Bachelor Earth Sciences
Examination Course: GEO3-4306 Coastal Morphodynamics

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voor de verzameling

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Question 1 Morphological and tidal changes in an estuary

Paleogeographic developments in the Western Scheldt estuary are illustrated in Fig. 1.1; it shows the effect of both natural and man-induced developments inside the estuary. Meanwhile and over the same period tidal conditions in the Western Scheldt estuary have also changed; the modification in tidal range is demonstrated in Fig. 1.2 ; the diagram is based on tidal observations since 1650.

a) What is the relation between the development of the tidal range and the morphological development of the estuary ? Explain the longitudinal change in tidal conditions inside the estuary. Motivate your answer.

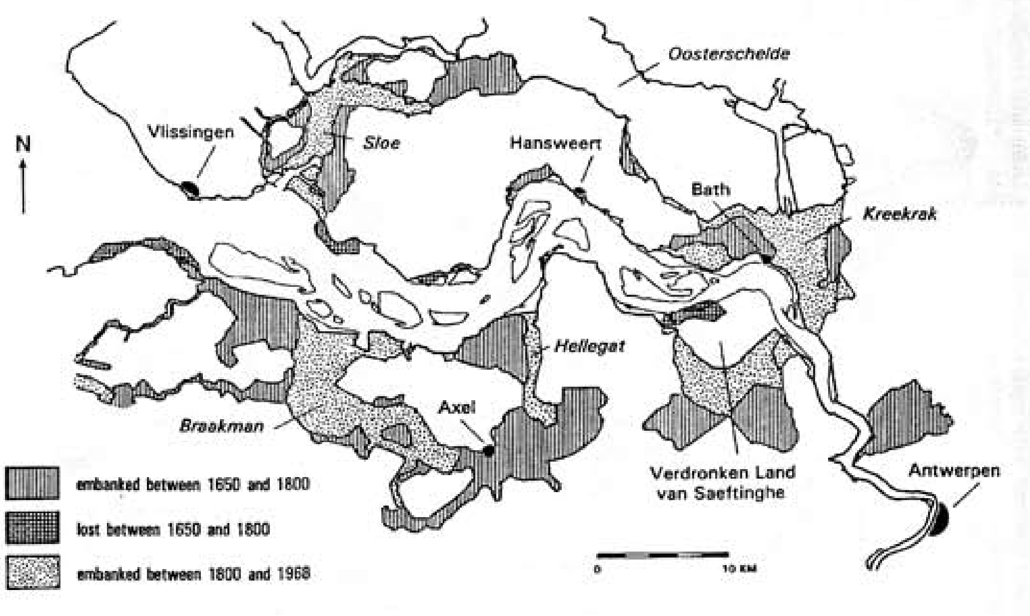

Fig. 1.1: Changes in intertidal morphology in the estuary of the Western Scheldt since 1650.

b) What will happen with the time lag between the moment of high water at Vlissingen (almost at the mouth of the estuary) and the moment of high water at Antwerpen (about 75 km upstream in the estuary) in the same period ?

c) What will happen with the tidal prism of the Western Scheldt and what kind of morphological feedback can be expected ?

d) What is the effect of an increase in tidal range for the erosional and depositional processes that operate in salt marshes? Discuss both wave- and current-driven processes.

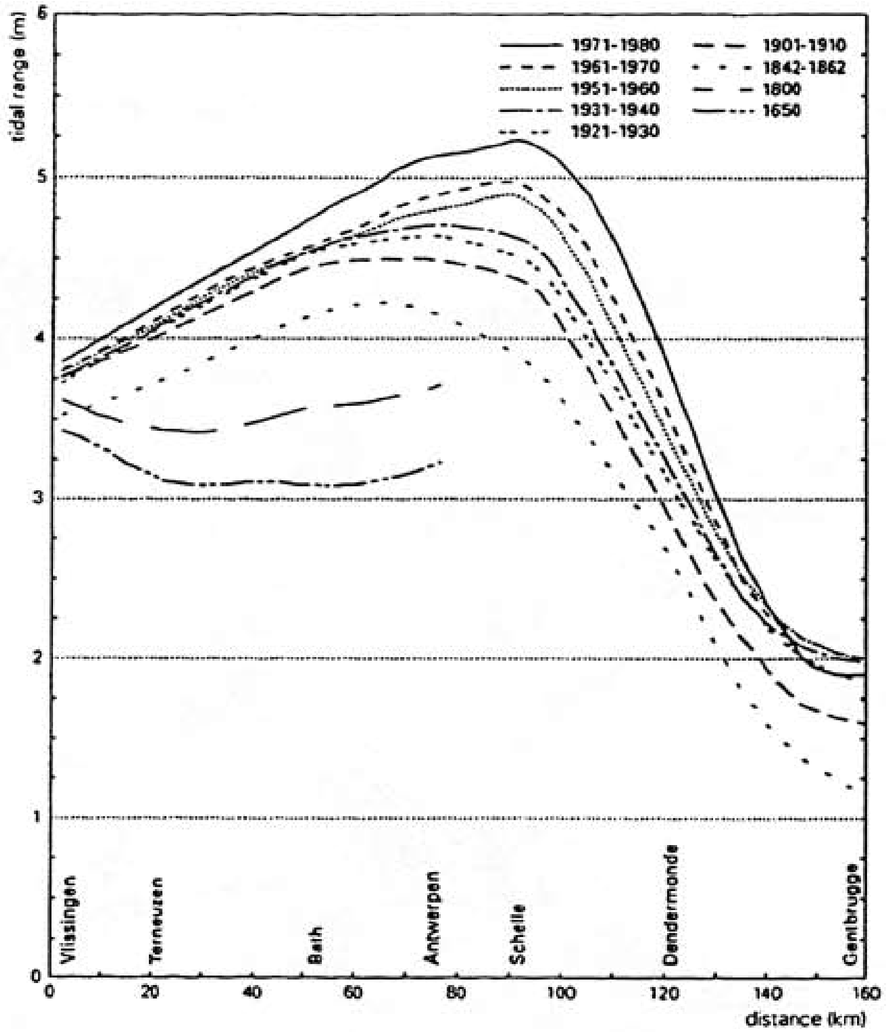

Fig. 1.2: Tidal range in the estuary of the Western Scheldt as function of time (developments since 1650) and location inside the estuary. The mouth of the estuary corresponds to km section 0 (close to Vlissingen).

Question 2 River outflow in a tropical delta system

River outflow and sediment transport in a tropical delta system is depicted in Fig. 2.1; the morphology of the system is illustrated in Fig. 2.2.. Measurements were carried out in the river mouth and include water depth, flow velocity and direction, salinity distribution, the Ri – number and the suspended sediment concentrations as function of height above the bed.

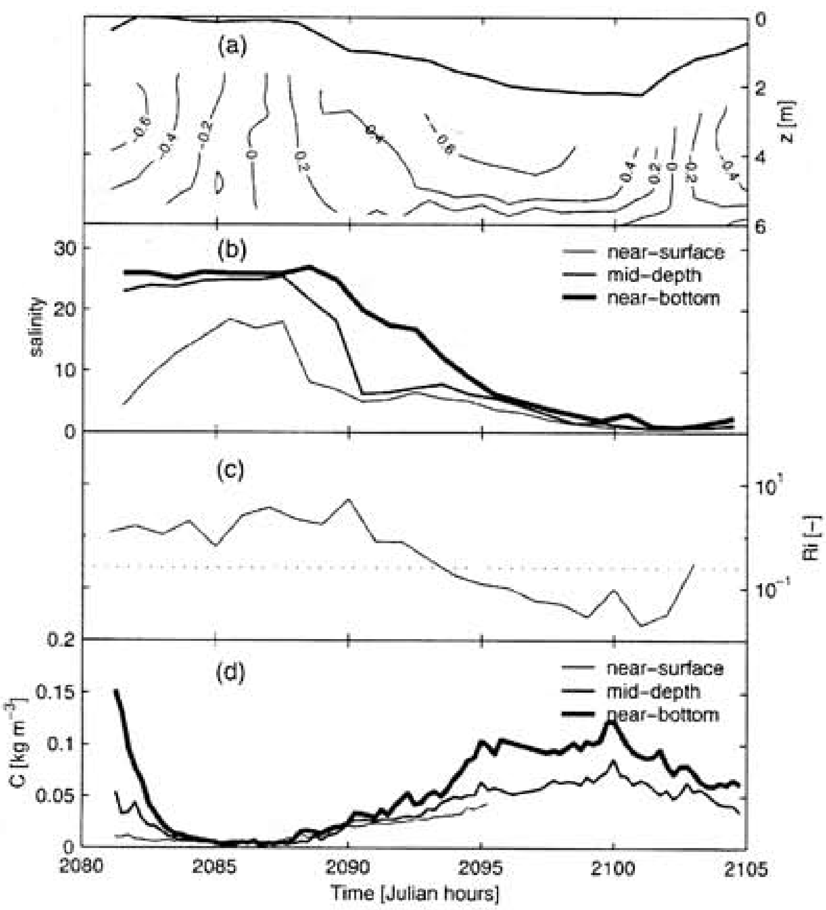

Fig. 2.1: Hydrodynamic and sediment transport conditions in the mouth of a tropical river. It shows water levels and flow velocity (a, positive flow is in downstream direction), salinity distribution (b), Ri-number (c, dashed line Ri = 0.25) and suspended sediment concentration.

a) Are tidal conditions in the river mouth a product of a progressive wave, a standing wave or a mixture of both ? Explain your answer.
b) Explain the relations between the velocity, salinity and suspended load patterns measured at this location.

c) How stable is the density stratification in the system and how will it be affected by tidal straining, a density-driven circulation and tidal stirring/mixing ?
d) How representative are the measurements in this diagram to explain the overall morphology of this delta system (see Fig. 2.2). Motivate your answer.

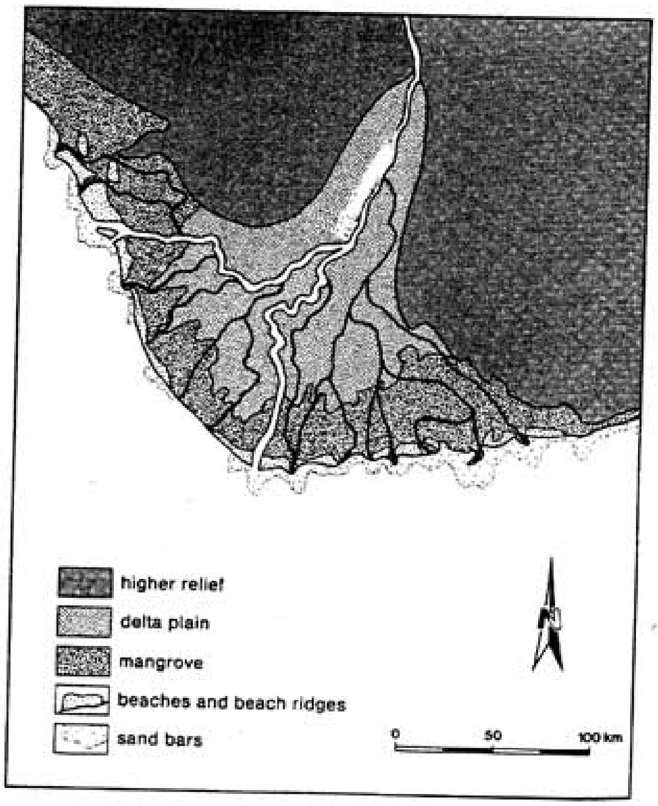

Fig. 2.2: Overall morphology of a tropical delta system

Question 3 Wave shape and cross-shore morphological evolution

Cross-shore sediment transport in the nearshore depends, in part, on the shape of the incident surface gravity waves. Broadly speaking, the wave shape can be sinusoidal, skewed (also known as 'Stokes'), and saw-tooth like.

a) Make a schematic drawing of each wave shape. Use your drawings to indicate the fundamental differences between the three wave shapes.

b) Figure 3.1 shows the cross-shore evolution of the wave height (top panel) over a plane-sloping beach (bottom panel). Specify where in the cross-shore profile you expect the wave shape to be sinusoidal, where to be skewed, and where to be saw-tooth like. Motivate your answer.

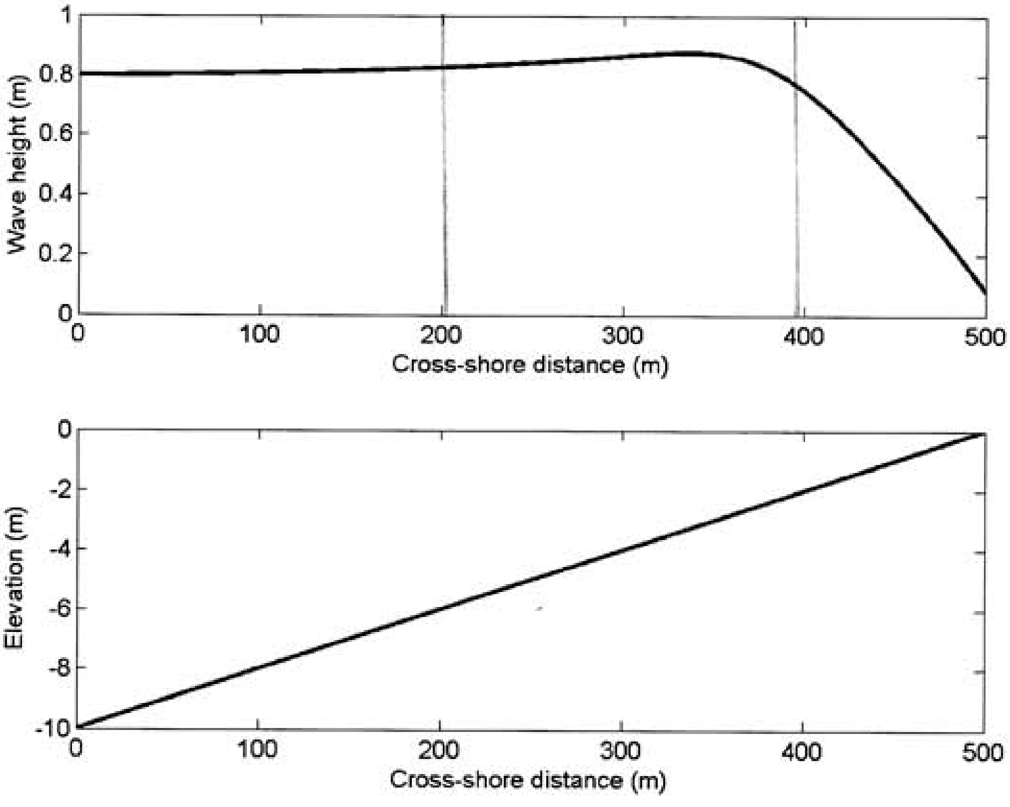

Figure 3.1 (top panel) Cross-shore transformation of the wave height, computed over a plane-sloping beach (bottom panel)

c) Why do skewed waves commonly result in onshore sediment transport? Provide a detailed answer.

d) Measurements of sediment transport under skewed waves sometimes show offshore wave-driven sediment transport. Provide one possible reason for this reversal in sediment transport direction. Explain your answer.

e) Figure 3.2 shows the change in the position of the sandbar after one month of relatively low-energy wave conditions. In this period, the sandbar moved onshore from a cross-shore position of approximately 500 m from the offshore boundary to approximately 575 m from the offshore boundary. The sediment transport near the sandbar was dominated by sheetflow under skewed waves. Use the morphodynamic-system approach to explain why skewed waves under sheetflow conditions generally result in the onshore migration of a nearshore sandbar.

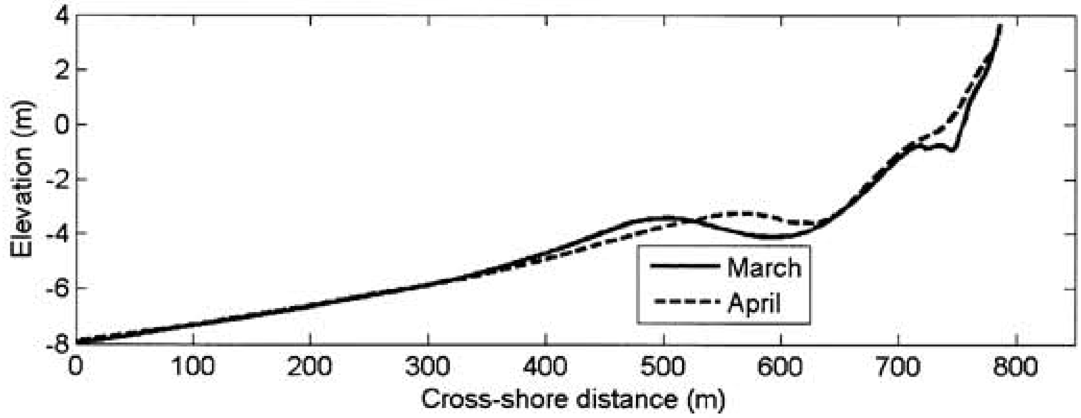

Figure 3.2 Bed elevation (relative to mean sea level) versus cross-shore distance.

Question 4 Alongshore currents and morphological evolution of the shoreline

The left panel of Figure 4.1 is a snapshot of the nearshore zone near Duck, North Carolina, USA. The seven (almost) horizontal black lines are so-called pixel arrays. The arrays are located from 220 m to 120 m from the beach. Time series of instantaneous video intensity can be processed into estimates of alongshore current velocity. The right panel of Figure 4.1 shows the results for the wave conditions shown in the left panel of

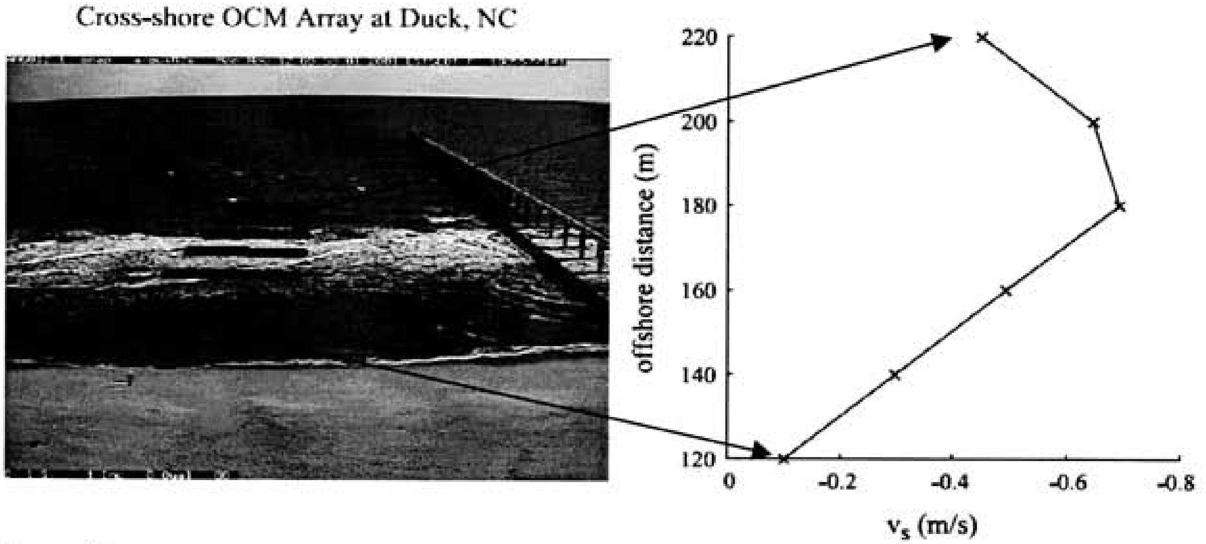

Figure 4.1.

Figure 4.1 (left panel) Snapshot of the nearshore zone near Duck, North Carolina, USA. The black lines are pixel arrays to measure the alongshore current velocity. The right panel shows alongshore current velocities (on the horizontal axis) versus cross-shore distance (on the vertical axis). The pixel arrays are located from 220 m to 120 m from a baseline in the dunes.

a) Does the cross-shore depth profile at Duck contain a sandbar? Use the snapshot in Figure 4.1 to motivate your answer.

b) According to the researchers at Duck, the computed cross-shore structure of the alongshore current signifies that there is no rip channel in the vicinity of the pixel arrays. Are the researchers correct? Motivate your answer.

Some 100 kilometers away from Duck, North Carolina, the beach is plane sloping, like in the bottom panel of Figure 3.1. This beach is alongshore uniform.

c) Compute the mid surfzone value of the alongshore current for this plane sloping beach when the height of the breaking waves is 1.5 m and their angle with the shore normal is 30°. Specify the equation you used.

d) Compute the surfzone averaged alongshore sediment transport rate in m^3/day for this plane sloping beach when the height of the breaking waves is 1.5 m and their angle with the shore normal is 30°. Specify the equation you used.

e) Based on your answer at d), will this beach erode or accrete? Assume that the cross-shore sediment transport is negligible relative to the alongshore sediment transport. Motivate your answer.