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Turning the tide: experimental formation of dynamic tidal basin morphology

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Tidal channel networks, estuaries and ebb deltas usually formed over a period longer than observations cover. Much is known about their characteristics and formation from linear stability analyses, numerical modelling and field observations. However, experiments are rare whilst these provide data-rich descriptions of their evolution in fully controlled boundary and initial conditions. Our objective is to ascertain whether tidal basins can be formed in experiments, what possible scale effects are, and whether morphological equilibrium of such systems exist.

We experimentally created tidal basins with simple channel networks and ebb deltas with fixed and self-formed tidal inlets. We used a 3.5m by 1.3 m basin with initially flat bed in the basin, raised above the bed of the sea. Rather than create tides by varying water level, we tilted the entire basin over the short axis, and used polystyrene 2 mm particles. The advantage of this novel method is that the bed surface slopes in downstream direction both during flood and ebb phase, resulting in significant transport and morphological change in the flood phase as well as the ebb phase. This overcomes the basic problem of earlier experiments which were entirely ebb-dominated and took months to reach equilibrium. The experiment time to reach equilibrium is in the order of days.

Tidal basins with extensive ebb deltas formed from initial perturbations in the coastline. Most tidal basins remained short relative to tidal wavelength and basin width. Channels and bars were dynamic with variable curvature. Sometimes separate ebb- and flood-dominated short-cut channels evolved as in natural estuaries. Basins slowly widened while the basin evolved towards equilibrium when inlet boundaries were protected against erosion. A highly dynamic and long estuary with migrating bars and meanders formed when a minor amount of fluvial flow input was applied. These results show that dynamic tidal inlet systems can be created in days by tilting basins.