

Marine and Coastal Collaborative Research Ideas

The purpose of this document is to outline marine and coastal evidence needs where we have identified opportunities for collaborative research.

Natural Resources Wales' purpose is to pursue sustainable management of natural resources in all of its work. This means looking after air, land, water, wildlife, plants and soil to improve Wales' well-being, and provide a better future for everyone. Since its creation NRW has made a strong commitment to be an evidence based organisation. We seek to ensure that our strategy, decisions, operations and advice to Government and others are underpinned by sound quality-assured evidence. Whilst we have limited funds available for research, we recognise that there are many delivery mechanisms (e.g. academic partnerships, citizen science and collaborations) that will provide the evidence that is fundamental to our work.

NRW has a marine and coastal evidence programme that identifies our priority strategic and operational evidence needs; we intend to update this on a yearly basis.

This document lists the projects that we think would be particularly suitable for research collaborations and is primarily aimed at increasing awareness and supporting further dialogue between NRW and the research community around opportunities to address these. Our highest priority evidence needs are described in a separate document, along with a brief description of work being done to address them.

If you are interested in working with us on these, or any other research ideas, please contact Kirsten Ramsay: kirsten.ramsay@cyfoethnaturiolcymru.gov.uk.

1. List of Research Ideas

More information about each project is given in the following section (click on each project for the detail).

Activities & Impacts

Impacts of abandoned, lost and / or discarded fishing gear in Welsh waters

Developing acceptable limits and stock levels for gathering of non-commercial marine resources

Modelling underwater noise of wave and tidal energy devices

Reducing impacts to the marine environment from slipway cleaning

Operational noise from renewable energy devices (floating offshore wind & tidal energy)

Benthos

Impacts of dredge disposal on subtidal habitats

Understanding impacts of anchoring on marine habitats

Impacts of potting on *Modiolus* beds

Impacts of potting on fragile sponge and anthozoan communities

Sensitivity of *Modiolus* and other habitats of conservation concern to smothering by sediment

Developing methods for active restoration of marine habitats

Investigating the effectiveness of alternative mooring systems for reducing damage to sensitive habitats

Investigating the causes of the decline in health of a sponge community in the Menai Strait

Investigating the causes of decline in *Eunicella verrucosa* populations around Skomer Marine Conservation Zone

DNA sampling for crawfish across different populations in Wales and the wider Irish Sea

Birds

Diet of seabird species in Wales

Seabird tracking studies to ascertain areas of use and impacts

Understanding how to increase resilience in seabird populations by restoring Welsh islands for seabird colonisation

Coastal Habitats

Impacts of woodland management and tree felling on estuarine habitats

Evolution of Welsh estuaries (morphological and habitat changes)

Investigating habitat resilience: saltmarsh

Saltmarsh habitat as fish nurseries

Nitrogen deposition & sea cliffs

Sand dunes and water filtration

Impacts of coastal defences on coastal habitats

Value of coastal habitats in contributing to sea defences

Carbon sequestration and storage potential of sea cliff habitats

Evaluating perception of the value of coastal habitats as coastal defence structures and confidence in their use as nature based solutions

eDNA assessment of species in lagoons

Recording and evaluating grazing levels, timing and abandonment for saltmarsh, sand dunes and cliffs

Developing methods to initiate the creation of coastal and intertidal habitats (other than saltmarsh)

Ecosystems

Ecosystem level effects of restricted water exchange between tidal lagoons and the area outside

Understanding pre 1900 distribution and abundance of flora and fauna in Welsh waters

What impact could climate change have on marine ecosystem services?

High resolution hydrodynamic modelling across Wales

Fish

How to develop appropriate models for fish behaviour around marine renewable energy developments

How to deliver feasible mitigation and compensation for loss of fish associated with tidal lagoon developments

Investigating the status and ecology of the Critically Endangered angel shark (*Squatina squatina*) in Welsh waters

Expand use of eDNA sampling undertaken as part of the successful Angel Shark Project Wales trial to incorporate other rare and scarce species

Distribution and abundance of sandeels in Welsh waters

How will climate change impact upon fish and fish communities in Welsh waters?

Noise and vibration impacts upon fish

Effects of electromagnetic fields (EMF) on fish

What are the effects on fish communities from the presence of offshore wind farms, or marine renewable energy device arrays?

Assessing incremental losses to fish populations

An assessment of the suitability of 'preferred' and 'marginal' sandeel habitat in Welsh waters

Timing of sandeel burial and emergence in the Severn Estuary

eDNA screening study of diadromous fish in marine waters

Understanding post release mortality in recreational angling

What are the impacts of removal of slow growing, long lived fish species by recreational angling?

Invasive Non-Native Species

Understanding impacts of non-native species on Marine Protected Area features in Wales

eDNA analysis of dredge vessel hopper water to identify presence of invasive non-native species

Investigating the distribution of slipper limpet (*Crepidula fornicata*) in North and West Wales

What is the origin of the of the slipper limpet (*Crepidula fornicata*) in North Wales?

Chinese mitten crab ecology and behaviour in the Dee Estuary

Investigating the spread of *Agarophyton* (*Gracilaria*) in Wales

Marine mammals

Diet of marine mammals, especially bottlenose dolphin, harbour porpoise and grey seal in Wales and adjacent Seas

Connectivity of grey seals and bottlenose dolphin around Wales and adjacent Seas

Modelling population consequences of habitat loss for marine mammals

Population structure and dynamics of marine mammals in Welsh waters and adjacent Seas

Recreational disturbance of marine mammals

Risso's dolphin distribution, range, and abundance

Noise disturbance of marine mammals

Impacts of acoustic surveys on marine fauna

Physical processes

Understanding regional and sub-regional sediment budgets

Development and improvement of models to predict behaviour of physical processes, and / or the complex interactions between physical, biological, and ecological components of a marine and coastal environment

Resilience and vulnerability of marine and coastal habitats to climate change (physical processes)

Collection and analysis of bathymetric and topographic data within the marine and coastal environment, and advancement of methodology and instrumentation to support data collection

Wave data collection, collation, and analysis

Requirements for shingle resource to support nature based solutions at the coast

Source of sediment in the Milford Haven Waterway

Identification of opportunities to support beneficial use of dredge material in Wales

Improve understanding of potential array scale impacts of wave and tidal stream devices on physical processes parameters over the medium-long term

Improve understanding and assessment of potential impacts and interactions of different types of renewable energy devices to physical processes parameters

Determine potential impacts to sediment transport processes and sediment budgets within and between sediment systems arising from single or multiple tidal range developments

Develop and improve numerical modelling capabilities to predict medium to long-term morphological changes arising from single or multiple tidal range developments

Provide clarity on how existing assessment methods and modelling can be used to assess effects of decommissioning scenarios of renewable energy developments on the future physical processes baseline environment

Improve and develop numerical models which can predict complex interactions between physical, biological, and ecological components of a coastal / estuarine system and changes arising from renewables devices

Determine nature-based solutions that could be applied for use as cable protection measures

Review and refinement of seabed mobility factor for cable protection and assessment requirements

Changes to sediment transport from large-scale wind arrays and cumulative effects

2. Project Details

Impacts of abandoned, lost and / or discarded fishing gear in Welsh waters

This evidence review will build on Defra Impacts Evidence Group funded review of abandoned, lost and / or discarded fishing gear (ALDFG). This review would provide an assessment of this issue in Welsh waters and would include sections such as number of pots / nets lost and collate evidence of currently known impacts in Welsh waters.

Suggested level of research: PhD

Developing acceptable limits and stock levels for gathering of non-commercial marine resources.

Currently little is known about sustainable catch / collection levels for several living marine resources that are not covered by Total Allowable Catch / quota. Work could take the form of a stock assessment and might include species such as razor shells and winkles. Acceptable take limits could be developed. Ecosystem impacts as a result of removal of these species should also be investigated, although other options could also be explored in project development.

Suggested level of research: MSc and above

Modelling underwater noise of wave and tidal energy devices

The development of noise propagation models is required to further reduce uncertainty regarding the potential impacts of commercial scale arrays of wave and tidal energy devices.

Suggested level of research: Postdoc

Reducing impacts to the marine environment from slipway cleaning

NRW wish to explore whether ecoengineering and 'green' products used to clean slipways could be a realistic alternative to chemical treatment. Many areas currently use sodium hypochlorite, applied by brush and spray to clean the slipways it manages. NRW wish to better understand:

- 1) the impact to the marine environment
- 2) whether the products marketed as green alternatives are as effective or to compare their cost with the cost of sodium hypochlorite.

Various projects have looked at ecoengineering to enhance biodiversity. This project should also test whether it is possible to create a slipway with crevices for grazers, to reduce the need for cleaning. This project could work with a willing stakeholder and engineers to design, produce and test such a slipway.

Suggested level of research: PhD

Operational noise from renewable energy devices (floating offshore wind & tidal energy)

There is little evidence of the operational noise from floating offshore wind; particularly 'thrums' from anchor cabling. A field study is needed to monitor the noise from an operational device / array. Evidence of operational noise from tidal turbines is limited to a few device types from single devices. There is no information on how noise from single devices will extrapolate to an array scale project, and no information on operational noise for a wide range of device types currently proposed. Field observations are required to measure operational noise of different tidal turbine devices, and arrays. This would require collaboration with industry to record underwater noise around operational projects.

Suggested level of research: MRes or PhD. Would require industry collaboration.

Impacts of dredge disposal on subtidal habitats

Further evidence is needed on the impacts of dredge disposal on subtidal habitats. This practical evidence collection project will include the monitoring of dredge disposal impacts and investigations into impacts of smothering, particularly on habitats of conservation importance using existing available evidence and new data collected in Wales.

Suggested level of research: PhD or Postdoc

Understanding impacts of anchoring on marine habitats

Experimental studies are needed to progress our understanding of the impacts of anchoring, with an emphasis on the potential impacts on a range of sensitive marine habitats. A recent desk study has highlighted a number of Welsh sites where anchoring is potentially causing an impact to sensitive habitats and part of this evidence requirement will involve investigating these sites and assessing the current impacts and severity.

Suggested level of research: PhD or Postdoc

Impacts of potting on *Modiolus* beds

Modiolus modiolus beds are an extremely sensitive habitat and there have been indications recently that even infrequent activity may have the capacity to degrade the habitat. Therefore there is a need to investigate the possible impacts of any activity that takes place that involves physical contact with a *Modiolus* bed. This study could be carried out in a number of ways, including direct observations of fishing activity, or an experimental potting study.

Suggested level of research: PhD or Postdoc

Impacts of potting on fragile sponge and anthozoan communities

Whilst impacts of pot fisheries on reef habitats is in part covered by a Defra Impacts Evidence Group review, there are site and intensity specific scenarios which require further consideration and understanding. Recent studies in Lyme Bay have highlighted the potential impacts of potting on fragile benthic species, like pink sea fans. A similar experimental study in Welsh waters would help us to understand at what intensity potting is likely to impact fragile sponge and anthozoan communities.

Suggested level of research: PhD or Postdoc

Sensitivity of *Modiolus* and other habitats of conservation concern to smothering by sediment

There is a need to better understand the impacts of smothering on *Modiolus modiolus* (horse mussel) and other key habitats. This would be a practical (potentially lab based) study which would build on existing studies by investigating smothering at a variety of depths in order to assist NRW to develop thresholds to be able to provide robust advice.

Suggested level of research: PhD or Postdoc

Developing methods for active restoration of marine habitats.

There is a need to develop methods to create new intertidal and subtidal habitat, in particular habitats of conservation concern (e.g. Habitats Directive Annex 1, Environment Act Section 7 etc). Methods are more advanced for some habitats (e.g. saltmarsh, seagrass, and oyster beds) but others are very much undeveloped. Projects are needed at a variety of different scales, from small scale developments of techniques to larger scale habitat creation trials.

Suggested level of research: PhD or Postdoc

Investigating the effectiveness of alternative mooring systems for reducing damage to sensitive habitats

Studies are required on the effectiveness of Advanced Mooring Systems in terms of reducing impacts on important habitats, e.g. seagrass beds. This work would need to build on the research which is already underway at other locations and tailor this to the sites in Wales. This work would start with a literature review of the current studies and trials so far.

Suggested level of research: MSc

Investigating the causes of the decline in health of sponge community in the Menai Strait.

Monitoring has shown a decline in the biomass and diversity of sponges at the Coleg Normal monitoring site in the Menai Strait. Work is needed to identify the cause(s) of this decline and to ascertain whether the decline has happened throughout the Menai Strait or is restricted only to this area. Initially this could be a scoping exercise to identify the most likely cause(s), plus further survey work in other areas of the Menai Strait, especially where comparisons with historic data is possible. Depending on the outcome of the scoping exercise and surveys, experimental work, data analysis, or further data collection and research may be required.

Suggested level of research: MSc and above

Investigating the causes of decline in *Eunicella verrucosa* populations around Skomer Marine Conservation Zone

Monitoring has shown a decline in numbers of *Eunicella verrucosa* around the Skomer MCZ. Work is needed to identify the cause(s) of this decline. Initially this could be a scoping exercise to identify the most likely cause(s). Depending on the outcome of the scoping exercise, experimental work, data analysis, or further data collection and research may be required.

Suggested level of research: MSc and above

DNA sampling for crawfish across different populations in Wales and the wider Irish Sea

This work would provide a better understanding of the population dynamics of this species in Welsh waters and highlight potential relationships between sub populations. The project would incorporate Ireland and Southern England. Outputs would better inform management and restoration goals and could be undertaken in collaboration with a V-notching scheme.

Suggested level of research: PhD or Postdoc

Diet of seabird species in Wales

Monitoring of seabird diet is already in place at some colonies around the Welsh coast but could be expanded to other areas, especially where the colonies are easily accessed. This project will involve practical research work to investigate the prey species being returned to colonies. Species of particular interest would include shags, cormorants, and puffins.

Suggested level of research: MSc and above

Seabird tracking studies to ascertain areas of use and impacts

This practical study will develop our understanding of Welsh seabirds, especially in relation to the main areas of Welsh seas that they use to help inform potential impacts. The project will involve using GPS and data loggers fitted to birds and will particularly focus on diving birds such as auks, cormorants, and shags.

Suggested level of research: MSc and above

Understanding how to Increase resilience in seabird populations by restoring Welsh islands for seabird colonisation

Rat free islands are a great resource for seabirds due to the lack of predation by these invasive mammals. However, often after eradication, populations of ground or burrow nesting birds do not increase due to lack of management e.g. grazing. To increase resilience to climate change impacts, ensuring connectivity and ensuring adequate locations for these birds to breed is important. By improving management on islands we increase the distribution of populations and have less of our eggs in one basket. Also by improving seabird islands this can lead to a positive impact on the local economy by attracting charismatic species such as puffins or Manx shearwaters. Different management techniques could be considered as an experiment to see what works best on different islands.

Suggested level of research: PhD or Postdoc

Impacts of woodland management and tree felling on estuarine habitats

Forestry plantation occupies a significant proportion of the catchments of many of our estuaries. Our understanding of the impacts of this land use on estuarine habitats and species is limited. Large scale cultivation of coniferous trees and forestry operations such as felling and track construction and maintenance could lead to pressures on the protected estuary features within Marine Protected Areas, such as increased sediment input, increased nutrients, acidification, and changes to hydrodynamic regime. A range of impacts on estuarine habitats and species should be reviewed as part of this work.

Suggested level of research: MSc and above

Evolution of Welsh estuaries (morphological and habitat changes)

This evidence review will develop an understanding of the historic evolution of Welsh estuaries in terms of morphological and habitat distribution changes. A wide range of information could be used to inform the study including bathymetric charts, aerial photographs, LiDAR, topographic information, wave and tidal data and sediment budget

information. It will be important to consider the influence of natural and anthropogenic changes and their impacts. It would also be beneficial to develop an updated baseline understanding of present day physical processes. It will first be necessary to determine priority areas for review which could be based on availability of existing and new data / information and casework demand. When a priority area is determined, a review should be undertaken of the adequacy of existing information. Recommendations could also be made in relation to any data / evidence gaps.

Suggested level of research: PhD or Postdoc

Investigating habitat resilience: saltmarsh

There is currently conflicting evidence regarding the resilience of coastal ecosystems. Evidence to confirm the assumption that saltmarsh moves inland with sea level rise is required. A research project to test this assumption in Wales would help with our understanding of resilience and coastal management. Long term surveillance would be required at locations where there are no constraints such as sea defences to the inland movement of saltmarsh.

Suggested level of research: long term research

Saltmarsh habitat as fish nurseries

There is a lack of evidence surrounding the use of saltmarsh habitat as fish nurseries. The study will determine the potential of specifically Welsh saltmarsh to act as a fish nursery and investigate link this has to biodiversity and economic benefits and the provision of ecosystem services. It should also further our understanding of the management required of saltmarsh for juvenile fish.

Suggested level of research: MSc and above

Nitrogen deposition & sea cliffs

A study is required to determine the critical thresholds for nitrogen deposition on maritime cliff and slope. There are no critical thresholds for nitrogen deposition on maritime cliff and slope, this component feature is made up of different vegetation types (maritime heath, maritime grassland, crevice and ledge communities, supra littoral lichen communities etc) not covered by the Air Pollution Information System (APIS) data. The study will investigate the effects of nitrogen deposition on the sea cliff habitats to 2030.

Suggested level of research: PhD

Sand dunes and water filtration

Sand dune aquifers are used as a potable water source in the Netherlands as the sand dunes naturally purify water passing through them. Similar natural filtration processes almost certainly remove nutrients from groundwater in the UK, thus reducing diffuse pollution to the marine environment. However, in the UK this is not well studied. This desk based project should provide a review of this process and its applicability in Wales.

Suggested level of research: PhD

Impacts of coastal defences on coastal habitats

NRW wish to better understand of the impact of coastal defences on adjacent coastal margin habitats, which will include consideration of coastal geomorphology impacts. This review will include a consideration of what the positive and negative impacts of coastal defences are and where they are located along the coastline of Wales. Suitable case studies could include Borth and Morfa Dinlle.

Suggested level of research: MSc and above

Value of coastal habitats in contributing to sea defences

The value of coastal margin habitat in providing / contributing to soft sea defences, including system thresholds which govern that role.

Suggested level of research: PhD

Carbon sequestration and storage potential of sea cliff habitats

The rates of carbon sequestration and storage potential for cliff habitats (particularly coastal grassland and maritime heath) is not known. An investigation into rates of carbon sequestration and storage potential in these habitats would provide a better understanding of the ecosystem services these coastal margin habitats provide.

Suggested level of research: PhD

Evaluating perception of the value of coastal habitats as coastal defence structures and confidence in their use as nature based solutions.

A study investigating the social perception of coastal margin habitats (particularly dunes and shingle) in relation to coastal defence is required to improve our social evidence base for the value and potential inclusion of coastal margin habitats. This study will assist with future reporting within NRW.

Suggested level of research: MSc and above

eDNA assessment of species in lagoons.

There is a lack of contemporary information relating to species communities and diversity of Welsh saline lagoons. eDNA analysis of water samples from saline lagoons could provide valuable information on species diversity and presence / absence of notable species.

Suggested level of research: PhD or Postdoc

Recording and evaluating grazing levels, timing and abandonment for saltmarsh, sand dunes and cliffs.

Grazing is an integral part of maintaining coastal habitats in favourable condition. A review is required to evaluate grazing levels, timings, and effects of grazing abandonment on coastal margin habitats, particularly saltmarsh, sand dunes and cliffs.

Suggested level of research: MSc and above

Developing methods to initiate the creation of coastal and intertidal habitats (other than saltmarsh).

There is currently a good evidence base for the methods to initiate the development of saltmarsh. However, there is sparser evidence for the other coastal margin habitats, such as sand dunes, sea cliffs, shingle, and saline lagoons. Gaining this information will aid us in providing advice where required on the creation of coastal margin habitats.

Suggested level of research: MSc and above

Ecosystem level effects of restricted water exchange between tidal lagoons and the area outside

Tidal lagoons are likely to create areas with less exchange of water with surrounding areas than was the case before construction. This desk based study would investigate these possible changes and specifically whether there may be changes to pelagic communities (including plankton) as a result.

Suggested level of research: PhD

Understanding pre 1900 distribution and abundance of flora and fauna in Welsh waters

This desk based exercise would build on work already carried out and investigate historical distributions of marine flora and fauna to understand changes in the Welsh marine environment over time. This will highlight changes such as historical losses of habitat and which species and habitats have experienced the most changes.

Suggested level of research: MSc and above

What impact could climate change have on marine ecosystem services?

A review is required to investigate potential changes in marine ecosystem services in Welsh waters resulting from climate change. This will include the known impacts that climate change could cause (e.g. water temperature and chemistry, sea level rise, non-

native species). It will assess how these changes could affect those provisioning, regulating and cultural services that marine ecosystems provide.

Suggested level of research: PhD

High resolution hydrodynamic modelling across Wales

NRW are interested in the production (building and validation) of hydrodynamic models to enable particle tracking input scenarios for a range of point sample data, for example angel shark eDNA records, oyster larval recruitment, invasive non-native species data and crawfish larval dispersal. This is in order to test / predict a range of hypotheses associated with different species.

Suggested level of research: PhD or Postdoc

How to develop appropriate models for fish behaviour around marine renewable energy developments.

Several types of modelling are likely to be required to predict impacts to fish from marine renewable energy devices in several stages; to predict encounter rates, avoidance rates and injury rates. Currently, the modelling tools to do this are limited and do not allow different modelling approaches to be compared or contrasted to further understand the range of impacts and provide confidence in the overall assessment. This desktop project will research the appropriate input into the parameters required to adequately develop new, or improve existing modelling tools, including how to incorporate uncertainties within the statistical analysis of the models.

Suggested level of research: PhD or Postdoc

How to deliver feasible mitigation and compensation for loss of fish associated with tidal lagoon developments?

A review is required of the effective and suitable mitigation and compensation strategies available for marine / estuarine and freshwater diadromous fish in relation to tidal lagoon developments. Measures to mitigate impacts on key fish species and populations are likely to play key roles in consenting processes for tidal lagoon developments and need to be better understood.

Suggested level of research: PhD

Investigating the status and ecology of the Critically Endangered angel shark (*Squatina squatina*) in Welsh waters

Evidence to support the current status and ecology of angel sharks in Welsh waters is needed to ascertain if current protection under the Wildlife and Countryside Act is adequately protecting this species in Welsh waters. This would include eDNA sampling, DNA mucus sampling and tagging using targeted surveys and utilising existing survey mechanisms (including fishers) to build up a better understanding of population status and how angel sharks are using Welsh waters at different times of year.

Suggested level of research: MRes or PhD

Expand use of eDNA sampling undertaken as part of the successful Angel Shark Project Wales trial to incorporate other rare and scarce species.

The work undertaken as part of the Angel Shark Project Wales successfully demonstrated the eDNA methodology in being able to detect rare / scarce species in Welsh waters. This could be utilised for a range of other species of principle importance (e.g. Environment Act Section 7) as well as marine invasive non-native species (INNS) (as a potential surveillance mechanism) for high risk species e.g. mitten crab and other species from the Wales INNS monitoring and surveillance list. This project will develop NRW's understanding of what is feasible and develop and carry out trials in the field.

Suggested level of research: PhD

Distribution and abundance of sandeels in Welsh waters

Sandeels are a key prey species for marine mammal and seabird species and are an important component of marine ecosystems and trophic structures in Welsh waters. Identification of the areas of potential sandeel residency and spawning habitat in Welsh waters using existing mapping is needed, along with ground truthing studies using sandeel dredges or grab sampling to identify the use of this habitat by sandeels. Trawling is also needed to identify whether sandeels are using these areas in their pelagic phases. This will build upon the work presented in Ellis et al. (2012) and allow assessments to robustly consider the effect upon this species, which is often overlooked by standard survey techniques. Similar studies for other species which show habitat preferences e.g. Atlantic herring, black bream, sand goby and European plaice would also be of value.

Suggested level of research: PhD

How will climate change impact upon fish and fish communities in Welsh waters?

A desk based review is required which will investigate how climate change (including changes in water temperature and chemistry, sea level rise and invasive non-native species) might affect key fish populations and fish communities in Welsh waters.

Suggested level of research: MSc and above

Noise and vibration impacts upon fish

This practical study will investigate responses of key fish species to noise and vibration. This is likely to be through monitoring of piling in situ or experimental trials.

Suggested level of research: MSc and above

Effects of electromagnetic fields (EMF) on fish

This practical research project would investigate responses of key fish species to Electromagnetic Fields. It would involve monitoring of cables or experimental trials.

Suggested level of research: PhD or Postdoc

What are the effects on fish communities from the presence of offshore wind farms, or marine renewable energy device arrays?

An evidence review is required on the response of fish communities to the presence of offshore wind farms or marine renewable energy device arrays. This would weigh the potential for habitat loss and displacement from spawning / nursery / feeding grounds and migratory routes and disturbance / electromagnetic fields, with the potential for reduced fishing pressure and increased habitat complexity / hard substrates within the array area. Key questions to consider in this review would be: Is the effect beneficial overall? Is there a changed community structure, diversity, or abundance as a result? Which key species are positively and negatively affected?

Suggested level of research: BSc or MSc

Assessing incremental losses to fish populations

Understanding how incremental year-on-year losses of fish from project level impacts or commercial fishing may affect population abundance, structure and functioning is important when conducting Habitats Regulations Assessments and assessing how projects will change the abundance or structure of a population. Development of models for key fish species in Welsh waters is needed, building on existing work.

Suggested level of research: MSc and above

An assessment of the suitability of 'preferred' and 'marginal' sandeel habitat in Welsh waters.

Habitat is often defined as preferred, marginal, or unsuitable for sandeel occupancy. However, within the preferred and marginal habitats, there are sub-classifications (prime, sub-prime etc.) and many marginal habitats / substrates are unsuitable for sandeels. A more refined sandeel habitat map than that available from the British Geological Survey seabed sediment map is required considering these sub-classifications.

Suggested level of research: MSc and above

Timing of sandeel burial and emergence in the Severn Estuary

Sandeels are generally understood to show diurnal behaviour, spending time swimming in the water column and time buried in seabed sediments. However, it is not clear whether this behaviour is seen in highly turbid environments where light penetration may be limited. The timing of sandeel burial and emergence influences their vulnerability to different impacts (such as dredging, entrainment / impingement, turbine encounters etc.). A field study is needed to understand whether sandeels show this diurnal behaviour in the Severn Estuary, a highly turbid environment and a site designated for its fish assemblage.

Suggested level of research: MSc and above

eDNA screening study of diadromous fish in marine waters

Based on the recommendation in the Evidence report: 'Feasibility Study of Methods to Collect Data on the Spatial and Temporal Distribution of Diadromous Fish in Welsh Waters'. A strategic and comprehensive marine eDNA survey to establish presence or effective absence of key fish (and other) species in each marine energy resource zone. This would comprise a two-year, comprehensive survey using automated samplers to collect eDNA across full tidal cycles, with replicate samples spread across each area every two weeks. As eDNA screening is an emerging technology, such a study could include an initial, short pilot phase to test and refine these field techniques across a number of selected areas.

Suggested level of research: PhD

Understanding post release mortality in recreational angling

In Wales, more information regarding fish stocks and post-release mortality is required to better understand the overall effect of biological removals. This is especially relevant for species which are valued by both the recreational and commercial fisheries sector.

Suggested level of research: PhD

What are the impacts of removal of slow growing, long-lived fish species by recreational angling?

It has been identified that the pressures of recreational sea angling may have the greatest effect on species which are slow growing, long-lived, and late maturing (e.g. wrasse). Work is required to investigate the impacts of removal of these types of species in angling hotspots in Wales and link this to important species for protected features of Welsh MPAs such as reef.

Suggested level of research: PhD

Understanding impacts of non-native species impacts on Marine Protected Area features in Wales

NRW wish to gain a better understanding of the impacts of non-native species on Welsh Special Area of Conservation features. This will build on a recent report which assessed the impacts of key marine invasive non-native species on Welsh MPA habitats and features, fisheries, and aquaculture (Tillin et al., 2020). This work would need to use the evidence review as a base and go on to undertake desk and site based investigations to document evidence of impacts in Welsh waters.

Suggested level of research: PhD

eDNA analysis of dredge vessel hopper water to identify presence of invasive non-native species

This practical study would provide a better understanding of the risks of introduction and spread of invasive non-native species due to marine dredging activities in Wales. An important part of this work would be to develop working relationships with dredge operators.

Suggested level of research: PhD. Would require industry collaboration.

Investigating the distribution of slipper limpet in north and west Wales.

We wish to increase our knowledge of the distribution and density of the slipper limpet (*Crepidula fornicata*) in north and west Wales, as new records in 2020 and 2021 suggest there is now an established population in north Wales. There are currently no records from Cardigan Bay, which would indicate that the species may not have moved naturally from south to north Wales, although movement from Northern Ireland is possible. We will use this evidence to target monitoring and understand spread of the slipper limpet. Evidence on distribution of species is vital when working with stakeholders that have an interest in the area and will be impacted by the introduction of slipper limpet. Distribution information will be used to target biosecurity measures and understand more about impacts to protected features. Understanding the presence and extent of slipper limpet in the Menai Strait will inform future management of shellfisheries and assist in providing guidance to the industry.

Suggested level of research: BSc or MSc

What is the origin of the of the slipper limpet (*Crepidula fornicata*) in North Wales?

We are aware that an established population of the slipper limpet (*Crepidula fornicata*) is likely in the Menai Strait and south-east Anglesey due to a number of records in 2020 and 2021. NRW wish to understand more about the method of introduction of this species to North Wales. An established population exists in Milford Haven and Northern Ireland but it is as yet unclear whether this species has arrived through natural spread or whether it was introduced through a specific introduction event, either a new event or whether the species has been present since the introduction event of 2006. This project could involve genetic analysis and an examination of pathways. Evidence on the method of introduction is important to ensure existing biosecurity protocols are adequate and will help target pathways for potential future introductions to an area.

Suggested level of research: MSc and above

Chinese mitten crab ecology and behaviour in the Dee Estuary

Currently there is no formal monitoring programme of mitten crab however some data on population trends is collected from the fish trap in Chester. This shows that numbers have been increasing steeply in recent years. Additional monitoring and research such as planktonic megalopa studies, mark release recapture and genetic investigations are needed to better understand the Dee population and potential impacts. We have no evidence about natural predator response, but this could be incorporated into a monitoring programme. This evidence will help us better understand the population of mitten crab in the Dee, including the size of the population and the movements of this species within the estuary and river catchment system.

Suggested level of research: MSc and above

Investigating the spread of *Agarophyton (Gracilaria) vermiculophylla* in Wales

This red algal species was recently found in Porthmadog and quickly further discovered in the Mawddach, and Malltraeth and was also present in 2020 in the Burry Inlet. The extent suggests a mass influx of propagules, and maybe not a localised source around Porthmadog. It is likely that this species has not yet reached its extent and density limits in Wales. This project could review likely propagule spread (e.g. through modelling). It could also model the habitats where we could expect this species to be found and where it could prove problematic through the recycling of propagules locally, which would increase the density to problem levels. The project could also include an investigation into the likely impacts of this species on Welsh habitats.

Suggested level of research: MSc

Diet of marine mammals, especially bottlenose dolphin, harbour porpoise and grey seal in Wales and adjacent Seas

Knowledge of diet in marine mammals in Wales is minimal and / or dated. There are no stomach content samples from bottlenose dolphins in Wales although a proposed project to biopsy dolphins could allow forensic techniques to examine diet (stable isotope analysis). There is stomach content information from stranded and bycaught harbour porpoise but data is not analysed. Grey seal diet work in Wales is from a single report from 1996 in Pembrokeshire (Strong 1996) and requires updating. Diet is an important descriptor of prey changes in the ecosystem. As diet is intricately linked to habitat, knowledge of diet will inform our assessments of the condition of marine mammal habitats. This project will primarily involve desk based collation of existing data.

Suggested level of research: MSc and above

Connectivity of grey seals and bottlenose dolphin around Wales and adjacent Seas

This desk based project involves the collation of data on movements of marine mammals in Welsh waters / the management unit and quantification of the degree of connectivity between areas. This work will help NRW to develop advice on management of grey seal and bottlenose dolphins, especially relating to Habitats Regulations Assessment.

Suggested level of research: MSc and above

Modelling population consequences of habitat loss for marine mammals

The population consequences of habitat loss are poorly understood. Current population prediction models concern disturbance only, rather than actual loss caused by, for example, permanent displacement or habitat removal from sea wall construction (e.g. tidal lagoons). A modelling framework is required to predict effects on populations.

Suggested level of research: MRes or PhD

Population structure and dynamics of marine mammals in Welsh waters and adjacent Seas

We have a limited understanding of how our marine mammal populations are structured around the UK and Europe. Further information is needed to investigate potential population structuring (including genetic structuring) and regional population dynamics (including age and sex ratios). This report should be broader than just abundance and distribution.

Suggested level of research: Postdoc

Recreational disturbance of marine mammals

The aim of this work is to gather evidence to assess whether disturbance from recreational vessels or other recreational activities is having an impact on marine mammals, especially bottlenose dolphins, in Welsh waters. This follows on from PhD work carried out at Bangor University. While there are detectable impacts e.g. changes of behaviour in cetaceans, we need to investigate whether these changes are having any detrimental effect on the population or is it mainly a perception that this kind of disturbance is adverse. More work is needed to understand the impacts and to assess potential management options if there is an adverse impact, given the unregulated nature of this activity.

Suggested level of research: PhD

Risso's dolphin distribution, range and abundance

Small Cetaceans in European Atlantic waters and the North Sea (SCANS) data, plus some localised info from Bardsey surveys, are the only information NRW currently have on Risso's dolphin. There is recent anecdotal evidence of frequent sightings of Risso's dolphins, including calves, which appear to persist throughout the year. This poses a potential consenting risk for marine renewable energy and is a potential conservation issue if important areas for this species are not recognised. NRW require better information on abundance, range, breeding, site fidelity, distribution of this species. Boat based photo ID is likely to be the best method, in addition to collation of existing data.

Suggested level of research: MSc and above

Noise disturbance of marine mammals

Information on the behavioural effects on marine mammals from underwater noise such as seismic surveys, unexploded ordnance detonation, or piling, is limited. Standard deterrent ranges are used in some assessments, but they are often based on limited evidence, and there is a lack of consensus over whether they would apply under different hydrographical conditions such as those in Welsh waters. An understanding of how underwater noise might disturb Annex II species, particularly harbour porpoise; and what the spatial footprint of such disturbance might be, is urgently needed to inform consenting advice for imminent offshore wind projects.

Suggested level of research: PhD or Postdoc

Impacts of acoustic surveys on marine fauna

A practical study is required on the potential impacts from acoustic surveys (geophysical e.g. multibeam, boomer) on marine mammals, birds, and invertebrates. A desk based study has been completed, active field research is now needed. This is likely to include research on effects of sound on diving birds and impacts of particle motion components of sound.

Suggested level of research: PhD or Postdoc

Understanding regional and sub-regional sediment budgets

This project aims to improve the evidence base on sediment budgets in Welsh waters, by conducting a review of the adequacy of existing information, the methodology applied, identification of any data / evidence gaps and areas that need to be updated. The review, intended to be a desk based study, should provide recommendations as to the merit in updating the sediment budget. This will inform further work on sediment budgets in NRW. Whilst this evidence request applies to the whole Welsh coast it can be delivered through smaller scale projects applied regionally. The methodology should be informed by this handbook: <https://www.gov.uk/flood-and-coastal-erosion-risk-management-research-reports/sediment-budget-analysis-practitioner-guide>

Suggested level of research: PhD or Postdoc

Development and improvement of models to predict behaviour of physical processes, and/or the complex interactions between physical, biological, and ecological components of a marine and coastal environment

NRW is interested in the development of new numerical models or the improvement of existing numerical models which could be applied to the marine and coastal environment. Potential models of interest to NRW include those which predict physical processes behaviour, and models which are able to predict the complex interactions between physical, biological, and ecological components of a coastal / estuarine / marine system.

Suggested level of research: PhD or Postdoc

Resilience of and vulnerability of marine and coastal habitats to climate change (physical processes)

The nature and shape of the Welsh coastline has significantly altered following storm events (e.g. the 2013/14 storms), to the extent that ecosystem structure and functioning will have changed. NRW is seeking to understand to what extent dynamic coastal systems have the capacity to recover following storm events and gain an understanding of habitat resilience and vulnerability to climate change. Analysis could include one or several coastal types (open coast / estuaries, beaches and dunes, shingle, mudflats, and saltmarsh) and could reflect on the storm effects noted following the 2013/14 storms. Physical and ecological data could be used to inform understanding of recovery and resilience.

Suggested level of research: PhD or Postdoc

Collection and analysis of bathymetric and topographic data within the marine and coastal environment, and advancement of methodology and instrumentation to support data collection.

This evidence need relates to collection of topographic and bathymetric data and analysis to address gaps in our understanding. For example, we are aware that topographic and bathymetric data within Welsh estuaries is a significant data gap. It is also required to support routine monitoring undertaken by external partners such as the Wales Coastal Monitoring Centre which requires NRW support. NRW require an evidence review of the existing methods for collection and analysis of bathymetric and topographic data and how methods could be improved through new methodologies and instrumentation.

Suggested level of research: MSc and above

Wave data collection, collation, and analysis

There is a need to improve the understanding of wave data availability in Wales including existence of historic, present, short-term and long-term deployments. NRW supported a KESS II project which provides an insight into wave data available in Wales but there is a need to understand the availability of project level data/any new datasets that have become available. It would be beneficial to:

- 1) create a look up guide for wave data (including metadata) as a source of reference
- 2) develop an understanding of data gaps
- 3) analyse data to improve our understanding of the welsh wave climate and analyse wave data with other physical processes datasets such as topography and bathymetry to understand past and coastal change.

Suggested level of research: PhD or Postdoc

Requirements for shingle resource to support nature based solutions at the coast

A review is required to develop the evidence concerning the type and quantity of shingle required to help deliver nature based solutions at the coast and identify whether there are suitable supplies. The purpose of the review is to assist NRW's use of appropriate nourishment material. The British Geological Survey directory of quarries lists all potential sources of land based quarries; however it would be valuable to understand what size, colour, and mineralogy they can supply, and what reserves are available (if possible) and then match these to coastal shingle resource. This could inform where nourishment material could be sourced from and whether there is adequate resource available.

Suggested level of research: BSc and above

Source of sediment in the Milford Haven Waterway

The Estuary feature of the Pembrokeshire Marine Special Area of Conservation is currently unfavourable due to a variety of factors mainly related to water quality. NRW

advice on casework and our ability to address the unfavourable condition is hampered by uncertainty around whether the sediments are of marine or terrestrial origin. Land management upstream may be leading to increased sediment in the two Cleddau estuaries than was present historically. This investigation needs to present evidence to determine if this is the case to enable NRW to develop management actions.

Suggested level of research: PhD

Identification of opportunities to support beneficial use of dredge material in Wales.

This review is aimed at identifying opportunities where use of beneficial use of dredge material may be possible in Wales. Whilst the concept of 'beneficial use' is advocated in policy in proactive terms there are many barriers to delivery. One of the obstacles is not knowing where opportunities exist for implementation. This evidence project will look to help support operational delivery and will assist with putting into practice NRW Guidance on the Sustainable Management of Coastal Shingle and the Sustainable Management of Marine and Coastal Sediment. Working with key partners will be important for this work, and this handbook should be used to inform the approach:

https://catchmentbasedapproach.org/wp-content/uploads/2021/10/Restoring-Coastal-Habitats_V8.pdf

Suggested level of research: PhD or Postdoc

Improve understanding of potential array scale impacts of wave and tidal stream devices on physical processes parameters over the medium-long term

There is a need to better understand potential array scale effects of wave and tidal stream devices on physical processes (e.g. water flow and energy removal). As these are embryonic renewable energy devices, there is limited validation of impacts at an array scale. Improvements could be made to numerical model validation by using data collected for single or small scale array projects, and / or through developing modelling capabilities (including resolution).

Suggested level of research: PhD or Postdoc. Would require industry collaboration.

Improve understanding and assessment of potential impacts and interactions of different types of renewable energy devices to physical processes parameters

There is a need to better understand potential array scale effects of wave and tidal stream devices on physical processes (e.g. water flow and energy removal). As these are embryonic renewable energy devices, there is limited validation of impacts at an array scale. Improvements could be made to numerical model validation by using data collected for single or small scale array projects, and/or through developing modelling capabilities (including resolution).

Suggested level of research: PhD or Postdoc. Would require industry collaboration.

Determine potential impacts to sediment transport processes and sediment budgets within and between sediment systems arising from single or multiple tidal range developments

Identify the approach and techniques that may be used to quantify and qualify the rate of sediment erosion, transport, and deposition within and in between tidal lagoons at local (single lagoon) and regional scale (multiple lagoons). Associated works such as aggregate extraction to supply construction material, plus likely maintenance dredge and disposal operations if these need to be done at scale as will be the case in the Severn Estuary need to be factored in to the determination of the sediment budget and pathways.

Suggested level of research: PhD or Postdoc

Develop and improve numerical modelling capabilities to predict medium to long-term morphological changes arising from single or multiple tidal range developments.

Predicting medium to long-term morphological changes arising from single or multiple tidal range developments is difficult to achieve with any degree of certainty. There is a requirement to increase confidence in predicted impacts of numerical models and to develop and improve model capabilities. For example iCOASST explores the use of decadal scale modelling for estuarine and coastal evolution - consider whether these tools could be applied to assessing tidal lagoon impacts over the longer term or learn from these tools in terms of capabilities and limitations.

Suggested level of research: PhD or Postdoc

Provide clarity on how existing assessment methods and modelling can be used to assess effects of decommissioning scenarios of renewable energy developments on the future physical processes baseline environment

There is a need to clarify how decommissioning impacts to the physical processes receptor is adequately assessed. Generally, construction phase modelling is used to inform the decommissioning impacts but the length of time and the future scenarios e.g. climate change impacts won't have been factored in. This research could involve testing model predictions incorporating climatic change influences (e.g. sea level rise, increase in storminess) on various decommissioning scenarios to establish the most appropriate course of action.

Suggested level of research: PhD or Postdoc

Improve and develop numerical models which can predict complex interactions between physical, biological, and ecological components of a coastal/estuarine system and changes arising from renewables devices

NRW is interested in the development of new models or the improvement of existing models which could be used to assess the potential effects of renewable energy devices on complex interactions between physical, biological, and ecological components of different marine and coastal systems.

Suggested level of research: PhD or Postdoc

Determine nature-based solutions that could be applied for use as cable protection measures

Review nature based solution methods that would be appropriate to use as cable protection measures for seabed infrastructure. This is with a view to minimise potential impacts to physical processes and other receptors; secure a more sustainable approach; increase environmental resilience and opportunities for enhancement.

Suggested level of research: PhD or Postdoc

Review and refinement of seabed mobility factor for cable protection and assessment requirements

Review available project assessment and monitoring information to review / refine seabed mobility calculations / factors for use in cable protection assessments and design. Recent projects may have underestimated the seabed mobility factor and the cable protection required.

Suggested level of research: PhD or Postdoc

Changes to sediment transport from large-scale wind arrays and cumulative effects

There is the potential for large scale offshore wind developments in combination with other projects to impact on sediment transport, and lead to gradual changes to habitats at various spatial and temporal scales. There is a need to better understand whether there is any evidence from existing offshore wind farms in Liverpool Bay for such effects and whether these effects can be better predicted.

Suggested level of research: PhD or Postdoc

This list was last updated in November 2021.

Next update due November 2022

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