Ecomorphological effects of human interferences in estuaries and their consequences for management

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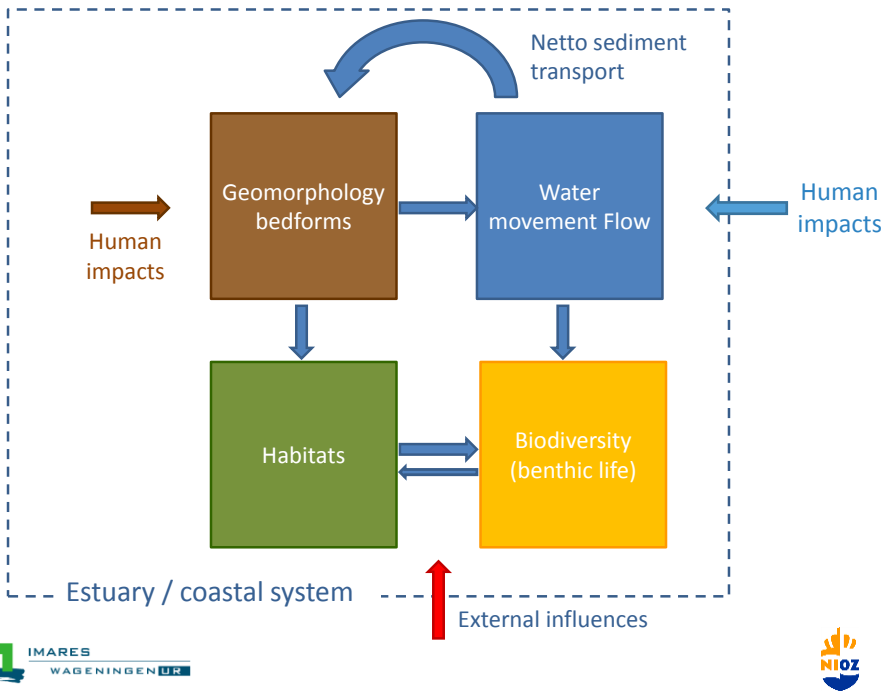
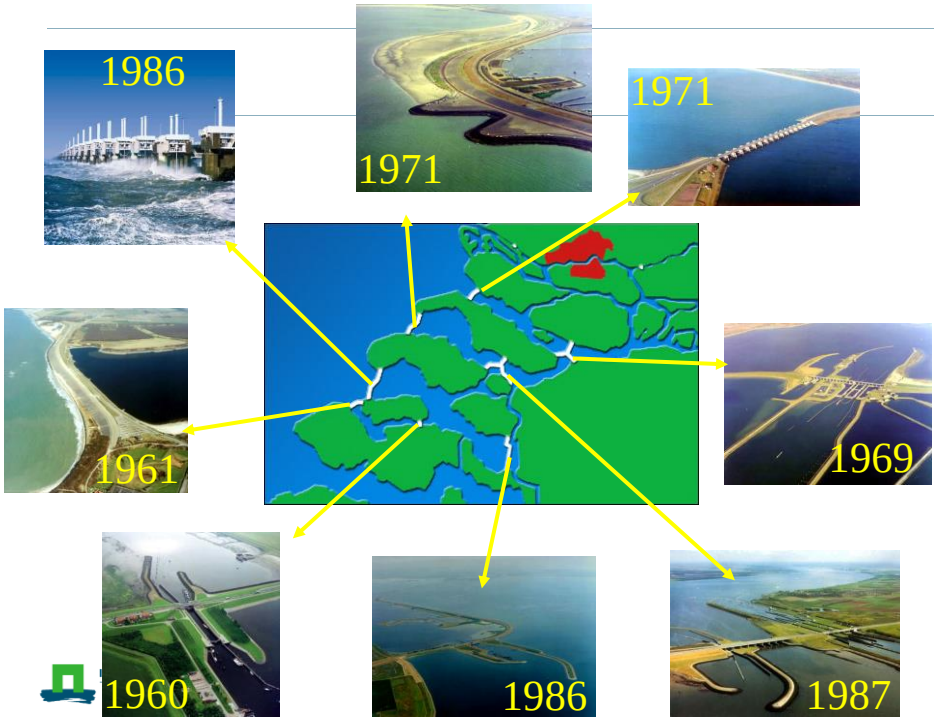
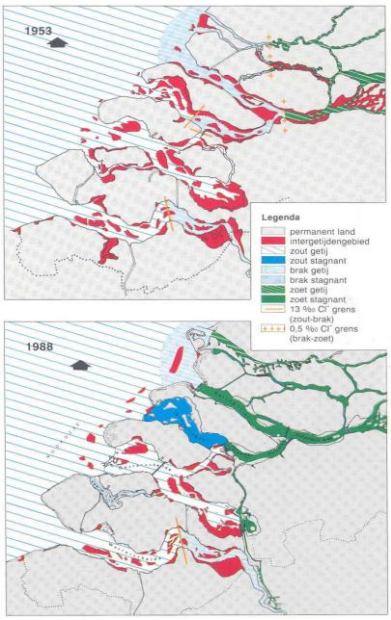
DELTAS IN TIMES OF CLIMATE CHANGE II
OPPORTUNITIES FOR PEOPLE, SCIENCE, CITIES AND BUSINESS
ROTTERDAM, THE NETHERLANDS, 24-26 SEPTEMBER 2014





Loss of estuarine dynamics in SW Delta

- SW Delta: before – after
  - (estuarine) dynamics disappeared through Delta works
  - Loss of intertidal areas
  - hard-engineered barriers, no transition zones
  - Two tidal systems left: Oosterschelde (OS) and Westerschelde (WS)



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Management OS and WS

- The Oosterschelde and Westerschelde, two adjacent water systems, evolved differently over the past decades due to a different management and use.
- The Oosterschelde was partly closed off by a storm surge barrier
- In the Westerschelde the main channel has been deepened for navigation.

The Oosterschelde storm surge barrier

Initially a closure dam was planned.

Organised protest against closure started in 1970, for ecological *and* economical reasons.

1974 decision for alternative solution = open storm surge barrier that maintains tidal system (accepting high additional costs to preserve nature and shellfish culture).

Direct consequences of Oosterschelde project

	Pre-barrier	Post-barrier	% change
Total surface area (km^2)	452	351	-22
Intertidal surface area (km^2)	183	118	-36
Tidal volume (10^6 m^3)	1283	915	-29
Average current velocity (m/s)	1.2	0.8	-33
Residence time water (days)	50	100	+100
Fresh water input (m^3/s)	70	25	-63
Salinity (‰)	>25	>30	+15
Average tidal range (Yerseke) (m)	3.7	3.25	-12
Average concentration suspended matter (mg/l)	25	15	-40

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Nienhuis and Smaal, 1994

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Tidal landscape and species still present

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But balance between erosion and sedimentation on tidal flats changed

Sediment is deposited on the flats by tidal flow

Sediment is eroded by waves (+ removal by tidal and wind-driven flow

0.5 - 1.5 Mm^3 annual loss due to erosion of the flats
0.4 - 1.5 Mm^3 annual loss due to sea level rise
=> total: 1 – 3 Mm^3 annual loss = 50 Ha annually

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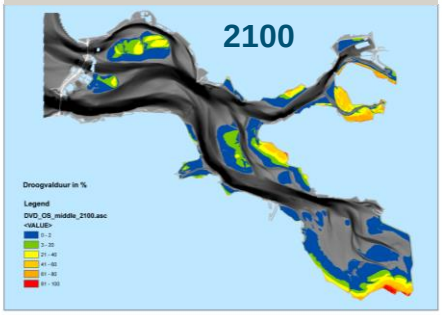
Future of the Oosterschelde

Consequences for nature and safety

‼ Issues of natural values: Oosterschelde is an important area for wading birds
‼ Issues of safety: less inter-tidal area, larger fetch, larger waves

Exposure time (%)



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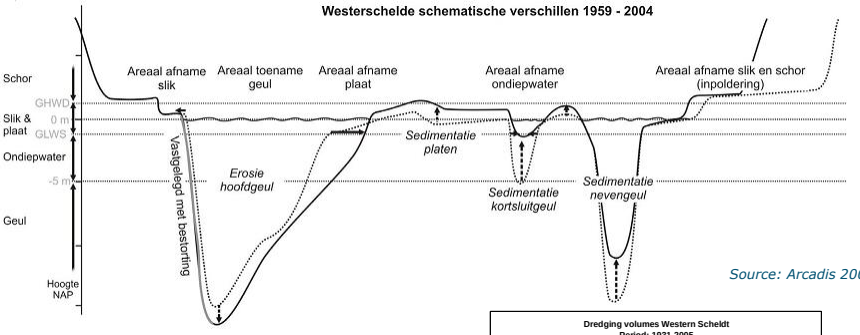
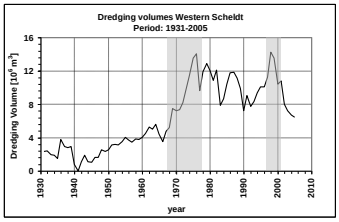
Westerschelde

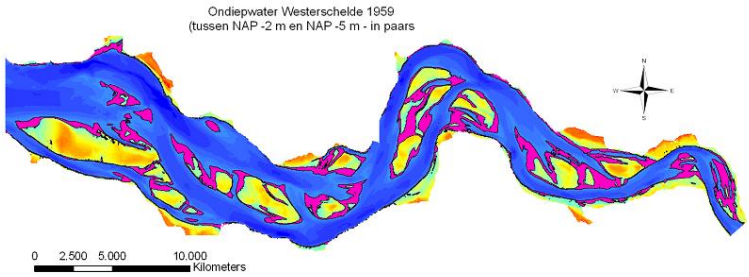
- Deepening & widening of the navigation channel

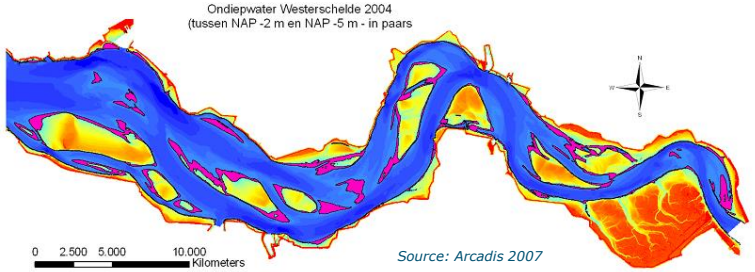


Source: Arcadis 2007



Westerschelde intertidal and shallow subtidal habitats



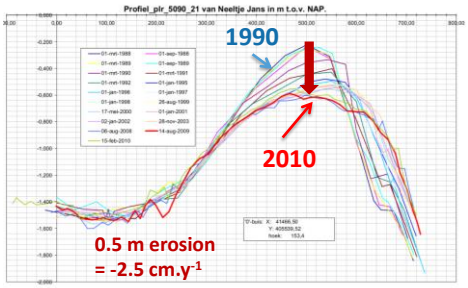


Source: Arcadis 2007

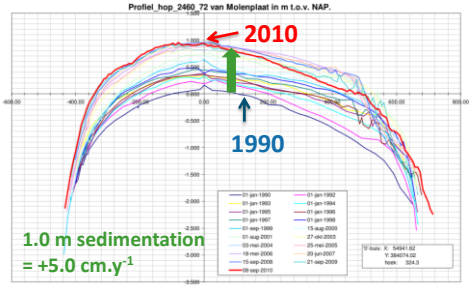
Consequences of management in OS & WS

- The structural changes evoked changes and feedback mechanisms between hydrodynamics and sediment dynamics, channel dynamics and tidal flat morphology.

Oosterschelde



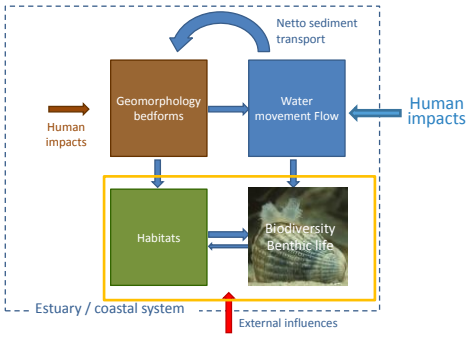
Westerschelde



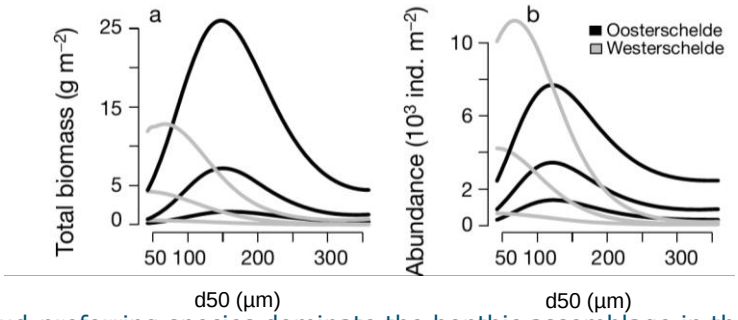
Source: Rijkswaterstaat

Habitat consequences in OS and WS

- Tidal flat and salt marsh habitats clearly responded differently: intertidal habitats in OS eroded/flattened and in WS accreted/steepened.
- Also subtidal habitats changed, with increased hydrodynamics in WS and more calm conditions in OS.



Comparison OS and WS



- mud-preferring species dominate the benthic assemblage in the Westerschelde, and sand-preferring species in the Oosterschelde.
- WS: strong hydrodynamic stress is correlated with sandy habitats, causing impoverishment of assemblages at sandy sites. OS: sandy sediments are associated with much more benign conditions and have the richest species assemblage.

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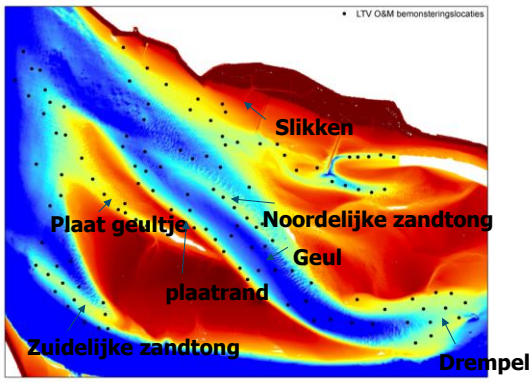
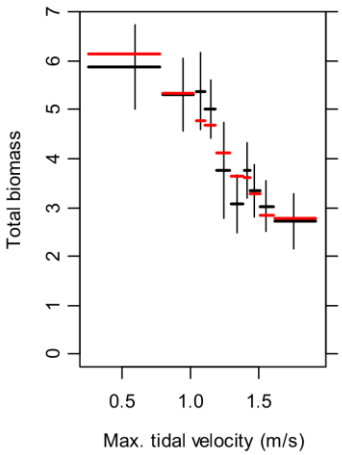
Cozzoli, Bouma, Ysebaert, Herman, MEPS 2013

Current velocity and benthic biomass





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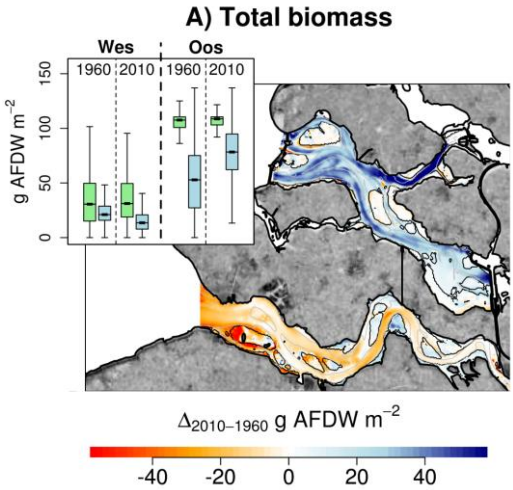
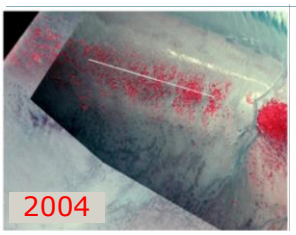
Source: Ysebaert et al. 2010

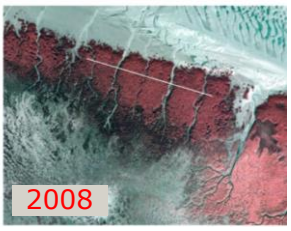
Historical development OS and WS

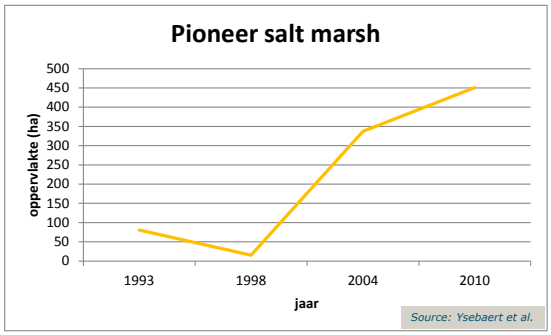


Cozzoli et al. submitted

Salt marsh development Westerschelde







- Ecosystem engineering effects of salt marsh plants on macrofauna are conditional.
- Related to organic enrichment and mechanical hindering of macrofaunal activity by the plant roots (Van der wal et al., Estuaries and Coasts 2012).

Estuarine management OS and WS

- intertidal and shallow subtidal habitats sustain coastal food webs and provide essential ecosystem services such as dampening of waves in front of dikes, …
- need for conservation/restoration of these habitats (quantity & quality) is increasingly recognized. The problems that arise nowadays call for new management strategies.

Current measures Westerschelde

- Westerschelde: new disposal strategy for dredged material: relocate material along sandbars, safeguarding multi channel system, while creating ecologically valuable areas.

Current measures Oosterschelde

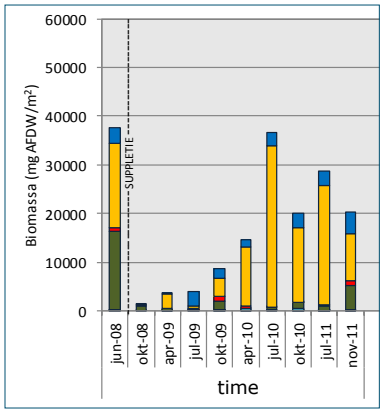
- Short / midterm Building with Nature solutions for erosion problem in the Oosterschelde:
  - Nourishments to replenish the tidal flats
  - Reef structures (e.g. ecosystem engineers) to stabilize tidal flats and create valuable habitats

Galgeplaat nourishment

- In order to (temporarily) stop the loss of intertidal area, a pilot nourishment was executed at the Galgenplaat, a tidal flat in the Oosterschelde.

Monitoring - ecology

- Recolonization: Recovery of total biomass of benthic macrofauna



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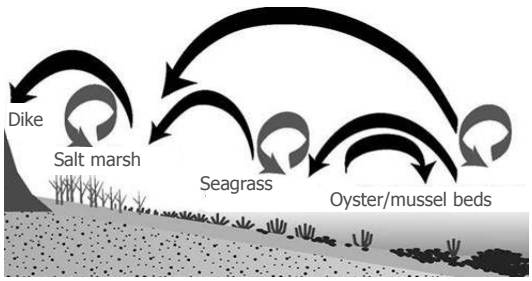
Coastal protection by ecosystem engineers

Ecosystem engineers, such as reef building oysters:

- reduce wave energy and trap sediment
- protect tidal flats against erosion
- and deliver many other ecosystem services

=> test in large-scale pilots



Natural oyster reef in the Oosterschelde

Construction of oyster reefs




Safety buffer Oesterdam

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Conclusions management OS and WS

- Human interventions evoked changes and feedback mechanisms between hydrodynamics, sediment dynamics, tidal flat morphology, and ecological processes.
- This had consequences for the animal and plant species inhabiting these habitats.
- The (habitat) problems that arise nowadays in the WS and OS call for new management strategies.

Challenges

- BUT: what is **optimal scale** for management measures: change the overall system characteristics, interfere at the level of large portions of the estuary or apply a multitude of local mitigation measures?
- AND: how can minimal interferences be planned for **maximal effect** on ecological value?
- Pressing need for better understanding of the **eco-morphological development** and **ecosystem functioning** of estuarine systems at different spatial & temporal scales.

Thank you

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