iCOASST Newsletter

www.icoasst.net

Spring 2014 Issue 2

Highlights in this issue:

- Conceptual coastline compositions
- Coastal Area Modelling in iCOASST
- Data Driven Modelling
- Raster Behavioural Approach
- iCOASST International Confernece

Contact

- **If you would like to know more about the iCOASST Project please contact: Jon Lawn j.lawn@soton.ac.uk**
- **iCOASST Website: www.icoasst.net**

WELCOME

Welcome to the second twice yearly newsletter for the iCOASST project. These newsletters will:

· Provide a regular update on the project research and outcomes.

· Communicate with a wide range of interested parties.

· Encourage a wider discussion and debate about the iCOASST project

What is the iCOASST Project?

This four-year project runs from 2012 to 2016, and is funded by the National Environmental Research Council (NERC) with the support of the Environment Agency. The consortium, led by Professor Robert Nicholls (University of Southampton), brings together a number of leading UK universities, research laboratories and consultants in the fields of coastal geomorphology, engineering, oceanography and related software development. They are developing and integrating several distinct approaches to achieve the aim. More details can be found at www.coasst.net.

Aims and Objectives

The aim of this project is to improve our capability to predict erosion and accretion around the coast and estuaries of the UK over 10 to 100 years. This is also designed to enhance strategic erosion and flood risk management, such as strategy studies and shoreline management.

Who will benefit from the project?

We envision the main beneficiary of this research will be Local Authorities and the Environment Agency (EA) in England and equivalent bodies around the UK, who have the main responsibility for delivering flood and coastal erosion risk management. Other beneficiaries include the Department for Environment, Food and Rural Affairs (DEFRA - UK Government), specialist consultants who undertake the Shoreline Management Plans (SMPs), local stakeholders (including community groups, commercial concerns and the general public) and the national and international research communities.

What's new?

This newsletter highlights important developments in iCOASST, such as the design of coastal model compositions, the role of coastal area modelling and data-driven modelling, issues of geomorphic model integration, and the iCOASST International Conference in October 2013.

Project Partners

University of Southampton · National Oceanography Centre, Natural Environment Research Council · UCL · British Geological Survey, Natural Environment Research Council · Swansea University Prifysgol Abertawe · HR Wallingford, Working with water · Manchester 1824, The University of Manchester · University of Oxford

Project Lead:

University of Southampton

Subcontractors:

University of Liverpool

Cardiff University

Channel Coast Observatory

Conceptual iCOASST Compositions

James Sutherland (HR Wallingford)

One of the main objectives of iCOASST is to link models with the goal of providing more informative and realistic simulations. In this context, a composition is a set of linked numerical models that exchange information as they run. In this way a model of coastal erosion in one area can pass information on the volumes of sediment that leave it onto the next model in time for it to influence the behaviour observed in the second model. We have developed conceptual compositions (which we have yet to implement) of sections of Liverpool Bay (below, left) and the Suffolk Coast (below, right) that both require the following elements:

- L – littoral drift model of coastal plan-shape evolution;
- E - Estuary model;
- D - An open coast – estuary exchange (or delta) model;

and,

- Onshore-offshore linkages.

These model compositions will be able to:

- Provide a picture of sediment transport and shoreline evolution that treats the coast as an interacting system;
- Be used to engage with stakeholders over perceived validity and priorities;
- Be used to develop a probabilistic approach to model running and presenting the results;
- Be extended with the addition of modules for overwash, breach, dunes, etc.;
- Potentially be linked (beyond iCOASST) to flood risk assessment models or habitat / species models to look at economic and environmental effects, as well as morphology.

For more information, please contact j.sutherland@hrwallingford.com

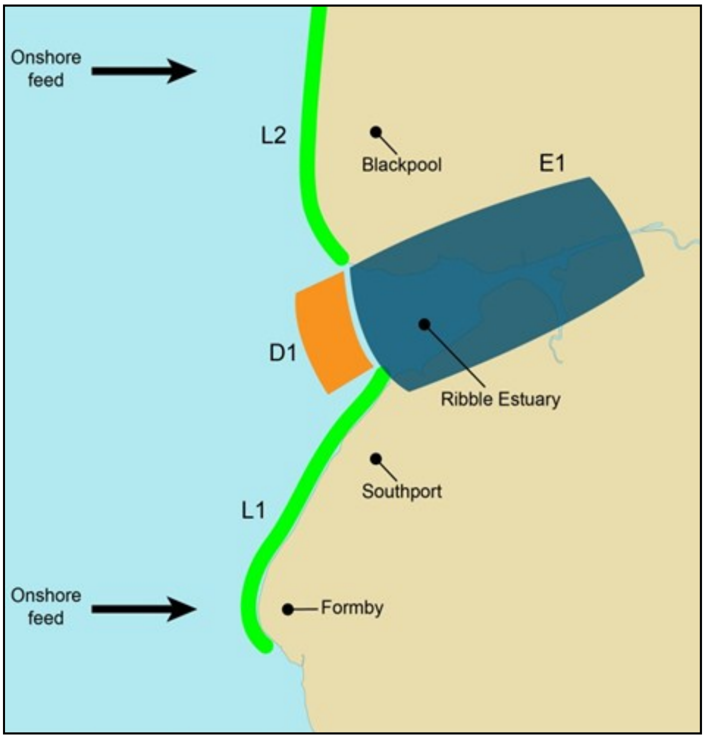

Figure 1: Conceptual composition of Liverpool Bay Coastline

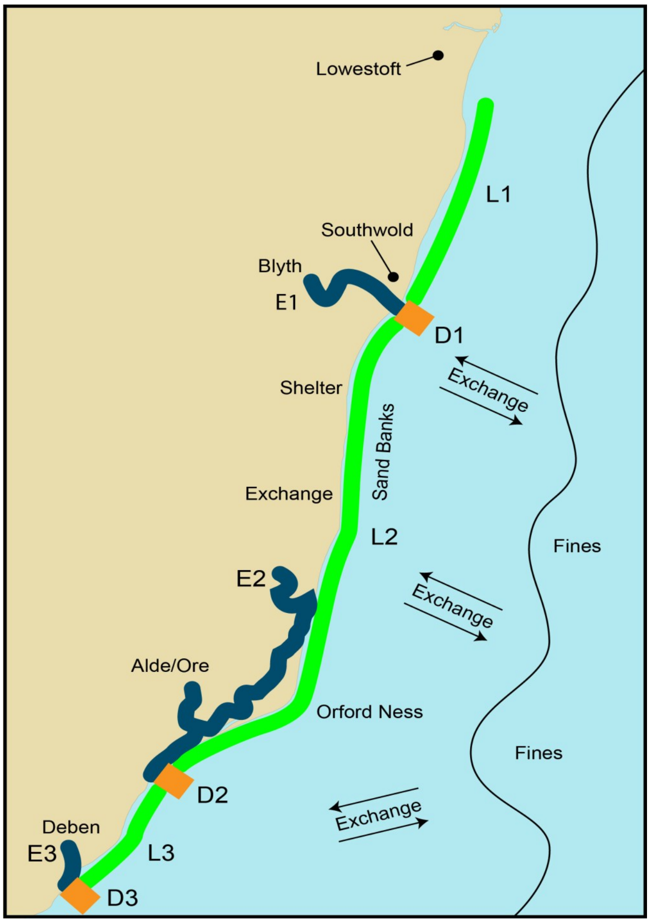

Figure 2: Conceptual composition of Suffolk Coastline

Coastal Area Modelling—How does it fit into iCOASST?

Peter Stansby, Fay Luxford, Ben Rodgers (University of Manchester) & Alex Souza, Jenny Brown, Laurent Amoudry (NOC Liverpool)

Coastal area modelling provides information on residual sediment pathways over large domains showing how pathways in the open coast connect and control small-scale coastal features acting as sediment sources (or sinks). These may be estuaries, beaches, cliffs, etc., or offshore sandbanks. These pathways and sources will inform long-term large-scale bathymetric change and hence coastal evolution. There is the question of what is small scale and large scale? For fine sediments (silt/clay) large scale can mean 100s of km, for example as sediment from the Humber is transported to East Anglia and the Thames estuary. However, for sand/shingle it normally refers to a coastal cell or domain with a length scale of around 100km where quite fine scale residual pathways may be shown which in some cases are markedly influenced by wave stress or forcing, notably over offshore banks. Small scale certainly refers to beaches, cliffs and rivers where local mechanisms of sediment erosion, supply or sometimes accretion, are too complex for direct modelling. Direct measurements of sediment flux or magnitudes deduced from data driven modelling may be input into coastal area modelling. For more complex sources, such as cliffs, reduced complexity or heuristic approaches may be used. Estuaries are a particular problem as they may be large or small. Large estuaries like the Mersey or Dee will be included as part of the coastal area modelling while small estuaries will be represented with reduced complexity models. Inclusion in coastal area modelling enables important density driven effects due to fresh water and temperature to be simulated in 3-D.

Sediment pathways have previously been computed off N Norfolk showing the connections between the Gt Yarmouth and Happisburg sandbanks with the coast and also the dominance of wave-induced stresses over sandbanks (via the Tyndall Centre). But this is a classical example of an open coast. In iCOASST we consider more complex regions with large estuaries: Stour/Orwell in Suffolk and the Dee, Ribble and Mersey in Liverpool Bay. The first job is to compute residual currents for these domains which might seem straightforward using tidal boundary conditions from continental shelf models. The coarse model CS3 with a 12km grid is well calibrated and gives tidal elevations generally in agreement with coastal tide gauges. However models have phase errors near M2 amphidromes. This issue remains to be fully resolved, but residual currents and sediment fluxes may now be computed with appropriate outer boundary conditions some distance away from the domain of interest to give reliable sediment pathways. Coupling with coastal features and density-driven estuary interfaces remains to be undertaken. The approach is twofold. The 3-D baroclinic continental shelf model POLCOMS with a refined embedded mesh in a region of interest will give a complete picture at a relatively large scale. Depth-averaged modelling will also be undertaken giving greater refinement in regions of interest but obviously without accounting for variations through the water column.

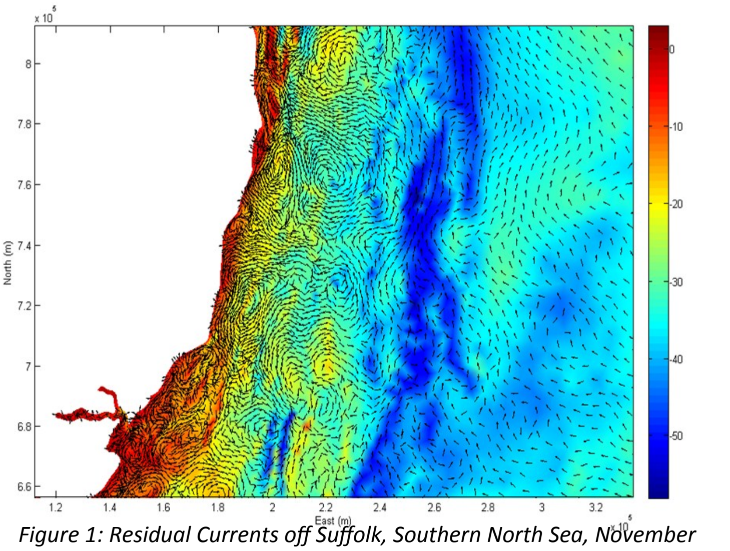

Figure 1: Residual Currents off Suffolk, Southern North Sea, November 2007. X,Y are a simple Mercator projection, the arrows are all the same length, the colour bar represents bathymetry in metres.

The end result will be estimates of sediment pathways linking with coastal features. This will be over long time scales including sea level rise and climate change. This will be for the Suffolk and Liverpool Bay regions but also extended to the continental shelf for fine sediments as far as possible. Quantification of sediment flux has much greater uncertainty although for the N Norfolk study the accumulated sediment ingress for the Gt Yarmouth banks was in quite close agreement with monitoring over a period of 140 years.

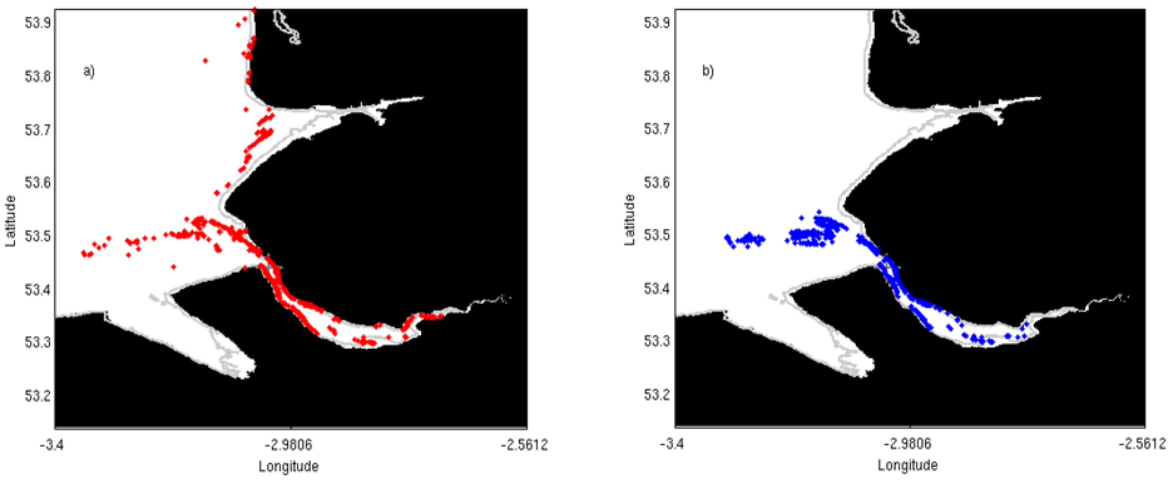

Fig 2 (right): The position of fine sediment (red) and coarse sediment (blue) within Liverpool Bay after a 3 month simulation (Jan -Mar 2008) with disposal site marked with a + in the Mersey estuary.

The position of fine (9 mm/s W_s, red left column) and coarse (35 mm/s W_s, blue right column) sediment classes within Liverpool Bay after a 3 month simulation (Jan – Mar 2008). The disposal site location is marked with a '+' within the Mersey Estuary.

Data Driven Modelling

Prof Dominic Reeve, Dr Harshinie Karunarathna, Dr Jose Horrillo (Swansea University), Dr Shunqi Pan (Cardiff University).

We are all likely to have done some form of data-driven modelling in our lives. Judging when it is safe to cross the road or deciding whether to take a raincoat when going out of the house are forms of data-driven modelling. That is, based on some observations and analysis of these we make a prediction of future events. The key element of this approach is that we do not solve the equations of motion for the movement of a car or the atmosphere. Rather, we make observations, analyse these for patterns, then make a prediction. This process can be formalised in the context of coastal systems by treating measurements of beach levels, waves, tides and so on as 'observations', using sophisticated statistical techniques and historical records for analysis and advanced forecasting for prediction.

Thus we might take observations of waves and tides (e.g. Figure 1) together with measurements of beach levels, and analyse them to look for patterns of behaviour that link various sequences or combinations of waves and tides with particular beach responses. Then, given forecasts or scenarios of future wave and tide conditions we can take the patterns we found to extrapolate how beaches may respond in the future.

Figure 1: Current and wave measurement devices

In the context of the range of tools available for medium to long term morphological prediction such methods lie part way between intuition or 'gut feel' and detailed process modelling. It provides a means of dealing with incomplete information and to make forecasts with moderate certainty. Forecasts are made on the basis of patterns of correlation found in historical measurements and do not rely on physical understanding encapsulated in the equations of fluid dynamics

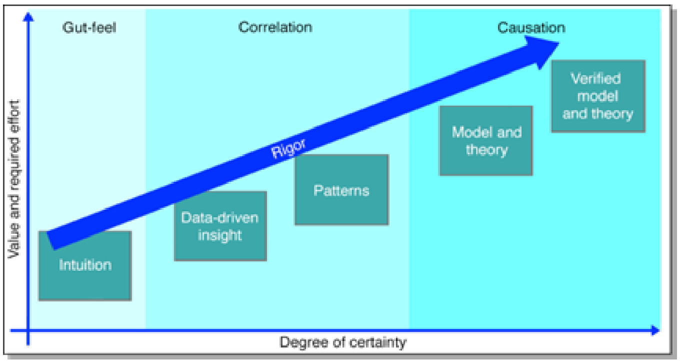

Figure 2: Value/required effort versus degree of uncertainty

Figure 2 illustrates the process through which 'gut feel' becomes modified by observation and analysis to understanding of patterns of change, which is turn may evolve into formal theory when sufficient observations, tests and experiments have been accumulated.

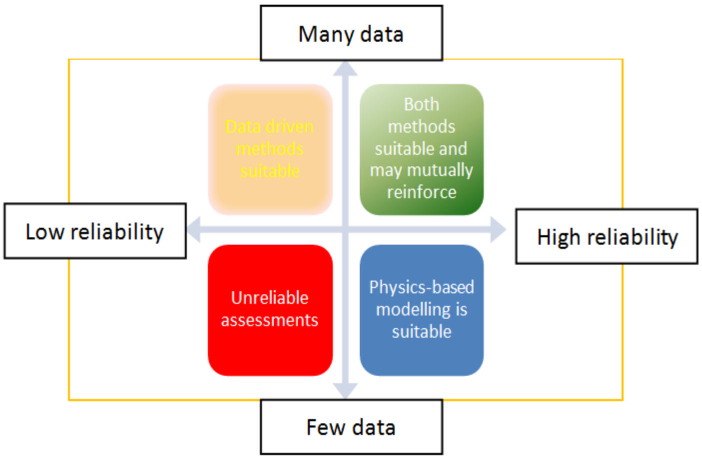

Figure 3: Data availability versus understanding

Data driven methods are most suitable where there are many data but little understanding leading to unreliable predictions. (Figure 3). Where physical understanding is developed, but there are few measurements, physics-based modelling can be helpful. Where there is reasonable understanding and good data both methods can be used and may be mutually beneficial in providing new insights. Where there is little data and poor understanding forecasts are likely to be unreliable.

As part of our contribution to iCOASST we are examining datasets from around the world to investigate which variables and parameters provide the most reliable correlations. As the next stage we will apply this new understanding to study sites in Liverpool Bay and Suffolk. We are currently examining an extensive beach profile dataset covering the whole of the Suffolk coast.

Geomorphic model integration: raster behavioural approach

Andrés Payo & Jim Hall (University of Oxford)

The modelling approach that underpins iCOASST is based on the notion that long-term projections of coastal behaviour will be best modelled through integrated analysis of interacting coastal behaviours. Based on the observation that most of the behavioural models often used for engineering assessment operate on some abstraction of a full 3D topography/bathymetry (e.g. shoreline, shore profiles, estuary areas, etc.) a raster based behavioural framework has been identified as an alternative representation that is worthy to explore. The rationale and key challenges of this approach are summarized below.

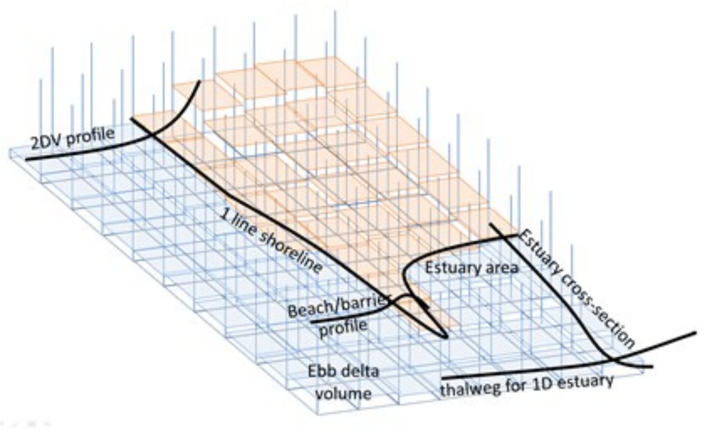

Figure 1. Main shape objects and landforms for behavioural modelling.

A number of candidate models have been reviewed in Oxford's WP1.1 review e.g. 1-line coastal plan-shape models, SCAPE (a 2DV model that is extended to quasi-3D implementation), ASMITA, CEM etc. Each of these models has some notion of sediment conservation and morphological updating, but each operates on a different abstraction of coastal geometry and uses a different structure to conduct sediment accounting. More significantly, each model has implicit assumptions about volumes and locations of sediment (e.g. SCAPE deals with a beach of finite thickness perched at the top of the shore profile).

Having considered the potential for coupling these types of models we have two concerns: (1) There may be implicit assumptions about sediment accounting that are not consistent between different models, (2) Coupling models with different geometrical structures may lead to unforeseen difficulties in harmonising those geometrical structures.

These concerns also potentially apply to the process of supplementing behavioural models with full 2D coastal area models, which is also part of the iCOAST approach. Furthermore, we make the following observations:

1. All of the models under consideration in iCOAST have some version of sediment accounting. This may include different sediment fractions (gravel, sand, mud).

2. The most general form of sediment accounting is on a 2DH grid. 1D versions (such as in a 1-line model) can be disaggregated to 2DH with an appropriate disaggregation routine. 2DH grids may take various forms (e.g. TIN, regular, curvilinear, quad-tree). The simplest is a regular raster grid.

3. Behavioural models operate on some abstraction of a full 3D topography/bathymetry e.g. shorelines, shore profiles, sandbank/delta volumes, estuary volumes/cross sections, estuary channel networks, mudflat areas etc.

4. Implicit in the application of behavioural models is some classification of landforms: a 1-line model is applied to a gently curving beach; a SCAPE model is applied to a shore profile; ASMITA involves identification of morphological elements such as an ebb-tidal delta, a channel and a tidal flat.

We therefore seek a generic modelling framework that accommodates these various representations in a consistent and coherent way.

How different geometries interact with each other?

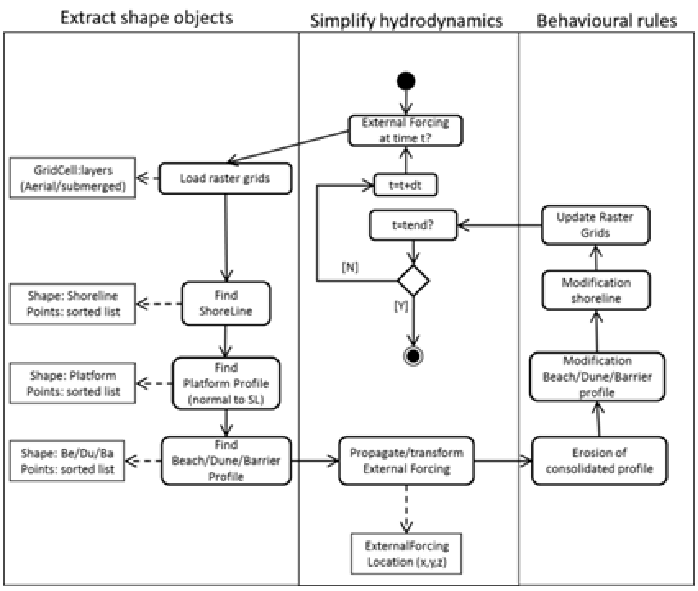

Figure 2. Example of shape and raster objects interaction activity diagram using the UML convention. A unified convention aids to build confidence on the model behaviour for a broad number of actors

Central to this approach is capturing how different geometries interact with each other. Since every geometry has its own attributes and behaviour it lends itself to object oriented programing. The Causal Loop analysis (see 1st iCOASST newsletter) is used to guide and document the rules that define the behaviour and interactions. The Unified Modelling Language (UML) is used to communicate how different geometries interact aiding the multi-disciplinary model development process.

iCOASST International Conference - Simulating decadal coastal morphodynamics

Robert Nicholls and Jon Lawn (University of Southampton)

The first iCOASST International Workshop was held at the Holiday Inn Southampton for 15-17th October 2013. It brought together the iCOASST research team with 13 international experts from Australia, USA, Spain, Italy, the Netherlands and the UK. It enabled the ambitious goals and early deliverables of the iCOASST project to be discussed and reflected upon in a constructive yet critical manner. Several issues were raised by the international experts:

- iCOASST's vision is ambitious and worthy – but how does it link together, especially the data-driven approaches?
- Process-based modelling has promise – but not at the iCOASST scales and not for consideration of uncertainty.
- What level of abstraction is appropriate for the reduced complexity models?
- Clearer definition of terminology will facilitate research and application development.

The Workshop included a field trip to Bournemouth and Chesil beaches where many participants had their first experience of shingle beaches

The conference consisted of six sessions:

1: How to encode qualitative understanding of estuary and coastal geomorphic behaviour

2: How to parameterise coastal behaviour within meso-scale geomorphic models

3: Coastal Area Models: How to inform a framework for long-term large-scale coastal behavioural models

4: How can data-driven modelling inform a framework for long term large-scale coastal morphological modelling?

5: The Legacy of iCOASST ?

6: Beyond iCOASST: Engaging humans and human behaviour

The main output of the conference is a special issue of papers in the journal, *Geomorphology* entitled "Simulating Decadal Coastal Morphodynamics"

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Upcoming activities

- **Special Issue in *Geomorphology* on "Simulating Decadal Coastal Morphodynamics" (editors: Nicholls, R.J., French, J. R. and van Maanen B.)**
- **Proposal to Royal Society for conference in late 2015/early 2016 on iCOASST results.**
- **Round 2 of stakeholder engagement**.

NATURAL ENVIRONMENT RESEARCH COUNCIL

ENVIRONMENT AGENCY

The iCOASST integrating COASTal Sediment Systems project is funded by the National Environment Research Council (NERC) and supported by the Environment Agency for England.