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Marine science for strategic planning and management: the requirement for estuaries

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Abstract

Strategic management and planning within estuaries seeks to identify a framework that enshrines sustainability. Within the UK, a scoping exercise has been used to clarify user requirements and define the economic benefits that could be derived from a supporting programme of research. The programme recognises the need for a mix of fundamental, strategic and applied research, to address, in particular, issues of

- long-term change;
- physical, chemical and biological interactions and
- system response (including socio-economic interactions).

Achieving such a programme will need to take advantage of research at a number of different spatial and temporal scales. These span from global climate change initiatives, through catchment and estuary wide studies to work on specific features (banks, mudflats, etc.). They necessarily consider changes over time scales of seconds to aeons. Realistically, for strategic planning and management, the goal is to be able to predict, with a reasonable degree of confidence over a 20–50 year time horizon. Given the highly non-linear and complex adaptive nature of estuary systems, absolute predictions may not be possible. Rather, it will be necessary to identify probable/possible outcomes, or system states, as a basis for guiding management actions. This, in itself, will require managers and planners to move away from a prescriptive interventionist approach towards a more adaptive one.

1. Introduction

Estuaries are a focal point for a wide range of human activities of increasing social and economic importance. The semi-enclosed basin that forms the estuary provides an area that is relatively sheltered, with a complex interplay of physical, chemical and biological processes, all of which are influenced by the marine environment and the surrounding catchment. With growing pressures comes the increasing risk that important habitats, such as mudflats and saltmarsh, will be lost or severely diminished.

Throughout history, man has settled near to the coastline and has used estuaries and rivers as a transport artery to inland areas. At first, estuaries were places of relative shelter and also provided a source of food and means of transport. As trading between different locations developed, ports grew up, initially as far inland as possible, since boats and ships offered the simplest form of transport. With time, ships have become larger so that the ports have moved progressively nearer the coastline where deeper water provides an economy of scale.

The industrial revolution increased the use of rivers and estuaries not only in transport of raw and finished goods but also in new uses, such as water extraction and discharges of waste. As populations grew there became a greater need for drinking water and the disposal of human waste, which was often taken from and/or discharged into rivers. Land for agriculture to feed the population and space for dwellings and industry was also required which led to reclamation or draining of low-lying areas. Thus, as man's ingenuity has evolved, increasing pressures have been imposed on the natural river and estuary system.

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Today, there are probably relatively few estuaries (particularly in the developed world) which have not been affected in some way by man's intervention. Furthermore, this interaction has now been ongoing for many hundreds of years, although most significant effects have taken place in the last 100–200 years.

Anthropogenic effects are therefore a major agent influencing the morphology of an estuary either directly by means of engineering works and/or indirectly by modifying the physical, biological and chemical processes at work within the estuary. Since any change rarely has an instant effect, changes to the governing processes caused by an intervention in the past may not have completely worked through the system before further modifications are made thus increasing the complexity of the interactions. The timing of any anthropogenic effects relative to previous modifications along with the magnitude of the effect are important when trying to predict future estuary evolution.

With growing pressures, comes the increasing risk that the long recognised areas of nature conservation importance will be compromised and hence a much more proactive approach is being adopted towards positive management for future generations. Estuaries are also extensively used for recreational activities, such as sailing, fishing and walking. Conservation and recreation have the potential to both contribute to, and conflict with, social and economic development and as such require careful balancing. Hence, an integrated approach is needed to address multiple uses and interests, with sustainability central to the management process.

Within the UK, the use of scientific advice in decision making is an area that has recently been under close scrutiny and a more open and structured approach is now recognised as a necessary starting point [1]. For estuaries, there have been a number of initiatives to define the requirements for such a process and to set a research agenda to meet these needs. The starting point was the user needs and this in itself raised a number of apparent conflicts. Once distilled, this does however provide a rationale for a mix of fundamental, strategic and applied research on the various scales noted above, embracing traditional research themes, developing fields that arise from the study of complex, non-linear adaptive systems and a social–economic interface that is essentially fuzzy. This paper provides a review of the issues identified and some suggestions for the way forward.

2. Nature of the problem

The nature conservation importance of estuaries has already been noted and within the UK this is reflected in the fact that some 76% of the area in estuaries has some form of European nature conservation designation[1] [2]. Estuaries are also highly productive and play an important role in the food chain. At the same time, conurbations that have developed alongside estuaries are often low lying and prone to flooding. The defences that now protect these areas inevitably constrain the estuary and, in the face of sea level rise, potentially limit the way in which the estuary can respond. Equally, as a trading nation, 84% by tonnage of UK imports and exports pass through ports in estuaries [3]. Continued growth, the development of shipping and the greater emphasis being placed on short-sea shipping to improve the intermodal transport balance, mean that there are pressures for ports to expand and develop new facilities. As with flood defence this has the potential to constrain the future evolution of the natural estuary system.

The problem is made more complicated by the very nature of estuary systems. Within an estuary, form and process are inextricably linked and there are no obvious dependent and independent variables, or clear cause–effect hierarchies. For example, although the size and shape of an estuary channel is a response to tidal processes, the tidal discharge is itself dependent on the morphology of the channel, since this determines the tidal prism.[2] This interdependence means that changes in one part of the system can cause responses elsewhere in the estuary. It follows that a strategic approach to estuary management must consider the estuary as a whole, managed within the spatial context of river/estuary/sea.

Changes such as reclamation, dredging and the removal of flood storage areas by the introduction of flood defences, all alter the dynamics of the system. Ironically, schemes to protect fresh water habitats at the margin of estuaries are progressively having the same effect. Many of these anthropogenic changes can be likened to various geological features that occur within estuary basins. Both serve to apply constraints on how the estuary can evolve. As the estuary adjusts to these various constraints, particular features within the estuary, such as the extent or position of intertidal, saltmarsh, sandbanks, etc., will also change. It is important to recognise that the estuary will adjust to the imposed constraints. Consequently, there is little point in seeking to define what the "natural" estuary system would look like. The central question for management is, rather, whether imposed changes will alter particular estuary features, that *we* value, in a way that *we* consider unacceptable?

This inevitably leads to the question of sustainability and some determination of what we are seeking to sustain. The guiding principle stated in the Bruntland

[1] Special Protection Area or candidate Special Area of Conservation.
[2] The volume of water that moves in and out on each tide.