

# Geology, Substrates and Coastal Processes - Seabed Substrates and Bathymetry, Coastal Features and Processes

## Baseline/issues: North West Plan Areas 10 11

- Bathymetry consistently shallow with depths increasing from the coast to a maximum of approximately 50m in some parts of the offshore area. Features include estuarine channels associated with the Dee, Mersey and Solway estuaries and the Lune Deep channel off Fleetwood (Geol\_158)
- The inshore plan area is dominated by shallow subtidal sediments, ranging from infralittoral and circalittoral sandy mud, fine muds to infralittoral mixed sediment, with patches of circalittoral deep sand with few areas of hard substrate (Geol\_160)
- The inshore plan area is considered to have a smooth seabed (mud belt) with net sediment movement in to this area from the wider Irish Sea (Geol\_205)
- Intertidal sediment forms beaches, sandbanks, saltmarshes and muddy shorelines with a variety of habitats ranging from rocky coasts to extensive areas of sediment in Morecambe Bay and sandbanks/ridges in the Solway Firth
- High sediment mobility and rates of coastal erosion (e.g. north of Liverpool) are both characteristics within the inshore area (Geol\_157)
- Much of the plan area is underlain by undifferentiated Triassic Period rocks with sandstone notable near much of the Cumbrian coast and a generally complex underlying bedrock geology (Geol\_161)
- The East Irish Sea sedimentary basin covers a large proportion of the offshore and part of the inshore plan area and (predominantly) gas production occurs (Geol\_159). As of 2014, 66.6km<sup>2</sup> is licensed for sand extraction (Geol\_163)
- Shoreline Management Plan (SMP) policy for much of the Lancashire, Merseyside and Cheshire coast is to hold the line, with managed realignment the stated strategy around Formby north to Birkdale. The Cumbrian coast has a more mixed strategy combining no active intervention, hold the line and managed realignment (notably in the Solway Firth) (Geol\_155)
- The Cell 11 Regional Monitoring Strategy has collected significant information in relation to coastal processes and flood risk/erosion along the NW coast

## Issues for the South West Plan Areas 8 9

- Diverse bathymetry including: the Severn Estuary and Bristol Channel complex; part of the southern Celtic Sea (depths up to 200m); the continental shelf edge; and a small portion of the Atlantic abyssal plain (where depths plunge to over 2000m) (Geol\_133). Coastal features include: steep coastal cliffs broken by estuaries and rias; sand -beach/dune systems along the Bristol Channel coast; and various notable estuarine and shingle structures (Geol\_207)
- There are some distinct differences in the bedrock underlying the SW inshore plan area: in the Bristol Channel the bedrock is predominantly lower Jurassic Period mudstone and limestone along with Triassic Period mudstone; further east within the Seven Estuary mudstone dominates; off north Cornwall Devonian and Carboniferous Period mud and sandstone dominate; off south Cornwall Permian and Triassic Period rocks dominate. In the offshore plan area the predominant bedrocks are mudstones and siltstones. It should also be noted that there are also extensive areas of chalk and sandstone (Geol\_135)
- In the inshore plan area the seabed sediment is predominantly gravelly sand, which is interspersed with sandy gravel, sand, rock, gravelly muddy sand and muddy sandy gravel. In the offshore plan area the seabed sediment is mainly slightly gravelly sand, gravelly sand, sand, and muddy sand. There are extensive areas of hard substrate in the SW compared to other plan areas including those within the Bristol Channel and in the offshore plan area (Geol\_134). Moribund sand ridges are present occasionally including the Celtic Banks (a qualifying geological feature of the South-West Deep (West) MCZ) (Geol\_206). As of 2014, 101.5km<sup>2</sup> is licensed for aggregate (sand and gravel) extraction within the Bristol Channel – within both English and Welsh waters (Geol\_131)
- A notably different coastline exists as the Bristol Channel transitions in to the Severn Estuary. The shoreline is fringed by mudflats, saltmarsh and sand beaches (Geol\_126). There is a recent history of continuing coastal erosion of beaches and salt marshes which form natural/soft coastal defences. The natural shoreline movements are now largely curtailed by artificial defences and a more mixed SMP policy environment is present in the estuary (Geol\_127)
- The coastal protection policy to 2030 for the SW coast is primarily one of no active intervention in most locations outside of the estuaries with exceptions near coastal communities (Geol\_125)

## Baseline/issues: North East Plan Areas 1 2

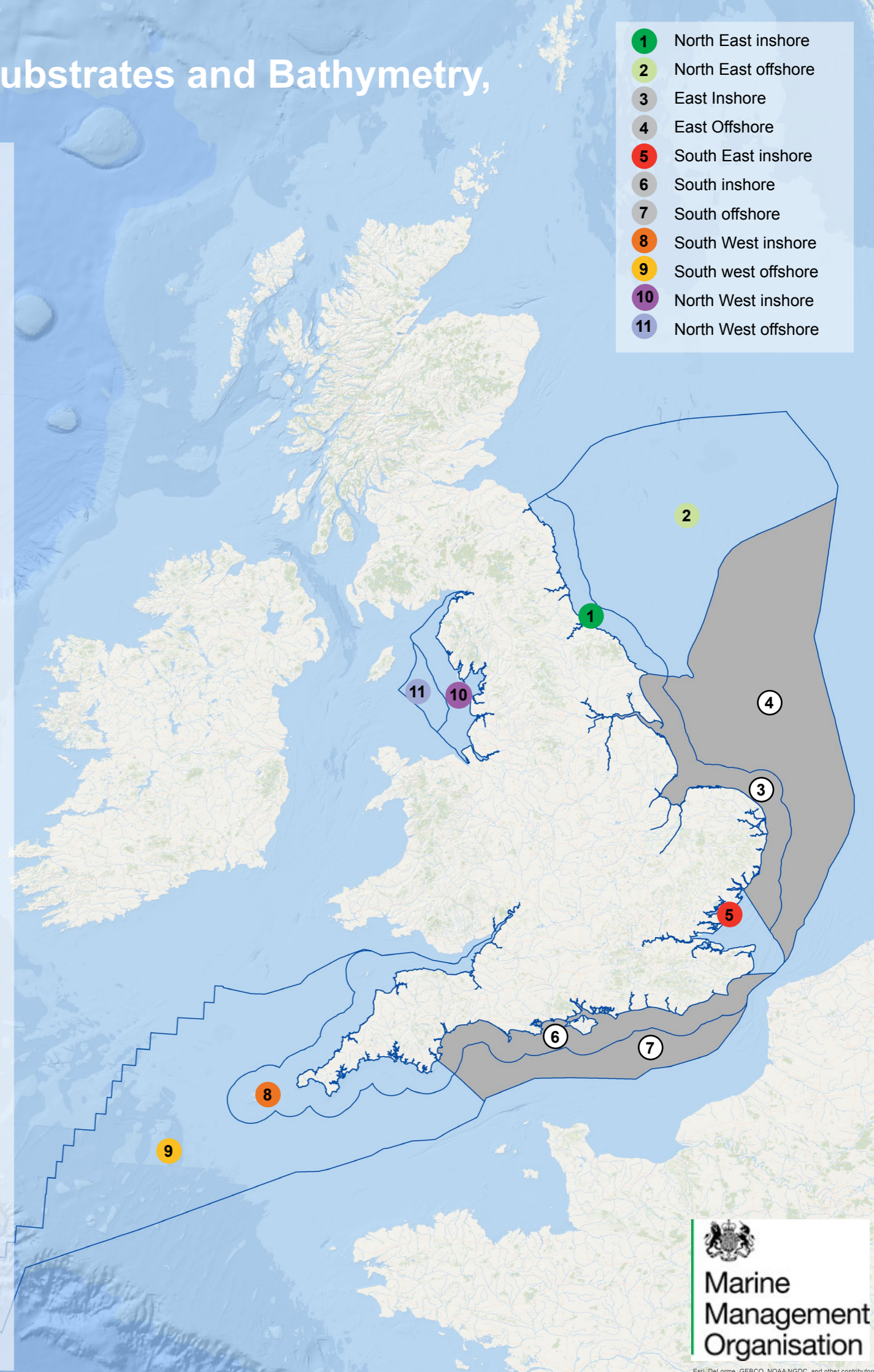
(Please note that the figures in brackets refer to the SA scoping database. This is available on the MMO website)

- The majority of this plan area consists of an undulating submarine plain with offshore depths between 70 and 90m with some prominent shelf troughs providing limited deeper water in the north of the offshore plan area (Geol\_169)
- The underlying bedrock within the plan area forms distinct north-south trending bands of differing strata moving offshore (Geol\_172). The inshore plan area is dominated by shallow subtidal sediments, ranging between circalittoral fine and muddy sand, mixed and coarse sediments and rock (sometimes exposed), with patches of deep circalittoral coarse sediment and mud, and localised infralittoral fine sand, muddy sand and rock along coastal areas (Biodiv\_368)
- Parts of the offshore plan area contain favorable petroleum geology with the majority of the plan area covered by the southern, mid- and central North Sea geological basins (Geol\_171)
- Coastal features range from the wide embayments of Northumberland through to the cliffs of the Jurassic Yorkshire coast which are softer than the rocks to the north and highly susceptible to erosion, landslips and coastal retreat (Geol\_181 and 202) and provide many geological sites of note. Between the Tyne and the Tees estuaries geomorphological landforms including wave-cut platforms, caves, arches and stacks, with sandy bays and sand dunes present (Geol\_203)
- SMP policies include no active intervention along the vast majority of the rural Northumberland, County Durham and North Yorkshire coastline, hold the line near coastal communities and some managed realignment, notably in rural Northumberland (Geol\_166)

## Issues for the South East Plan Areas 5

- Bathymetry is consistently shallow, with depths of only 20 to 50m. The outer Thames Estuary is dominated by a series of parallel sand bank features which fan out further in to the wider North Sea and aggregate extraction is licensed within the Greater Thames Estuary (Geol\_152). Nearshore, the Thames Estuary is characterised by coastal mudflats and saltmarshes created by the deposition of the sediment load into the broadening waters of the outer estuary. Along the Suffolk coast, a mosaic of smaller estuaries creates a complex coastline which also contains relatively large areas of nearshore mudflats and saltmarsh (Geol\_138)
- Highly variable sediment types form a complex mosaic in this plan area, with shallow and deep circalittoral coarse sediment (notably sand) and patches of circalittoral rock extending further away from the coast notably near Margate and Ramsgate, with isolated occurrences scattered throughout the Essex estuaries (Geol\_139). A variety of other bedforms exist in the area including dunes, sand patches, ribbons and streaks. Much of the area is underlain by undifferentiated Eocene Epoch rocks with a substantial area of chalk present off the eastern Kent coast (Geol\_140). As of 2014, 35.3km<sup>2</sup> is licensed for aggregate (sand and gravel) extraction within the plan area (Geol\_152)
- Much of the coastline is protected by a range of flood defence infrastructure (including the Thames Barrier) with policy support for managed realignment around the Medway Estuary. The low lying coastal features of the plan area are punctuated occasionally by higher coastal relief such as the chalk cliffs on the Isle of Thanet with features including sea stacks and arches such as at Botany Bay (Geol\_204). SMP policy to 2030 comprises of hold the line along much of the Essex and North Kent coastlines with the exception of fairly long stretches of coast around the Isle of Sheppey where managed realignment is proposed (29% of all policy units in the plan area) (Geol\_141 and Geol\_142). No active intervention is only proposed for 12% of policy units – a relatively low percentage compared with the other marine plan areas
- Coastal systems can adapt to sea-level rise by re-arranging their sediments; however, in many coastal systems this adaptive capacity has been compromised by coastal protection structures. This is an issue especially prevalent within this marine plan area (along with the East and South inshore plan areas) (Geol\_195) where (for example) flood defences protect 25 million residents in London and numerous economic, cultural and community receptors (Geol\_219)

- 1 North East inshore
- 2 North East offshore
- 3 East Inshore
- 4 East Offshore
- 5 South East inshore
- 6 South inshore
- 7 South offshore
- 8 South West inshore
- 9 South west offshore
- 10 North West inshore
- 11 North West offshore





# Geology, Substrates and Coastal Processes - Seabed Substrates and Bathymetry, Coastal Features and Processes

## Summary of the legislative / policy context

The key policy considerations include:

- [The Marine and Coastal Access Act \(2009\)](#) provides a means for the conservation of specific “features of geological and geomorphological interest” through the designation of Marine Conservation Zones (MCZs)
- [The UK Marine Policy Statement \(2011\)](#), includes coastal change as a key consideration stating that, “Marine plan authorities should seek to minimise and mitigate any geomorphological changes that an activity or development will have on coastal processes, including sediment movement.”
- [The National Planning Policy Framework](#) states that, “In coastal areas, local planning authorities should take account of the UK Marine Policy Statement and marine plans and apply Integrated Coastal Zone Management across local authority and land/sea boundaries, ensuring integration of the terrestrial and marine planning regimes.” This specifically relates to adapting to climate change in full recognition that coastal change is likely to occur
- [The Marine Strategy Framework Directive \(2008/56/EC\)](#) and the Marine Strategy Regulations (2010). GES Descriptor 6 (Sea-floor integrity is at a level that ensures that the structure and functions of the ecosystems are safeguarded and benthic ecosystems in particular are not adversely affected) is especially pertinent
- [Wildlife and Countryside Act \(1981\) \(as amended\)](#) (<http://www.legislation.gov.uk/ukpga/1981/69>) – allows establishment and protection of Sites of Special Scientific Interest (SSSIs) which can be designated for geological features and processes
- [The EC Habitats Directive \(92/43/EEC \(1992\)\)](#) – allowing designation and protection of a marine protected area network where geological, sediment and coastal features may be key features and considerations
- [Water Framework Directive \(2000/60/EC\)](#) – many coastal and transitional water bodies are defined as heavily modified or artificial for the purposes of the Water Framework Directive (WFD) due to the presence of (inter alia) coastal structures (including flood defences), aggregate extraction and port activity

Hydromorphological quality is a key consideration within the WFD and Good Ecological Potential is required in such heavily modified waterbodies. Other considerations include legislation/policy and guidance relating to flood risk and management (e.g. Shoreline Management Plans (SMP)), geological storage of carbon dioxide, climate change, aggregate dredging, retrieval of oil/gas reserves and the Geological Conservation Review (GCR). SMPs provide policy recommendations for sub-cells covering the entire coastline. These policies take the form of Hold the Line, Advance the Line, No Active Intervention or Managed Realignment

## Key cross cutting baseline / issues across all plan areas

- The vast majority of the English marine plan area lies on the UK Continental Shelf – the exception being the furthest south west part of the SW offshore plan area where the shelf edge leads down to the deep ocean. Geological processes, resulting in differing strata help shape the macro-scale bathymetry of the sea bed with major topographic features including canyons, seamounts and trenches being present along with evidence of past glacial activity. Differing overlying sediment types interact with physical marine processes and seabed energy to help define finer scale bathymetry which can be complex, especially in the coastal zone
- Physical processes that affect the highly dynamic coastal environment (causing either erosion or deposition) include those derived from wind, waves, currents and tides. However, in the absence of human intervention or activity, rapid changes caused by coastal processes are restricted to shallow areas where wave action is strong. The area of greatest change is in the coastal zone with softer coastlines most at risk from rapid change. Coastal erosion is mainly a local to regional process (Geol\_193) and erosion is predicted to affect approximately 30% of England’s coastline (Geol\_175)
- Given the potential issues at the coast local planning documents provide many locally focused policies relating to the interaction of geology, physical processes, flood defence and economic activity/coastal communities. Such documents identify sites which are deemed to require specific policy protection which are too numerous to mention in this summary – but which are all set out individually in the database associated with this topic (Geol\_10-91 and Geol\_101-121)
- Eroding coasts backed by coastal structures (e.g. hard flood defences) experience a ‘coastal squeeze’ as the intertidal profile is steepened. Adverse impacts can include reduction in intertidal area and changes to sediment transport and associated physical processes (Geol\_194 and Geol\_198). Where hard defences (e.g. to achieve Hold the Line policies) are in place long term impacts on sediment supply can result. The issues of coastal erosion and squeeze are of crucial concern around the English coast in general (Geol\_176) with loss of saltmarsh and mudflats of particular concern (Geol\_179) in certain locations
- Managed realignment of coasts is one measure that can be undertaken which can help with sustainable management of the wider coastline (Geol\_213). Some development of innovative concepts and early stage work to promote coastal management using the Dutch sand engine principle is taking place, notably the Crown Estate’s sandscaping work (with high potential sites identified in the NW and SW marine plan areas) (Geol\_208)
- Sediment transport around much of the UK is dominated by tidal influences. However, areas of wave dominance (with limited transport) are present across much of the offshore NE plan area and inshore NW plan area, and shelf edge transport mechanisms occur in the very south west of the SW offshore plan area (Geol\_217). Human intervention is most acute at the coast and developments in this sensitive and dynamic environment, plus offshore developments such as offshore wind farms, can have the potential to affect sediment transport and distribution with potential consequences for marine habitats and species

## The likely evolution of the environment over the plan duration

- Geological timeframes are long and it is the dynamic coastal zones which are most likely to change over the plan period where natural processes resulting in erosion/deposition are influenced most strongly by human activity. With both steeping of intertidal profiles and rates of coastal erosion expected to increase in the future, coastal squeeze and associated habitat loss may well be accelerated by continued sea level rise. Local and regional factors, including coastal management strategies (and funding), will also be important considerations in future outcomes. There is only low confidence of any predictions at present
- Managed realignment is likely to increase in the future as a key management strategy and although this will result in increased local erosion rates, the enhanced erosion may benefit other sections of coast by reducing erosion or even causing accretion. Adaptation and realignment is emerging as the key coastal management concept to cope with coastal erosion, with novel approaches already being explored in some areas
- There are clear links to economic activity, as increased activity in the coastal zone can potentially lead to changes to coastal and sediment processes in particular. The more notable activities include: dredging for ports (especially in the SE plan area), aggregate dredging, certain forms of fishing activity that interact with the seabed, coastal developments, power generation, growth (or otherwise) of our coastal communities and development of offshore renewable energy projects. Additional economic activities which may affect geological or coastal receptors in the future also include using geological voids for deep storage of CO2 within the NW and NE offshore plan areas, tidal lagoon developments (potentially in the SW and NW inshore plan areas), new nuclear power stations (NW, SW and SE plan areas) and underground coal gasification off the NE and NW coasts. Predicting such change is extremely difficult and macro-political and economic drivers become important in directing such activity

## Potential interactions with other topics

- There is a direct link to climate change as consideration of its effects and any resultant mitigation or adaption to coastal change will have a direct influence on coastal processes and features
- Economic and development activities have the potential to affect the seabed, coastlines and related processes and dependent habitats causing a variety of issues. Aggregate extraction has the potential to affect areas of seabed altering physical/sediment processes and creating sediment plumes, but our understanding of the environment and issues associated with this activity are improving (and also noting that actively dredged parts of the seabed are often significantly smaller than the wider licenced areas). Impacts from oil/gas exploration are normally considered to result in only local scale effects on sediments, but not exclusively so. Capital dredging for ports must be assessed carefully in relation to changes to coastal or sediment processes and the cumulative effects of developmental activities can be complex, resource intensive and difficult to assess with little current guidance
- Marine Protected Areas (MPAs) can include geological or geomorphological features which are afforded protection under European or national legislation with the Marine Strategy Framework Directive (descriptor 6) requiring sea-floor habitats to be productive and sufficiently extensive. Such geo-conservation and diversity may be under threat in specific locations by a range of activities such as those which physically impact the seabed or cause changes to sediment patterns or sedimentation (Geol\_225). The reader is directed to both the benthic and various economic report cards for a more full view of potential interactions
- Coastal squeeze resulting in loss of intertidal habitats and species may affect the extent or quality of protected sites and require new compensatory habitat to be created and/or designated in coastal areas, particularly estuaries, noting that existing Shoreline Management Plans (SMPs) may already have set the basis for such management change. Additionally, issues relating to access to the coast and other indirect effects on coastal communities can result dependent on the coastal protection strategy selected. Changes to erosion and sedimentation patterns are known to cause heritage assets to be exposed and degraded in the coastal zone
- Large scale, nearshore sandscaping/sand engine coastal management schemes have the potential to trigger regeneration or enhance the resilience of coastal communities through enhanced amenity benefits, habitat creation and or economic development opportunities (Geol\_208)
- Offshore activities such as oil/gas production and the potential for CO2 to be stored in geological strata are two activities where geological formations may be affected by man to a relatively high degree





# Geology, Substrates and Coastal Processes - Seabed Substrates and Bathymetry, Coastal Features and Processes

## Potential transboundary issues

- Coastal and sedimentation processes can operate over large areas spanning UK administrative boundaries (England, Wales, Scotland, Northern Ireland) and UK borders (EU and non-EU countries), requiring co-ordination between devolved administrations and wider governments. Specific large scale issues relating to contamination of sediments and the overall functioning of habitats that rely on key sediments and substrates are being tackled through key EU Directives with implementation at member state level
- There are a number of sites of conservation importance which rely on substrates/sediments for their functioning and character which span the Severn and Dee estuaries (sites that overlap with the Wales National Marine Plan area) and the Solway Firth and Tweed Estuary (overlapping with Scotland's Marine Plan area). It is perhaps these estuarine environments where the greatest transboundary issues occur due to their connectivity and sharing of coastal and sediment processes
- Existing Shoreline Management Plans and Flood Risk Management Areas, through which managed realignment may take place, may cross boundaries of multiple plan areas

## Key data gaps

- Despite some progress in recent years, there is relatively little information on seabed composition from very shallow waters and gaps still exist in coverage. However, the coastal zone is so important in relation to erosion, flooding, habitats, and commercial uses, that this is a key area for future work (Geol\_185)
- Coastal response to sea level rise is strongly determined by site-specific factors and usually it is these factors that determine the coastal response, rather than a global change in sea level or a regional change in wave climate. Predictions of general coastal response due to climate change therefore have a low confidence, and more detailed local or regional studies of coastal response to climate change will increase confidence in predictions. Understanding the rates and distribution of coastal erosion and changes to beach dynamics in response to climate change and sea level rise will be an area for new research and monitoring. The importance of the coastal zone in terms of coastal erosion and flooding, habitats and commercial uses, make this a key area for future work (Geol\_199)
- More information is needed on how sea level rise will affect both sediment supply, and sediment transport on UK coasts, and the implications for coastal margin habitats (Geol\_182)
- Local responses to climate change will vary in relation to climate change factors (e.g. sea level rise and changes to wave heights and directions). There is only low confidence of any predictions at present (Geol\_212)
- Whilst not strictly a data gap, it should be noted that there is no consistently adopted practice for how to assess impacts on geological features through marine planning (Geol\_222)