Autocyclic channel migration in experimental self-formed tidal inlets

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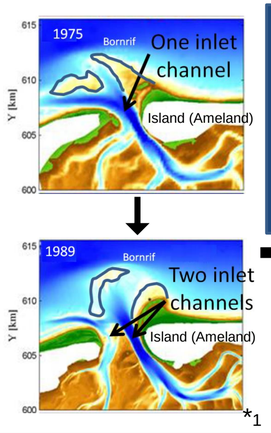
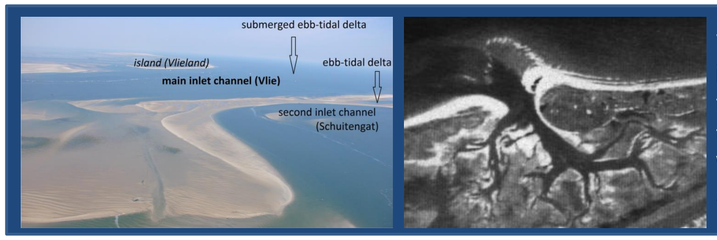
Research group

River and delta morphodynamics

Problem definition





Tidal inlets between barrier islands connect to dendritic tidal channels separated by tidal flats, such as in the Waddensea (Netherlands; Sha, 1989).

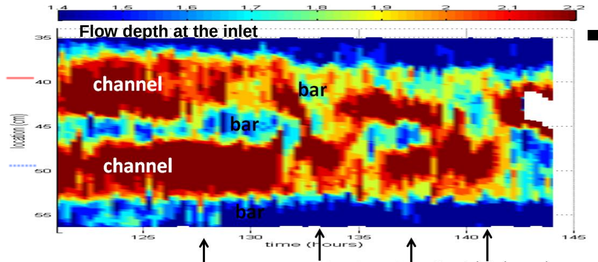
Field studies show that tidal systems generally remain dynamic over time. Tidal inlet channels shift continuously between the barrier islands and often occur in a cyclic pattern (Sha, 1989). However, the question is whether that is due to long-term tidal components and storms or intrinsic to the system.

*1

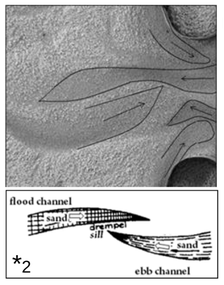
Objectives

Our objectives are to ascertain whether a dynamic morphological equilibrium can exist in an experimental scale model and whether cyclic inlet channel behaviour is intrinsic without external forcing.

Results

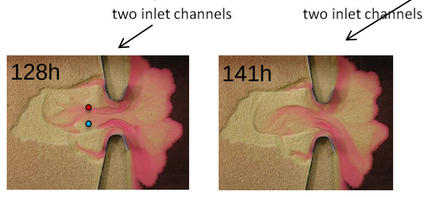


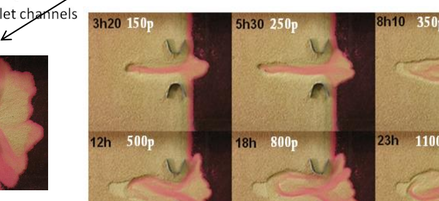
The channel In the inlet migrated and switched between single and multiple channels.



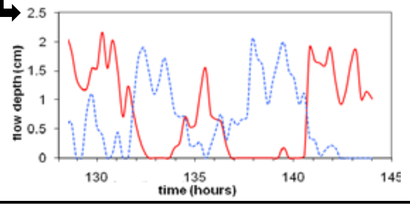
*2

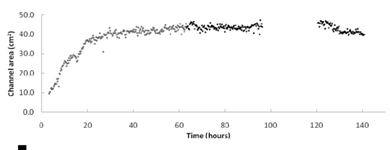
Existence of flood and ebb channels typical for tidal channels. It proves alternation of flood and ebb transport.





The switches were repeated and were related to channel switching in the basin (red line) and on the ebb delta (not shown here).





Cross-sectional area of entire inlet showing equilibrium after 40 hours or about 1500 tidal cycles.

The basin slowly widened while the system evolved towards equilibrium when inlet boundaries were protected against erosion. Channels and bars remained dynamic and shifted between straight and curved channels.

Method

- The experimental fast tilting flume of 1.2 x 3.5 m creates enhanced shear stress that is required to balance the effect of small water depth and relatively large sediment particle size.
- Low-density sediment for mobility in suspension regime.

EXPERIMENT	number	28	1 to 36
total tidal cycles	nr	6619	1-12000
Total duration	hours	145	1-264
tiltspeed	mm/min	50	30-100
tilt from MSL	mm	10	3-35
duration tidal cycle	sec	79	58-214
Sediment	description	Polystyrene	Mixed sand/ polystyrene
Sediment level	cm	4.1	2.0-4.1
Water level at MSL	cm	2.8	1.9-3.8
Initial configuration		short	short and long

Photo and table: Experimental apparatus at U.U. and table with experimental settings.

* Initial conditions: land raised slightly above sea level; initial minor channel; coastal barrier.

* Boundary conditions: no flow on landward side, constant water level on seaward side

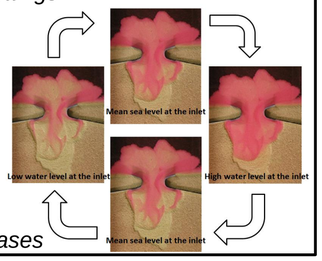


Image showing the subsequent tidal phases

References

- *1 image: Elias. E, van der Spek, A., Wang, Z.B. and de Ronde, J., 2012. Morphodynamic development and sediment budget of the Dutch Wadden Sea over the last century. Netherlands Journal of Geosciences — Geologie en Mijnbouw | 91 – 3 |
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- *Sha, L.P.*, 1989. Variation in ebb-delta morphologies along the West and East Frisian Islands, the Netherlands and Germany. Marine Geology 89: 11-28.
- *2 image: Van Veen, J., 1950. Eb- en vloedschaar systemen in de Nederlands getijwateren. Tijdschrift Koninklijk Nederlandsch Aardrijkskundig genootschap. Vol. 67. Pagina 303-325

Conclusion

We conclude that short tidal basins can attain (1) morphodynamic equilibrium that is (2) dynamic under purely constant tidal conditions. We found (3) repeated shifting between single and double channels in the inlet as also observed in the Waddensea. Our results indicate that shifting between the number of channels is related to channel dynamics within the tidal basin and on the ebb delta and occurs in a limited range of inlet width and depth.

Great movie!

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