Universität Hamburg

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Department Biologie

Estuarine marshes along the Elbe: past, present and future

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&
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Outline

Introduction
- What are estuarine marshes?

Past
- Historic alterations of the Elbe estuary
- Recent impacts

Present
- Current distribution
- Zonation and biodiversity: Patterns and mechanisms
- Ecosystem functions: The Si-cycle

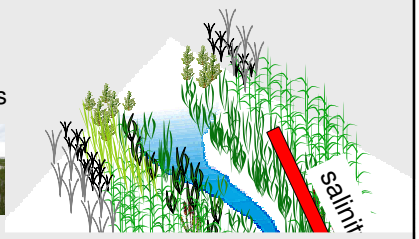
Future
- De-Embankment and vegetation succession
- Sea-level rise and sedimentation

Summary and outlook

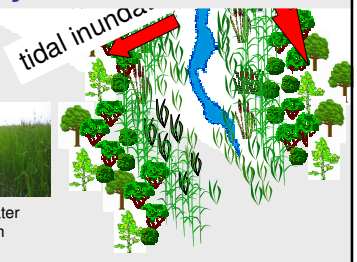
What are estuarine marshes?

Site conditions

- Salinity gradient: 0 to 34 psu
  - Tidal freshwater, brackish and salt marshes
- Flooding gradient: -1.5 to +1.5 m above mht
  - Low, mid and high marshes



Importance: Biodiversity and Ecosystem Functions

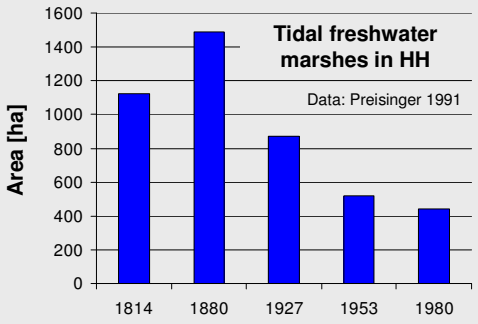


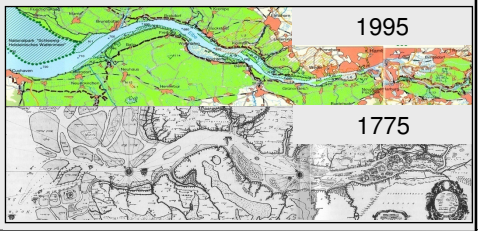
past

Historical changes of the Elbe estuary

Historical human impacts

- Construction of dikes started appr. 1000 ago
- Late 18th century: still many natural islands and large marsh areas in front of the dikes
- Traditional land use:
  - *Salix* brushwood / coppicing
  - *Scirpus* wickerwork
- Since 19th century: Port development, channel deepening
- Since 1970: abandonment of traditional land use; nature conservation



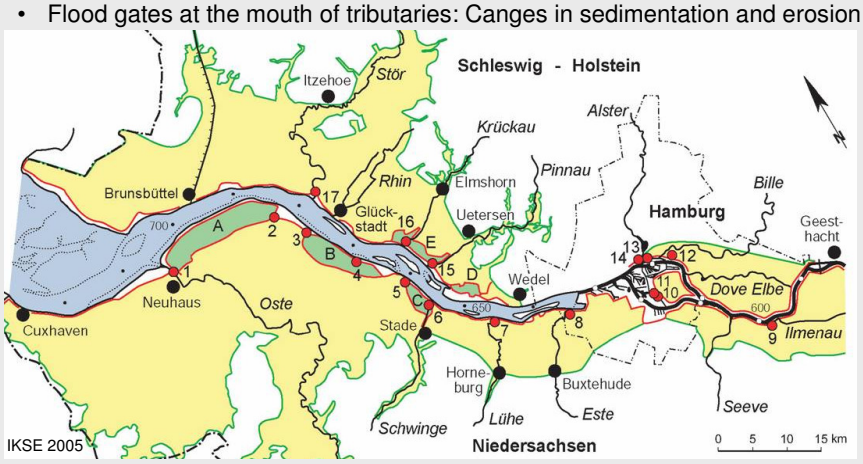


past

Human impacts I

Recent human impacts

- Coastal defence after storm surge in 1962
  - Dike constructions: Loss of 75 % of flooding area
  - Flood gates at the mouth of tributaries: Canges in sedimentation and erosion

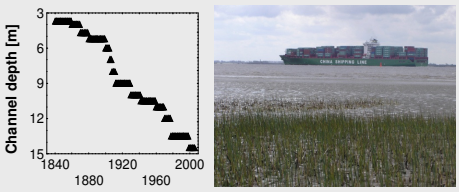


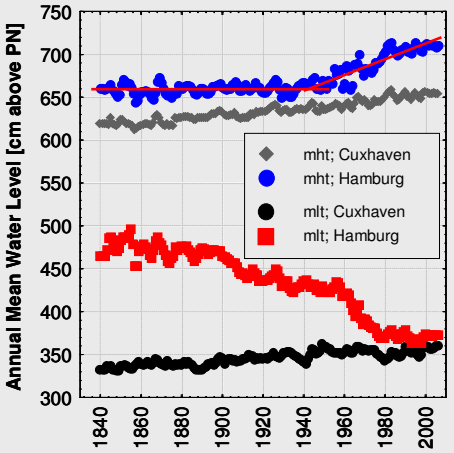
past

Human impacts II

Recent human impacts

- Channel deepening
- Increase in tidal amplitude in Hamburg from 1.8 to 3.5 m
- Increase in mht in Hamburg of appr. 1 cm/yr since 1950
- Increase of mht & mlt in Cuxhaven of appr. 0.2 cm/yr since 1840
- Saltwater intrusion: Upstream movement of the brackish water zone of appr. 25 km since 1950



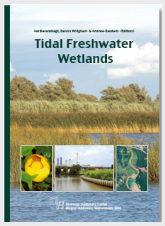


data: Immeyer 1996, BSD 2007

present | Current distribution of estuarine marshes

Marsh area

- 1400 ha tidal freshwater and brackish marshes
  - Largest area of low marsh zone in European estuaries
- 2000 ha salt marshes



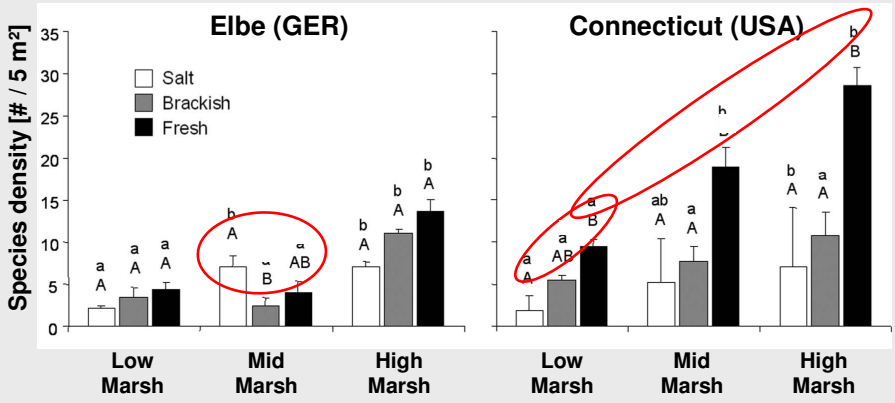
		Low marsh	Mid marsh		High marsh			
Estuary	Tidal amplitude	*Schoeno-plectus* or *Bolbo-schoenus* dominant	Only *Phragmites* dominant	*Phragmites* - tall herbs co-domination	Tall herbs dominant	*Salix* shrubs	*Salix* woods	*Salix* coppice / plantations
Elbe	2.4 - 3.6 m	458	826		?	448		
Weser	3.8 - 4.1 m	1,088				214		
Oude Maas	1.1 m	18	28	112		19	99	134
Biesbosch	0.2 - 0.6 m	?	1,920			1,530		
Scheldt	2 - 6 m	?	23	49	218	191	75	0

Struyf, Jacobs, Meire, Jensen & Barendregt (2009)

present | Patterns of biodiversity

Plant species density

- Increase of biodiversity with decreasing stress (salinity, flooding)
- Higher biodiversity in N-America than in Europe
- Low diversity in low and mid tidal freshwater marshes of the Elbe

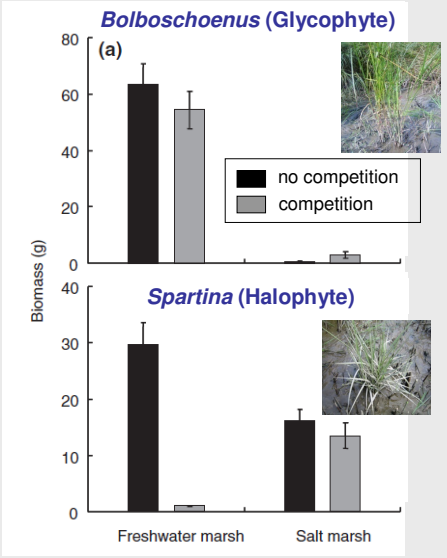


Engels & Jensen (2009)

present | Mechanisms of vegetation development

Mechanisms

- Physiological stress tolerance as a prerequisite for establishment at high salinity and/or flooding conditions
- Low competitive ability of stress-tolerant species precludes them from low stress environments
- In summary: Species adaptations and interactions are of equal importance for the development of biodiversity pattern at the landscape scale

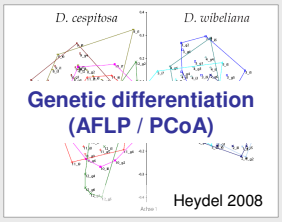


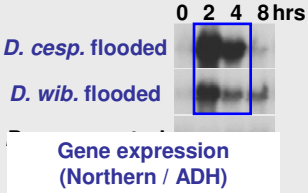
Engels & Jensen (2010)

present | Biodiversity: endemic plant species

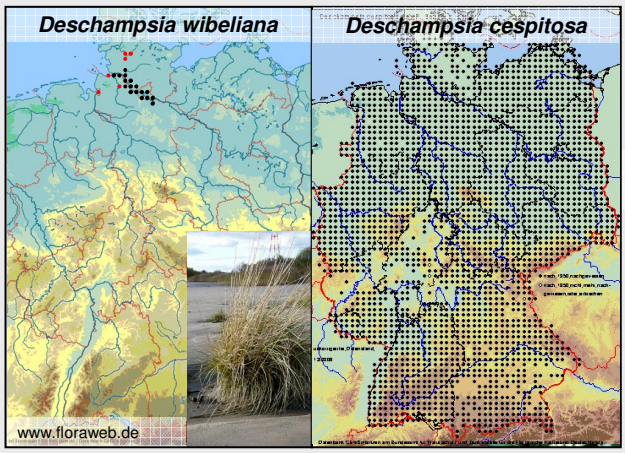
Endemics

- High nature conservation priority and importance
- Recent evolution of endemics at stressfull environments a „cutting edge“ research field





Ambroselli (unpubl.)



present

Ecosystem functions and services

Si-cycle in salt marshes

- High tide: low DSi concentration in creek water, no management effects
- Low tide: high DSi concentration in creek water; increased values in ungrazed site

Frauke Müller (unpubl.)

future

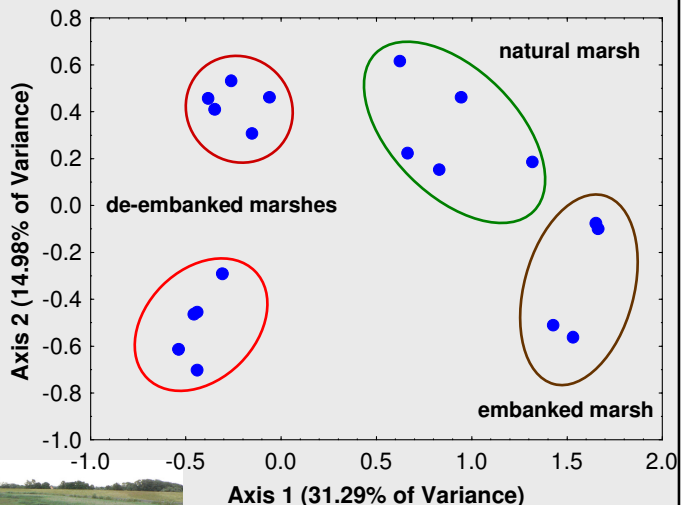
De-Embankment: vegetation succession

De-embankment

- Measure to increase flooding area and decrease tidal amplitude
- Compensation measure for channel deepening or other human impacts

Vegetation

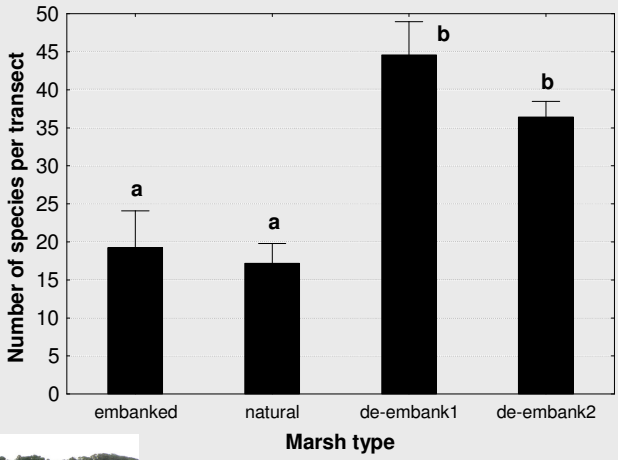
- Difference in species composition of natural, diked and de-embanked freshwater marshes



future — De-Embankment: vegetation succession

Biodiversity

- Species density of de-embanked marshes high
- Both endemic species established



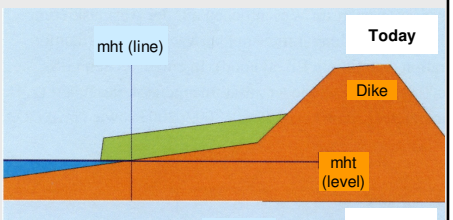
future — Sea level rise: coastal squeezing?

Sea level rise

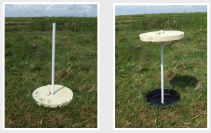
- Recent increase of mht of 0.2 and 1 cm in Cuxhaven and Hamburg, respectively
- Future accelerated sea level rise caused by climate change
- Loss / die-back of estuarine marshes could be expected (coastal squeezing)

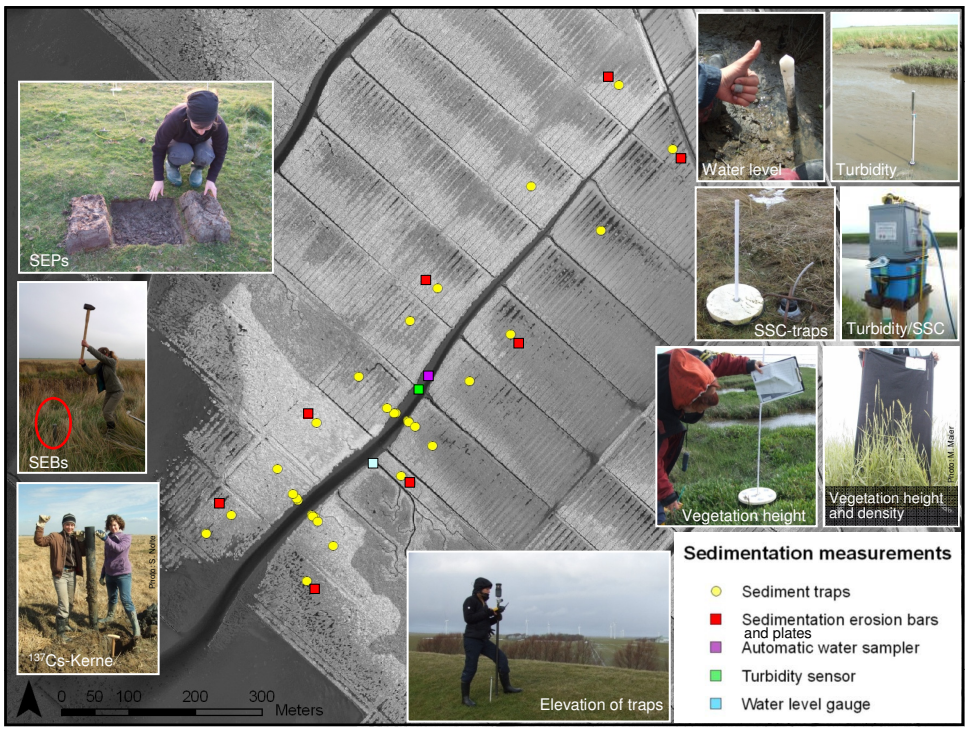
Sedimentation

- Analyses of sedimentation rate in estuarine and coastal marshes
- Multiple regression model: Impact of flooding frequency and height, SSC, distance to marsh edge and creek, vegetation biomass on sedimentation rate



Schröder 2007

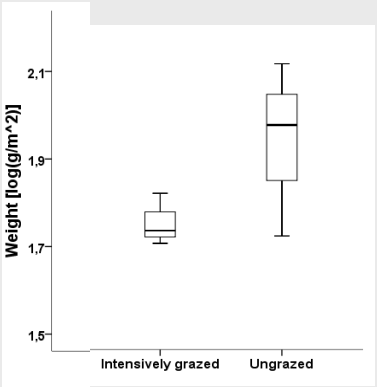




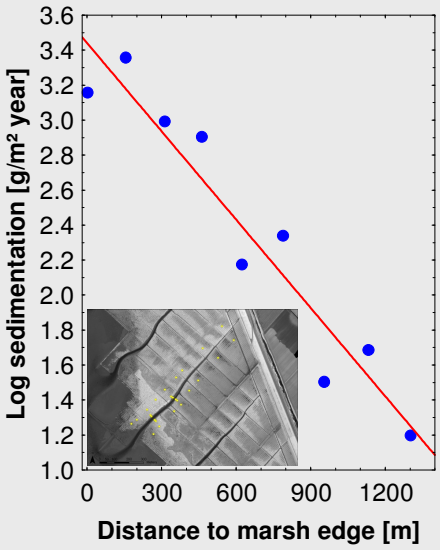
future

Sedimentation

- Sedimentation decreases with increasing distance to marsh edge
- Sedimentation higher in ungrazed marshes

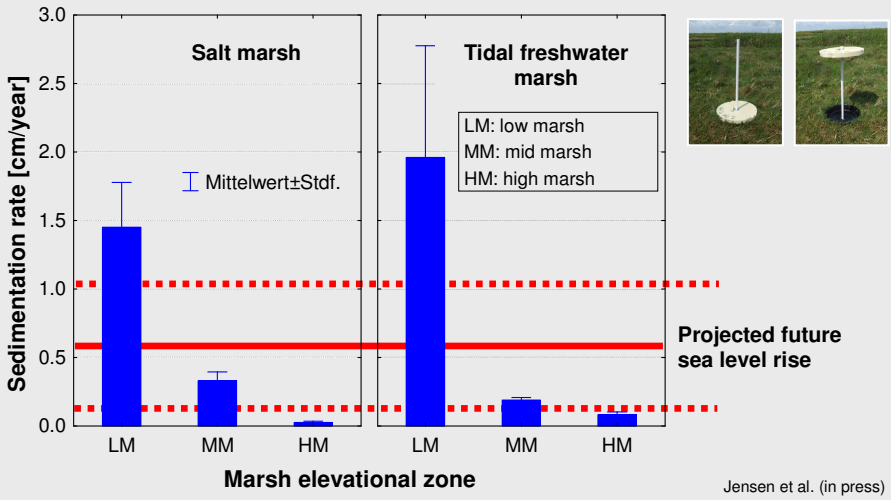


Frauke Müller (unpubl.)



future

Sedimentation



Jensen et al. (in press)

Summary

- Human impact on estuarine marshes since 1000 BP
- Loss of 75 % of former flooding area after 1962
- Distinct zonation patterns along salinity and flooding gradient
- Stress tolerance and biotic interactions contribute to the development of vegetation pattern
- Endemic species in EM: Conservation and evolution
- Ecosystem functions: EM play a critical role in nutrient cycles (e.g. N, P, Si)
- De-embankment: Establishment of typical estuarine plant species
- Sedimentation rates seem to compensate current and projected future rates of sea level rise

Take Home Message

After centuries of estuarine marsh loss, it is time to reverse this trend and utilize ecosystem services of these habitats

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!! Thank you for your attention !!

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