Bristol Channel sediment regime

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Introduction

In the United Kingdom, the extraction of marine sand and gravel from territorial waters is regulated through a 'Government View' procedure, in which a judgement is made on the suitability of an application, based on information which includes a description of the extent and distribution of a specific marine resource, an assessment of the physical regime and a review of the environmental constraints of working the area. The permission to extract material from the area is dependent on obtaining a positive view on these issues, and the granting of a license. However, with limited published information on the wider extent of marine resources, environmental constraints and the overall movement of sediments, it is difficult to assess the effects of individual and cumulative dredging activity, either in its own right or compared with natural processes and other marine engineering works.

A major strategic research project has begun to address these problems to provide an improved understanding of the sediment regime, resource potential and environmental constraints of the Bristol Channel. The three year study (Bristol Channel Marine Aggregates: Resources and Constraints) has been funded by the UK Government and co-ordinated by a steering group with representation from the wide variety of user interests. The success of the study has, in part, been due to the pro-active co-operation of the project group and the desire to achieve a landmark statement on the Bristol Channel system. The key details from the project have been captured in a geographical information system to enable a more informed 'Government View' to be made on future applications for commercial extraction of marine aggregates in this area.

The study has developed in three phases;

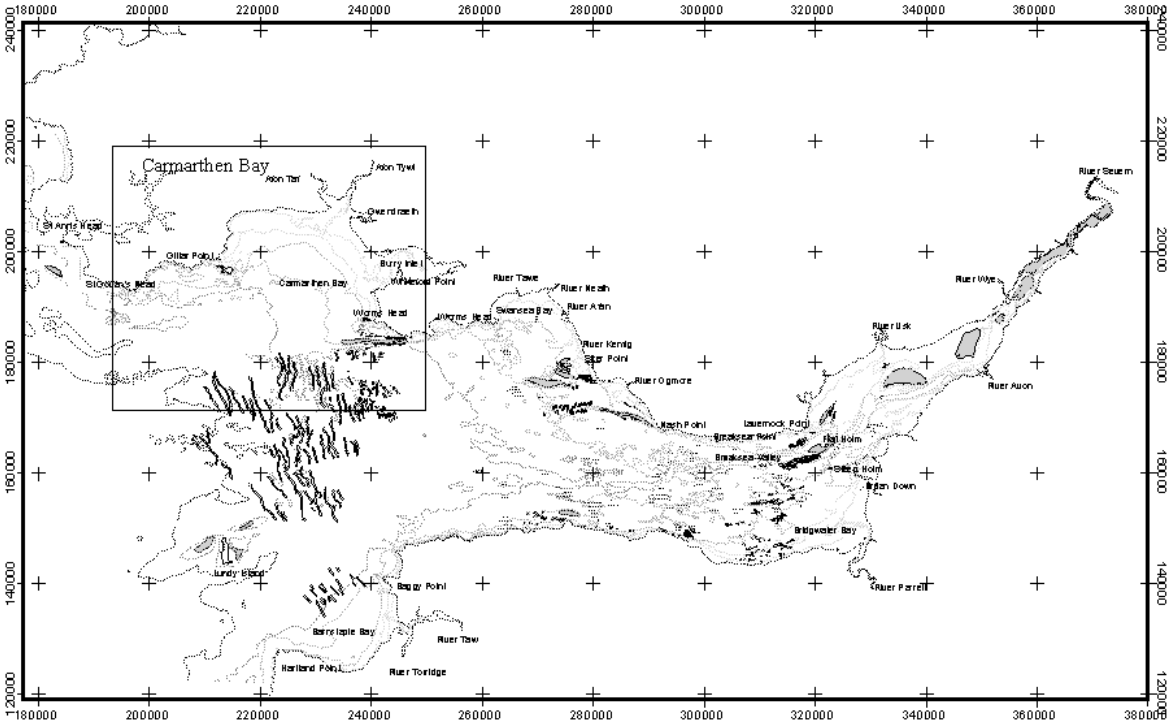
Phase 1: Consultation to determine major issues, collation of available data, development of an initial conceptual model for sediment transport, identification of key data gaps and recommendations for primary research priorities.

Phase 2: Commissioning of agreed scope of primary research to fill key gaps.

Phase 3: Analysis and interpretation of new data, production of an improved conceptual sediment transport model, report and dissemination of findings.

Phase 1

An initial 'conceptual' sediment transport model was produced to characterise the behaviour of the sediment regime based on a synthesis of existing information and present understanding. Of particular significance are the distributions of macro bedform features of sandbanks, sandwaves and sand ribbons, and examining the form and inter-relationship between such features (Figure 1). This data has come from seabed mapping, satellite imagery, geophysical surveys and sediment modelling. The conceptual model defines the regional pattern of net sediment movements and exchanges, based on a synthesis of these indicators (Figure 2).



Physiography of the study area	**Date:** April 1999	**Drawn By:**	**Checked By:** WSC
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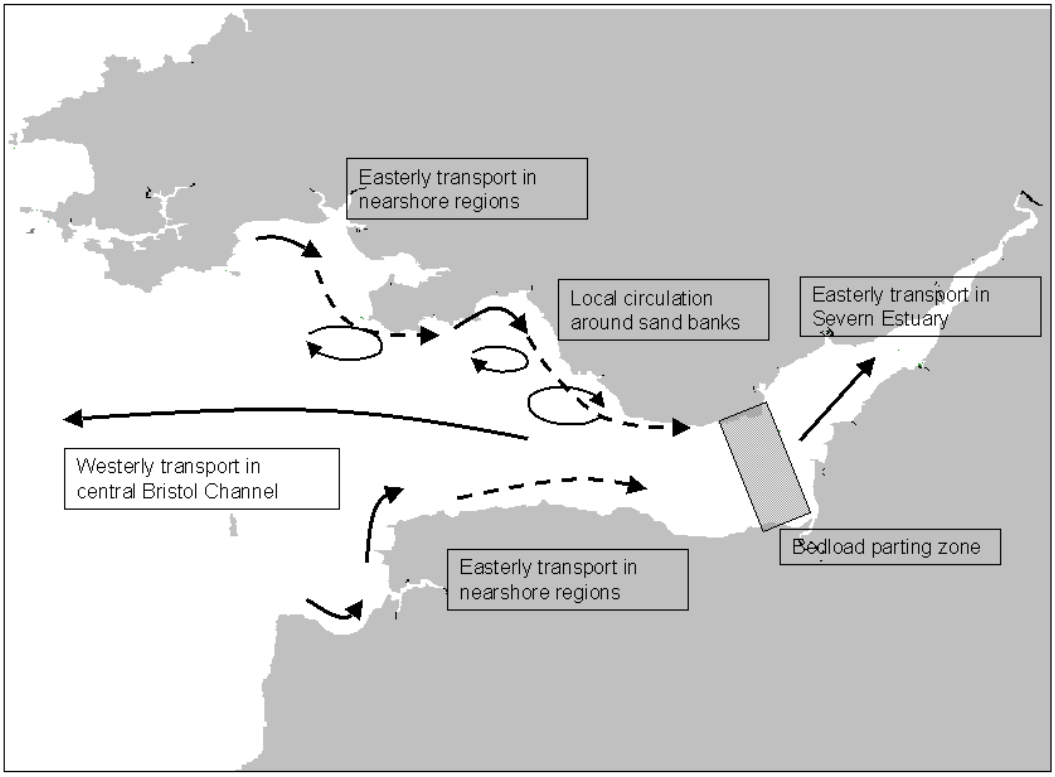
Figure 2. Simplified conceptual model of sand transport in the Bristol Channel



The key outcome from Phase 1 identified the importance to learn more about sediment exchanges and in particular examine through primary research;

- the possibility for new sediments to enter the system from the 'ocean' boundary, and the mechanisms responsible
- the transport pathways for mobile sediments, rates of transport and the mechanisms responsible
- the possibility for sediment exchanges between a licensed sand resource and a neighbouring coastline

Phase 2

Carmarthen Bay (Figure 1) was identified as the most appropriate area in the Bristol Channel for combining the elements of primary research, as the initial conceptual model suggested that if new sand was entering the system then it would most likely have to pass through this area. In 1998, an agreed scope of field experiments was completed. The experiments were designed to sample a range of indicators, which when bought together offered were aimed at providing an improved understanding of the sediment regime in this area. The experiments included:

- Sand tracer studies off St Govan Head, combined with wave and flow monitoring

- Comprehensive sediment sampling across Carmarthen Bay, with particular focus around the licensed sand resource area of Helwick sandbank. Data enabling detailed sediment trends analysis, macrobenthic mapping and mineralogical analysis

- Further sand tracer experiments off Helwick sandbank and also neighbouring beaches.
- Broad geophysical survey to compliment existing information

Phase 3

Modelling was used to expand the interpretations made from the primary research activities in Carmarthen Bay to develop an understanding across the whole system. Hypotheses put forward from the initial conceptual model were evaluated to determine mechanisms and rates of sediment exchanges. The modelling supported many of the initial hypothesis and identified the specific mechanisms responsible for the suggested pathways.

Data from all phases of the project has been brought together to determine the synergy which could be made, assigning high confidence levels where common agreement existed and low confidence in areas of conflicting evidence. The analysis took special account of problems in comparing data from various spatial and temporal scales.

To understand the manner in which the range of natural sediments populate different parts of the system the study area has also been broken down into discrete 'sediment environments'. These are based on sub-areas of the system which are shown to exhibit a similar component of the sediment regime, governed by similar process conditions, geology, resource potential, etc. In total, 50 individual sediment environments have been defined.

One such sediment environment is characterised by a prominent area of sandwaves in the Outer Bristol Channel which extends from a large linear sandbank in the north (Helwick) down to Barnstaple Bay in the south (Figure 3). The orientations of these sandwaves is normal to the direction of the regional peak tidal flows, with an asymmetry following the ebb tide (Figure 1). Based on comparative survey and satellite data spanning a 6 year period, these sandwaves have been determined to migrate at rates which vary from 'relatively stable' to 100m/year (Harris *et al,* 1986). In general, the dimensions of sandwaves fit the following criteria (Belderson *et al,* 1982);

i. Wavelength (crest to crest separations) up to x20 water depth
ii. Height (crest to trough) 1/3 of water depth
iii. Lee slope (steeper side) 4° to 20° (asymmetrical)
iv. Flow environment >0.65m/s mean spring tide

v. Probable origin turbulence in tidal flow

With reference to the Bristol Channel, and for comparison with other sandwave areas, the following general properties apply;

Parameter Outer Bristol Channel Dover Straits (Tail of the Falls)

Wavelength 100 to 150m 150 to 300m

Crest height 10 to 15m 10 to 15m

Peak spring flow 1.4m/s (ebb) 1.4m/s (ebb)

Local depth 30 to 40m 35 to 40m

Tidal range 7.2 spring, 3.2m neap 5.9m spring, 3.3m neap

The largest sandwaves in the Outer Bristol Channel have crest heights of more than 15m with megaripples superimposed on top of the sandwaves. Modelling the sediment transport process by the action of waves and tides indicates that the net transport direction across the area of sandwaves is maintained under all conditions, including opposing Atlantic storms.

Recent research conducted by EPSHOM in France (funded by the North Sea Hydrographic Commission) has established the following general characteristics for sandwave areas;

i. New sandwaves form slowly;
ii. Locations of sandwave fields are precise and lasting;
iii. Morphology of sandwave fields are stable because they are in general equilibrium with their local hydrographic environment. During reduced tidal streams (neap tides) and calm conditions sandwaves will favour growth (given sediment supply) or maintain their existing form. This is balanced by periods of erosion during storms.
iv. The movement of isolated sandwaves is dependent on several inter-related factors.

Summary

The significance of the sandwaves to the overall sediment system, the sediment budget and the question of a sustainable resource all remain as issues of key interest. Recommendations for improved mapping and monitoring for the whole area have been put forward, and it is hoped that in the near future the role of these sandwaves can become better understood.

References

Harris, P.T., Ashley, G.M., Collins, M.B. and James, A.E., 1986. Topographic features of the Bristol Channel sea-bed: a comparison of SEASAT (synthetic aperture radar) and side-scan sonar images, *Int. J. Remote Sensing,* 7: 119-136.

Belderson, R.H., Johnson, M.A., and Kenyon, N.H., 1982. Bedforms. *In:* A.H. Stride (Editor): *Offshore Tidal Sands: Processes and Deposits.* Chapman and Hall, London. 27-57.

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