Bachelor Earth Sciences
Examination Course: GEO3-4306 Coastal Morphodynamics

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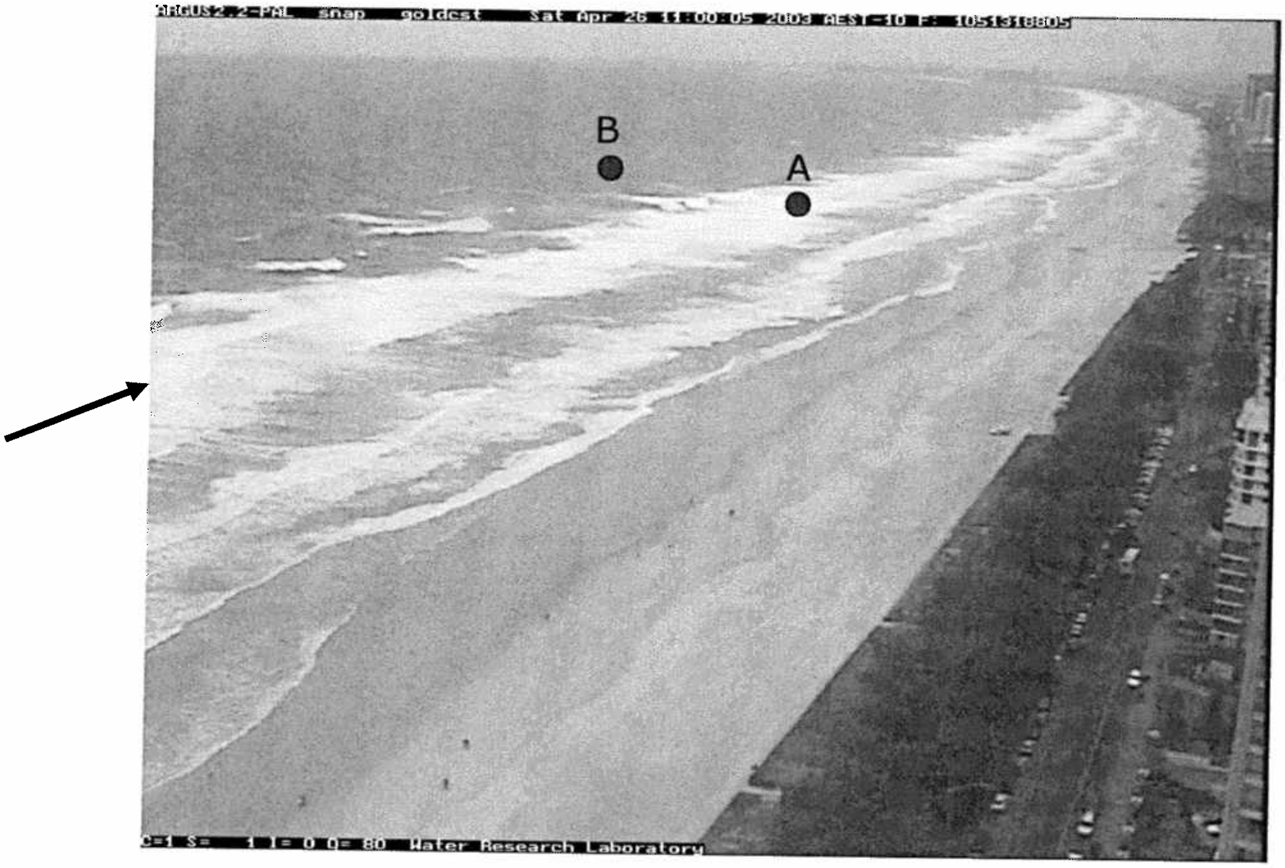
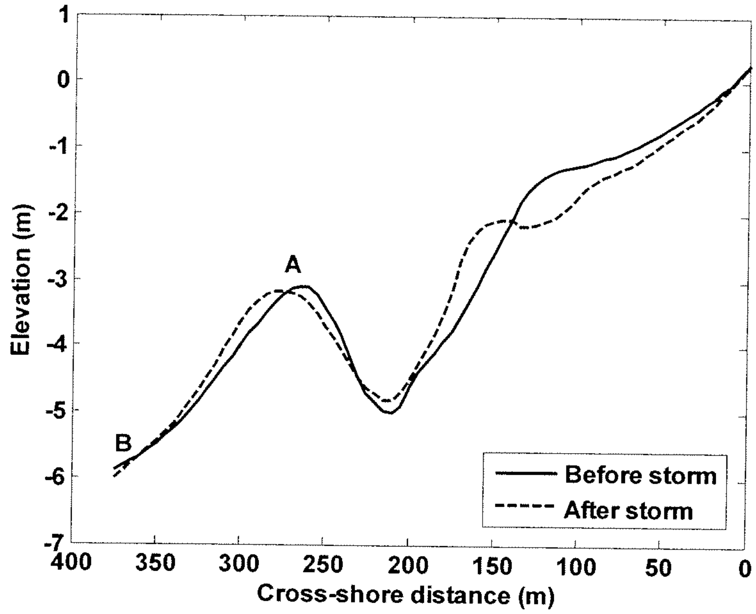
Question 1 Nearshore sediment transport and morphology

The photograph below shows a picture of a beach during a storm. The waves, which have a height of about 2 m in deep water, break on the sandbar as indicated by the arrow. The sandbar is approximately 275 m from the shoreline. During the storm, nearshore scientists deployed instruments at the crest of the sandbar (indicated by A) and about 100 m seaward of the sandbar (indicated by B, mean waterdepth = 6 m). The instruments measured the cross-shore and alongshore near-bed velocity and concentration with a sampling frequency of 2 Hz. In addition, the scientists deployed an instrument at each location to determine whether the sea bed was flat or contained ripples. The median grainsize at both A and B is 250 μm. The tidal range at this site is about 2 m.



The figure on the next page shows two cross-shore profiles, one before the storm (solid line), the other after the storm (dashed line). The locations of the instruments are also indicated. The elevation is with respect to mean sea level.



a) Use the morphodynamic system approach to explain why the sandbar migrated offshore (from approximately 265 to 275 m from the shoreline) during the storm. In your answer, use the photograph to reason about the dominant water motions during the storm.

b) During the storm, the sea bed at location B was observed to be flat (sheetflow conditions). The measurements showed the wave-induced suspended sediment transport to be in the onshore direction. What is the most logical cause for this onshore transport? Clearly motivate your answer

c) Now suppose that the median grain size sediment at location B was not 250 μm, but 100 μm. How would this finer sediment have affected the direction and magnitude of the wave-induced sediment transport at location B during the storm? Assume that the sea bed remains flat.

d) After the storm, the wave height reduced to values of about 1 m. Yet, the instrument at location A measured a strong (about 1 m/s) seaward-directed mean current, especially at low tide. Make a sketch of the anticipated sandbar morphology (alongshore planview) after the storm and indicate the location of the instrument position A with respect to the sandbar morphology. Explain your choices.

e) As mentioned under d), the seaward-directed mean current was particularly strong during low tide (about 1 m/s), while the seaward-directed mean current during high tide was essentially absent. Provide a reasonable cause for the dependence of the strength of the mean seaward-directed current on the tidal level.

Question 2 Shoreline and dune evolution

The following figure provides a (cross-shore) definition sketch describing variables used in scaling the impact of storms on barrier islands and dune coasts. D_{LOW} and D_{HIGH} are the elevation of the dune base and the dune crest, respectively. R_{HIGH} and R_{LOW} are the maximum and minimum run-up on the beach, respectively. T stands for wave period in the swash and t for time. The value of R_{HIGH} is often computed as the sum of the maximum wave set-up, the swash height exceeded by 2% of the swash events, the tidal level and the storm surge level.

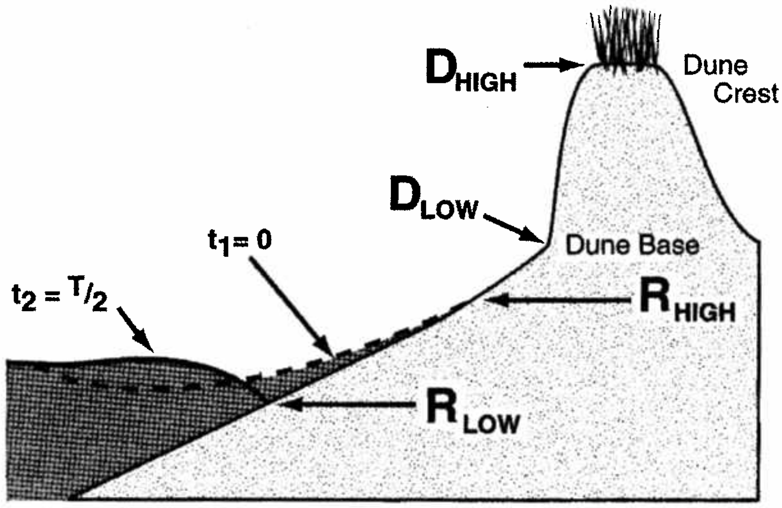


Figure 3. Definition sketch describing variables used in scaling the impact of storms on barrier islands.

a) What is a typical value for the swash wave period T on high-energy, dissipative beaches? Motivate your answer.

b) Estimate the value of R_{HIGH} for a storm with an offshore wave height of 6 m and an offshore wave period of 10 s. The beach slope is 1:30. The storm hits the coast during high tide (1.5 m above mean sea level) and causes a surge level of 2.0 m.

c) During another storm, the dune is largely destroyed and pushed onshore in the form of overwashes. What was the relative magnitude of R_{HIGH} versus D_{HIGH} and of R_{LOW} versus D_{HIGH} during this storm? Explain your answer. [Note: answer in terms of "larger than", "smaller than", or "equal to"]

Question 3 River outflow processes and patterns in the Po Delta

River outflow processes and conditions have been measured in the Po Delta, in the Adriatic Sea (Italy). The Po River is Italy's largest river with a length of 675 km and a drainage basin of 71.000 km^2. The river enters the Adriatic Sea through a large delta with five distributary mouths; the Pila distributary is the main mouth (Fig. 3.1). River outflow patterns are recorded in Figures 3.2. and 3.3, and respectively show the offshore dispersion and distribution of Suspended Matter (SPM; during two surveys in 2000 and 2001) and the salinity and SPM distribution, including the grain size distribution of SPM (in the form of spectra). In October 2000 major floods were observed in the river whereas in 2001 the river discharge was clearly below average.

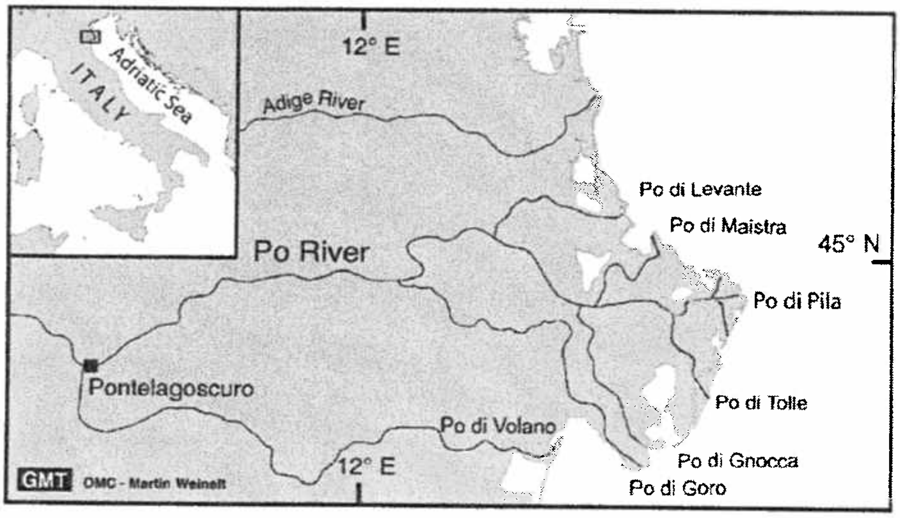


Figure 3.1: Map of the Po River and delta showing the five distributaries and the main outlet (Pila mouth).

a) Which hydrodynamic processes and mechanisms explain the seaward dispersion and distribution of SPM? Also explain the interannual variability in the system.

b) How relevant are these hydrodynamic processes for the overall morphological development of the Po delta system. Motivate your answer and discuss the role of waves, tides and river outflow.

c) The longitudinal pattern in concentration and grain size distribution of suspended matter (SPM) show a clear pattern (Fig. 3.3). Explain both patterns.

d) At times of high river discharge fluvial and brackish water masses will be transported into the basin and along the coast. Will the transport be dominantly to the north, the south or offshore; motivate your answer.

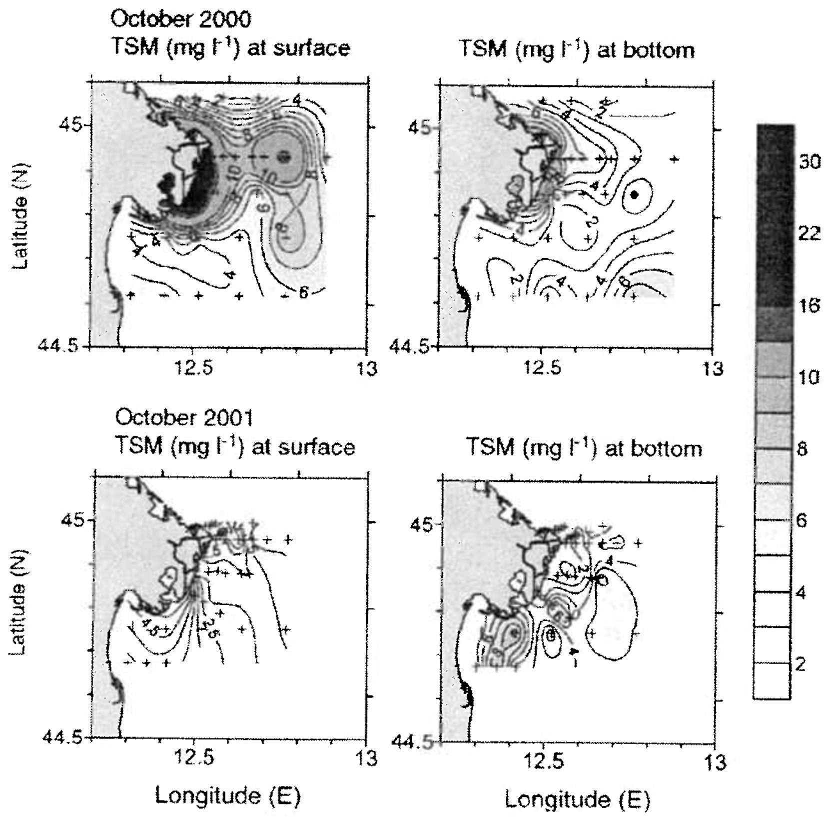


Fig. 3.2: Distribution of SPM at the surface and bottom in October 2000 and 2001.

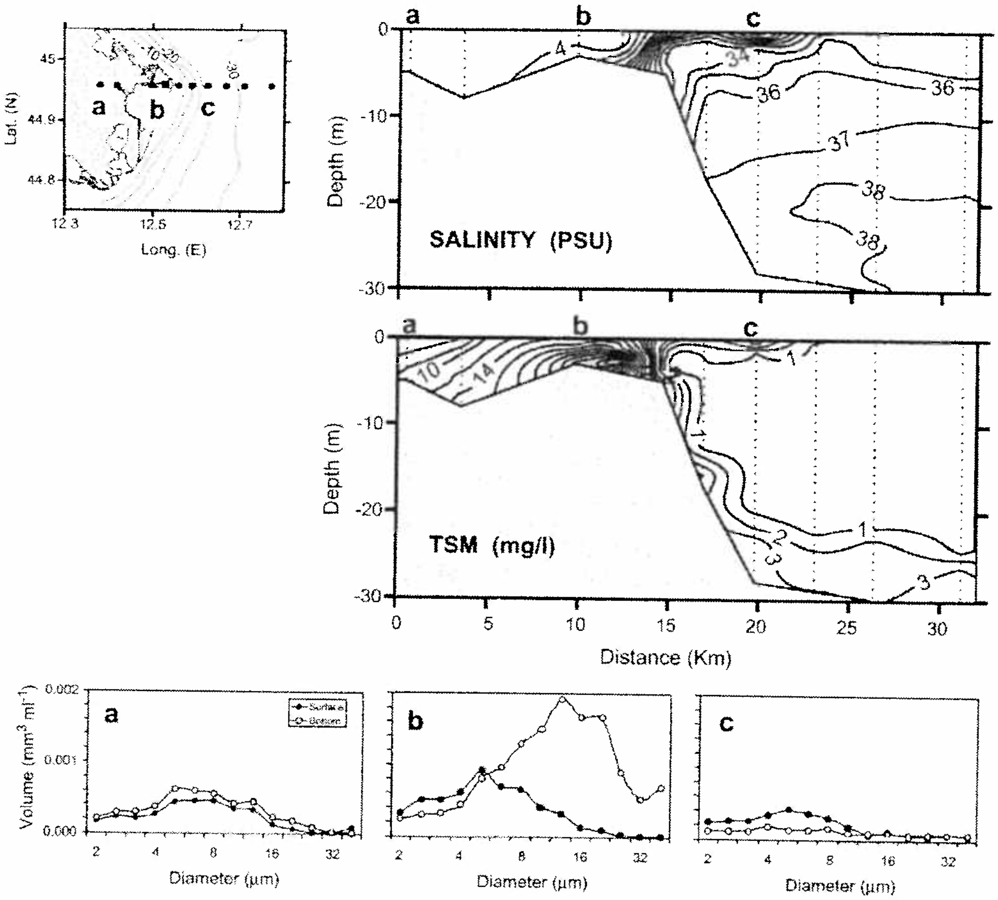


Figure 3.3: Salinity and Total Suspended Matter distribution in the coastal water, including particle grain size spectra in 3 different stations (October 2001).

Question 4 **Barrier islands Alaska**

The Pacific south coast of Alaska is characterized by a chain of barrier islands, including tidal inlets and tidal basins. On the landward side of the barrier system one can also observe a number of river mouths/estuaries (Fig. 4.1). Morphological parameters for the barrier island system are also depicted in Fig. 4.1.

a) Indicate the direction of the average longshore drift in this coastal region (give arguments!). Where can one observe the largest tidal prism?

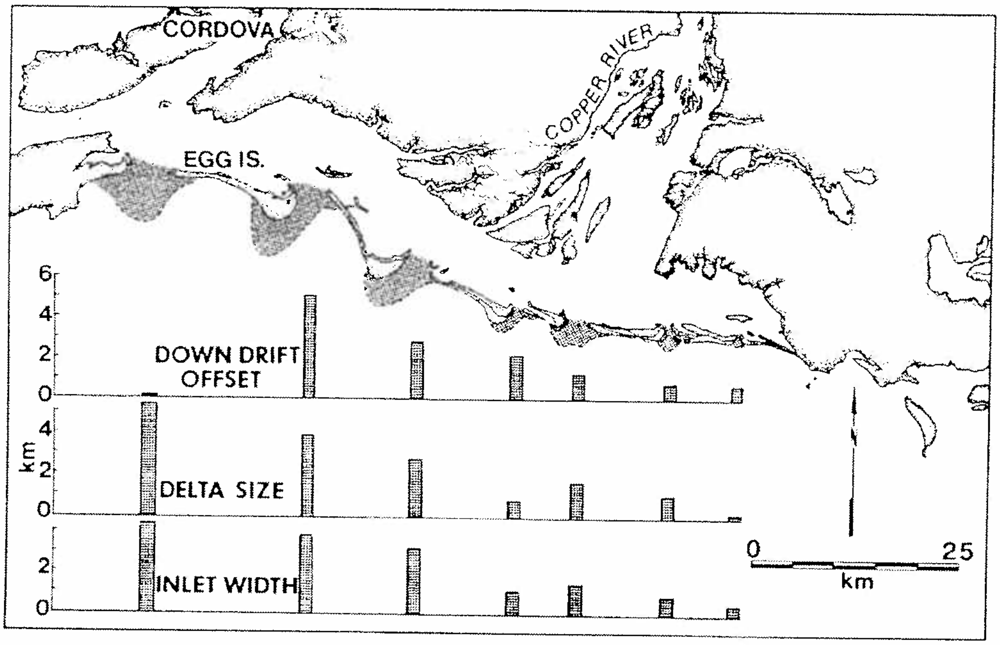


Fig. 4.1: Barrier islands along the south coast of Alaska; variability of morphological parameters.

In 1964 the southern part of Alaska was subjected to a heavy earthquake that resulted in a local uplift of the coastal zone and the marine system. This uplift is anticipated to have pronounced effects on the hydrodynamic and associated morphological developments in the coastal region. The uplift is illustrated in Fig. 4.2.

b) What are the expected consequences for the following processes and/or parameters: I) the tidal regime in the area II) the tidal prism and III) the wave action?

c) What are the potential morphological effects of this uplift for: I) the tidal inlets II) the degree of offset of the islands and III) the length of the islands and the associated patterns of erosion and deposition?

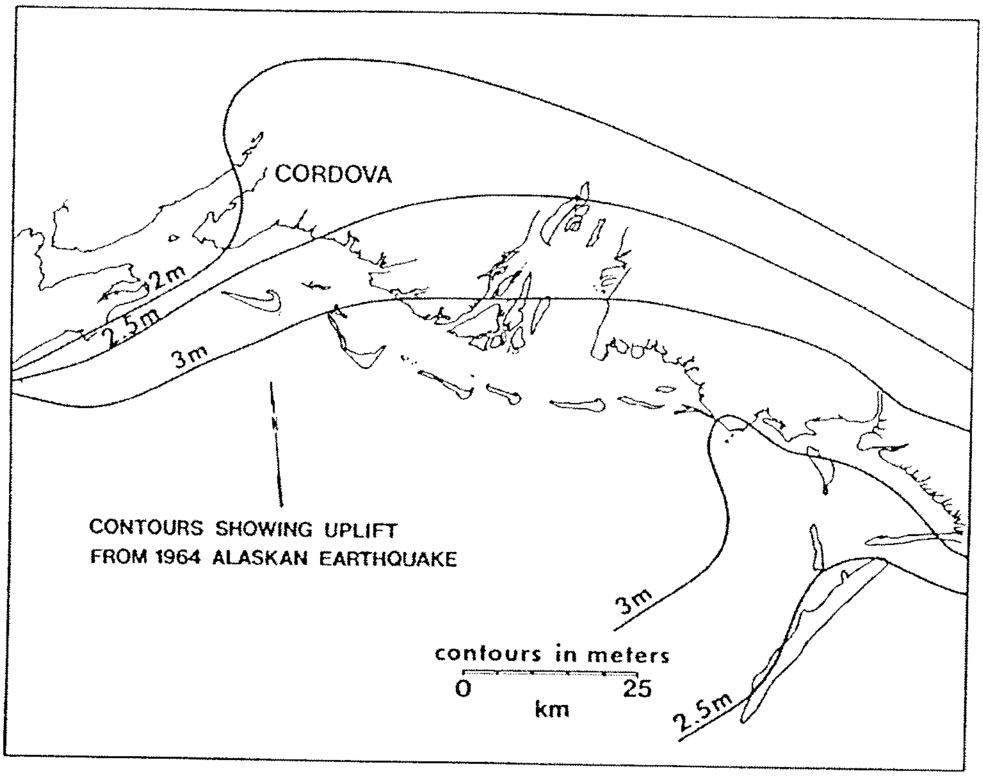


Fig. 4.2: Uplift in the coastal zone of South Alaska due to the 1964 earthquake.