Environment and Rural Affairs Monitoring & Modelling Programme

ERAMMP Year 1 Report 19: Review of Monitoring at the Land-Sea Interface

Garbutt, R.A.[1], Alexander, M.[2], Ballinger, R.[2], Bowgen, K.[3], Cooper, D.[1], Frost, N.[4], Hull, S.[4], Jones, L.[1] & Mant, J.[5]

[1] Centre for Ecology & Hydrology, [2] Cardiff University, [3] British Trust for Ornithology, [4] ABPMarine, [5] Ricardo

Client Ref: Welsh Government / Contract C210/2016/2017

Version 1.0

Date 30/09/2019

Funded by:

Llywodraeth Cymru
Welsh Government

Centre for Ecology & Hydrology
Natural Environment Research Council

Programme/ Project	Environment and Rural Affairs Monitoring & Modelling Programme (ERAMMP)
Title	ERAMMP Year 1 Report 19: Review of Monitoring at the Land-Sea Interface
Client	Welsh Government
Reference	C210/2016/2017 NEC06297 Task 8.7
Confidentiality, copyright and reproduction	
CEH contact details	Bronwen Williams Centre for Ecology & Hydrology, Environment Centre Wales, Deiniol Road, Bangor, Gwynedd, LL57 2UW t: 01248 374500 e: erammp@ceh.ac.uk
Corresponding Author	Angus Garbutt, CEH
How to cite (long)	Garbutt, R.A., Alexander, M., Ballinger, R., Bowgen, K., Cooper, D., Frost, N., Hull, S., Jones, L. & Mant, J. (2019) Environment and Rural Affairs Monitoring & Modelling Programme – **ERAMMP Year 1 Report 19: Review of Monitoring at the Land-Sea Interface.** Report to Welsh Government (Contract C210/2016/2017). Centre for Ecology & Hydrology Project NEC06297.
How to cite (short)	Garbutt, R.A. et al. (2019) **ERAMMP Report 19: Review of Monitoring at the Land-Sea Interface.** Report to Welsh Government (Contract C210/2016/2017)(CEH NEC06297)
Approved by	James Skates
Signed	

This document is also available in Welsh / Mae'r ddogfen yma hefyd ar gael yn Gymraeg

Version History

Version	Updated By	Date	Changes
0.1	PMO	30/4/19	Initial draft.
0.11	PMO	8/5/19	Mainly formatting edits – draft for SG
0.12-0.13	PMO	16/9/19	Formatting edits
0.14	PMO	27/9/19	Approved for publication
1.0	PMO	30/9/2019	As published

Contents

To be reviewed in conjunction with the corresponding Technical Annex (19TA1).

Abbreviations and some of the technical terms used in this report are expanded in the project glossary: https://erammp.wales/en/glossary (English) and https://erammp.cymru/geirfa (Welsh)

1 Introduction

This report was commissioned under ERAMMP to review monitoring activity at the Land-Sea interface identifying opportunities to better align monitoring activities and improve understanding of pathways and impact, working with Natural Resources Wales (NRW) and Welsh Government (WG) marine policy.

The Welsh nation is closely connected to the sea with 60% of the population living on or near the coast, with the furthest settlement only 50 miles from the Irish Sea. The coastal economy makes up a significant percentage of national GDP through tourism, ports and shipping.

Natural capital and ecosystem services-thinking and recent instruments such as the Wellbeing of Future Generations (Wales) Act 2015, asks new questions and requires more integrated consideration of environmental, social and economic factors. In relation to coastal margins, the complexity of terrestrial, freshwater and marine interactions necessitates integration in monitoring activities, management and governance regimes to better deliver the full economic, social and cultural potential of natural resources.

However, monitoring programmes have been developed to address specific requirements of individual policy initiatives and specific statutory requirements (e.g. fulfilment of the Habitats Directive), rather than integrated monitoring programmes for monitoring terrestrial, freshwater and marine systems. More integrated approaches not only have the potential to improve resource efficiency, but are essential for improving our understanding of environment, society and economy linkages at the Land-Sea Interface, which in turn could help maximise and quantify benefits, as well as improving evidence and reporting for SoNaRR[1], Valuing Nature and the Well-Being agenda.

[1] State of Natural Resources Report (SoNaRR) https://naturalresourceswales.gov.uk/media/678370/sonarr.pdf

2 Approach

A Land-Sea Interface Working Group made up of WG and NRW staff met twice with Centre for Ecology & Hydrology (CEH)/Welsh Government ERAMMP leads to agree the Terms of Reference and Scope of the review. The structure to frame the review followed the ERAMMP ‘NRW Monitoring Review’ Activity table and the likely structure of the next State of Natural Resources Report (SoNaRR). This table was populated by the project team with monitoring activities likely to meet national reporting requirements by NRW and also other key sources. A workshop then reviewed the combined tables to identify gaps and identify priorities going forward.

Members of the WG / NRW working group:

Mike Nelson, Louise George (WG); Mike Camplin, Nicola Rimington, Louise Pennington, Ceri Seaton (NRW)

3 Monitoring scope and purpose

This project aimed to review existing NRW and other monitoring activities relevant to the Land-Sea Interface to help identify opportunities and inform recommendations to address evidence gaps and/or better align monitoring activities in the future.

During the scoping workshop, objectives were defined as follows:

- To produce a table populated with monitoring activities likely to meet national reporting requirements, framed under the DPSIR structure (drivers, pressures, state, impact and response).
- To hold a workshop for the Land-Sea Interface Working Group to review the table, identify gaps and overlaps, and to agree on key drivers that exert pressures that in turn could help inform practical recommendations for WG and NRW to address.

It was agreed that the seaward extent of the Land-Sea Interface was limited to inshore waters (12 nautical miles) and that the landward extent should include monitoring downstream of headwaters to capture land use / catchment effects of land management impacting on the coastal and marine environment.

Monitoring activities that report on pressures and drivers for change were included, but limited to those concerning the natural environment. Social and economic issues were not explicitly included in the review, but opportunities to link to social and economic and health data have been noted.

4 Current Monitoring Activities and Gaps

The Technical Annex (separate document) provides a structured list of all current monitoring activities set against the SoNaRR likely reporting framework. A total of 358 monitoring activities were identified as related to the Land-Sea Interface. Following the workshop to review the table, the Working Group agreed upon 3 case studies where better integration of monitoring across the Land-Sea Interface could be beneficial. The three case studies lead to recommendations for 4.1) additional monitoring, 4.2) making better use/integration of existing datasets, and 4.3) further investigation.

1.1 Understanding the contribution of minor streams to water quality in Marine Protected Areas

Water quality is monitored within some estuarine waters (transitional waters) to meet requirements of the Water Framework Directive (WFD). At present there are 28 transitional waterbodies recorded at below good status (the majority) (classed “Moderate”, “Poor” or “Bad”) mostly down to nutrient levels or associated biological effects – see coastal and transitional waters current results[2]. This classification is based on assessments made at a waterbody level using information of levels of Dissolved Inorganic Nitrogen (DIN), phytoplankton and opportunistic macroalgae. Even where the assessment for the waterbody as a whole is good, there can still be significant localised areas of impact present, particularly in relation to DIN and opportunistic macroalgae.

Increased nutrient inputs can result in:

- Increased phytoplankton
- Increased macroalgae
- Increased light attenuation (murkier water)
- Reduced growth and/or change in subtidal algal communities due to light reduction
- Reduced health/loss of subtidal seagrass due to light reduction
- Impacts to feeding activities of birds that feed on mudflats (due to high coverage by opportunistic macroalgae)
- Reduced oxygen in the water and/or sediment due to increased biological oxygen demand (decomposition of excessive plant matter)
- Smothering of saltmarsh where dense mats of decaying macroalgae are washed ashore
- Changes in estuarine nutrient cycling
- Changes in marine algal and faunal communities.

Relevant WFD monitoring typically covers concentrations of DIN, phytoplankton and/or opportunistic macroalgae. Nutrient levels, as well as resulting in WFD failures, can also impact Wales’ Marine Protected Areas (MPAs). While monitoring of DIN is typically

[2] https://drive.google.com/file/d/14w17jL05sNuToVELqMCK_yc6DdHU7STb/view

undertaken within the main body of water (coastal, transitional or riverine waterbodies) concentrations close to input sources may be much higher.

Nutrient inputs from sewage treatment work (STW) discharges can be significant (particularly for phosphorus) but usually the greatest input by far of nitrogen is from diffuse sources and land runoff, particularly from agricultural land. Whilst there is monitoring of nitrogen levels in main rivers and consented discharges from STWs, inputs from minor streams are usually unknown even though they can make a significant contribution to the waterbody loading and can generate significant local impacts.

Having a better understanding of the relative inputs of nutrients from different catchments would help identify the key land areas contributing to marine impacts (particularly to MPAs) and would enable management action to be focussed when required, achieving maximum returns on efforts made. To achieve this, it is recommended that a costed proposal for water quality monitoring of smaller streams running directly into estuaries using the GMEP / ERAMMP methods for headwater streams is developed. Combining a better understanding of land use (for example through remote sensing) with knowledge of catchment inputs would improve our understanding of the degree to which specific land management activities influence diffuse input levels. To demonstrate how this could be achieved, a case study is presented below.

While the growth of algae in estuaries and on mudflats is strongly influenced by nutrient contamination, a further consideration from a bathing water and aquaculture perspective is bacterial and viral contamination. The loading of *E. coli* in estuary waters, and subsequently in shellfish depends on a range of environmental variables, including agricultural land use in the drainage area, sources of sewage, tidal flow, rainfall and run off into estuaries and extreme weather resulting in overflow from combined sewage overflows (CSOs). Discharge from major point sources such as waste water treatment works is monitored by NRW, with nutrient and bacterial analysis. A review of this monitoring activity in Wales might be timely, leading to recommendations on reducing or extending its scope, according to local conditions and concerns. Such monitoring data has already been used with models to simulate the transport of contaminants from sources to the mussel beds of the Conwy estuary and elsewhere, and to relate simulations to bacterial counts in shellfish.

Modelling of catchment inputs from ungauged streams and adjacent land use into the coastal zone. Modelling using nutrient transport models and ecosystem service models can be used to guide locations for water quality monitoring. More importantly, such models can be used to estimate nutrient impacts from direct run off into the coastal zone which is not mediated by stream networks, or stream systems that are too small to cost-effectively monitor.

It is recommended that a costed proposal for water quality monitoring of smaller streams running directly into estuaries using GMEP / ERAMMP methods for headwater streams is developed.

Case study: Survey design for smaller streams to Milford Haven

The two main rivers draining to Milford Haven are the Eastern and Western Cleddau. However, these rivers account for only some 50% of the land area draining to the estuary. In assessing stream-borne contamination to the estuary, the remaining area needs to be considered. This is drained by numerous small streams whose individual contribution of water and contaminants may be small, but whose total contribution is significant.

The Milford Haven Waterway itself is designated as a SAC, and SSSI along its foreshore. The Pembrokeshire Marine SAC is currently in unfavourable condition within the Waterway due in part to nutrient pollution from agricultural run-off. The Milford Haven Waterway inner section is currently failing to meet 'Good' status which is required for Water Framework Directive (WFD) compliance by 2027. NRW routinely collect information on this but data on localised pollution sources is lacking. More data will help to identify problem areas and help to best target effective management effort. Currently data collected by volunteers through the SWEPT project (Surveying the Waterway Environment for Pollution Threats) supplement NRW's statutory monitoring and add to the evidence base upon which conservation management decisions can be taken by NRW.

Using a digital elevation model (DEM) based on a 50m grid square the number of land area grid squares draining to each grid square along the estuary shore have been identified (Figure 1). Each separate block of colour represents a separate drainage area, some of which are so small as to have no associated permanent surface stream. However, certainly for drainage areas of upwards of 1 km^2 there is likely to be an associated stream which can be sampled.

As an example Figure 2 shows 11 land areas between 4 and 25 km^2 draining directly to the estuary. These might be potential locations for sampling stream water for analysis for contaminants. Other drainage area size ranges may be preferred for consideration, and can readily be identified. If the number of resulting small catchments is impractical, a sample selected according to repeatable criteria (such as simple random sampling) may be used to reduce the number. A possible complete sampling design might be used for stratification according to size range. This would facilitate extrapolation from the sample of streams selected to the whole of the catchment. In stratifying, we further suggest that further account should be taken of land use, so as to ensure in particular that those land uses expected to be generating high concentrations or loads of nutrients are adequately sampled.

While this exercise is purely illustrative, a design such as the above assumes a statistical distribution of contributions from a range of land drainage areas and implicitly diffuse sources. The design does not take account of local knowledge of likely major sources of contamination, which might require a special focus. While such sources may be important and need to be identified and measured, it would not generally be possible to extrapolate from them to estimate inputs to the estuary from the whole of the drainage area.

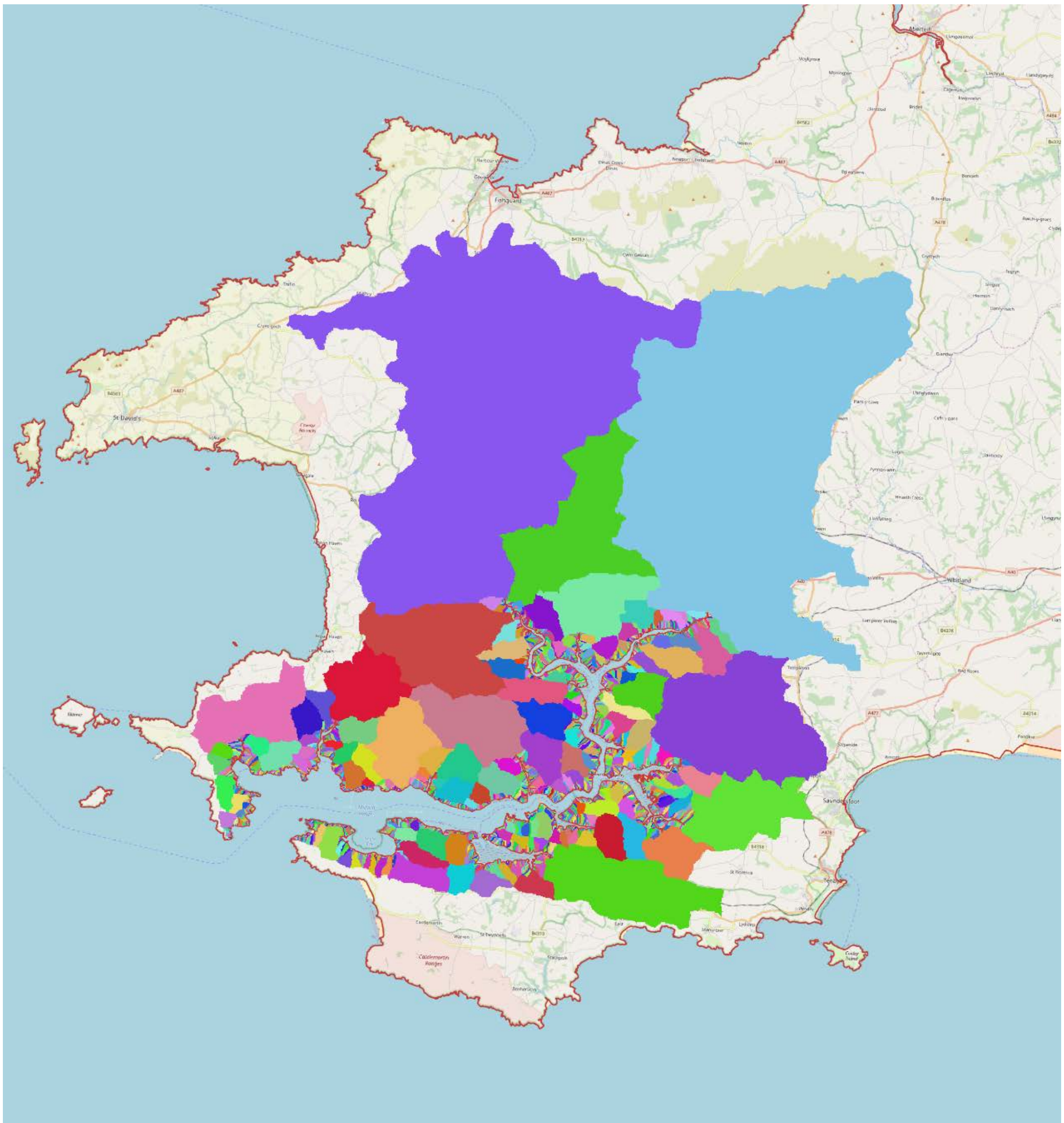

Figure 1. Land areas draining into Milford Haven

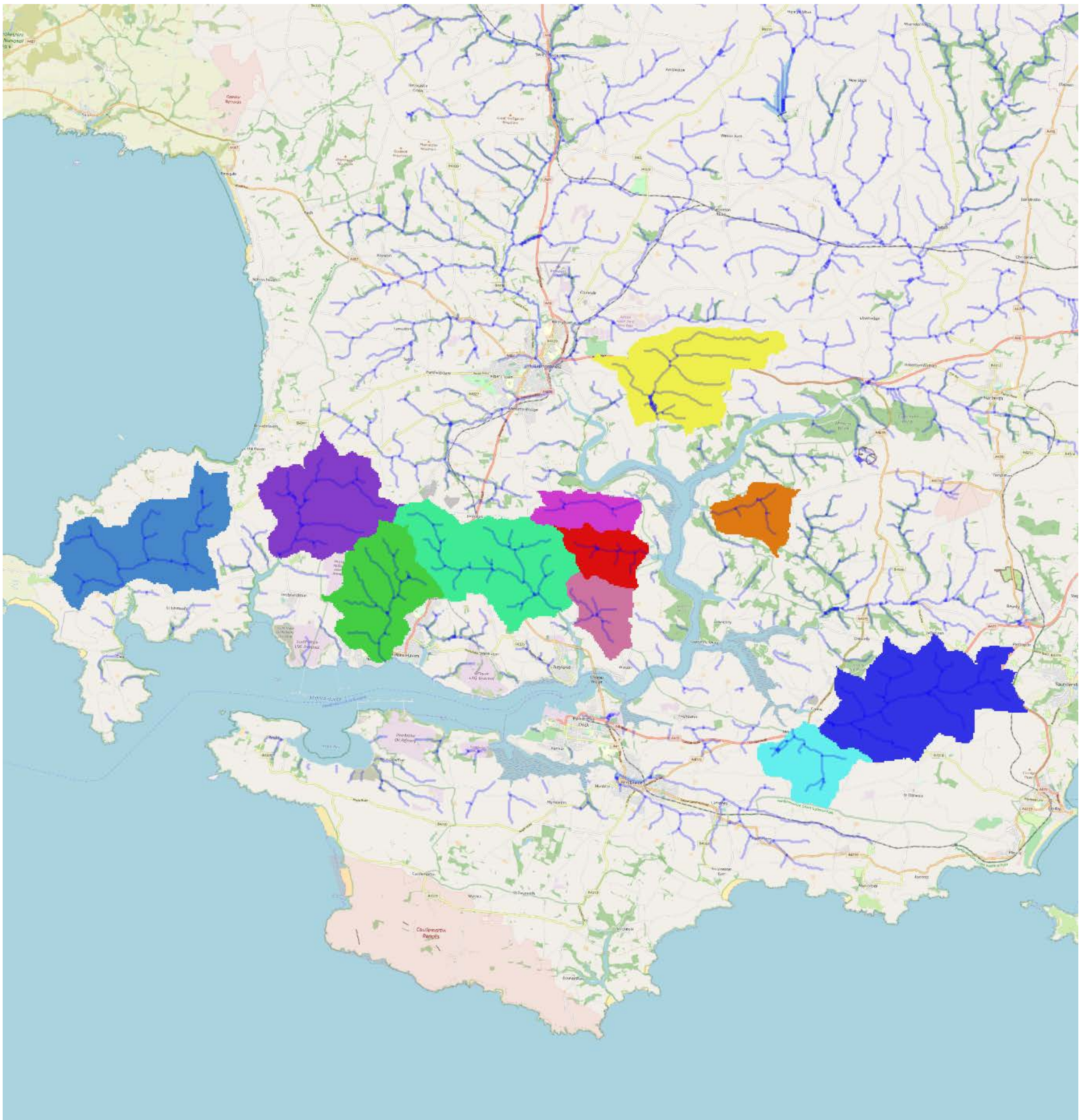

Figure 2. Catchments between 4 and 25 km^2 draining directly into Milford Haven

1.2 Coastal squeeze and the coastal economy: better use and integration of existing data

Coastal locations support important economic and social activities as well as hosting habitats and species of national and international nature conservation importance. Coastal change as a result of climate change and natural processes present significant challenges to coastal managers in seeking to maintain and enhance the benefits that society receives from coastal areas. The availability of robust data on current and potential future coastal change is important in supporting sound and evidence based decisions relating to coastal change.

Oaten et al (2018) recently reviewed existing monitoring in Wales relevant to coastal squeeze and wider coastal change on behalf of Natural Resources Wales (NRW) in support of their delivery of the National Habitat Creation Programme (NHCP) on behalf of Welsh Government. The purpose of the NHCP is to identify opportunities for habitat creation and deliver timely environmental offset to facilitate the implementation of the Shoreline Management Plans (SMPs) and protect the Natura 2000 network in Wales. The study identified a wide range of existing monitoring that is already carried out in Wales that is relevant to coastal change and coastal squeeze (see examples in Table 1). The research further developed costed options to inform understanding of coastal squeeze losses in Wales arising from implementation of SMP Hold the Line (HTL) policies and made recommendations on a preferred approach, making best use of available data. To align with existing WFD monitoring as well as State of Natural Resources reporting (SoNaRR) it was suggested that data is assembled on a 6 yearly timescale, with a more detailed analysis undertaken every 18 years.

Moreover, Oaten et al. (ibid) recognised that the collation of these data could also have potential benefits to other initiatives, such as the Environmental and Rural Affairs Monitoring and Modelling Programme (ERAMMP). Other initiatives such as the Welsh Coastal Monitoring Centre could benefit too. Collated information on coastal change is relevant for understanding the ecosystem services provided by the marine and coastal environment (such as natural hazard protection, coastal recreation and tourism) and how these may vary in the future. For example, changes in saltmarsh, sand dune and shingle extent and condition may affect the natural hazard protection benefits provided by such habitats. Similarly, erosion of amenity beaches could directly affect coastal leisure, cultural heritage or tourism activities.

The role of saltmarsh in reducing coastal erosion and reducing wave energy on low lying shorelines is well recognised. This can provide significant benefits in helping to stabilise shorelines and reducing the costs of flood protection. Shingle and sand dune habitats can also provide important natural flood protection. The Office for National Statistics (ONS, 2016) estimated that there were around 5,800 ha of saltmarsh in Wales (14% of the UK total) and around 800 ha of sand dunes (just over 10% of UK total) and 109 ha of shingle around 2% of UK total). It assessed the UK value of the flood protection benefits of saltmarsh, shingle and sand dunes as £4.05bn (net present value over 50 years). It separately assessed the UK value of shoreline stabilization of saltmarsh as £4.58bn (net present value over 50 years) while recognising that there was likely to be some overlap with the flood protection estimate.

Coastal erosion or flooding can change the utility of coastal locations for tourism and recreation activity, for example, loss of sand from amenity beaches or loss of coastal footpath. Coastal tourism is important to the Welsh economy. The Strategic Scoping Exercise for the Welsh National Marine Plan (Cefas et al, 2015) estimated that coastal tourism was worth £602 million for Wales in 2013 and generated around 3.6 million trips, based on Great Britain Visitor Survey data. A separate report commissioned by Welsh Government indicated that there were more than 43 million visits to the Welsh coastal path in 2014 with a direct expenditure of £547m.

There is a clear opportunity to maximise use of data collected to inform understanding of coastal change, the impacts on the coastal economy and to also better understand the implications for important ecosystem services and the benefits to wellbeing.

It is recommended that a detailed project plan is developed following an initial workshop to establish and test methodologies for using coastal change data to inform:

- **Assessment of change in coastal margin habitats on natural hazard protection ecosystem service benefits.**
- **Assessment of coastal change (extent and quality) on benefits from tourism and recreation.**
- **Recommendations on how these assessments can be incorporated into SoNaRR and local wellbeing assessments.**

Table 1 Relevant Data Sources

Data Description	Spatial Coverage	Frequency
Historic Aerial Imagery to Monitor Temporal Change in Intertidal Habitats 1963 - 2013.	National	Annual / ad-hoc basis
Welsh Government Historic Aerial Photography WMTS 1945 – present.	National	Annual / ad-hoc basis
Water Framework Directive (WFD) Saltmarsh monitoring 2007 – present.	National	6 yearly reporting with interim monitoring
Marine Regulation 35 Feature Maps.	National	6 yearly reporting with interim monitoring
UK Article 17 Habitats.	National	6 yearly reporting with interim monitoring
LiDAR Archive NRW 1998 – 2015.	National	Annual / ad-hoc basis
Living Wales (integration of earth observation data, supportive ground measurements and process models) 1980's – present.	National	Various
Archived satellite imagery (e.g. optical/multispectral imagery, RADAR).	National	Various
UKHO INSPIRE and MEDIN Bathymetry Data Archives 2014 – 2018.	National	Various
National Tide and Sea Level Facility.	National	15 minutes (post-1993)
Cefas WaveNet.	National	30 minutes
UK Climate Projections (UKCP) 18.	National	Decadal
Wales Tourism Performance Reports.	National	Annual
Great Britain Visitor Survey.	National	Annual
Great Britain Day Visits Survey.	National	Annual
Economic Value of Wales Coastal Path.	National	One off assessment 2015
Wales Marine Planning Portal – locations of tourism and recreational activity; coastal path.	National	Ad hoc
Wales Activity Mapping Project – location of recreational activities in Pembrokeshire.	Regional	One-off survey, 2014
Shoreline Management Plans & Local Authority monitoring of beach profiles.	National	Various
National Survey Wales	National	Various

1.3 Further investigation into sediment transport from land to sea and impacts

Terrestrial runoff from land and riverine inputs can be a significant contributor to sediment in transitional and near coastal waters, particularly where coastal waters have low natural suspended sediment concentrations and thus there is limited marine sediment supply. Such inputs can change water clarity and levels of silt deposition, particularly in transitional waters where fresh and salt waters mix and the finer silts and clays are deposited through flocculation. Land management is a major influence on soil erosion and transport into the marine environment. Extreme weather events can exacerbate this.

Anecdotally, levels of silt appear to have been increasing within some Welsh estuaries. Monitoring is limited, but appears to corroborate this in some instances (e.g. there are examples of increases such as Milford Haven which is still filling in post Holocene and thus a sink for riverine sediment). Marine habitats sensitive to fine sediment levels have also been recorded as being in a less than good condition (e.g. 90% decrease in maerl in Milford Haven, reported condition of seagrass around Wales) these habitats are also sensitive to other factors (e.g. nutrients) so the silt link is not definitive.

Increased silt can:

- Increase light attenuation,
- Reduce light available to photosynthesising plants (marine algae (e.g. maerl) and seagrass),
- Change marine faunal communities (i.e. more deposit feeders), knock on from changes to primary production,
- Result in reduced sediment oxygen (smaller gaps between sediment particles so less water movement, exacerbated by increased organic input),
- Change the habitat type – muddier sediments, sediment instead of reef – and consequently the marine community,
- Increase longevity of pathogens transported from terrestrial to coastal systems, with implications for bathing water quality and coastal shellfisheries

At present, monitoring of sediment levels is limited. Sediment deposition can be addressed in part by examining the results of particle size analysis (PSA) of sediment samples (typically obtained when grab sampling for sediment macrofauna). However, in depositional areas the substrate may already be almost entirely fine silt and increased deposition would not show as a change in the composition of the sediment even though the depth of silt may have increased. Monitoring water turbidity typically used a sonde/logger (they use various methods to determine the turbidity) but these are susceptible to marine fouling and even with mitigation measures in place require frequent maintenance. Remote sensing can be used to determine sea surface turbidity, but only for larger areas of water (due to pixel resolution and having to exclude areas of land).

Whilst monitoring silt levels directly may remain difficult and expensive, a better understanding of what is happening within the catchments of transitional waterbodies would go a long way to help 'explain' changes observed (anecdotally and through WFD and MPA monitoring) to silt levels, turbidity and marine life within the waterbody. Increased fine particulate silt and increased nutrient levels can combine, exacerbating each factor's individual impact on the marine life of transitional waters. It is recognised that sediment availability is a vital component of the long term sustainability of coastal ecosystems, including depositional habitats such as sand dune and saltmarshes, maintaining extent and providing coastal protection. Sediments typically bind with pollutants which are then deposited within estuarine systems.

It is recommended that a workshop is held to bring together expertise in soil erosion, freshwater sediment transport, pathogen transport and marine sediments to scope the relative importance and impacts on changing land-use and erosion on marine ecosystems and coastal use and activities.

5 Conclusions

The recommendations above (and summarised in Section 6) highlight the importance of joining-up monitoring activities and/or datasets at the Land-Sea Interface. However, realising this goal may also require consideration of the underlying governance structures and practices that may impede this. For example, promoting better use and integration of existing datasets will require agreed data sharing protocols and provision of data in useable formats to match the technical capacities and capabilities of other data users. More broadly, there is a need to consider the extent to which current funding arrangements may constrain opportunities for cross-departmental and cross-sectoral working if joint-monitoring programmes are proposed.

6 Recommendations Going Forward

Recommendation 1: A costed proposal for water quality monitoring and water quality modelling of smaller streams running directly into estuaries using GMEP / ERAMMP methods for headwater streams is developed

Recommendation 2: Following an initial workshop a project plan is developed to establish and test methodologies for using coastal change data to inform:

- An assessment of change in coastal margin habitats on natural hazard protection ecosystem service benefits and benefits from tourism and recreation.
- Recommendations on how these assessments can be incorporated into SoNaRR.

Recommendation 3: A workshop is held to bring together expertise in soil erosion, freshwater sediment and pathogen transport and marine sediments to scope the relative importance and impacts on changing land-use and erosion on marine ecosystems and coastal use and activities.

7 References

Cefas, ABPmer & Eunomia (2015) Marine Planning for Wales Strategic Scoping Exercise. Available at: https://gov.wales/sites/default/files/publications/2018-05/strategic-scoping-exercise-for-the-national-marine-plan.pdf

Hambridge, C. and Phelan, N. (2014). Saltmarsh mapping standardisation for the Water Framework Directive. [Online] Available at http://www.nmbaqcs.org/scheme-components/under-development/reports/saltmarsh-mapping-standardisation-for-the-water-framework-directive/ .

McDonough, S. & Roche, N. (2016). The Wales Coast Path Visitor Survey 2015 and The Economic Impact of Coastal Walking in Wales 2014. NRW Evidence Report No 171, 80pp, Natural Resources Wales, Cardiff. Available at: https://www.walescoastpath.gov.uk/about-us/resources/reports/?lang=en

Oaten, J., Brooks, A. and Frost, N. (2018). Coastal Squeeze Evidence and Monitoring Requirement Review. NRW Evidence Report No. 307. 188pp, Natural Resources Wales, Cardiff.

Office for National Statistics (2016). Scoping UK coastal margin ecosystem accounts. Available at: https://www.ons.gov.uk/economy/environmentalaccounts/methodologies/scopingukcoastalmarginecosystemaccounts

Intentionally blank.

Enquiries to:
ERAMMP Project Office
CEH Bangor
Environment Centre Wales
Deiniol Road
Bangor
Gwynedd
LL57 2UW
T: + 44 (0)1248 374528
E: erammp@ceh.ac.uk

www.erammp.cymru

www.erammp.wales