IMPACTS OF CLIMATE CHANGE ON SEABED (NEARSHORE AND OFFSHORE)

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Executive Summary

I would anticipate that the view from coastal and marine sedimentologists would be that no major changes in habitats are likely to result from changed physical processes, except in some coastal and estuarine circumstances where some subtle changes in sediment transport regimes might have a broad impact, for example at estuary mouths. Generally, below depths of 20 – 30 m, there would be little change anticipated from purely physical impacts. However, there would be the possibility of: subtle regional changes in the subtidal zone, where gradients in wave energy at the bed and sediment availability can be high, and near some oceanographic features where production of biogenic material and it's incorporation into the sediments may be altered.

Level of Confidence

Generally, confidence is low-medium, as indicated in the supporting evidence. Work has been lacking, understanding weak, and cause and effect poorly demonstrated with respect to marine climate change.

The relationships between the basic physical drivers, sediment type, bio-geochemistry, eco-hydrodynamics etc and biology are relatively poorly understood, and poorly predictable at present.

As a result of the above, it is difficult at present to propose what might be measured to assess possible changes in physical habitats. Some work is needed to examine this.

Key sources of Information

See Supporting Evidence

Supporting Evidence

Definitions / Scope

Here, the sea bed is taken to mean those parts of the UK, which are subject to and controlled by marine processes. There are two distinct parts, the boundary between which is gradational and variable in time and space:

1. The sea bed of the continental shelf, where the physical controls upon the sediments are exclusively marine processes; and,

2. Some shallow areas near coastlines and in estuaries, where the physical control upon the sediments is influenced by non-marine processes.

Hence the 'UK sea bed' includes a wide variety of estuarine sedimentary environments (e.g. saltmarsh, intertidal mudflats and sandflats, tidal channels), tidal lagoons with restricted (e.g. Langstone Harbour) or highly restricted (Slapton Ley) exchange with the sea, gravel and sand beaches, muddy shorelines, a wide variety of mobile and immobile sea-bed types on the continental shelf, as well as the sea bed in deeper waters on the UK continental slope and rise. It includes environments where the sediments are mostly derived from reworking of material from the marine environment (common), from rivers (less common) and from biogenic production (regionally important, e.g. NW Scotland, and locally important, e.g. the maerl beds off Falmouth) (Farnham and Jephson, 1977) and includes sedimentary environments that are being formed today and others that are essentially unchanged since their inundation by the post-glacial sea-level rise. There are also large areas of rocky sea bed, near the coast and in deeper water. A series of 'marine landscapes' have been defined by the JNCC (2004) for the Irish Sea. These components are a mixture of geological, oceanographic, biological and other descriptive terms, and it is not clear how these will serve in supporting scientific analysis of management and change.

This document has limited focus on the complex sedimentary changes in the intertidal zone.

This document does not relate to the nature of the shoreline or sea defences.

This document is written largely from the view that the sea bed sediments are habitats and the location of many vital ecosystem processes.

Observed Changes

- For most of the UK continental shelf, the basic knowledge of natural sedimentary changes on timescales of decades is insufficient to allow changes to be confidently identified and their significance assessed. There are few defensible observations of changes in sediments of any kind, and none which can be definitively attributed to 'climate change'.

- Some coastal and estuarine sedimentary environments exist in a semi-continuous state of change related to natural processes. At present there are no changes definitely attributable to 'climate change'.

- Estuaries regularly change the distribution of different sediments, especially in response to the changing position of tidal channels. Many estuaries are continuing to be infilled with marine sediments as a response to their post-glacial inundation (e.g. Jago, 1980), and the sedimentary environments within them are migrating seawards overall.

- Regionally, some beaches may have changed their steepness over the last century (Taylor *et al.,* 2004), with, for England and Wales, steepening of 66% of the south coast, 64% of the east coast and 58% of the west. In part, this may result from the presence of coastal defence structures and the cohesive nature of some sediments, but no analysis of cause has yet been undertaken.

Potential Future Changes

- Models which can reproduce the main elements of the UK sea bed sediments are not yet available, and combined with uncertainties over the main driving forces, reliable models of future changes are unlikely to be available for some time. Therefore, possible changes can only be speculated upon using first principles.

- In estuaries and at the coastline, there may be some minor changes in sediment distributions and types related to sea-level change, waves and changed water temperatures. Changed conditions at some coastal environments, such as partially-enclosed lagoons and bar-built estuaries, may induce major changes in sedimentation through altering the exchanges of water and sediments.

- Some beaches may steepen and coastlines recede, but this is likely to be related to ongoing long-term processes of change (e.g. erosion of the Norfolk coastline), rather than being related or relatable to climate changes.

- Away from estuaries and the coastline, marine processes dominate sedimentation, and processes such as changed oceanic circulation patterns, with consequent changes in temperature and storminess, may be more important in controlling sea bed type. Predictions of the nature and magnitude of any changes are not possible at present.

- Regarding sediment texture, measuring changes is unlikely to be possible without careful, detailed, tightly focussed work, because the magnitude of changes is likely to be small. Changes would need to be mapped using sea bed samples, but the nature of sampling and analyses which led to the production of existing BGS maps of sea-bed

sediments means that they are insufficient as a baseline to detect future change.

- Regarding sediment composition, regional studies of, for example, the proportion of organic matter or other biogenic material may be useful, especially in combination with biological data.

- If the future holds changed river flow regimes, forced, for example by longer drier summers and more flashy flows overall, then this has the capacity to alter fluvial sediment supply, either upwards or downwards. Impacts, if any, will not be noticeable on the open continental shelf, and, if anywhere, might be noted in estuarine systems. However, given the geologically low level of fluvial sediment inputs compared to marine inputs in most UK estuaries, it is unlikely that many UK estuaries have saltmarshes highly dependent upon fluvial inputs (c.f. Adam, 2002). Change in saltmarshes and other estuarine sedimentary environments might arise if the relationship between the availability of material supplied into the estuary and the rate of sea-level rise is changed, but distinguishing such changes from natural variations will be extremely difficult. Improvements in land management, leading to decreased sediment loss from agricultural areas may impact some estuarine environments locally.

To my knowledge, little work and discussion on this subject has taken place. The range of views is largely unknown. Further, the range of views may be wider than anticipated because of the very broad range of sedimentary environments, and hence expertise, covered by the scope of this document.

Quantification of any changes is not possible at present. Across most of UK waters, magnitudes of change would be low to immeasurable, except for:

- Some zones, probably near the coast, where there might occur a marked change in sediment supply, and;

- Some zones in the open sea where changed oceanography (temperature, stratification) may change the supply or distribution of biogenic material, whether from plankton settling or in-situ benthic production (Austin and Scourse, 1997).

What physical factors might contribute to seabed change?

Relative sea-level change
Period, height, frequency & direction of fairweather waves
Ditto major storms or stormy periods
Salinity
Water temperature
Air temperature (e.g. for a few select shallow environments)
Tidal range change

Main factors are weakly relatable (as opposed to 'related') to climate change (i.e. understanding is poor). The key factors are that natural variation is high and that baseline data are weak.

Regional variations

Little or no information is available but it is highly likely that there will be variation dependent upon the great range of sediments and sedimentary environments. The long-term trend is of estuarine accumulation of land- and marine-derived sedimentary material. Sediments are limited across much of the UK shelf, so that the location of boundaries of sediment cover is an important factor.

As such, in the most general terms, the subtidal zone is likely to display most vulnerability to change, because here tends to lie the transition zone from the relatively sediment-rich nearshore and estuarine zones to the sediment-limited offshore zone. Any changes in the sea bed caused by changed physical processes are mostly likely to occur in this transition zone.

The location of zones between seasonally stratified and well-mixed regions is relatively well defined at present (e.g. Brown et al, 2003). Some regional changes in the composition of sea-bed sediments might occur preferentially at the edge of these zones if the zones are enhanced or moved slightly by future changes in stratification (Cefas, A1225 Final Report to Defra). Nutrient supply in estuaries may also be a factor, especially regarding the potential for altered occurrence of sediment-stabilizing micro- and macro-flora.

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