Effect of dredging and disposal on tidal bifurcations and flow asymmetry

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Background and Methodology

Shoaling fairways in estuaries are continuously dredged to maintain access of large commercial ships to many ports. However, various estuaries worldwide show adverse side effects to dredging and disposal, including shifts from a multi-channel system to a single channel and loss of ecologically valuable intertidal areas. The morphological development of multi-channel estuaries is controlled by tidal asymmetry that determines sediment import and sediment diversion through the asymmetric bifurcations.

Objective:

Effect of dredging and disposal (D2D) on the tidal and bifurcation asymmetry.

Methodology

- Hydrodynamic and morphodynamic modelling with Delft3D.
- Channel network extraction that includes channel junctions.
- Analyse tidal asymmetry and tidal bifurcations on the channel network.

Tidal Asymmetry

1. Peak velocity is stronger during flood flow ($\alpha_2 < 1$).
2. The ebb phase is longer than the flood phase ($\alpha_3 < 1$).
3. The ebb-channel network shows less flood dominance.

Bifurcation Asymmetry

1. High-order channel smaller bifurcation angle and deeper ($\alpha_2 > 0 & \alpha_3 < 0$).
2. Connecting channels wider variation in elevation jump, but not in the angles.
3. Ebb direction bifurcation angle difference is smaller than flood direction.

Dredged Model Runs

(a) Effect of dredging and disposal on the tidal asymmetry over the channel network. Dashed lines indicate equal peak flow and duration for the ebb and flood phases. (b) Effect on tidal asymmetry per channel scale.

Channel Network Complexity

- Number of channels (bathymetry) decreases over time due to dredging.
- Channel network complexity varies over a tidal cycle, especially the number of connecting channels.
- The channel network during ebb conditions is more complex than during flood.

Conclusions

- The current alternative shoal disposal strategy increases the bifurcation asymmetry by increasing the elevation jump.
- Proposed future shoal disposal strategies are most effective in increasing peak velocity ratios, which should result in more sediment import in the system.
- Dredging shows that the number of connections within the estuary.
- Bifurcations are asymmetric and last stable at the connecting channel scale.
- Changes in flood-ebb dominance affects salt-marsh growths.

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