

## Welcome to the marine Area Profile

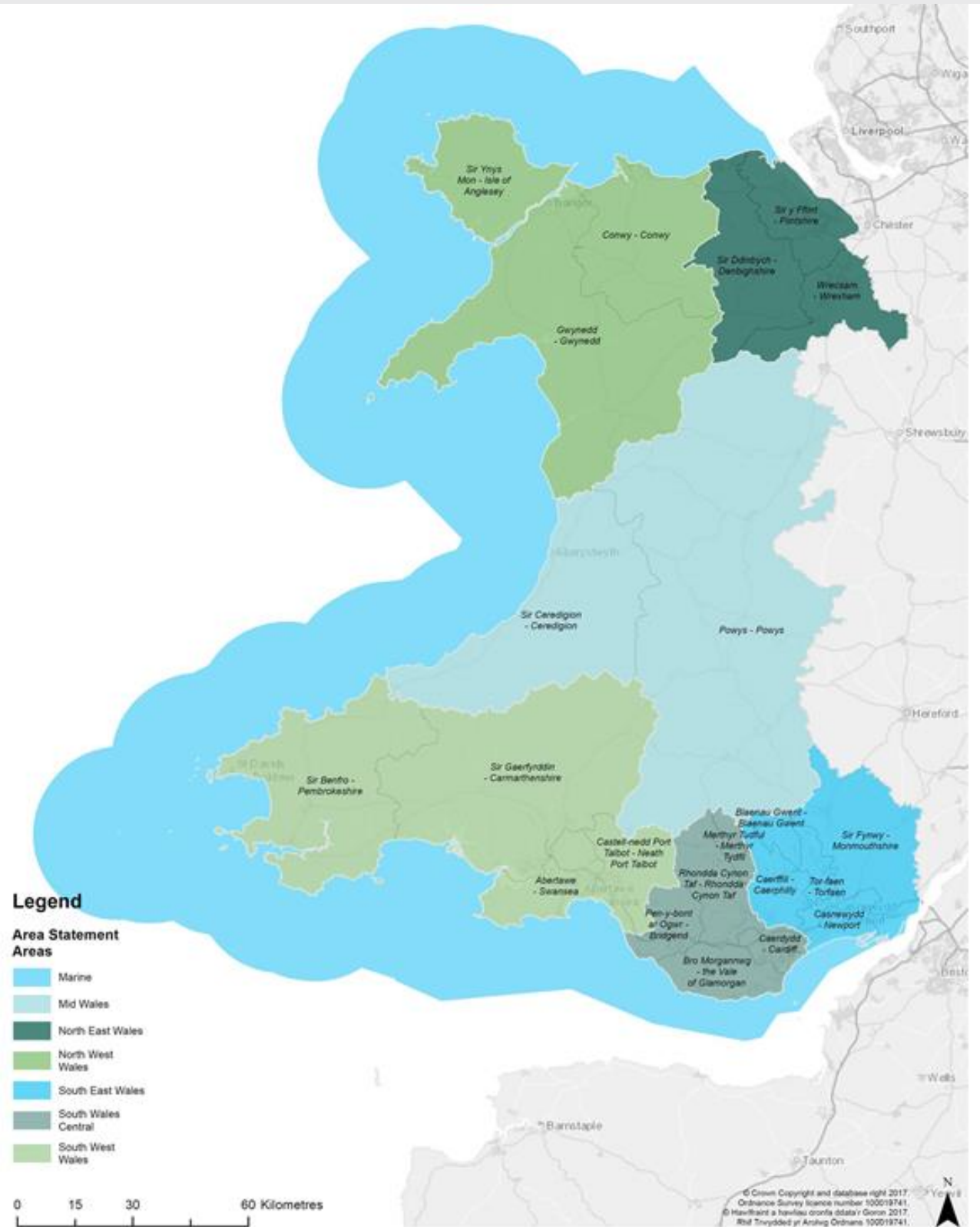
Natural Resources Wales (NRW) is responsible for Area Statements under the Environment (Wales) Act<sup>1</sup>. Area Statements are a way of gathering evidence on natural resources and ecosystems in an area that can be used by everyone for making decisions on how to manage them sustainably.

We have started by producing an Area Profile for each of the seven areas for which an Area Statement will be developed. Area Profiles provide a concise and user-friendly summary of robust evidence about our natural resources and the issues they face. It is the basis for conversations with our partners.

This Area Profile draws on existing quality assured and peer reviewed evidence and data, particularly those set out in Welsh Government's 'Wales Marine Evidence Report'<sup>2</sup>, and its online marine data portal<sup>3</sup>. These provide a more comprehensive review of marine evidence for Wales and are regularly updated.

All Area Profiles have been split into three sections: *people and place*, *natural resources and our environment*.

Each of the land based Area Profiles contain locally relevant marine and coastal information, reflecting the important relationship between land and sea.





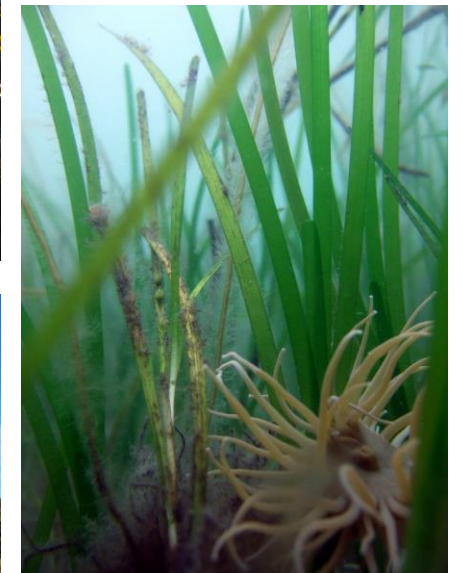
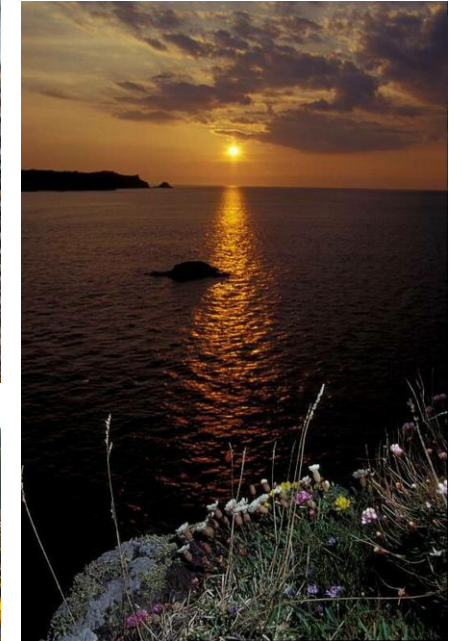


## Wales' marine area

The Welsh marine environment is highly diverse, unique and very special<sup>4</sup>.

The Welsh inshore marine area extends out to 12 nautical miles (nm)<sup>5</sup>, covering just under 15,000 km<sup>2</sup> or 41% of the territory of Wales. Our seas provide a wealth of natural resources that we all benefit from – sand for construction, fish for food, a range of wildlife, space for recreation and enjoyment, climate regulation, clean energy to support our lifestyles and a means of global trade and transport<sup>2</sup>.

Although the maps are static, the Area Profile contains many clickable buttons (such as the top bar). You can use these to navigate through our evidence for the marine area.



All images © Natural Resources Wales. Going clockwise from top left: Grey seal and pup, sunset over Skomer Island Marine Conservation Zone (MCZ), subtidal Seagrass in Skomer MCZ, Martin's Haven beach. Intertidal area of the Menai Strait





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## People and place

An introduction to the marine area profile and the people who live at the coast



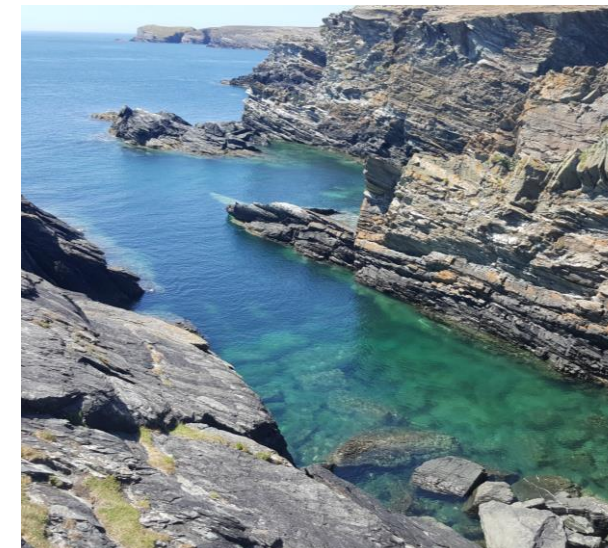
## Natural resources (biodiversity, water, and physical processes)

An introduction to our natural resources the elements that make up our environment



## Managing our environment

Our natural resources combine and interact in unique ways to produce a variety of different ecosystems



## Area Statement overview

Area Statements will help coordinate our work and the work of others, to build the resilience of our ecosystems

All images © Natural Resources Wales. Clockwise from top left: Wales coast path © Visit Wales Image Centre; Barnacles on mussels – subtidal biodiversity in Wales, the Anglesey coast; Anglesey coast near Southstack, Holyhead; A bottlenose dolphin in Welsh waters

## Glossary of Acronyms

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© Natural Resources Wales. The Menai suspension Bridge between Anglesey and Gwynedd

**Population**

**Health**

**Seascapes**

**Tourism and recreation**

**Coastal flood and erosion  
risk management**

**Shoreline management**

**Waste**

**Industries and  
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## Population



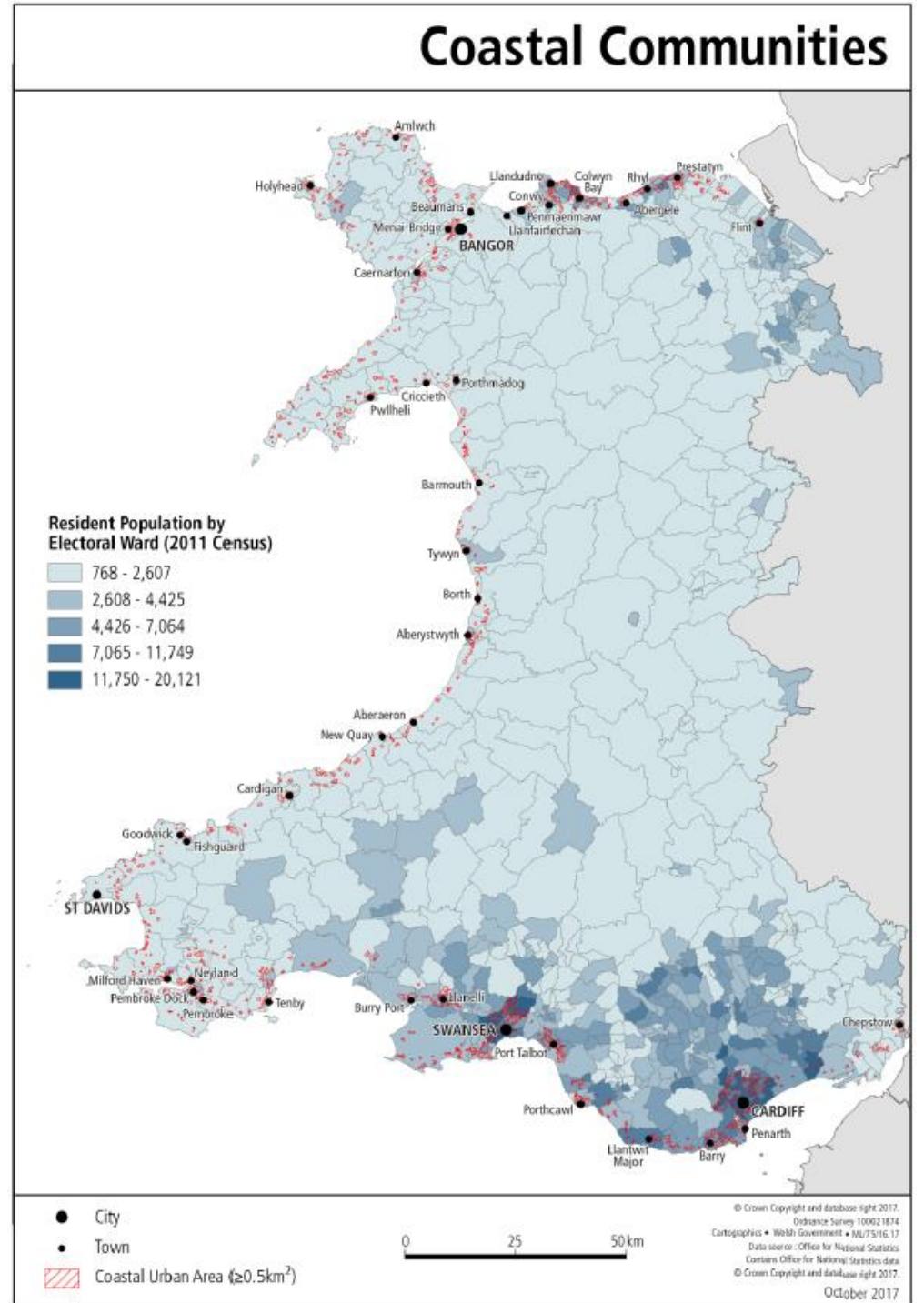
In Wales, most major towns and cities are by the sea, with over 60% of our population living along the coast<sup>2</sup>.

The seas around Wales and activities associated with the sea, play a significant role in peoples' wellbeing by providing jobs, opportunities for recreational activities, and by supporting cultural diversity and a sense of heritage<sup>2</sup>.

Those living near to the coast are more likely to be skilled and employed part time, compared to those living more inland<sup>6</sup>. There is, in general, less poverty, along with lower disability levels and better health, compared to non-coastal areas<sup>6</sup>. However, there are higher levels of overcrowding and housing lacking in central heating and some of the most deprived areas in the UK are along the Welsh coastline<sup>6</sup>. The potential is high for our coastal environments to be some of the most attractive in Europe, for living, working and visiting<sup>5</sup>.



© Natural Resources Wales. Paul Brazier. Visit to Borth with British Broadcasting Company Countryfile Diaries



Above image taken from draft Welsh National Marine Plan (accessed December 11<sup>th</sup> 2018, page 64)





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## Health



Evidence shows that spending time around the coast and sea can have multiple benefits for physical and mental wellbeing<sup>7</sup>. People who live nearer the sea rate their health as being better, with stronger results coming from poorer communities<sup>7</sup>.

The data demonstrates that when people lived nearer the coast, they were healthier and experienced lower mental distress<sup>8</sup>. Correlations such as better air quality and more frequent opportunities for experiences that strengthen social support networks, provide the backdrop for some of these findings<sup>8</sup>. Statistically, people who live by the coast are much more likely to exercise regularly, whether that be surfing, sailing, walking, fishing or swimming<sup>8</sup>.

Benefits of living in a coastal community include<sup>8</sup>:

- A view of the sea can promote reductions in heart rate and improvements in mood
- Those who live within 5km of the coastline rate their health as significantly better
- Those who live within 1km of the coastline are statistically more likely to exercise regularly than those living outside 1km of the coastline
- Living within 5km of the coastline means you are more likely to have improved mental health, compared with those living outside 5km
- Water based recreation could benefit the economy by saving up to £176m on healthcare per year
- Coastal areas and beaches provide 3 major health benefits<sup>9</sup>
  - Reduction in stress
  - Increased physical activity
  - Stronger communities

For further information see [www.bluehealth.2020.eu](http://www.bluehealth.2020.eu)





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## Seascapes and heritage



The coast, or seascape character, is the focus for the interaction between people, land and sea<sup>10</sup>. In Wales we have a remarkable variety of coastal places<sup>11</sup>. Highlights range from the remote islands, sounds, peninsulas and cliffs of Pembrokeshire and the Llŷn, to the numerous sandy beaches from Gower to Meirionnydd and major estuaries from the Severn to the Dee<sup>11</sup>. Human activities and heritage, range from ancient castles and quays to busy traditional seaside resorts such as Tenby<sup>11</sup>.

Legends about lost lands and sunken vessels abound, and our coastal landscapes and seascapes have inspired many artists and writers over the centuries. Representing places at a broad-scale, we have 29 National Marine Character Areas. Marine Character Areas highlight the key natural, cultural and perceptual influences that make the character of each seascape distinct and unique (see [here](#) for more information). While smaller scale local character studies provide detail of more local places for about 65% of the coast<sup>12</sup>.

All seascapes matter but certain places have been popularised by society over time. Seascapes tend to have a distinct and well-conserved character; they range from the spectacular and remote Pembrokeshire Coast National Park and Gower<sup>13</sup>, to built heritage that uses the natural setting, such as Llandudno which is flanked by craggy limestone headlands. Their high quality and great diversity provide the sought-after settings for many cultural and economic activities. Cardiff Bay is now the setting for our Senedd, reviving former docks that enabled the growth of our capital city as a port<sup>14</sup>.

Seascapes reflect the links between people and our culture, the local natural resources and the heritage of past human activity<sup>15</sup>. Seascapes influence both terrestrial coastal and marine planning<sup>2,5</sup>. Seascapes around Wales are important for activities including health and wellbeing, tourism, quality of life and economics<sup>2</sup>. Coastal areas in Wales draw in many visitors who support tourism and recreation, such as the top tourist attraction Caernarfon castle<sup>16</sup>, the tranquil and vast Oxwich Bay<sup>17</sup> and the coves and small bays of the Llŷn Peninsula<sup>18</sup>. Promoting what is distinctive and special to visitors helps bring prosperity and wellbeing to our coastal communities<sup>2</sup>.

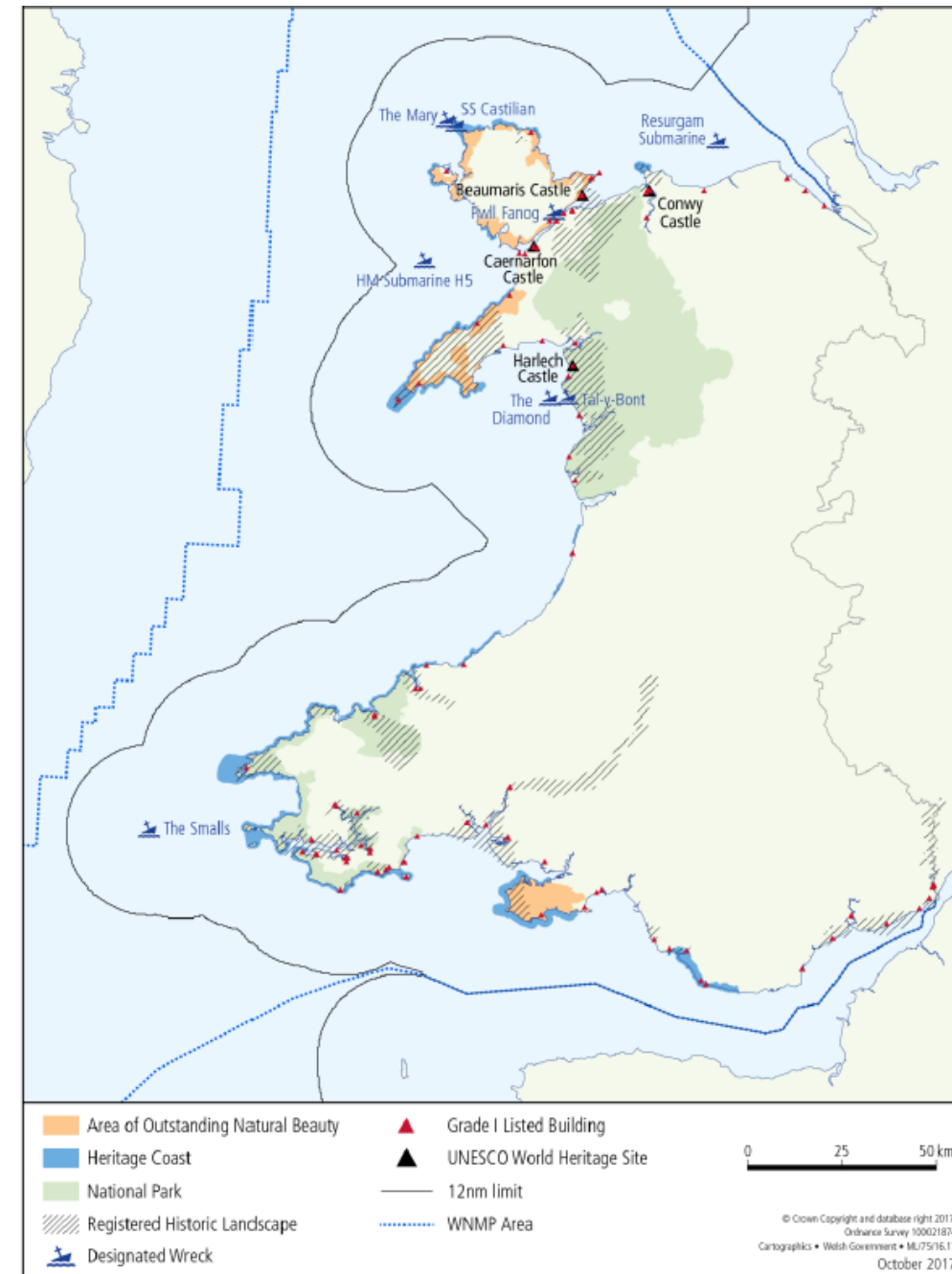


Image taken from draft Welsh National Marine Plan (accessed December 11<sup>th</sup> 2018, page 71)





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## Marine tourism and recreation



Our coast is spectacular and offers so much to local residents and tourists in Wales<sup>2</sup>. Coastal tourism in Wales is important to local economies, and includes accommodation, restaurants, cultural activities, sports activities and recreation<sup>2</sup>. The Wales Coast Path is a great example. In 2013 coastal tourism was estimated to be worth £602 million and totalled 3.6 million trips<sup>19</sup>. The greatest proportion of coastal tourism is for leisure and holiday purposes; it is particularly important for north and south west Wales, where it accounts for 57% and 48% of tourism respectively<sup>20</sup>.

Pembrokeshire Coast National Park is the only National Park in the UK to be designated for its coastline<sup>13</sup>.

Coastal World Heritage sites include castles such as Harlech, Conwy, Caernarfon and Beaumaris<sup>21</sup>. The Wales Coast Path is common to all seven Area Statements, running the whole coast of Wales<sup>22</sup>. The Wales Coast Path showcases some of the diverse coastlines we have<sup>22</sup>. Coastal tourism was estimated to be worth £602 million in 2013<sup>2</sup>. The tourism market has a target growth figure of 10% up to 2020, particularly for sustainable tourism<sup>2</sup>.

Promoting sustainable tourism while supporting the natural environment is a major challenge for the tourism and recreation sector, particularly as tourism and recreation are often centred around areas of high biodiversity (such as marine reserves and Sites of Special Scientific Interest)<sup>2</sup>.



© Crown Copyright (2011) Visit Wales. Walkers along the Wales Coast Path





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## Coastal flood and erosion risk management

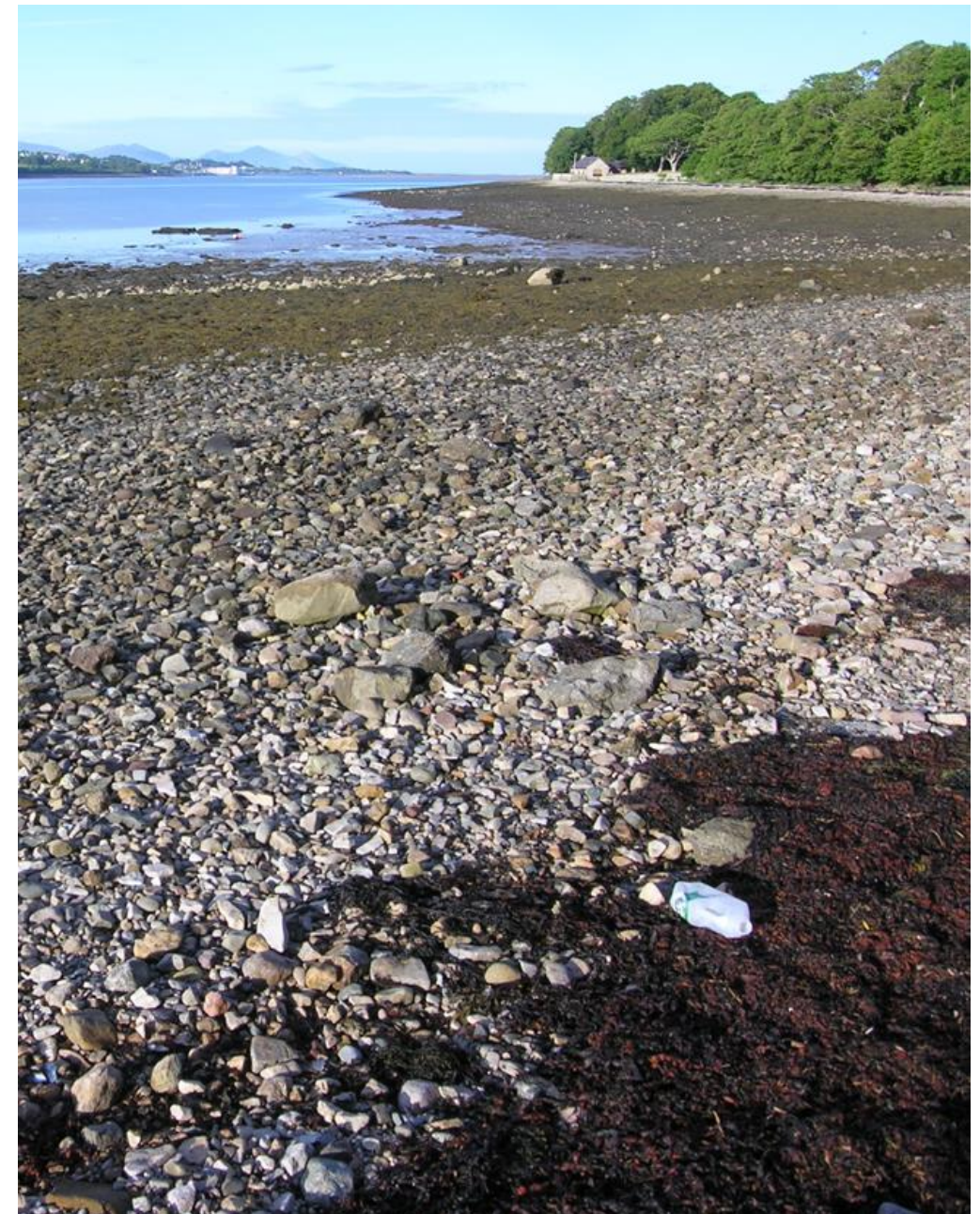


The coastal environment is dynamic and the coastline of Wales is vulnerable to coastal erosion and flooding<sup>23</sup>. There are about 415 km of man-made sea defence structures to protect over £8 billion of assets from coastal erosion and tidal flooding<sup>23,24</sup>. Natural habitats also protect the coast by directly dissipating or absorbing wave energy, or indirectly through regulating sediment movement<sup>25</sup>. Both natural habitats and man made defences are important for providing protection to coastal areas<sup>25</sup> which is important to the people, communities, economy and environment of Wales<sup>23,24</sup>.

Climate change will increase the exposure of low lying areas to risks associated with sea level rise including flooding<sup>26</sup>, and the frequency and severity of storms is expected to increase<sup>23,24</sup>.

Flood and Coastal Erosion Risk Management (FCERM) is a priority for Wales, and difficult decisions will have to be made at national and local levels in terms of acceptable levels of risk, affordability and adaptation<sup>23,27</sup>. Flood and coastal erosion risk must be considered with other sources of flood risk which may arise from rivers and watercourses, runoff from the land, urban drainage and reservoirs<sup>23</sup>.

Multiple stakeholders are involved in the management and maintenance of sea defence structures. Flood and coastal erosion risk has the potential to affect a significant part of the population and natural resources. It will be important for FCERM to be delivered in cooperation between partners and communities<sup>23</sup>. We need to work co-operatively to manage this risk.







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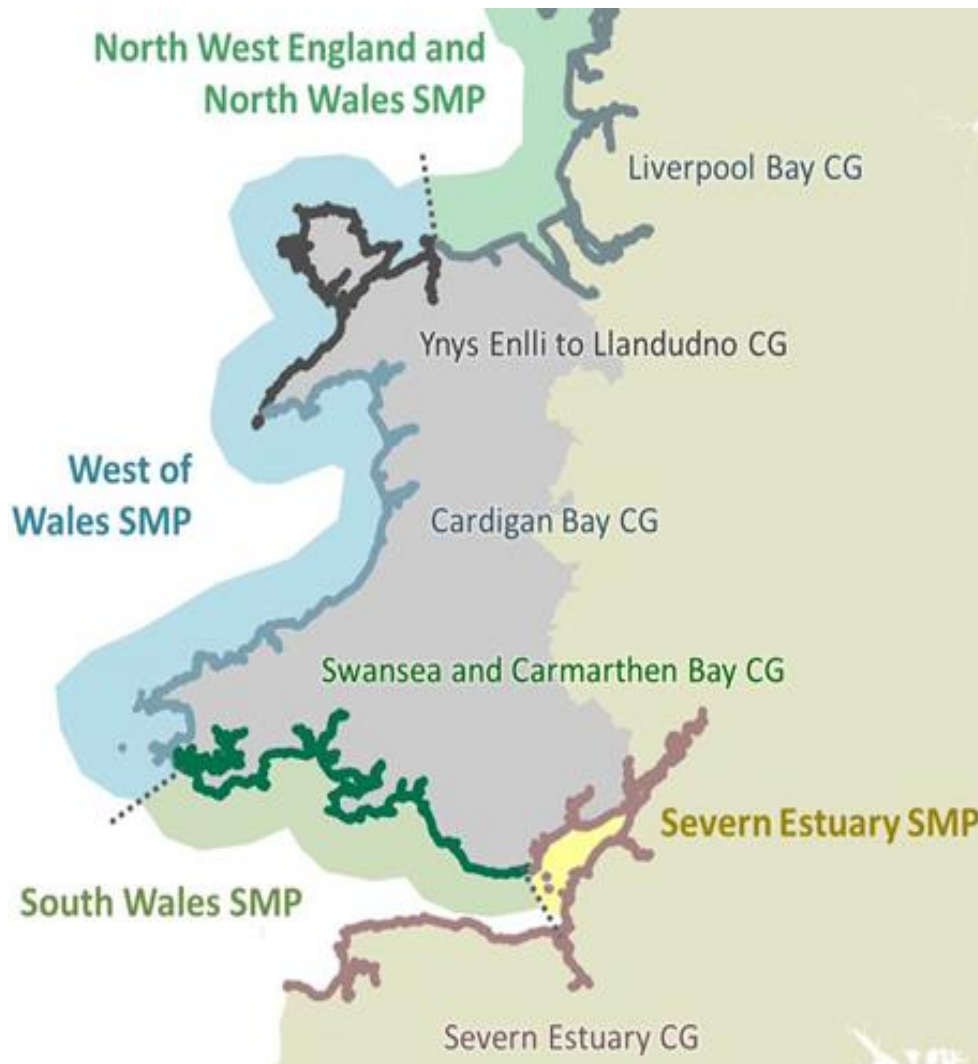
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## Shoreline management



### SMP2s and coastal groups relevant to Wales



The second generation of Shoreline Management Plans (SMP2s) have been developed by stakeholders to facilitate development of sustainable Flood and Coastal Erosion Risk Management (FCERM) policies over the long-term<sup>28</sup>. These will reduce the risks to people and the built, historic and natural environments<sup>28</sup>. SMP2s are used to inform wider strategic planning to reduce risk<sup>28</sup>.

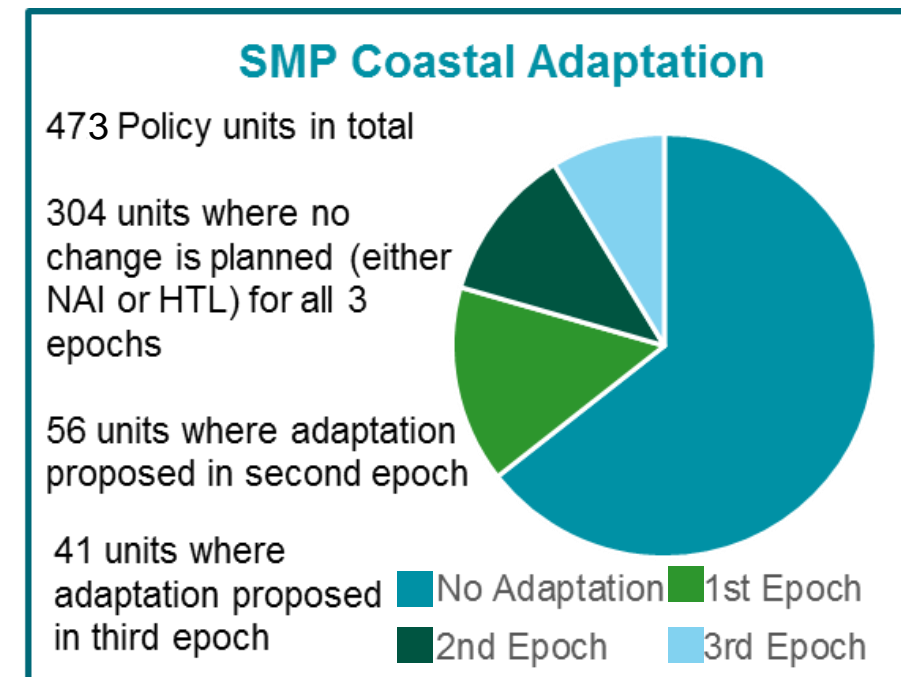
Policy options of: Hold The Line, No Active Intervention and Managed Realignment are assigned to sections of the coastline over the short (2005-2025), medium (2025-2055) and long terms (2055-2105)<sup>28</sup>. A combination of policies may be proposed over the length of the SMP2 for a coastal area<sup>28</sup>.

Coastal adaptation (modifying the coast to make it more resilient) will be required as directed by changes in the SMP2 policy to deliver a more sustainable and resilient coastline to help manage and mitigate flood and coastal erosion risks.

Where No Active Intervention is proposed, there will be a need to consider how this is undertaken e.g. potential to stop maintaining flood defence assets

Nature based solutions where locations are expected to remain defended will also need to be considered to improve environmental resilience and deliver wider benefits. Such approaches may be considered as a stand along or hybrid intervention with a traditional hard engineering design.

Welsh Government's Natural Resources Policy prioritises actions to tackle the challenges and in addition realise opportunities associated with coastal zone management, adaptation and nature-based solutions<sup>29</sup>.







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## Marine waste



Waste in the marine environment includes waste water from housing and industry, drainage from storm water and runoff, agriculture and pollution from urban and rural areas<sup>2</sup>. If run off from land enters the environment, it is called diffuse pollution and can have negative impacts on large areas of freshwater and marine systems<sup>30</sup>. Point source pollution are discrete discharges from a single source; these are often individually minor but collectively can result in significant environmental impacts<sup>30</sup>. The impacts of untreated waste water range from oxygen depletion leading to ecosystem damage and potential health risks from water-borne diseases; on top of this, litter poses a significant threat to marine ecosystem integrity and resilience, plastics in particular<sup>2</sup>.

Wales has made progress to ensure that crude sewage outfalls have been replaced with waste water treatment works, and Welsh Water has a strategic response to help achieve 'good' environmental status for our rivers, lakes and coastal waters<sup>31</sup>. Some diffuse source pollution that contributes to bacterial loading of bathing waters includes incorrectly connected drainage; badly managed private sewage treatment systems; unmaintained septic tanks serving dwellings and public toilets; poor management and runoff of livestock rearing areas<sup>32</sup>. In future plans for treatment works, the risk to bathing water and shellfish beds are taken into account and the number of spills allowed per year is restricted<sup>31</sup>.

For several reasons including more frequent severe storms, and the growth of built up areas, Welsh Water's sewer network has to deal with increasing flows of surface water<sup>2</sup>. Viable sewerage infrastructure and drainage is important in supporting economic and social development and for reducing the risk of flooding in urban areas<sup>2</sup>.

Some agricultural practices such as cattle accessing streams and rivers, can have a negative impact on the water quality and in particular pose a threat to coastal waters<sup>33</sup>. Looking after our soils by preventing erosion and runoff into streams and rivers and ensuring that manures, slurry and other wastes are spread and managed in line with the Code of Good Agricultural Practice is important to protect water quality<sup>34</sup>. Fencing out river banks to prevent livestock entering the river and poaching (trampling) the banks (leading to soil erosion), is also beneficial to water quality, while also providing valuable habitat corridors for wildlife<sup>33,35</sup>.



©NRW. Borth Neigwl EC bathing water. Coastal (bathing waters and shellfish) virtual team



©NRW. Morfa Nefyn EC bathing water Coastal (bathing waters and shellfish) virtual team





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## Marine industries



Our marine area supports many industries (see [following slide](#) for “energy”):

- **Marine aggregates** involve the extraction of sands and gravels from the sea bed. 47% of sand and gravel sold in Wales is from the marine environment, with 80% of south Wales fine aggregate demand being met from marine sources.
- **Dredging around ports**, marinas and harbours removes silts and maintains navigable depths.
- **Aquaculture** includes different systems of rearing shellfish, fish and seaweeds, including harvesting. Marine biomass for energy production from seaweed harvesting is emerging as one of the newest prospective aquaculture business sectors. In Wales, there are nine aquaculture businesses across 13 sites employing 23 fixed term staff. The bulk of production is live mussels at 37% of the UK total tonnage of mussels.
- **Fisheries** includes inshore and offshore commercial fishing, including harvesting molluscs and crustaceans, seaweed, sponges and algae. Other areas associated with this industry include fisheries enforcement agencies, boat building and boat maintenance. There are 33 fishing ports and 417 boats with 842 fixed term staff employed, in Wales. Recreational sea angling is a growth sector for fishing and tourism.
- **Defence** includes operational vessels and aircraft, HM naval bases, surface and sub-surface navigational interests, underwater acoustic ranges, maritime exercises, amphibious exercises, coastal training ranges and test and evaluation ranges.
- **Subsea cabling** includes laying, operating and maintaining submarine telecommunication cables. The value of telecommunications cabling to Wales is estimated at £260 million.
- **Welsh ports** handled 59 million tonnes of cargo in 2014 representing 12% of total UK throughput. Ports and shipping include sea and coastal water freight transport, sea and coastal water passenger transport and cargo handling. Other activities that support shipping include the building and repairing of ships, the construction of water projects, navigation, pilotage and berthing, storage and warehousing. The demand of importing and exporting of goods, and the capacity of ports is key in driving the direction of ports and shipping in Wales.



© Blaise Bullimore. NRW. Aggregates ship

All information from Wales Marine Evidence Report<sup>2</sup>. See this summary about [Marine Planning for Welsh Seas](#) for more information, and this [Guidance Spreadsheet](#)





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## Marine energy



There is currently limited conventional oil and gas exploration or production taking place within Welsh waters<sup>5</sup>. Wales' deep-water port facilities have significant oil and gas infrastructure for imported fossil fuels, the Port of Milford Haven is capable of delivering 30% of the UK gas demand<sup>36</sup>. Welsh Government has recognised the potential role of the marine environment in new coastal nuclear energy generation facilities<sup>5</sup>.

In Wales there is a high potential for a successful, competitive marine renewable energy industry in Wales due to the abundant wave, tidal and wind resources including good supply chain and grid infrastructure<sup>37</sup>. If harnessed sustainably, marine renewable energy can play a major role in meeting Wales' energy needs<sup>5</sup>.

Deployment of tidal stream devices has included DeltaStream and Minesto Tidal Kite<sup>38</sup>. Planned marine renewable energy developments include the Morlais Tidal Demonstration Zone off the coast of Anglesey<sup>39</sup>, Pembrokeshire Wave Demonstration Zone<sup>40</sup> and the Marine Energy Test Area in Milford Haven<sup>41</sup>. Wales has some of the first offshore wind farms and associated infrastructure (North Hoyle and Rhyl Flats) in the UK and Gwynt y Môr, one of the largest windfarms in the world<sup>42</sup>. There is also potential for future offshore wind installations in Welsh waters<sup>5</sup>.

Some of the challenges for marine renewable energy include uncertainty of environmental impacts, visual impacts and the need for clear policies and strategic planning<sup>5</sup>.



© John Briggs. NRW. Windfarm installation, Wales





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## Marine aquaculture



Aquaculture is the farming of fish and shellfish (WMER). The main types of aquaculture that currently exist in Wales are:

**1. Fish aquaculture**<sup>2</sup> in Wales is land based seawater recirculation systems<sup>2</sup>. Seawater recirculation systems have mainly focused on bass (*Dicentrachus labrax*)<sup>43</sup> and are currently focusing on raising fish for cleaning parasitic sea lice for salmon farms, such as Ballan wrasse (*Labrus bergylta*)<sup>44</sup> and the Lumpsucker (*Cyclopterus lumpus*)<sup>45</sup>.

**2. Shellfish aquaculture**<sup>2</sup> which primarily comes from on-bottom cultivation of mussel (*Mytilus edulis*)<sup>5</sup>. There is currently an interest in growing mussels on ropes strung between buoys in the water column and letting mussel seed settle naturally on the ropes<sup>46,47</sup>.

Welsh Government are committed to develop the sustainable growth of finfish and shellfish aquaculture by 2020<sup>48</sup>.

The non-native Pacific oyster *Crassostrea gigas* is grown on trestles in the Menai Strait<sup>49</sup> and the native oyster is grown on trestles in Milford Haven<sup>50</sup>. There are restrictions on the growth of these aquaculture businesses due to the lack of suitable sites, seed resource and environmental constraints<sup>47</sup>.

There is a growing interest in farming various seaweeds in our waters<sup>47</sup>. Initially seaweeds will be used as a raw material, added-value ingredient and extract for the Welsh food / drink and nutri-business industries<sup>51</sup>.



© Natural resources Wales. Mussel bed.





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In this section we're looking at aspects of the environment which cut across the marine area. These include protected sites, invasive non-native species, physical processes, climate and water quality



© NRW. Subtidal scene in Welsh waters

**Biodiversity: Marine Protected Area (MPA) network**

**Biodiversity: Invasive non-native species**

**Physical processes**

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## Biodiversity: Marine Protected Area (MPA) network

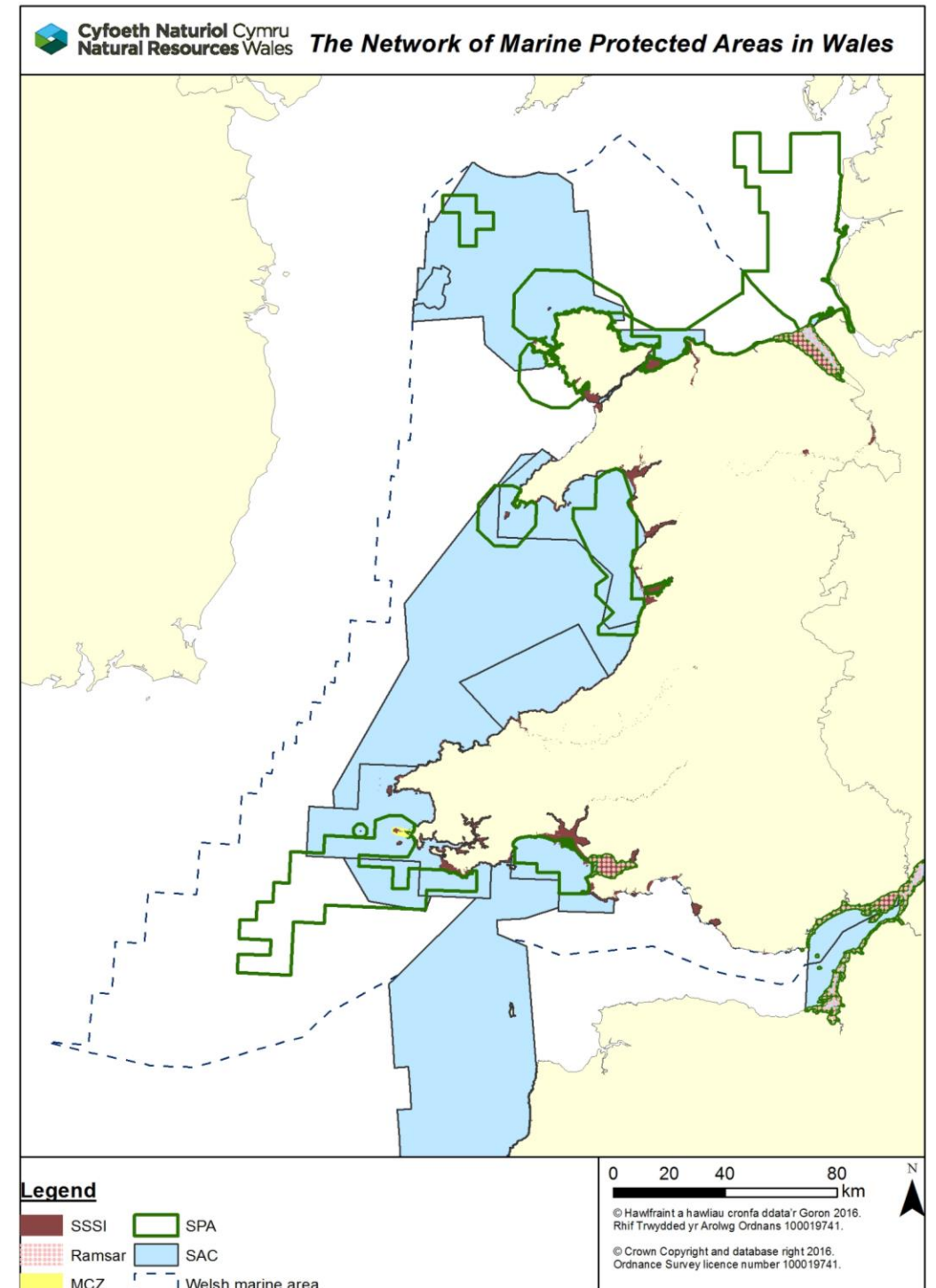
Wales has a rich and diverse marine ecosystem<sup>52</sup>, with 69% of the inshore Welsh waters designated as part of the network of 139 Marine Protected Areas (MPAs)<sup>53</sup>. This [video](#) explains why we have marine protected areas and why they are so important.

Biodiversity is an indicator of the health of our seas<sup>54</sup>. Biodiversity is also one of the measures of resilience of an ecosystem<sup>55</sup> and high biodiversity can also support greater productivity of an ecosystem<sup>56</sup>. Welsh waters are particularly important for some habitats and species<sup>57</sup> e.g. some of the most southerly instances of the highly sensitive and threatened horse mussel beds occur in Welsh waters<sup>58</sup>.

The waters around Cardigan Bay are nationally important for having the only recognised resident community of bottlenose dolphins in England and Wales<sup>59</sup>, with the population numbering somewhere between 200 and 300<sup>60</sup>.

Together with Scotland, Wales holds over 90% of the UK population of Manx shearwaters<sup>61</sup> and over 8% of the world population of Northern gannet<sup>62, 63</sup>. Carmarthen Bay SPA was designated in June 2003 solely for wintering common scoter and is the most important individual wintering site in Britain and Ireland for this species<sup>64</sup>.

A biodiverse marine ecosystem increases resilience and provides many direct and indirect benefits<sup>65, 66, 67, 68</sup>. The fish and shellfish that we eat are part of the marine food web and are therefore dependant on the productivity and interactions within that food web. Some species and habitats (e.g. dolphins and seabirds) are important for tourism, attracting people to the coast<sup>69</sup>. Other habitats and species are important for storage of carbon<sup>70</sup>, maintenance of water quality<sup>71</sup> and waste removal<sup>72</sup>.







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## Biodiversity: Invasive non-native species



Invasive non-native species (INNS) include animals or plants that can spread outside their native range causing damage to the environment, the economy, our health or the way we live<sup>73</sup>. INNS have been estimated to cost the economy of Wales £128 million annually<sup>74</sup>. Marine INNS are often difficult to control or eradicate once they are present<sup>75</sup>. Tackling marine INNS should concentrate on measures to prevent their introduction and spread. Some human activities act as pathways for carrying INNS such as<sup>73</sup>:

- shipping
- recreational boating
- aquaculture
- dredging<sup>76</sup>

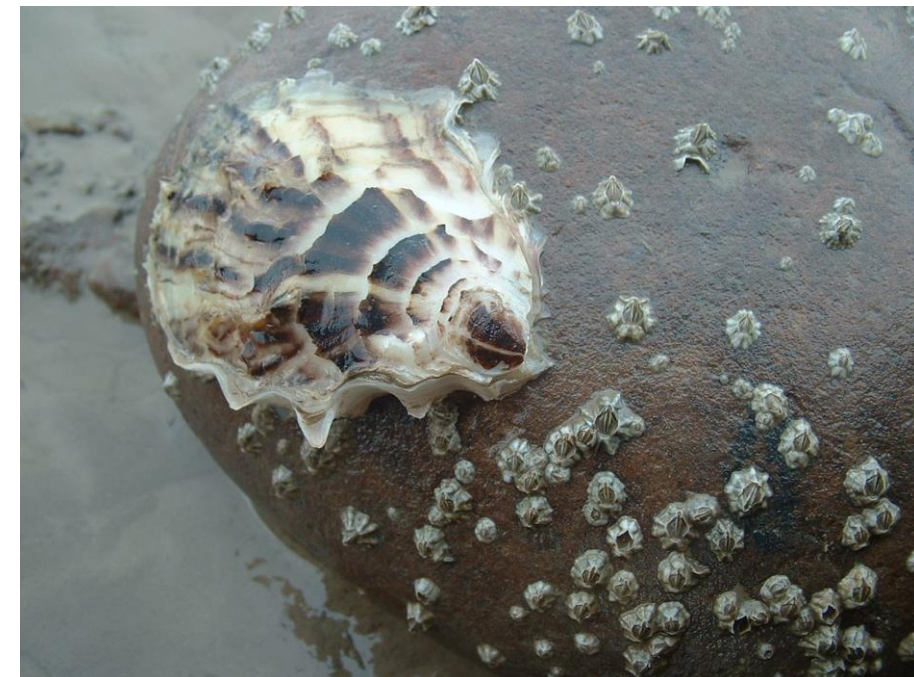
There is a strong correlation between activities in the marine environment and records of INNS<sup>77</sup>. Hotspots for records include marina sites throughout Wales<sup>78</sup>. Priority should be given to targeting the relevant pathways in these areas to reduce the risk of the introduction and spread of INNS<sup>73</sup>. You can find more information [here](#) and [here](#).

In some cases if a species is identified at an early stage and it is a type which can be controlled, it is possible to eradicate it<sup>73</sup>. Ongoing monitoring and surveillance is important to identify the distribution of marine INNS so we can take swift action to control the risk of spread or possibly remove new introductions<sup>73</sup>.

You can find more information in the Welsh Governments [Priority Marine INNS Species](#) publication.



**Right:** Slipper limpet (*Crepidula fornicata*) © Great Britain Non Native Species secretariat 2018  
**Below:** Pacific oyster (*Crassostera gigas*) Paul Brazier NRW







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## Physical processes



Marine and coastal physical processes consists of:

- hydrodynamics (e.g. waves, tides, currents, water levels)
- sediments and their transport and geology
- topography
- morphology

The interaction of these components give rise to dynamic conditions which change over a range of time and spatial scales, and respond to both natural and human changes<sup>79, 80, 81</sup>.

Physical processes are not uniform and vary based on the regional and local geology, sediments and the exposure to external forces<sup>79, 80, 81</sup>. Different conditions give rise to a mix of high energy to low energy (sheltered) environments, which support different landforms and bedforms, and a diverse range of habitats and species<sup>79, 80, 81</sup>.

The Welsh coastline has a large tidal range e.g. the Severn Estuary has the second highest tidal range in the world<sup>82</sup>. Fast tidal current speeds are present in the Severn Estuary and also off the coast of Pembrokeshire and Anglesey<sup>2</sup>. Parts of south west Wales can experience high energy waves<sup>2</sup>.

The coast and seabed has variable sediment types from fine muds and silts in sheltered estuaries, to sandy beaches, dunes and subtidal banks, shingle beaches and 'Sarnau' that extend into Cardigan Bay, and rocky shores, cliffs and seabed<sup>2</sup>. Physical processes interact and influence marine receptors in some way, and are a fundamental element influencing the nature and condition of the marine and coastal environment<sup>79, 80, 81</sup>.

Physical processes support a range of benefits such as:

- the quality and extent of marine and coastal habitats, species, and geological forms
- natural assets/infrastructure for recreation, tourism and businesses (e.g. beaches)
- providing energy for marine renewables, sand resource for aggregates and water for coastal based industries
- providing natural flood and coastal erosion protection<sup>2, 79, 80, 81</sup>.

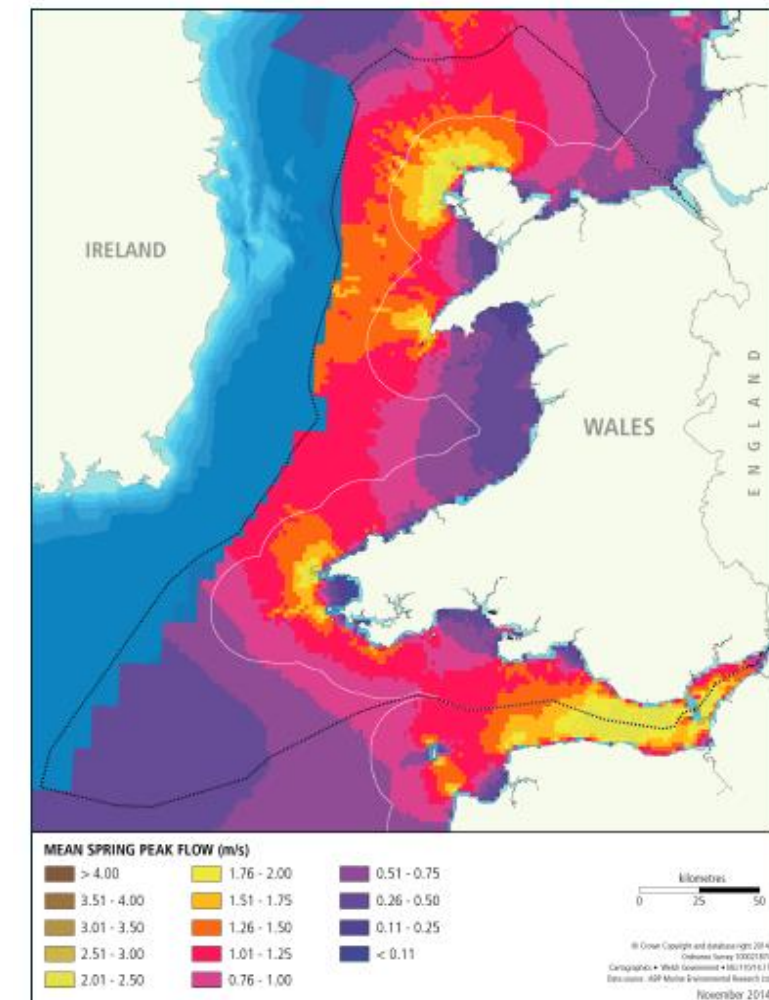


Image from Wales Marine Evidence Report: Summary. Page 25





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## Climate



The rising global concentration of greenhouse gases in the atmosphere is understood to be driving climate change<sup>26</sup>. It is estimated that human activities have driven approximately 1.0°C of global warming above pre-industrial levels with a predicted rise to 1.5°C between 2030 and 2052, should the current rate continue<sup>26</sup>.

The UK Marine Climate Change Impacts Partnership ([www.mccip.org.uk](http://www.mccip.org.uk)) demonstrates the effects climate change is having on UK seas and coastlines. Evidence shows increased sea surface temperature and ocean acidification levels, which are causing major issues for marine ecosystems<sup>83, 84</sup>. Some southern marine species are becoming more commonplace in UK waters and the future distribution of seabirds is uncertain as sea temperatures rise and extreme high-water events are becoming more frequent<sup>85, 86, 87</sup>. For more information around how climate change may impact protected marine species and habitats see [here](#) for a series of summary cards. For further detail on top down and bottom up process and climate change in UK shelf seas see [here](#).

Welsh Government's "[Climate change strategy for Wales](#)" has a target to reduce greenhouse gas emissions in Wales by 3% every year and achieve at least a 40% decrease by 2020 compared to 1990 levels.

The marine area provides a large potential for low carbon energy sources. Wales has 1200km of coastline, strategically located deep sea ports, accessible grid infrastructure, a manufacturing base and up to 6.2GW of estimated generating capacity<sup>88</sup>. This gives us the potential to become a global leader on low carbon energy production.



© Sarah Wood NRW. Wind Farm installation, Wales





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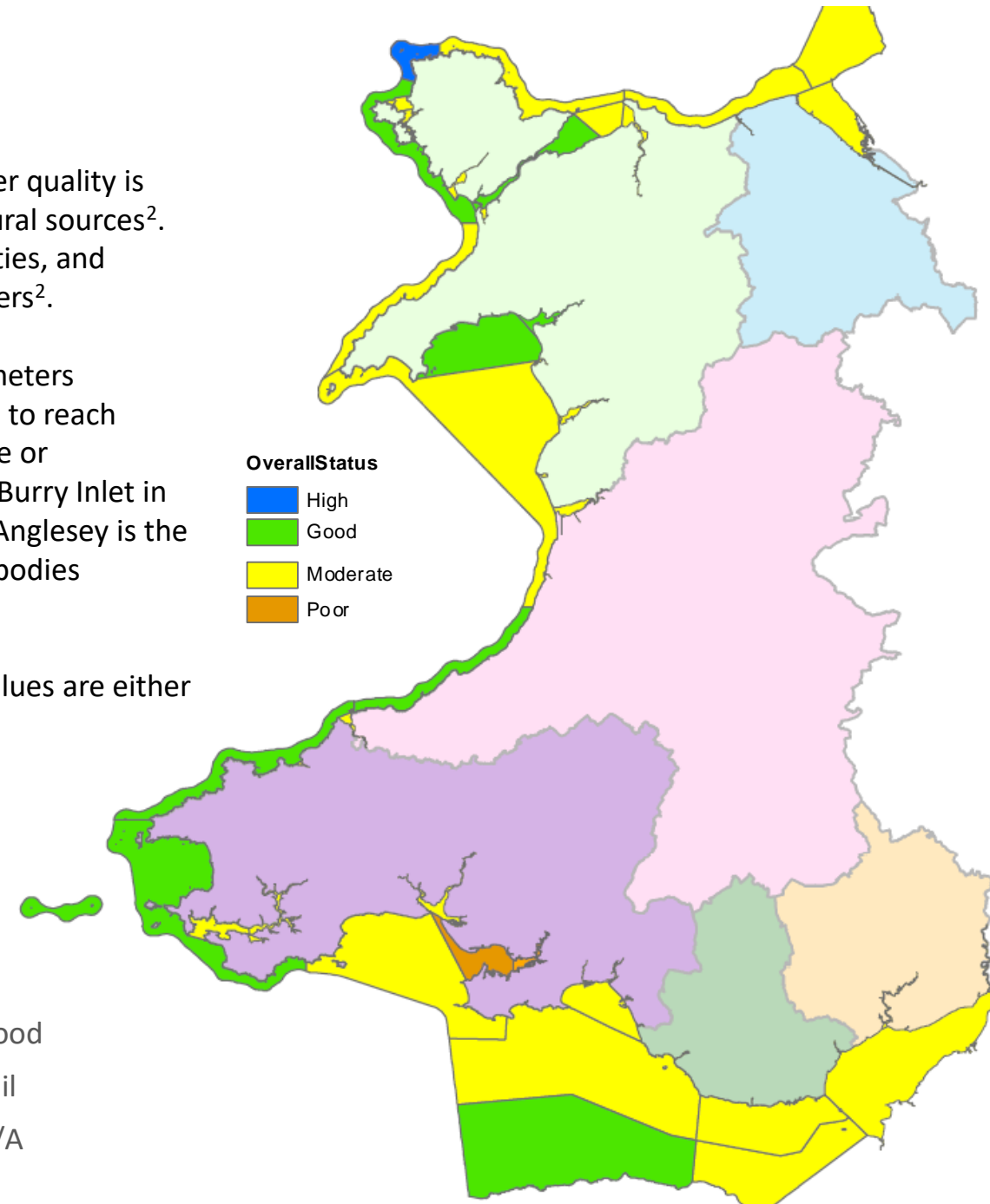
## Water quality status



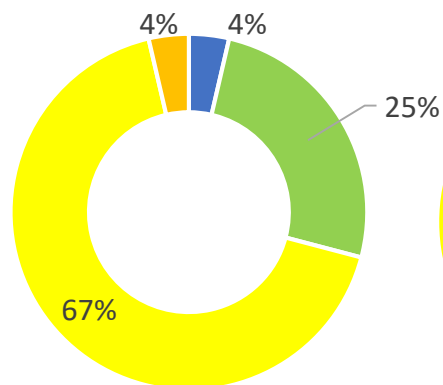
Good water quality is the foundation to a healthy marine and freshwater ecosystem<sup>96</sup>. When water quality is high (or good), the water body has more resilience to change and pressures from human and natural sources<sup>2</sup>. Having good water quality benefits tourism and recreation and the wellbeing of coastal communities, and supports coastal development, coastal economic prosperity, coastal social wellbeing amongst others<sup>2</sup>.

The Water Framework Directive (WFD) requires Wales to monitor a range of environmental parameters (physical, chemical and ecological) to assess the overall status of water bodies<sup>89</sup>. WFD requires us to reach 'good' overall status for all water bodies<sup>89</sup>. There are 55 water bodies classified as either estuarine or coastal<sup>91,95</sup>. The map opposite shows the status of these water bodies. Both the inner and outer Burry Inlet in South West Wales are classified as 'poor' water bodies, while the Skerries coastal water body off Anglesey is the only marine water body classified as 'high' in Wales<sup>95</sup>. These represent 4% of total marine water bodies respectively.

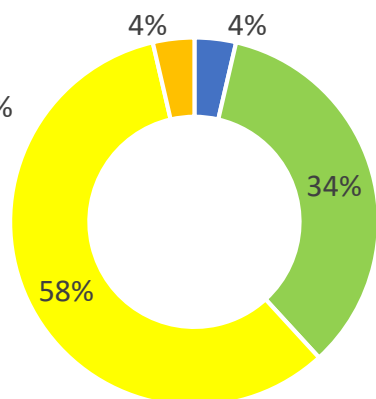
Chemical status contributes to the overall status results for marine water bodies. Classification values are either 'good' or 'fail' for chemical status<sup>91,95</sup>.



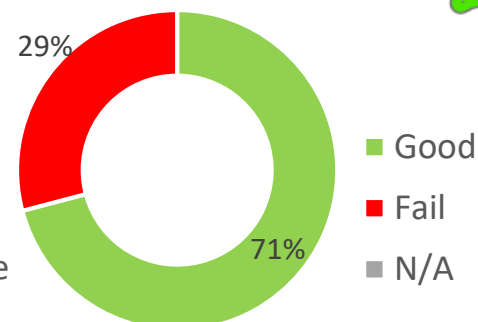
**Overall Status**



**Ecological Status**



**Chemical Status**



High

Good

Moderate

Poor

Bad

Good

Fail

N/A





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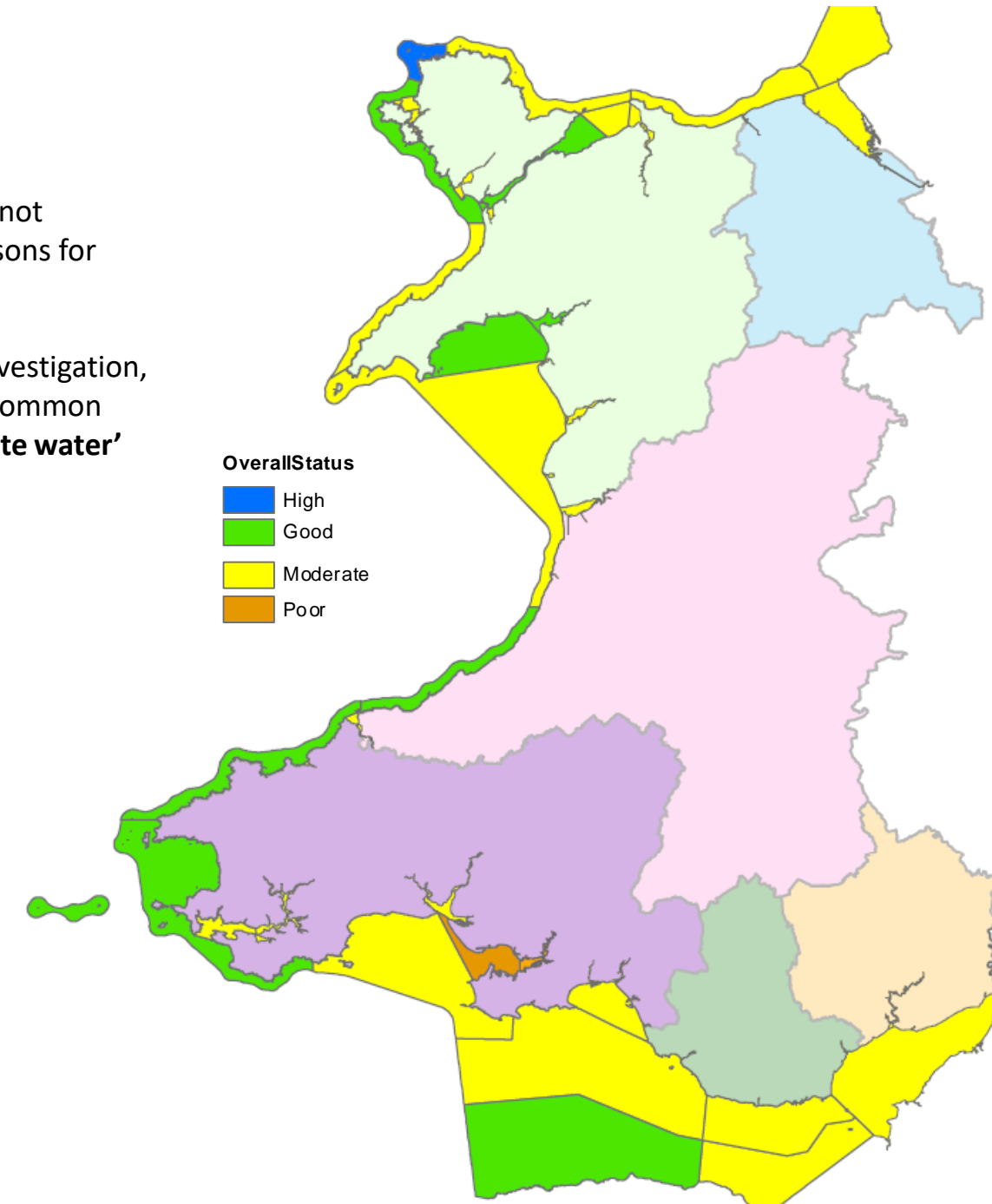
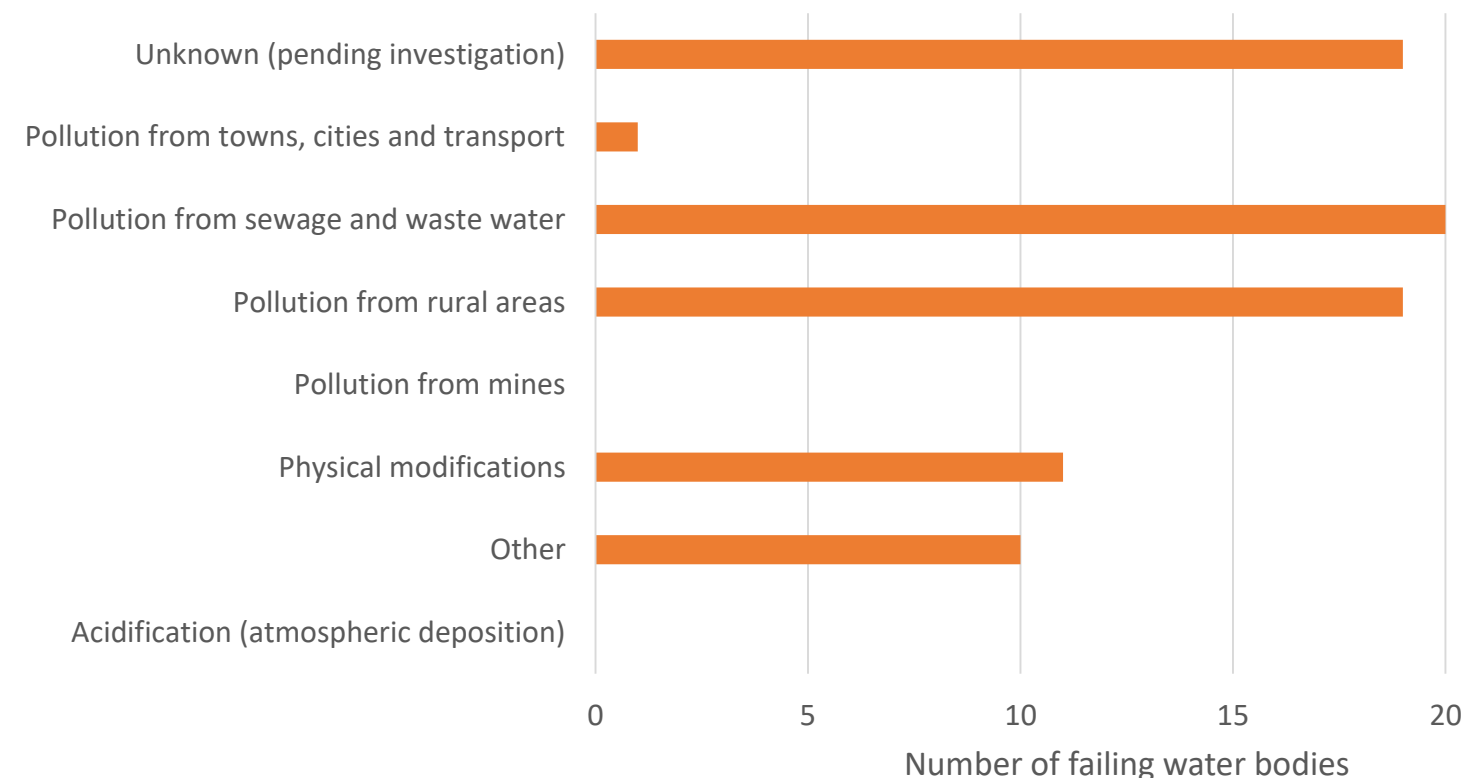
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## Water quality status: Reasons for not achieving good status (RNAGs)

The Water Framework Directive (WFD) requires us to investigate the reasons why water bodies are not achieving good overall status under the assessment criteria<sup>89</sup>. We refer to this list of factors as 'Reasons for Not Achieving Good (status)', abbreviated to RNAGs.

The chart below represents an overview of RNAGs into 8 broad categories. Many sites are under investigation, which means that NRW can not say why a particular water body is failing. For 2018, the two most common confirmed RNAGs for the coastal and transitional water bodies are '**pollution from sewage and waste water**' and '**pollution from rural areas**'<sup>90,91</sup>.

Reasons for Not Achieving Good Status







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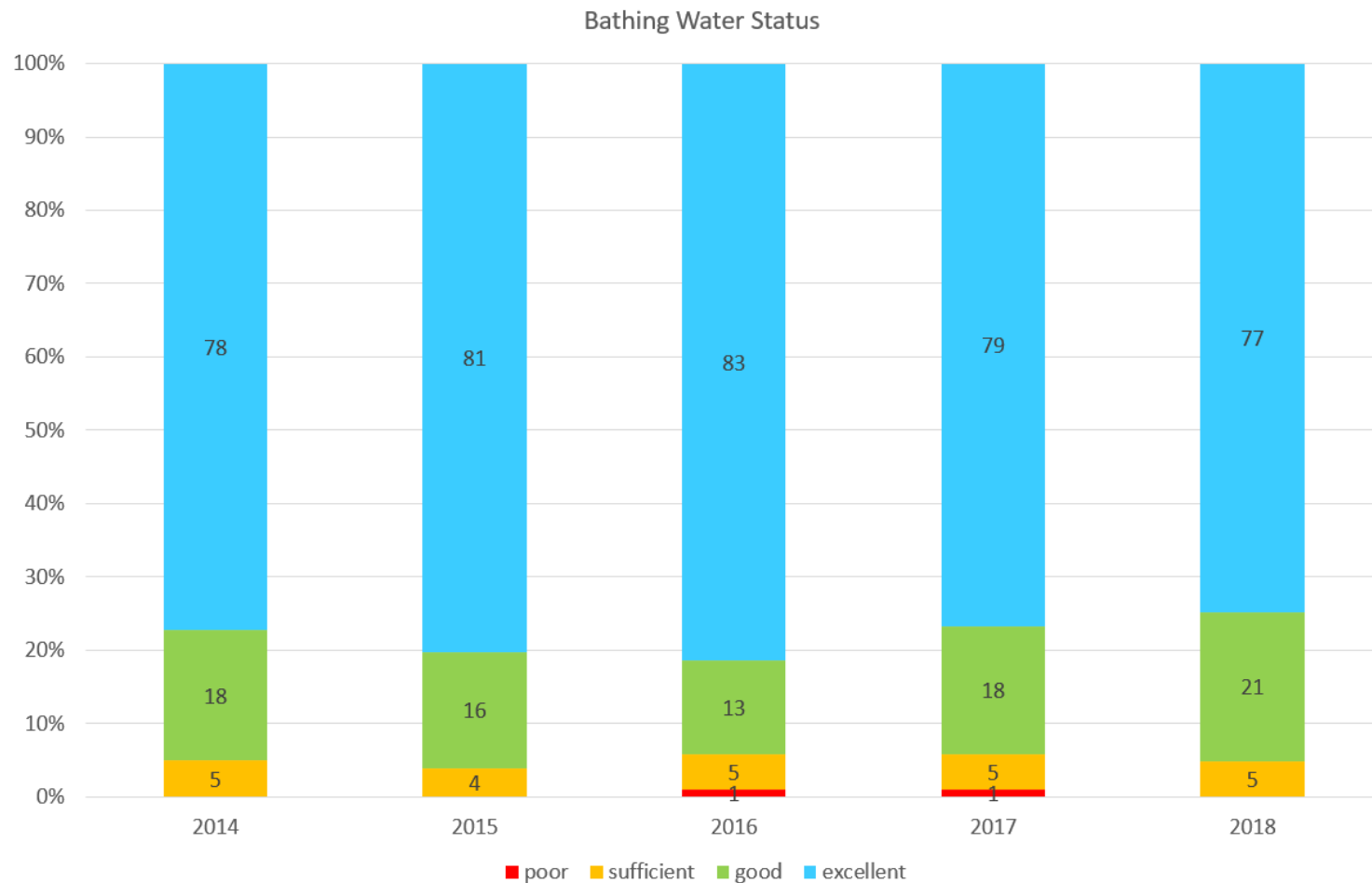
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## Bathing Waters

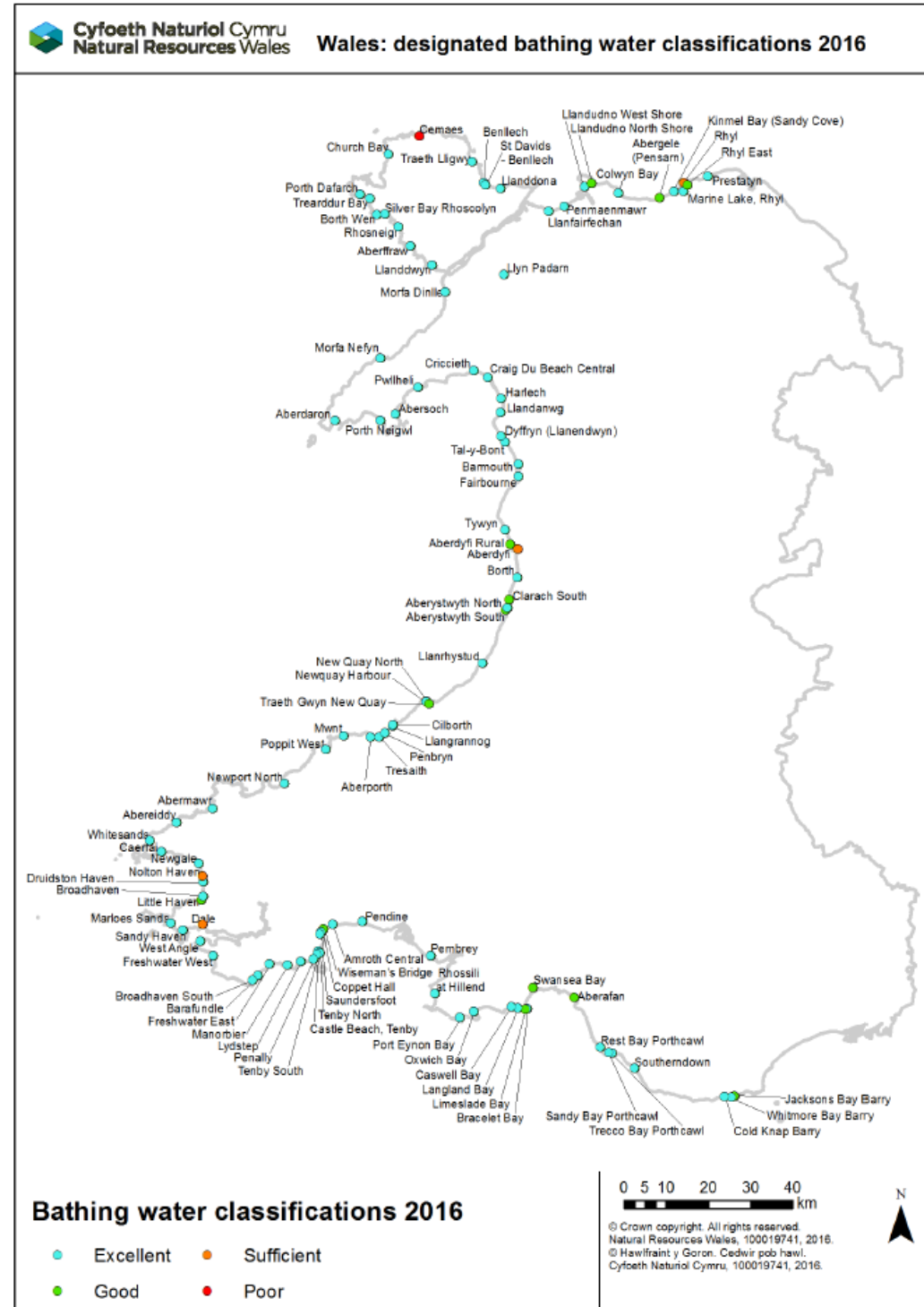


There are 104 designated bathing waters in Wales: In 2017 Wales had 45 Blue Flag Awards, 25 Green Coast Awards and 85 Seaside Awards<sup>92</sup>.

There are 22 designated areas where water quality is maintained and improved for shellfish growth<sup>92</sup>. The Water Framework Directive monitors a variety of ecological, chemical and physical elements and in 2015 37% of water bodies were at Good or Better Overall Status<sup>89, 90, 91</sup>.



Bar chart of bathing water status for all Wales 2014 - 2018







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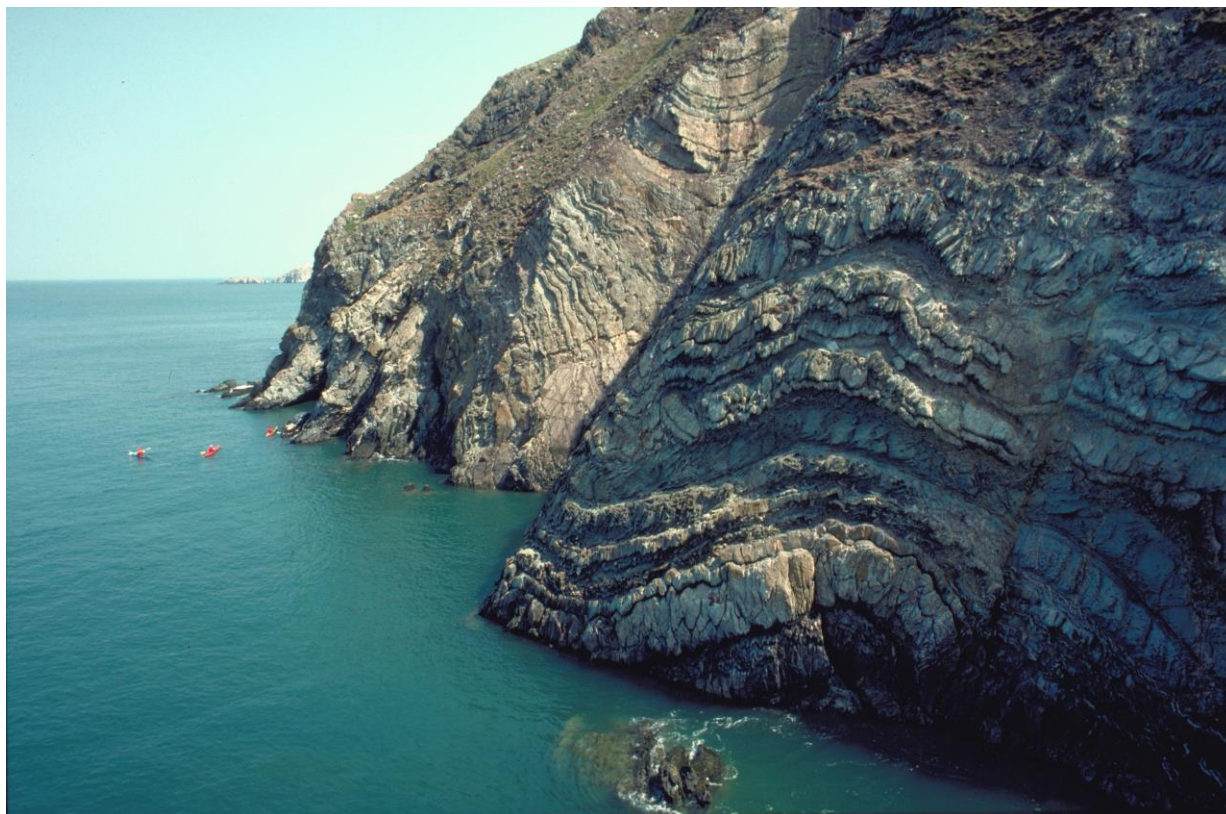
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## Geodiversity



Geodiversity is the variety of rocks, minerals, fossils, landforms, sediments and soils, together with the natural processes which form and alter them<sup>2</sup>. Geodiversity provides many of Wales' natural resources, strongly influences our landscape, biodiversity and culture and is internationally important for geoscience research<sup>2</sup>.

For a relatively small country Wales has some of the most varied geology in the world and provides evidence from the Earth's early history through the last Ice Age to the present day – covering some 700 million years<sup>93</sup>. Within Wales and the adjacent seas, elements of all the major geological systems are to be found<sup>94</sup>. It is this variety, together with structural features such as folds and faults, and many landforms created by ice and water, which give us such a rich geodiversity<sup>94</sup>.



©Peter Wakeley. Marine coastline of Wales



Three Cliffs Bay. Natural Resources Wales





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© Natural Resources Wales. Skomer Island Marine Conservation Zone (MCZ)

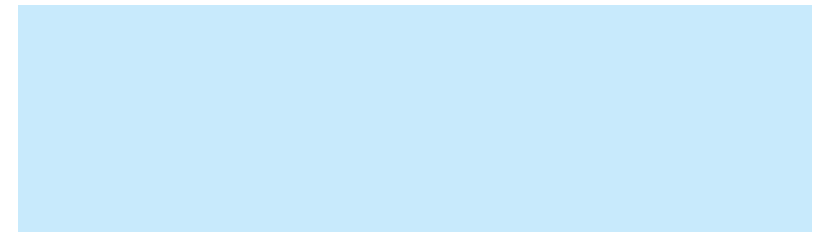
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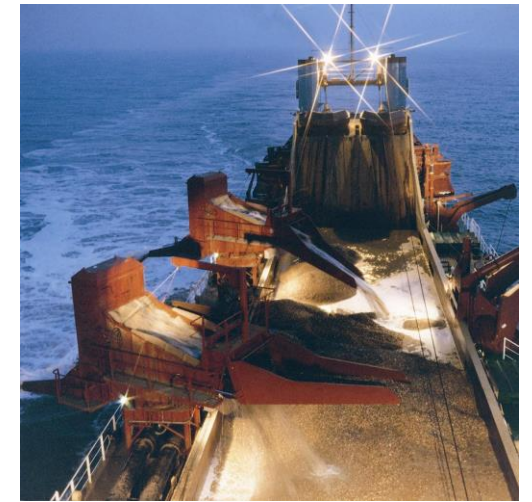
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## Management



The rich marine resources of Wales support a range of activities and developments. Approaches to management of marine natural resources are quite different to that on land, where we commonly manipulate the environment to deliver the benefits we need– planting trees, growing crops etc. Manipulating habitats and species in the marine environment is much more challenging than at the coast and on land, and because of this, marine management focusses on **managing human activities at sustainable levels**. There is a range of [legislation](#), policy and regulation currently in place to manage the marine area that can support the Sustainable Management of Natural Resources.



Images from top left, clockwise: Amlwch Harbour, Anglesey - © John Briggs (NRW), Windfarm – © John Briggs (NRW), Dredging for mussel spat off Caernarfon Bar - © Kate Smith (NRW), Sand dredger loading cargo – courtesy of Tarmac Marine Dredging Ltd., Windfarm horizon – © Charlie Lindenbaum (NRW).



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## Legislation

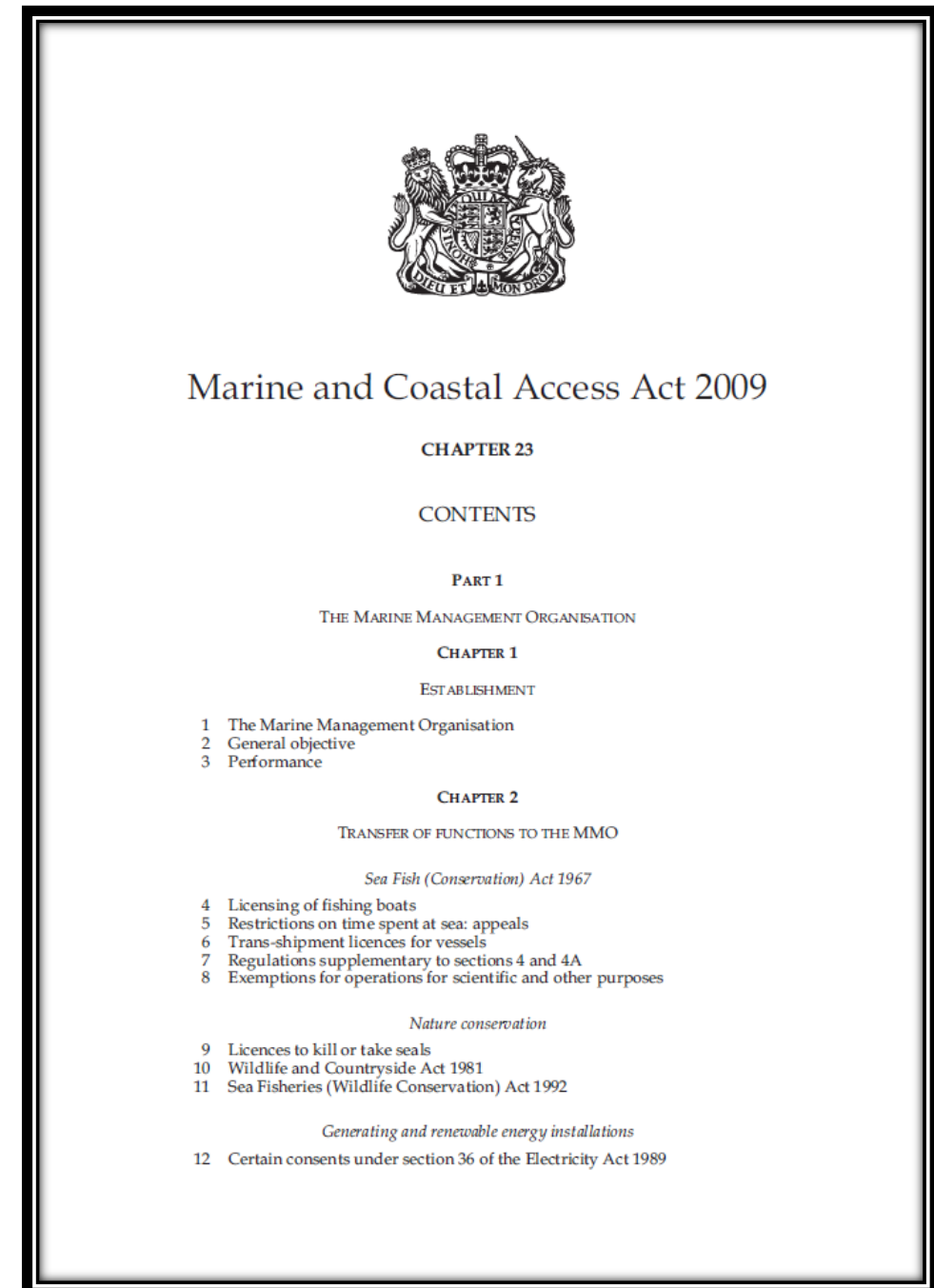


There is a wide range of legislation that applies to the marine area of Wales, including:

- **Marine Strategy Framework Directive** – achieving Good Environmental Status of our Seas through an Ecosystem Approach
- **Water Framework Directive** – achieving Good Ecological Status of Water bodies
- **UK Marine and Coastal Access Act** – Marine Planning, Licensing and Marine Conservation Zones
- **Habitats Directive** – Special Areas for Conservation (habitats and species)
- **Birds Directive** – Special Protection Areas (Birds)
- **Environmental Impact Assessment Directive** – Integrated assessment of impact of activities
- **Strategic Environmental Assessment Directive** – Integrated assessment of impact of plans
- **Environment (Wales) Act** – Sustainable Management of Natural Resources in Wales
- [Natural Resources Policy](#) – Welsh Governments National Priorities

Legislation is important because it sets the legal framework for the development of plans and policies that in turn drive the regulation and management of the marine environment.

Different legislation can support the sustainable management of natural resources in different ways. The Marine Strategy Framework Directive is particularly important as it requires the application of an ecosystem-based approach to managing the marine area. The principles of the Ecosystem Approach are well aligned with the principles of Sustainable Management of Natural Resources set out in the Environment Act.







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## Plans and policy



- **The Welsh National Marine Plan (WNMP)** – sets the framework for the Sustainable Development of Welsh Seas
- OSPAR commitment to develop an **ecologically coherent, well-managed network of Marine Protected Areas**
- **Shoreline Management Plans** – sets out policies for the sustainable management of coastal flood defence assets into the future
- **River Basin Management Plans** – sets out local and national actions needed to improve water quality of fresh, estuarine and coastal waters
- **Area of Outstanding Natural Beauty Management Plans** – sets out management to conserve and enhance the ‘special qualities’ of Areas of Outstanding Natural Beauty
- **Special Area of Conservation Management plans** – sets out actions needed to improve the condition of Special Areas of Conservation

Plans and policies are important as they influence what decisions are made about the use of the marine and coastal environment, and can drive action around priority issues.

The WNMP is key to supporting the sustainable management of marine resources, because once in place, it will govern any authorisation or enforcement decisions that are relevant to the marine environment. The WNMP embeds the sustainable management of natural resources and ecosystem approach principles, supports integrated decisions that take full account of environmental, social and economic issues. Welsh Government have brought together evidence and developed a data portal to hold information that could support decision-making in line with the plan.

Having an ecologically coherent, well-managed network of Marine Protected Areas will help us maintain and enhance the resilience of marine ecosystems, particularly as such sites make up a significant proportion of our inshore waters.

Shoreline Management Plans set out policies for the short, medium and long term to inform decision around managing our coastline.



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## Regulation and enforcement



- **Marine licensing** - authorisation required for many activities that occur below high water
- **Planning permissions** - terrestrial permissions that are required for many activities happening above low water
- **Discharge permits** - environmental permission required for discharging water
- **SSSI assents and consents** - required for certain activities taking place within Special Site of Scientific Interest
- **Fisheries byelaws** – enabling management of a variety of aspects of fisheries
- **Enforcement regimes** for all of the above

Regulation enables the environmental (and other) impacts of an activity to be assessed, and modified where necessary, before allowing it to go ahead. It also prevents unsustainable activities occurring and ensures that legislation, plans and policies have been taken into account.

Enforcement is necessary to ensure compliance with regulation that has been put in place. Many regulatory regimes involve public participation, and require us to bring together evidence to support decision-making. Regulation supports integrated decisions making by taking into account relevant legislation, planning, policies and interests.

Not all activities that occur in the marine and coastal environment are regulated, and a number of other voluntary initiatives and tools can be used where necessary to support sustainable use when necessary e.g. codes of conduct have been adopted to reduce disturbance to wildlife by recreational vessels.



Image from:

[http://www.westerntelegraph.co.uk/news/15888677.Fishing\\_patrol\\_vessel\\_being\\_built\\_in\\_Pembroke\\_Dock\\_to\\_b\\_e\\_named\\_after\\_former\\_First\\_Minister\\_Rhodri\\_Morgan/](http://www.westerntelegraph.co.uk/news/15888677.Fishing_patrol_vessel_being_built_in_Pembroke_Dock_to_b_e_named_after_former_First_Minister_Rhodri_Morgan/) Accessed 27.04.18





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## Challenges and opportunities



The marine area faces lots of challenges and opportunities – many of these have been explored and identified, but there are lots we still don't know about. Here are some that we know about:

**Natural Resources Policy challenges.** These are some of the challenges we are trying to address through the Area Statements

- Reverse the decline in biodiversity
- Safeguard and increase carbon stores
- Maintain productive capacity
- Reduce the risk of flooding
- Support climate change mitigation and adaptation through ecosystem approaches
- Reducing noise and air pollution
- Improve the quality and ensure the quantity of our water
- Taking action to reduce the pressures on natural resources such as through resource efficiency and renewable energy
- Supporting preventative approaches to health outcomes, with a particular focus on key public health issues of transport related air and noise pollution, tackling physical inactivity and mental health

### Improving the Ecological Status of coastal and estuarine water bodies in Wales

- Physical modification
- Nutrient Enrichment
- Chemicals

### Improving condition of Welsh Marine Protected Areas network

- Marine fisheries
- Marine litter
- Coastal and flood erosion risk management
- INNS
- Access and recreation
- Water pollution

### Marine planning

- Growth in Tourism and Recreation
- Growth in Marine renewables
- Growth in Aquaculture
- Ensuring multiple benefits
- Supporting ecosystem resilience
- Supporting wellbeing of coastal communities

### Coastal adaptation

- Sustainable decision making at the coast
- Implementing Shoreline Management Plan policy (and challenging the policy if appropriate)
- Working with natural processes to mitigate flood risk and enhance the environment





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## Evidence



Natural Resources Wales has produced an Area Profile for each of the 7 Areas for which it will be developing an Area Statement. Area Profiles provide a concise and user-friendly summary of the evidence about our natural resources and some of the issues they face. The Area Profiles aren't an exercise in gathering new data but are a collation of existing evidence displayed and interpreted for that area.

The Marine Area Profile draws heavily on existing quality assured and peer reviewed evidence and data, particularly those set out in Welsh Government's 'Wales Marine Evidence Report', and the associated online marine data portal. These products provide a more comprehensive review of all relevant marine evidence for Wales and will be regularly updated. The Marine Area Profile seeks to reflect key aspects of this evidence as a basis for comparison with the other Area Profiles, and to support conversations with partners to develop a marine Area Statement. All Area Profiles have been split into three sections: *people and place*, *natural resources* and *our environment*.



© NRW. Skomer lobster carapace measurement





## Glossary of Acronyms



**FCERM:** Flood and coastal erosion risk management

**INNS:** Invasive non-native species

**KM:** Kilometres

**MCZ:** Marine Conservation Zone

**MPA:** Marine Protected Area

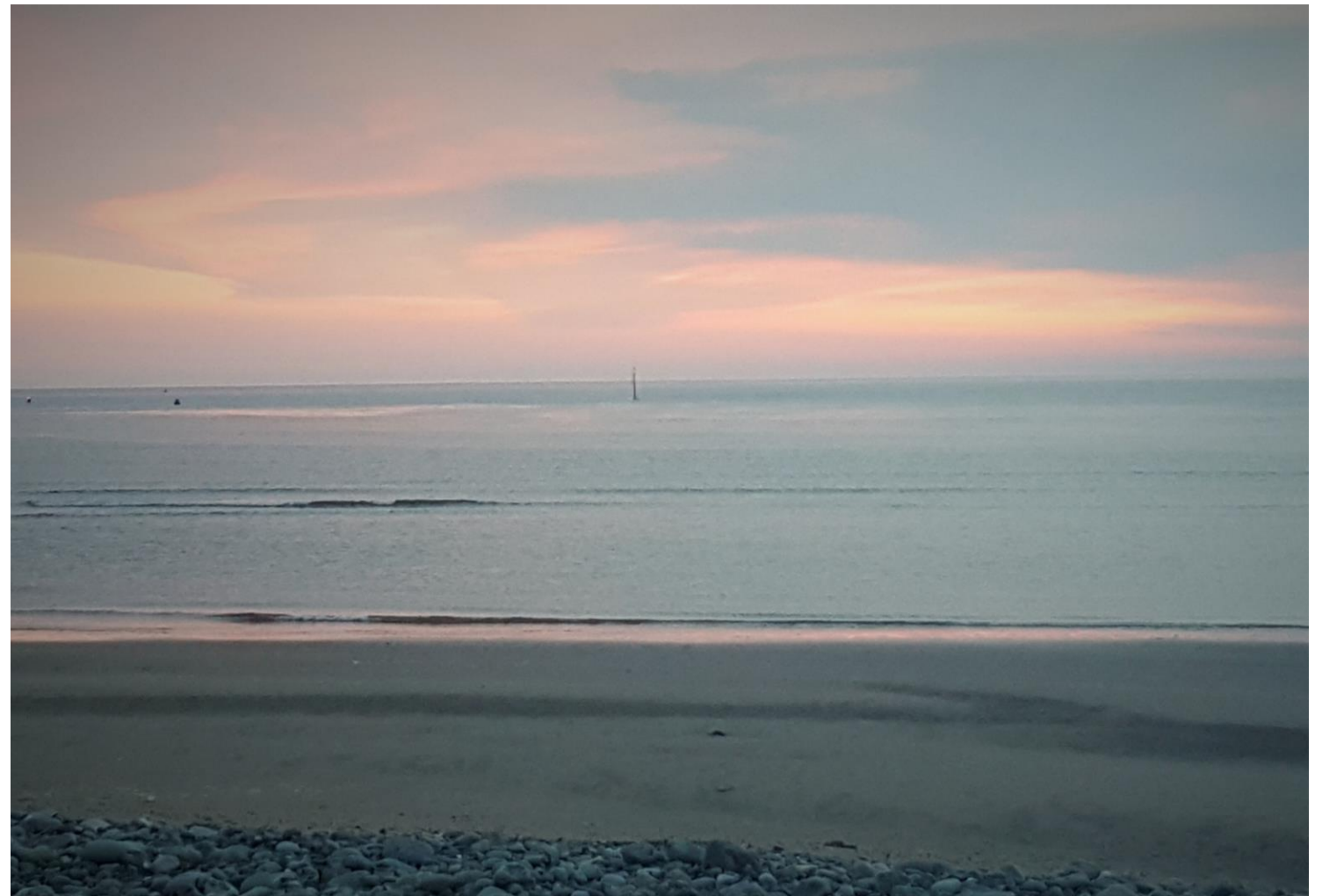
**NRW:** Natural Resources Wales

**RNAG:** Reason for not achieving good status

**SMP:** Shoreline Management Plan

**WFD:** Water Framework Directive

**WNMP:** Welsh National Marine Plan



© NRW. Barmouth beach at sunset 2018



## References



1. Environment (Wales) Act, 2016. <http://www.legislation.gov.uk/anaw/2016/3/contents/enacted>
2. Welsh Government. 2015. Wales' Marine Evidence Report <https://gov.wales/sites/default/files/publications/2018-05/wales-marine-evidence-report-wmer.pdf>
3. Welsh Government. 2019. Wales Marine Planning Portal. <http://lle.gov.wales/apps/marineportal/#lat=52.5145&lon=-3.9111&z=8>
4. Marine Conservation Society. 2019. Wonderful Welsh Seas. <https://www.mcsuk.org/wales/> Accessed 10.04.2019
5. Welsh Government. 2019. Draft Welsh National Marine Plan. WG25663 <https://gov.wales/sites/default/files/consultations/2018-02/draft-plan-en.pdf> Accessed 10.04.2019
6. Welsh Government. 2014. "Welsh Coastal Communities Typology: Final Report" Oxford Consultants for Social Inclusion (OCSI)
7. Sea Change. The sea and our physical and mental wellbeing. <https://www.worldoceannetwork.org/wp-content/uploads/2016/09/5.-Blue-Gym.pdf> Accessed 11.04.2019
8. Turns, A. 2017. The Ocean Effect. Coast Wellbeing [https://bluehealth2020.eu/wp/wp-content/uploads/2017/01/Coast\\_January-2017\\_BlueHealth.pdf](https://bluehealth2020.eu/wp/wp-content/uploads/2017/01/Coast_January-2017_BlueHealth.pdf) Accessed 08.02.2019
9. Depledge, M.H., and Bird, W.J. "The Blue Gym: Health and wellbeing from our coasts" Marine Pollution Bulletin 58 (2009) 947 – 948
10. Natural England. 2012. An approach to seascape Character Assessment. Natural England Commissioned Report NECR105
11. Natural Resources Wales. 2015. National Seascape Assessment for Wales. Evidence Report No: 80 <https://naturalresources.wales/evidence-and-data/maps/marine-character-areas/?lang=en>
12. National Marine Character Areas. 2015. Natural Resources Wales Evidence Report No. 80 <https://naturalresources.wales/evidence-and-data/maps/marine-character-areas/?lang=en>
13. Pembrokeshire Coast National Park Authority. 2014. Management Plan 2015 – 2019 <https://www.pembrokeshirecoast.wales/default.asp?PID=196>
14. National Assembly of Wales. Senedd. 2019. <http://www.assembly.wales/en/visiting/senedd/Pages/senedd.aspx> Accessed 10.04.19
15. European Landscape Convention. 2000. No. 176 <https://www.coe.int/en/web/conventions/full-list/-/conventions/treaty/176>
16. Visit Snowdonia. 2019. Snowdonia mountains and coast. Caernarfon. <http://www.visitsnowdonia.info/caernarfon-48.aspx> Accessed 26.02.2019
17. Wales Directory. 2019. Oxwich, City of Swansea. [https://www.walesdirectory.co.uk/Towns\\_in\\_Wales/Oxwich\\_Town.htm](https://www.walesdirectory.co.uk/Towns_in_Wales/Oxwich_Town.htm) Accessed 26.02.2019
18. Visit Wales. Hidden beauty: Exploring the Llŷn Peninsula AONB. <https://www.visitwales.com/destinations/north-wales/snowdonia/hidden-beauty-exploring-llyn-peninsula-aonb> Accessed 26.02.2019
19. Visit Britain. 2017. Great Briton Tourism Survey. <https://www.visitbritain.org/gb-tourism-survey-2017-overview> Accessed 11.04.2019
20. Welsh Assembly Government. 2008. Coastal Tourism Strategy. <https://gov.wales/docs/drah/publications/Tourism/090612coastaleng.pdf>





## References



21. Visit Wales. 2019. <https://www.visitwales.com/> Accessed 10.04.2019
22. Wales Coast Path. 2019. <https://www.walescoastpath.gov.uk/?lang=en> Accessed 26.02.2019
23. Natural Resources Wales. 2014. Wales Coastal Flooding Review Phase 2 Report. A National Overview by Natural Resources Wales for Alun Davies AM, Minister for Natural Resources and Food.
24. Natural Resources Wales. 2014. Wales Coastal Flooding Review Phase 1 Report, Assessment of impacts, A National Overview by Natural Resources Wales for Alun Davies AM, Minister for Natural Resources and Food.
25. Natural Resources Wales. 2014. Welsh Coastal Storms, December 2013 and January 2014 an assessment of environmental change. Natural Resources Wales Evidence Report No. 33.
26. Intergovernmental Panel on Climate Change (IPCC). 2018. Global Warming of 1.5°C, an IPCC special report on the impacts of global warming of 1.5°C above pre-industrial levels and related global greenhouse gas emission pathways, in the context of strengthening the global response to the threat of climate change, sustainable development, and efforts to eradicate poverty. Summary for Policymakers. IPCC.
27. Natural Resources Wales. 2016. Flood and Coastal Erosion Risk Management in Wales, 2014-2016, Report to the Cabinet Secretary for Environment and Rural Affairs under Section 18 of the Flood and Water Management Act 2010. NRW, Cardiff.
28. Defra. 2006. Shoreline management plan guidance Volume 1: Aims and requirements. Defra, London.
29. Welsh Government. 2017. Natural Resources Policy.
30. British Geological Survey. 2019. Point source and diffuse pollution. <https://www.bgs.ac.uk/research/groundwater/quality/home.html> Accessed: 08.02.2019
31. Welsh Water. 2017. Welsh Water 2050 Consultation document.
32. NRW. 2013. Diffuse strategic action plan. 2013. <https://cdn.naturalresources.wales/media/4059/diffuse-water-pollution-in-wales.pdf?mode=pad&rnd=131596369370000000>
33. Kay, D., Crowther, J., Stapleton, C.M. and Wyer, M.D. 2018. Faecal indicator organism inputs to watercourses from streamside pastures grazed by cattle: Before and after implementation of streambank fencing. Water Resources. 143 229-239
34. Welsh Assembly Government. 2011. The code of good agricultural practice. <https://beta.gov.wales/sites/default/files/publications/2018-02/code-of-good-agricultural-practice-introduction.pdf> Accessed 27.02.2019
35. Bragina, L., Sherlock, O., Rossum, A.J.Van. and Jennings, E. 2017. Cattle exclusion using fencing reduces Escherichia coli (E coli) level in stream sediment reservoirs in northeast Ireland. Agriculture, Ecosystems and Environment. 239 349-358



## References



36. Port of Milford Haven. Port and Dock Facilities. 2019. <https://www.mhpa.co.uk/port-and-dock-facilities/> Accessed 11.04.2019
37. Marine Renewable Energy Strategic Framework (MRESF):  
<http://mresf.rpsgroup.com/resources/Documents/SPP%20and%20Public%20Documents/Public%20Resources/Stage%203/Approach%20to%20Sustainable%20Development/MRESF%20Stage%203%20-%20Approach%20to%20Sustainable%20Development%20March%202011.pdf> Accessed 11.04.2019
38. Wave Hub. Momentum building for the Welsh marine energy sector. 2019. <https://www.wavehub.co.uk/latest-news/momentum-building-for-the-welsh-marine-energy-sector> Accessed 11.04.2019
39. Marine Energy Wales. 2019. West Anglesey tidal demonstration zone. <https://www.marineenergywales.co.uk/marine-energy-in-wales/demonstration-zones/anglesey-demonstration-zone/> Accessed 11.04.2019
40. Marine Energy Wales. 2019. West Anglesey tidal demonstration zone. <https://www.marineenergywales.co.uk/marine-energy-in-wales/demonstration-zones/pembrokeshire-demonstration-zone/> Accessed 11.04.2019
41. Marine Energy Wales. 2019. Marine energy test area <https://www.marineenergywales.co.uk/meta/> Accessed 11.04.2019
42. Innogy. Gwynt y Môr offshore wind farm. <https://iam.innogy.com/en/about-innogy/innogy-innovation-technology/renewables/offshore/gwynt-y-mr-offshore-wind-farm> Accessed 11.04.2019
43. Fish Farming Update. 2018. Harvesting Welsh sea bass. <https://www.fishfarmingexpert.com/article/harvesting-welsh-sea-bass/> Accessed 11.04.2019
44. FISHupdate. 2018. Machrihanish milestone as farmed wrasse spawn. <https://www.fishupdate.com/machrihanish-milestone-farmed-wrasse-spawn/> Accessed 27.02.2019
45. FISHupdate. 2018. Lumpfish farmer plans £1m expansion. <https://www.fishupdate.com/lumpfish-farmer-plans-1m-expansion/> Accessed 27.02.2019
46. Seafish. 2018. Introduction to the Wales Seafood Industry. <https://www.seafish.org/article/introduction-to-the-wales-seafood-industry> Accessed 27.02.2019
47. ABPMer. 2015. A spatial assessment of the potential for aquaculture in Welsh Waters. Proj Ref: R/4297/01 Report No. R.2384  
<https://beta.gov.wales/sites/default/files/publications/2018-05/assessment-of-the-potential-for-aquaculture.pdf> Accessed 27.02.2019
48. Welsh Government. 2013. Wales Marine and Fisheries: Strategic Action Plan. <https://beta.gov.wales/sites/default/files/publications/2018-05/strategic-action-plan-for-marine-and-fisheries.pdf> Accessed 11.04.2019
49. Spencer, B.E., Edwards, D.B., Kaiser, M.J., Richardson, C.A. 1994. Spatfalls of the non-native Pacific oyster, *Crassostrea gigas*, in British Waters. *Aquatic Conservation marine and Freshwater Ecosystems* 4 (3): 203-217
50. The Fish Site. 2018. High hopes for aquaculture in Milford Haven <https://thefishsite.com/articles/high-hopes-for-aquaculture-in-milford-haven> Accessed 27.02.2019  
Accessed 11.04.2019





## References



51. Seaweed Forum Wales 2017. Purpose, aims, opportunity, links. <http://seaweedforumwales.org.uk/> Accessed 27.02.2019
52. Wales Biodiversity Partnership. Biodiversity in Wales. <https://www.biodiversitywales.org.uk/Biodiversity-in-Wales> Accessed 11.04.2019
53. Welsh Government. 2018. Marine Protected Area network management framework for Wales. <https://beta.gov.wales/sites/default/files/publications/2018-10/marine-protected-areas-network-management-framework-for-wales-2018-2023.pdf> Accessed 11.04.2019
54. Féral, J.-P., Fourt, M., Perez, T., Warwick, R.M., Emblow, C., Hummel, H., Van Avesaath, P. and Heip, C., 2003. European marine biodiversity research indicators. Report on Workpackage 1 of BIOMARE (Implementation and networking of large scale, long term marine biodiversity research in Europe).
55. Oliver, T.H., Heard, M.S., Isaac, N.J.B., Roy, D.B., Procter, D., Eigenbrod, F., Freckleton, R., Hector, A., Orme, C.D.L., Petchey, O.L., Proença, Raffaelli, D., Suttle, K.B., Mace, G.M., Martín-López, B. and Bullock, J.M. 2015. Biodiversity and resilience of ecosystem functions. *Trends in Ecology and Evolution*. 30 (11) 673-684
56. Tilman, D., Reich, P.B. and Forest, I. 2012. Biodiversity impacts ecosystem productivity as much as resources, disturbance, or herbivory. *PNAS* 109 (26) 10394 – 10397
57. WWF. 2012. Valuing Wales' seas and coasts. [http://assets.wwf.org.uk/downloads/marine\\_survey\\_report\\_final.pdf](http://assets.wwf.org.uk/downloads/marine_survey_report_final.pdf) Accessed 11.04.2019
58. MCCIP. Marine climate change Impacts Partnership. 2018. Climate change and marine conservation. <http://www.mccip.org.uk/media/1817/mccip-horse-mussel-beds.pdf> Accessed 08.02.2019 Accessed 11.04.2019
59. Seawatch Foundation. 2013. Cetaceans of Wales. <http://www.seawatchfoundation.org.uk/wp-content/uploads/2013/09/Wales-Fact-Sheet.pdf> Accessed 11.04.2019
60. Cardigan Bay SAC. 2019. [http://www.cardiganbaysac.org.uk/?page\\_id=72](http://www.cardiganbaysac.org.uk/?page_id=72) Accessed 11.04.2019
61. JNCC. 2018. Manx Shearwater *Puffinus puffinus*. <http://jncc.defra.gov.uk/page-2869> Accessed 08.02.2019
62. JNCC. 2016. Northern Gannet *Morus bassanus*. <http://jncc.defra.gov.uk/page-2875> Accessed 08.02.2019
63. JNCC. 2016. Northern Gannet. <http://jncc.defra.gov.uk/page-2875> Accessed 11.04.2019
64. Holt, C.A., Austin, G.E., Calbrade, N.A., Mellan, H.J., Hearn, R.D., Stroud, D.A., Wotton, S.R. and Musgrove, A.J. 2012. Waterbirds in the UK 2010/11: The Wetland Bird Survey. BTO/RSPB/JNCC, Thetford.
65. Hopkins, J.J., Allison, H.M., Walmsley, C.A., Gaywood, M. and Thurgate, G. 2007. Conserving biodiversity in a changing climate: guidance on building capacity to adapt. UK Biodiversity Partnership, Defra.
66. MacDougall, A.S., McCann, K.S., Gellner, G. and Turkington, R. 2013 Diversity loss with persistent human disturbance increases vulnerability to ecosystem collapse. *Nature*, 494, 86-89.
67. Atwood, T.B., Hammill, E., Greig, H.S., Kratina, P., Shurin, J.B., Srivastava, D.S. and Richardson, J.S. (2013) Predator-induced reduction of freshwater carbon dioxide emissions. *Nature Geoscience*, 2013/02/017/online
68. Mouillot, D., Bellwood, D.R., Baraloto, C., Chave, J., Galzin, R., Harmelin-Vivien, M., Kulbicki, M., Lavergne, S., Lavorel, S., Mouquet, N., Paine, C.E.T., Renaud, J., and Thuiller, W. 2013. Rare species support vulnerable functions in high-diversity ecosystems. *PLOS Biology*, 11 (5), 1-11



## References



69. Parsons, E.C.M., Warburton, C.A., Woods-Ballard, A., Hughes, A and Johnston, P. 2003. The Value of Conserving Whales: the Impacts of Cetacean-Related Tourism On The Economy of Rural West Scotland. *Aquatic Conservation: Marine and Freshwater Ecosystems*. 13. 397 - 415
70. Beggins et. al., 2010. Seagrass sediments as a global carbon sink: Isotopic constraints. <https://agupubs.onlinelibrary.wiley.com/doi/full/10.1029/2010GB003848> Accessed 11.04.2019
71. Porter et al, 2004. Effect of oysters *Crassostrea virginica* and bottom shear velocity on benthic-pelagic coupling and estuarine water quality <https://www.int-res.com/abstracts/meps/v271/p61-75/> Accessed 11.04.2019
72. Jones and Preston, 2008. Sydney rock oyster, *Saccostrea commercialis* (Iredale and Roughley), filtration of shrimp farm effluent: the effects on water quality <https://onlinelibrary.wiley.com/doi/abs/10.1046/j.1365-2109.1999.00299.x>
73. GB Non-native species secretariat. 2019. Definition of Terms. (<http://www.nonnativespecies.org/index.cfm?pageid=64>) Accessed 08.02.2019
74. Williams, F., R. Eschen, A. Harris, D. Djeddour, C. Pratt, R.S. Shaw, S. Varia, J. Lamontagne-Godwin, S.E. Thomas, S.T. Murphy (2010) The Economic Cost of Invasive Non-Native Species on Great Britain, CABI: Wallingford
75. GB Non-native species secretariat. Marine pathways. <http://www.nonnativespecies.org/index.cfm?sectionid=136>
76. Fasher, M. and Trumper, K. 2001. Review of non-native species legislation and guidance. Ecoscope Applied Ecologists for DEF Accessed 11.04.2019RA
77. Gallardo, B., Zieritz, A. and Aldridge, D.C. 2015. The importance of the human footprint in shaping the global distribution of terrestrial, freshwater and marine invaders. *Plos One*
78. NBN Atlas Website at <http://www.nbnatlas.org> Accessed 08.02.2019
79. Brooks, A.J., Whitehead, P.A., Lambkin, D.O. 2018. Guidance on Best Practice for Marine and Coastal Physical Processes Baseline Survey and Monitoring Requirements to inform EIA of Major Development Projects. NRW Report No: 243, 119 pp, Natural Resources Wales, Cardiff.
80. French, P.W. 2001. Coastal Defences, Processes, Problems and Solutions. 362 pp Routledge, London.
81. Masselink, G., Hughes, M. 2003. Introduction to Coastal Processes and Geomorphology. Arnold.
82. JNCC. 2001. Severn Estuary <http://jncc.defra.gov.uk/default.aspx?page=2066> Accessed 08.02.2019
83. Hughes, S.L., Tinker, J. and Dye, S. with: Andres, O., Berry, D.I., Hermanson, L., Hewitt, H., Holliday, N.P., Kent, E.C., Kennington, K., Inall, M. and Smyth, T. 2017 Temperature MCCIP Science Review 2017 [http://www.mccip.org.uk/media/1750/2017arc\\_sciencereview\\_003\\_tem.pdf](http://www.mccip.org.uk/media/1750/2017arc_sciencereview_003_tem.pdf) Accessed 11.04.2019
84. Williamson, P., Turley, C. and Ostle, C. 2017. Ocean Acidification: Marine Climate Change Impacts Partnership: Science Review 2017 doi:10.14465/2017.arc10.001-oac [http://www.mccip.org.uk/media/1760/2017arc\\_sciencereview\\_001\\_oac.pdf](http://www.mccip.org.uk/media/1760/2017arc_sciencereview_001_oac.pdf) Accessed 11.04.2019
85. Daunt, F. and Mitchell, I. 2013. Impacts of climate change on seabirds, MCCIP Science Review 2013, 125-133, doi:10.14465/2013.arc14.125-133





## References



86. Mieszkowska, N., Firth, L. and Bentley, M. (2013) Impacts of climate change on intertidal habitats, MCCIP Science Review 2013, 180-192,
87. MCCIP. 2013. Marine Climate Change Impacts Report Card 2013 (Eds. Frost M, Baxter JM, Bayliss-Brown GA, Buckley PJ, Cox M, Withers Harvey N) Summary Report, MCCIP, Lowestoft.
88. Welsh Government. 2012. Energy Wales: A low carbon transition. <https://gweddill.gov.wales/docs/desh/publications/120314energywalesen.pdf> Accessed 10.04.2019
89. Water Framework Directive. 2000/60/EC <https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:32000L0060>
90. Natural Resources Wales. 2015. Western Wales River Basin Management Plan 2015 – 2021. Summary. <https://cdn.naturalresources.wales/media/676165/wwrbdsummary.pdf?mode=pad&rnd=131596369400000000> Accessed 11.04.2019
91. Environment Agency. 2015. Severn river basin district. River basin management plan. [https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment\\_data/file/718336/Severn\\_RBD\\_Part\\_1\\_river\\_basin\\_management\\_plan.pdf](https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/718336/Severn_RBD_Part_1_river_basin_management_plan.pdf) Accessed 11.04.2019
92. Natural Resources Wales. 2017. Wales Bathing Waters Report <https://naturalresources.wales/guidance-and-advice/environmental-topics/water-management-and-quality/water-quality/bathing-water-quality/?lang=en> Accessed 11.04.2019
93. McIlroy, D. and Horák, J.M. 2006. Neoproterozoic: The late Precambrian terranes that formed the Eastern Avalonia. In: Brenchley, P.J and Rawson, P.F (eds) 2006. the Geology of England and Wales. The Geological Society of London 131 – 146
94. Howells, M.F. 2007. British Regional Geology: Wales. British Geological Survey, Keyworth, Nottingham
95. Natural Resources Wales. 2015 Dee River basin Management Plan 2015 – 2021. Summary. <https://cdn.naturalresources.wales/media/685098/deerbdssummary.pdf?mode=pad&rnd=131705195500000000> Accessed 25.04.2019
96. European Environment Agency. 2017. Water and marine environment. <https://www.eea.europa.eu/themes/water/intro>. Accessed 25.04.2019