Impacts of Sea Level Rise and Sediment Grain Size on Sediment Balance and Morphological Change During Floods in the Abukuma River Estuary

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During flood events in estuarine areas, a series of morphological processes occur, including erosion of sandbars, formation of estuarine terraces, and subsequent redistribution of sediment by waves and tides. Understanding these processes is important for flood control and land protection. Sea level rise may alter these dynamics, increasing vulnerability to sandbar loss and coastal flooding. However, the impact of flood events has not been evaluated in future predictions of morphological changes under sea level rise. This study aims to quantitatively evaluate the impact of sea level rise on sediment balance and morphological change in the Abukuma River estuary during flood events.
The study area is the Abukuma River estuary in Miyagi Prefecture. We used Delft3D, a coupled numerical model of waves, currents, and sediment transport, to analyze hydraulic conditions and morphological changes in the estuary where river flow, waves, and nearshore currents interact with each other. The study period was set from August 1 to August 15, 2009. The calculation cases were a base case with a sea level rise of 0.00 m and a grain size of 0.2 mm, cases with different sea level rises of 0.17, 0.40, 0.68, and 0.88 m, and cases with different grain sizes of 0.1, 0.3, 0.4 mm, taking into account uncertainties in sea level rise and sediment grain size.
As a result of calculation using Delft3D, when sea level rise was considered, sediment transport volume decreased as the magnitude of sea level rise increased. This is likely because the backwater effect caused by sea level rise altered the water surface profile, reducing the downstream gradient and thereby decreasing the tractive force. The sediment balance around the sandbar indicated a tendency for erosion and the occurrence of sandbar flushing. As sea level rises, the amount of erosion has decreased, resulting in the suppression of sandbar flushing. This result suggests that morphological recovery after flooding, as well as maintaining shoreline stability, may become more difficult. Furthermore, the sediment balance in front of the river mouth indicated the amount of sediment transport volume that contributes to the formation of an estuarine terrace, but this balance also decreased with sea level rise. The suppression of estuarine terrace formation could reduce the long-term protective function. Whan grain size was varied, erosion around the sandbar decreased as grain size increased. However, no significant difference was observed between the 0.1mm and 0.2mm grain sizes. Deposition in front of the river mouth increased under finer conditions. These results suggest that fine sediments are more easily eroded but tend to redeposit and redistribute within the river mouth, especially near the sandbar. Moreover, the spatial extent of the estuarine terrace varied depending on the grain size. Coarser sediment transport tended to confine the deposition area near the river mouth, while finer sediment allowed the deposition area to expand further offshore. Future work will involve a detailed analysis of particle size-specific sediment balance and transport characteristics to clarify the redeposition and redistribution processes in the estuary.

Keywords: river mouth, Delft3D, sediment transport, sea level rise

