BEHAVIOUR MODELS

Method Indicator		
Bottom-Up	Hybrid	Top-Down
		YES

Summary of key issues

Issue	Description
Description	To develop an understanding of the behaviour of the system by capturing the nature of relationships between system components and mapping it onto a simple model, which exhibits the same behaviour, but which does not need to have any relationship to the underlying physical processes. Process based models provide insight into short term system behaviour, but evolution towards a longer term and / or larger scale equilibrium is often incorrectly reproduced. Behavioural models provide an alternative basis for understanding the behaviour of estuary and coastal systems at the scale of most relevance to management questions. Behavioural models is an overall model grouping and can cover a range of specific approaches. Further details of specific types of behavioural models can be seen for example under 'Regime Relationships'.
Temporal Applicability	Years to decades (short-term)
Spatial Applicability	Whole estuary or specific geomorphological features
Links with Other Tools	Behavioural models provide an insight into estuary behaviour that can also provide a basis for evaluating the output from more quantitative models.
Data Sources	Highly variable depending on precise nature of behavioural model. Data sources can include: • Qualitative understanding of estuary systems; • Process-based model results; • Parameters characterising / quantifying gross estuary properties; • Empirical relationships.
Necessary Software Tools / Skills	Highly variable depending on precise nature of behavioural model. However, typically there is a high degree of expertise and knowledge required to apply such approaches. Some behavioural models tend of offer indicative rather than strictly quantitative insights into system behaviour. Although it is noted that other approaches can be considered quasi or fully quantitative.
Typical Analyses	Typically, application of a behavioural type model involves mathematical analysis of a system in order to achieve insights into the direction of change of any or all of the system variables in response to external forcing or an imposed alteration to the system.
Limitations	• Behavioural models are inherently limited by our ability to formalise known system behaviour mathematically within a logically consistent framework.

Example Applications	Example applications are highly variable, given the potential variation in type of behavioural model. However, indicative examples: • Assessment of direction of predicted change to different geomorphological elements present in an estuary following major perturbation; • Assessment of cross sectional change under sea level rise

The systems approach seeks to explain how the different elements that make up the system *interact* (Cowell & Thom, 1994; Capobianco *et al.* 1999). Hence from the outset there is a need to have a clear understanding of what the elements are and the processes that cause different elements to interact. This is the essence of the system behaviour and importantly can only be understood by considering how the elements change with time. For management purposes the morphological responses of interest will primarily be 1 to 100 km scale and over years to decades.

The limits of current understanding mean that we are not yet in a position to frame all of the interactions at the higher levels in a quantitative manner and we have to make use of qualitative descriptions. These can take advantage of short-term process knowledge and empirical knowledge based on observations, comparison with other systems and intuition. This has led to the application of behavioural models to describe particular aspects of a system. These take two forms in the literature. The first are those that summarise steady-state conditions, or explain transitional behaviour, in effect *functional behaviour models*. Some of these are discussed more fully in the paper on Coast & Estuary Behaviour Systems (or see Townend, 2003; Capobianco *et al*., 1999).

The second is a class of models derived from running more detailed process models, to formulate an empirical description that summarises the behaviour in a simplified form (typically some form of parametric equation). They are therefore *empirical behaviour models,* to distinguish them from the first type of behaviour model. This was an approach developed as part of the Dutch Kustegenese programme (Stive *et al.*, 1990) and subsequently developed more formally as "behaviour-oriented models" by Capobianco *et al*. (1993; 1999). The concept is to use field observations and results from process-based models (run with real input conditions) to establish simple mathematical models that exhibit the same behaviour. Quite often the resulting model does not have any direct relationship with the underlying physical processes but does reflect the net change of some characteristic form (e.g. shoreline position). Capobianco *et al.* (1999) group both *functional* and *empirical* behaviour models under the heading of behaviour-oriented models. However given the emerging development of systems based approaches to studying complex geomorphic systems, such as estuaries and tidal inlets, it is considered useful to draw the distinction between the former as a more qualitative or descriptive representation of behaviour and the latter as a quasi or fully quantitative representation. There is however an inevitable overlap between the two.

A number of examples of behavioural models are contained and described within the Estuary Guide, for example Regime Methods and the Prototype Simulator developed within the EstSim project.

References

Capobianco M, de Vriend H, Nicholls R, Stive MJE, 1993, Behaviour-oriented models applied to long term profile evolution, Large scale coastal behaviour, USGS, Report No: Open File Report 93-381, 21-24.

Capobianco M, de Vriend H, Nicholls R, Stive MJF, 1999, Coastal area impact and vulnerability assessment: the point of view of a morphodynamic modeller, Journal of Coastal Research, 15(3), 701-716.

Cowell PJ, Thom BG, 1994, Morphodynamics of coastal evolution, In: Carter RWG, Woodroffe CD (Eds.), Coastal Evolution: Late Quaternary shoreline morphodynamics, Cambridge University Press, Cambridge, UK, pp. 33-86.

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Townend IH, 2003, Coast and estuary behaviour systems, In: Coastal Sediments '03: Crossing Disciplinary Boundaries - Proceedings of the Fifth International Symposium on Coastal Engineering and Science of Coastal Sediment Processes, East Meets West Productions (EMW) Inc., Corpus Christi, USA, pp. 1-14.