DHI SOLUTION

LONG-TERM SHORELINE PREDICTION

Forecasting the impacts of coastal structures on coastal processes

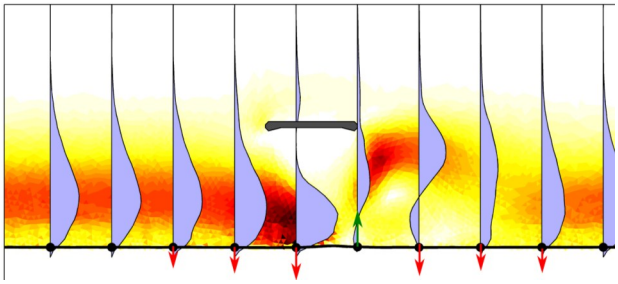
PREDICTING LONG-TERM SHORELINE MOVEMENTS – A VITAL NEED

Shoreline evolution can be natural or can be caused by the side effects of marine constructions, designed/artificial beaches and shoreline protection structures. Furthermore, climate change alters the base conditions under which coastlines evolve. In both cases, valid predictions of long-term shoreline movements are vital to mitigate or prepare for erosion and changes in coastal stability. Shoreline modelling addresses questions such as equilibrium shoreline, shoreline erosion and envelope (seasonal/event driven), sediment budget and so on.

Our old 'working horse' shoreline model LITPACK (now known as Littoral Processes FM) is valid in cases where the coastline is open and fairly straight. However for other types of coastlines and for coastlines with coastal structures, an assumption of alongshore uniformity will not be valid. As such, a more detailed and robust method is required – one that can cater to long time scales and resolve gradients in the hydrodynamics along the shoreline at the same time. This is where our new shoreline evolution model comes in.

THE NEXT GENERATION SHORELINE MODEL

The new shoreline model introduces the concept of a 1-line model for shoreline evolution within the MIKE 21 FM framework. The shoreline model can be applied to problems over a longer time scale. This is due to the simplifications imposed on the morphologic evolution of the coastal profile, when compared with the existing two-dimensional (2D) morphological model MIKE 21 Coupled FM. The shoreline evolution is based directly on the calculated sediment transport field from the area model MIKE 21 ST FM. The latter calculates the transport of non-cohesive sediments due to the action of waves and currents. Effects from coastal structures on shoreline evolution are inherently included in the new shoreline model because their effect on the waves and flow are included in the underlying models for wave transformation and hydrodynamics.



Shoreline evolution is based on a 2D sediment transport field. Changes in shoreline affects wave transformation, flow and the sediment transport. Source: Kristensen et al. (2013).

SUMMARY

CLIENT

- Coastal authorities
- Consultants and contractors
- Offshore renewable industry
- Port and terminal owners

CHALLENGE

- Need to understand and predict the interaction of several coastal structures and their impact on coastal processes
- Lack of adequate computational requirements for such long-term predictions
- Degeneration of coastal profiles due to uncertainties in cross-shore transport

SOLUTION

Detailed sediment transport description from a two-dimensional (2D) coastal model combined with a shoreline evolution model

VALUE

- Ability to calculate stable shoreline and shoreline envelopes and compare shoreline movements for different scenarios
- Seamless integration of a shoreline model into the existing detailed 2D coastal model
- Inherent inclusion of the effects of coastal structures in the shoreline model
- Ability to make long-term predictions of coastal structure interactions and their impact on coastal processes
- Maintenance of coastal profile integrity

Example: Examination of beach nourishment at Dunkeque Port, France. Red colours indicate erosion. Source: Grunnet et. al. 2012.

EXAMPLES

1. Nourishment at the Port of Dunkerque

In 2012, researchers investigated long-term shoreline evolution following different nourishment scenarios (nourishment on the beach, nourishment in the profile, how much and when to nourish and so on) at the French port of Dunkerque. We used our new shoreline model for this purpose. The aim of the study was to improve protection of the dike (immediately east of the harbour) to increase safety against flooding of the hinterland.

The complex coastal processes in the area are caused by:

- a tidal range of 3.5-5.5 m
- drying of tidal banks located several kilometres offshore
- complex tidal driven transport in the tidal channels

Several scenarios were investigated with 10 years of numerical shoreline modelling. The scenarios were compared by evaluating the remaining volume of nourished sediment. Regular maintenance nourishment was also considered in the study.

Palm Beach. Illustration of management scheme with two headlands. View towards north. Source: DHI (2013). Photo: Google Earth

1. Shoreline management at Palm Beach

A number of different shoreline management schemes at Australia's Palm Beach were investigated by using the new shoreline model. The study compared three different protection strategies. During the work a, number of iterations were performed together with the customer in order to obtain the best solution for Palm Beach.

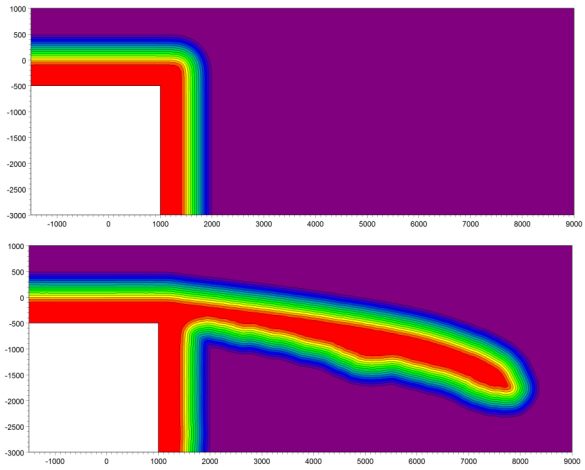
FLEXIBILITY TO CHOOSE

The coastal profile included in the simulations may be specified by:

- a constant profile along the entire shoreline
- interpolation between a number of profiles
- direct extraction from a bathymetric survey

The new shoreline model implements a flexible dynamic baseline, thereby allowing the model to be applied to problems with a curved coastline.

CPU time spent on long-term shoreline evolution may be kept low by using the new quasi steady hydrodynamics formulation. In this formulation, we utilise a transition between real-time simulation of storms and simulations of more calm events where a speed up method for the calculations can be used.



A dynamic baseline allows simulation of spit evolution in MIKE21 Hybrid FM. Source: Kaergaard (2013).

BUILDING ON OUR VAST KNOWLEDGE OF COASTAL PROCESSES

The first of our numerical models for coastal processes were developed in the 1980s. These models were all based on generic descriptions of coastal processes founded on research carried forward by the Technical University of Denmark. Present day models continue along this path, relying on process-based descriptions. This allows for the application of the models to as wide a range of coastal types as possible.

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