The nature perspective: Environmental effects of sediment management

Photo: Winny Adolph

Dr. Gregor Scheiffarth, Dr. Inga Nordhaus

Lower Saxon Wadden Sea National Park Authority in Wilhelmshaven, Germany

Nationalpark Wattenmeer

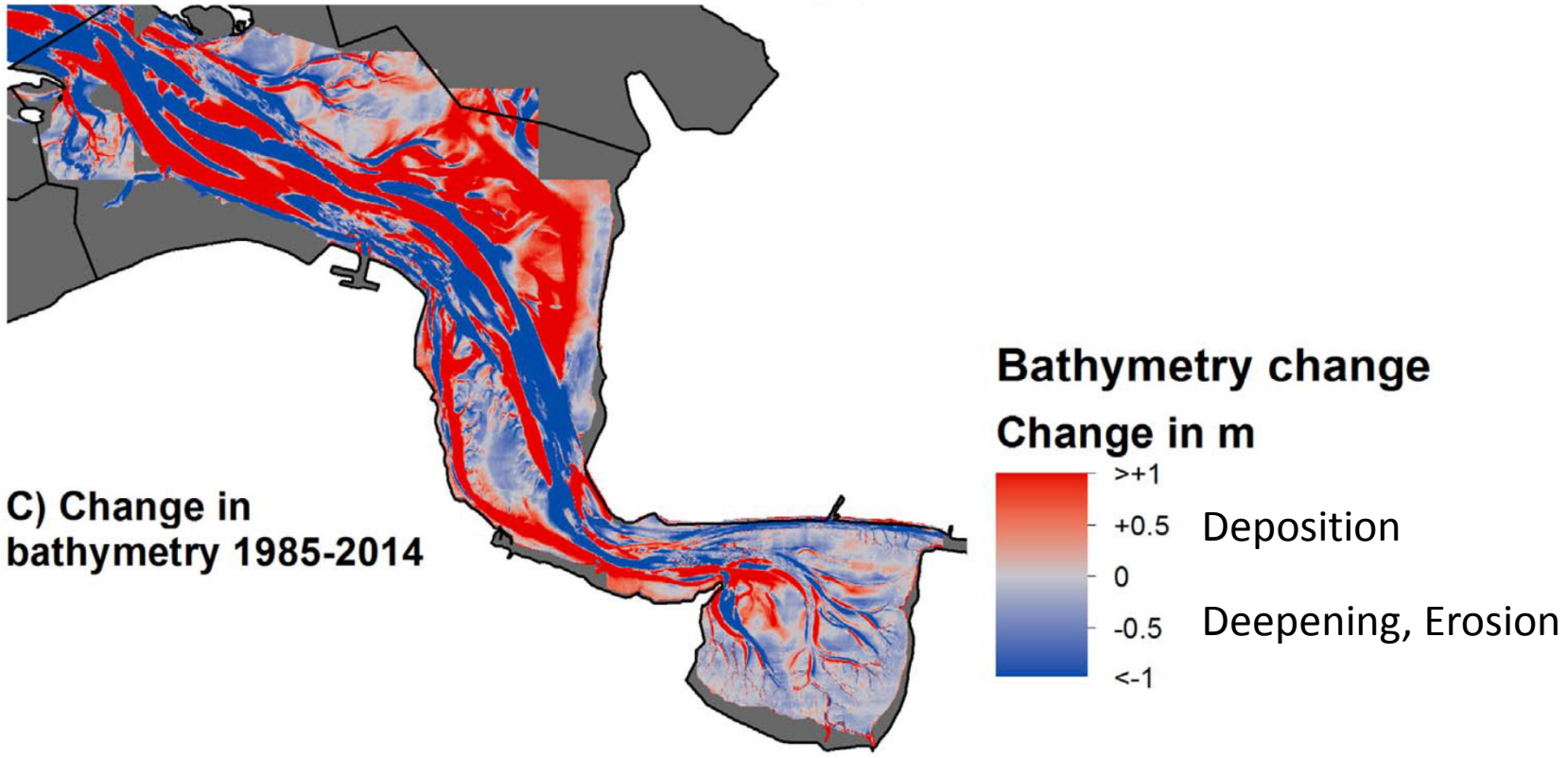
Eemshaven, 29.10.2019, Workshop: Sediment management in ports

Environmental effects…..

- …include physical, chemical and biological impacts
- …on natural processes, on hydrology and morphology, on habitats, on species, on people, on landscape
- …can be divided into direct and indirect impacts
- …occur at the excavation site, during sediment transport, at the disposal site and further away from these sites
- …depend on the dredging technology and sediment characteristics
- …include, among others, increased water turbidity, increased oxygen consumption, release of bound contaminants from the sediment, siltation of benthic organisms, noise and scare impacts on animals → Decreased abundances and biomass of flora and fauna, altered food web structure

Effects of dredging on water depth

→ Change in water depth between 1985 and 2014 in the Ems Estuary



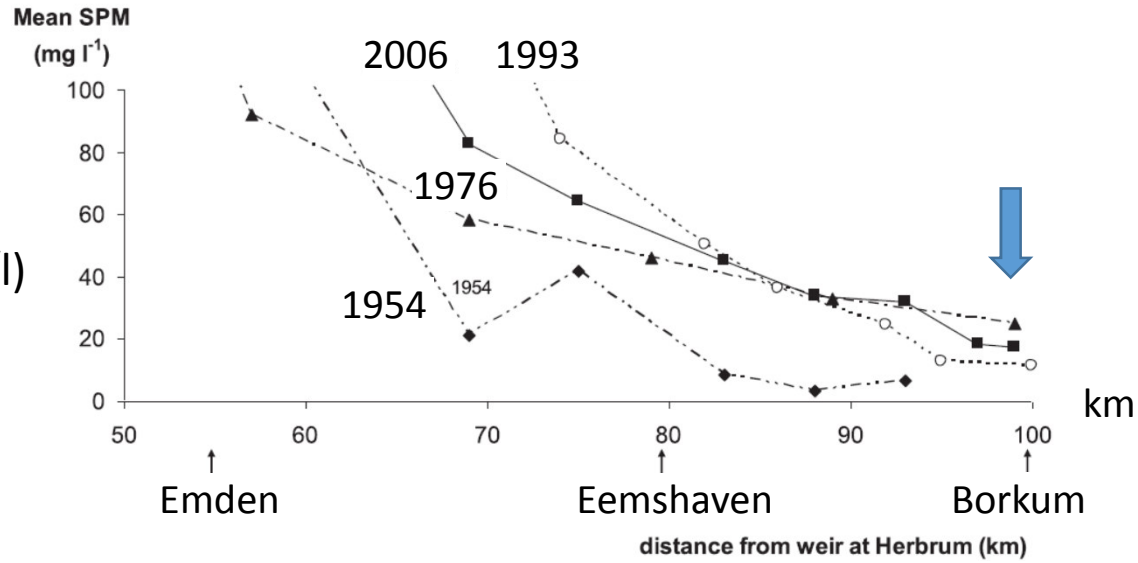
Nationalpark Wattenmeer
NIEDERSACHSEN

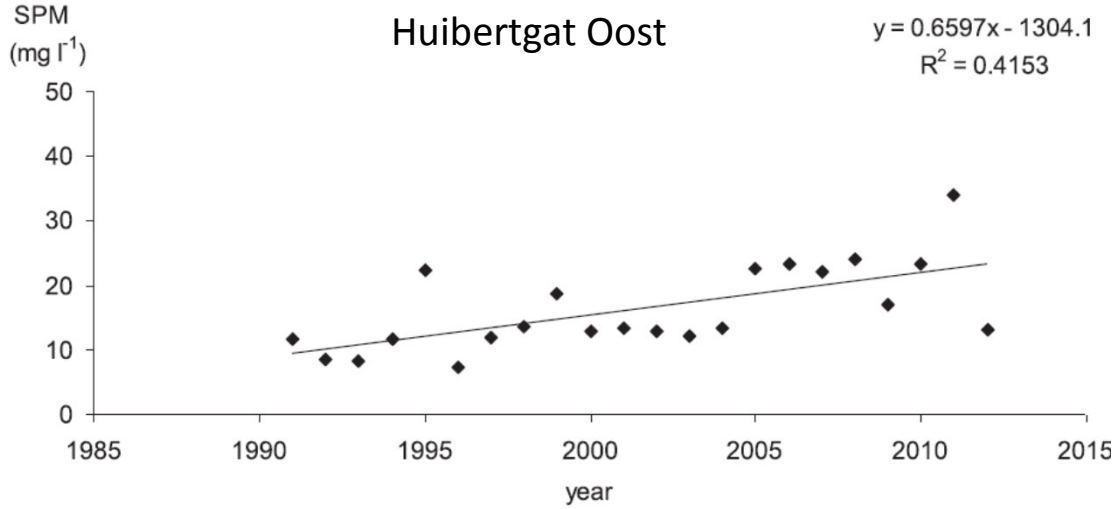
Source: Compton et al. (2017)

Effects of dredging on water turbidity

→ Increased water turbidity (1954 – 2012) in the Ems estuary

Suspended particulate matter (mg/l)





Nationalpark Wattenmeer
NIEDERSACHSEN

Source: de Jonge et al. (2014)

Impacts on flora and fauna

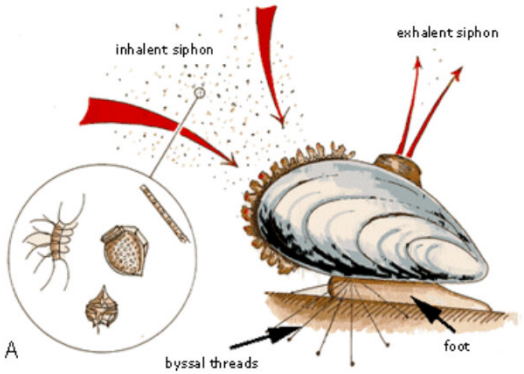
Direct effects:

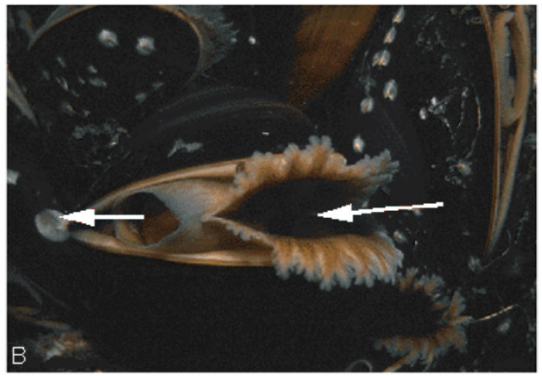
- Removal of surface sediments → Local decrease of benthic species abundance, diversity, and biomass.
- Herring, sand eel, and crabs require certain substrate conditions for spawning or breeding activities → Changes in or loss of a preferred grain size can disturb these species.

Indirect effects:

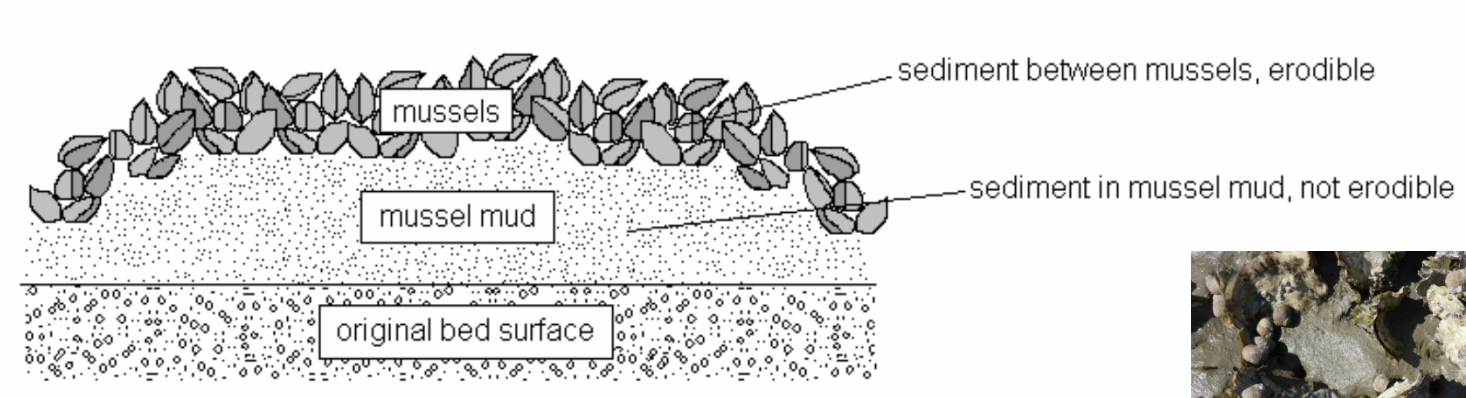
- Sediment plumes → Impact on benthic organisms through smothering and through damage and blockage to respiratory and feeding organs.
- Reduction in light penetration → Negatively affects phytoplankton growth → Effects on higher trophic levels.
- Distribution of marine organisms is strongly related to hydrodynamic, morphological, and sediment parameters → Changes in benthic assemblages → Less food for fish, birds, and mammals.

Sedimentation on mussels





→ Sedimentation can limit or even prevent the filtration; mussels can suffocate.



The blue mussel (*Mytilus edulis*) can crawl to the sediment surface if sedimentation is not too fast.

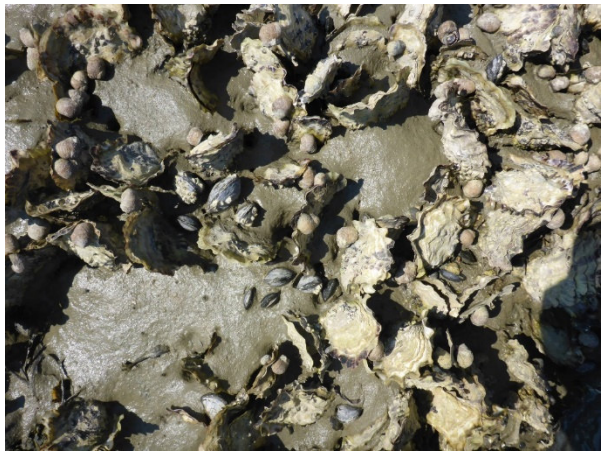


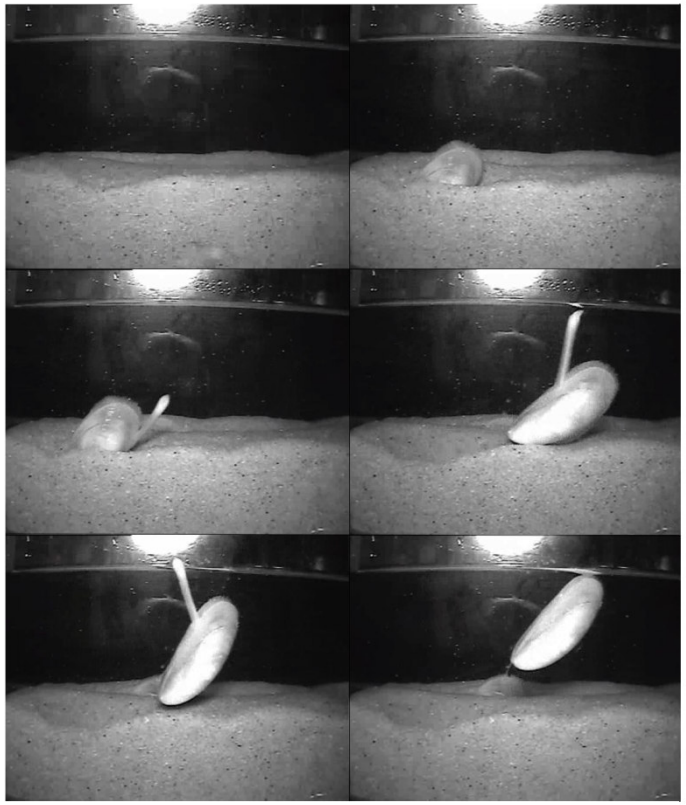
Photo: Winny Adolph

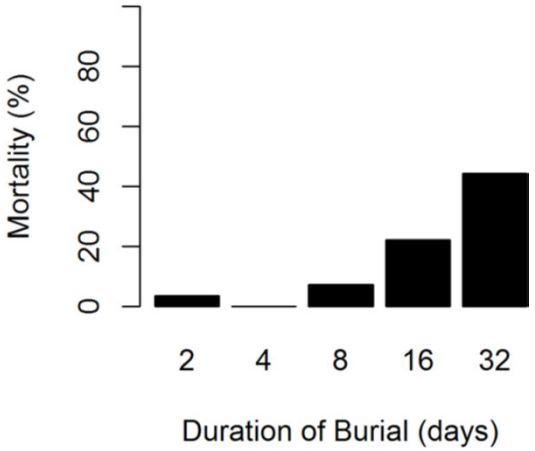
Source: Van Leeuwen (2008)

Nationalpark Wattenmeer
NIEDERSACHSEN

Sedimentation on mussels

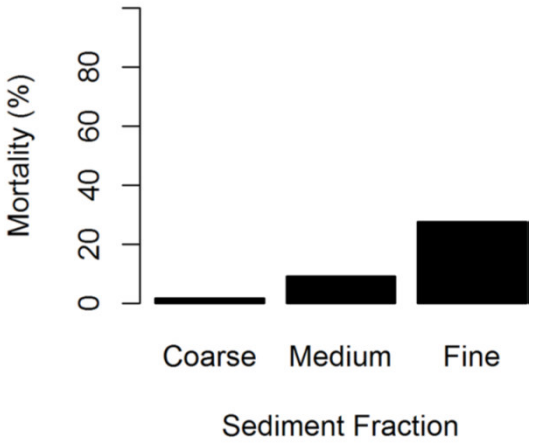
Laboratory experiment

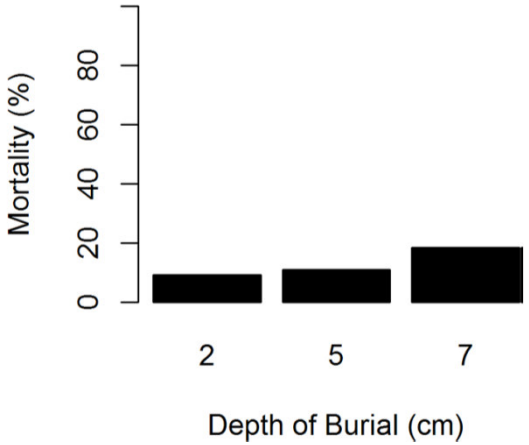




- Increase in mortality with time of burial
- Highest mortality in fine sediment
- Increase in mortality with thicker sediment layer

E





Nationalpark Wattenmeer
NIEDERSACHSEN

Source: Hutchison et al. (2016)

Impacts on benthic invertebrates

→ **Response to burial and SPM is very variable between species**

Sea anemone (*Sagartiogeton laceratus*):

- Highly tolerant of shorter term (< 16 d) burial

Yellow sea squirt (*Ciona intestinalis*):

- Highly intolerant of burial events, with 100% mortality after 2 days

Green sea urchin (*Psammechinus miliaris*):

- Moderately tolerant of shorter-term (< 12 d) burial; high mortality after 12 d

General observation:

→ % mortality increased with depth and increasingly finer sediment

Nationalpark Wattenmeer
NIEDERSACHSEN

Source: ICES (2016)

Sedimentation on seagrass beds

→ Critical thresholds of seagrasses for turbidity and sedimentation

→ Thresholds are species-specific; *Zostera noltii*: 2 cm/yr in Spain

Source: Vermaat et al. (1997)

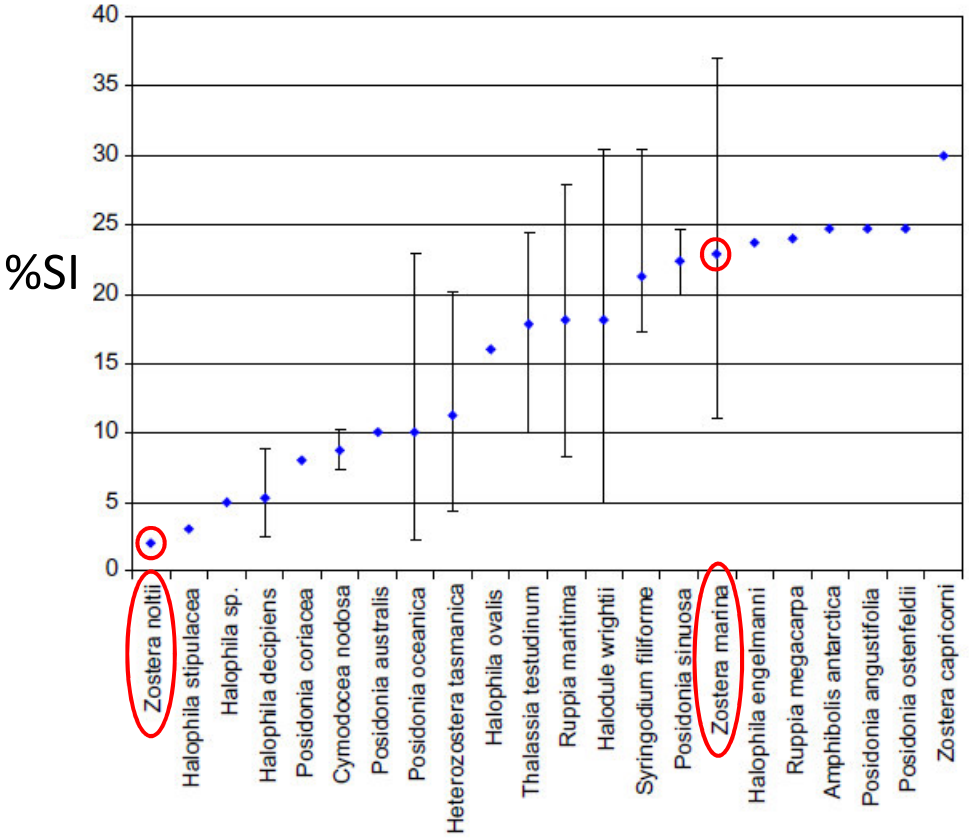
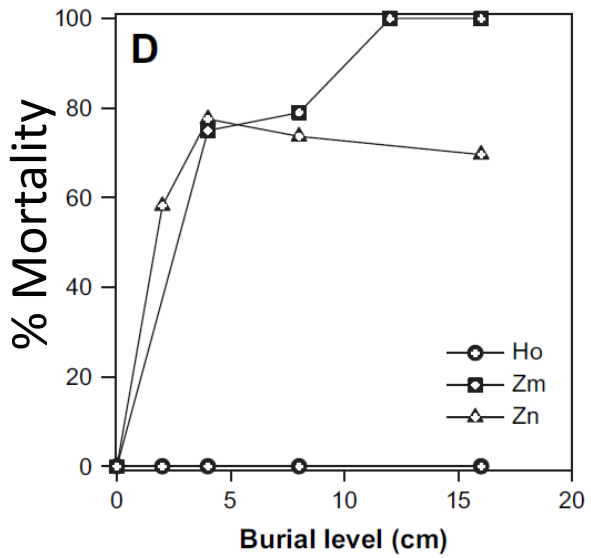


Fig. 1. Range of critical threshold values for light availability (as % surface irradiance SI) reported in the literature for various seagrass species.

Source: Erftemeijer et al. (2006)



Z. marina

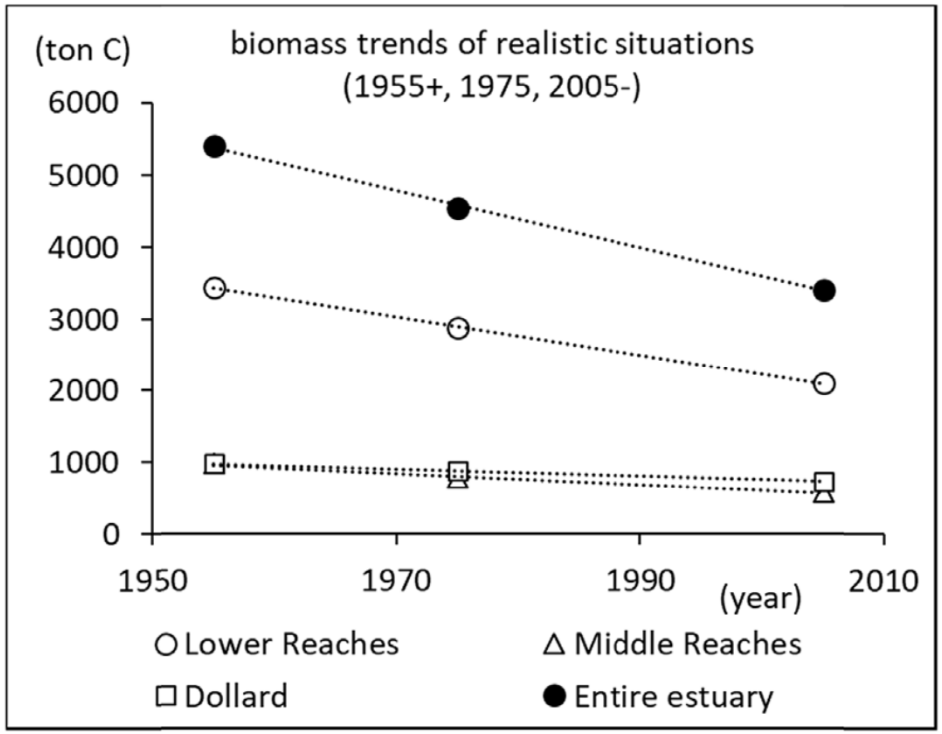
Zostera noltii

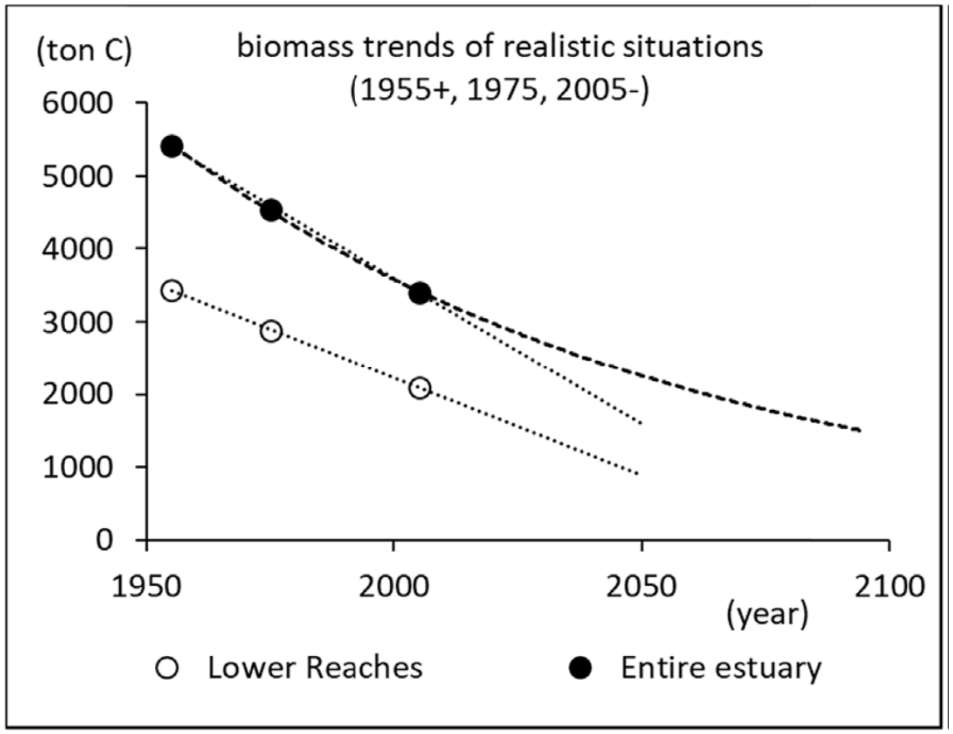
Source: Cabaço et al. (2008)

Nationalpark Wattenmeer
NIEDERSACHSEN

Effects of dredging on the food web

→ Decrease of biomass and change in food web structure (1955 – 2005) in the Ems estuary as a result of dredging and organic waste





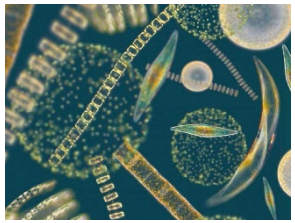
- Decrease of total estuarine biomass by 37% for the period 1955–2005.
- Speculative further development of the observed linear 1955–2005 trend under unchanged political direction: a levelling off around 25% of the 1955 biomass.

Nationalpark Wattenmeer
NIEDERSACHSEN

Source: Jonge & Schückel (2019)

Effects of dredging on the food web

→ Decrease of biomass and change in food web structure (1955 – 2005) in the Ems estuary as a result of dredging and organic waste



Nationalpark Wattenmeer
NIEDERSACHSEN

Source: Jonge & Schückel (2019)

Development of basics for a strategy for ecological sediment management on the river Ems

- Lower Saxony Water Management, Coastal Defence and Nature Conservation Agency - Research Centre Coast (Dr. Andreas Wurpts) &

  Lower Saxon Wadden Sea National Park Authority &

  Christian-Albrechts-University of Kiel (Prof. Dr. Christian Winter)

→ Gain a better understanding of the changed sediment dynamics and its ecological and morphological effects in the outer Ems estuary.

→ Methods will be developed and feasibility studies carried out for allowing an assessment of natural and anthropogenically influenced ecological developments.

→ Impact assessment: for natural mussel beds, mussel cultures and seagrass beds.

Nationalpark Wattenmeer
NIEDERSACHSEN

Feasibility study: What is the impact of sediment shift and sedimentation on natural mussel beds and mussel cultures (eulittoral & sublittoral)?

→ Blue mussel (*Mytilus edulis*) and Pacific oyster (*Magallana gigas*)

→ Important ecological functions

Nationalpark Wattenmeer
NIEDERSACHSEN

Quantification of sedimentation and erosion rates

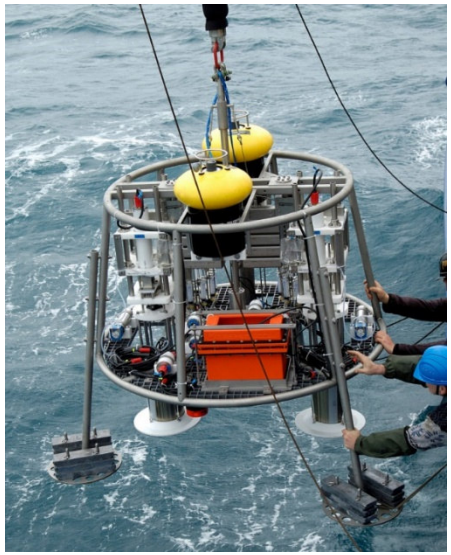
Sedimentation erosion bar (SEB)
2 m long

→ Sedimentation: SEBs and pins, 1-2 yr

→ Extent, biomass, diversity in relation to the sediment load

→ Continuous measurement of turbidity, currents, turbulence,…on natural beds and mussel cultures

Erosion pin



Where do we want to go?

- Flexibility in dumping sites (considering the high geomorphological dynamics of the system)
- Sandy sediments have to remain in the Wadden Sea; no dumping outside the Wadden Sea area (sediment deficit, climate change)
- Water injection as alternative dredging method? Ecological impacts not well understood
- Adaptation of navigation channels to natural dynamics
- Think of alternatives to further deepening of shipping channels
- Gain knowledge on sediment dynamics


UNESCO
United Nations
Educational, Scientific and
Cultural Organization
World
Heritage
Convention
WADDEN SEA
WORLD HERITAGE
The Wadden Sea is the largest tidal flat system in the world, where natural processes proceed largely undisturbed.
© NLPV

References

- Cabaço et al. (2008) The impact of sediment burial and erosion on seagrasses: A review. ECSS 79: 354-366.
- Compton et al. (2017) Shifting baselines in the Ems Dollard estuary: A comparison across three decades reveals changing benthic communities. J Sea Res 127: 119-132.
- Erftemeijer & Lewis III (2006) Environmental impacts of dredging on seagrasses: A review. Mar Poll Bull 52: 1553-1572.
- Hutchison et al. (2016) Buried alive: The behavioural response of the mussels, *Modiolus modiolus* and *Mytilus edulis* to sudden burial by sediment. PLoS ONE 11(3): e0151471. doi:10.1371/journal.pone.0151471.
- ICES (2016) Effects of extraction of marine sediments on the marine environment 2005-2011. ICES Cooperative Research Report No. 330. 206 pp.
- De Jonge et al. (2014) The influence of channel deepening on estuarine turbidity levels and dynamics, as exemplified by the Ems estuary. ECSS 139: 46-59.
- Jonge & Schückel (2019) Exploring effects of dredging and organic waste on the functioning and the quantitative biomass structure of the Ems estuary food web by applying Input Model balancing in Ecological Network Analysis. Ocean Coast Manag 174: 38-55.
- Van Leeuwen (2008) Modeling mussel bed influence on fine sediment dynamics on a Wadden Sea intertidal flat. Master thesis, Deltares, 110 pp.
- Vermaat et al. (1997) The capacity of seagrasses to survive increased turbidity and siltation: The significance of growth form and light use. Ambio 25: 499-504.

References

- Picture sea anemone: http://www.habitas.org.uk/marinelife/photo.asp?item=saglac
- Picture yellow sea squirt: https://www.eurekalert.org/multimedia/pub/124805.php
- Picture green sea urchin: http://www.european-marine-life.org/30/photo-psammechinus-miliaris-wb02.php
- Picture phytoplankton: https://www.pnas.org/content/110/18/7107
- Picture mussels: https://www.123rf.com/photo_79073333_blue-mussel-mytilus-edulis-and-limpet-aquatic-snail-on-rocky-beach-with-brown-seaweed-ascophyllum-no.html
- Picture polychaete: https://de.wikipedia.org/wiki/Bernstein-Ringelwurm
- Picture plaice: https://brightonboat.co.uk/wp-content/uploads/2013/04/Plaice.jpg