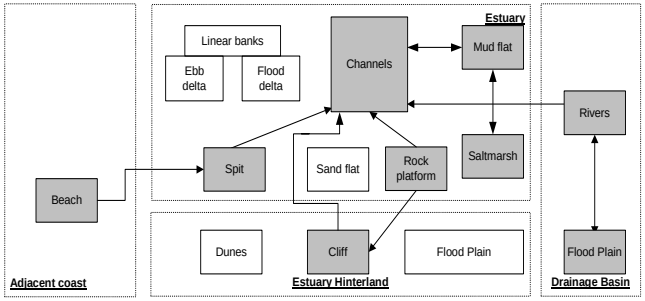


Figure: Example Systems Diagram: Generic Ria

At the level of system abstraction used within EstSim, the components of the system are the geomorphic elements that make up an estuary, such as saltmarsh, mudflat, spits, channels etc. EstSim has applied these systems-based concepts to estuaries to define and subsequently formalise the understanding of the system in a way that allows the qualitative prediction of long-term estuary morphological evolution and responses to environmental change (e.g. sea-level rise or sediment supply changes) or interventions (e.g. dredging or coastal protection). This research has been used to demonstrate the potential of such a systems-based approach.

Theory

Development involved first providing a formal definition of estuary systems through mapping of the system components (via production of systems diagrams) and providing an understanding of how these components interact.

This definition of an estuary system maps a set of influences between the morphological and process components. This definition has been formalised using a Boolean network approach. The Boolean approach is mathematically straightforward. An estuary is conceptualised as a set of morphological features (inlet channels, tidal flats, saltmarshes, spits etc.) and processes (waves, tides, sediment supply etc.), which can be represented in the form of a network of interconnected components. An example of a simplified Boolean network model is provided below.

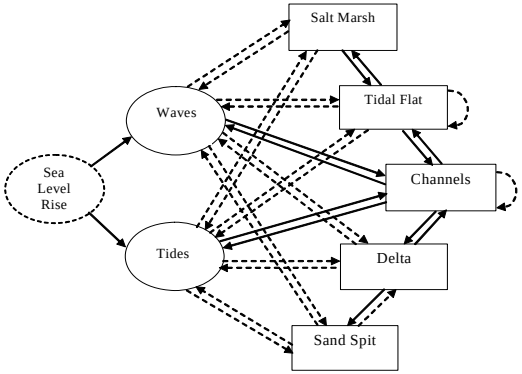


Figure: Boolean network model for simplified generic tidal inlet

At any time, a given morphological feature is either present or absent (or 'on' or 'off' in a logical sense) depending on the status of the other components with which it interacts. The Boolean formulation has been used to develop a *proof-of-concept* estuary system simulator. The prototype simulator incorporates linked sub-systems for inner and outer estuary zones, and for the interaction between the estuary and the open coast, and includes additional variables to represent engineering interventions (e.g. coastal groynes, seawalls, dredging). The prototype simulates the evolutionary trajectory in terms of the state of each of the components within the system.

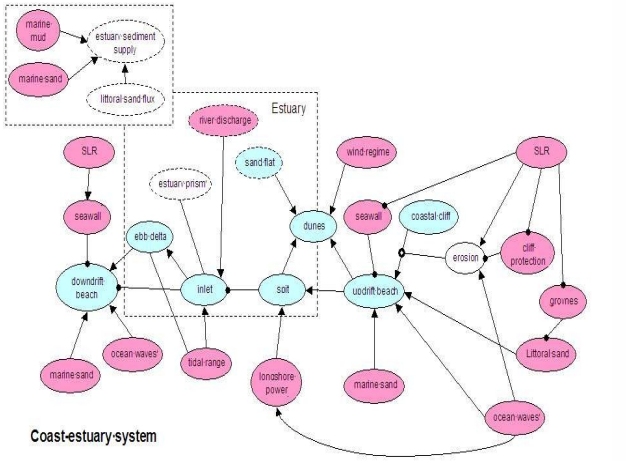


Figure: Example Influence diagram for interface between coastal and outer estuary sub-systems

This prototype simulator has been developed into a web-based interface. This provides full simulation functionality through an easy to use Graphical User Interface (GUI) and provides a means to promote systems based knowledge and understanding.

Validation

The prototype simulator has been applied to the Ribble Estuary and Southampton Water during development and to the Thames and Teign during the pilot-testing phase. In all cases it was shown that the prototype simulator can obtain a largely correct depiction of broad scale estuary changes and tendency. This conclusion is made in terms of the qualitative output of the model compared with observed features and known responses and behaviour of the estuary. Given the qualitative predictions of the approach, this is not a quantified validation, rather a knowledge based assessment. It has been concluded that there are subtle estuary-specific aspects of inherited morphology, sediment transport, hydrodynamics (e.g. the double high water in the Solent), and intervention history that would require customisation of the model functions.

The pilot testing exercise concluded that the prototype simulator was able to reproduce the observed features of the Thames and Teign. However, further validation studies are recommended to obtain more confidence in the results, i.e. by verifying the rule base and examining the response to particular effects in specific documented cases.

Range of Applicability

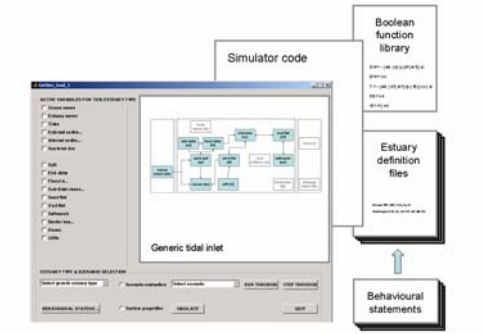
In its generic form, the prototype simulator can be applied to any one of seven UK estuary types, as well as user-defined estuaries. The approach requires expert knowledge of estuary morphology in order to set up the model for specific estuaries. The present implementation of the model does not allow for the magnitude of an effect to be determined, but it does capture the characteristic behaviour of an estuary system. The approach can therefore be used to determine directions of change or tendency but cannot quantify this change.

At the present level of development, the prototype simulator is *not* designed as a universal tool to evaluate estuary management options. The Prototype can be used to explore geomorphological behaviour, provide a guide to other modelling studies and provide a means to promote systems based knowledge and understanding.

Accessibility

The Prototype Simulator is accessible either as:

- Web-based graphical user interface http://www.discoverysoftware.co.uk/estsim/EstSim.html
- Open source Matlab code for the academic community, with a simple GUI, generic estuary function libraries, and technical information. http://www.geog.ucl.ac.uk/ceru/estsim



Figures: Above – Web based interface
Below – Illustration of GUI for Matlab prototype simulator

Acknowledgement

FD2117 was funded by the Joint Defra / Environment Agency flood and coastal erosion risk management R&D Programme as part of Phase 2 of the UK Estuaries Research Programme.

Partners

The EstSim project was undertaken by a consortium consisting of the following organisations:

- ABP Marine Environmental Research
- University of Plymouth
- Delft Hydraulics
- University College London
- Discovery Software
- HR Wallingford

Contacts:

For further information regarding FD2117 please contact:
Alun Williams(ABPmer)
awilliams@abpmer.co.uk

or Kate Scott (Environment Agency)
kate.scott@environment-agency.gov.uk

FD2117: Development and Demonstration of System Based Estuary Simulators (EstSim)

Introduction

Phase 2 of the UK Estuaries Research Programme (ERP2) has further developed tools to enhance our ability to assess morphological change in estuaries. Running in parallel to this development, FD2117: Development and Demonstration of System Based Estuary Simulators (EstSim) has investigated an alternative, yet complimentary, approach to help understand morphological behaviour in estuaries. This involves application of a systems-based approach to estuary environments. The research has been undertaken under the Joint Defra / Environment Agency flood and coastal risk management R&D Programme.

Aims

One of the key aims of the approach developed is to provide a qualitative framework to understand and explain the behaviour of geomorphological features within estuaries, the linkages that exist between them and hence their response to change.

The Systems Approach

A system-based approach involves defining the individual components that make up a given environment and characterising how these components interact in order to understand the system organisation and define its behaviour. Systems diagrams, such as that presented below, provide one simple means of mapping the components and linkages. A qualitative behavioural model can be developed by formalising the defined components and linkages that make up a system. Systems-based thinking is a well-established conceptual framework in geomorphology, however methodologies for converting system diagrams into practical simulation tools have not previously been investigated.