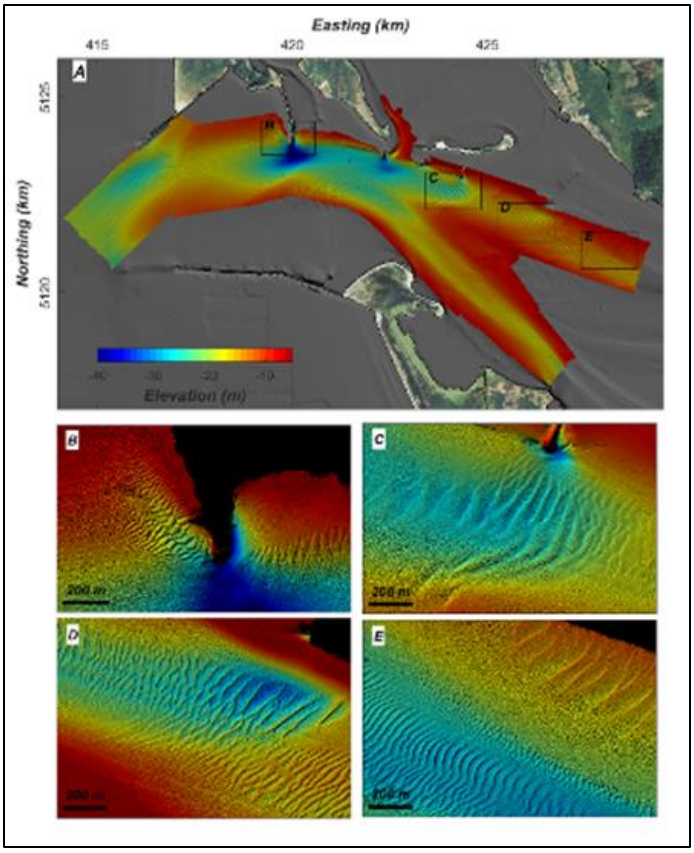
US Army Corps of Engineers®
Engineer Research and Development Center

National Regional Sediment Management Program Portland District (NWP):

Hydrodynamic Controls of Sand Wave Growth in the Lower Columbia River

Description

NWP dredges millions of cubic yards of sediment every year from the Lower Columbia River. A considerable portion of sediment within the navigational channel is in the form of sand waves, which can rapidly shallow during high flow conditions thereby requiring dredging at significant cost to the Corps. This work builds on historical bathymetric datasets and collects new multibeam data in order to identify the flow conditions which cause sand waves in the Lower Columbia River to grow in height – supporting efforts for optimum sediment management in a dynamic and economically important estuarine system.



Sand Waves in the Lower Columbia River. Figure from USGS – Gelfenbaum et al (2015).

Issue/Challenge To Address

Shoaling in rivers and inlets is a major navigational hazard and serves as a major operations and maintenance cost for the US Army Corps of Engineers. Hundreds of millions of cubic yards (cy) of sediment are dredged annually around the country to maintain adequately deep navigational channels requires creative solutions for effective management of sediment resources. About 6.5 million cy of sediment are removed annually from the Lower Columbia River federal navigation channel. Although shoaling occurs from a variety of mechanisms which produce gradients in sediment transport, the generation and evolution of sand waves throughout the Lower Columbia River has proven to be a major operations challenge which produces serious navigation hazard.

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Fully understanding the flow criteria driving sand wave growth could serve to optimize dredge timing and frequency. Currently, the crests of sand waves are commonly dredged in the Columbia River – serving as a temporary measure to reduce the depth below the mandated navigation depth (NWP, 2017). A quantitative framework of the drivers of sand wave height growth could enhance management of sediment resources in the Lower Columbia River, thereby reduce expenditures for NWP by optimizing dredge timing and magnitude and better understanding the sediment transport pathways within this dynamic estuarine system.

This RSM initiative will exploit existing high-resolution multibeam bathymetry datasets and collect new targeted bathyemtry datasets to understand the time scales of sand wave amplitude growth and the flow conditions which promote growth. The historical data which have been collected by NWP and the USGS, as well as new datasets collected during targeted flow conditions, will be processed to generate spatial maps of sand wave height and wavelength from each dataset. This will follow USGS-developed methods for automated and robust characterization of these complex bedforms. This information will be combined with modelled flow conditions. For this analysis we will utilize hydrodynamic forecasts/nowcasts from the Columbia River Estuary Operational Forecast System from which there are continuous model outputs available for the entire Columbia River estuary since 2013. This validated model will provide a comprehensive representation of the tidal and rive flow conditions in the area of interest. With the combination of flow and sand wave properties we will develop relationships between flow magnitudes and the rate of change of bar crest growth. This will inform the District when sand waves may grow rapidly in height and therefore pose navigational hazards and require subsequent dredging and re-distribution of those sediments in the system. Understanding the behavior of these sand wave features is critical for better management of sand resources.

Successes Lessons Learned

Portland District has a wealth of survey data, collected regularly throughout the year. These data sets provide the framework for understanding how sand waves propagate through the Lower Columbia River. USACE and USGS have conducted large scale field efforts to understand the bedform dynamics in the Columbia River. Coupled with dredging records, and the institutional expertise at both agencies, a foundation exists to grow the model and understanding of its application to O&M dredging practices.

Estimated Benefits & Cost Savings

- Efficiencies to the dredging program to minimize the movement of dredge plant to react to sand waves.
- Economic benefits as a result of a reduction in draft restrictions.
- Life-Safety benefits be reducing the number of prohibitive sand waves.

Expected Products

- Analysis of existing survey and flow data, as well as new data collection
- Extract sand wave height and wavelength from all available bathymetric datasets using USGS-developed methods. Extract current velocities from the Columbia River Estuary Operational Forecast System (CREOFS). Compare velocity and sand wave height information to generate relationships between equilibrium height for various flow conditions. Assess whether these relationships vary throughout different sections of the estuary.
- Journal Paper
- IPR Presentation

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Stakeholders/Users

NWP, ERDC, USGS

Projected Benefits Value Added

An ideal outcome of this study will be a spatial and temporal characterization of sand wave geometry throughout the Lower Columbia River. Addressing the flow and depth conditions which cause sand wave growth are critical for determining dredge frequency and timing. As the dredging of sand wave sediments constitutes a large volume and large cost to NWP, new tools for assessing sand wave growth would contribute to cost-effective management of sediment resources. Findings will be immediately applicable for how and when NWP mobilizes dredges to address sand waves.

Leveraging Opportunities

This proposal leverages previous field efforts by NWP and the U.S. Geological Survey (USGS) on characterizing subaqueous bedform dynamics. This collaborative RSM proposal will leverage existing datasets, resources, and efforts. Additionally, this work fits in well with the Coastal Engineering Research Board (CERB) initiative to improve understanding of sediment dynamics relevant for regional sediment management applications. These datasets may also provide value for testing, validating, and/or extending the ISSDOT v2 bedload transport tool.

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Participating Partners

USGS, others may be included as applicable.