1 Introduction

One of the main needs of coastal engineering is the understanding of coastal evolution at the time and space scale that fits with human needs, of course related to the technical and economical human means. This is because this understanding becomes indispensable to properly predict the coastal behaviour, which will determine the type and intensity of the use to be supported by the coast. Moreover, to (well) design any coastal engineering action it is necessary to predict the coastal response under such actions.

Tidal lagoons and estuaries, collectively named tidal basins, and barrier islands interrupt a large part of the world's shorelines with their associated coastal inlets. They comprise approximately 13% of the total coastline (245000 Km) of the world. Compared to the morphodynamic behaviour of uninterrupted coastlines and of rivers, the behaviour of a tidal basin is a degree more complex and less well understood (Stive et al., 1990). Also, there are strong indications that morphological response of tidal basins to natural and human interventions has an impact on the coastal sediment budget. Thus, modelling medium to long-term morphodynamic behaviour of tidal inlets play an essential role in modern coastal zone management.

Estuaries and tidal lagoons attract a variety of human activities, such as navigation, recreation, fishing and aquaculture, economical activity in the border zone… On the other hand, many estuaries and lagoons form the basis of highly valuable and sometimes unique ecosystems. Hence, human activities do have an effect on these systems. For their proper management it is essential to be able to predict the impacts of such activities (De Vriend, 2002).

Substantial advances in the field of behaviour prediction have been achieved in the past two decades while different numerical models are being developed in order to satisfy this need of prediction. Thorough analysis of field data for instance, has revealed that many inlet systems show a tendency to evolve gradually towards a state of morphodynamic equilibrium. In such a state, the morphology of an inlet may show comparatively small fluctuations but it remains constant in terms of averages over periods of years to decades. Thus, any human or natural disturbance to the system will break the morphodynamic equilibrium state; however, subsequent morphological changes will occur in order to reach again a steady state.

Because of complexity and diversity of phenomena involved in the morphological processes, and also, because of the different physical scales: from sand grains to dunes or shoals, and time scales from minutes to decades, these tidal systems seem to satisfy all conditions for inherently unpredictable behaviour (De Vriend, 1998). Recent experience, with a number of 2-D and 3-D morphological simulations of inlet systems in the Netherlands, including new small-scale mechanisms which at first sight should give more precision to the modelling, sometimes improves the results, sometimes it does the opposite (De Vriend et al., 2002). In summary, our capability to predict the morphological behaviour of tidal inlets and tidal basins is still unsatisfactory for practical use. Thus, each small advance in this field is strongly worth.

Main objective of this study

The present study aims at: (a) contributing to further developments in understanding the morphodynamics and extending the knowledge on fundamental behaviour of tidal inlets and basins and (b) to improve the prediction of the response of the system at the long-term scale, under the presence of a river discharge. In particular, an existing (ASMITA) modelling concept will be extended and adapted to reproduce the effect of a river discharge in a tidal basin.

Since, under this new situation, the model formulation becomes more complex, a simplification of the governing equations is proposed. The results of the (approximated) solution are compared to the exact solution to assess the validity and/or “error bounds” of this approach. For further applications, a generalisation of the equations that lead the model is also included.

Subsequently, this extension is applied to the Santander Bay (Spain) to gain insight into its morphodynamic behaviour. This bay is characterised for the presence of a small river discharge and for a harbour sited into the basin, taking profit of the sea climate: tidal-dominated. Every year, principally after storms, dredging activities are needed because of the channel operation. Moreover, the beach in Santander bay, which forms the boundary of the tidal basin, is retreating. This seems to be related to the dredging works. Advances in this field based on ASMITA model formulation will be used to see how the river in the Santander bay do affect to the system, and how this is related to the human intervention: the dredging works.

So, in summary, the main objectives of this study are:

- to extent the ASMITA long-term morphodynamic model for tidal inlets and basins by including a new term, the river discharge.
- to analyse the improvement of the prediction with this new term
- to apply this new formulation to a real case

Study outline

The outline of this study is as it follows:

In chapter 2, a general description of tidal inlets and basins is given, considering its importance in the world's shoreline. The need of prediction becomes clear, and the existence of different models trying to satisfy this needs. Then, in chapter 3, we will focus on ASMITA model. How tidal systems are schematised, hypotheses and mathematical formulation of the model will be explained. Afterwards, the new condition in the system, the river discharge, is considered. Subsequently, new equations will be presented. In the next chapter, we will apply the modified model to some examples. But, for this purpose, a simplification of the model equations is needed. We will start from a system with one element and end in a general formulation of the simplified ASMITA equations for a n-elements system. Simultaneously, comparison between a system without river will be presented. Chapter 5 presents a sensitivity analysis, which is necessary because of the nature of the input data. This analysis is also used to see the coherence of the model. Chapter 6 presents the application of the model to a real case (Santander Bay). And finally, chapter 7 summarises the main findings and results.