum degree of institutionalisation is needed: the criteria of the scheme (who is in, who is not, what are the goals of the scheme) must be clear.
3. The scheme needs to meet the market demand (primary buyers and/or final market).


Abby Masterson


Credit: Matt Slater, CWT

Organisations we've worked with

Cornwall Wildlife Trust

CORNWALL GOOD SEAFOOD GUIDE

For more information contact sweep@exeter.ac.uk

About SWEEP

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UKRI Natural Environment Research Council

Pioneering marine Natural Capital Approaches to enable a new way of considering, valuing and managing the marine environment in the South West and beyond

sweep
Impact Summary

SWEEP has collaborated with multiple partners in the South West of the UK, to co-create innovative tools and approaches that are changing the way the marine environment is managed. This impact summary showcases the full 5-year SWEEP marine project, which builds on and encompasses Phase 1 work.

17 governance policies and programmes strengthened

£50m new funds and investments influenced; **£28m** more anticipated

New marine Natural Capital approach engendered; embedded within:
6 **partner** organisations
3 European Marine sites

Ways of Working

Innovative Knowledge Provision | Effective Collaboration | Capacity Building | Tailored Decision Support | Natural Capital Valuation

Why it mattered?

The marine environment is an incredibly diverse biological resource providing a wide range of benefits and services to society. It supports more than 29,000 jobs in the South West region and delivers direct impact Gross Value Added (GVA) of £1.4bn and aggregate GVA (including sector multipliers) of £3.6bn[1]. The marine environment influences the region's culture, shapes coastal communities and benefits human health and wellbeing. Marine habitats have the potential to mitigate climate change by storing carbon, supporting sustainable marine industries and underpinning a blue economy. However, this marine's natural capital (NC), with a national estimated value of £211bn[2], is threatened by human activities, population growth and climate change.

With increasing government investment and policy aiming to better protect and manage the marine environment, the SWEEP marine team have pioneered a new holistic approach to marine management, for the first-time producing asset and risk registers of marine habitats in their current conditions to strengthen decision making at local and national level. This science-backed Natural Capital approach enables a whole ecosystem view that considers the functioning of the marine environment and all of the environmental, economic and societal assets and services it provides.

Defra set up its Marine Pioneer Programme to test approaches to delivering the 25 Year Environment Plan (25YEP), specifically testing of new tools and methods as part of applying a natural capital approach in the marine environment.

SWEEP tools and services facilitated the success of this new approach, underpinning the outcomes and recommendations the Pioneer produced. The Pioneer programme and its SWEEP work fed directly into the UK Government's marine Natural Capital Ecosystem Assessment, providing foundational evidence for the approach going forward.

SWEEP outputs underpinned the World's 1st Marine Natural Capital Plan, designation of the UK's first World Surf Reserve and fed directly into the development of fisheries management plans for North Devon, which are now informing national processes. The tools were replicated in other areas, including two other European Marine Sites, and informed the development of the UK's 1st National Marine Park. Application of SWEEP outputs to fisheries underpinned legal protection of 304km^2 of seabed to restore kelp forest and provided key evidence for an Isles of Scilly byelaw review.

SWEEP has continued to inform academic publications and project design, such as through the £6.5m Stronger Shores project in the North East, as well as national level programmes. Hence, the impact of SWEEP will continue for some time with long-term implications for marine policy, practice and investment.

1 The economic contribution of the UK Maritime Sector. Cebr report (Apr 22).
2 Marine accounts, natural capital, UK (2021)

What we did

During phase 1 (Feb 2017 - March 2019), SWEEP provided the scientific underpin for the North Devon Marine Pioneer (NDMP) Key to this success was the co-development of 3 novel assessment tools and approaches: the NC Asset and Risk Register (the first published example of a methodology for an asset register developed in the context of English marine policy), a framework for integrating NC values into sustainability appraisals, and options for the application of marine net gain.

During phase 2 (April 2019 – Dec 2022) the SWEEP team – Dr Sian Rees, Dr Matthew Ashley, Prof Mel Austen, Prof Martin Attrill and Tom Mullier (University of Plymouth) – built on this success by applying and extending the impact of their tools and methods both within the North Devon Biosphere Reserve (NDBR) and to other regions in the South West. Working with the NDBR, SWEEP outputs, particularly the Geonode and Asset & Risk Register were used to co-produce the UK's 1st Marine Natural Capital Plan (MNCP). Additional funding enabled the team to develop detailed business cases relating to Blue Carbon, Aquaculture and no-take and harvest, to guide strategic development and planning towards a blue economy.

For the first time, a natural capital approach was taken to develop a sustainability appraisal and applied to the MNCP with the methodology shared through a public report. A peer-review paper was produced on 'Developing policy and practice for marine net gain'. The principles were applied to a case study to test the applicability of offshore wind farm ecological monitoring data to net gain and natural capital frameworks and the treatment of socio-economic issues within environmental impact assessment for offshore wind to provide lessons for the future application of natural capital and net gain frameworks.

Working with the Inshore Fisheries and Conservation Authority (IFCA) on the Isles of Scilly, SWEEP developed a Natural Capital Asset and Risk Register to Inform Management of Isles of Scilly Fisheries Resources. Alongside this, 'An evaluation of the social and economic impact of a Marine Protected Area on commercial fisheries' was published to provide insight into the spatial use and economic performance of a fishery, and linked fisher wellbeing across economic, social and health domains, over a 12-year timescale pre- and post-Marine Protected Area (MPA) designation.

SWEEP NC approaches were integrated into management plans on the Exe (through a report on 'Enabling an Ecosystem Service and Natural Capital Approach') and Tamar Estuaries and the emerging governance framework for the Plymouth Sound National Marine Park. In Cornwall,

Plymouth Sound National Marine Park

Puttsboroughbeach, North Devon

working closely with Cornwall and Isles of Scilly Local Nature Partnership (CIoSLNP), the Marine Liaison Committee and Cornwall County Council, SWEEP co-defined a marine Nature Recovery Strategy.

Beyond the region, SWEEP collaborated with: Sussex IFCA to undertake a NC assessment as part of a trawling byelaw review; Tyneside Council to integrate SWEEP learning into an outline business case for a six year coastal resilience project on the North East Coast; the Yorkshire Marine Nature Partnership to develop understanding of NC.

At a national scale, SWEEP produced guidance on 'Developing policy and practice for marine net gain' that has directly contributed to the development and delivery of the UK Government's marine Natural Capital and Ecosystem Assessment (mNCEA) programme, advising the lead delivery bodies (e.g., MMO, Defra, EA) on the planning of evidence collection to integrate the NC approach. SWEEP continued to input to emerging plans for a sustainable finance mechanism and a Blue Impact Fund; and contributed to public outreach including WWF films and a Blue Carbon artist in residence.

At an international scale, SWEEP contributed to 'A report for Ascension Islands-Natural Capital Assessment' and embedded SWEEP methods into the £5.8m Blue Communities project, funded from the UK Government's Global Challenges Research Fund.

Contributing to SWEEP's influence has been the significant roles key researchers and partners have performed e.g., Prof. Mel Austen was the first and only marine representative on the Government's Natural Capital Committee (NCC), feeding SWEEP knowledge into national level decision-making processes, and is Chair of the North Devon Biosphere Partnership. Dr Sian Rees is a member of the Cornwall and Isles of Scilly Marine Liaison group and the Heart of the SW local Enterprise Partnership.

At a national level SWEEP researchers contributed to the Defra Marine Natural Capital Ecosystem Assessment Advisory Group, Codeveloping marine net gain working group with Defra and the MMO, Defra Science Advisory subgroup: Biodiversity Targets, and the Environment Bill Targets workshops.

The team have produced more than 44 academic publications, including 'A marine natural capital asset and risk register - Towards securing the benefits from marine systems and linked ecosystem services' (Rees et al 2022) along with accessible reports, infographics and presentations.

Impacts & benefits delivered

The impacts of this work have been far reaching; informing and enhancing marine policy and management, the economy and perceptions at local to international scales.

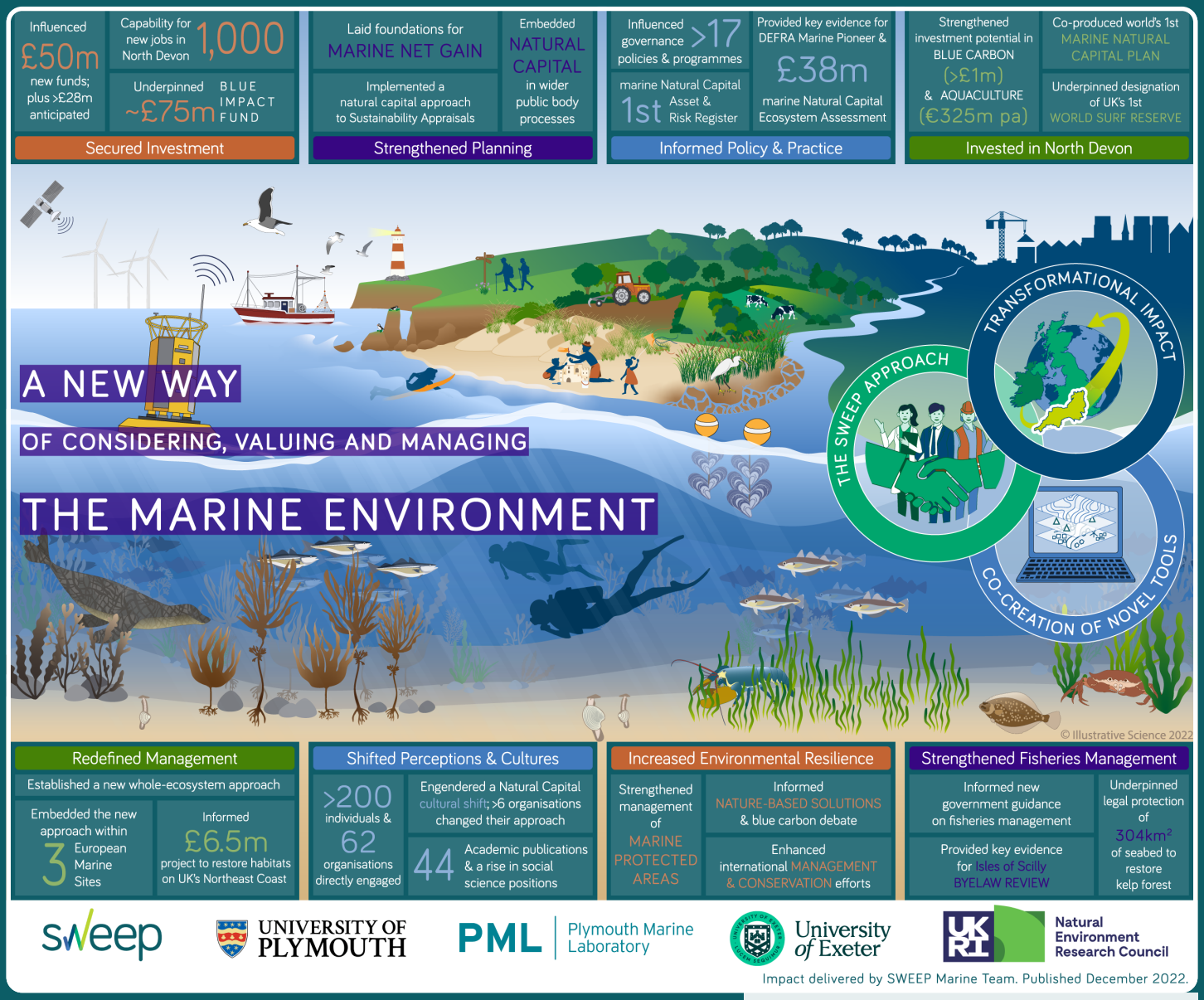


Image credit: Illustrative Science 2022

Policy & Legislation

Informed Policy and Practice: SWEEP has influenced more than 17 governance policies and programmes to date across a range of local level plans to national policies. For example, by playing a fundamental role in the delivery of the North Devon Marine Pioneer (NDMP), SWEEP scientists underpinned the final Marine Pioneer recommendations report. Led by the Marine Management Organisation (MMO) the report informed the 25-year Environment Plan and is expected to significantly influence the use and implementation of NC approaches by government agencies such as DEFRA, Natural England and the Environment Agency. The SWEEP Asset and Risk Register has been described in government guidance as the 'key foundation of the evidence base' when adopting a NC approach to management (Defra et al., 2019). Key characteristics of the SWEEP approach, such as the need to take a holistic approach to marine

> *"SWEEP outputs were the fundamental basis upon which all of the rest of the work was done in the marine pioneer. It would have been next to impossible to do a lot of the other work without that basis."*
>
> **Aisling Lannin, Head of Evidence and Marine Pioneer Programme Lead, MMO**

> *"We are seeing the SWEEP thinking, approaches and learning feeding into government projects, it's clear it is continuing to influence and feed into how people think about Natural Capital and how they take things forward."*
>
> **Tara Hooper, Natural England**

management, have been recognised in the 'Nature Recovery Green Paper: Protected Sites and Species', which states *"We cannot achieve the level of nature recovery we want with site-based protections alone: we need to look after nature across our entire sea area"*.

SWEEP research has fed into a wide range of reports, policies and programmes including Natural Capital Committee advice to government; Cornwall Environmental Growth Strategy; the Cornwall Local Nature Recovery Strategy (Pilot) which is informing national Marine Nature Recovery networks; more than 4 government reviews and consultations; and been critical to both the development of the £38m marine Natural Capital and Ecosystem Assessment (mNCEA) programme, the methods proposed and its delivery. There are currently 47 mNCEA coastal projects, most of which have been informed by SWEEP, either directly through expert adviser roles, or indirectly through the Pioneer outputs and/or SWEEP reports. The long-term impact of this activity will be that NC approaches are embedded in key government department processes, based on SWEEP research and outputs.

> *"The mNCEA came about because of the Marine Pioneer, which was also directly linked to SWEEP and we are looking at producing asset and risk registers as part of mNCEA."*
>
> **Sofiya Stoyanova, Defra**

> *"I do think the marine NCEA is actively trying to change and transform and do something a bit different, it is trying to make a really strong thread between the policy, the place, the ambition, the outcome we want and what we need to do."*
>
> **Aisling Lannin, MMO**

Natural Capital

Invested in North Devon NC: The North Devon NC Asset & Risk Register provided the basis for the world's first Marine Natural Capital Plan (MNCP) for the North Devon Biosphere Reserve. As well as underpinning the plan, SWEEP supported the funding bid to the European Maritime and Fisheries Fund (EMFF) to create it. The plan aims to draw partners together to invest in North Devon's marine natural capital and improve how it is managed, to drive the future use of the marine environment, such as, through fisheries management, mariculture and conservation.

The MNCP has underpinned a £1.37m investment in North Devon through the Government's Community Renewal Fund (CRF), the largest green economy award allocated nationally. SWEEP researchers directly contributed to the bid and played a key role in delivering the Blue Biosphere element of the project inputting to structured business plans for investment in North Devon marine NC and the involvement of statutory agencies. The SWEEP team identified areas for investment in blue carbon habitats, providing evidence on the opportunities to recover, restore or create blue carbon habitats and how related investment potential for carbon credits can be developed, which are estimated to run into millions of pounds. This approach provides a model which can be replicated in other coastal communities around the UK.

SWEEP work enabled the identification of a 25km^2 aquaculture investment zone that could support seaweed, scallop and mussel farming opportunities. The business case identified a potential value of €325m p/a to the SW sector, based on the €1bn European market, and the creation of 4,025 new coastal jobs harvesting 280,000 wet tonnes

> *"The SWEEP tools have been at the core of the development of the MNCP and critical to understanding what needs to be managed better within our marine environment. We're using it as a basis to comment on development proposals, such as cable installations, to inform decisions and support local stakeholders."*
>
> **Andy Bell, UNESCO World Biosphere Reserve Co-ordinator**

North Devon coast

of seaweed. They also discovered significant environmental and social mobility benefits for investment in a sustainable blue economy.

The long-term legacy of this work for North Devon will be significant investment in new sustainable industries, new jobs and skill development for local people. It will redirect private investment into the area while contributing to mitigation measures to address the climate and ecological emergency.

The CRF has also led to a new project with Siemens to launch and globally scale the critical market infrastructure for nature-based solutions to address climate change. The Biosphere Reserve will benefit from technology licenses, Siemens development and management input, and global marketing support to assist in scaling and roll out. In addition, a £15m bid has been submitted to the levelling up fund for a maritime research hub at Appledore dockyards in North Devon as a direct result of the CRF work. It is focused on (i) clean propulsion, (ii) marine environmental intelligence and (iii) aquaculture in the Middle Dock area. The work on marine environmental intelligence and aquaculture will build on SWEEP work.

In June 2022 North Devon won a prestigious accolade becoming the UK's first World Surfing Reserve (WSR), only the 12th in the World. SWEEP researchers played a key role in developing the nomination and reside on the steering committee to inform its delivery. The designation, awarded by the Save the Waves Coalition, covers approximately 30km of coastline and recognises the high quality and diversity of surf breaks, but also the unique natural beauty of the surroundings, North Devon's deep-rooted and historic surf culture, and its importance to the wider community. It is hoped the evolving delivery strategy will boost the already considerable value of surfing in North Devon, which is estimated to be in excess of £52.1m per annum (Abell & Mallett, 2008), attract investment for new facilities and encourage more children to take up the sport. A similar designation in East Devon (Jurassic Coast) is thought to influence ~£100m a year in economic activity.

Knowledge/Capacity

Redefined management: One of the key characteristics of SWEEP is taking a holistic approach to marine site management. SWEEP researchers informed the development of management plans for the Exe Estuary and for the Tamar Estuary (under development), which intersects with the UK's 1st National Marine Park, and. This marked the first applications of natural capital into the management of European Marine Sites, accredited for their conservation importance. The continued development of these approaches is increasing the utility of the data and will minimise the need for academic input thus ensuring site managers can use the tools independently with limited additional support for maximum application.

> *"A lot of the work done in the CRF built on SWEEP outputs, such as the Geonode. The marine pioneer provided a first critical step in delivering NC approaches, by providing a cogent and cohesive knowledge base for the Biosphere Reserve to build on, that has led to significant further investment and innovation."*
>
> **Andy Bell, UNESCO World Biosphere Reserve Co-ordinator**

> *"SWEEP has provided expert input to the management of the Plymouth Sound and Tamar Estuaries Marine Protected Area (MPA) and the development of the National Marine Park (NMP), which has been instrumental in providing the scientific evidence underpinning for much of our work."*
>
> **Kaja Curry, Natural Infrastructure Officer, Plymouth City Council**

An additional £95k of funding has been secured for carbon mapping and to investigate risks to sea grass beds in Plymouth Sound. This will build on SWEEP work through a partnership of Plymouth City Council, the Ocean Conservation Trust, Finance Earth and Plymouth University and is being complimented by a new PhD research project, supervised by Prof. Mel Austen, to monitor the ascendency of intertidal seagrass and create a monitoring tool.
While SWEEP has been a Southwest focussed project, the reach has been much broader with the tools developed shared with other coastal management groups. Through presentations at a stakeholder workshop, SWEEP fellow Tara Hooper shared learning with the Yorkshire Marine Nature Partnership (YMNP). 93% of participants stated that the workshop had helped them to understand the benefits of using the NC approach and 100% said it had increased their understanding of the NC approach. Building on the workshop, YMNP have led the grant-funded project, Connecting the Dots, which expanded on initial NC work to commission a feasibility study and create 'explainer' films. They are also in talks with Natural England around using the site as a case study in the mNCEA.

SWEEP fellow Dr Sian Rees contributed to the outline business case for a £6.5m Stronger Shores project based on SWEEP methods and activities. Stronger Shores will fulfil the evidence gap to improve understanding of the costs and benefits of kelp, seagrass and native oyster habitats with regard to coastal erosion, flood risk, climate change, biodiversity management and wider benefits for the Northeast Coast (Lindisfarne, Northumberland to Skinningrove, North Yorkshire). The output of the project will provide a mechanism for incorporating nature-based solutions in future coastline management strategies through a transformative natural capital/ecosystem services framework.

Organisational Function

Strengthened Planning: The SWEEP team evaluated how 'net gain', previously only considered for developments on land, can be applied to the marine environment and provided strategic advice directly to MMO and Defra. SWEEP research was referenced in a Defra consultation document on the Principles of Marine Net Gain, the responses to which will help inform more detailed policy development. The consultation was also informed by the NCC and SWEEP fellow Mel Austen, the only marine expert on the NCC panel. Mel drew on SWEEP research in the development of NCC reports, including Advice to Government on Net Environmental Gain, which informed the consultation. A key aspect of this was the recommendation that net gain should be marine as well as terrestrial.

SWEEP researchers have created novel tools to enable NC values to inform decision making in relation to the benefits and risks of new plans and developments. £155k additional funding was secured from Defra to improve understanding at a UK Government level on how the natural capital approach can be applied to the marine environment and how this links to UK national policy, particularly in terms of assessing trade-offs and value for money in monitoring, protection and rebuilding of marine assets.

> *"The academic input provided by SWEEP has meant that the Exe Estuary Management Plan 2022-2027 has been informed by not only the latest natural capital approaches but also the real ecosystem benefits provided by the different habitats of the estuary. We plan to build on this approach and integrate habitat values and NC approaches into estuary management decisions going forward."*
>
> **Stephanie Harper-Chung, Exe Estuary Officer**

> *"The SWEEP presentations really helped us to establish some foundational knowledge and frame the natural capital approach within our wider discussions. It has inspired our work going forward and allowed us to access additional funding to carry out further feasibility studies and engage wider stakeholders in the conversation."*
>
> **Heather Davison-Smith, Yorkshire Marine Nature Partnership Development Officer**

Seagrass farming

> *"We want to develop a big case study on the application of natural capital approach and if we decide to look at offshore wind as a potential area, we would hope to build on the work done by Tara & Matt."*
>
> **Sofia Stoyanova, Defra**

> *"In terms of net gain, Tara has pretty much done all of that herself. So, that's an obvious, huge impact. You know, I think single-handedly, she has moved that thinking on"*
>
> **Aisling Lannin, MMO**

The SWEEP report is one of the selected biophysical data sources, tools and evidence under the Marine Environment tab of Defra's "*Enabling a Natural Capital Approach*"(ENCA). ENCA is recommended for use by HM Treasury's Green Book: appraisal and evaluation in central government (2020) and represents supplementary guidance to the Green Book. The government's Nature Recovery Green Paper plans to review environmental impact assessment, offering new opportunities for SWEEP approaches to impact policy in the future.

Responding to stakeholder needs, SWEEP created practical methods to integrate NC values into local decision-making processes. The approach, that had never been attempted for either marine or terrestrial environments before, was developed primarily for sustainability appraisals. However, the application principles can be applied more broadly to impact assessments of new plans and development proposals.

SWEEP has demonstrated how these methods can be applied by regional planners in local area plans in collaboration with North Devon Council; provided suggestions for straightforward and practical ways the statutory Sustainability Appraisal for the South West Marine Plan could adopt a natural capital approach and created a sustainability assessment for the North Devon Marine Natural Capital Plan, ensuring it is a proof of concept for what a marine plan can be. Ongoing discussions are underway between Natural England and the MMO with regard to using a natural capital approach to sustainability appraisal under the mNCEA.

Strengthened Fisheries Management:

As part of the NDMP, SWEEP worked with Devon and Severn IFCA to create a survey to collate comprehensive social data from the fishing industry. The results led to the development of five Fisheries Research and Management Plans (FRMPs). The North Devon Marine Natural Capital Asset and Risk Register provided evidence on which to build further knowledge and potential interventions for the FRMPs. FRMPs have since become a recognised tool that has been included in the Fisheries Act as the process used to manage fisheries collectively and the official guidance for writing FRMPs has been informed by the experience in North Devon.

With input from the SWEEP team, Sussex IFCA replicated the SWEEP methodology to create an Impact Assessment that highlighted the need for a trawling byelaw in West Sussex. Approved by Defra in 2019, the byelaw protects 117 square miles (304 square kilometres) of coastal seabed to allow for the regeneration of underwater seaweed forests.
It is hoped that through protection of the area, kelp beds will be rejuvenated providing vital habitats and feeding grounds, which will help to support both wild and commercial stocks. The kelp can also help

Higher Town Bay, St Martins, Isles Of Scilly, Cornwall

Seaweed farming, Porthallow Bay, Cornwall

> *"The FRMP will include both scientific and local anecdotal information and consider a broader range of activities than would typically be included in a fisheries management plan, as a first step towards a local application of the Ecosystem Approach. The approach has a strong social and economic component that is informed by SWEEP activities."*
>
> **Dr James Stewart, Senior Environment Officer D&S IFCA**

Fishing boats, Plymouth

to reduce carbon levels, improve water quality and reduce coastal erosion. As the first fisheries byelaw to be based on an Impact Assessment of the NC it demonstrates that Defra recognise the credibility of this method, setting a precedent for future applications.

Following the byelaw and inspired by SWEEP work, Adur District & Worthing Borough Councils secured £79k for the Sussex Kelp Restoration Project. The grant will help restore almost 200 square kilometres of kelp forest that have been lost to trawling and create a blue carbon bank to support and sustain the restoration of a large kelp forest in the new Trawler Exclusion Zone.

The Isles of Scilly Asset and Risk Register was used to underpin a fisheries Impact Assessment, informing a proposed new byelaw to prevent the use of mobile gear in sensitive habitats, which is under review with DEFRA. SWEEP researchers worked with the IFCA to secure a £71k grant to map natural capital for fisheries management on the Isles of Scilly and deliver the SCILL-E Project (Site Classification to Inform Sustainable Lives and Livelihoods for Fisheries and Ecosystems).

The Sussex byelaw and Isles of Scilly proposed byelaw are documented as real-world marine management case studies in the JNCC report 'Case studies on the natural capital approach in marine decision making: The development of fisheries management byelaws'.

Increased Environmental resilience:

Drawing on SWEEP outputs, partners WWF developed a new tool for evaluating the effectiveness of Marine Protected Areas (MPAs) and tested it on the MPAs in North Devon. The Compass tool identifies weaknesses and supports future planning for MPAs, and wider marine governance and management. It has been used in other areas in the UK, such as Argyll and Flamborough Head and there are plans to use it to assess two MPAs along the Yorkshire coastline.

SWEEP researchers provided expert input to the 'Benyon review into Highly Protected Marine Areas' which concluded that Highly Protected Marine Areas (HPMAs) are an essential component of the Marine Protected Areas network and should be introduced. The review culminated in 25 recommendations covering what HPMAs are and how they should be identified and managed. Five candidate sites in England inshore and offshore waters have since been identified and consulted on, with sites expected to be designated in 2023. Further HPMA site identification is underway in Scotland with HPMA designation expected in 2026. Marine Pionner partners also drew on SWEEP outputs in their response to the review.

SWEEP researchers contributed to the landmark 2021 report 'Nature-Based Solutions for Climate Change in the UK', by the British Ecological Society (BES), co-authoring the marine chapter, with the North Devon Marine Pioneer included as a case study. The report offers a complete assessment of the

> *"Information compiled in the Assets and Risk Register provided useful guidance on how we can assess conditions, ecosystem services etc. We were able to lift and adapt this for our area to inform the evidence-base to underpin the rational for the management. This is a fundamental change to a more holistic fisheries management approach."*
>
> **Erin Laws, Sussex IFCA**

> *"I was certainly inspired by the North Devon work. My application to NEIRF didn't directly reference the North Devon evidence base, but absolutely it is a vital milestone pointing the way. I think it's hard to quantify the impact, but clearly in the influence that it gave to the IFCA report and by extension, the framework of thinking that the IFCA report provided to local partners like us."*
>
> **Paul Brewer, Director for Digital, Sustainability & Resources, Adur & Worthing Councils**

> *"We are amongst the first to be recommending a closure to mobile gear for sensitive habitats underpinned with a justification based on ecosystem services and the asset and risk register work that Sian and her team did for us."*
>
> **Tom Hooper, Isles of Scilly IFCA**

> *"The successful outcome of the Sussex IFCA byelaw review further demonstrates that the natural capital approach is sufficiently robust to support the development of legally enforceable management measures in the marine environment. More generally, the report shows that organisations have embraced the concepts the approach encapsulates and have used them for communicating the need for, and aims and objectives of, management measures."*
>
> **JNCC report**

> *"It is the first time we have undertaken a report on this scale and we are already beginning to see the impacts in how we interact with policymakers and others. We are very grateful for the time, effort and expertise you have dedicated to this very timely report, which we are sure will have a significant impact on policy making."*
>
> **Jane Memmott, President, British Ecological Society**

potential of nature-based solutions in the UK for the first time. They also fed into the Parliamentary Office of Science and Technology, integrating key SWEEP outputs and text into such as the Blue Carbon and the Climate Adaptation for Nature. Dr Sian Rees is specifically acknowledged as a contributor on both.

Dr Sian Rees contributed to the evidence base for the designation and management of a Marine Protect Area (MPA) for the Ascension Islands as part of the South Atlantic Natural Capital Assessment Project. Analysis that any activities which were to take place that result in abrasion, penetration and damage to the substratum, extraction or physical change of deep-sea habitats should be subject to impact assessments was included in the Ascension Island Marine Protected Area Evidence and Options Document. The document was created by the Ascension Island Government to set out the importance of Ascension Island's marine environment and provide options for an MPA, which was upheld by the UK Government in March 2019. The Evidence and Options paper underpinned a public consultation and the Management Plan for the site. Fishing is not permitted beyond 12 nautical miles of the island for any species or using any type of gear, except licensed research fishing. No mineral extraction is permitted within the MPA and all new developments are subject to an environmental impact assessment. These restrictions support the vital ecosystem services provided by the deep-sea.

Tools developed in SWEEP have been applied to coastal areas in Vietnam, Indonesia, Malaysia and Philippines through the Blue Communities project, led by Prof Mel Austen, contributing to international capacity development. The project has engaged broadly with local communities, raising awareness of the NC of the area and demonstrating these values are considered in decision-making processes.

"There were elements from the Natural Capital Assessment report that were used within the Evidence and Options paper itself, pulled out from that into the main body of the text. Then it has also been pulled through into the evidence for the management plan. It was an incredibly useful baseline and I think as they start looking and developing work, they'll come back to this again to look at where research might be focussed in the future."

Ness Smith

"The Blue Communities program has driven communities to participate and get involved in coastal marine protection, conservation, and development. It has increased their faith in the power of their local ecological knowledge in research and policy initiatives. The program has also increased the coastal community's appreciation of the coast and the ocean as not only a source of their food and livelihood but also a space for recreation and better mental health."

Prof Lota Creencia, Project lead, Western Philippines University

Economic

Secured investment: Throughout SWEEP, additional funds have been secured for complimentary research by the team and in collaboration with partners. The outputs and activities have also informed a wide array of additional projects, as described in this summary, resulting in more than £50m in new funds to improve management and restoration of the marine environment. An additional £27m in funding is anticipated through developing schemes. A key component of this has been the CRF project in North Devon which has led to the development of business cases for future investment and innovation in the area. The opportunities for sustainable growth in the maritime sector, as calculated by SWEEP researchers, offer the potential for significant job creation with a long-term ambition to create 1,000 new jobs.

SWEEP research formed the baseline and evidence to support the creation of the Blue Impact Fund and contributed to the WWF sustainable finance working group that developed it. The UK Seas project, funded by WWF, investigated sustainable financing mechanisms and identified the Blue Impact Fund as having the most potential to enhance local economies. SWEEP outputs provided the basis

"In the long term we're expecting to generate a ~£12.5m private investment fund for marine projects. We are hoping to secure a further £15m for investment into middle dock from the levelling up fund. Hence the long-term impact of the CRF will be significant investment and innovation."

Andy Bell, UNESCO World Biosphere Reserve Co-ordinator

"We couldn't have done any of the work we did on the UK Seas without Sian and the team in particular! Her intellect was the foundation and gave us an evidence-base that we didn't exist before, providing credibility."

Sarah Young, WWF

for identification of investable projects which were developed into a portfolio of investable products for the Marine Pioneer. The Blue Impact Fund has been developed into a national scheme that aims to raise > £75m to invest in sustainable enterprise models that both benefit the marine and coastal environment and can generate returns for investors. The Blue Impact Fund has been recognised in the government's Nature Recovery Green Paper, which aims to raise 'at least £500m in private finance to support nature's recovery every year by 2027 in England, rising to more than £1bn by 2030'. The Green paper states "*We welcome the pace of innovation in the private sector to enable more investment in nature's recovery, for example, and Finance Earth's work with WWF to create a Blue Impact Fund*".

Attitudinal/Capacity

Shifted Perceptions and Cultures:

Throughout SWEEP the team have directly engaged with >200 individuals & 62 organisations through workshops, meetings, advisory roles and events. They have also contributed to public awareness raising, such as a series of 6 WWF films, Journey to the sea (>13,000 views on YouTube). The team directly engaged with 7 local authorities in the SouthWest, which collectively serve a population of more than 1.1 million people, working with them to utilize natural capital approaches to improve the management of coastal and marine spaces. An MMO survey found that >64% of respondents felt the tools produced during the Marine Pioneer presented very useful options to inform decision-making and >80% found the application of scientific research very useful.

During SWEEP, an artist has been embedded within the blue carbon research culture at the University of Plymouth. An additional ~£30k was secured through NERC Creative Commissions to ensure SWEEP knowledge informed public engagement activities in Plymouth. The project aimed to connect city residents though an immersive living arts piece (The Seagrass Walk), based at the National Marine Aquarium (NMA), with accessible and highly visible satellite installations around the City. 87,375 people interacted with the visual outputs. An independent evaluation indicated positive learning outcomes associated with understanding blue carbon and the role of biodiversity in climate change action and local ownership. NMA visitors expressed an interest in eating more sustainably caught fish after visiting the exhibition.

A highly collaborative process, the NDMP brought together statutory organisations, management and conservation bodies and local interest groups (e.g. local fishermen). SWEEP researchers played a key role in communicating the use and benefits of the natural capital approach to the other partners and wider stakeholder group. By engaging them in the academic process being undertaken they informed their views and use of the tools in their own organisations. A noticeable increase in the number of social science roles in government bodies has been seen as Natural Capital has become more and more integrated into practice and policy. A key contributing factor to this is the breadth of the mNCEA programme, which has a budget of £38m and 45 coastal projects. Led by government agencies there is a direct link between the need for practitioners and academics with an understanding of NC approaches to deliver this programme. The networks developed through SWEEP have engendered lasting relationships with key external partners, fostering a basis of credibility and trust in the academic community. SWEEP Co-Is have built on this to develop additional collaborations that take forward SWEEP methods and achievements. A key example of this is the £2.4m UKRI NERC funded Centre for Doctoral Training in Sustainable Management of UK Marine Resources (CDT SuMMeR). Led by SWEEP Co-I Prof Mel Austen the CDT is training 48 PhD students over 3 cohorts to be the next generation of innovative, transdisciplinary researchers, solution providers and practitioners needed to support the government and non-government sectors who must deliver sustainable management of our precious marine resources.

> *"It [the pioneer] was transformational in bringing actors together to develop processes and outcomes and the model should be replicated"*
>
> **Anonymized response data**

> *"Meetings and workshops have been found to be valuable in developing a common understanding; for example, workshops in the North Devon Marine Pioneer area have been found to be particularly productive and well-received by stakeholders."*
>
> **Independent evaluation of the 25YEP Pioneers**

> *All the work that SWEEP has done, and the Marine Pioneers have done is absolutely fantastic. I think what it actually has done is to translate the NC approach from something that is very abstract to something quite practical to tell us and show us how we could potentially apply the approach in practice."*
>
> **Sofiya Stoyanova, Defra (SWEEP expo)**

> *The Marine Pioneer has driven a change in perception of natural capital by local stakeholders, particularly the fishermen who understand how it can work for them and are more engaged in fisheries management."*
>
> **Andy Bell, UNESCO World Biosphere Reserve Co-ordinator**

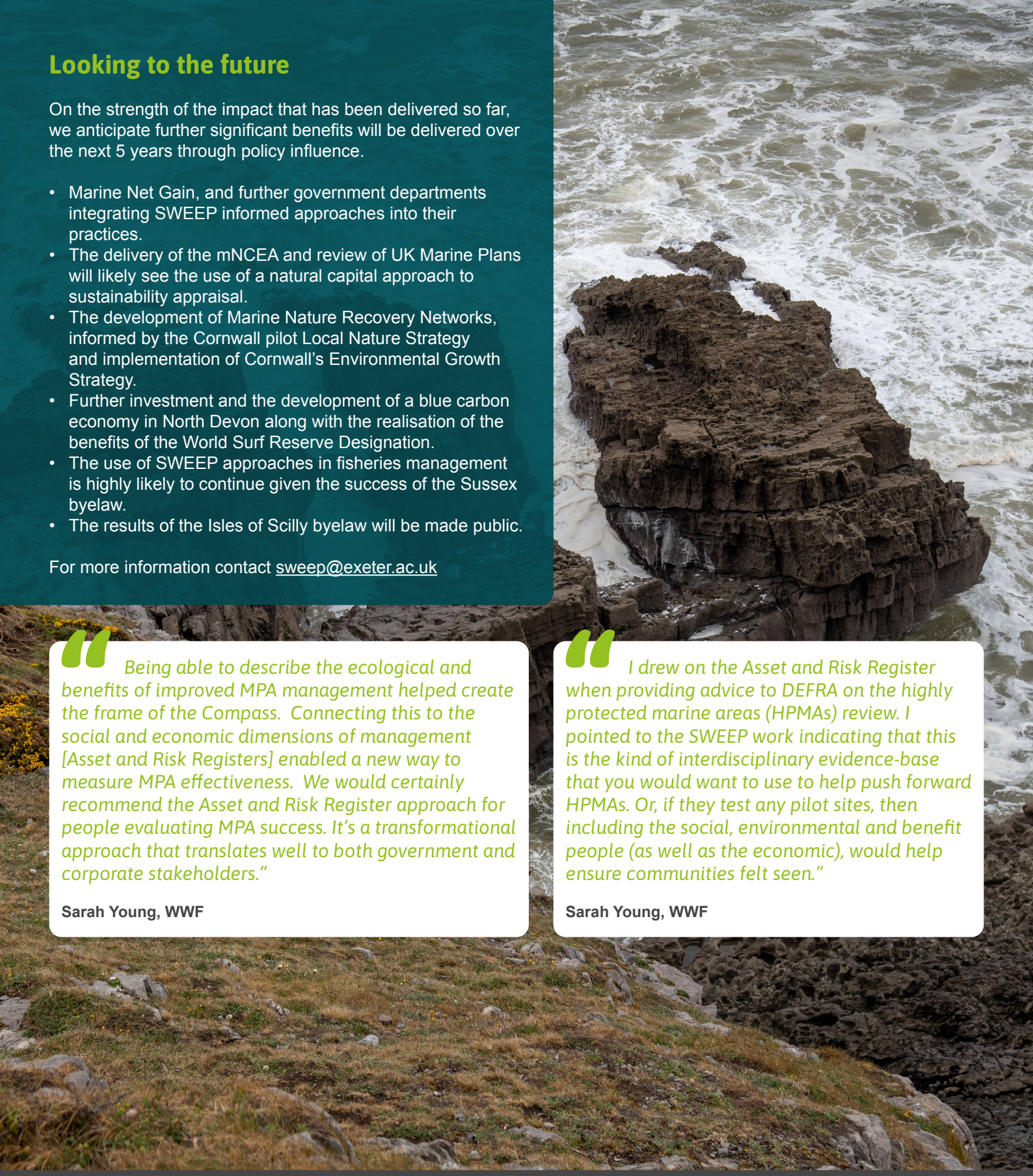
> *Every organization now is getting more and more social scientists and environmental economists involved. It certainly has influenced the MMO, we've got 2 senior marine social scientists now. Our experience in the Pioneer, and working with SWEEP, helped us to make a really coherent argument for them to be employed."*
>
> **Aisling Lannin, MMO**

Looking to the future

On the strength of the impact that has been delivered so far, we anticipate further significant benefits will be delivered over the next 5 years through policy influence.

- Marine Net Gain, and further government departments integrating SWEEP informed approaches into their practices.
- The delivery of the mNCEA and review of UK Marine Plans will likely see the use of a natural capital approach to sustainability appraisal.
- The development of Marine Nature Recovery Networks, informed by the Cornwall pilot Local Nature Strategy and implementation of Cornwall's Environmental Growth Strategy.
- Further investment and the development of a blue carbon economy in North Devon along with the realisation of the benefits of the World Surf Reserve Designation.
- The use of SWEEP approaches in fisheries management is highly likely to continue given the success of the Sussex byelaw.
- The results of the Isles of Scilly byelaw will be made public.

For more information contact sweep@exeter.ac.uk



"Being able to describe the ecological and benefits of improved MPA management helped create the frame of the Compass. Connecting this to the social and economic dimensions of management [Asset and Risk Registers] enabled a new way to measure MPA effectiveness. We would certainly recommend the Asset and Risk Register approach for people evaluating MPA success. It's a transformational approach that translates well to both government and corporate stakeholders."

Sarah Young, WWF

"I drew on the Asset and Risk Register when providing advice to DEFRA on the highly protected marine areas (HPMAs) review. I pointed to the SWEEP work indicating that this is the kind of interdisciplinary evidence-base that you would want to use to help push forward HPMAs. Or, if they test any pilot sites, then including the social, environmental and benefit people (as well as the economic), would help ensure communities felt seen."

Sarah Young, WWF

Underpinning NERC Science

- NE/L003279/1 - Integrating Macroecology and Modelling to Elucidate Regulation of Services from Ecosystems (IMMERSE)

Other funding bodies

European Union (Framework Programme 7 and INTERREG), Natural England, Department for Environment, Food and Rural Affairs, Blue Marine Foundation, World Wildlife Fund, Devon & Severn Inshore Fisheries & Conservation Authority, European Maritime and Fisheries Fund, Marine Conservation Society.

About SWEEP

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UKRI Natural Environment Research Council

Transforming leak detection capabilities using landscape modelling and drone thermal imaging

sweep

Impact Summary

This project boosted South West Water's understanding and potential capabilities to identify underground leaks, which can be hard to identify using standard 'in-pipe' monitoring. Operational leak detection methods and approaches were developed using publicly available datasets, remote sensing tools and drone technology. SWW's £10.5m investment in the Centre for Resilience in Environment, Water and Waste (CREWW) continues to strengthen their relationship with the University of Exeter.

Ways of Working

Innovative Knowledge Provision | Effective Collaboration | Capacity Building

Why it mattered?

Leaks from submerged water mains pipes and aqueducts give rise to major operational and environmental costs within the water services industry. Within the South West England water network, overseen by South West Water (SWW), there are over 15,000km of buried pipes and every year £7m is spent on detecting and tackling leaks in the network.

The biggest challenge towards addressing major systematic leaks is detecting them. Pipes often lie deep underground and identifying the exact location of a leak can be hard using standardised 'in-pipe' monitoring. Optical signatures of leaks seen above ground can be indistinguishable from natural patterns in soil surface wetness.

State-of-the-art thermal imaging approaches, previously developed by the University of Exeter SWEEP team, allow patterns of near-surface and surface water to be mapped from proximal sensing technology, including lightweight drones.

Analysis of thermal imaging data can be combined with spatial information describing surface structure, to provide useful proxies for identifying pathways of water movement through landscapes. This SWEEP project was developed to test these approaches in an operational setting.

> *"We've halved leakage levels in our region, but we know there's more work to do. We'll be investing over £50m in the next ive years to help us achieve a minimum 15% reduction in leakage by 2025."*
>
> **Tackling leakage, South West Water**

What we did

The SWEEP team was comprised of University of Exeter Impact Fellow Dr David Luscombe, and academics Dr Karen Anderson and Prof Richard Brazier. They worked closely with SWW staff to develop the technology and trial its operation. Activities involved:

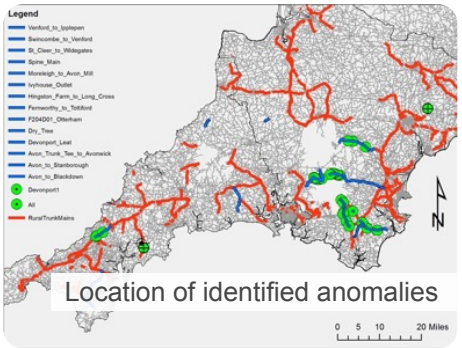
- Construction of the drone platform for data acquisition.
- Design construction and programming of ground validation sensors.
- Developing and implementing a provisional method to target leak detection effort, by combining the above technologies with freely available remote sensing data. Features which are not clearly visible on the ground, or able to be hydrologically understood in isolation from the surrounding landscape, can also be identified.
- Deploying Unmanned Aerial System (UAS) mounted thermal cameras, in combination with near infrared imaging sensors, to detect leaks from rural water supply infrastructure.

Key outputs included:

- Twenty candidate anomalies (areas where leakage from the water supply network is likely) identified in 2019 and supplied to SWW.
- Case study and report detailing the investigation of a specific anomaly near the village of Tregony in Cornwall.
- Review of limitations of approach for: (1) drone flight operation and subsequent data processing and interpretation; and (2) targeting of on-the-ground leak detection actvities.

Reports include:

- Poster report: Mains water leak detection using landscape modelling and UAV-based thermal imaging data: methods and approach.
- Final report to SWW.
- Tregony Case Study.



Location of identified anomalies

Impacts & benefits delivered

Attitudinal

Strengthened partnership approach at strategic level with SWW: Undertaken in partnership with SWW, this work enhanced the collaboration and transfer of research-based knowledge into SWW and the new £31m Centre for Resilience in Environment, Water and Waste (CREWW). CREWW is a transdisciplinary research centre, located at the University of Exeter, established in 2020 with investment from SWW (£10.5m) and Research England (£21.5m). CREWW is undertaking research into some of the most pressing environmental challenges facing the waste and water sectors.

Extended learning - methodologies developed were also used in:

- SWW-funded MIRES Project on peatland restoration monitoring.
- Research into UAS-based thermography and restoring (re-wetting) of drained peatland landscapes.
- £30k SWW-funded project on impact of summer drought on water pipe leakage.

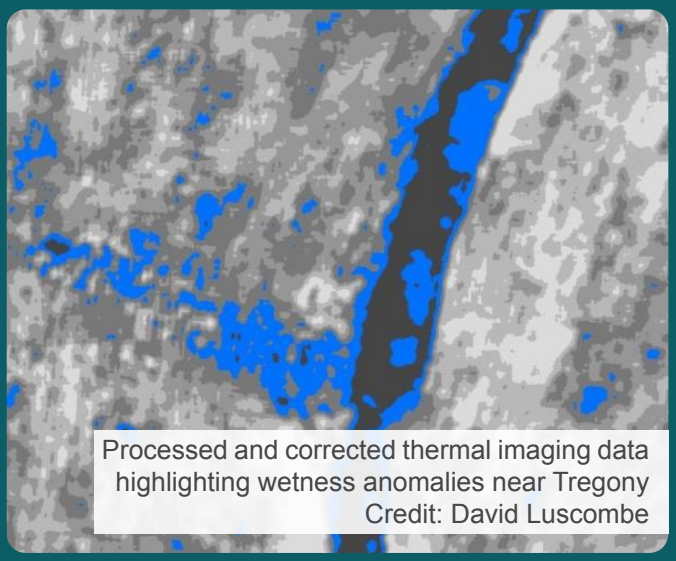
Organisational Function

Improved SWW's capabilities and knowledge for leak detection: This project developed: (1) operational leak detection method for detecting surface anomalies consistent with water main leaks using publicly available datasets and remote sensing tools; and (2) an operational approach for deployment of drones at locations identified as candidate leak anomalies, to aid in leak detection in hard to access or survey locations.

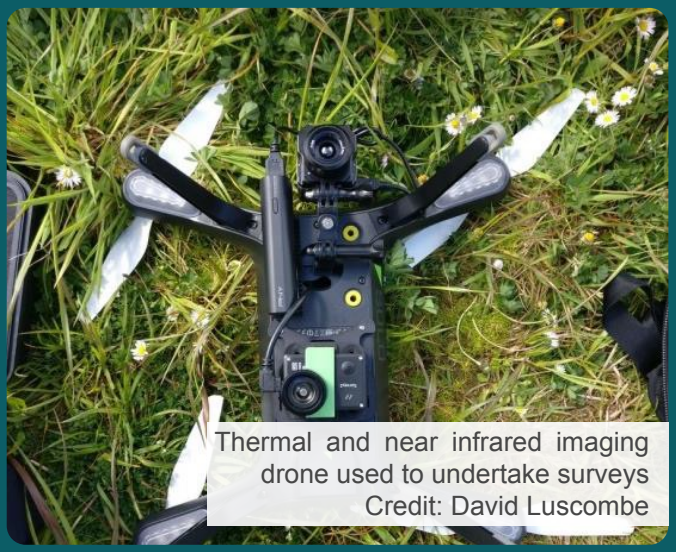
Organisational Function

Potential reductions in potable water lost from the water network:

- may reduce the requirement to abstract water from natural watercourses, improving overall aquatic health and environmental/resource resilience.
- benefit business and consumers via reduced water supply costs.



Processed and corrected thermal imaging data highlighting wetness anomalies near Tregony
Credit: David Luscombe



Thermal and near infrared imaging drone used to undertake surveys
Credit: David Luscombe

Looking to the future

For more information contact sweep@exeter.ac.uk

Organisation we worked with

South West Water

Underpinning NERC Science

- NE/J015237/1 - Fragments, functions and flows - the scaling of biodiversity and ecosystem services in urban ecosystems
- NE/F000421/1 - Remote sensing of peatland responses to hydrological change
- NE/TS/K00266X/1 - Developing a New Integrated Aerial Vehicle Platform 'Quest Earthwater' for assessing hidden blue water supplies

About SWEEP

The South West Partnership for Environmental & Economical Prosperity (SWEEP) is a partnership between the University of Exeter, the University of Plymouth, and Plymouth Marine Laboratory. Funded by the Natural Environment Research Council and stakeholders together to solve key challenges faced by those working with our natural resources. **www.sweep.ac.uk**

UKRI Natural Environment Research Council

Enabling Dartmoor National Park Authority to prepare for future population growth and the increasing impact on recreation

sweep

Impact Summary

South Hessary tor Princetown, Dartmoor

SWEEP helped Dartmoor National Park Authority (DNPA) apply a Natural Capital Approach to better understand, and mitigate for, the impact new housing would have on recreation in the area. The work directly informed the Authority's plans and policies, and expanded their thinking around possible mitigation measures, as well as giving staff the confidence to move these conversations forward.

Informed **2** key management plans Dartmoor Local Plan 2018-2036 and National Park Management Plan 2020-2025

Increased understanding of the **£25.6m** (2018) of welfare benefits delivered to local residents

Building resilience to manage a **13%** population rise over the next **25** years

Ways of Working

- Innovative Knowledge Provision
- Effective Collaboration
- Capacity Building
- Tailored Decision Support
- Natural Capital Valuation

Why it mattered?

Dartmoor National Park is a unique landscape of vital conservation importance and rich in wildlife, history and culture. In addition to conserving and enhancing everything considered special about the Park, the core work of DNPA is to balance the needs of Dartmoor's residents, businesses and visitors, and to foster the economic and social well-being of local communities.

Delivering on these goals is an increasing challenge in the face of rising visitor numbers driven by population growth and new housing developments. The number of people living in and around Dartmoor is set to increase by 13% over the next 25 years (from 2018 to 2039), with day visits by local residents projected to rise by 10% to nearly 8 million in 2039. With this backdrop of uncertainty and change, DNPA is keen to explore new ways to manage and monitor its park.

> *"We know that there are significant health and well-being benefits when people spend recreation time on Dartmoor but continuing to provide a growing population with easy access to the National Park can be a challenge."*
>
> **Ally Kohler, Dartmoor National Park Authority's Director of Conservation and Communities**

What we did

The University of Exeter's Prof. Brett Day, Prof. Charles Tyler, Dr Michela Faccioli, Dr Sara Zonneveld and Dr Amii Harwood worked in close collaboration with DNPA in 2017/8 to study the effects and opportunities presented by a growing local population.

The team applied a Natural Capital Approach to identify areas of potential conflict and mitigation measures. This improved on previous DNPA methods for predicting future recreation growth (which were less focussed and based on a large number of assumptions).

Key wildlife hotspots were mapped and the information was combined with data from the ORVal model. ORVal is a sophisticated tool for modelling recreational demand on outdoor green spaces. It was able to project how population growth in areas surrounding the Park would affect visitor numbers and footfall rates in specific areas over the 25 years to 2039.

Utilising DNPA's local expertise, the team calibrated ORVal to enable spatial predictions of changes in footfall over the coming decades. They developed projections of how this would impact footpath erosion and wildlife, and were able to quantify the welfare values and health benefits derived from recreational visits.

The research revealed that each year Dartmoor provides an estimated £25.6m of welfare benefits to residents of neighbouring Local Authority Districts, and this was expected to increase by £2.5m by 2039.

Impacts & benefits delivered

Policy & Legislation

Informed DNPA plans and policies: Findings informed paert of the evidence-based within both the Dartmoor Local Plan 2018-2036 and National Park Management Plan 202-2025 through the Habitats Regulations Assessment which was used to assess the potential impacts of increased population and recreational pressures on designated nature conservation sites.

Organisational Function

Contributed to decision-making, funding bids, saving money and adding value: Findings are regularly used by project managers to (i) inform DNPA visitors management practices; (ii) in local planning discussions with neighbouring authorities around the need for funding to contribute to mitigation as a consequence of increased growth in recreation, and; (iii) to support new DNPA funding applications (e.g., to Heritage Fund) and its partner organisations (including the Environment Agency) aimed at mitigating the effects of increased rercreation growth. SWEEP was able to save DNPA money, through providing expertise and resoutrces that DNPA lacked in-house, and bring additional value by improving on previous DNPA methods for predicting future recreation growth.

Attitudinal/Capacity

Developed understanding and thinking around population futures and 'welfare valuation': The work has challenged perceptions and attitudes of the DNPA and its wider stakeholders around the impact of ncreasing footfall pressures and the Park's future survival as a 'wild place'. DNPA staff have an increased understanding and confidence in talking about the benefits, imapcts, and possible mitigation measures of various recreation futures.

> *"This improvement in resource targeting [as a result of the OWWL model] will have saved the EA thousands of pounds during each of the six largest storms over the last two winters by being able to be more targeted in our working, and reducing unnecessary trips and deployments.."*
>
> **Nick Ely, Environment Agency Coastal Modelling & Forecasting Manager**

> *"SWEEP brought an academic rigour that has given our staff confidence to talk about what the future might look like in terms of visitors and move the conversation forward!"*
>
> **Nick Ely, Environment Agency Coastal Modelling & Forecasting Manager**

It was estimated that visitors from across England walked around 18 million kilometres in the park each year and when combined with benefits to mental health that arise from spending time in nature, the findings highlighted Dartmoor's significant contribution to maintaining the health and well-being of the region's population. Full details can be found in the report 'Population Futures and Dartmoor National Park'.

Looking to the future

- SWEEP maintains a close working relationship with DNPA through work on the new Quantitative Habitat Mapping project which is developing novel remote-sensing methods for mapping and monitoring woodlands, moorlands and key habitats.
- It is anticipated that further dissemination of this recreational futures work may lead to it potentially being adopted as a methodology for National Parks further afield, both regionally in the South West and nationally.

> *"The recreational futures work provided a very strong evidence base that influenced the management plan, helped us look at recreation management and zoning, and some of the future actions that we'd like to take."*
>
> **Ally Kohler, Director of Conservation and Communities, Dartmoor National Park Authority**

Underpinning NERC Science

The team drew on NERC funded data, remote sensing tools, and state-of-the-art welfare valuation modelling tools ORVal and NEVO.

About SWEEP

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For more information contact sweep@exeter.ac.uk

UKRI Natural Environment Research Council

Local Natural Capital Accounting: A case study of Dartmoor and Exmoor National Parks

sweep

Impact Summary


Haytor, Dartmoor

This project improved the knowledge and capacity of Dartmoor and Exmoor National Park Authorities relating to Natural Capital Accounting approaches and methods, and continues to inform their thinking and plans. The critique of issues stemming from applying national level 'standard' guidance at the sub-national local level, was included in the government's revised Enabling Natural Capital Approach (ENCA) guidance and informed a Defra Environmental Land Management Scheme Test and Trials project.

1st set of Natural Capital Accounts developed for **2 National Parks**

Valued natural capital and ecosystem services for **1646km²**

10 recommendations in Briefing Note guidance adopted into ENCA

Ways of Working

Innovative Knowledge Provision → Effective Collaboration → Capacity Building → Natural Capital Valuation

Why it mattered?

In 2017, the UK's National Parks were encouraged to develop Natural Capital Accounts (NC Accounts) as part of the Glover's Landscapes review: National Parks and AONBs. The government's Natural Capital Committee also advocated the same: in support of the 25 Year Environment Plan ambition "the UK intends to use a natural capital approach" to enable local decision makers to be "*equipped with the tools they need to assess the benefits that come from their land and water assets so they can use them most effectively*".[1]

Despite the existence of international guidance[2] and national recommendations[3], specific guidance was not available for developing NC Accounts at a local, sub-national scale at that time; something acknowledged at the time in the government's own Enabling a Natural Capital Approach (ENCA): Guidance report and the 2019 Sixth Natural Capital Committee report.

This SWEEP project originally set out to work with Dartmoor National Park Authority (DNPA) and Exmoor National Park Authority (ENPA) to help them build sets of NC Accounts. As it became clear that there were serious deficits in data required to build NC Accounts at a local level, the project switched focus to provide DNPA and ENPA with a critical assessment of the usefulness of NC Accounting as a tool to inform decision-making for environment-facing organisations, at the local level.

Key questions critiqued were:

- Are large-scale approaches to NC Accounting appropriate at a smaller scale?
- How sensitive are local NC Accounts to variability in the quality and availability of data and changes in methods and assumptions?
- Given that sensitivity, how useful are NC Accounts as a strategic planning tool for land managers?

What we did

During 2017-2019, the SWEEP team – Dr Michela Faccioli, Dr Sara Zonnevald, Prof Brett Day and Prof Charles Tyler, based at University of Exeter – worked collaboratively with staff from DNPA and ENPA to:

- Build NC Accounts for both National Park Authorities (NPAs) following the 'standard practice' approaches adopted by environmentally-facing organisations.
- Compare outputs from the 'standard' approach, with outputs from methods more consistent with the formal rules of NC Accounting applied to detailed local data.
- Build capacity within both NPAs to understand and produce NC Accounts, including around decision-making about natural capital assets, ecosystem services focus, and data provisioning.

Outputs from the SWEEP work include:

- Local Natural Capital Accounting: does it deliver useful management information? A case study of Dartmoor and Exmoor National Parks. November 2019. Full Report to Exmoor National Park Authority and Dartmoor National Park Authority, with Extended Summary.
- Academic paper published in Journal of Environmental Management, Volume 327, 116272
- SWEEP Briefing Note (May 2021), Local Natural Capital Accounting: does it deliver useful management information? A case study of Dartmoor and Exmoor National Parks.

This Briefing Note made 10 recommendations to improve the effectiveness of NC Accounting as a management tool generally, but also specifically for environmental organisations such as NPAs operating at a sub-national scale.

1 25 Year Environment Plan
2 System of Environmental-Economic Accounting, SEEA
3 ONS/ Defra Principles of Natural Capital Accounting

Impacts & benefits delivered

Attitudinal

Developed knowledge and understanding: both Dartmoor and Exmoor NPAs benefited from an improved understanding of NC Approaches and Accounting methods. Over 200 people attended presentations organised by DNPA.

Improved national Enabling Natural Capital Approaches (ENCA) Guidance: SWEEP reporting was included as a formal Case Study in Defra's influential ENCA Guidance (Aug 2021 revision).

Informed Dartmoor ELMs Test and Trial: Known as the Dartmoor Hill Farm Project, this ELMs Test and Trial explored the feasibility of using a Natural Capital Approach for local priority setting and landscape-scale planning. SWEEP findings were central to a critique of issues in the context of Dartmoor, with a focus on: (1) issues around data gaps, resources for monitoring and land access issues affecting data gathering; and (2) lack of guidance for sub-national approaches, especially in relation to biodiversity and peat, being two of Dartmoor's most significant NC Assets.

Organisational function

Built capacity within the NPAs: through the process of co-creating NC Accounts with each Park, the SWEEP team helped build staff capacity.

Met government's ambition for NPAs developing NC Accounts: NC Accounts were developed for both Dartmoor and Exmoor NPA for 2015. However, their limitations restricted the way in which the information could subsequently be used by the NPAs to inform decision-making (see Table 1).

Informed Exmoor National Park Partnership Plan 2018-2023: The Mid-term progress report (Nov 2021) of ENPA's five-year Partnership Plan, setting out joint ambitions and strategies required to maintain the special qualities of the park, included a Case Study (Section 47) on the SWEEP 'Local Natural Capital Accounting' work.

> *"This was a really useful piece of work bringing together academic expertise and specialist staff at the National Parks. We entered into this process to develop a robust natural capital account for the National Park. We hope the learning from this Project can be shared to improve the tools available and ensure a consistent approach."*
>
> **Ally Kohler, Director of Conservation and Communities, Dartmoor National Park**

> *"It's really useful to see research like this from the ground. The SWEEP work will add to the body of evidence that helps to inform Defra on how to implement the recommendations of the Glover Landscapes Review, in particular integrating better nature and climate targets, and natural capital accounting, into protected landscape management plans."*
>
> **Amy Chadwick, Team Leader, Environmental Outcomes in Protected Landscapes, Defra**

> *"The SWEEP project delivered a rigorous and robust assessment of natural capital accounting in the National Park. With an expectation that the natural capital approach will form the basis of our future planning and decision-making. I feel it's very important we feedback the learning to Government in order to improve the processes and tools."*
>
> **Clare Reid, Head of Strategy and Performance, Exmoor National Park**

Wimbleball Lake, Exmoor National Park

Ecologist studying the Rhos Pasture on Dartmoor

	Exmoor National Park	Dartmoor National Park	
	Provide improved information to feed into the State of the Park report	Provide improved information to feed into the State of the Park report	
	Provide input into the Environment Land Management Schemes (ELMS)/payment for farming e.g., by putting value on provided eco-system services.	Explore the use of Natural Capital accounting for investment decision-making e.g., when needed to prioritise between choice of two management/ restoration options.	
	Land ownerships/land holdings: understand best use for land owned by Exmoor National Park.	Leverage funding/justifying spending. Understanding the monetary value resulting from e.g., a restoration project, and use this knowledge to leverage money for cost of project.	
	Use to show where (data) gaps are in decision-making.	Influencing management decision-making, e.g., increasing amounts of stock which are shown to have high value.	

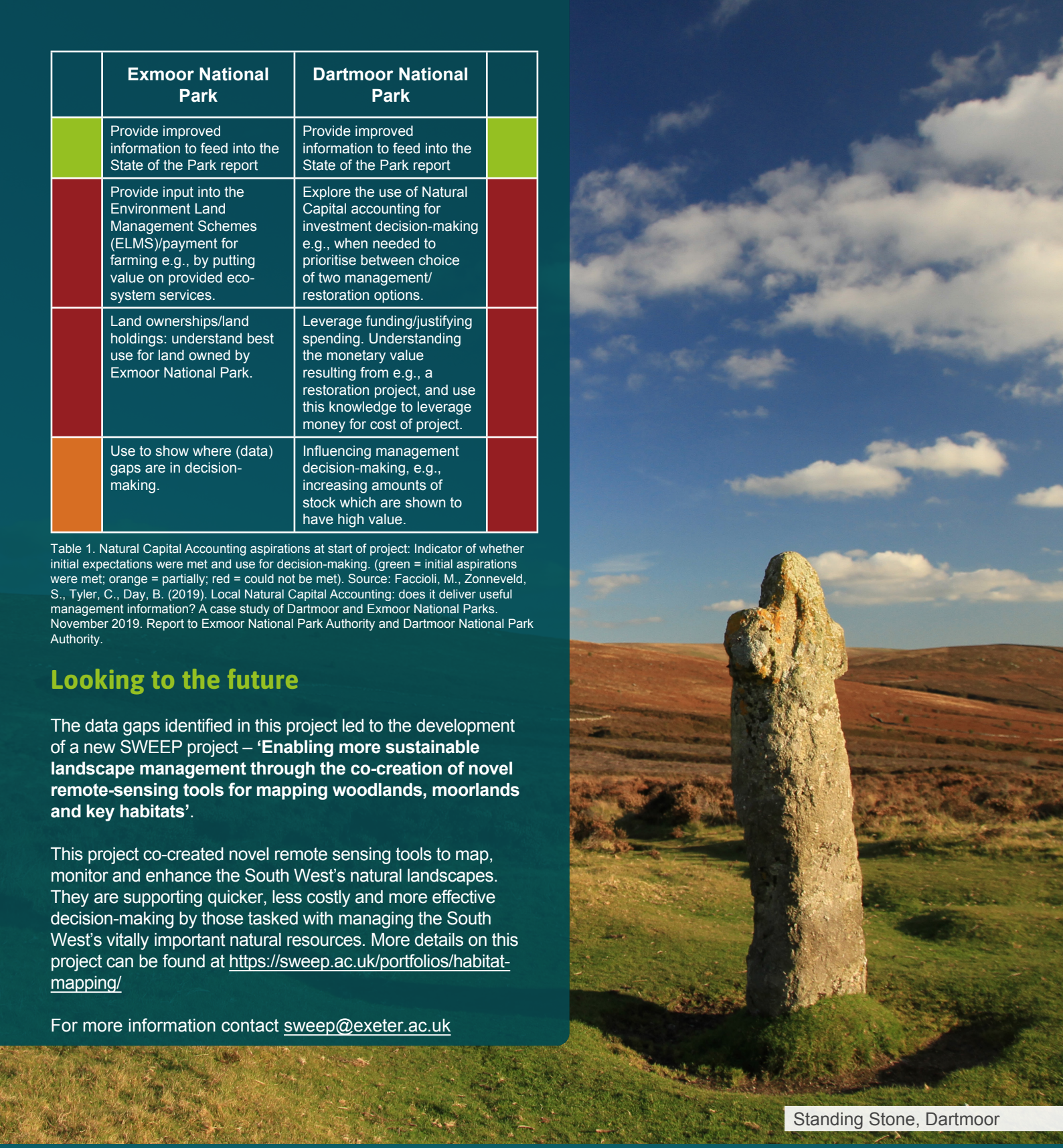
Table 1. Natural Capital Accounting aspirations at start of project: Indicator of whether initial expectations were met and use for decision-making. (green = initial aspirations were met; orange = partially; red = could not be met). Source: Faccioli, M., Zonneveld, S., Tyler, C., Day, B. (2019). Local Natural Capital Accounting: does it deliver useful management information? A case study of Dartmoor and Exmoor National Parks. November 2019. Report to Exmoor National Park Authority and Dartmoor National Park Authority.

Looking to the future

The data gaps identified in this project led to the development of a new SWEEP project – **'Enabling more sustainable landscape management through the co-creation of novel remote-sensing tools for mapping woodlands, moorlands and key habitats'**.

This project co-created novel remote sensing tools to map, monitor and enhance the South West's natural landscapes. They are supporting quicker, less costly and more effective decision-making by those tasked with managing the South West's vitally important natural resources. More details on this project can be found at https://sweep.ac.uk/portfolios/habitat-mapping/

For more information contact sweep@exeter.ac.uk



Standing Stone, Dartmoor

Organisations we've worked with

DARTMOOR NATIONAL PARK

EXMOOR NATIONAL PARK

About SWEEP
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UKRI Natural Environment Research Council

Managed saltmarsh realignment: Exploring economic and natural processes

sweep

Impact Summary

This SWEEP project explored a Natural Capital Approach towards identifying and selecting areas suitable for managed realignment of saltmarsh in the North Devon Biosphere Reserve (NDBR) based on locations which maximised the benefits saltmarsh provides to society, relative to the costs of removing land from its current use. Geomorphology and tidal hydrodynamics were also investigated. The findings developed NDBR's knowledge base and compliments ongoing work in this area.

Ways of Working

Why it mattered?

Saltmarshes are rapidly degrading and decreasing worldwide. They produce a range of ecosystem services including carbon sequestration, recreational benefits and fisheries support services.

Managed realignment is the process of returning land back to saltmarsh, in areas where they have occurred historically occurred. This can improve coastal stability against flooding and erosion – which are likely to increase with climate change.

What we did

In 2017-2019, SWEEP Impact Fellow Dr Katrina Davis worked closely with the NDBR managers and other SWEEP team members to:

- Using an integrated natural capital methodology, identify areas where the ecosystem services generated by new saltmarsh in the Biosphere would generate the greatest economic benefits, relative to the economic costs.
- Produce the published paper A generalisable integrated natural capital methodology for targeting investment in coastal defence, describing GIS methodology, economic evaluation, and site prioritisation of candidate managed re-alignment sites, and the North Devon Marine Pioneer, Project Update (Mar 2019) Creating saltmarsh - a natural capital approach.
- Carry out a series of dissemination and engagement actvities, including with the North Devon Marine Pioneer.
- Oversee linked Master Thesis project: 'Using a residency index to estimate the value of saltmarsh for fisheries.'

Over the winter of 2018/19, Dr Tim Poate (SWEEP UoP team) led a new project commissioned to evaluate the geomorphology and tidal hydrodynamics of sites in the NDBR, to provide a new understanding of the potential for managed re-alignment in the Taw-Torridge estuary.

The work undertaken by Tim Poate helped to provide a more accurate estimation of the changes that might be expected at the mouth of the estuary to provide a basis for planning policy for the coming years.

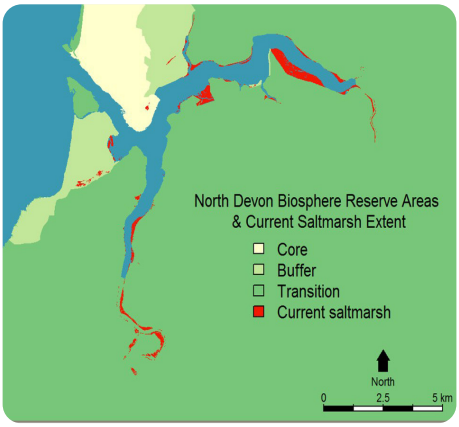
The contemporaneous tidal recording information carried out by SWEEP provided fundamental information for the Biosphere management team to implement a Sea level and Marsh Management model to further refine the management re-alignment strategy for the estuary.

As a consequence of this modelling work, a £6m project for creation of estuary habitats has been initiated.

Figure below: North Devon Biosphere Reserve areas and current saltmarsh extent. Credit: Davis, et al (2018)

"This SWEEP work gave us an alternative view of benefits of intertidal habitat creation in terms of the cost and benefit flows to both people and nature depending on location, from an economic perspective. The geomorphology and tidal hydrodynamics work in the estuary gave us more a more solid platform from which we undertook our more detailed modelling to result in a healthy mix of different intertidal habitats looking into the future (100 years). The work has helped us to develop practical and sustainable financing mechanisms for our £6m CRITTER project."

Andy Bell, North Devon Biosphere Reserve Foundation



Looking to the future

The NDBR continues to explore issues around saltmarsh realignment through:

- Sea Level Affecting Marshes Model (SLAMM) modelling – this work simulated the potential impacts of long-term sea level rise on wetlands and shorelines.
- The £100k 'Blue Carbon and the Natural Capital Marketplace' project - funded under the Environment Agency's Natural Environment Investment Readiness Fund (NEIRF), this project aims to 'Deliver saltmarsh restoration using finance raised from carbon credit sales. Water quality improvements, improved flood risk management and Site of Special Scientific Interest improvements will also be modelled.' See the Biosphere Foundation's Natural Capital Marketplace for more details.
- The £6m CRITTER project (Coordinated Response for Intertidal Taw Torridge Estuary Restoration – this project aims to work with landowners and land managers to improve water quality, reduce flood risk, increase the health of local soils, create areas of new saltmarsh, all supported through a simple small grant scheme process. https://www.northdevonbiosphere.org.uk/critter.html

For more information contact sweep@exeter.ac.uk

Salt Marshes at Northam Burrows, North Devon

Organisations we've worked with

unesco

biosphere north devon

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UKRI Natural Environment Research Council

Sustainable Drainage Systems (SuDS): Developing 'landscape-scale'approaches in the South West

sweep

Impact Summary


SuDs retention pond

The new SWEEP-designed SuDS Strategic Screening Tool was used by South West organisations on a range of drainage projects delivering business efficiencies. Training in its use and other flood risk tools boosted capacity and commercial strategic advantage. The new innovative Opportunity Mapping Tool further identifies where SuDs measures can be applied at scale, across Devon.

Strategic Screening Tool supported projects valued at **£355k** and a further **£370k** bids

6 staff trained in use of SWEEP SuDS and flood-risk tools with **28** jobs safeguarded

£20k cost saving to customers per use of Strategic Screening Tool

Ways of Working

Innovative Knowledge Provision — Capacity Building — Tailored Decision Support

Why it mattered?

Sudden flash flooding can be devastating, risking lives, homes and vital infrastructure. Damages in the UK are estimated between £250m and £500m annually. The environment suffers through uncontrolled sewer discharges into rivers, lakes and bathing waters. Public health and tourism can also be affected. South West England has been particularly badly hit by surface water flooding, with major flash flood events at Boscastle, Coverack and Clovelly in recent years.

SuDS

New 'green' sustainable drainage systems (SuDS) provide a natural approach to combat increased surface water flooding risks, driven by climate change and urbanisation, and to tackle deteriorating 'traditional' infrastructure, such as sewers, tanks and overspills.These systems manage surface water before it reaches sewers and can improve water quality and biodiversity by mimicking natural draining through the use of green roofs, permeable surfaces, ditches, swales (shallow drainage channels), ponds and wetlands. SuDS have proved successful at sitescale - but widespread implementation across whole water catchments remains fragmented and opportunistic.

> *"Good forecasting is the most cost effective way to safeguard communities at the coast and, ultimately, save lives."*
>
> **Nick Ely, Environment Agency Coastal Modelling & Forecasting Manager**

What we did

Between 2018 and 2020, Dr James Webber & Prof Guangtao Fu of the University of Exeter's Centre for Water Systems promoted an integrated, collaborative and strategic view of surface water management in South West England through these activites:

1. **Developed the new SuDS Strategic Screening Tool**, which maps surface water (overland exceedance) flow paths and catchments for South West England, promoting an early-stage, 'whole catchment' approach to surface water management, in contrast to conventional ad-hoc, site-specific approaches. The Tool was used in 8 flood risk assessment and SuDS-landscape management analyses in Devon, Cornwall.Yorkshire and the USA.
2. **Delivered training** in the use of the **SuDs Strategic Screening Tool**, the University of Exeter's **CADDIES -2D lood model** and the **CORFU lood damage assessment tool** to key project partners, including environmental charity Westcountry Rivers Trust and international engineering consultancy Pell Frishmann. Knowledge was also shared with 250 water industry professionals and other organisations such as South West Water and marine and consultancies Jacobs and Fjordr.
3. **Developed the new SuDS Opportunity Mapping Tool** which indicates high-level opportunities for SuDS application in Devon by incorporating a range of environmental (land uses, slopes, water environment, hazards), human (socio-demographics, buildings) and engineering (SuDS suitability) factors.


SuDS swale

Impacts & benefits delivered

Organisational Function

Strategic commercial advantage and cost savings: The SuDS Strategic Screening tool supported £355K of sustainable drainage and flooding project work carried out by Pell Frischmann and Westcountry Rivers Trust and an additional £370K of bids. Projects included Dartington Estate, Clinton Devon Estates, Burrator Reservoir, Kingsbridge and the Rivers Culm & Otter in Devon, and Cornwall's St. Austell Bay StARR flood alleviation and regeneration scheme. The tool was used as a high level screening tool by Pell Frischmann for initial SuDS catchment assessment, one of their strategic growth areas. It delivered operational efficiencies, enhanced capacity and its use enables us to "reduce the bid value and therefore improve our competitive edge." Jonathan Hubbard, Pell Frischmann.

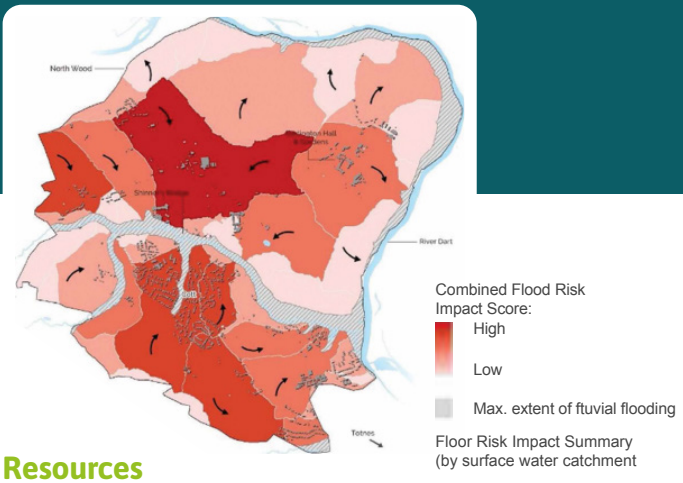
Organisational Function

Strengthening capacity and increasing resilience: Training in the use of the SuDS Strategic Screening tool and other surface water management abd flood risk tools (e.g., CORFU and CADDIES) was delievered to six staff across Pell Frischmann and Westcountry River Trust. The skills of three early career technical specialist jobs were ehanced and their jobs safe-guarded in the Westcountry Rivers Trust team , as a result of this training. The enhanced organisational capacty which, in turn, helped to support their whole Natural Flood management of approx. 25 people going forward.

> *"There's nothing out there at the moment defining which SuDS solutions are viable in an area. The SWEEP Strategic Screening Tool and Opportunity Mapping will help to fill that gap in the South West."*
>
> **Jonathan Hubbard, Pell Frischman**

> *"The Strategic Screening Tool helped us to rapidly identify a previously unknown, hidden culvert in the town of Kingsbridge. It was significant to the final design concept for the flood mitigation works which will cost around £8-1Om to construct."*
>
> **Jonathan Hubbard, Pell Frischman**

> *"The SWEEP SuDS project provided a huge opportunity for us to access tools such as CADDIES and the Strategic Screening Tool, and for our staff to be trained in their use. This delivered significant cost savings in terms of access to tools, training, salary costs and time savings. We are now able to offer a broader, integrated package of natural flood management and SuDS services to our clients which has definitely boosted our reputation and opened up doors for us and is helping to transform WRT and make it more resilient going forwards. A real game-changer for WRT!"*
>
> **Nick Paling, Westcountry Rivers Trust**



Resources

The SWEEP SuDS Tools are available directly from Dr. James Webber and further guidance and Case Studies can be found here:

- How the SuDS Strategic Screening Tool works, with a Case Study application at Dartington Estate, Devon, produced collaboratively with Westcountry Rivers Trust.
- How the SuDS Opportunity Mapping Tool helps spatial planners in Devon to understand; (a) where SuDS are needed, and, (b) where they can be placed, considering SuDS solutions.
- The Cost effectiveness of a SuDS Strategic Screening Tool, viewed through a Case Study in Exeter, Devon.
- Addressing urban surface water flooding, through the use of SuDS, at city catchment scale with a Case Study in Melbourne, Australia.
- Targeting property flood resilience and investigating methods, with a Case Study in Bristol.

The SWEEP team continues this pioneering work through the University of Exeter's Smarter Stormwater Research Group and continued collaboration with the SuDS expert community.

Underpinning NERC Science

- NE/K008765/1 Susceptibility of catchments to intense rainfall and flooding (Project SINATRA)
- NE/N01670X/1 Coupled Human And Natural Systems Environment (CHANSE) for water management under uncertainty in the Indo-Gangetic Plain
- NE/K00896X/1 TENDERLY: Towards end to end flood forecasting and a tool for real-time catchment susceptibility

For more information contact sweep@exeter.ac.uk

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UKRI Natural Environment Research Council

Tackling pollinator decline in Cornwall through enhanced natural capital management policies and practices

sweep

Impact Summary

SWEEP delivered a first-of-its-kind approach to pollinator-friendly habitat management for Cornwall. Phase 1 of this project used a combination of auditing, mapping, evaluation and business engagement, to safeguard or enhance the ecosystem services that pollinators provide, and strengthen local and national policies to benefit birds and insects.

Fast-tracking delivery of the UK's **1st** county-wide approach to pollinator habitat management in Cornwall

8,000ha of pollinator-friendly habitat, including wildflower meadows, created, safeguarded or enhanced.

Strengthened **5** policies including Cornwall's Pollinator Action Plan 2019-2023 and the UK's National Pollinator Strategy

Ways of Working

Why it mattered?

Over the past century, 97% of Britain's wild flower meadows have been lost and with them, a significant proportion of pollinating insects, including a third of our wild bee species. This drastic decline is detrimental to the ecosystem services that our grasslands and pollinators provide, such as plant pollination - fundamental for food production, soil quality, pest regulation and, where grasslands protect water courses and prevent flooding, water management.

Three quarters of Cornwall's land area is farmed, with the majority dominated by grass production for dairy and beef (73% of 262,790ha). A strong horticultural industry covers only 1 % of farmed land, yet produces around 30% of the South West's fruit and vegetables through high-value crops reliant on insect pollination. Cornwall Council also owns vast areas of common land, greenspaces and road verges (around 16,000ha).

> *"One out of every three mouthfuls of our food depends on insect pollination… Without (pollinators), treasured landscapes would be devoid of colour and life; agriculture and tourism would suffer; and wildlife would perish."*
>
> **Foreword, Cornwall's Pollinator Action Plan, 2019-2023**

Despite a number of existing initiatives to manage grassland in a less intensive fashion - such as the charity Plantlife's 'NoMowMay' and the Countryside Stewardship scheme - most grassland in Cornwall still remains heavily mown, grazed and fertilised, resulting in a 'green desert' which lacks biodiversity.

What we did

Responding to this growing issue, Prof. Juliet Osborne, Dr Grace Twiston-Davies and Dr Jess Knapp from the University of Exeter's Environment and Sustainability Institute worked closely with Natural England, Cornwall Area of Outstanding Natural Beauty, Cornwall Council, Duchy of Cornwall, Buglife, and two EU-funded growth programmes for Cornwall and the Isles of Scilly - Tevi and Future Focus.

Engaging 34 active partners and completing 24 outreach/engagement activities, the team delivered:

- a new version of Bee-Steward - an award-winning landscape-scale decision support tool that helps farmers and land managers understand how their practices affect bee survival and pollination. It has been enhanced to provide grassland and horticulture settings, and financial costs and benefits;
- 39 bespoke 'Pollinator Management Reports', including Bee-Steward reports, to land-owners (such as farmers, orchards and holiday parks) and other businesses, and supported 38 Cornish SMEs on business-led pollinator-enhancing solutions via Tevi;
- Buglife's North Cornwall B-Lines - a series of 3km wide 'insect pathways' along which wildflower-rich habitats are being restored, created and linked together - in collaboration with Cornwall Council;
- a pollinator audit for Cornwall and the Isles of Scilly - reviewing pollinator and habitat projects from 2018-19.
- publically accessible GIS map of pollinator hotspots and top habitat creation areas - with Kernow Ecology;
- integration of Bee-Steward into the New Environment Management Scheme through delivery of two trials by the National Association of AONBs and Plantlife in collaboration with Detra and Natural England.

Impacts & benefits delivered

Natural Capital

Creating improved habitat for pollinators: 7,384ha of land has been created, enhanced or safeguarded specifically for pollinators (through the Bee-Steward plans) across farms, orchards, holiday parks and other businesses in Cornwall and the Isles of Scilly, with more expected in phase 2 of this SWEEP project. A further 545ha of new pollinator habitat has been pledged (flowering cover crops, perennial wildflower meadows, trees and hedgerows), and 391 ha of habitat enhanced by seeding or management.

Attitudinal/Capacity

Improved stakeholder knowledge and shifting attitudes: Stakeholders are now better informed about the benefits of adopting a natural capital approach to pollinator-friendly land management. They are working in a more engaged, collaborative way across Cornwall which is accelerating the pace of change.

Organisational Function

Delivering cost-savings, organisational efficiencies and strategic improvements

- Buglife completed its Cornwall B-line mapping faster and more efficiently and used it to support more robust funding proposals leading to the listing of nine pollinator habitat creations.
- The new Bee-Steward model has created more pollinator-focused and resilient land management plans, for example, enabling the Duchy of Cornwall to develop 112 pollinator-friendly natural capital planswith 112 of their tenant farmers across Devon, Cornwall, and the Isles of Scilly.
- Bespoke SWEEP 'Bee-Steward action plans', have saved landowners money across the region through costs avoided from hedgerow management (£3,380pa), cover crop planting (£29,337pa) and a provision of £2,000 of wildflower seeds. They also supported four successful Countryside Stewardship applications providing financial returns for the next five years.

Policy & Legislation

Strengthening pollinator olicy both regionally and nationally

- Cornwall's Pollinator Action Plan 2019-2023 directly refers to SWEEP's Bee-Steward model and Buglife B-lines
- Cornwall's Wildlife Trusts' Nature Recovery Networks and Cornwall Council's tree planting guidelines both reference Buglife B-lines
- Cornwall AONB's successful application to Defra for an Environmentyal Land Management scheme test trial is using Bee-Steward to help guide landscape-scale management decsions
- The National Pollinator Strategy incorporates SWEEP's Buglife B-line work into its evidence base.

> *"Working with SWEEP helped us gain a high level of stakeholder engagement in the county, accelerate the B-Lines mapping process and identify synergistic and complementary projects to deliver B-lines on the ground."*
>
> **Andy Whitehouse, Buglife**

Case Study: Cusgarne Farm

Cusgarne Farm successfully applied for mid-tier organic Countryside Stewardship funding worth £26,430 over five years to develop pollinator-friendly habitat. Greg Pascoe, Owner of Cusgarne Farm said: "*Collaboration with SWEEP showed us how important our hedgerows are for pollinators, especially queen bumblebees... 20% of our farm in now in the Wild Pollinator and Farm Wildlife Package.*"

> *"Visualising the impact of establishing certain habitat types via the Bee-Steward model reports brings the process of land management for pollinators to life, greatly helping discussions with our farming tenants."*
>
> **Jeremy Clitherow, Natural Capital Project Adviser, Duchy of Cornwall**

Looking to the future

Phase two of this project builds on this pioneering work and strong relationships forged with partners. It wil continue to deliver impacts that integrate pollinator-management ideas into decision-making and policy, scaling these from local to national level. It will also develop novel opportunities for natural capital business excellence in the South West and create a legacy of grass-roots environmental leadership in the region, drawing upon the 70 stakeholders and partners engaged with so far.

Underpinning NERC Science

- NE/J014893/1 - NERC WESSEX BESS project - Biodiversity and the provision of multiple ecosytem services in current and future lowland multifunctional landscapes.
- NE/P016731/1 - NERC Innovation Project - Bee-Steward: A decision-support tool for land owners, managers and advisors to support pollinator populations on farmland.
- NE/J015237/1 - NERC F3UES BESS project - Fragments, functions and flows - the scaling of biodiversity and ecosystem services in urban ecosystems.
- NE/P010725/1 - NERC Knowledge Exchange Fellowship - using bee models to support decision-making in the implementation of the National Pollinator Strategy in Cornwall.

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UKRI Natural Environment Research Council

Developing an integrated 'whole-catchment' approach to water management

sweep

Impact Summary

Over the course of SWEEP's 5 year programme, the UoE SWEEP team have supported South West Water (SWW) to embed a Natural Capital and Whole Catchment Approaches to their business planning, monitoring and investments.

Phase 1 work (2017-2019) supported SWW and their Upstream Thinking (UST) Delivery Partners in planning for the PR19 business case submission, helping SWW achieve coveted Fast Track Status and £15m investment in catchment management approaches. The relationship between SWW and UoE was further strengthened with the establishment of the £31.5m Centre for Resilience in Environment, Water and Waste (CREWW), funded jointly by SWW and Research England.

Phase 2 work (2019-2022) involved collaborative development, with SWW and Delivery Partners organisations, of the innovative UST Portal and Decision Support Tool, now being used to record, monitor and potentially evaluate SWW commitments on biodiversity and environmental enhancements to improve catchment water quality.

£15m investment in catchment management supported (2020-2025)

40 jobs (15 FTE) safeguarded across UST programme

Evidencing water quality and biodiversity interventions on **50,000** ha land (2020-25)

Ways of Working

- Innovative Knowledge Provision
- Effective Collaboration
- Capacity Building
- Tailored Decision Support
- Natural Capital Valuation

Why it mattered?

Freshwater quantity and quality are key environmental concerns for the South West. Numerous economic activities rely on good water quality, either directly or indirectly, including the delivery of clean drinking water, fish and shellfish aquaculture, recreational fishing and the use of the region's fresh and coastal waters as recreation and tourism destinations.

> *"Healthy rivers are vital for biodiversity and to human health and well-being. Rivers provide habitats for a range of wildlife, protect against flooding and provide beautiful places for recreation and reflection."*
>
> **House of Commons Environmental Audit Committee[1]**

In 2020, the Environment Agency reported that 0% of rivers, lakes and streams in England were in good overall health[2]. Affected by pollution from agricultural and industrial activities, urban runoff and sewage, and surface water flooding.

The build-up of excessive nutrients like phosphorus and nitrogen from animal waste and sewage reduces oxygen in rivers which harms its biodiversity. Plastic and synthetic chemical pollution and climate change further weaken the resilience of freshwater ecosystems[3].

Following the publication of Defra's 25 Year Environment Plan in 2018, water companies began considering how they could better account for the environment in their 5-yearly cycle of business planning, both generally through catchment management and specifically via Natural Capital Accounting[5].

> *"It is manifestly apparent that the preservation of natural capital stocks—such as the biodiversity in rivers—has not been valued highly enough in decisions by regulators, water companies and successive administrations over recent decades."* **House of Commons Environmental Audit Committee[4]**

In 2017, at the start of this SWEEP project, South West Water (SWW) had begun designing their five-year Asset Management Plan (AMP7) and were planning for the related Price Review process (PR19) which, subject to Ofwat approval, would direct the company's investments from 2020 to 2025.

SWW were keen to invest further in **catchment management solutions** within their business planning and to be delivered through their innovative **Upstream Thinking programme (UST)** but, at the time, lacked the key evidence needed to support the investment case.

1 p7. House of Commons Environmental Audit Committee. (2022). Water quality in rivers. Fourth Report of Session 2021–22.
2 Environment Agency, 2020.
3 p193 CIWEM, 25 Year Environment Plan. Ambition to realisation.
4. House of Commons (2022)
5 p108 House of Commons (2022).
6 South west Water.Who we are.
7 South West Water. Green Recovery Initiative

Phase 1 (2017-2019) - What we did

Between 2017-2019, the SWEEP team worked closely with South West Water and its catchment management delivery partners to develop an **integrated, spatially explicit understanding of catchment scale processes that impact water-based natural capital, economic development and health/wellbeing in the South West**. A key objective was to collate and translate existing research and evidence into a coherent argument to Ofwat for investment in catchment management under PR19.

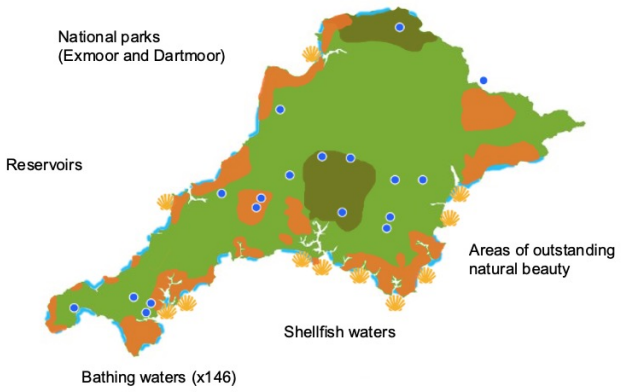
- The phase 1 SWEEP team was comprised of UoE Impact Fellows Dr Donna Carless, Dr Mandy Robinson, Dr Michela Faccioli and Gemma Delafield and Prof. Richard Brazier and Prof. Brett Day.
- Extensive stakeholder engagement was undertaken with UST delivery partners (Westcountry Rivers Trust, Devon Wildlife Trust and Cornwall Wildlife Trust) as well as Exmoor National Park Authority, the Water Research Centre, Environment Agency and Natural England.

Outputs include:

- 10 Catchment Summary reports, relating to new Drinking Water Catchment Schemes or Investigations, and 11 Business as Usual cases, supporting SWW's PR19 process.
- A suite of GIS maps and spatial analysis outputs, including: (1) maps of catchment locations, SWW assets, environmental designations such as priority habitats, and analysis of current UST coverage; and (2) mapping and analysis of pollution incidents and biodiversity enhancement opportunities.
- A Natural Capital Accounting Ecosystem Services Valuation Tool, with analysis of planned interventions and their impacts. The simplified natural capital accounting[8] exercise included analysis of interventions such as woodland and grassland management, peatland restoration, other soil management practices and changes in agricultural practices.

Our natural capital environment

South West Water



SWW provides water and wastewater services to a resident population of 1.7 million and over 2 million people in peak tourist months[6]. The majority of water supply (93%) comes from reservoirs and rivers and the area includes 34% of England's bathing waters, 25 designated shellfish waters and 2 National Parks[7].

SWW's Upstream Thinking programme (UST)

The UST is an award-winning catchment management scheme launched in 2010 by South West Water and delivered in collaboration with regional environmental and conservation charities (Cornwall and Devon Wildlife Trusts, the Farming & Wildlife Advisory Group South West, Natural England and Westcountry Rivers Trust). Innovative in its conception, it recognises that, by changing land use and land management practices, pollution can be eliminated at source. By paying landowners to deliver these changes it can, in the long run, also generate wider environmental benefits beyond water quality improvements. It can also do this at far less cost compared to over engineered solutions which remove pollutants in water treatment works, and generally require multi-million pound investments. The programme supports farm advisers who work closely with landowners to advise on water friendly farming practices.

8 Natural capital accounting is the attempt to bring a systematic, standardised and repeatable framework to recording information on: (1) natural capital (i.e. stocks on natural assets) and the flow of ecosystem services and goods they supply; and (2) a measure of the benefits or costs to society linked to changes in these ecosystem services flows, whether or not they have a market value.

Good Farm, Bad Farm. Source: West Country Rivers Trust

Impacts & benefits delivered

SWEEP's phase 1 work delivered the following benefits:

Attitudinal/Capacity

Transformed SWW's understanding and knowledge base: SWEEP-produced information and the Natural Capital Accounting Ecosystem Service Valuation Tool transformed SWW's understanding of its natural capital assets, business challenges and the investment case for potential catchment solutions.

Strengthened SWW's reputation for catchment management and environmental protection: SWW PR19 business plan was ranked 1st by Wildlife and Countryside Link[9] in their Blueprint for Water (2019), in terms of how England's nine water and sewage companies matched the coalition's view of the environmental challenges and opportunities facing the water sector in England[10]. SWW also scored well in relation to commitments to protect and restore catchments from source to sea.

Organisational Function

Embedded the Natural Capital Approach: Using the SWEEP Natural Capital Accounting Ecosystem Services Valuation Tool, SWW embedded environmental values directly within its PR19 catchment business planning, demonstrating that the expected return on primary investments would be fourfold.

Helped secure £15m investment in catchment management approach: this new SWEEP-informed approach directly contributed to SWW being awarded £15M by Ofwat to deliver on their catchment management ambitions delivered through interventions aimed at tackling diffuse pollution.

Value of being awarded Fast Track Status: SWW's PR19 submission was awarded Fast Track Status by Ofwat for innovation, around its adoption of the Natural Capital Approach. This delivered a £200m cost saving due to SWW being able to make early planning decisions and gaining access to preferential borrowing rates.

Water treatment cost savings: It is anticipated that SWW and customers will benefit from reduced water treatment costs in the long-run under UST3.

> *"The SWEEP team helped us look at our data in a new, and really valuable, way. We benefited from their academic perspective and best-available mapping, data analysis and processing skills... and became much better-informed about the natural environment in the South West river catchments."*
>
> **David Smith, UST Programme Manager, SWW**

> *"Our PR19 Business Plan, for the first time, adopted a natural capital approach and we couldn't have done that without SWEEP."*
>
> *"The SWEEP natural capital valuation tools helped us show that the expected return on our primary investment in the catchments was fourfold, where the return on investments included the value of water quality improvements, as well as the value of a range of other possible natural capital outcomes."*
>
> **David Smith, UST Programme Manager, SWW**

> *"SWEEP work helped secure over £15m of new funding from Ofwat for the 2020-2025 period... It was vital in demonstrating quantitatively the benefits of catchment management to our customers and the environment. This also helped us achieve an 'exceed expectations' from Ofwat on our Water Resources Management Plan."*
>
> **Simon Bird, Former Managing Director, SWW**

> *"Adopting a Natural Capital Approach to our Business Planning aligned with Ofwat's priorities around customer value and innovation. It made it easier for us to explain the case for investing in catchment management to Ofwat which was reflected in our achieving Fast Track Status for our overall PR19 Business Plan."*
>
> **David Smith, UST Programme Manager, SWW**

> *"The SWEEP work on catchment management impacts is helping us reduce operation costs and improve reliability. At Wendron water treatment works we have seen shut downs reduce from 19 to zero over a two month period... On this site alone, this is a saving in two months in the order of £50k in lost productivity."*
>
> **Simon Bird, Former Managing Director, SWW**

9 Wildlife and Countryside Link is the largest environment and wildlife coalition in England, bringing together 67 organisations to use their strong joint voice for the protection of nature.
10 Blueprint for Water (2019) Blueprint for PR19. Our Environmental Scorecard. Wildlife and Countryside Link.

Strengthened relationship between UoE and SWW: contributing to £21m investment from Research England and £10m from SWW for the new Centre for Resilience in Environment, Water and Waste (CREWW).

Deepened long-term collaborations with UST Delivery Partners: during the PR19 process and going forwards.

Economic

Jobs safeguarded: approximately 15 FTE jobs in the UST programme were safeguarded during 2020-2025 through the PR19 investment in catchment management.

Natural Capital

Biodiversity and water quality improvements: SWEEP information enabled SWW to make the business case for delivering environmental improvements, even beyond its regulatory requirements, and then set ambitious targets for area of land 'actively engaged' for water quality or biodiversity enhancement.

Argal Reservoir. Source: Emilie Grand-Clement, UoE

Upstream thinking: Natural Capital investment: Moors

> *"The process of engaging with SWEEP strengthened our relationship with the University of Exeter. It helped shape our thinking around data handling, laboratory capacity and analysis, which ultimately led to our investment in, and the development of, the Centre for Resilience in Environment, Water and Waste (CREWW)."*
>
> **David Smith, UST Programme Manager, SWW**

> *"Working with SWEEP gave me a really clear insight into the water companies business planning process. As a result, it feels like we're now in a good place to begin negotiations on PR24, which sounds bizarre because it's 2019, but this is when the conversations need to happen."*
>
> **Nick Paling, West Country Rivers Trust**

> *"The UST programme and Farming Advisory Service is delivered by around 40 people in different organisations... The SWEEP work helped us deliver more environmental improvements through natural solutions, supporting jobs within the environmental sector and water industry."*
>
> **David Smith, UST Programme Manager, SWW**

> *"The SWEEP process enabled us to commit to a biodiversity Outcome Delivery Incentive (performance commitment) of 50,000 ha of catchment environmental improvements over 2020-2025. And to continue this ambition at the same scale over the next 25 years."*
>
> **David Smith, UST Programme Manager, SWW**

Source: David Smith, SWW

Phase 2 (2019-2022)

What we did

During the PR19 planning process, the need for a new method for recording UST activity was identified, to provide evidence of achievements and ensure consistency in reporting.

> *"The SWEEP catchment management project was completely aligned with the work we were trying to do with SWW. The first phase put in place the building blocks. The second phase, developing the UST Portal, will completely change the way we report and monitor UST! Developing a single, integrated data capture solution that everybody can use… is critical and will utterly transform the UST monitoring and evaluation process."*
>
> **Nick Paling, West Country Rivers Trust**

Phase 2 of the SWEEP project 'whole catchment approach to water management' was delivered by UoE SWEEP Impact Fellows Dr Donna Carless, Dr Mandy Robinson, Dr Ben Jackson and Jess Kitch, and Prof Richard Brazier, working in collaboration with South West Water and UST Delivery Partners: Cornwall Wildlife Trust, Devon Wildlife Trust, Farming and Wildlife Advisory Group South West, Catchment Sensitive Farming (Natural England) and Westcountry Rivers Trust.

In 2021, reporting capabilities for the South West Lakes Trust and South West Peatland Partnership were developed within the Portal.

In the same year, reporting capabilities were also developed for the post-Covid Green Recovery Initiative. Relating to catchment management, the aimed to deliver 10,000 hectares of additional activity, including restoration of some of Dartmoor's most damaged degraded peatland and work to improve biodiversity and enhance natural habitats.

Outputs include:

- **Upstream Thinking Portal** – designed to allow Delivery Partners to consistently record interventions and activities delivered as part of the UST programme. The portal uses the ArcGIS Online platform and is only accessible to SWW and the UST Delivery Partners. Details of the Portal and its Instruction Manual are located at: https://sweep.ac.uk/tools/ust/
- **UST Decision Support Tool (DST)** - developed for use alongside the UST Portal, the DST is a series of Contextual and Evaluation Data Layers. It was designed to help Delivery Partners and SWW improve UST management within catchments, by enabling them to be better informed about the landscape and natural processes and to help evaluate the impact of interventions on water quality and biodiversity. This tool is also only accessible to SWW and the UST Delivery Partners via ArcGIS Pro. A report detailing the DST is located at: https://sweep.ac.uk/tools/ust/

South West Water

SWW provides water and wastewater services to a resident population of 1.7 million and over 2 million people in peak tourist months. The majority of water supply (93%) comes from reservoirs and rivers and the area includes 34% of England's bathing waters, 25 designated shellfish waters and 2 National Parks.

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Innovative in its conception, it recognises that, by changing land use and land management practices, pollution can be eliminated at source. By paying landowners to deliver these changes it can, in the long run, also generate wider environmental benefits beyond water quality improvements.

It can also do this at far less cost compared to over engineered solutions which remove pollutants in water treatment works, and generally require multi-million pound investments. The programme supports farm advisers who work closely with landowners to advise on water friendly farming practices.

Farm land along the River Exe, Devon

Impacts & benefits delivered

SWEEP's phase 2 work delivered the following benefits:

Attitudinal/Capacity

Improved collaboration and understanding: Development of the UST Portal led to improved collaboration, co-operation, understandings and knowledge sharing between SWW and the Delivery Partners.

Organisational Function

Enhanced data and capabilities: The SWEEP UST Portal provides SWW with a new, more powerful mechanism to record UST3 engagement activities and interventions, both through time and spatially in greater depth of detail than previously possible.

Trusted evidence: In 2021 it demonstrated the potential for an "auditable and transparent delivery data trail" essential for auditors to sign off on number of hectares of land actively engaged for water quality and biodiversity enhancement ODI targets. It 2022 it was the sole reporting mechanism for this audit process.

Supporting future business planning: With business planning for PR24 ongoing, the UST Portal is expected to generate data for SWW's PR24 Business Plan, influencing OFWAT's decision making and SWW's future investments post-2025. Data is to be used to help understand and model outcomes of Nature Based Solutions, leading to investment, cost savings or potential new income sources from Biodiversity net gain or carbon credits.

Delivering outperformance awards and cost savings: In 2020-21 the UST Portal helped SWW claim the maximum possible annual outperformance rewards for ODI targets, which are capped at £4.02M. In the following year (2021-2022), the UST Portal became SWW's primary tool for quantifying UST performance enabling SWW to again claim the maximum annual outperformance reward of £4.02M. Internal cost savings were also expected to accrue to SWW during 2021-2022.

Capacity building and upskilling: 8 UST Delivery Partners and 3 SWW staff were trained in the use of new UST Portal.

Anticipated benefits to UST Portal users: UST Portal users anticipate that the newly created DST will be used to support planning for PR24 and UST4, could identify new areas of opportunity and improve cross-team relations and understandings. It is also hoped that work on the UST Portal can continue to boost its function for Delivery Partners.

> *"The collaborative process of developing the UST Portal has given us a better understanding of the reporting requirements of the Delivery Partners and the challenges faced by them in terms of their resources and capacity to record interventions and complete their monitoring and evaluation of activities. This has improved the levels of engagement, collaboration and transparency of all involved."*
>
> **David Smith, UST Programme Manager, SWW (2021)**

> *"For the first time we know exactly where we've been in terms of spatial mapping and what we've done on every farm that we've engaged. The process of inputting data using the UST Portal is now more streamlined, easy, time-efficient, consistent and ultimately more effective, as more detailed data can be recorded."*
>
> **David Smith, UST Programme Manager, SWW (2021)**

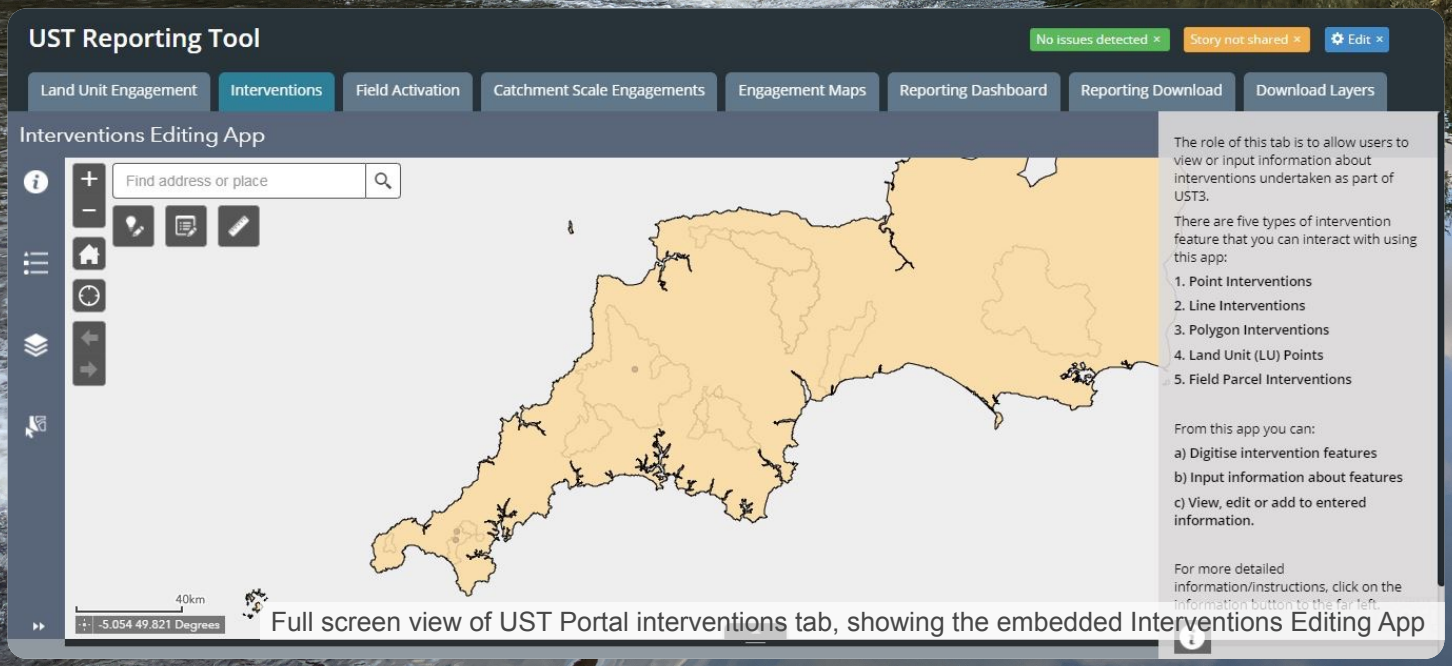
> *"The SWEEP UST portal has great potential to be a useful tool helping us to monitor our catchment work and report on it accurately. We would value it being developed further to iron out a few teething issues, for example, adjusting it so we can monitor the intensity of UST catchment interventions per hectare, which have a cumulative impact on water quality and biodiversity. We anticipate that the DST will aid us in our planning for PR24 and UST4... and will help us identify additional new areas we can work in."*
>
> **Gwen Maggs & Vicky Brewis, Cornwall Wildlife Trust**

> *"(The) external auditors, carrying out the 2020-21 audit of performance for SWW's annual business reporting to OFWAT and shareholders, were impressed with the development and demo of the (SWEEP-designed) UST Portal and the new levels of visibility and accuracy that it brings to SWW's reporting of UST performance in relation to our Biodiversity enhancement ODI (outcome delivery incentive) targets set by OFWAT."*
>
> **David Smith, UST Programme Manager, SWW (2021)**

Looking to the future

UoE work continues to support and maintain the UST Portal and DST under the new CREWW centre.

For more information contact sweep@exeter.ac.uk



Full screen view of UST Portal interventions tab, showing the embedded Interventions Editing App

Organisations we've worked with

Underpinning NERC Science

Phase 1:

- NE/TS/KTP8009/1 - Understanding the impact of moorland restoration on water quality
- NE/D003199/1 - Understanding the environmental behaviour and biological impacts of manufactured nanoparticles in natural aquatic systems
- NE/L007371/1 - Metal/metal oxide nanoparticles and Oxidative Stress – Are there harmful health effects in fish for environmental exposures?
- NE/N019687/1 - Chicken or the Egg: Is AMR in the Environment Driven by Dissemination of Antibiotics or Antibiotic Resistance Genes?
- NE/N019792/1 - Does the potential for AMR selection differ between common UK cattle grazing systems?
- NE/M01133X/1 - Using next generation sequencing to reveal human impact on aquatic reservoirs of antibiotic resistant bacteria at the catchment scale
- NERC/ESRC/EPSRC/BBSRC/AHRC funded Drought Risk and You (DRY) project
- NE/M010252/1 Climate, Harmful Algal Blooms and Human Health
- NE/M019713/1 Addressing valuation of energy and nature together

Phase 2:

- NERC CASE Multi-scale predictions of soil erosion and water quality from intensively managed grasslands
- NE/H01814X/1 - Impacts of farm-scale ecosystem management on water quality in intensively managed grasslands.
- NERC/TSB KTP - Understanding the impact of moorland restoration on water quality
- NE/TS/K00266X/1 - Developing a New Integrated Aerial Vehicle Platform 'Quest Earthwater' for assessing hidden blue water supplies

About SWEEP

The South West Partnership for Environmental & Economical Prosperity (SWEEP) is a partnership between the University of Exeter, the University of Plymouth, and Plymouth Marine Laboratory. Funded by the Natural Environment Research Council and stakeholders together to solve key challenges faced by those working with our natural resources. **www.sweep.ac.uk**

UKRI Natural Environment Research Council

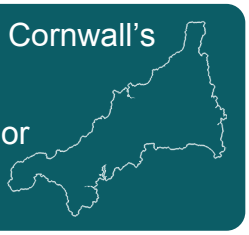
One Coast project - creating a Cornish coastal corridor for nature and people

sweep

Impact Summary

The One Coast project has at its heart a shared vision for a continuous, accessible, nature-rich corridor around the South West coast, for the benefit of nature and people. This SWEEP project developed rich environmental and economic datasets, and a review of finance mechanisms, to support the National Trust and other key partners, in identifying delivery mechanisms for this ambition, with a potential £7.8m of investments outlined for Cornwall.

Transforming Cornwall's **330**mile coastal corridor



National Trust plans informed for: **7** coastal habitat restoration sites and **5** coastal hubs

£7.8m of investment proposals informed

Why it mattered?

The One Coast project's original aim was to articulate the economic context and delivery mechanisms for a continuous, accessible, and nature-rich corridor around the South West (SW) coast for the benefit of nature and people. The coastal corridor is defined as the continual strip of land stretching from Mean High Water to 1km inland around the entire SW coast – all 630 miles. The SW coastal area's natural beauty and wildlife are core to its essence and value. Visitors come to see the wealth of historic, artistic and cultural heritage and to spend time in nature.

The SW Coast Path is one of the region's principal tourist attractions. Used by more than 8.9m people per year, it brings an estimated £520m per year to the local economy, supports over 10,400 jobs (full-time equivalent) and the health and wellbeing benefits of walking on path are valued at over £75m per year.[1]

Originally intended as a joint initiative between the National Trust and RSPB, the RSPB shifted priorities before the Covid 2019 pandemic and, whilst they remain supportive, the ambition for a wider, wilder coastline is now being taken forward by the National Trust, with other organisations, such as the South West Coast Path Association, promoting the same concept.

Anticipated benefits included new direct and indirect employment, leveraged public grants and other investments, and to inform and shape nature recovery and Environmental Land Management Schemes (ELMS) on the SW coast.

In 2022, the NT's work remains focused on a series of strategic ambitions, including restoring the natural environment, making at least half of its farmed land "nature friendly" by 2025, creating 25,000 ha of priority habitat by 2025, and improving the quality of existing nature sites on its land[2]. The National Trust also has a commitment to making its sites better for people who need support to access them, working through partnerships and testing new approaches.

The current focus for One Coast project lies within Cornwall, home to over half (330 miles) of the South West's coast path.

Ways of Working

What we did

SWEEP Impact Fellow Dr Rachel Morrison and Prof Kevin Gaston, University of Exeter worked in collaboration with project partners - National Trust and RSPB - to assess their needs for the One Coast project. The following resources were developed providing a wide range of information and data that could be drawn upon to realise the One Coast ambition.

- **One Coast Evidence Base: An Environmental and Economic Review of the Cornish Coastal Corridor:** This review provides a catalogue of information for project partners on a range of environmental, socio-demographic and economic aspects of the Cornish coastal corridor.
- **Financing One Coast. A review of possible finance mechanisms for the One Coast Project:** This review highlights the range of possible relevant finance mechanisms which could be used to help fund the One Coast project, ranging from traditional grants to philanthropic sources of finance. A series of recommended or priority investments for project partners are provided.
- **A suite of environmental datasets and ecosystem services GIS maps** - linked to the One Coast project.

Initial findings were presented to 40 participants at a joint event with the SWEEP-linked TEVI project: 'Showcasing innovations along the South West Coast Path in Cornwall in the context of the county's Environmental Growth Strategy', 15 May 2019, Porthcurno Telegraph Museum.

1 Petersen, C. The South West Coast Path Health and Wellbeing. Assessment 2020 Report.
2 https://www.nationaltrust.org.uk/who-we-are/about-us/our-views-on-nature-and-wildlife

Impacts & benefits delivered

SWEEP work is supporting the National Trust commitment to play its part in working in partnership to restore a healthy, beautiful natural environment. It also identifies opportunities in two cross-cutting priority areas where the NT is seeking to make a step change, 1) better reflecting the changing communities they serve (Everyone Welcome); and, 2) becoming net zero carbon as an organisation by 2030 (Climate Action).

Attitudinal/Capacity

Informed NT thinking on development of the Cornish and wider South West Coastal Corridor: SWEEP outputs were used by the National Trust to produce an Advocacy Document which was shared in 2019 with NT staff – coastal managers and national coast policy leads - and the Cornwall and Isles of Scilly Local Nature Partnership Board (CIoSLNP). (see Figure 1 National Trust advocacy slide setting out the ambition for Coastal corridor economy)

Organisational Function

Underpinning NT strategic vision for the South West coast: The NT has committed to develop and implement its next-stage vision for the South West coast in its 2022-2025 Plan, which sets out how the region is moving from pandemic recovery and renewal, back to delivery. The NT is focusing on two areas to deliver on this ambition:

1. restoring the coastal natural environment by creating habitat
2. developing a series of natural environment visitor hubs and sites

Cornwall remains one of the biggest opportunities for delivery, and the NT's South West leadership team is commissioning a strategic regional programme for the South West coast, to deliver a step-change in outcomes for nature, people and climate. It will cover the way land is managed, how people access the coast, how we respond to the changing climate, how communities are involved, and how projects are funded.

> *"As we emerge from the pandemic and explore significant opportunities to deliver nature's recovery in Cornwall, and new financing models for delivery across the county, the NT team believe there will be other opportunities to share the SWEEP outcomes, for example, with the team developing the Cornwall Habitat Bank as a Natural Environment Investment Readiness Fund project."*
>
> **Sarah O'Brien, External Affairs Advisor, National Trust**

This programme will deliver public benefits which include: improved state of nature – bigger, better, more and joined up; improved quality of place; greater climate resilience; increased connection to the coast for people, for greater physical and mental wellbeing; and increased financial sustainability. Sponsored by the Regional Director, a team led by a Senior Programme Manager will be developing this long-term programme over the next year, drawing in both regional and national expertise.

Supporting future NT funding applications – including expressions of Interest submitted to the CIoSLNP, which is building a pipeline of projects to put forward to the UK government's new Shared Prosperity Fund and other funds, with two potential projects for the next 3 years (2022-2025):

- Creating a landscape for nature, carbon, and people through restoring coastal habitats at 7 sites (**c. £1.3m**)
- Creating 5 coastal hubs which would be exemplary in enabling access, provide facilities for local communities and improve provision of coastal visitor assets (**c. £6.5m**).

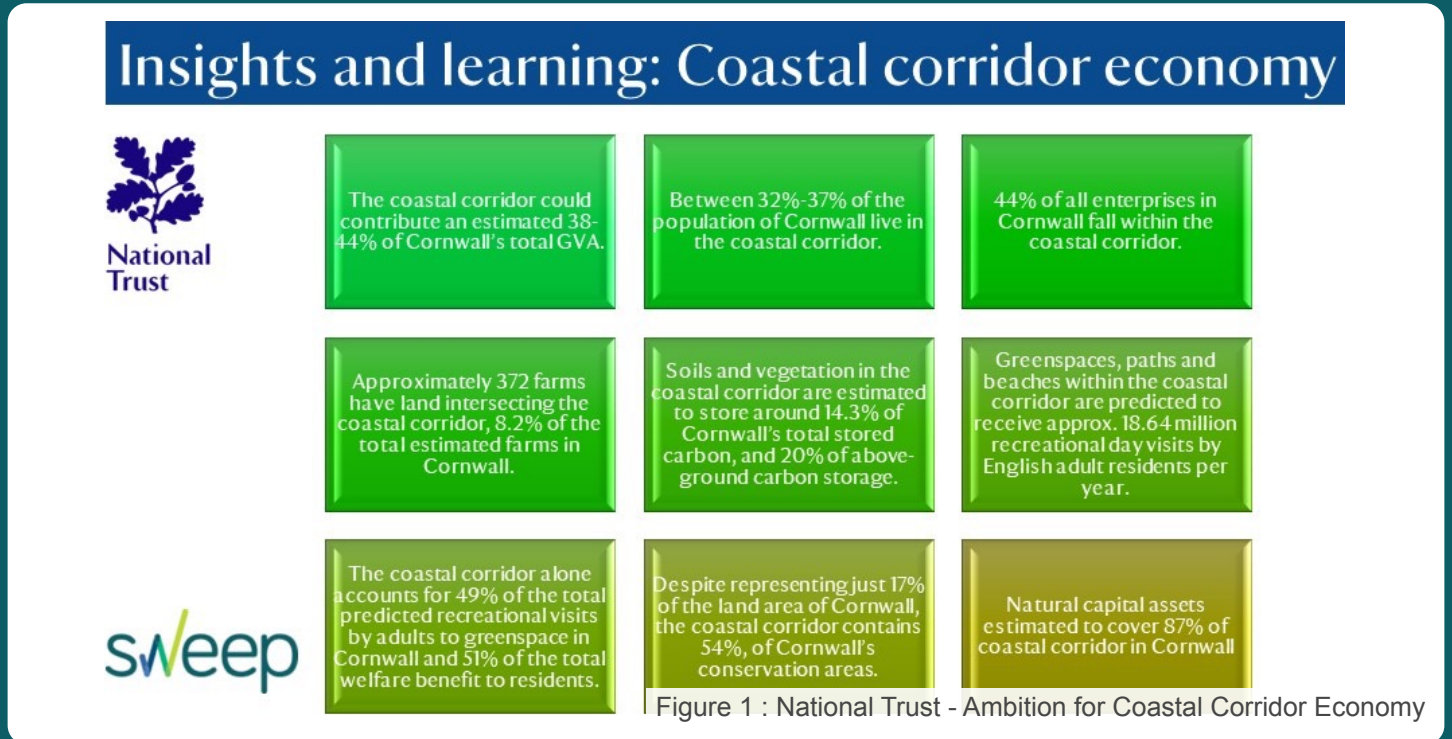


Figure 1 : National Trust - Ambition for Coastal Corridor Economy

Looking to the future

The National Trust continues to make the case for a wide coast and marine corridor, as a key opportunity for nature's recovery in Cornwall and the South West. They are keen to work with partners to develop funding packages and proposals in partnership with farmers and landowners for landscape-scale coastal conservation areas, for example, as part of the next stage of ELM delivery (Landscape Recovery Schemes). Through its ongoing partnership with the South West Coast Path Association, NT will be exploring how the Coastal Margin designated as part of the England Coast Path process, can be incorporated into a Wild Belt along the coast.

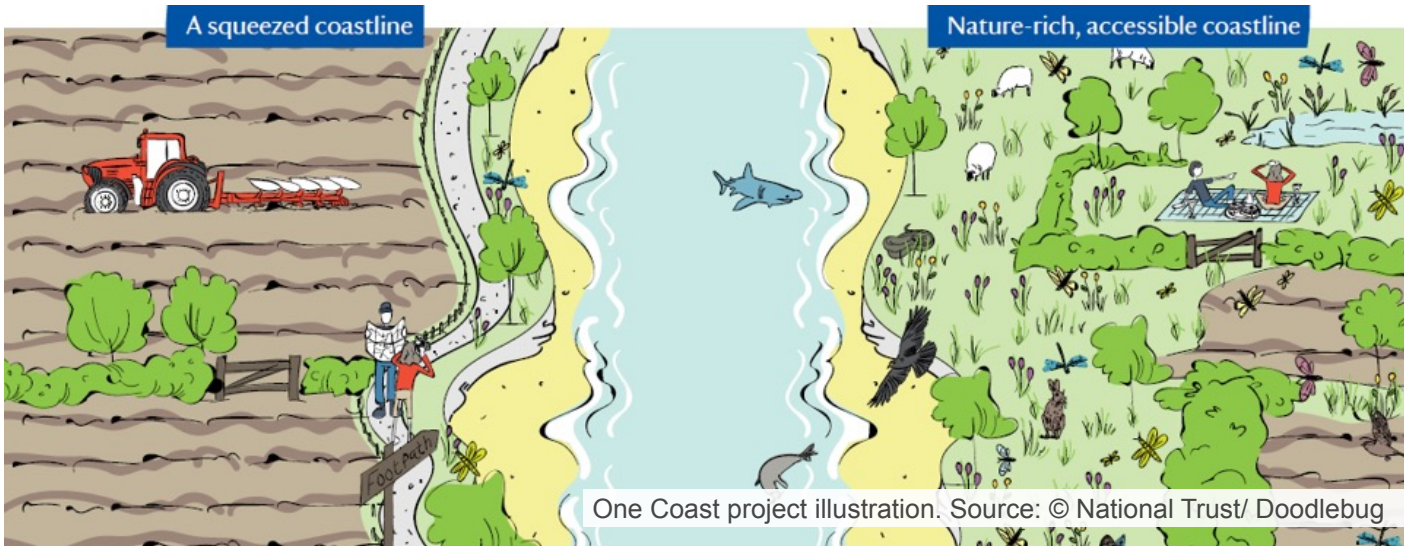
> *"Our challenge is to see if we can direct biodiversity net-gain and progressive agri-environment schemes to help us get maximum benefit from the Coastal Margin and mitigate against the worst impacts of climate change."*

SW Coast Path Association
A wild belt to protect the coast – The South West Coast Path

Livestock on Coast Path, Cornwall

> *"We recognise the coast is so crucially important to the local economy. It's probably our biggest asset. We have nearly 22 million visitors a year come down to the South West to enjoy the coast and 10 million of those come to the National Trust sites themselves."*

National Trust. Source: The South West Coast presented by the National Trust



One Coast project illustration. Source: © National Trust/ Doodlebug

Organisation we worked with

National Trust

Underpinning NERC Science

- NE/J015237/1 - Fragments, functions and flows - the scaling of biodiversity and ecosystem services in urban ecosystems
- NE/L009137/1 - Testing agricultural impacts on breeding ground food resources as a driver of population decline in a brood parasite

About SWEEP

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UKRI Natural Environment Research Council

For more information contact sweep@exeter.ac.uk

Strengthening nature-based decision-making capacity in Cornwall

sweep

Impact Summary

SWEEP helped Cornwall and the Isles of Scilly deliver environmental policies and strategies, and inform the location of £6.5bn of development decisions under the Local Plan 2010-3020. This was achieved through natural capital mapping, mapping of historic woodland, and co-creative development of the 'Lagas' natural capital intelligence platform. Hundreds of small businesses were also supported through the SWEEP-linked ERDF-funded Tevi project, boosting the region's Circular Economy.

Lagas Woodland Opportunity Map for Cornwall

13 policies and strategies informed by natural capital mapping

£30m 'Forest for Cornwall' informed by innovative historic woodland mapping

Over **100** Cornwall Council staff trained in use of Lagas Natural Capital tool

Ways of Working

Innovative Knowledge Provision → **Capacity Building** → **Tailored Decision Support**

Why it mattered?

A healthy natural environment underpins the economy of Cornwall and the Isles of Scilly (CIOS). However, the region's environment has come under increasing pressure in recent years and, despite the region's dependence on its natural systems, this is set to continue. For example, a further 52,500 new homes are anticipated in Cornwall by 2030 to meet local need.

In 2016 Cornwall Council launched its Environmental Growth Strategy. Ground-breaking in its ambition, it aimed to reverse the decline of the regions' natural assets and ensure it has a sustainable, productive future, by placing the environment at the heart of decision making and economic growth. The Strategy recognises the need to protect Cornwall's environment for its own sake and as an economic driver, and to build and maintain resilience to climate change.

What we did

The SWEEP team worked closely with Cornwall Council, Cornwall & Isles of Scilly Local Nature Partnership (CIoS LNP) and Cornwall Area of Outstanding Natural Beauty (CAONB) throughout 2017-2019 to deliver this project. They also worked collaboratively with the SWEEP-linked Tevi project – Tevi being the Cornish for 'grow', which was a 5-year EU-funded venture aiming to create both economic and environmental growth in Cornwall and the Isles of Scilly.

> *"In 2065, Cornwall's environment will be naturally diverse, beautiful and healthy, supporting a thriving society, prosperous economy and abundance of wildlife."*
>
> **Cornwall Council Environmental Growth Strategy**

1. Developed a suite of landcover and ecosystem service provision maps, including a novel synthesis of existing and new landcover information for Cornwall, to support delivery of the ground-breaking Environmental Growth Strategy. Existing landcover resources were improved through innovative integration with remote sensing data.[1]
2. Instrumental in developing Cornwall Council and Cornwall AONB's new environmental intelligence platform 'Lagas', which adopted many of the SWEEP-developed natural capital maps, and was delivered as part of the Tevi project.
3. Developed a novel, automated method to digitise information about Cornish woodland and orchard coverage, from 1st Edition Ordnance Survey 1880 maps. Valuable in its own right, this work also provides 'proof of concept' for additional historic habitat layers to be extracted including, wetlands, heathland, rough pasture, built-up areas, and hedgerows/field boundaries.
4. Initial development of structured interview guide for small business engagements, which became spring-board for programme of ERDF-funded business assistance under the Tevi project and development of sustainable, circular economy-focused projects.[2]

1 Remote sensing data is collected by sensors which detect energy reflected from Earth. These sensors can be located on satellites or mounted on aircraft.
2 A circular economy is a model of production and consumption, which involves sharing, leasing, reusing, repairing, refurbishing and recycling existing materials and products as long as possible.

Impacts & benefits delivered

Knowledge/Capacity

Co-creative development of Cornwall's capacity to access and use natural capital information spatially: The SWEEP mapping work brought together, for the first time, geospatial information on the relative value of natural assets and services across Cornwall.

The maps and Lagas tool (which embeds them and makes them widely available) were developed in partnership with Cornwall Council and Cornwall Area of Natural Beauty to inform their ground-breaking and innovative environmental strategies and plans.

Tailored training workshops and ongoing face-to-face support not only helped ensure these resources directly met partner organisation needs, but also became embedded for their use. Over 100 Cornwall Council and AONB staff were trained in the use of 'Lagas'.

Attitudinal/Capacity

Fostering wider understanding and debate on the use of natural capital spatial information: SWEEP contributed to an evolution in strategic decision making among Cornish partner organisations, in particular, their use of spatial information on environmental assets and opportunities. Outputs were presented and discussed at various workshops and inter-organisational meetings and resulted in:

- Environment Agency interest in opportunity mapping re: Working with Natural Processes for flood risk reduction
- Cornwall Wildlife Trust opportunity mapping method developments
- Interest from several other organisations including Dartmoor National Trust, Devon County Council, Devon and Somerset Wildlife Trusts.
- Cornwall Biodiversity Initiative Nature Recovery Network Mapping
- Defra ELMs Tests and Trials in Cornwall

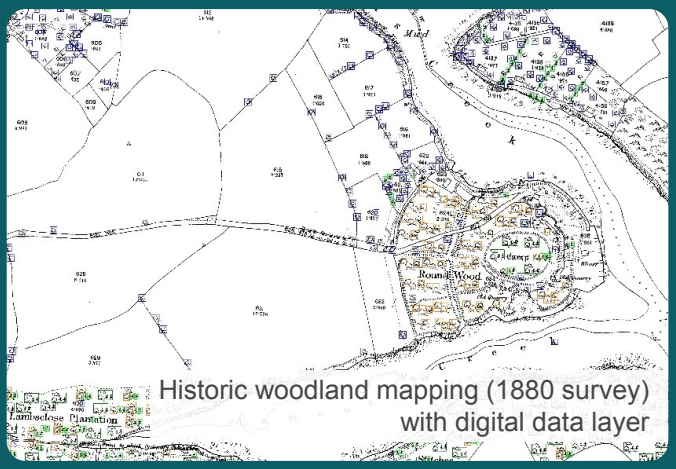
Activities, outputs, and lessons learnt from the SWEEP work also informed the establishment of the Environmental Growth Evidence Group for Cornwall which seeks to ensure that evidence about the environment informs policy development and business activity.

Policy & Legislation

Informing regional environmental policies and strategies: 13 major regional policies and strategies informed – SWEEP-produced landcover and ecosystem service provision maps shaped a raft of Cornwall Council statutory development plans & strategies including:

- **Environmental Growth Strategy (2020-2065)** – adopted alongside Cornwall's LNP, providing a long-term framework to conserve and grow nature.

> *"Lagas has absolutely been designed to be accessible to a variety of users, whether that's developers, their ecologists, potentially development managers, asset managers and people developing policy. We've been involved from the outset, working with SWEEP and others to ensure its functionality and presentation is 'fit for purpose' for end users. Its success has been in its co-design. We're developing joint training sessions and super-users within Cornwall Council and other partner organisations who can champion its use."*
>
> **Philippa Hoskin, Partnerships & Policy Lead, Environmental Growth Team, Cornwall Council**



Historic woodland mapping (1880 survey) with digital data layer

> *"Lagas is fundamental to delivering on the ground-breaking Environmental Growth Strategy for Cornwall. For the first time, (we can) adopt a very ambitious, genuine, spatial allocation for nature within the planning system. The work involved in delivering this environmental Intelligence platform will positively impact nature protection and regeneration and will encourage environmental growth for years to come."*
>
> **Philippa Hoskin, Partnerships & Policy Lead, Environmental Growth Team, Cornwall Council**

- **Biodiversity Net Gain (BNG) Planning Tool** – helping to locate delivery of c.£6.5B of 2010-2030 Local Plan housing need and biodiversity offsets.
- **Cornwall Nature Recovery Network maps** – providing a spatial prioritisation for nature and opportunities for habitat (re)creation.
- **Climate Change Action Plan** - adopted following Cornwall's Climate Emergency declaration in 2019.

Knowledge/Capacity

Informing the flagship £30m project Forest for Cornwall: SWEEP's innovative mapping of historic woodland cover helped to inform plans to deliver of the Forest for Cornwall - Cornwall Council's flagship natural capital solution project supporting its Climate Change Action Plan (2019).

The Forest for Cornwall initiative plans to create 8,000 hectares of canopy cover from individual trees in gardens, to whole woodlands, to urban trees, parks and hedges, covering approximately 2% of Cornwall's land area. It will capture 38,000 tons of carbon dioxide a year and sequester (remove) upwards of 1% of Cornwall's greenhouse gas emissions from the atmosphere.

Organisational Function

Supporting the Tevi business engagement programme: SWEEP's early support of Tevi developing a semi-structured, interview guide for small business engagements, helped lay the foundations for its subsequent engagement with over 600 SMEs (since 2018) and direct support of 413 enterprises with a variety of tailored support.

This included direct funding of 171 projects to help enterprises invest in the circular economy and environmental growth aspects of their business and developing 25 national and five international partnerships.

Tevi used circular economy and environmental growth strategies to help businesses improve the resilience of their processes, increase productivity, and play their part in growing Cornwall's unique natural environment. It worked with businesses across Cornwall and the Isles of Scilly in all sectors, from agri-food and the marine sector to including clean energy, geo-resources, data and space, the visitor economy, and financial services.

> *"The Lagas maps have really helped Cornwall AONB identify opportunities and priority areas for nature restoration, as part of our Lizard AONB Test and Trial – a national pilot project for Defra... It's also helped inform and guide the direction we go in for nature recovery in our 5 yearly review of the Cornwall AONB Management Plan – a statutory document and material consideration in planning."*
>
> **Emma Browning, Cornwall Area of Natural Beauty**

> *"Lagas is key to delivering on nature recovery and the natural climate solution elements of our Climate Change Action Plan. It already acts as our prototype Nature Recovery Network Map. Lagas maps are embedded within the Biodiversity Net Gain (BNG) calculator... as well as delivering on natural flood management and management of Cornwall Council's green and blue spaces."*
>
> **Philippa Hoskin, Partnerships & Policy Lead, Environmental Growth Team, Cornwall Council**

> *The SWEEP historic woodland and hedgerow mapping was game-changing for us. Jonathan's work formed a powerful evidence base that was just not available to us before giving us a firm foundation to develop plans for the Forest for Cornwall".*
>
> *"It encouraged wider conversations within Cornwall Council.... going beyond the stark facts of climate change, to embedding the story of the development and history of an area - and people can relate to that."*
>
> *"The SWEEP historic woodland mapping has shown us the synergies between the historic and natural environments. It gave us insights into the possibilities of re-creating urban orchards in a modern way, but which is still true to the heritage of the area"*
>
> **Ann Reynolds and Francis Shepherd, Historic Environment Service, Cornwall Council**

Looking to the future

SWEEP mapping work is informing further Cornwall Council initiatives, including:

- The ambition to make the 104 farms owned by Cornwall Council (covering 4,525 hectares in total) "*exemplars in low carbon and regenerative agriculture*" (Cornwall's Climate Change Action Plan; 6.25)
- Cornwall's flood mitigation strategy, by helping to identify catchments and areas where natural flood mitigation schemes will deliver the greatest and most wide-ranging strategic benefit.
- Environmental opportunity mapping for Cornwall Wildlife Trust.

For more information contact sweep@exeter.ac.uk

Woodland near Truro, Cornwall

Organisations we've worked with

lagas

Tevi Growing Your Business, Growing Our Environment.

one and all CORNWALL COUNCIL

CORNWALL & ISLES OF SCILLY LOCAL NATURE PARTNERSHIP

Cornwall Area of Outstanding Natural Beauty

Underpinning NERC Science

- NE/J015237/1 - Fragments, functions and flows - the scaling of biodiversity and ecosystem services in urban ecosystems
- NE/L00268X/1 - Using microclimate to adapt conservation to climate change

About SWEEP

The South West Partnership for Environmental & Economical Prosperity (SWEEP) is a partnership between the University of Exeter, the University of Plymouth, and Plymouth Marine Laboratory. Funded by the Natural Environment Research Council and stakeholders together to solve key challenges faced by those working with our natural resources. **www.sweep.ac.uk**

UKRI Natural Environment Research Council

Strengthening the climate change science behind marine planning to deliver economic, social, and environmental benefits to the South West

SWEEP strengthened the scientific evidence that underpins the effectiveness of the South West Marine Plan through its inclusion of climate change model data. This will lead to better planning decisions affecting marine and coastal activities through an enhanced understanding of temporal changes in the marine environment and their impact on new activities.

sweep

Impact Summary

Illustration from MMO report

Strengthened effectiveness of South West Marine Plan by being **1st** English plan to include climate model data

Increasing the robustness of MMO's iterative process of implementing, reviewing and Improvmg Marine Plans across the UK's **11** designated areas

Contributed to UK's Marine Plan process which will deliver an estimated **£446bn** net benefit across the country

Ways of Working

Innovative Knowledge Provision — **Capacity Building** — **Tailored Decision Support**

Why it mattered?

The South West's marine and coastal environments are increasingly busy places where shipping, recreation and tourism, fishing and energy production compete for space. These industries are vital to the region's economy - the South West has one of the largest fishing fleets in the UK, landing seafood worth over £86m annually, recreation also attracts an estimated £4-5bn[1] (pre-COVID-19 pandemic).

Prior to the establishment of the Marine and Coastal Access Act 2009, there was no formal process for collectively managing the wide range of activities in the marine environment. This changed when the Marine Management Organisation (MMO) was tasked with developing a series of Marine Plans for each of the 11 designated areas around England's coast by 2021. Marine plans must be used in all planning decisions for the sea, coast, estuaries and tidal waters, as well as developments that impact these areas, such as infrastructure, and aim to protect and enhance the marine environment, whilst allowing for sustainable economic growth.

Turning to its scientific community for advice to ensure it was underpinned by the best-available, evidence-based guidance to inform the location of marine and coastal activities, the MMO began to develop the South West Marine Plan in 2016.

To confidently plan for sustainable regional activity, it is vital that Marine Plans recognise the the effect of climate change on the marine environment. Evidence shows that higher seawater temperatures and lower pH levels, caused by climate change, are affecting the distribution and activity of marine life which, at a regional level, raises concerns over whether marine habitats will continue to support indigenous species, as well as ecosystem function and service provision.

What we did

From early 2017 to June 2018, Dr Darren Clark and Dr Gennadi Lessin at Plymouth Marine Laboratory (PML) and Prof. Mel Austen (University of Plymouth/PML) worked in close collaboration with the MMO, drawing on the best NERC science available, to address 'SWMP Evidence Requirement R009: Climate Change'. This key requirement aimed "To understand environmental, social and economic impacts of climate change in space and time at scales suitable for marine planning". As part of the approach the SWEEP team drew expertise from the region's consortium of internationally leading marine scientists, and coordinated with the activities of Defra's North Devon Marine Pioneer.

The team analysed existing Marine Plans, data, models and natural capital valuation approaches to understand their relevance and identify the most appropriate inputs for the SWMP. They used sophisticated modelling techniques to understand how physical, chemical and biological features of the South West's marine environment may respond to climate change over a 20-year time frame. The model projection data and accompanying report (published by the MMO) contributed to the evidence base for the SWMP.

In their final report, Model projections of marine environmental variables' response to climate change within England's South West marine plan areas (MMO1169), the team found that changes in habitat suitability and distribution of marine species are a likely consequence for the plan area. The report highlights where changes are projected to be significant in response to climate change, and how these may impact on sectors and receptors - eg. tourism, aquaculture, and the incidence of potentially harmful (invasive) species.

Impacts & benefits delivered

Organisational Function

Improved capacity for decision making: SWEEP's climate change projections have provided thr MMO with the scientific evidence needed to understand temporal changes in the marine environment, and their potential impact on the long term viability of new activities over the next 20 hyears. This has contributed to a more integrated, forward-looking SWMP that provides those making licensing and other marine management decisions with the information they need to take account of externalities imposed by different marine uses. SWEEP data is also delivering wider benefits to marine planning processes by feeding directly into other MMO work. For example, multi-trophic aquaculture modelling and co-existence conflict of marine issues such as the growth of renewables.

Attitudinal/Capacity

Changing perspectives: SWEEP work has prompted new thinking within the MMO, highlighting the importance of understanding climate model projections and incorporating them into their marine plans and wider work.

Organisational Function

Enhancing stakeholder knowledge and engagement: Using their existing models, the SWEEP team created bespoke knowledge that directly contributed to the development of a scientifically robust SWMP through inclusion of climate model data which was used to inform a Marine Plan for the first time. Directly available via the MMO evidence portal and GOV.UK, the SWEEP report will be one of the key resources for South West stakeholders to inform and support their marine licence applications and business plans.

> *"A key strength of SWEEP was accessing a pool of expertise we just don't have in-house."*
>
> **MMO Evidence Team**

> *"SWEEP has provided evidence to help us validate some of the climate change issues that were raised for the South West marine plan areas, and has informed our policy approach."*
>
> **MMO Marine Planning Team**

Policy & Legislation

Informing regional and national policy delivery and development: SWEEP's work is informing the iterative process of marine planning implementation, review and improvement regionally and nationally. It is also supporting the development and delivery of further marine policies and programmes both at the MMO and other stakeholders.

Economic

A more robust SWMP delivering economic, environmental and social benefits: SWEEP's scientific evidence has increased the robustness of the SWMP, which will play a fundamental role in guiding future conservation, business planning and economic development in the South West. Learning and findings from this project will contribute to the many benefits that arise from the marine planning process - including the estimated £446bn net benefit derived from UK marine plans.

Looking to the future

The full benefits of SWEEP's work, contributing to a more scientifically robust SWMP, will be seen over the forthcoming years and decades as the MMO requires public authorities to implement the plan through existing regulatory and decision-making processes, and for all parties to use it to inform more robust marine and coastal planning and development decisions.[2]

> *"In the future, scaling the SWEEP work up to a national scale could be useful for multiple marine plan areas. National level evidence would allow us to understand if there are any regional differences between plan areas with respect to the effects of climate change."*
>
> **MMO Marine Planning Team**

Underpinning NERC Science

- NE/L003279/1 - NERC research Marine Ecosystems Research Programme
- ROAM / NE/H017372/1 - NERC and DEFRA funded UK Ocean Acidification Research Programme, and NERC Natonal Capability programme in Ocean Modelling

1 Model projections of marine environment variables' response to climate change within England's South West marine plan areas (MMO1169)
2 The understand the importance of SWMP going forward, note 'Using the plans' section of East Marine Plans on GOV.UK

For more information contact sweep@exeter.ac.uk

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UKRI Natural Environment Research Council

Enhancing access to NEVO – the Natural Environment Valuation Online Tool

sweep

Impact Summary

The Natural Environment Valuation Online (NEVO) Tool is a powerful, open-access, web application designed for regional spatial planning. NEVO's function and accessibility were enhanced under this SWEEP project. This extended the benefit delivered to its diverse range of users. NEVO's close alignment with the NetZeroPLUS project has leveraged new funding. Ultimately, NEVO continues to accelerate the mainstream adoption and application of the Natural Capital Approach.

1,464 registered NEVO users

1,900 views of training videos

£25k new funding to develop more stable platform

Why it mattered?

NEVO is a simplified (yet still highly sophisticated) online version of the **Natural Environment Valuation (NEV) suite of models** - a ground-breaking, spatially-explicit, integrated modelling platform which quantify and value the cascading effects of land use change through ecological and economic systems. The NEV models were originally developed to support land-use change analysis relating to the new post-Brexit Environmental Land Use Management Scheme (ELMS).

Defra funded NEVO's initial development NEVO Tool (2016-2019), to bring the sophistication of the NEV models to a wider range of users, including business, policy-makers and the public. NEVO was soft-launched in Nov 2018 with over 20 organisations including the Environment Agency, Defra, Department for Transport, Balfour Beatty, eftec consultancy, Forestry Commission and the Rivers Trusts, and generally released in Jan 2019.

Under SWEEP, it was planned to continue to evolve and improve NEVO to ensure it was accessible and delivered needed-functionality to all those interested in exploring regional spatial planning, and the integrated relationships between climate change, land-use change, ecosystem service flows and economic values, at a time of flux in land-use management post Brexit.

What we did

During 2019-2022, the NEVO-SWEEP team – Prof Brett Day, Prof Amy Binner, Dr Nathan Owen, Patrick Collins, Dr James Webber, Dr Sara Zonnevald, William Clibborn-Booth and Dr Diana Tingley, based at University of Exeter (UoE) – worked collaboratively to achieve the following:

Ways of Working

Function

- Streamlined NEVO's 'back-end' to strengthen its function and longevity.
- £25K new funding secured from UoE Business School to transfer NEVO (and the aligned Outdoor Recreation Valuation Tool - ORVal) to a more stable platform, and provide ongoing UoE technical/IT maintenance support for 5 years (2021-2026).
- Reviewed Intellectual Property rights and licensing options.
- Google analytics and user-password system set up to monitor and support the user experience.

Accessibility

- Developed NEVO's 'front-end', following a 'cold-review' of the user experience, to include a demo video (shown at COP26) and series of User Guide videos (hosted on NEVO's YouTube Channel) and as series of in-Tool resources, including an interactive 'Welcome Tour', explanations, Help functions and CSV Variable Name download.
- NEVO Tool Information Sheet produced providing an accessible review of NEVO's capabilities and to establish a single entry-point to NEVO's resources
- Report produced - Day D, Owen N, Binner A, et al (2020). The Natural Environmental Valuation (NEV) Modelling Suite: A Summary Technical Report. LEEP Working Paper.
- In-model NEVO documentation, including Case Study 'Reconnecting and improving the River Wey'.
- Held series of SWEEP-linked Ecosystem Knowledge Network webinars (138 participants in 2018; 104 in 2019) and presented NEVO at variety of SWEEP-linked events, including during COP26, HMT Green Book workshop, and Civil Service Live conference.

Development

- Included new coverage of beaches and coastal areas. Reviewed capacity to water and pollinator ecosystem services.
- Series of meetings with current and potential new 'organisation-level' users, including the Environment Agency, NatWest Bank, Church Commissioners, Savills and other consultants and Ministry of Defence (MoD).
- Developed new 'custom area' functionality allowing users to upload their own area shapefiles and create bespoke 'My Region' analyses within NEVO. This was beta-tested in Nov 2022 with selected users, and supported by a 'Custom Area – Shapefile Upload Function' training video.
- Boosted delivery of underpinning NEV models in NetZeroPLUS project (£5m), a UKRI-funded Greenhouse Gas removal Demonstrator Project, which is combining natural and social science to guide a massive expansion of woodland in the UK.

Impacts & benefits delivered

NEVO user review

- NEVO has 1464 registered users, with 699 being active in the last 12 months (to 1st Dec 2022). Approximately 27% were returning users, indicating that NEVO is still being discovered by new audiences. It has a core set of frequent, including consultancies Mott MacDonald, eftec, Arup and AECOM. The majority of registered users are based in the South West region of England (23%), London (17%) and South East (13%).
- The series of NEVO training videos on its YouTube Channel have been viewed over 1900 times.
- The new NEVO 'custom area' functionality was beta-tested by a select group (17 people) comprised of some of NEVO's most frequent users and potential new organisation-level users, including the Environment Agency (EA), The Rivers Trust and Ministry of Defence.

Attitudinal/Capacity

High-level endorsements

NEVO was powerfully endorsed by:

- UK government's Department for Environment and Rural Affairs (Defra), in its highly influential 2020 guidance 'Enabling a Natural Capital Approach'.
- Committee on Climate Change, an independent, statutory body advising government on building a low-carbon economy and preparing for climate change.

Boosting development and intellectual input

- NEVO's development under SWEEP has strengthened the intellectual and technical development of the NetZeroPLUS modelling work, also based on the underpinning NEV models.

Organisational Function

Informed reviews, strategy and planning – including:

- National Infrastructure Commission's natural capital analysis of 'Rail Needs Assessment'.
- EA's review of tools linked to a judicial review of Diffuse Water Pollution Plans and the 'nutrient neutrality' requirement.
- EA's Natural Capital Evidence programme of work.

NEVO is also used by a range of local organisations, e.g., Shropshire Council, The Rivers Trust and National Parks, investigating the effect of potential land-use change on, for example, carbon sequestration, river water quality and biodiversity.

Case Study

In 2020 consultants (Wood Group UK Ltd) used NEVO extensively as part of a Defra-backed Environment Agency project which sought to review the nutrient impacts from diffuse pollution sources, in freshwater catchments draining into the Solent European Protected Sites, as well as the Itchen Special Area of Conservation.

Delivered commercial advantage

Environmental consultancies use NEVO in their commercial practices as a knowledge-gathering and high-level screening and analysis tool. For example, Mott MacDonald routinely use NEVO's accessible interface to upskill staff, introduce welfare values into environmental assessments (which would previously have been impossible), and boost their commercial capability through early-adopter advantage.

Leveraged funding opportunities

- NEVO has already provided the impetus for new funded workstreams under NetZeroPLUS.
- NEVO's status as a high-profile 'gateway tool', and the development of new 'custom area' functionality which directly meets the current demand for bespoke-area land use analyses, is anticipated to provide further leveraged funding opportunities into the future.

> *"The NEVO tool was instrumental in helping our consultants (Wood Group UK Ltd) demonstrate the costs and values of the broader benefits associated with land use change (e.g. conversion of grassland to woodland), whilst also taking forecast future trends in farming practices and yields into account, with the principle aim being to reduce excessive nutrient inputs into the water environment.*
>
> *The evidence was shared with Defra and may help to influence Environment Agency policy direction. It enabled us to start looking at the benefits of "doing different things" or "doing things differently" in the agricultural landscape, to help move failing European Protected Sites back towards "favourable condition" status.*
>
> *One of the key challenges we have with enabling improvements to the environment is justifying values. For decision makers, fiscal value is an essential component, both in practical and strategic terms."*
>
> **Jonathan Garland, Senior Environmental Planner, Environment Agency**

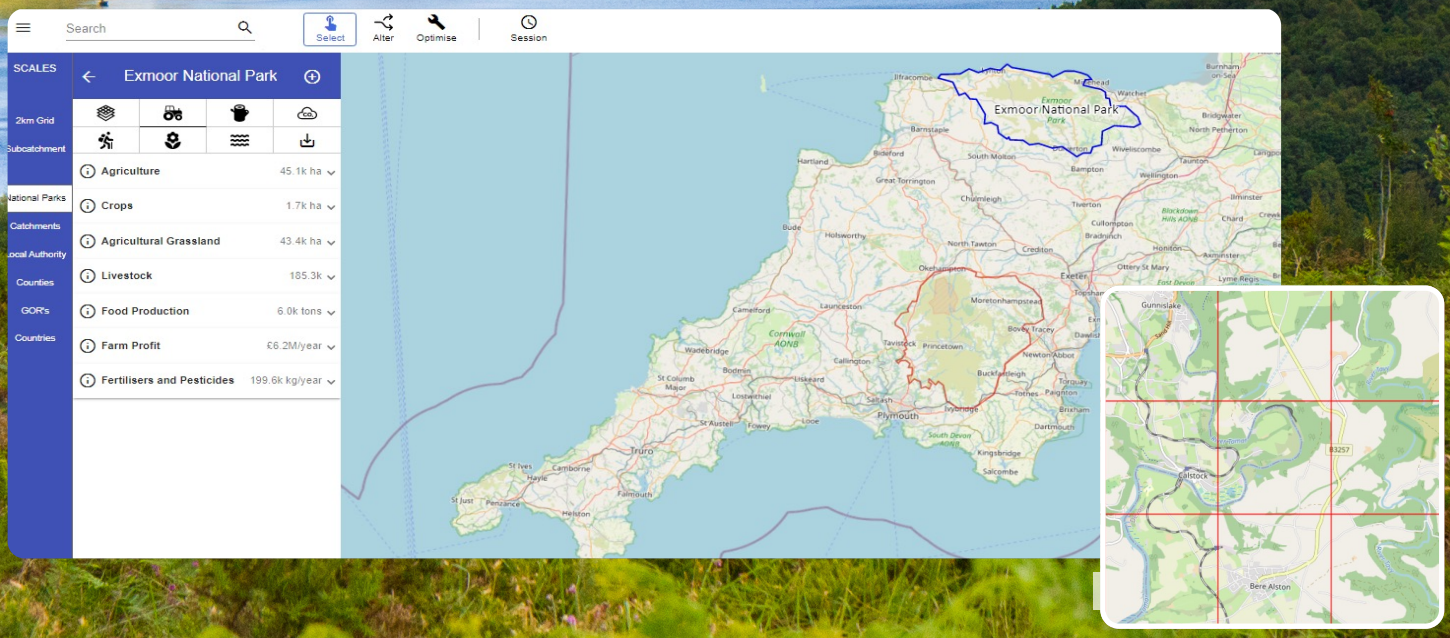
Looking to the future

Land use change and its impacts on ecosystems services remain a critical area of concern for many organisations engaged in land management; particularly in the context of UK ambitions for net zero and biodiversity recovery.

NEVO remains the archetype of a user-focused, free-to-use tool to support complex land use planning decisions. But such decisions are complex and often specific to the context of the organisation making them.

Building on the NEVO technologies and the strength of the user group built up under SWEEP, near future plans are to develop bespoke user tools that more closely ally with the decision-support needs of particular organisations, while integrating developing state-of-the art science and economics to ensure NEVO delivers robust evidence.

For more information contact sweep@exeter.ac.uk or nevo@exeter.ac.uk



Organisations we've worked with

NetZero PLUS

defra
Department for Environment Food and Rural Affairs

Underpinning NERC Science

- NE/P016944/1 - Web-based tools for natural capital management and investment
- RES-227-25-0024 - Catchment Hydrology, Resources, Economics and Management
- NE/P007880/1 - Identifying potential tipping points in the benefits derived from the UK's land ecosystems
- NE/P019773/1 - Feasibility of Afforestation and Biocrops
- NE/M019713/1 - Addressing the Valuation of Energy and Nature Together
- NE/N013573/1 - Coastal Ecosystems Value at Alleviating Natural Hazards and Extreme Events

About SWEEP

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UKRI Natural Environment Research Council

Supporting the sustainable expansion of aquaculture in the South West

sweep

Impact Summary

By directly addressing a range of critical issues constraining the development of the marine aquaculture (seaweed and shellfish mariculture) sector in SW England, this SWEEP project has contributed to its advancement in the following ways:

1. Implementing a source-to-sea modelling application of a wholescape approach in the Exe estuary catchment demonstrating that modest long-term changes in catchment land use (e.g. strategic tree planting +0.5% land cover) can improve water quality and shellfish production in the Exe Estuary. However, reductions in Combined Sewer Overflow (CSO) spills in closer proximity to estuarine and coastal shellfish beds would likely have even greater benefits.
2. Policy and evidence contributions towards meeting the ambitions of Seafood2040 and the English Aquaculture Strategy (relating to marine spatial planning and Marine Protected Areas), Exe Estuary Catchment Management Plan and Natural England seaweed culture sector review.
3. Raising the profile of critical 'constraining' issues through extensive stakeholder engagement, development of the 'One Health' concept to sustainable food systems, application of the 'Positive Tipping Points' framework, assessment and mitigation of Harmful Algal Blooms and contribution to the Exe Catchment Investigation Programme.
4. Developing evidence to support Food Standards Agency consideration of adopting a more flexible, risk-based approach to shellfish food safety assessment and testing.

1st application of wholescape land use and water quality modelling approach to the River Exe Estuary Catchment

21 publications, reports, policy statements and briefing notes

14 models, tools, and resources developed

Ways of Working

Innovative Knowledge Provision | Effective Collaboration | Capacity Building | Tailored Decision Support | Natural Capital Valuation

Why it mattered?

Sustainable growth in marine aquaculture (mariculture), involving the farming of seaweeds, shellfish and finfish, will be essential in helping to provide global food security for the ever-expanding human population. Shellfish and seaweed mariculture are highly sustainable; they use natural sunlight, available nutrients and/or marine planktonic microalgae to grow.

Seaweeds remove nutrients, shellfish help curb eutrophication[1] and seaweed and shellfish mariculture can also contribute to climate change mitigation, through carbon sequestration and net zero carbon emissions respectively, and to habitat enhancement for biodiversity.

Shellfish mariculture production in the South West (SW) is currently estimated at 7,300 tonnes per year (£8m; 2022) from across 35 registered production sites, with around 53 individual beds (Figure 1).

The predominant species produced by value is blue mussel, followed by Pacific oyster and clams. Production methods include rope, net/cage, trestle and bed culture (Figure 2). Seaweed mariculture is in early stages of development, with production levels currently limited to <100 tonnes (wet weight) per year.

Poor water quality is the main environmental constraint to bivalve shellfish production and results from microbial contamination originating from Combined Sewer Overflows (CSOs), extensive grazing of livestock on grassland, indoor livestock rearing and poor slurry management. Production sites compete for space with capture fisheries and Marine Protected Areas (MPAs). The sector is also at risk from Harmful Algal Blooms (HABs). A rigid testing regime and highly precautionary approach to interpretating results (including outliers) for authorisations also inhibits growth[2].

There is potential to grow the mariculture sector around the SW coastline in coastal and estuarine areas, as well as less congested offshore areas. However, this would require a holistic catchment-wide approach to water quality management and an integrated approach to marine spatial planning.

1 Eutrophication is an overabundance of nutrients in water, which can induce Harmful Algal Blooms (HABs). HABs (or excessive algae growth) are algal blooms that causes negative impacts to other organisms by production of algal toxins, mechanical damage to other organisms, or by other means. HABs can occur naturally or appear as a result of human activity.
2 Seafood 2040. English Aquaculture Strategy.

The 2020 English Aquaculture Strategy (EAS), to which this project contributed evidence, recognises the sector's potential in its central vision:

> *"By 2040 English aquaculture is a significant contributor to seafood consumption and the Blue Economy, providing sustainable, healthy food and rewarding employment opportunities."*
>
> **English Aquaculture Strategy. Seafood 2040**

> *"The neglect of water quality over the past 30 years has severely damaged the shellfish industry inshore and now threatens the survival of developments offshore."*
>
> **John Holmyard, Offshore Shellfish Ltd**

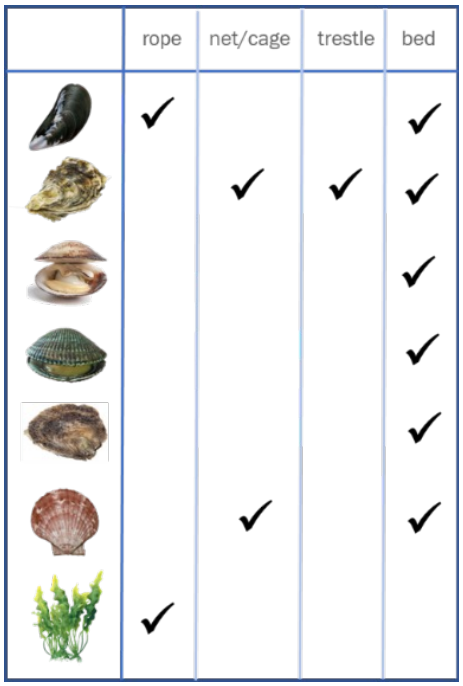

Figure 2: Mariculture methods by species
Species shown (in order down the table) are blue mussel, Pacific oyster, clam, cockle, native oyster, scallop, seaweed. Source: Ross Brown

What we did

During 2019-2022, the SWEEP team worked flexibly on issues relating to the SW mariculture sector development according to their specialisms, and was comprised of:

- University of Exeter – Prof Charles Tyler (Principal Investigator), Dr Ross Brown (Technical Lead), Dr Donna Carless, Dr Ben Jackson, Dr James Webber, Dr Sara Zonneveld, Dr Carly Daniels, Dr Amy Binner, Prof Richard Brazier, Dr Diana Tingley.
- Plymouth Marine Laboratory – Dr Riccardo Torres, Dr Yuri Artioli, Dr Giovanni Galli, Dr Peter Land, Dr Peter Miller.
- University of Plymouth – Prof Mel Austen.
- QUEX Institute of Global Sustainability and Wellbeing - Dr Phoebe Stewart-Sinclair.
- UoE SWEEP-affiliated PhD student – Sophie Corrigan.

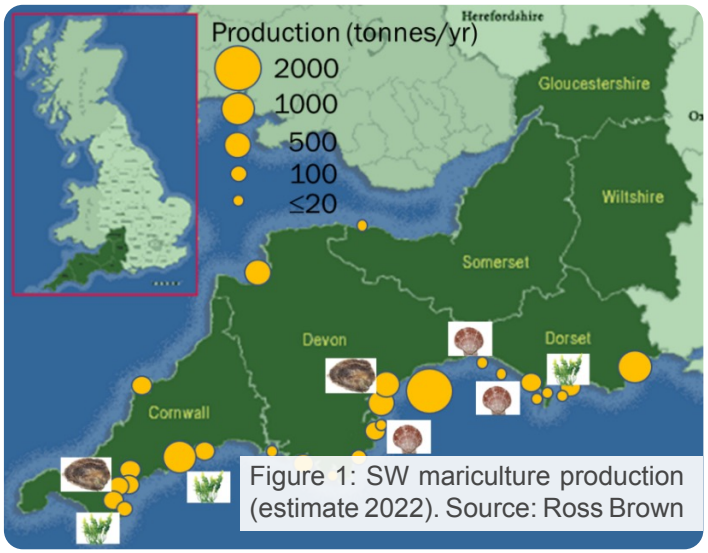

Figure 1: SW mariculture production (estimate 2022). Source: Ross Brown

Activities included:

1. Development of a unique wholescape modelling application - to examine the effects of potential future land use changes on water quality in the Exe Estuary catchment, and associated impacts on shellfish farmed in the Estuary and adjoining coastal waters. Summary modelling results are available here. Detailed results will be published in 2023.

This **keystone project activity** was strengthened by a range of supporting work packages including development of:

- **Series of integrated catchment models** – for predicting nitrogen, faecal pathogen indicator (*E. coli*) and copper inputs from agricultural and urban land use and riverine concentrations and loads throughout the Exe Estuary catchment
- **Estuary and shellfish production (growth) models** - to assess the impact of riverine loads on the estuary water quality of and to predict mussel growth in response to nitrogen and copper exposures in the Exe Estuary and the accumulation of *E. coli*
- **Future land use scenarios to 2050** affecting water quality and under climate change – co-created with stakeholders, these scenarios and related resources are available here.
- **Farmscoper models** - linking land use change and water quality in the Exe catchment
- **Acid herbicide wash-off exploration tool** - exploring the potential impacts of acid herbicide wash-off (i.e., agricultural run-off from grassland) during periods of intense rainfall, on phytoplankton in South West's estuaries. The tool, guidance document and report are available here.
- **Natural Environment Valuation (NEV) model extension work**: (1) for Exe Catchment linked to Future Land Use Scenarios, and (2) Clyst Catchment linked to Future Land Use Scenarios for NEIRF-funded Clyst Bond Canopy Project. Details of the NEV models are available here.

Exe Estuary Partrnership. Credit: Stephanie Clark

2. Extensive programme of stakeholder engagement - over 34 events were attended or organised in the SW to promote SWEEP work, develop networks for information sharing and provide strategic input. Engagement occurred with a wide range of stakeholders from industry, with interests in mariculture, water quality, regulation, farming and land use.

Partner organisations actively engaged with and supported by SWEEP include:

- Dorset Marine Aquaculture Strategy
- One Health Dorset Local Enterprise Partnership
- Connecting the Culm
- Exe Estuary Management Partnership
- East Devon Catchment Partnership
- East Devon District Council's Clyst Canopy Project
- Aquaculture Research Collaborative Hub-UK
- South West Aquaculture Network
- Wholescape Approach to Marine Management.

A Water Quality and Aquaculture resource Hub was set up to share SWEEP information and resources.

A workshop attended by >100 participants at the SWEEP 2020 Expo developed Stakeholder perspectives on the importance of water quality and other constraints for sustainable mariculture to inform modelling work. Paper available here.

3. Baseline review of SW mariculture sector – presented at the Aquaculture ResearCh Hub ARCH-UK meeting (21 April 2021).

4. Policy briefs developed for links between mariculture and Marine Protected Areas (MPAs):

- Report 'Developing general rules to facilitate evidence-based policy for mariculture development in and around Marine Protected Areas (MPAs) in England'
- Policy Brief 'Potential for Marine Aquaculture Development in and around Marine Protected Areas (MPAs) in England'
- Policy Statement and Policy Brief 'Supporting Mariculture Development: Evidence for Informed Regulation'

5. Sustainable aquaculture through the One Health Lens - led by the Centre for Sustainable Aquaculture Futures (a joint initiative between Cefas and the UoE), Sustainable aquaculture through the One Health Lens applies a 'One Health' approach to the Aquaculture industry which recognises that societal buy-in, equity of access to the food produced, and environmental protection must be adequately addressed as the industry expands over the coming decades. Paper available here. Further paper 'A seafood risk tool for assessing and mitigating chemical and pathogen hazards in the aquaculture supply chain', available here.

6. Positive Tipping Points workshop for mariculture in SW – workshop held 'Applying a positive tipping points framework for the sustainable development of the mariculture sector in the SW England' (15 Sep 2022) linked to UoE meeting 'Tipping Points - from climate crisis to positive transformation' (12-14 Sep 2022).

7. Investigation work around incidences of offshore faecal pollution – paper 'Identifying possible sources of faecal pollution in coastal shellfish waters using particle back trajectory modelling' submitted to the journal 'Environmental Monitoring and Assessment'. Report with Food Standards Agency.

8. Exe Estuary Catchment investigation - Wholescape Assessment of Water Quality status, drivers and impacts in the Exe Estuary Catchment and implications. Report produced with West Country Rivers Trust. Available here.

9. Harmful Algal Blooms monitoring and modelling – 'Assessing risks and mitigating impacts of harmful algal blooms on mariculture and marine fisheries' - critical review and analysis of HAB impacts on mariculture (and wild capture fisheries) and recommend research to identify ways to minimise their impacts on the industry. Available here.

Papers on 'HAB monitoring and modelling' available here, here, and here.

10. SWEEP-affiliated PhD studentship – Maximising the environmental benefits of SW seaweed farming potential - work focused on how commercial seaweed farms influence local biodiversity, physical conditions and dissolved nutrient chemistry in the South West. Sophie Corrigan carried out field work at a Cornish Seaweed Company's farm working alongside the company to maximise benefits for both their harvest and the local environment. Details are available here including paper on Quantifying habitat provisioning at macroalgal cultivation sites, available here.

Impacts & benefits delivered

Knowledge/Capacity

Development of a unique wholescape modelling application: the modelling work provided a 'proof of principle' exposition of a complex, whole-system modelling approach developed for the Exe Catchment, connecting future predicted land-use scenarios to freshwater catchment water quality, to estuarine and coastal water quality and effects on shellfish growth and quality (mussels).

Summary findings from this work are:

- By linking a number of modelling approaches, this 'whole catchment' approach provides the first highly-integrated method for comprehensively evaluating the effects of potential future land use changes on water quality, and their associated impacts on shellfish farming in estuarine and adjoining coastal waters. Innovations notably include modelling the shellfish uptake of the faecal pathogen indicator E. coli (via ShellSIM) and the valuation of costs and benefits throughout the aquatic system (via the NEV models).
- The application of this approach to water quality in the Exe Estuary catchment and shellfish farming in the Exe Estuary, brings to life the UK's National Ecosystem Assessment scenarios in the South West for the first time.
- Adopting more sustainable land-use approaches, than currently in operation, will have broadly similar, positive effects on water quality and shellfish production, due to reductions in E. coli and nitrogen inputs. Scenarios: 2) Extensive regenerative agriculture; 4) Increased renewable energy and 5) Strategic tree planting - have similar positive effects on water quality.
- Strategic tree planting is arguably the most straightforward to implement. Extensive regenerative agriculture requires a broad cultural change. The Increased renewable energy scenario is based on positive assumptions about ability to maintain land use for grazing on solar and wind farms and to limit impacts on soil erosion from biofuel cropping, including short coppice rotation.
- A warmer and wetter climate will likely result in increasing waterborne concentrations of nitrogen and copper, due to increasing land runoff, but is likely reduce faecal pollution (E. coli) overall, due to reducing bacterial survival with increasing temperature.
- Whilst agricultural sources of faecal pathogens may be equally as important as those from urban and municipal discharges (Brown et al, 2022), the biggest single risk to shellfish production comes from the proximity of maricultural sites to these inputs.

> *"The SWEEP modelling process and approach is innovative. The South West appears to be leading the way in developing a holistic approach to predicting future water quality, especially when also taking into account, for example, the work of the North Devon Biosphere Reserve testing real-time monitoring of environmental and water quality parameters to predict water quality lower down in the catchment. These advances will potentially lead to the development of a more risk-based approach to managing shellfisheries in the South West, which would deliver significant benefits for both shellfish producers and consumers."*
>
> **Martin Syvret, Aquafish Solutions Ltd**

> *"It's good that this work shows this is not just a livestock issue, which is often seen as the key problem, but also one of municipal effluent discharges and Combined Sewage Overflows."*
>
> **Hattie Severinsen, Environment and Land Use Adviser, National Farmers Union South West**

> *"Valuing wider ecosystem services across the Exe catchment provides more evidence to support growth of the bivalve shellfish sector."*
>
> **Keith Jeffery, Principal Aquaculture Scientist, Cefas**

> *"These insights can be used by SWW to guide and support future investment strategies and planning and will translate out as learning that can be applied to other large catchments in the SW."*
>
> **David Smith, Natural Resources Team Manager**

Westcountry Mussels of Fowey

Knowledge/Capacity

Novel application of positive tipping points framework to SW mariculture sector: this workshop helped to reframe issues constraining development of the SW shellfish mariculture sector as a series of critical interventions required to address the constraints.

Policy & Legislation

Policy briefs developed for links between mariculture and MPAs: This work informed policy recommendations within Seafish's 'English Aquaculture Strategy', setting out vision and plan for ten-fold increase in food production from sector 2020-2040.

Policy & Legislation

Shaped Exe Estuary Management Partnership strategy: Dr Ross Brown was invited to Chair the water quality breakout group, which shaped partner priorities in the Exe Estuary Management Plan 2022 – 2027.

An article on the SWEEP Wholescapes Exe Estuary Catchment Investigation was published in Newsletter of the Exe Estuary (Management) Partnership. Exe Press Issue 60, Autumn/Winter 2021, (8th Nov 2021), page 7.

Policy & Legislation

Informing Natural England's evidence review: Drawing on her PhD literature review (Maximising the environmental benefits of SW seaweed farming potential), Sophie Corrigan contributed to the recently published Natural England Report, Seaweed aquaculture and mechanical harvesting: an evidence review to support sustainable management (NECR378); leading on section 3.6 Artificial Habitat Creation. This document will be used to inform best practice.

Attitudinal/Capacity

Strengthening collaboration and knowledge: Collaborative development of 'Future land-use scenarios 2050 affecting water quality in South West' developed connections and common understandings around water quality issues between West Country Rivers Trust, South West Water, National Farmers Union, Food, Farming & Countryside Commission, Natural England Catchment Sensitive Farming, Cefas and Sustainable Aquaculture Futures.

Organisational Function

Business support: Support was given to Offshore Shellfisheries Ltd through the back-trajectory particle modelling to identify (possibly anomalous) FSA test results indicting that sources of faecal pollution were found to be present in waters at their offshore mussel rope cultivation sites in Lyme Bay.

> *"This SWEEP workshop gave stakeholders an opportunity to apply the new Positive Tipping Points framework to long-recognised issues faced by the South West's aquaculture sector. This novel process identified critical interventions (e.g. regulatory, technical and market-related) which, if addressed, could help to realise growth targets for the shellfish industry, as set out in the English Aquaculture Strategy (2020). Bringing new insights and perspectives to old problems, this novel approach is helping to build the momentum needed to deliver positive change - both in the short and longer-term, and in the South West and potentially further afield too."*
>
> **Tim Huntington, Director, Poseidon Aquatic Resource Management. Co-author of English Aquaculture Strategy, Seafood 2040**

Leveraged and Affiliated funding

Leveraged funding:

- £54k for Artificial Intelligence for predicting Harmful Algal Blooms (HABs) funded by Regulators Pioneer Fund (total project funding £200k)
- £70k for 'Sustainable Future Global Aquaculture – Water Resources, Pollution and Biodiversity Protection'
- £30k for workshop 'Applying a positive tipping points framework for the sustainable development of the mariculture sector in the SW England'
- £48k 'Transitioning towards more sustainable food systems through the application of a positive tipping points framework
- £2.5k for MSc Data Science solutions (2021) for sustainable aquaculture (seaweed element) funded by 5G Rural Dorset (total project funding £4.6m). Two further MSc projects in Data Science & Global Sustainability Solutions linked to modelling work
- £3k for 'Extractive Aquaculture in the UK and its Human and Environmental Health Benefits'.

Exmouth Mussels

Affiliated funding:

- £250k European Maritime and Fisheries Fund - Development of seaweed cultivation
- £100k European Maritime and Fisheries Fund - Assessing risk of harmful algal blooms to marine fisheries and aquaculture
- £10k Research England – Strategic Priorities Fund - Developing a policy brief on the compatibility of aquaculture and MPAs
- £15k HEFCE Fund - Data Science tools statistical models for predicting HABs
- £1.7m for affiliated BBSRC funding into co-location of UK king shrimp production on terrestrial farming sites.

Looking to the future

- A major research proposal is being developed with SWW, for potential funding under the UoE's Centre for Resilience in Environment, Water and Waste (CREWW; jointly funded by SWW and Research England), to investigate the nature and impact of CSO spills and to develop a risk assessment approach that could be applied more widely across the SWW network and used to inform policy and CSO regulation guidance.
- When published (anticipated in 2023), the investigation 'Identifying possible sources of faecal pollution in coastal shellfish waters using particle back trajectory modelling', will be considered by the Food Standards Agency as evidence to support a more flexible approach to shellfish hygiene testing in the face of potentially anomalous results.
- A £50k research proposal to extend the application of the Positive Tipping Point Approach to sustainable international development of seaweed, crustacean shellfish and finfish aquaculture is being developed between UoE and Cefas as part of the collaborative centre for Sustainable Aquaculture Futures.
- A series of journal publications are planned as outputs from the modelling work:
  1. Integrating land use and climate change in future predictions of water quality throughout the Exe Estuary catchment
  2. Understanding the consequences of future land use and climate driven changes in water quality for shellfish aquaculture in the Exe Estuary
  3. Valuing terrestrial and aquatic ecosystem services under future land-use and climate change scenarios in the Exe Estuary catchment

For more information contact sweep@exeter.ac.uk

Organisations we've worked with

- **West Country Rivers Trust**
- **South West Water**
- **Natural England**
- **Catchment Sensitive Farming**
- **Food, Farming & Countryside Commission**
- **Cefas**
- **Sustainable Aquaculture Futures**
- **Offshore Shellfisheries Ltd**
- **Exmouth Mussels**
- **Aquafish Solutions**
- **Dorset Marine Aquaculture Strategy**
- **One Health Dorset Local Enterprise Partnership**
- **Connecting the Culm**
- **Exe Estuary Management Partnership**
- **East Devon Catchment Partnership**
- **East Devon DC's Clyst Canopy Project**
- **Aquaculture Research Collaborative Hub-UK**
- **South West Aquaculture Network**
- **Wholescape Approach to Marine Management**

Underpinning NERC Science

- NE/P011004/1- ShellEye
- BBSRC/NERC (BB/M026221/1) Risks and Opportunities for Sustainable Aquaculture
- NE/P016944/1 - Web-based tools for natural capital management and investment
- NE/R015953/1 - Climate Linked Atlantic Sector Science
- NERC/TSB KTP Understanding the impact of moorland restoration on water quality
- NE/K00722X/1 - Developing a biomonitoring tool to identify and quantify the impacts of particulate matter in freshwater ecosystems
- EU (H2020- SFS-11b-2015 – contract 678396) Tools for Assessment and Planning of Aquaculture Sustainability (TAPAS)
- BBSRC/NERC (BB/P017215/1) Aquaculture Initiative network
- NE/R011524/1 - DTP in Freshwater Biosciences and Sustainability
- BBSRC/NERC (BB/S004343/1) - AquaLeap: Innovation in Genetics and Breeding to Advance UK Aquaculture Production
- BBSRC/NERC (BB/S004122/1) - ROBUST-SMOLT Viability of Atlantic salmon from Recirculation Aquaculture Systems

About SWEEP

The South West Partnership for Environmental & Economical Prosperity (SWEEP) is a partnership between the University of Exeter, the University of Plymouth, and Plymouth Marine Laboratory. Funded by the Natural Environment Research Council and stakeholders together to solve key challenges faced by those working with our natural resources. **www.sweep.ac.uk**

UKRI Natural Environment Research Council

Strengthening investments in nature for human health and wellbeing in the South West and beyond

sweep

Impact Summary

Harnessing the latest scientific evidence, SWEEP delivered innovative resources and approaches that have strengthened a large network of cross-sectoral partnerships and influenced more robust and equitable investments, policy and practice, in the environment for health outcomes.

Network of **120** stakeholders; **12** evidence-based resources, strengthening cross-sectoral nature-based health outcomes.

7 business cases and interventions influenced; **5** jobs supported; **£2.4m** funding, and increased business profits.

3,626km² area of land informed for policy and practice to deliver nature and health

Ways of Working

- Innovative Knowledge Provision
- Effective Collaboration
- Capacity Building
- Tailored Decision Support

Why it mattered?

Increasing evidence shows that spending time in nature leads to longer term improvements in our physical, and mental health and wellbeing, and delivers £2.2bn health benefits each year in England via physical activity alone.

With rising public health challenges such as obesity, poor mental health and the impact of the recent pandemic, there has never been a greater need to access the health benefits of nature. Yet many of us live more disconnected from nature than ever before.

The UK Government's 25 Year Plan outlined a need for strengthening understanding of health outcomes of interventions through environmental investments.

A growing and diverse range of policy and practice has ensued, but lacks key elements for maximising human health and nature benefits - critically, cross-sectoral working between the health and environment sectors and strong scientific evidence underpinning how best to invest in green and blue spaces.

What we did

Responding to this, the SWEEP team - Dr Ben Wheeler, Dr Rebecca Lovell, Dr Sian de Bell, Kate Hind and Dr Karyn Morrisey (University of Exeter), Andy Edward Jones, Elaine Fileman and Dr Elizabeth Gabe-Thomas (Plymouth Marine Laboratory) and Professor Mel Austin (University of Plymouth) - worked in collaboration with key partners - Dorset Local Nature Partnership, Public Health Dorset, Cornwall Council, Wildfowl and Wetland Trust, the Dartmoor National Park Authority, Plymouth City Council - as well as a wider network of stakeholders.

These strong partnerships have strengthened cross-sectoral learning, working and investment in nature for health outcomes in the South West, and beyond, primarily through the development of:

A cross-sectoral network of stakeholders in the South West – via an online hub with 120 users representing all sectors of society, environment and health, both within and beyond the South West. This has provided a vital space for sharing regional good practice, policy and resources, delivering 11 public-facing cross-sectoral webinars to more than 1,000 people stimulating debate. SWEEP also co-created a suite of evidenced-based resources, disseminated via the network. For more information: https://sweep.ac.uk/project/020/

A business case for investing in nature for health – drawing from two academic databases (Web of Science and SCOPUS), SWEEP created its database with more than 500 papers connecting environmental interventions with health outcomes.

Providing evidence of how health benefits can be realised through natural resources investment, this was used to produce seven bespoke evidence reports used to successfully support partner's business cases for investment in the environment for human health outcomes.

Impacts & benefits delivered

Knowledge/Capacity

New, bespoke, evidence-based resources shaping conversations and new ways of thinking at strategic and project level: the process of co-creating 12 innovative nature-based health resources, and the resources themselves, have played a vital role in boosting stakeholder's confidence, credibility, and capacity to deliver nature-based health outcomes. This has sustained and increased levels of engagement, accelerating and improving decision making, policy and practice.

Attitudinal/Capacity

Enhanced cross-sectoral working: providing a space for networking and connection, especially during the challenging pandemic, has led to greater cross-sectoral sharing and working between the health and environment sector: a vital component for effective investment in more inclusive, sustainable nature-based health outcomes.

Organisational Function

Accelerated and enhanced nature-based health and wellbeing delivery across a wide range of organisations: e.g. SWEEP's work is strengthening strategic thinking and project evaluation approaches at the Wildfowl and Wetland Trust; local business sales and product development at Slyvawood Seeds; the equitable delivery of health benefits on Dartmoor National Park; the delivery of Plymouth City Council's Green Minds Derriford Community Park; the implementation of Health and Nature Dorset (HAND); business cases at Cornwall Council; the delivery of PH Dorset's Healthy Places programme; the evidence base, and supported development of the NATURE tool.

Policy & Legislation

Strengthened regional and national policy and strategies with robust evidence: e.g., Cornwall Council's 2023-2028 Social Prescribing Strategy, Dorset LEP's strategic policy development, and Wildfowl and Wetland Trust's contribution to Somerset's new 6,140 hectare 'super' National Nature Reserve.

Natural Capital

Contributed to environmental enhancement and safeguarding: via SWEEP-informed investments in health interventions, that extend over 3,626km^2 of the South West, and beyond.

Health & Wellbeing

Enhanced health and wellbeing benefits for local populations and visitors: through engagement with the nature-based health interventions delivered across this 1,402 square miles.

Economic

Delivered partner profits and cost-savings: through SWEEP undertaking this work and adding value by strengthening business cases, leveraging more than £2.43m funding, increasing Sylvawood Seed's forecasted revenue by 38%, and creating/safeguarding five jobs.

> *"One of the key benefits of SWEEP's work has been to keep the latest evidence and ideas at the forefront of our thinking. This is improving conversations, both on the ground and at senior level, fostering greater understanding about how best to bring together the many different, often fragmented, strands of work, and stakeholders, to deliver more effectively."*
>
> **Rupert Lloyd, Healthy Places Project Coordinator, Public Health Dorset**

> *"SWEEP's work has contributed to closer working relationships between the environmental and health sectors in the South West. This type of cross-sectoral working is key to our success in delivering interventions that target nature-based health outcomes."*
>
> **Richard Sharpe, Public health specialist & lead mental health & suicide, Cornwall County Council**

> *"SWEEP resources contributed to the thinking behind discussions with the Local Enterprise Partnership aimed at proving the value of nature based health and wellbeing and embedding this more in its policies and strategies. This has successfully resulted in getting the HAND collaboration included in Dorset LEPs Investment Prospectus Wellbeing portfolio, and embedding the natural capital concept."*
>
> **Maria Clarke, Dorset Local Nature Partnership Manager**

> *"The SWEEP resources are prompting discussions, informing conversations and sowing the seeds for a different way of thinking at WWT. This has significant potential to influence how we assess and value the health benefits of our work and ultimately manage new sites and advise policy development."*
>
> **Jonathan Reeves, Principle Research Officer, Wildfowl and Wetland Trust**

Westhay Moor Nature Reserve, Somerset

Looking to the future

The value of SWEEP's work has been widely recognised. Our partners confirm that through its robust scientific evidence, strong partnerships, advisory roles and ongoing work, SWEEP's impact will continue across the South West and beyond. For example, strengthening:

- Local Nature Recovery Strategies and Local Plans, delivering health and wellbeing outcomes.
- National policy, and business cases for investments in nature for health outcomes e.g. Environmental Land Management Schemes.
- Green social prescribing schemes.
- Flagship programmes such as Future Parks Accelerators enhancing green spaces, and innovative ecosystem services tools such as the NATURE tool.

For more information contact sweep@exeter.ac.uk

> *"SWEEP has provided valuable evidence-based work that plays an important part in helping to drive the agenda for a 'right' to nature - where we are investing in enhancing our natural resources to create spaces that make us happy, and save money on health treatments."*
>
> **Luke Pollard, former Shadow Secretary of State for Environment, Food and Rural Affairs**

Organisations we've worked with

Cornwall Council (one and all / onen hag oll)
Dartmoor National Park
Dorset Local Nature Partnership
Plymouth City Council
Public Health Dorset
WWT

Underpinning NERC Science

- NE/M005410/1 - Valuing Nature Programme Valuing Nature Programme Coordination Team
- NE/L002922/1 - Dan Bloomfield Dose of Nature Knowledge Exchange Fellowship
- NE/P01237X/1 - Developing a Nature and Health Hub for Cornwall
- NE/R006946/1 - Linking ecosystem services and businesses through Green Bonds
- NERC Oceans 2025 project - Plymouth Sound project
- NE/N013573/1 - CoastWEB - Valuing the contribution which coastal habitats make to human health and wellbeing

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UKRI Natural Environment Research Council

Driving innovative opportunities for enhanced landscape-scale pollinator policies and practices

sweep

Impact Summary

Building on the success of Phase 1, and strengthening the community of partners in the South West and beyond, this project has pioneered new research-based tools and services to tackle the decline of pollinators - delivering a legacy of impact around policy, landscape-scale management, new business opportunities and environmental leadership.

253 acres of wildflower meadow created or restored; delivering a potential **£209k** pa pollinator value

Business solutions generating: **£400k** in profits or costs-saved; **£50k** in health benefits; **3** new jobs

UK's **1st** prototype grass-roots Natural Capital handbook and novel 'Meadow Match' scheme

Ways of Working

- Innovative Knowledge Provision
- Effective Collaboration
- Capacity Building
- Tailored Decision Support
- Natural Capital Valuation

Why it mattered?

Many vital pollinators are facing extinction, largely due to human activity such as climate change, habitat loss and pesticide use. With almost 90% of wild plants, and 75% of crops, dependant on animal pollination, this loss of biodiversity poses a huge threat, not least of which to the £690m worth of value pollinating insects are estimated to bring to the UK's economy each year.

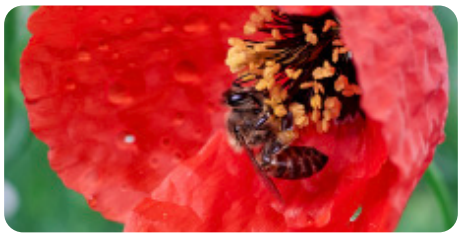
Pollinator decline is of particular concern in the South West which is home to nationally rare and threatened bee species and contains almost a fifth of England's total farmed area.

Following its 25 Year Environment Plan, the UK Government set a context for change with new pollinator policy and funding. The challenge now, is to translate this into real-world solutions that deliver significant and lasting change at a local level.

What we did

Professor Juliette Osborne and Dr Grace Twiston-Davies from the University of Exeter's Environment and Sustainability Institute worked in collaboration with key partners - the Duchy of Cornwall (DOC) Estate, the Lost Gardens of Heligan (LGOH), Cornwall AONB (CAONB), Sylvawood Seeds, and >80 other stakeholders in the South West and beyond - delivering 36 outreach and engagement activities as well as:

- **The integration of the BEE-STEWARD tool into pollinator land management decision making at landscape-scale** – 30 BEE-STEWARD reports for Cornish farmers; BEE-STEWARD predicting nature recovery for CAONB ELMs Test and Trials; a new landscape-scale approach for BEE-STEWARD mapping, with the Bumblebee Conservation Trust (BBCT) and SWEEP PhD Matt Holden at Devon Clinton Estates.
- **Novel business-led solutions to the pollinator decline** - a novel business model for local wildflower seed production with the LGOH (film and business case); creating new meadows with a Meadow Match service matching local 'donor' green hay seed sites to suitable 'receptor' sites with the DOC and Farming and Wildlife Advisory Group (FWAG); bespoke pollinator reports boosting local business sales.
- **A 1st of its kind grass-roots natural capital stewardship and environmental leadership offering** - delivering a prototype Natural Capital Handbook and feasibility study for a continuous professional development (CPD), with DOC.



"The pilot natural capital handbook is a long held ambition of mine and something that wouldn't exist today without SWEEP."

Jeremy Clitherow, NC Advisor, Duchy of Cornwall

Impacts & benefits delivered

Knowledge/Capacity

Enhanced knowledge, capacity and attitudes: the novel SWEEP tools and services are building wider collaborations and greater capacity for more effective and innovative policy and practice to tackle pollinator decline in Devon and Cornwall, and beyond.

Attitudinal/Capacity

Embedded pollinator-friendly approaches, improving partner policies and practice:

- The **Duchy of Cornwall (DOC)** now uses BEE-STEWARD in its land management plans; Meadow Match to help establish new wildflower habitat; and has empowered farmers to be more capable of delivering Natural Capital (NC) farming practices.
- **The Lost Garden of Heligan (LGOH)** has delivered its wildflower meadow ambition working with SWEEP - establishing this as part of its permanent retail offering, strengthening partner relationships, and inspiring further meadow creation with its wildflower business case.
- SWEEP's input has strengthened **Sylvawood Seeds** wildflower seed products, boosting customers and sales.

Policy & Legislation

Strengthened policy: Cornwall AONB (CAONB) 2022-2027 management plan; CAONB Environmental Land Management Test and Trial; Cornwall Council's Environmental Growth Strategy's Making Space for Nature programme.

Natural Capital

Innovative approaches to meadow creation: more than 215 acres (87 rugby pitches), with a further potential 38 acres from seed sold, enhancing ecosystem services such as pollination and carbon sequestration. Novel Meadow Match scheme with 18 'donor' and 23 'receptor' sites.

Health & Wellbeing

Delivering health & wellbeing: an estimated £42,546 - £52,564 return on investment for the health and wellbeing value of the LGOH wildflower site.

> *"SWEEP provided the scientific knowledge and academic rigor that underpins the Heligan wildflower project. Crucially this led to the development of the business plan which has been invaluable for us proving our profitable local wildflower seed business case, and inspire others. Without SWEEP this would not have happened."*
>
> **Alasdair Moore, Head of Garden and Estates Lost Gardens of Heligan**

> *"SWEEP's input has been a real game changer. I am now thinking more strategically about new product ideas and communicating more confidently about how my business helps boost biodiversity and deliver health and wellbeing benefits. The reputation and growth of my business has benefitted, such as from a new three year partnership with the RSPB."*
>
> **Matt O'Connell, Managing Director Sylvawood Seeds**

> *"We now have over 40 hectares of new species-rich wildflower meadow restoration in progress on Duchy of Cornwall land. This is a significant area and, along with our Plantlife partners, SWEEP was instrumental in making this happen."*
>
> **Jermey Clitherow, Natural Capital Advisor, Duchy of Cornwall**

Financial

Partner's profits boosted and costs-avoided including:

- **LGOH**: gross income of c.£17,749 in yr. 1 from wildflower seed; potential for £88,745 over 5 years. Attracting higher footfall generating a further c.£3,000 pa income.
- **Sylvawood Seeds** – diversification of seed products; new partnership deals with the RSPB and National Trust; and 38% increase in forecasted revenue.
- **DOC** - Meadow Match provided seed worth c. £130,000 and labour c. £2,500. Investment of £8,000 informed for new meadow creation at16 sites in Devon and Cornwall providing future seed sources, with an opportunity to access c. £167,000 in Countryside Stewardship funding.

Economic

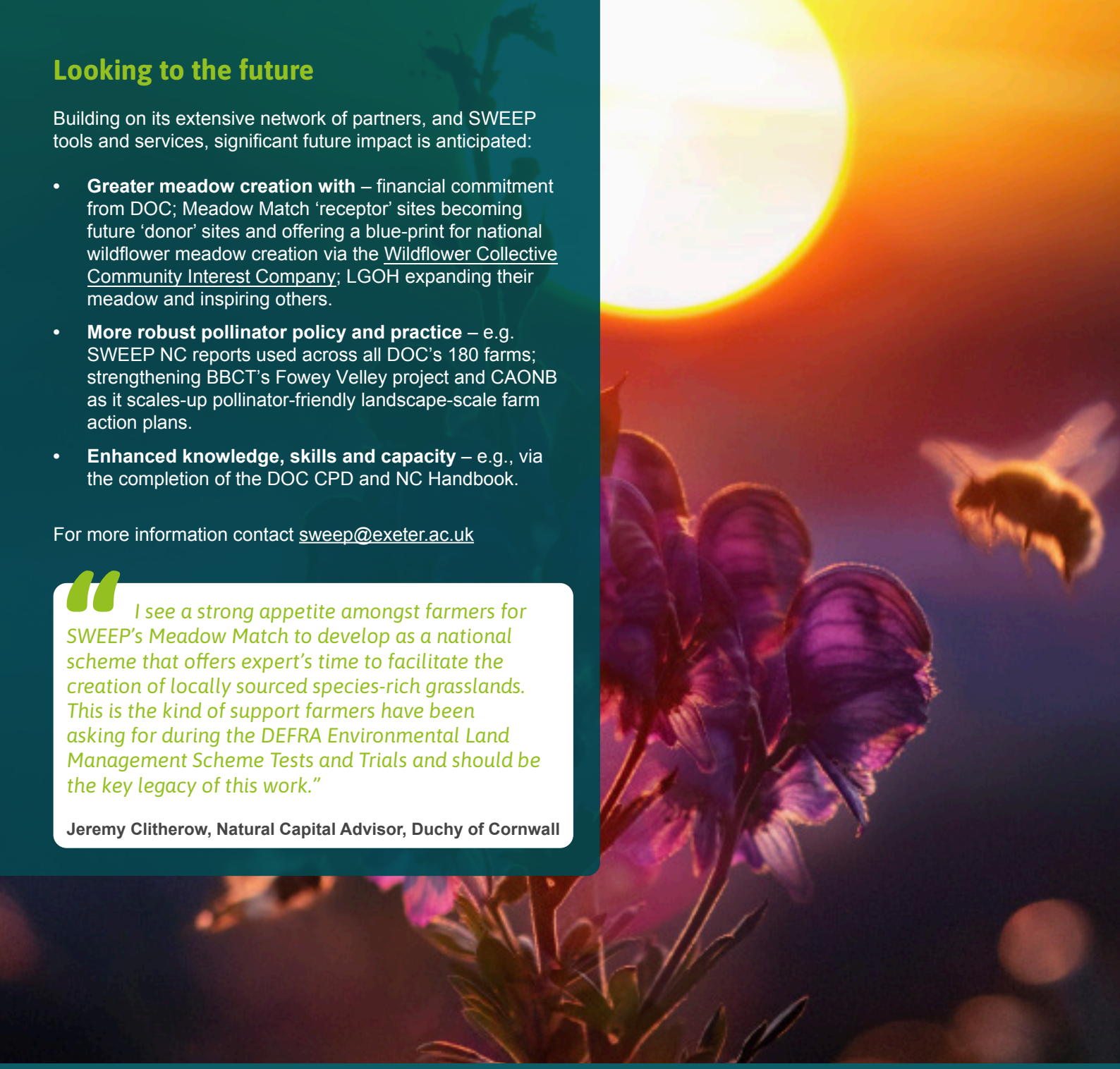
Economic benefits: 3 pollinator related jobs, £3.7m of leveraged or affiliated funding, and an estimated pollination value of £209k from the wildflower meadow created in this project.

Looking to the future

Building on its extensive network of partners, and SWEEP tools and services, significant future impact is anticipated:

- **Greater meadow creation with** – financial commitment from DOC; Meadow Match 'receptor' sites becoming future 'donor' sites and offering a blue-print for national wildflower meadow creation via the Wildflower Collective Community Interest Company; LGOH expanding their meadow and inspiring others.
- **More robust pollinator policy and practice** – e.g. SWEEP NC reports used across all DOC's 180 farms; strengthening BBCT's Fowey Velley project and CAONB as it scales-up pollinator-friendly landscape-scale farm action plans.
- **Enhanced knowledge, skills and capacity** – e.g., via the completion of the DOC CPD and NC Handbook.

For more information contact sweep@exeter.ac.uk



> *"I see a strong appetite amongst farmers for SWEEP's Meadow Match to develop as a national scheme that offers expert's time to facilitate the creation of locally sourced species-rich grasslands. This is the kind of support farmers have been asking for during the DEFRA Environmental Land Management Scheme Tests and Trials and should be the key legacy of this work."*
>
> **Jeremy Clitherow, Natural Capital Advisor, Duchy of Cornwall**

Organisations we've worked with

DUCHY of CORNWALL

The Lost Gardens of Heligan

SYLVAWOOD SEEDS

Cornwall Area of Outstanding Natural Beauty

Underpinning NERC Science

- NE/L002434/1 (GW4+ CASE PhD) - Where the bee flies: Discovering the hidden ecology of bumblebees in Cornish gardens
- NE/L002434/1 (GW4+ CASE PhD) - Importance and management of road verges for ecosystem services

About SWEEP

The South West Partnership for Environmental & Economical Prosperity (SWEEP) is a partnership between the University of Exeter, the University of Plymouth, and Plymouth Marine Laboratory. Funded by the Natural Environment Research Council and stakeholders together to solve key challenges faced by those working with our natural resources. **www.sweep.ac.uk**

UKRI Natural Environment Research Council

Enabling more sustainable landscape management through the co-creation of novel remote-sensing tools

SWEEP co-created novel remote sensing tools for mapping and monitoring key woodlands, moorlands, and habitats, to help enhance the South West's natural landscapes. These tools are already supporting quicker, less costly and more effective decision-making by those tasked with managing the South West's vitally important natural resources.

sweep

Impact Summary

Tree line and natural landscape, Dartmoor

1st of its kind, landscape-scale habitat mapping

Fast-tracking nature enhancement work by **2-3** years

£750k cost-savings delivered over 5 years

£40m of natural capital benefits & **700** jobs by 2030

Ways of Working

Innovative Knowledge Provision · Effective Collaboration · Capacity Building · Tailored Decision Support · Natural Capital Valuation

Why it mattered?

We are working in an age of open access geospatial data that is free to use and available at fine spatial resolutions. This has the potential to revolutionise the way we understand and monitor patterns and dynamics across landscapes.

However, highly complex, technical remote sensing workflows are required to translate these data into user-friendly, up-to-date, fine spatial resolution maps that can inform more robust, evidence-based land management decision making. These require skills not often found in organisations.

What we did

Responded directly to this issue, the University of Exeter's Dr David Luscombe, Dr Naomi Gatis, Dr Donna Carless, Dr Sara Zonneveld, Dr Karen Anderson, Prof Richard Brazier, Prof Charles Tyler worked in close collaboration with the Dartmoor National Park Authority, the North Devon UNESCO Biosphere Reserve and the Forestry Commission.

Using open source Earth Observation data they created a set of bespoke habitat mapping methods and tools. Responding to partner's needs, the team created remote sensing workflows to develop the tools, and these produced fine resolution, robust and repeatable mapping of habitat classes within Dartmoor National Park, and wooded areas within the North Devon UNESCO Biosphere Reserve. This was achieved utilising spaceborne radar (Sentinel 1, SAR), multispectral imaging data (Sentinel 2) and Tellus LIDAR data, in combination with machine learning approaches.

> *"This work has put us two or three years ahead of the game in terms of natural resource mapping data at landscape scale and therefore being able to deliver effectively on nature enhancement work. It simply wouldn't have happened without SWEEP in this timeframe, and quite possibly would not have happened at all."*
>
> **Richard Knott, DNPA's Ecologist**

The tools

Working with Dartmoor National Park Authority, habitat cover across the whole park extent was mapped using a classification system adapted from Level 4 of the national UKHab classification scheme. This led to the development of:

- **The Habitat Classification tool** -this classifies habitat types across the entire extent of the National Park area and enables the annual production of habitat classification maps.
- **The Habitat Change Detection tool** - this enables the detection of change in these habitats over time.

Working with the North Devon UNESCO Biosphere Reserve and the Forestry Commission, outputs focused on baseline mapping the extent and height of trees across both woodland and hedgerow habitats. This led to the development of:

- **The THAW (Tree, Hedgerow and Woodland) Mapping Toolbox** – which can autonomously generate a baseline THAW map using LiDAR Data.
- **The THAW Change Detection tool** - which dynamically maps the change/ loss of woodland and hedgerow biomass/stock over time using satellite-borne radar (SAR) data.

Impacts & benefits delivered

Attitudinal/Capacity

Building capacity and culture shits: our partner's capacity to understand and use these kind of remote sensing tools and mapping outputs has been significantly boosted, enabling them, and the partners they support, do their jobs better and embed new ways of working. Having delivered SWEEP training to more than 50 others, and with the tools now open access, this capacity is extending rapidly throughout the sector.

Organisational Function

A step-change in habitat data for management purposes: the datasets, tools and mapping outputs have provided our partners with a unique, bespoke and repeatable evidence base, of the extent and change of habitat cover over time. This is enabling more effective natural capital decision making, policy and practice and significantly improves upon previously available data.

Organisational Function

Environmental enhancement, safeguarding and increased resilience: for the first time SWEEP's tools are providing land managers with bespoke, accurate and repeatable landscape-scale habitat data enabling better decision making. This is already benefitting a wide range of work including nature recovery, Biodiversity New Gain, natural flood management, Defra's Environmental Land Management Schemes, carbon storage interventions, woodland protection, restoration and creation - both for our partners, and wider stakeholders such as the Environment Agency, Natural England, RSPB, Devon Wildlife Trust and the MOD. See Impact Case Studies.

Policy & Legislation

Contributing to strategic direction shifts and policy development: SWEEP's work has underpinned the development, and will be integral to the delivery and evaluation of, Dartmoor's National Park Partnership Plan 2021-2026, as well as the associated local DNPA plan and State of the Park report.

Economic

Financial and economic benefits: SWEEP's mapping is estimated to be saving our partners at least £750k/per 5 yrs in costs e.g., reducing the need for commercial mapping and ground surveys and enabling better allocation of resources to priority areas. The tools will play a key role in enabling North Devon realise c. £40m natural capital benefits and safeguarding or creating c.700 jobs by 2030, through better woodland creation and management. The work has already leveraged £6.7m of further funding, and a further £5.8m in expected.

> *"The SWEEP experience, and tools, have widened our horizons and been a game changer for us – it's made us think more ambitiously and innovatively about what we can do rather than continuing with how we've always done things."*
>
> **Ally Kohler, Previous DNPA Director of Conservation and Communities**

> *"We work in such large areas, with so few people, that having a remote sensing tool such as THaW has the potential to make a huge difference. It will allow us to be proactive, to seek out the areas that need intervention and take quick, positive action."*
>
> **Mark Prior, South West Area Director, Forestry Commission**

> *"SWEEP's Habitat classification and THaW baseline tools are now the primary landscape scale data for the National Park. Both datasets are being used on a daily basis and SWEEP mapping outputs provide the mainstay of our habitat monitoring from now on."*
>
> **Richard Knott, DNPA's Ecologist**

> *"SWEEP's THaW tool has already proven key to helping us provide more responsive woodland management advice, for leveraging further investment to deliver impact on a larger, wider scale, and in helping to deliver North Devon's considerable woodland targets towards 2030."*
>
> **Andy Bell, North Devon UNESCO Biosphere Reserve Co-ordinator**

Knowledge/Capacity

Legacy and sustained impact: has been built into this work from the robust science-based open source platforms on which the tools are constructed, the co-created process of development, the embedding of tools within partner organisations and their open access location. This is enabling the benefits to be extended more widely and for the tool to be further developed, and rolled out, both regionally and nationally, e.g. via programmes like NetZeroPlus.

For more information
contact sweep@exeter.ac.uk

THAW mapping output

Organisations we've worked with

Forestry Commission

Dartmoor National Park

biosphere north devon

Underpinning NERC Science

- NE/J015237/1 - Fragments, functions and flows - the scaling of biodiversity and ecosystem services in urban ecosystems
- NERC CASE Multi-scale predictions of soil erosion and water quality from intensively managed grasslands
- NE/H01814X/1 - Impacts of farm-scale ecosystem management on water quality in intensively managed grasslands.
- NERC/TSB KTP Understanding the impact of moorland restoration on water quality
- NE/L009137/1 - Testing agricultural impacts on breeding ground food resources as a driver of population decline in a brood parasite
- NE/TS/K00266X/1 - Developing a New Integrated Aerial Vehicle Platform 'Quest Earthwater' for assessing hidden blue water supplies

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UKRI Natural Environment Research Council

Strengthening longer term sustainable development decisions for the future of the South West's coastline

sweep

Impact Summary

The SWEEP team and partners developed a new, accessible, scientifically robust method for demarcating Coastal Change Management Areas, which significantly improve on previous guidance. Trials in the Taw Torridge estuary and Sidmouth areas met well with planners, and led to recommendations that the approach be adopted into Local Plans and be a 'material consideration' for coastal planning and engineering decisions going forward.

Erosion at Start Bay (A379) March 2018

New scientifically robust method for demarcating CCMAs applied to **115km** of Devon coastline in 2 case study areas

Natural England created **1** new post with a coastal and CCMA remit

Strengthened 'material considerations' for coastal planning decisions in light of **28%** of English and Welsh coastline experiencing erosion rates >10cm/year

Ways of Working

Innovative Knowledge Provision → **Effective Collaboration** → **Capacity Building** → **Tailored Decision Support**

Why it mattered?

The South West has 1,014km of beautiful, environmentally diverse coastline, yet it is vulnerable and faces increasing pressure from human activity and erosion.

At some locations the coastline retreats by a metre every decade due to erosion, landslips, flooding and shifting sediments. Local Planning Authorities (LPAs) have the difficult task of deciding where to site future developments along these changing coastal and estuarine margins. To address these issues the UK's National Planning Policy Framework requires LPAs to identify where shorelines are likely to change significantly over the next 100 years. These designated Coastal Change Management Areas (CCMAs) can then be used to inform planning and management.

LPAs have often lacked the confidence, in-house expertise, or consistent methodology to establish such designations. As such, very few CCMAs currently exist, and coastal development continues in active coastal zones with little regard for future shoreline shifts.

> *"CCMAs have the potential to benefit the natural environment by:*
> - *avoiding potential tensions between localcommunities and the needs of the natural environment in the face of predicted change;*
> - *securing benefits for biodiversity, landscapes and access to the natural environment by demonstrating positive management in areas subject to change."*
>
> **Source: Natural England Manager**

What we did

Scientists at the University of Plymouth's Coastal Processes Research Group, Prof. Gerd Masselink, Dr Tim Poate, and Dr Kit Stokes, as well as SWEEP PhD student Josie Kirby, worked closley with project partners Natural England, the Environment Agency, the Marine Management Organisation, Heritage England and the District Councils of North Devon, Torridge and East Devon.

An initial strategic review of existing CCMAs (and similar schemes internationally) gathered feedback from LPAs on the limitations of current criteria and approaches. Key issues identified were a lack of consideration of coastlines where 'hold the line' is the preferred management policy, the exclusion of the latest climate change projections, and insufficient spatial resolution in previous mapping. The team then set about developing an improved, scientifically robust method that planners could adopt, the public can understand, and which incorporates the latest climate science.

Using case study sites in Sidmouth, East Devon (a coastal wave-dominated environment prone to erosion) and the Taw Torridge estuary, North Devon (a tide-dominated environment impacted by flooding), the team developed methods to predict future shoreline positions and sea-level rise over a range of periods. The final output was a clear, concise methodology for use by any LPA, which could deliver the underlying science needed to support of the process of designating CCMAs. The team trialled this methodology in the case study areas and provided training support to the LPAs in its use.

Impacts & benefits delivered

Attitudinal/Capacity

Increased knowledge, confidence and skill sets: within the case study LPAs to engage with, and drive the CCMA process forward.

Enabling Project Partners: Natural England, the Environment Agency, Marine Management Organisation and Heritage England - and their stakeholders to reengage and reinvest in the CCMA process which will accelerate further uptake both within and beyond the South West.

Organisational Function

Accelerating LPA ambitions to deliver CCMA coastal change work: at the LPAs request, SWEEP has now extended CCMA mapping for the Taw Torridge Estuary and Sidmouth study sites, saving each partner c.£50k. Strengthened a funding application by Torridge District Council - to the Innovative Resilience Fund for developing new approaches to solving flooding and erosion risk.

Policy & Legislation

SWEEP- informed CCMAs: are now recommended for official adoption into partner LPA Local Plans. In the interim, they are being recognised as a key component of the 'best available material consideration' for planning and development decisions and coastal resilience funding applications.

Informing coastal management decisions: for example, through 'Shoreline Management Plan Refresh' work and the Marine Management Organisation 'Explore Marine Plans'.

Influence on national policy and uptake of CCMAs: a SWEEP CCMA methodology briefing document [add hyperlink] has been developed and dissemination widely. Through our partners this will feed into and strengthen the National Planning Policy Framework, contributing to more robust guidance on identifying and demarcating CCMAs and thus further improving the rate of CCMA implementation by LPAs not only for the South West but for other regions around the UK.

> *"The SWEEP approach was invaluable in bringing together all key stakeholders, including the Environment Agency and Natural England, to shape and move the CCMA work forward and increase our confidence in this area."*
>
> **Ian Rowland, Senior Planning Policy Officer, Torridge District Council**

> *"lllnformation from the SWEEP CCMA is helping us take a new approach to an adaptive pathway, thus strengthening our submission."*
>
> **Chris Wilson, Coastal Engineer, Torridge District Council**

Current cliff position (black line) with predicted cliff retreat and buffer zones over 20, 50 and 100 years

Looking to the future

Drawing on the SWEEP methodology briefing document, the team continues to work closely with LPA partners, Natural England and the Environment Agency, to drive forward and monitor the uptake of the methodology and designation of CCMAs in the South West and beyond, and its influence on the CCMA guidance in the National Planning Policy Framework. This work has been continued through a PhD studentship supported the University of Plymouth and the Environment Agency.

> *"SWEEP work allowed us to successfully make a case to include CCMAs in our Devon, Cornwall and Isles of Scilly team plan. On the back of this, we are currently recruiting a new lead advisor for our coastal work, including CCMAs."*
>
> **Corine Dyke, Lead Advisor, Natural England**

Underpinning NERC Science

Previous work as part of the NERC-funded BLUECoast project is an early example of the group's expertise in making coastal research relevant to policy and planning.

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For more information contact sweep@exeter.ac.uk

UKRI Natural Environment Research Council

Saving lives through enhanced hazard forecasting and public messaging at Crantock beach

sweep

Impact Summary

A wide variety of stakeholders across the South West and beyond, have approached the SWEEP team, keen to benefit from their cutting-edge science and collaborative approach to tackling coastal hazards. Applying their Operational Water and Wave Level (OWWL) science and approach more broadly, these impact summaries highlight the key benefits delivered from this work during SWEEP.

World 1st
community-led, science-based, smart beach safety technology

Catalyst for:
31 beach rescues (or help given);
91 advisory notices

Delivery of **innovative RNLI water safety measures** accelerated

Ways of Working

- Innovative Knowledge Provision
- Effective Collaboration
- Capacity Building
- Tailored Decision Support

Why it mattered?

Crantock is a popular beach on the north coast of Cornwall that has several significant bathing hazards, including rip currents, estuarine currents, headland boundary rip currents, and powerful breaking waves.

Following storms in 2013/14, the River Gannel broke free from the engineered wall holding it in place against the north headland and now runs freely across the beach to the sea.

Having carved deep troughs in the beach, and with estuarine currents that flow in multiple directions, this is a significant risk for beach users who can easily find themselves out of their depth.

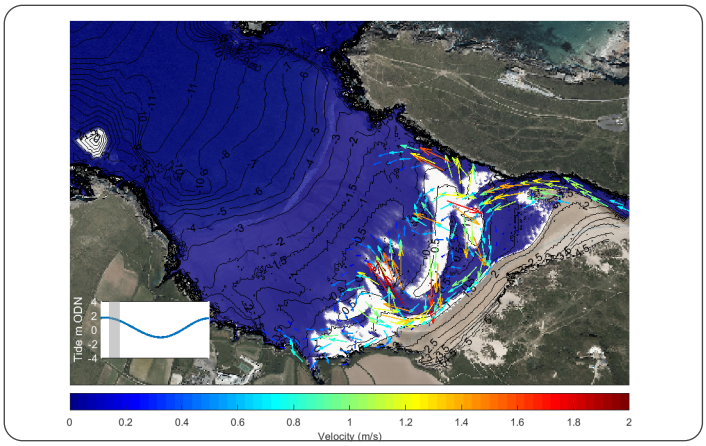
The RNLI have been at Crantock since 2001. They have seen a steep rise in safety incidences with rescue and incident assist figures of less than 40 pa in 2014, to over 190pa in 2018; including two fatalities when lifeguards were not present.

The lifeguard service is under increasing pressure and is keen to benefit from new innovations that deliver improved hazard data, and more effective methods of communicating this to the public, to enable better decisions about how to use the water safely.

What we did

Working closely with the RNLI, Crantock Steering Group and wider community groups, the SWEEP team delivered daily hydrodynamic bespoke forecasts for Crantock Beach (providing up to 5-days pre-warning of peak bathing hazards) and forecast outputs for potential public-facing usage.

Drawing on these, and working with the wider project team, SWEEP contributed to the development of new innovative digital public-facing beach hazard warning signage now installed in Crantock's car park. See Crantock Beach Hazard Forecasting film.



RNLI at Crantock, north Cornwal

Impacts & benefits delivered

SWEEP's work with the RNLI and wider Crantock partners has been truly ground-breaking and has delivered a wide range of impacts:

Knowledge

Delivered new knowledge and built capacity: SWEEP's hydrodynamic model provides new, localised, more-timely, accurate and repeatable data not previously available to the RNLI at Crantock, improving on existing sources. SWEEP's forecasts offer multiple hazard information in one place, supporting more efficient decision making, and RNLI capacity has been increased via the transference of local rip current hazard science expertise. The OWWL model has essentially 'automated' a lifeguard's brain by providing the bathing hazard foresight of an experienced lifeguard up to 5 days ahead; accessible to the public and beach safety champions, especially when lifeguards are off-duty.

Attitudinal/Capacity/Facilitation

Informed attitudes and cultures: by independently verifying the existing water safety knowledge of experienced lifeguards, SWEEP's forecasts have boosted confidence in the current RNLI Crantock service. It has also catalysed new ways of thinking about how best to deliver ground-breaking public-facing beach safety messages, especially in the mornings and evenings when lifeguards are off duty and risks for water users are high. SWEEP has also played a key role in harnessing local collaborative community life-saving efforts – already enhancing beach safety, and key for sustaining this into the future.

Health & Wellbeing

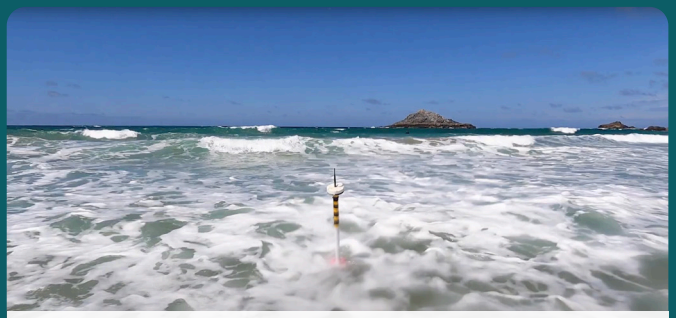
Informed and enhanced RNLI practice, ultimately saving lives: SWEEP's work at Crantock has contributed to the fast-tracking (delivered in 6 months, following 5 years of discussion) of this ground-breaking intervention delivering public-facing, digital beach hazard messaging for safer use of the sea. The establishment of the Surf School and Crantock Surf Club WhatsApp Group contributed to 31 'out of hours' rescues and assists, and 91 'out of hours' advisories during the Crantock 2021 season.

Policy & Legislation

The RNLI view Crantock as an exemplar of an innovative community approach to lifesaving: Crantock's Beach Safety Plan now includes digital signage as part of its suite of water safety interventions. Following further impact evaluation, and product development, the RNLI will consider incorporating this into organisational strategy, as part of a blended water safety service for other sites around the South West and UK. Cornwall Council have committed further funding to extend the lifeguarding season at Crantock by two months.

> *"This SWEEP project is exactly the sort of work RNLI like to align with. We've been impressed not only with the well-researched, cutting edge science the team have brought to this forecasting tool, but the professional way in which they have thoroughly tested and validated the data with local knowledge and experience, and worked with us to track and evidence impact."*
>
> **Adrian Carey, Head of RNLI SW region**

> *"SWEEP has played a pivotal role in this innovative approach to water safety at Crantock and it has already significantly improved the RNLI service here. We are committed to further refining, evaluating and, we hope, rolling-out this work going forward."*
>
> **Steve Instance, RNLI SW Water Safety Lead**



Monitoring equipment being used at Crantock Beach

> *"The SWEEP forecasting outputs have provided us with an exciting new opportunity to deliver public-facing digital beach hazard messaging at Crantock, particularly when lifeguards aren't on duty. This has been ground-breaking work and as far as we know, a world first."*
>
> **Steve Instance, RNLI SW Water Safety Lead**

Forecasting equipment at Crantock Beach

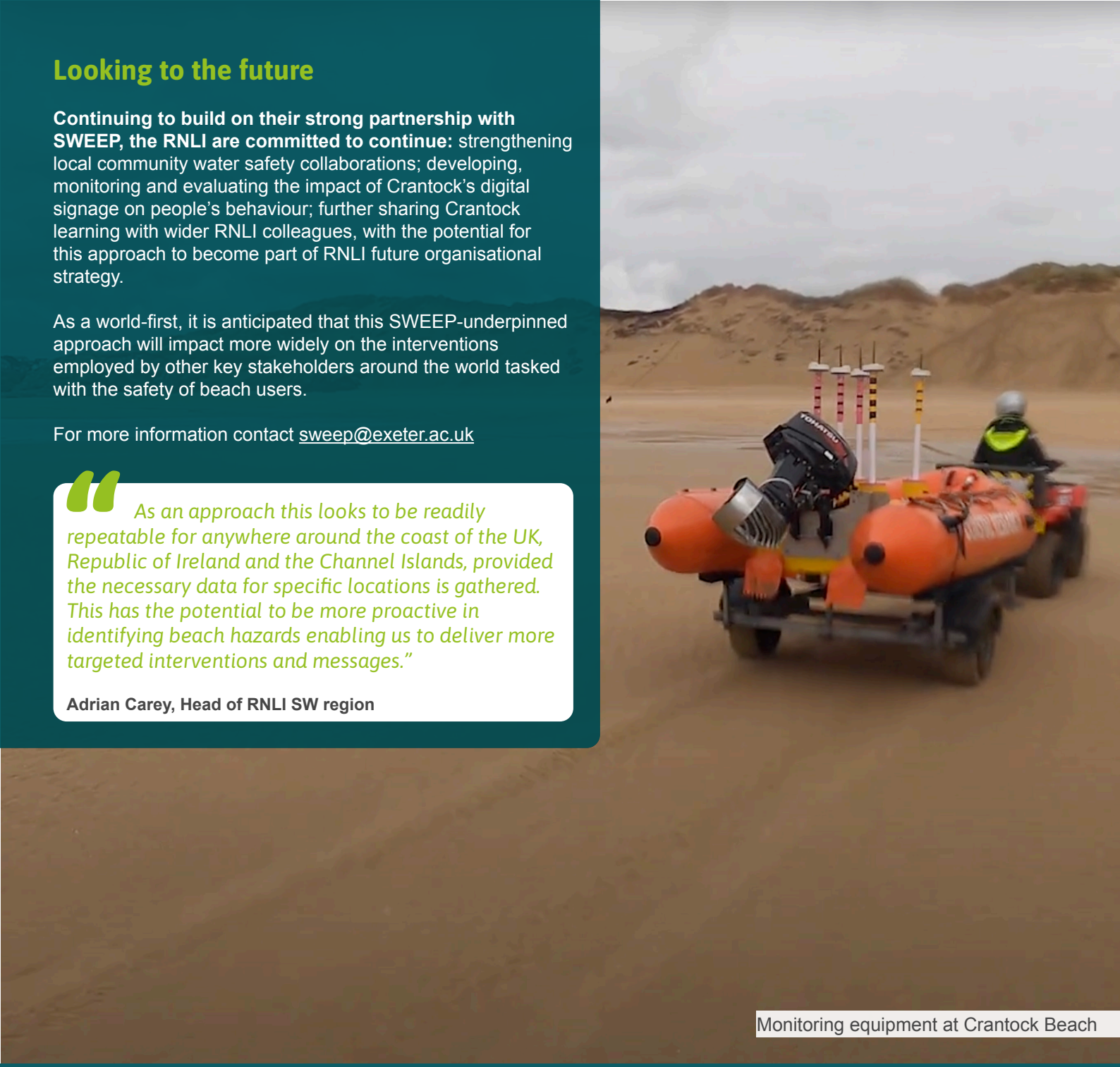
Looking to the future

Continuing to build on their strong partnership with SWEEP, the RNLI are committed to continue: strengthening local community water safety collaborations; developing, monitoring and evaluating the impact of Crantock's digital signage on people's behaviour; further sharing Crantock learning with wider RNLI colleagues, with the potential for this approach to become part of RNLI future organisational strategy.

As a world-first, it is anticipated that this SWEEP-underpinned approach will impact more widely on the interventions employed by other key stakeholders around the world tasked with the safety of beach users.

For more information contact sweep@exeter.ac.uk

> *"As an approach this looks to be readily repeatable for anywhere around the coast of the UK, Republic of Ireland and the Channel Islands, provided the necessary data for specific locations is gathered. This has the potential to be more proactive in identifying beach hazards enabling us to deliver more targeted interventions and messages."*
>
> **Adrian Carey, Head of RNLI SW region**



Monitoring equipment at Crantock Beach

Organisations we've worked with

Underpinning NERC Science

- NE/H004262/1 - Dynamics of Rip currents and Implications for Beach Safety (DRIBS)

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Natural Environment Research Council

Tackling the climate crisis by scientifically-underpinning seagrass restoration in the Isles of Scilly

sweep

Impact Summary

A wide variety of stakeholders across the South West and beyond, have approached the SWEEP team, keen to benefit from their cutting-edge science and collaborative approach to tackling coastal hazards. Applying their Operational Water and Wave Level (OWWL) science and approach more broadly, these impact summaries highlight the key benefits delivered from this work during SWEEP.

Why it mattered?

Seagrass beds are hugely important from a natural capital perspective. Not only do they harbour a wide variety of wildlife, they provide vital ecosystem services such as carbon storage. Capturing carbon at a rate 35 times faster than tropical rainforests, they are one of the most important natural solutions to the climate crisis. However, seagrass has declined drastically during the last century.

Much of this is due to increased human disturbance such as pollution, dredging, mobile fishing gear and coastal development. The Isles of Scilly (IOS), in the South West of the UK, are home to the main surviving UK seagrass habitats but even these are under threat, declining in both extent and quality.

What we did

Working with the University of Swansea, Natural England and the Environment Agency, the SWEEP team developed a bespoke Operational Wave and Water Overtopping (OWWL) model encapsulating the Isles of Scilly.

Ways of Working

The model was applied to, and helped to strengthen, a separate Natural England funded project called *Physical Characterisation of the Marine Environment in the Isles of Scilly: Wave and Hydrodynamic Modelling Report*. The SWEEP team input wave characterisation data into a Swansea University-led Habitat Suitability Model (HSM) – data that is often poorly represented in such models.

This provided insights into the wave climate outside, and within the interior of, the archipelago, as well as a characterisation of hydrodynamics and bed shear stresses. The outputs from the modelling work were fed into Z. Marina Habitat Suitability Modelling performed by Swansea University.

Impacts & benefits delivered

Knowledge/Capacity

As part of this work, SWEEP has:

- Enabled a better understanding of the current environment and habitat thresholds in which seagrass is present, and how these might change in the future - key information for informing strategic decision making for the restoration or future planting of seagrass.
- Highlighted to Natural England the importance of using high-resolution wave models that effectively capture physical wave processes (such as the SWEEP-OWWL model), when assessing potential sites for seagrass habitat restoration, thus ensuring they will be key to informing and strengthening seagrass research and restoration projects in the area and beyond.
- Strengthened the modelling methodology used in this project, as well as the requirements for modelling use in general - contributing to the wider body of knowledge, and confidence, needed to effectively apply these kind of models to enhance evidence-based research to underpin new policy and practice.
- Considerably strengthened the collaboration between marine biologists at Swansea University, and the physical coastal processes team at the University of Plymouth, which is expected to lead to further collaboration and a research paper.

Organisations we've worked with

Swansea University Prifysgol Abertawe

NATURAL ENGLAND

Environment Agency

For more information contact
sweep@exeter.ac.uk

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UKRI Natural Environment Research Council

Delivering Biodiversity and Environmental Net Gain in practice

sweep

Impact Summary

SWEEP helped to address knowledge gaps, understand social preference trade-offs and explore delivery mechanisms for Environmental Net Gain (ENG) which can deliver more than Biodiversity Net Gain (BNG) requirements under planning. The findings are intended to support **Defra, Local Planning Authorities and other organisations** developing BNG and ENG guidance, and with a practical interest in considering how to implement BNG and ENG.

Why it mattered?

Due to housing shortages and an increasing population, there is enormous pressure to build new homes. Until recently a target of building 300,000 new homes each year in England had been set by government. Whilst this target may change, the enormous pressure to build new homes remains. Despite efforts to avoid using new land, space constraints mean that about half of the new homes will be built on 'greenfield' sites that have not yet been developed. New housing built on farmland, at the edges of existing residential areas, will lead to a loss of natural environment and the wildlife species that live in these fields, illustrated in Figure 1.

Offsetting can provide opportunities for 'greenfield' site developments where environmental impact cannot be mitigated for, on the site itself. It can also deliver broader environmental and social values.

Biodiversity Net Gain (BNG) is a new approach to development that aims to leave the natural environment in a measurably better state than it was beforehand. It becomes a legal requirement at the end of 2023 (under the Environment Act 2021) and requires developers to minimise damage to the natural environment and wildlife species, restore nature lost due to the development, and deliver a minimum 10% net gain in nature. This net gain is measured in Biodiversity Metric units.

> *"(Offsetting) can allow the benefits from small developments to be aggregated around a larger restoration project with greater ecological connectivity and environmental benefits that would not otherwise be viable... resulting in environmental improvement happening closer to the communities who might benefit most... and giving communities greater access to the natural environment."* [1]
>
> **Environment Innovation Business.**

Environmental Net Gain (ENG) is a broader concept than BNG. First set out in the Government's 25 Year Environment Plan[2], it expands upon BNG approaches to include *"wider natural capital benefits, such as flood protection, recreation and improved water and air quality."* Adopting an ENG approach could enable local planning authorities to target the environmental enhancements most needed in their areas and offer developers more flexibility to provide them.

What we did

Starting in 2021, SWEEP Impact Fellows Dr Michaela Faccioli and Dr Diana Tingley, and Prof Ian Bateman (University of Exeter) have:

- Worked with a range of stakeholders in the South West to explore key issues relating to BNG and ENG implementation.

  Stakeholders included: Devon & Cornwall Planning Officers Group, Devon Landscape Character Group, Dartmoor ELMS Trial, Dartmoor National Park Authority, Devon Wildlife Trust, North Devon Council, South West Water, The Environment Bank, Westward Housing and WSP consultants (creators of the NATURE tool) and the Planning Advisory Service.

- Designed, tested, piloted, commissioned and launched a choice-based experiment and stratified survey of the general public in England (N=4,400) to explore a range of social preferences[3] and trade-offs between a range of different BNG and ENG 'offset' implementation scenarios.

  The responses provided a representative sample of the English population in terms of age, gender, regional location and by socio-economic group.

  The effect of a 'greenfield' development on nature is illustrated in Figure 1 and the range of scenario attributes considered in the survey illustrated in Figure 2. A number of other practical and technical issues, including scaling issues and cost attributes, were also explored.

- Provided project update documentation explaining the rationale for the survey, methods used and updated on progress.

- Created a SWEEP ENG information hub for the South West

Ways of Working

1 Environment Innovation Business. 2019. Delivering environmental net gain: an EIC position paper. p7. https://eic-uk.co.uk/media/eebhjdb3/delivering-environmental-net-gain-2019.pdf

2 Defra (Department for Environment, Food and Rural Affairs). 2018a. A Green Future: Our 25 Year Plan to Improve the Environment. p33. https://www.gov.uk/government/publications/25-year-environment-plan

3 Social preferences are one type of preference investigated in behavioural economics and relate to the concepts of reciprocity, altruism, inequity aversion, and fairness. Fehr, E. and Fischbacher, U., 2002. Why social preferences matter–the impact of non-selfish motives on competition, cooperation and incentives. The economic journal, 112(478), pp.C1-C33. https://doi.org/10.1111/1468-0297.00027

Looking to the future

The Esmee Fairburn Foundation have funded ongoing work to: (1) analyse survey results and combine this with other relevant datasets to examine possibilities to enhance offsetting outcomes; and (2) hold community engagement workshops in the South West to explore the results from a range of perspectives.

For more information contact sweep@exeter.ac.uk

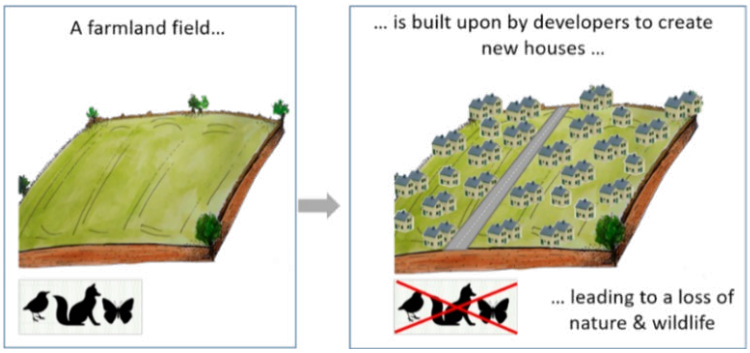


Fig. 1: Greenfield (farmland) development site - survey baseline

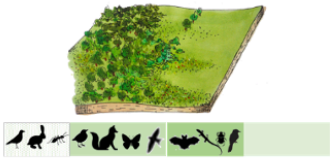
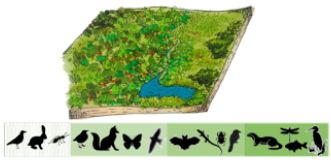
Level of Net Gain (Biodiversity Enhancement) delivered	 **Minimum Legal Requirement** (i.e. 10% BNG)	 **Moderate Enhancement** of natural environment and wildlife (ENG scenario 1)	 **High Enhancement** of natural environment and wildlife (ENG scenario 2)
Recreational access at the Net Gain site	 Public access	 No public access	
Proximity of respondent - to housing development - and Net Gain site	1, 2, 5, 10, 25, 50, 75, 100 miles A respondent's proximity to the housing development was fixed (at either 2 or 50 miles) and they were then asked to consider Net Gain schemes at differing distances.		
Neighbourhood wealth - at housing development - at Net Gain site	 **Low wealth** neighbourhood	 **Average wealth** neighbourhood	 **High wealth** neighbourhood The neighbourhood wealth of the housing development was fixed for each respondent and they were asked to consider Net Gain schemes in areas of differing neighbourhood wealth.

Fig. 2: BNG and ENG attributes explored in the survey

About SWEEP
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UKRI Natural Environment Research Council

Enhancing the design of ground-breaking market-based Payments for Ecosystem Services (PES) schemes

sweep

PhD Impact Summary

SWEEP-affiliated PhD student Ben Balmford's research was instrumental in improving the efficiency of the Forestry Commission's unique £50m carbon-reduction tree planting scheme, and Poole harbour nitrate-reduction auctions delivering cost savings to both business and the public purse, in addition to improved environmental outcomes. Ben continues to work with Exeter's Mechanism Design Team developing three world-first, double-sided catchment markets, designed to allow economic development to proceed without harming the planet.

Supported **2,750** hectares of new woodland creation

275 tonnes nitrogen prevented from entering Poole Harbour

Co-created **3** world-first double-sided catchment markets

Why it mattered?

Payments for Ecosystem Services (PES) schemes encourage or incentivise the conservation of natural resources, or delivery of specific ecosystem services. For example, payments can be made to farmers or landowners, who agree to take certain actions to manage their land in ways which improve water quality or biodiversity or sequester carbon. Schemes aimed at reducing the levels of nutrients in freshwater habitats and estuaries, help to reduce algal growth which disrupts natural processes and impacts wildlife. Whilst those aimed at planting trees or creating new or enriched habitat can boost carbon sequestration and deliver improved biodiversity.

PES schemes can take a range of forms, from flat-rate payments to auctions to full blown trading platforms, or what might be termed a PES market. PES markets provide a place where buyers and sellers make mutually beneficial trades and are increasingly being used to deliver environmental improvements. As prices are set by the market, they can overcome problems with predetermined price setting used in other forms of PES schemes.

Ben's PhD research explored a **range of design issues** relating to **PES markets**, including issues of perceived efficiency, trustworthiness, and fairness.

What Ben did

Ben began his PhD by exploring the principles of using 'public funding' for the provision of 'public goods'. He then explored emerging 'PES market' issues by conducting a series of experiments at the FEELE Lab, located in the University of Exeter Business School. Research topics included studying bidding behaviour in a range of 'reverse auction' formats (where the lowest bids win the contracts to provide services), and comparing different types of auction format, pricing rules, participant incentives and external influences. Through collaborative work with Prof Brett Day and Dr Luke Lindsay as part of the University of Exeter's Mechanism Design (EMD) Team, Ben applied his research to a range of PES markets and trials, including:

- One of the **UK's first catchment market schemes** for the rivers Dove and Wye in Derbyshire Severn Trent Water (2017-2019), in which landowners bid to undertake actions to improve water quality, with the market discovering prices, rather than predetermined fixed prices.
- The **Forestry Commission's** £50m Woodland Carbon Guarantee online auction scheme. Launched in 2019, the scheme was the UK's first auction for carbon and is helping to deliver on Net Zero 2030 ambitions by incentivising land-owners to plant particular types of trees which lock in carbon. To date, there have been 110 successful bids over 5 auctions running from Jan 2020 to May 2022, for tree-planting in an area of 2759 Ha[1].
- Wessex Water/EnTrade's **Poole Harbour Nitrate reduction** auction enabled farmers to bid to plant cover crops that reduce the amount of nitrogen run-off entering rivers. The Pay-as-Bid format was changed to one where everyone pays the same Uniform Price, making bidding more straightforward.
- Trials of **world-first catchment markets** (2020-ongoing), developed in collaboration with EnTrade/Wessex Water as national pilots. These trials are unique in their double-sided nature, with multiple buyers, multiple sellers and multiple environmental services being traded simultaneously. They also use an innovative settlement mechanism, designed by the EMD Team, ensuring fair payments for environmental credits.

The catchment markets provide a place where landowners and farmers can bid to deliver nature-based projects, primarily aimed at improving water quality, and housing developers and businesses can buy credits to meet their planning and 'Nutrient Neutrality' obligations for protected wildlife sites.

- **Solent Nutrient Market Pilot** – sponsored by Defra, the pilot involves Natural England, local planning authorities, the Department for Levelling Up, Housing and Communities, the Environment Agency and the Forestry Commission.
- **Somerset Catchment Market Pilot** – led by the Environment Agency, Wessex Water and Natural England, this pilot was created in response to a request from Defra and its agencies for innovative projects that could contribute to a Green Economic Recovery.
- **Bristol Avon Catchment Market** – developed with the Avon and Wiltshire Wildlife Trusts, the market is designed to enable businesses to meet their environmental obligations and commitments.

1 https://woodlandcarboncode.org.uk/woodland-carbon-guarantee

Impacts & benefits delivered

Ben's PhD research and collaborative work with the Exeter Mechanism Design (EMD) Team delivered significant impacts.

Policy & Legislation

Woodland Carbon Guarantee scheme: Ben's research findings and advice was ***"instrumental"*** in shaping the design of the Forestry Commission's Woodland Carbon Guarantee scheme, according to Pat Snowdon of Scottish Forestry. To date, the scheme has delivered 2,750 hectares of new woodland and encouraged a diversification in woodland type and tree species[2]. The research findings and advice allowed the FC to support woodland planting, which would not have otherwise happened, by incentivising future CO_2 removals at a significantly higher carbon price, helping to move the market price in the direction of the government's current estimated values per tonne of carbon required to meet climate change targets[3]. Based on current government values, the expected net reduction in carbon of 0.6m tonnes, directly resulting from this advice, offered a cost saving to the public purse for carbon bought of £6.2m.

Strategy and policy contributions: The strategic and policy decisions of a wide range of organisations were influenced, including: Defra, Environment Agency, Natural England, Wildlife Trusts, water companies, a number of Local Planning Authorities, EnTrade and NatureBid.

Organisational Function

Poole Harbour Nitrate reduction auction: The change in auction design, directly informed by Ben's research findings, resulted in a **cost saving of 30%** compared to under the previous auction rules. Moreover, removing that quantity of nitrogen through a built infrastructure/traditional approach **would have cost £11.45m**. An estimated **275 tonnes of nitrogen was prevented** from entering Poole Harbour as a result of the re-designed auction schemes informed by Ben's research findings[4].

Knowledge/Capacity

Catchment Market schemes: The catchment markets in **Poole Harbour** and the **rivers Dove and Wye** substantially reduced nutrient pollution entering rivers, and the improved water quality increased the recreation value people derived from using waterways. Farmers also benefited from payments that increased their income. Cost savings for water companies avoided the need for large infrastructure investments to reduce nutrient pollution and benefited customers where passed onto them. It is anticipated that the **national pilot and trial catchment markets** for the **Solent, Somerset Levels**, and the **Avon** will benefit farmers and rural communities by increasing and diversifying income streams in return for delivering nature-based projects. Housebuilders will benefit from being able to purchase verified nutrient credits and Biodiversity Net Gain (BNG) offsets. Nutrient offsetting will help protect fragile eco-systems, like saltmarshes and mudflats in the Solent and the lowland wetlands in Somerset. The BNG offsets will establish new habitats and these ecosystems will also provide opportunities for leisure activities, like birdwatching, that contribute to wellbeing.

Economic

Boosting business: A range of businesses have benefited from Ben's and the EMD Team's research and advice, particularly EnTrade, with whom they have a unique and close co-creative relationship, and also consultants Arup, Wheatley Young & Partners and Vivid Economics.

> *"Ben provided invaluable insights into the design and application of reverse auctions for a new policy initiative, the Woodland Carbon Guarantee. This advice was instrumental in giving us the confidence to carry out the auction. We subsequently ran five auctions under the Guarantee, helping drive woodland creation in England, which would not have otherwise happened, by incentivising future CO2 removals at a significantly higher carbon price than previously. The Forestry Commission considered this to be a very successful outcome and one that had also impressed H.M. Treasury."*
>
> **Pat Snowdon, Head of Economics, Scottish Forestry**

> *"The work that the Exeter team are doing to help design and operate catchment markets for nature-based solutions is world leading. Their innovation is creating the incentives for farmers and landowners to integrate nature with agriculture through a unique, high integrity mechanism (the Lindsay mechanism), that can enable private capital to be efficiently deployed to address climate change and nature recovery at a global scale."*
>
> **David Young, Senior Fellow at the Broadway Initiative**

> *"The Exeter team has the rare ability to apply world-leading academic expertise to the practical requirements of environmental market design. Their work is informing the development of well-designed high integrity markets that can fairly reward farmers and landowners for delivering environmental outcomes and integrate environmental measures with food production and other land uses in farmed landscapes."*
>
> **Guy Thompson, Managing Director, EnTrade**

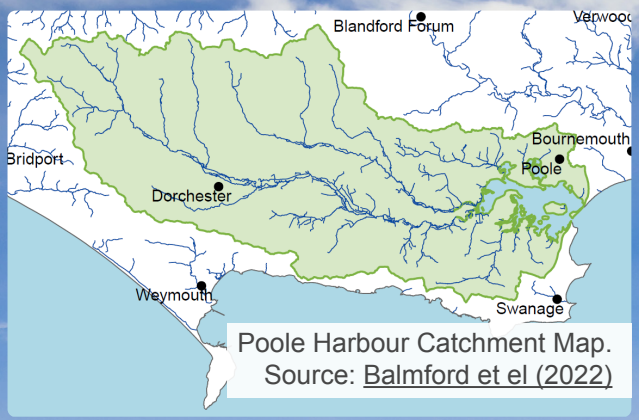
2 https://woodlandcarboncode.org.uk/woodland-carbon-guarantee
3 https://www.gov.uk/government/publications/valuing-greenhouse-gas-emissions-in-policy-appraisal/valuation-of-greenhouse-gas-emissions-for-policy-appraisal-and-evaluation#annex-1-carbon-values-in-2020-prices-per-tonne-of-co2
4 Balmford et el (2022): Pricing Rules for Pes Auctions: Evidence from a Field Experiment. Available at SSRN: https://dx.doi.org/10.2139/ssrn.4280685

Looking to the future

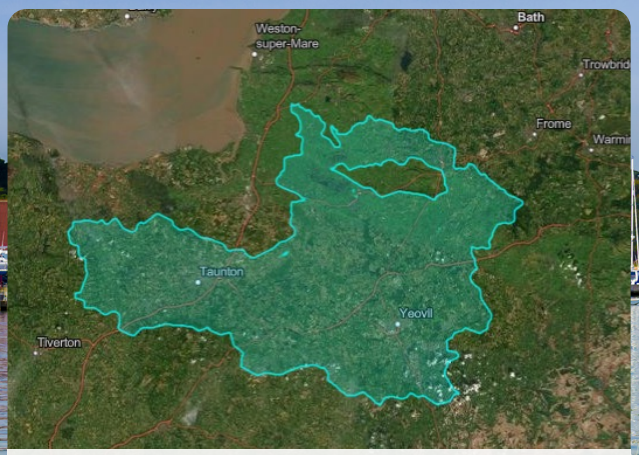
Awarded his PhD in 2022, Ben is now a Postdoctoral Research Fellow at the University of Exeter LEEP Institute. He works alongside Prof. Ben Groom, who holds the Dragon Capital Chair in Biodiversity Economics, on a specially-created 5 year programme examining: (1) the relationship between biodiversity and human well-being; (2) how much the economy depends on biodiversity and nature; and (3) how the well-being of future generations can be reflected in decisions today.

Ben also continues his work with the Exeter Mechanism Design Team and EnTrade to inform and advise the ground-breaking PES markets and trials currently underway in the UK, and offer similar advice to developing schemes in Wales.

For more information contact leep@exeter.ac.uk



Poole Harbour Catchment Map. Source: Balmford et el (2022)



Parrett area of risk, Somerset. Source: Click here

> *"The Bristol Avon Catchment Market is a genuine step change for the delivery of nature-based solutions at a landscape scale."*
>
> **Amy Coulthard, Director for Nature's Recovery, Avon Wildlife Trust**

> *"New housing schemes.... now having to demonstrate nutrient neutrality before building can commence or resume - an estimated 120,000 new homes are now delayed."*
>
> **National Federation of Housebuilders**

Organisations Ben worked with

EnTrade
Arup
Wheatley Young & Partners
Vivid Economics

SOLENT NUTRIENT MARKET PILOT

Somerset Catchment Market

Bristol Avon Catchment Market

PhD related publications

- B. Balmford, R.E. Green, M. Onial, B. Phalan, A. Balmford (2019) How imperfect can land sparing be before land sharing is more favourable for wild species? Journal of Applied Ecology, 56, 1, 73-84.
- Bateman, I. J. and Balmford, B. (2018) Public Funding for public goods: A post-Brexit perspective on principles for agricultural policy. Land Use Policy, 79, 293-300.
- Co-author of 7 Recommendation Reports written for the Forestry Commission (2018-2020)
- Balmford, B., Collins, J., Day, B., Lindsay, L. and J. Peacock. At what price? The effects of a pricing rule change on outcomes in a PES auction. 2022. Working Paper.
- Balmford, B. & L. Lindsay. Bidding in auctions with divided attention. (2022). Working Paper.
- Balmford, B. & L. Lindsay. Behaviour in sealed-bid and clock multi-unit reverse auctions. (2022). Working Paper.
- Balmford, B., Bateman, I., Day, B. & G. Smith. Incentivising efficient effort with minimal monitoring costs. (2022). Working Paper.
- NERC Business Engagement blog 'How to price environmental goods?' published May 2021.
- Balmford, Ben and Day, Brett and Lindsay, Dr Luke and Collins, Dr Joseph and Peacock, James, Pricing Rules for Pes Auctions: Evidence from a Field Experiment. http://dx.doi.org/10.2139/ssrn.4280685

Acknowledgements

Ben's SWEEP PhD was funded by South West Water and was supervised by Prof. Brett Day, Prof. Ian Bateman, Dr. Amy Binner and Dr. Greg Smith.

About SWEEP

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UKRI Natural Environment Research Council

Protecting the Australian coastline via a coastal erosion Early Warning System

sweep

Impact Summary

Coastal erosion, Ben Boyd NP, NSW

A wide variety of stakeholders across the South West and beyond, have approached the SWEEP team, keen to benefit from their cutting-edge science and collaborative approach to tackling coastal hazards. Applying their Operational Water and Wave Level (OWWL) science and approach more broadly, these impact summaries highlight the key benefits delivered from this work during SWEEP.

Ways of Working

Capacity Building

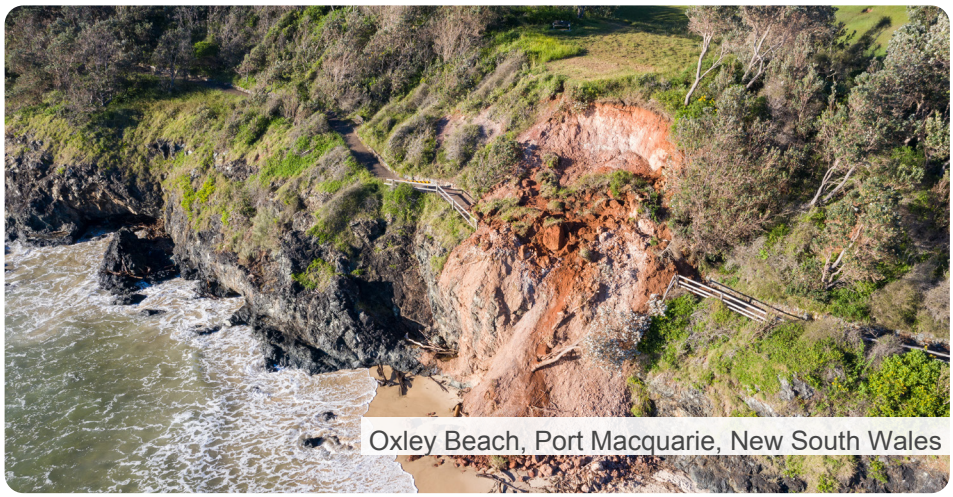
What we did and its impacts

The SWEEP team were invited to share best practice from their Operational Wave and Water Overtopping (OWWL) work with the Water Research Laboratory at University of New South Wales (UNSW), Australia, tasked with developing a novel coastal erosion Early Warning System for the entire coastline of Australia.

The system is intended to provide forewarning of severe coastal erosion events which, in the past, have led to significant damage to coastal properties in the Sydney region, and risk to life. This represents the first of its kind system applied in Australia and one of only a handful of such systems developed to date globally.

The knowledge and approach used in SWEEP's OWWL work has helped to strengthen this work. The knowledge exchange between SWEEP and UNSW was delivered via online workshops.

For more information contact sweep@exeter.ac.uk



Oxley Beach, Port Macquarie, New South Wales

> *"I lead a multi-disciplinary project team that will deliver new capability to our national forecasting agency the Australian Bureau of Meteorology to implement a fully operational coastal erosion Early Warning System. The SWEEP OWWL model has provided us best practice insight and practical guidance on how to successfully leverage cutting-edge research to deliver high-impact outcomes."*
>
> **Ian Turner, Professor of Coastal Engineering, UNSW Sydney, Australia**

Organisation we worked with

UNSW SYDNEY

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UKRI Natural Environment Research Council

Renewed Coexistence: Human dimensions of reintroducing the Eurasian beaver (*Castor fiber*) into England

sweep

PhD Impact Summary

SWEEP-affiliated University of Exeter PhD student Roger Auster, was the lead contributor on social research that fed into the River Otter Beaver Trial, which delivered a land-mark Government decision to permit England's first wild breeding population of beavers to remain permanently. The research defined a new concept - Renewed Coexistence - and provided a comprehensive evidence-based understanding of the human dimensions of beaver reintroduction, which is now directly contributing to more robust UK policy and practice in this field.

1st wild beavers granted permanent residency by UK Government in **400 years**

11 academic publications and reports, with **97** citations to date

2,910 participants and **26** agencies engaged including Natural England and Environment Agency

Why it mattered?

In 2020, Devon Wildlife Trust released the River Otter Beaver Trial (ROBT) report, which demonstrated that the reintroduction of beavers on the River Otter improved water quality, reduced flood risk downstream and benefitted other wildlife, such as otters and kingfishers.

Beavers were recorded moving into new areas and creating dams and ditches to create wetland habitat which holds more water in the landscape, and filtering silt and agricultural chemicals out of water.

Species reintroductions are growing in popularity as the natural capital services they provided are increasingly acknowledged, but a key factor for success is how humans and reintroduced species nteract. The term 'Renewed Coexistence' furthers a field of interdisciplinary social science in what is a contemporary debate and conservation solution, encouraging reintroduction approaches that work with communities and stakeholders to ensure successful long-term coexistence.

What Roger did

Working with Prof Richard Brazier and Prof Stewart Barr, SWEEP affiliated PhD University of Exeter student Roger Auster was the lead contributor on social research that fed into the ROBT.

Rogers's work has involved a nationwide survey of attitudes towards beaver reintroduction, followed by a series of more focused studies. These included: interview research with individuals who reported direct conflicts with beavers; Q-methodology research into the perspectives of the angling community in the River Otter catchment; and a mixed methods investigation into beaver tourism in the lower Otter. He also contributed towards a collaborative literature review on beaver impacts.

As an active member of the Science & Evidence Forum in the ROBT and the Trial Steering Group, he also deepened working relationships with Natural England, Environment Agency, Clinton Devon Estates and East Devon AONB.

He built strong partnerships with core partners - Devon and Cornwall Wildlife Trusts, and Plymouth City Council - meeting regularly to discuss ideas, keep informed, and feedback results. As leaders of beaver projects around Devon and Cornwall, Roger's research was also of direct relevance to them.

Eurasian Beaver

River Otter, Devon

Impacts & benefits delivered

The social research was an integral part of the final River Otter Beaver Trial Science and Evidence Report to Defra, which has led to the following contributions and benefits:

Policy & Legislation

A land-mark Government decision: to allow England's first wild breeding population of beavers for 400 years to be given the permanent right to remain in and spread naturally from their East Devon river home.

Informing Natural England policy: building on the research, SWEEP was part of a team commissioned to produce a Beaver Management Groups report by Natural England. This will provide further evidence for decision-making on future approaches to beaver reintroduction and management in England.

Attitudinal/Capacity

Providing management support for people who may experience conflicts with beavers: Natural England supported this recommendation on the basis of Roger's social research in the ROBT, which they also concluded had met the requirements of IUCN Guidelines and supported the recommendation for beavers to remain on the river.

Knowledge/Capacity

A new concept 'Renewed Coexistence' - defined by Roger as part of his PhD: helping to advance this field of interdisciplinary social science.

A more comprehensive evidenced-based understanding of the human dimensions of beaver reintroduction: including angler perspectives; the views of downstream communities on the role of beavers in natural flood management; engaging with individuals who report conflicts with beavers; wildlife tourism; national public attitudes; and the governance of reintroduction projects and beaver management.

> *"the most ground-breaking government decision for England's wildlife for a generation."*
>
> **Peter Burgess, Director of Conservation at Devon Wildlife Trust**

> *"Roger's research, alongside comprehensive partner and stakeholder engagement, had considerable impact informing and developing Defra's approach to the reintroduction of wild beavers in the UK."*
>
> **Peter Burgess, Director of Conservation at Devon Wildlife Trust**

Kingfisher, River Otter, Devon

Looking to the future

Wider policy and practice impacts – as a key part of the lessons learnt and scientific knowledge to have emerged from the ROBT, Roger's work is informing other managed beaver releases in the UK. With over 25 fenced beaver projects, and the imminent release of wild beaver licence applications, Roger's research will play a central role in this field. One example is an assessment for Cairngorms NPA, who have announced intent to take a lead in restoring beavers in the area. Another example where Roger is credited directly is in the reports of a recent consultation over a proposed beaver project on the Isle of Wight.

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UKRI Natural Environment Research Council

Applying the natural capital approach to farm-scale land management decision-making and evaluation

sweep

PhD Impact Summary


River Tavy, Tavistock, Devon

Matt Holden's SWEEP-affiliated PhD work represents one of the first attempts to implement a complete application of the natural capital approach, including detailed measurement of condition, ecosystem function and ecosystem value at farm scale. It has fed into the New Environmental Land Management Scheme (ELMS) Test and Trial process, helping to influence Defra agricultural policy development. It is already influencing attitudes and supporting better land management decision making at Clinton Devon Estates (CDE) and South West Water (SWW) who supply 40% of East Devon's water from ground water abstraction, much of which from CDE land.

One of the **1st** complete applications of the natural capital approach at farm scale

1st empirically informed estate-scale application of the BEE-Steward model

Informed Defra's agricultural policy and influencing business and farmer plans and practice

Strengthening Clinton Devon Estate's natural capital approach and SWW's interventions

Why it mattered?

Agricultural intensification through the 20th century has had a significant impact on natural capital (e.g., soil, water, ecosystems) and the flow of ecosystem services (e.g., clean air and water, climate regulation, recreational enjoyment).

In recognition of this, the UK government has set out ambitious targets through their 25 Year Environment Plan to deliver net improvements in England's environment within a generation.

Integral to this is the natural capital approach to decision making. Advocates of the approach have suggested it could be used in local farm scale decision making, but there are currently very few examples showing this.

Matt worked with Prof Richard Brazier and Prof Brett Day, in partnership with CDE - a large farming estate in East Devon - and Westcountry Rivers Trust who work with SWW's Upstream Thinking Programme, to address this need.

Matt's work investigated the natural capital impacts of different agricultural farm systems, over a range of intensities, applied on the same farming estate under two different farming systems (organic and conventional).

It was anticipated his findings would enable farmers, estate owners and policy makers to make more cost-effective long-term environmental and economically sustainable decisions.

What Matt did

Matt's research focused on four ecosystem pathways – climate regulation, food production, drinking water provision and pollinator services.

Its core contributions are both methodological and empirical; it explores how the natural capital approach can be applied robustly at the farm scale and how the adoption of different land management practices, including organic agriculture and intensive farm management, impact natural capital and ecosystem services.

Matt has tested the complete application of the natural capital approach in the evaluation of agricultural decisions made on the estate to establish whether they are improving or degrading their natural capital and the impact of this to ecosystem service value.


Westhay Moor Nature Reserve


Devon hedge bank

"Matt's scientifically robust, real-world data was invaluable and strengthened our natural capital valuation modelling work which fed directly into the Defra ELMs Test & Trial. I expect the findings of the PhD to enhance South West Water's strategic operations around ground water extraction and provisioning for East Devon."

Yog Watkins, Senior Land Officer, Westcountry Rivers Trust

Impacts & benefits delivered

Attitudinal/Capacity

Increased awareness and capacity, changing attitudes: of farmers, as well as at CDE, Westcountry Rivers and South West Water, around the application of the natural capital approach and valuation of ecosystem services. Matt's work enabled a continuous analysis and accurate quantification of nitrogen losses, and water quality, for the first time. This has improved conversations with farmers out the impact of certain management practices and is enhancing CDE's ability to monitor and enhance its performance into the future.

Organisational Function

Enhanced decision making, operational performance and reputation: Matt's work identifies the ecosystem services benefits and trade-offs of different land management strategies across CDE, particularly conventional vs organic farming. In this way, it is contributing key information for more environmentally and economically robust decision making and practice for CDE and South West Water. At CDE, this is already strengthening proposals, changing practice at the farm level, informing wider CDE work and adding weight to new CDE business cases looking to embed the natural capital approach.

Policy & Legislation

Influence policy: Matt's results strengthened CDE's contribution to the New Environmental Land Management Scheme (ELMS) Test and Trial that ran on its estate helping to support Defra agricultural policy development. A second phase is now underway.

Knowledge/Capacity

Advancing science: working with the SWEEP pollinator team, undertaking the first empirically informed estate scale application of the BEE STEWARD model with the aim of using pollinators as an indicator of soil quality, thereby informing management policies.

> *"The process of supporting this PhD, and the scientifically robust site-specific data it delivered, is contributing to the wider body of evidence that is changing our way of thinking, decision making and practices around how we manage our land at Clinton Devon Estates, to ensure we deliver maximum natural capital benefit for society and maintain our reputation as a business leader in this field."*
>
> **Sam Bridgewater, Head of Wildlife and Conservation, Clinton Devon Estates**

> *"Matt's work has been critical to understanding soil nutrient dynamics in the soils of the south west and costings relating to Nitrogen removal. The direct application of this learning into delivery, through his relationship with the Upstream Thinking (UST) Farm advisors, has been an additional bonus, as has the ongoing monitoring programme resulting from the research. UST is an evidence based programme and any targeted academic research such as this, that helps to inform and improve the effectiveness of current interventions or possible future innovations, is really important."*
>
> **David Smith, UST Programme Manager, SWW**

Looking to the future

It is anticipated Matt's work will continue to shape thinking and strengthen decision making:

- **At CDE**: to support the delivery of more environmentally and economically robust land management decisions, leverage further funding, and embedding the natural capital approach.
- **At SWW**: who are continuing to monitor nitrogen levels and assess groundwater quality using Matt's methods. The expectation is that this data will continue to be fed into UST to support strategic changes in the way it draws water from its boreholes, based on adjacent land activity.**More widely**: Matt's work has been shared with other land estates who have expressed interest in undertaking similar work.

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UKRI Natural Environment Research Council

SWEEP-affiliated PhD projects continuing beyond 2022/23

PhD Impact Summaries

Below is a brief description of the research being undertaken, and impact either delivered or anticipated, from three of our SWEEP's part-funded SWEEP PhD projects.

The first of these has been delivered as part of the wider SWEEP Coastal Change Management Areas project and has been captured as part of that work. The remaining two are ongoing and will be completed over the next few years.

Josie Alice Kirby: Application of Coastal Change Management Areas (CCMAs) for coastal adaptation to climate change impacts in South West England - working with: Dr Kit Stokes and Dr Tim Poate

The PhD

With the UK coastline retreating up to a metre every decade due to erosion, landslips, flooding and shifting sediments Local Planning Authorities (LPAs) have the difficult task of managing future developments along these unstable coastal and estuarine margins.

To inform planning and management decisions, the UK's National Planning Policy Framework requires LPAs to identify Coastal Change Management Areas (CCMAs) - where shorelines are likely to change significantly over the next 100 years. LPAs, however, often lack the ability to do this and uptake has been minimal.

Working in partnership with the University of Plymouth and the Environment Agency, Josie's research ran alongside, and fed into, the SWEEP Coastal Change Management Area project, contributing to the evidence base for a new scientifically robust methodology for demarcating CCMAs.

Specifically, Josie's PhD reviewed current UK and international CCMA practices and policies, and assessed current and future coastal erosion rates and flood risk in the South West, with the aim of better defining CCMAs around the South West coast.

Impact delivered

Josie has worked alongside coastal planners and management bodies to increase consideration and implementation of CCMAs across the region with the aim of strengthening community resilience along the changing coast.

Josie's work has fed directly into the SWEEP CCMA project and has contributed to the range of impacts this has successful delivered, including using the SWEEP CCMA methodology to map the coast lines of two areas in North and East Devon.

This is being used to strengthen planning decisions that will lead to enhanced environmental, economic, and societal benefits for local areas, and wider discussions and plans for further uptake of CCMAs across and beyond the region which, it is anticipated, will ultimately influence coastal planning and management policy in this area.

Cara Patel: Antimicrobial Resistance Research: An interdisciplinary approach to studying the impact of pollution on antimicrobial resistance (AMR) at the river catchment scale - working with: Prof Will Gaze and Dr Anna Leonard

The PhD

Antimicrobial resistance is one of the greatest health threats we face today. Each year more than 700,000 deaths occur globally due to resistant infections that can't be treated with antibiotics and other antimicrobial drugs, and it is feared this could rise to 10 million by 2050.

Funded by the Medical Research Foundation and the University of Exeter, Cara's PhD aims to understand the impacts of pollution on antimicrobial resistance (AMR) at the river catchment scale. Employing an interdisciplinary, natural capital approach to her work, and considering future climate change scenarios, Cara is examining catchment scale processes, including wastewater treatment and agricultural practice, to better understand the role human activity plays in the spread of AMR bacteria in the environment.

Cara's research aims to quantifying the drivers of environmental AMR prevalence and human exposure risk at a river catchment scale, and better understand the efficiency of mitigating interventions.

Anticipated impact

Through her research, Cara anticipates being able to provide evidence to support better decision making and environmental policy and practice that minimises environmental AMR, supports better health and enhances river catchment natural capital.

Hannah Forbes: Blue Prescriptions: using wetland visitor centres and reserves for site-based social prescribing - working with: Dr Ben Wheeler and Dr Becca Lovell

The PhD

There is growing evidence to support the health and wellbeing benefits of nature-based physical activities. Social Prescribing is used by the NHS to encourage individuals to undertake 'social' activities as part of their healthcare. Nature-based activities is one form of social prescribing and there is growing demand for nature-based social prescriptions, with significant investment for understanding how best to provide for, and evaluate the health benefits, of these types of activities.

Working in collaboration with the Wildfowl and Wetlands Trust (WWT), and conducting fieldwork at their Sites in South West England and in London, Hannah's work aims to gain a deeper understanding of 'what works, for whom, in what circumstances, and how?' in relation to nature based social prescribing and its potential to reduce health inequalities.

Anticipated impact

Hannah's PhD is contributing to the implementation of the UK Government's 25-year Environment Plan in relation to the adoption of social prescribing models that help alleviate burdens on health care budgets related to poor mental health, sedentary lifestyles, loneliness, and isolation.

Using realist methodologies, including working with stakeholders, evidence synthesis, and qualitative interviews, Hannah's work is helping to inform best practice around the design and delivery of effective and equitable prescription visits to nature reserves or wetland centres.

Her work will contribute to a broader programme of WWT work to deliver enhanced health, wellbeing, and conservation outcomes as part of the wider impacts successfully delivered via the SWEEP Investing in Nature for Health project.

It is anticipated that Hannah's work will also feed into policy decision making in this field, in particular contributing to the evidence base for NHS England's Common Outcomes Framework seeking to measure the impact of social prescribing as well as a Quality Assurance Framework aiming to build confidence amongst GPs and other commissioners.

It is also expected that Hannah's work with contribute to a wider understanding and debate on how society can effectively harness the natural environmental for individual and community health and wellbeing, thereby increasing the value society places on wetland nature.

About SWEEP
The South West Partnership for Environmental & Economical Prosperity (SWEEP) is a partnership between the University of Exeter, the University of Plymouth, and Plymouth Marine Laboratory. Funded by the Natural Environment Research Council and stakeholders together to solve key challenges faced by those working with our natural resources. **www.sweep.ac.uk**

UKRI Natural Environment Research Council

Evaluating and maximising the environmental benefits of seaweed farming in the South West

sweep

PhD Impact Summary

Porthallow Seaweed Farm, Cornwall. Credit: Cat Wilding

SWEEP-affiliated PhD student Sophie Corrigan is already delivering significant benefits for industry partners and is informing UK policy and best practice around seaweed farming. This aquaculture PhD project aims to assess the ecological impacts of seaweed farming for fish species of commercial and conservation importance while working closely with farmers to develop sustainable, ecosystem approaches to this emerging UK aquaculture sector.

Informing Government policy: **1st** comprehensive review of the habitat provisioning of seaweed farming

Influencing thinking and enhancing operational procedures at **3** businesses

£25k of secured new funding and accelerating licence application approvals

Why it mattered?

Seaweed cultivation is an emerging, highly profitable industry, with the potential to boost food and energy security, and biodiversity.

As the UK Government and Seafood Industry sets to grow the sector, quantifying wider ecosystem services, alongside food production, will further support the case for sustainable aquaculture production.

Sophie's research sits at the cutting edge of this emerging field and focuses on how commercial seaweed farms influence local biodiversity, physical conditions and dissolved nutrient chemistry in the South West:

- Understanding how seaweed farms support local biodiversity i.e., by creating a novel nursery ground habitat which could enhance recruitment of fish species that are of conservation or commercial importance to benefit the wider area.
- Understanding how seaweed farms may influence the wave dynamics and chemistry of the bay area i.e. by absorbing excess nutrients and increasing sedimentation rates.

What Sophie did

Working with Prof Charles Tyler and Dr Ross Brown, using novel camera techniques to monitor fish species of conservation and commercial importance, Sophie is evaluating habitat provisioning by seaweed (and shellfish) aquaculture installations, to determine the extent to which farms provide ecological stepping stones for Marine Protected Area networks and fish nursery areas.

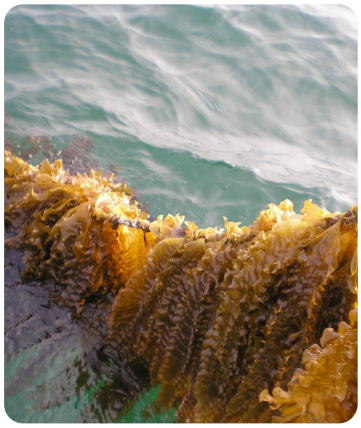
Sophie works closely with her four partner organisation funders – the Marine Biological Association (MBA), the Centre for Environment Fisheries and Aquaculture Services (CEFAS), the Fishmonger's Charitable Trust and the Cornish Seaweed Company - and other key business partners including BIOME Algae and Westcountry Mussels of Fowey building and maintaining strong working relationships and exchanging new knowledge to benefit their operations.

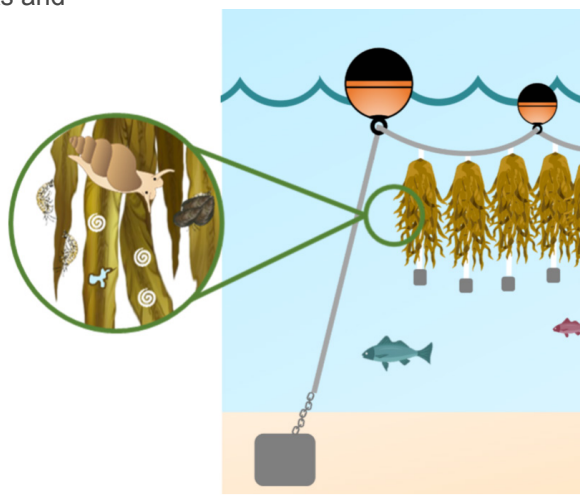
Sophie's ongoing environmental surveys are conducted on BIOME Algae's farm.

Corrigan et al (2022) Quantifying habitat provisioning at macroalgal cultivation sites

Corrigan et al (2023) Development and Diversity of Epibiont Assemblages on Cultivated Sugar Kelp (Saccharina latissima) in Relation to Farming Schedules and Harvesting Techniques

> *"We recognise that aquaculture, in particular algae aquaculture, is a relatively novel industry in England and therefore there are a number of knowledge gaps."*
>
> **Abbey Pennington, Marine Management Organisation**





Long line system suspending seaweed droppers. Credit: BioRender.com

Impacts & benefits delivered

Sophie's work directly benefits the operations and profits of the seaweed farming businesses she works with. This also helps to advance the UK and European seaweed farming industry.

Policy & Legislation

Informing best policy and practice: She is a lead contributor to Natural England's commissioned report on the potential environmental effects of seaweed farming. Further, Sophie has published the first comprehensive review, and novel recommendations, for monitoring the potential habitat provisioning by global seaweed farming in Reviews in Aquaculture. She has also enhanced their knowledge on the environmental impacts of seaweed farming to inform their licencing process.

Organisational Function

Securing funding for industry development: Sophie's work has directly contributed to BIOME Algae securing £25K funding from Devon Environment Fund, which will extend its seaweed farming business, making it competitive in the European marketplace.

Attitudinal/Capacity

Influencing thinking and enhancing operational procedures at the Cornish Seaweed Company (CSC): to ensure optimal growth, harvesting and profits. Sophie works closely with CSC to maximise their biodiversity value and crop yields, while minimising biofouling which ruins crops and introduces allergen risks into products. She has been investigating biodiversity development at the farm over and beyond the growing season and trialling new partial harvest techniques with the farmers.

Attitudinal/Capacity

Wider stakeholder bene its: Westcountry Mussels of Fowey Ltd. who hosts CSC and BIOME Algae, is also benefiting from Sophie's research on the environmental benefits of integrating seaweed and shellfish farming.

> *"Working with Sophie and the University of Exeter ensures that BIOME Algae delivers positive environmental benefits and can continue to grow as a sustainable independent business, providing robust evidence to licencing bodies."*
>
> **Angela Mead, BIOME Algae**

Westcountry Mussells of Fowey

Looking to the future

There is a great potential for wider impact from Sophie's work going forward as her papers and research are distributed and used more widely amongst other stakeholders not only in the South West, but in the UK and beyond.

- Sophie's paper in Reviews in Aquaculture attracted global attention, reaching 22,404 impressions on Twitter, 360 clicks, and is subsequently in the top 5% of research outputs ever tracked by Altmeric.
- Sophie's project contributes to the South West Network, comprising 120 members who represent aquaculture businesses, regulators and researchers.
- Sophie's work was included in a University of Exeter panel discussion video 'A Blue Recovery: How can we protect and restore our marine environment? which has been viewed 1,500 times on YouTube.
- Sophie has been contracted to write an article for Bloom magazine, 20,000 Instagram followers, on the South West farmers she works with and her collaboration and research with them.

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