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Observations and analysis of estuarine mixing dynamics influenced by floodgates and varying bathymetry

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Abstract Text:

Saltwater intrusion that widely occurs in estuarine environments can affect water quality and be problematic for local communities. Human activities and structural changes to estuarine areas, such as the construction of hydraulic structures, can aggravate freshwater salinization. At the mouth of the Haringvliet estuary in the Rhine-Meuse delta, a tidal basin in western Netherlands, floodgates restrict the free exchange of saltwater and freshwater. These hydraulic structures reduce the cross-section of the flow leading to local flow acceleration, which in combination with the alluvial bed have resulted in large-scale scouring in the vicinity of the Haringvliet floodgates. Subsequently, salt can accumulate in the gate scour holes, as well as in other bathymetric depressions in the estuary, and can potentially exacerbate the salinization of freshwater near the estuary once it is entrained by the flow. Field measurements of flow velocity, wind speed and direction, water level, and chloride concentration were carried out in various locations, including scour holes, throughout a large part of the Haringvliet estuary within a period of six months. The flow velocity data were collected using ten bed-mounted acoustic Doppler current profilers (ADCPs), with mean velocity profiles obtained every ten minutes with a vertical resolution of 50 centimeters. In addition, ADCPs were used to determine how salt concentrations in stratified flows change based on acoustic backscatter data. The vertical structures of the flow velocity profiles and salt concentration distributions within and above the scour holes are analyzed to detect correlations between different physical forcings and the frequency and severity of salt intrusion events and the associated intrusion lengths. The observed flow patterns at the Haringvliet estuary are also linked to the varying bathymetry and to flow alterations induced by the floodgates as well as to salt trapping in the scour holes and entrainment by the flow.

Acknowledgments: This research was funded by the Netherlands Organisation for Scientific Research (NWO), research program SALTISolutions with project number P18-32. Rijkswaterstaat, the Dutch Ministry of Infrastructure and Water Management, is thanked for providing extensive field data for this research.

Session Selection:

EP033. River Deltas: Hydrology, Geomorphology, and Sedimentology

Submitter's E-mail Address:

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Abstract Title:

Observations and analysis of estuarine mixing dynamics influenced by floodgates and varying bathymetry

Requested Presentation Type:

Poster Only

Previously Published?:

No

Abstract Payment:

Paid (agu-fm21-882144-3594-3828-2527-8469)

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