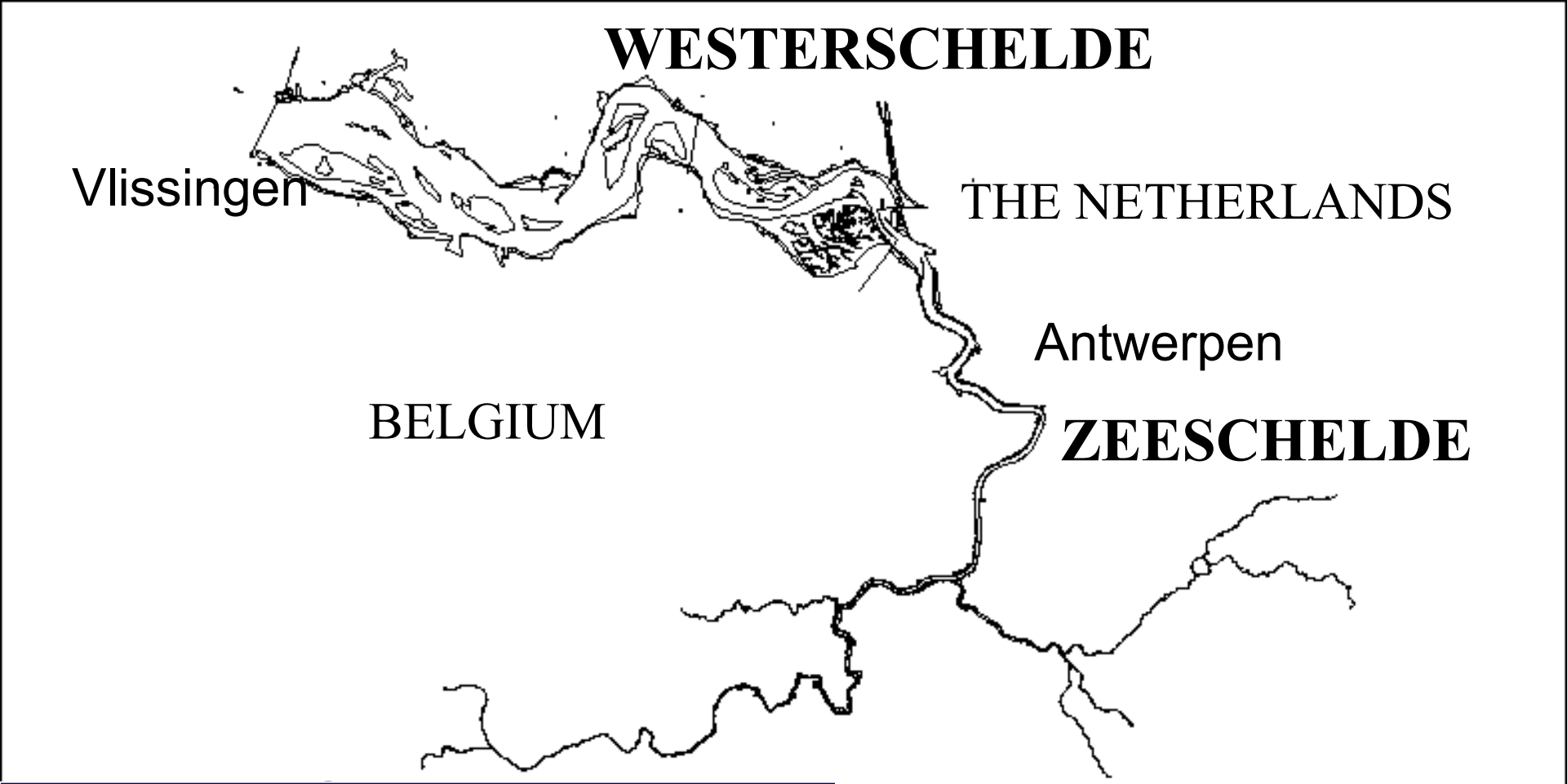
Rehabilitation of the Schelde estuary

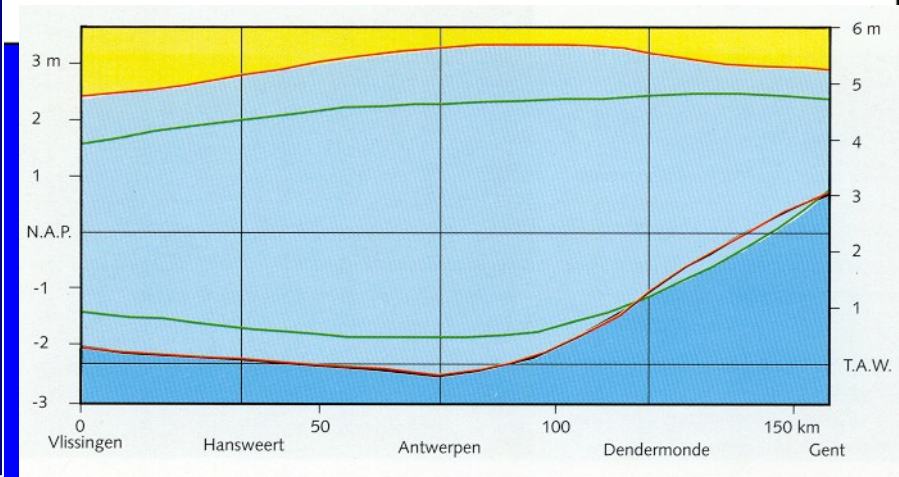
Patrick Meire and many others
University of Antwerp

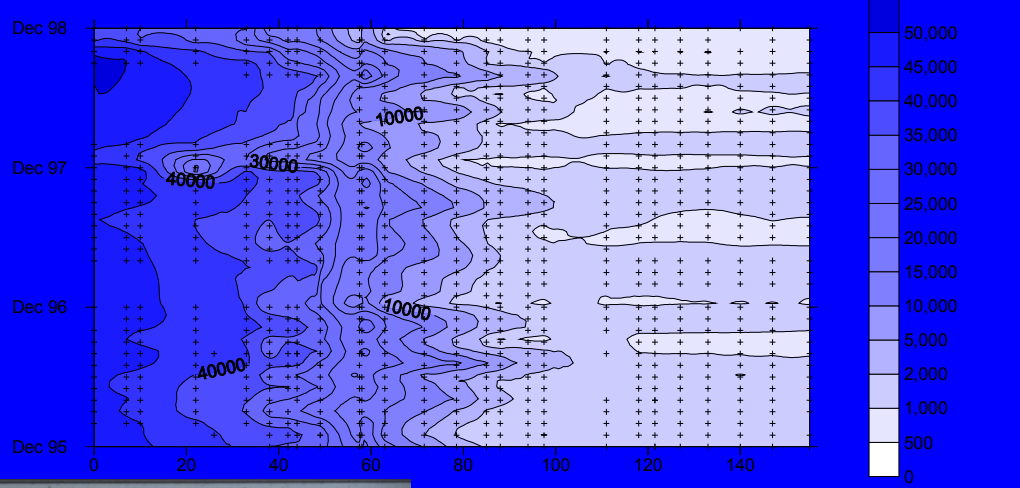
The Delta of Rhine Meuse and Scheldt



The Schelde estuary:

- 160 km long and macro-mesotidal
- Entire salinty gradient from fresh to salt




Dec 98
Dec 97
Dec 96
Dec 95
0
20
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1,000
500
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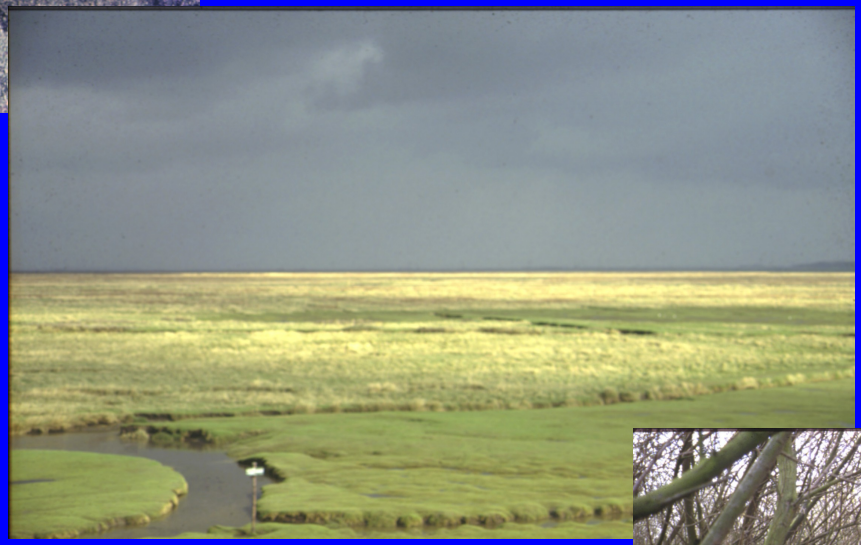
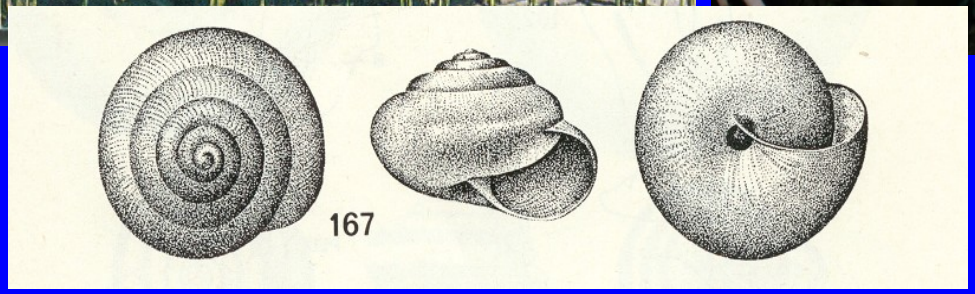
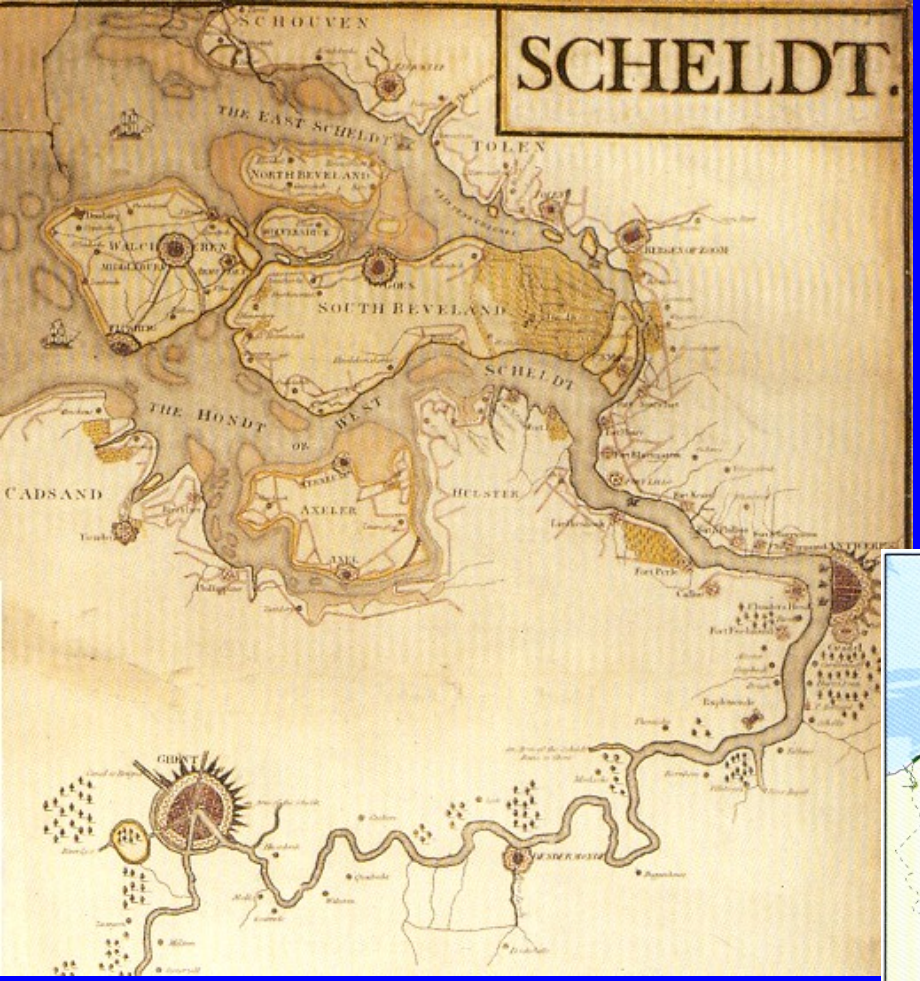
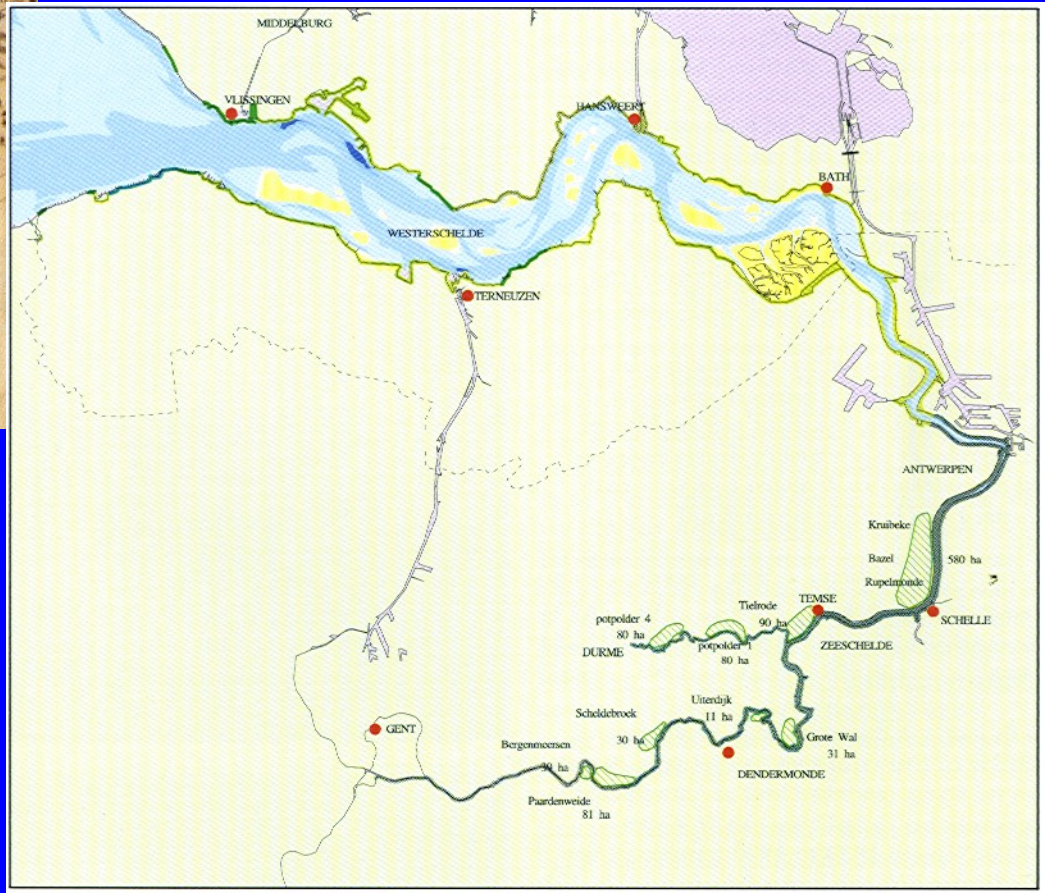


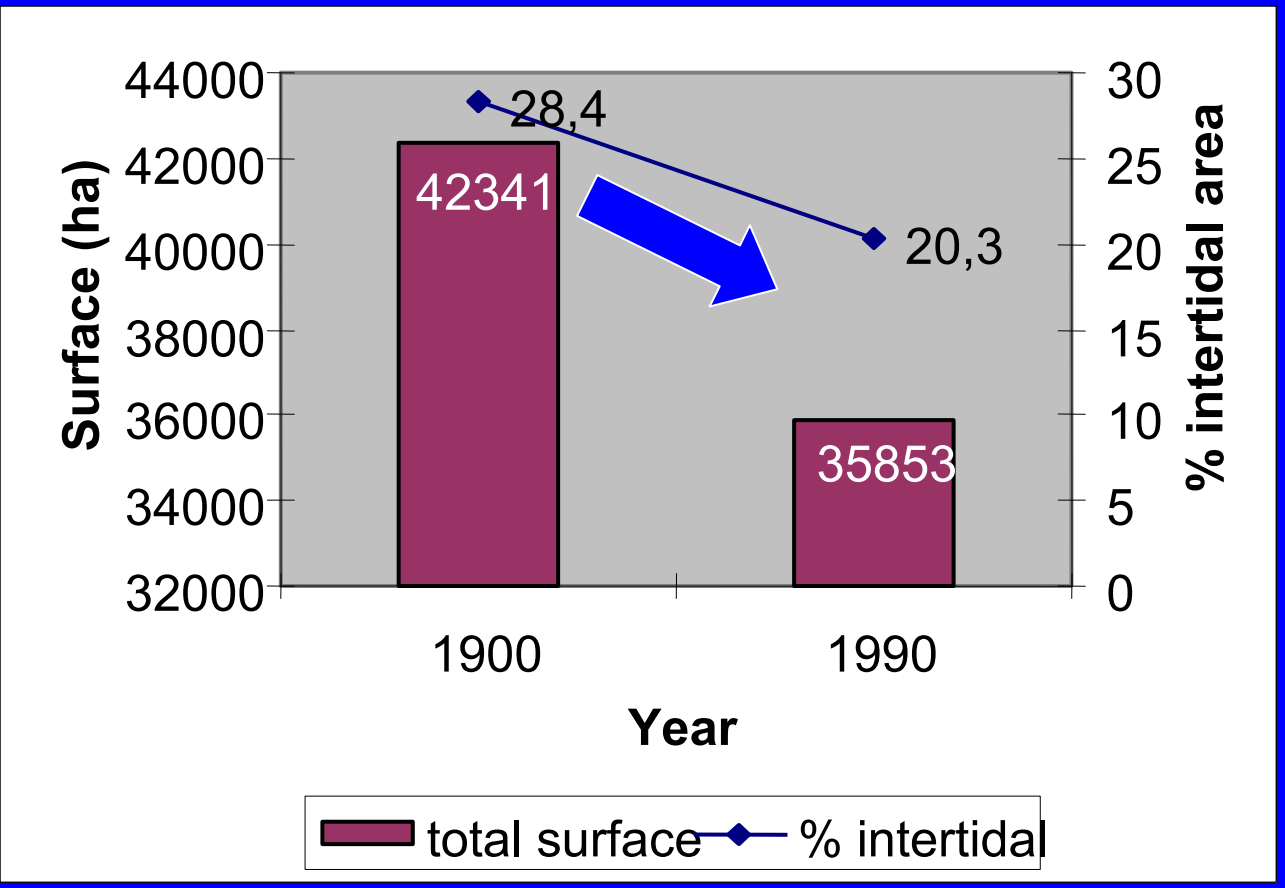

167

EMBANKMENTS



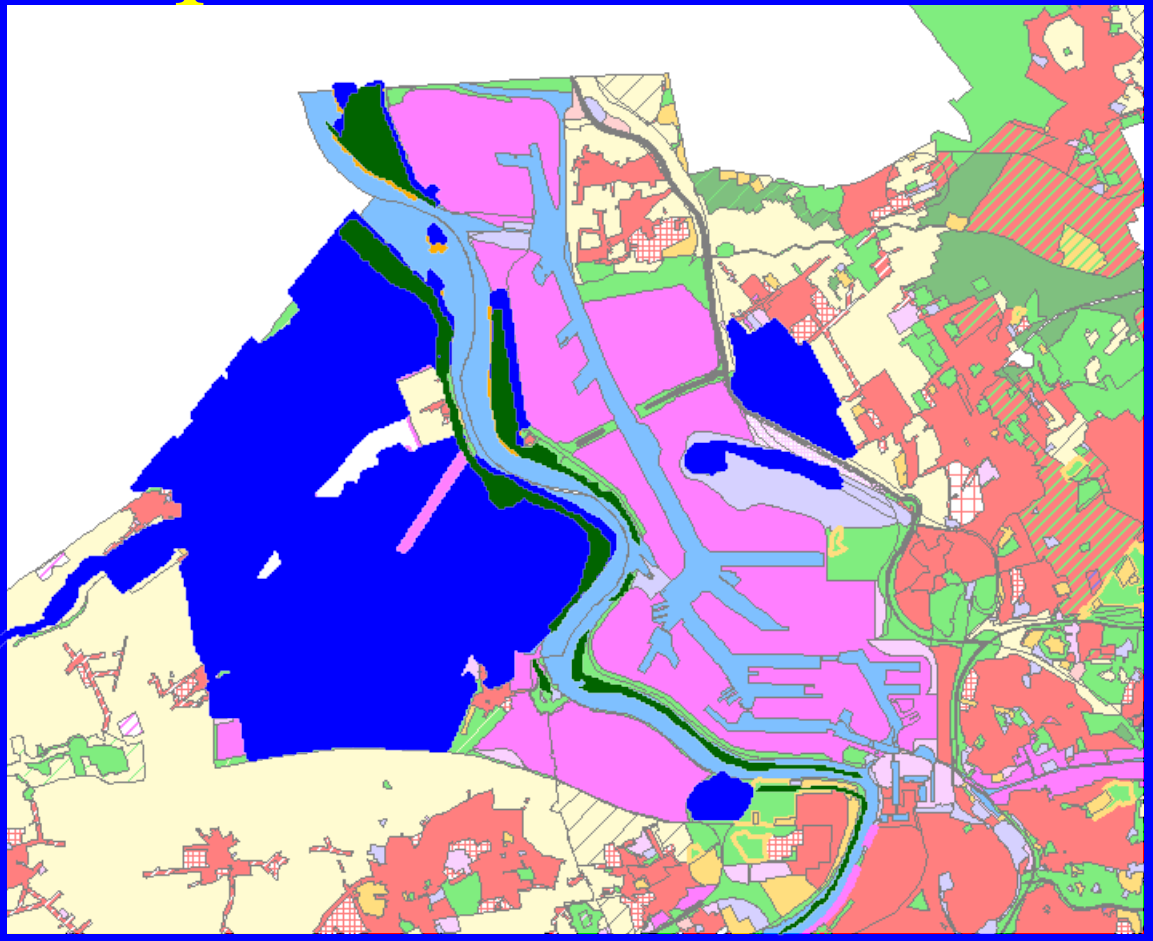


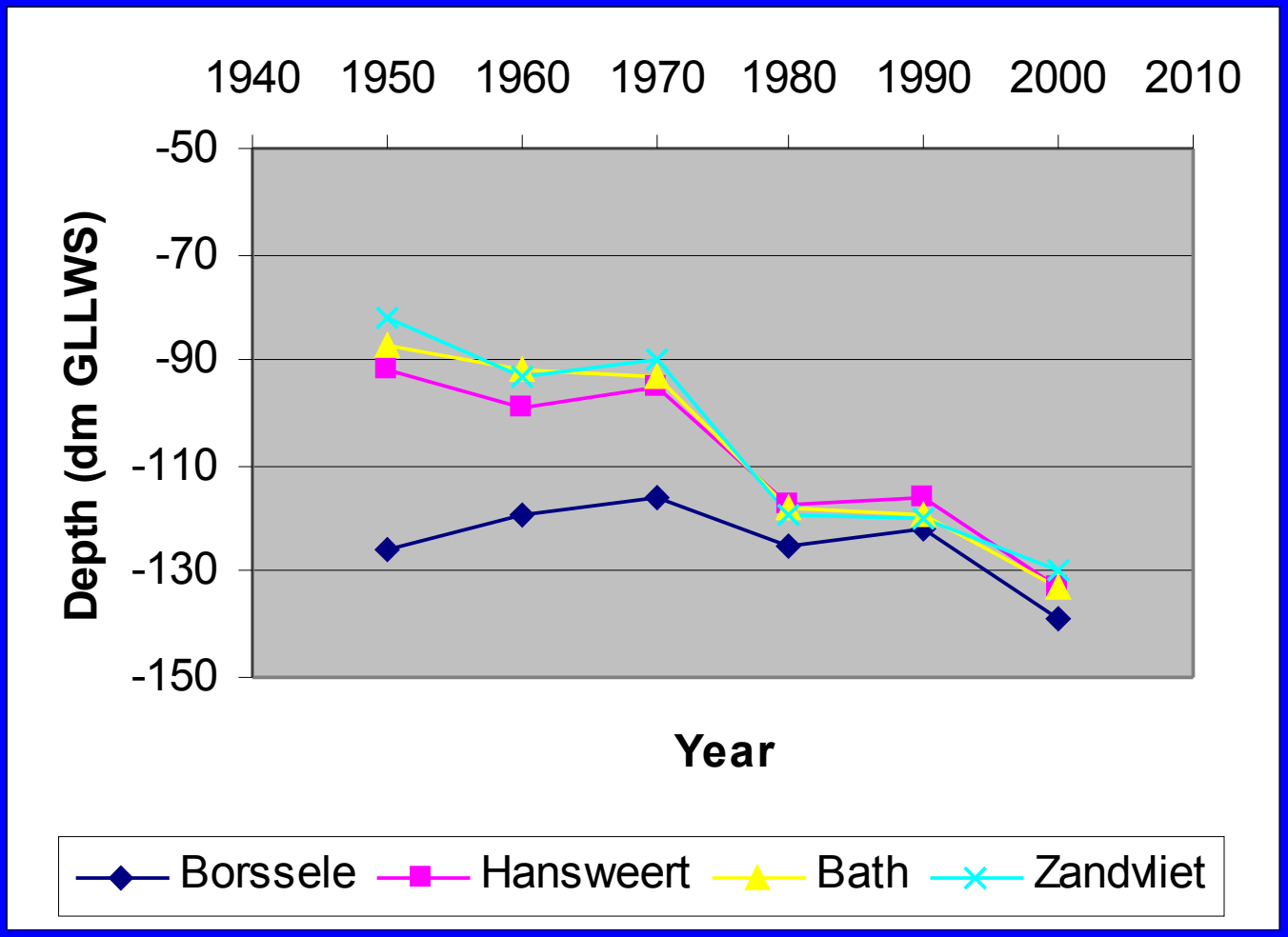
- Large loss of tidal habitats due to embankments since the middle ages
- A pattern that continues in the 20th century



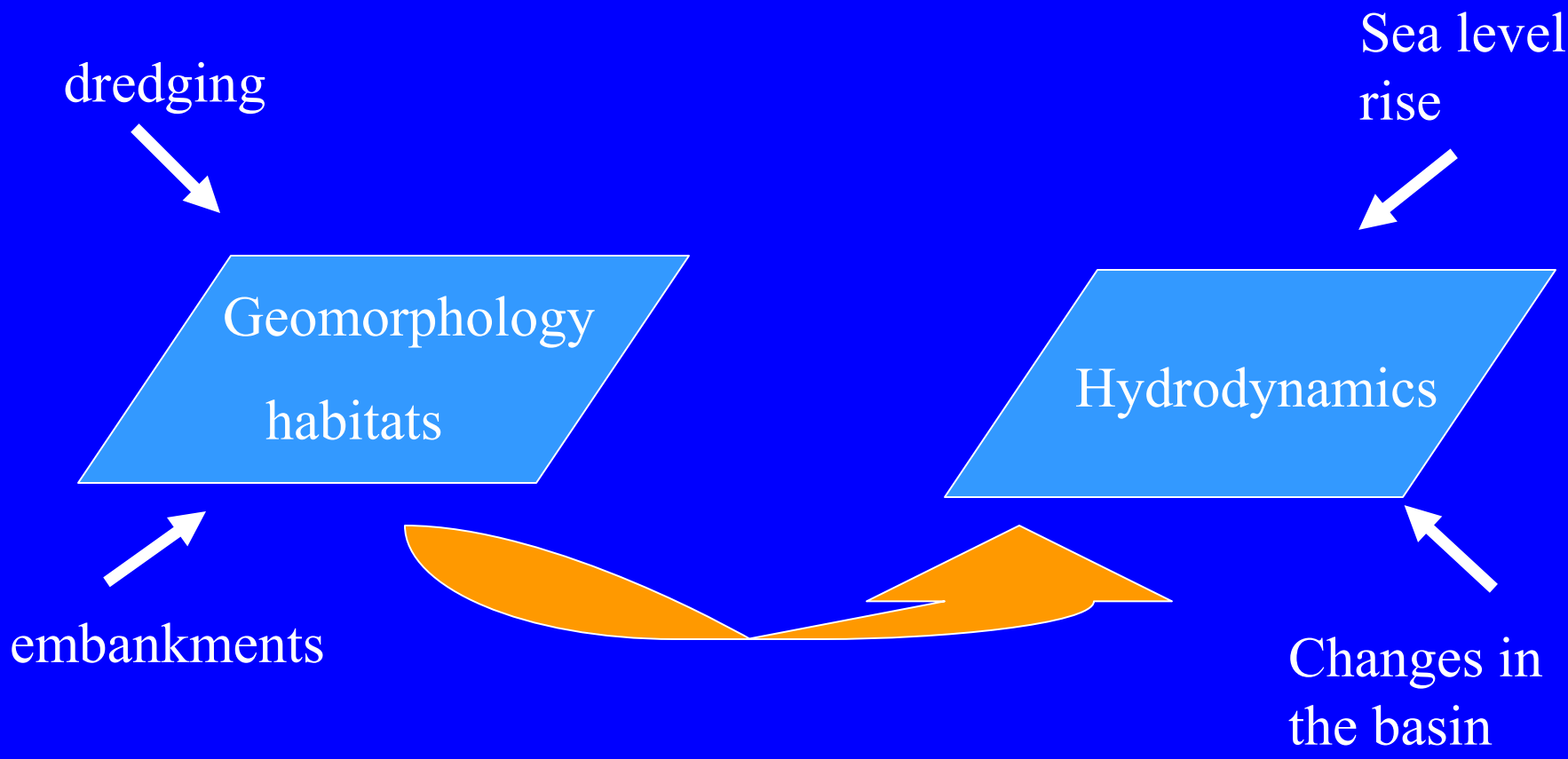
- A decrease in surface
- Loss of intertidal habitat proportionally more important

Development at the left bank

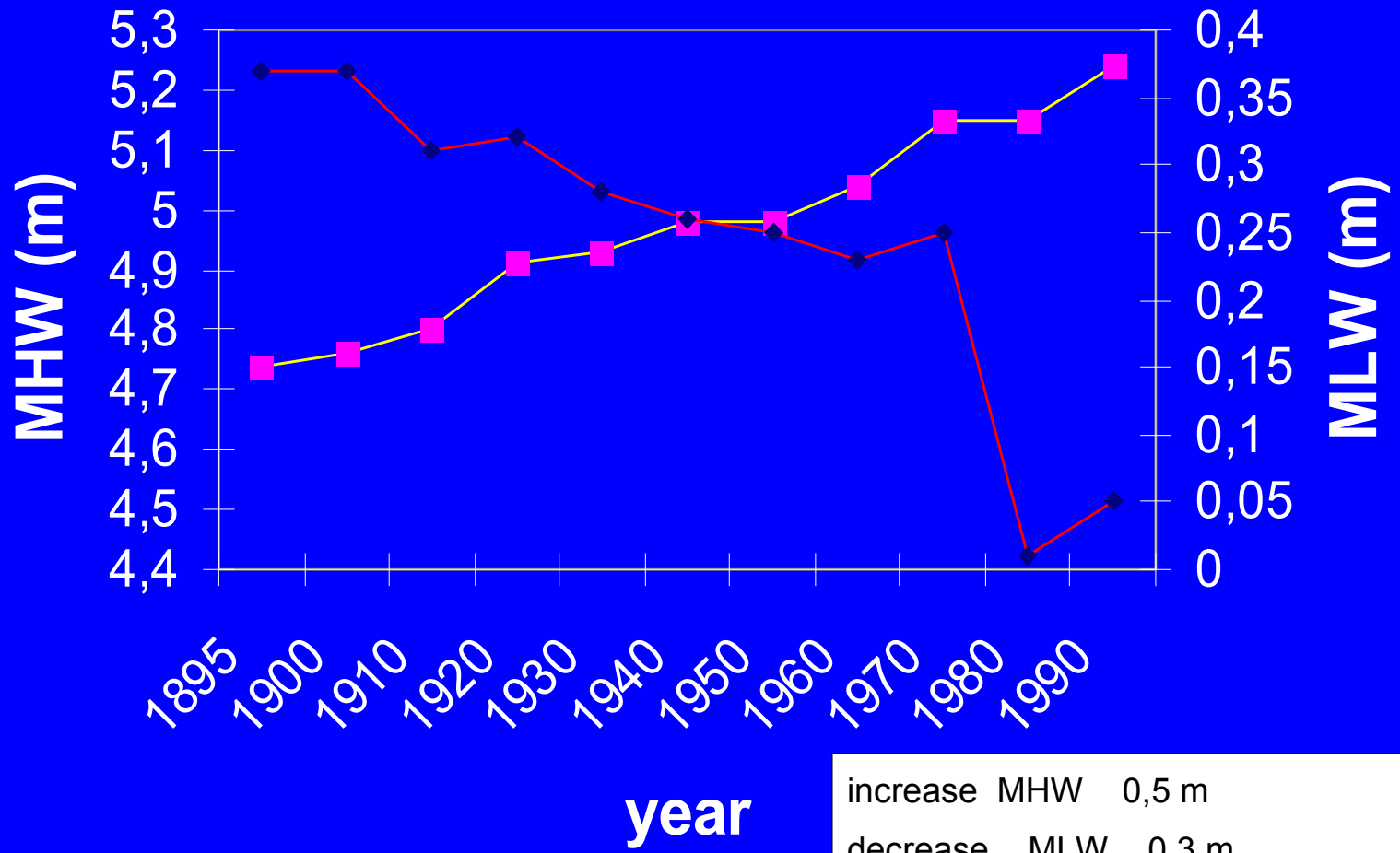




- Fairway deepened by dredging for access to the port of Antwerp


dredging
Sea level rise
Geomorphology habitats
Hydrodynamics
embankments
Changes in the basin

Changing tidal heights



increase MHW 0,5 m

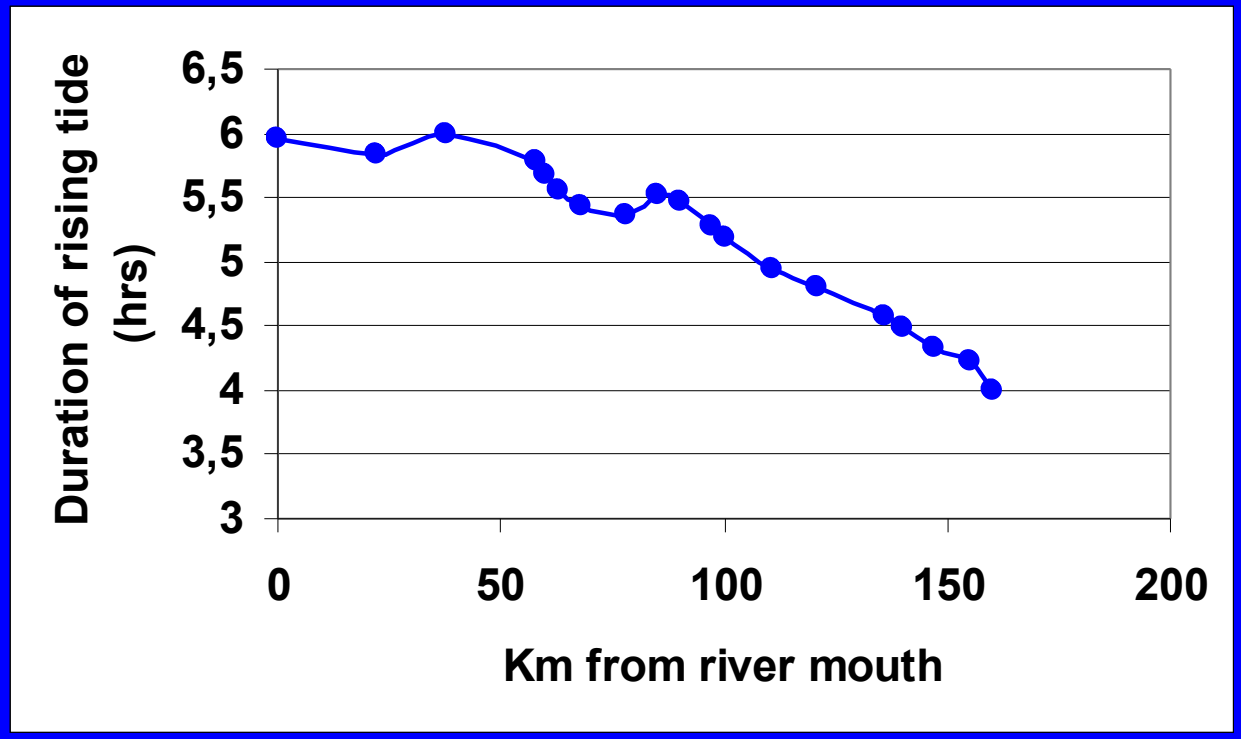
decrease MLW 0,3 m

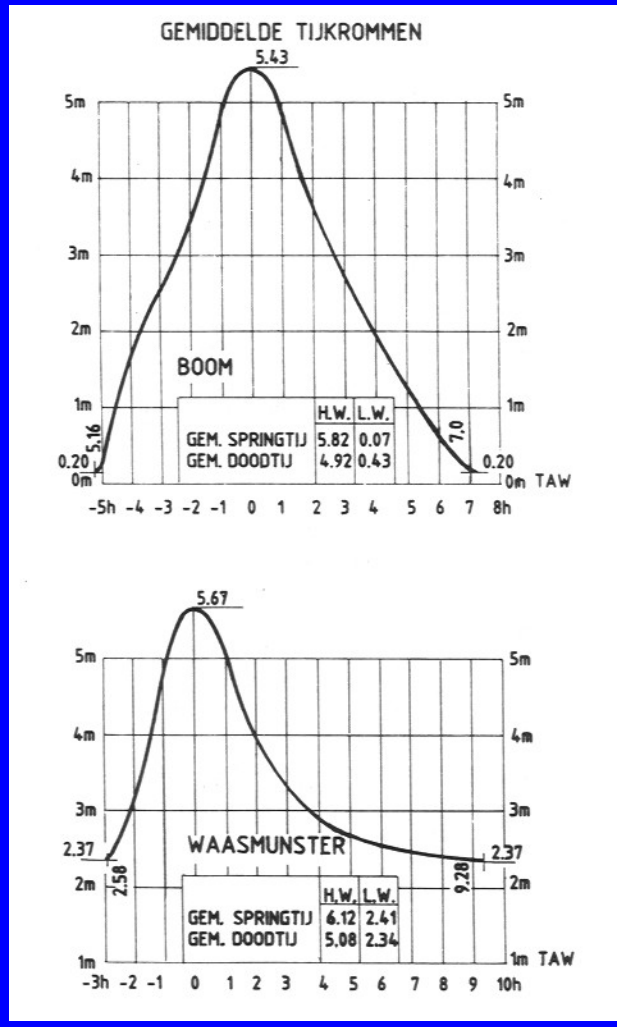
total increase tidal amplitude 0,8m

	1895	1925	1955	1985
Vlissingen - Hansweert	71	70	63	56
Vlissingen - Antwerpen	144	133	120	104

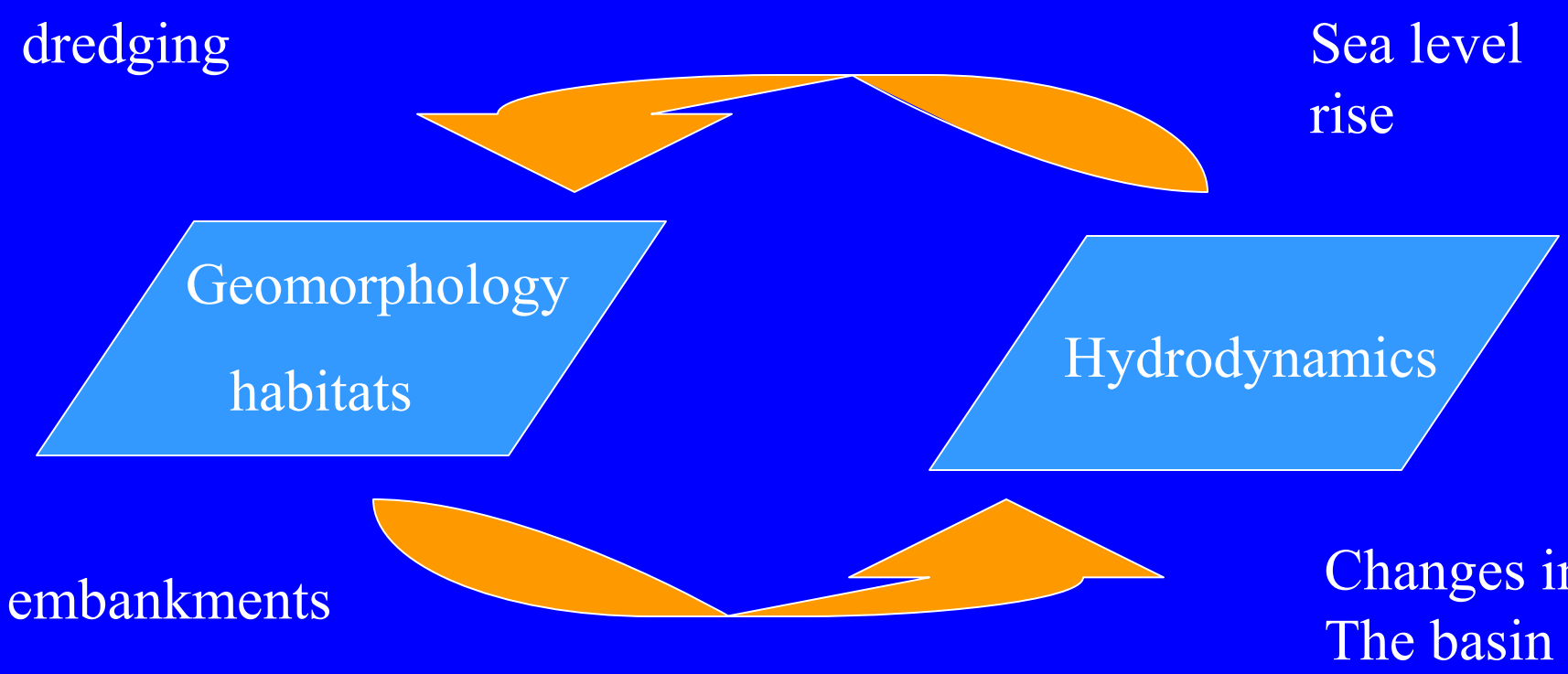
Looptijd van de vloedgolf (min)

Tidal asymmetry increases

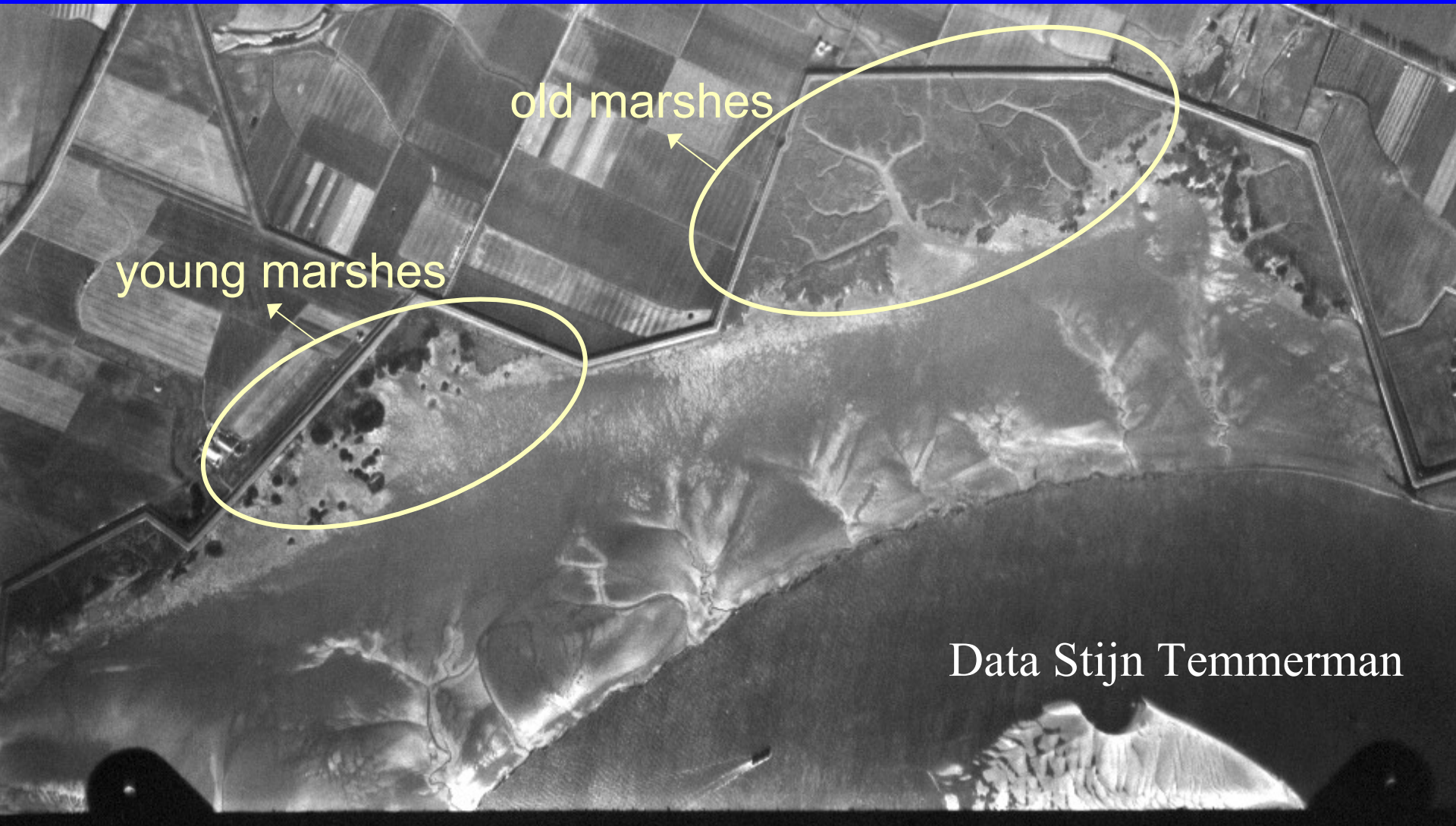




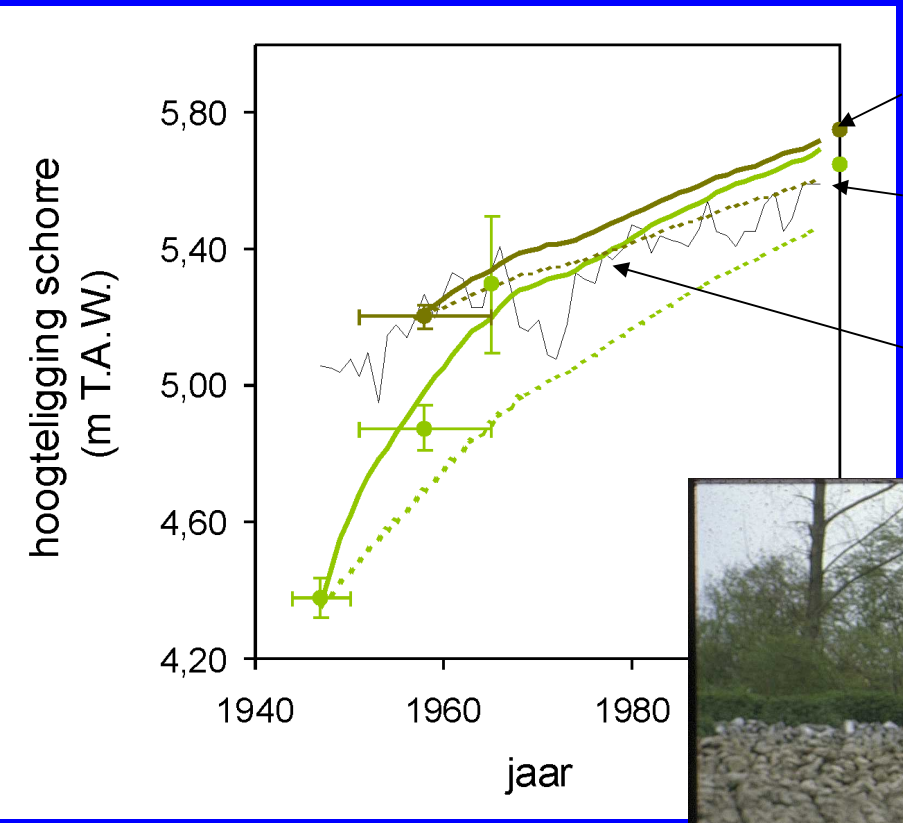
➔ Tidal pumping ➔ very strong sedimentation


dredging
Sea level rise
Geomorphology habitats
Hydrodynamics
embankments
Changes in The basin

Can habitats cope with the changing tidal amplitude?



Can habitats cope with the changing tidal amplitude?



Old marsh

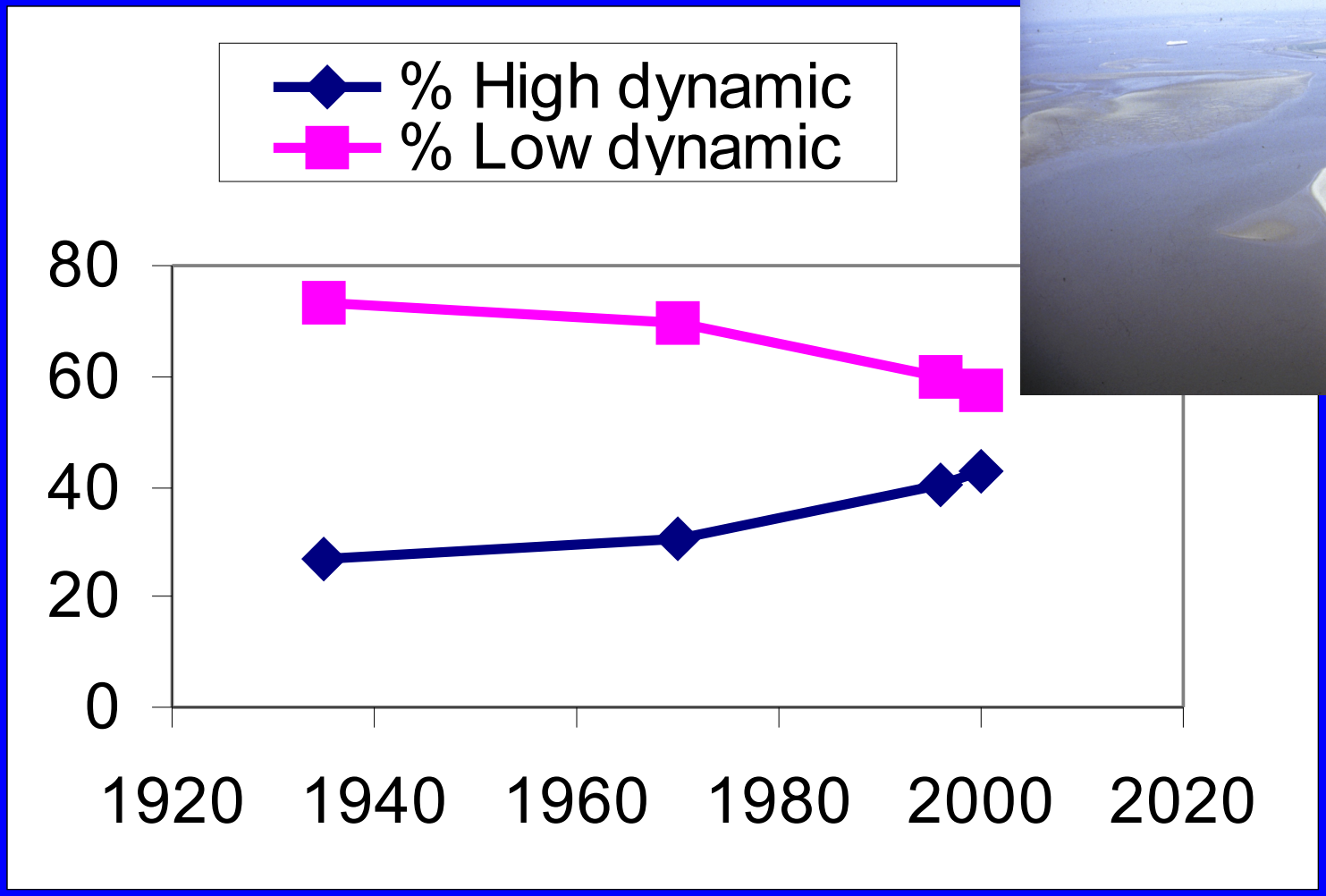
« young marsh »

Sea level

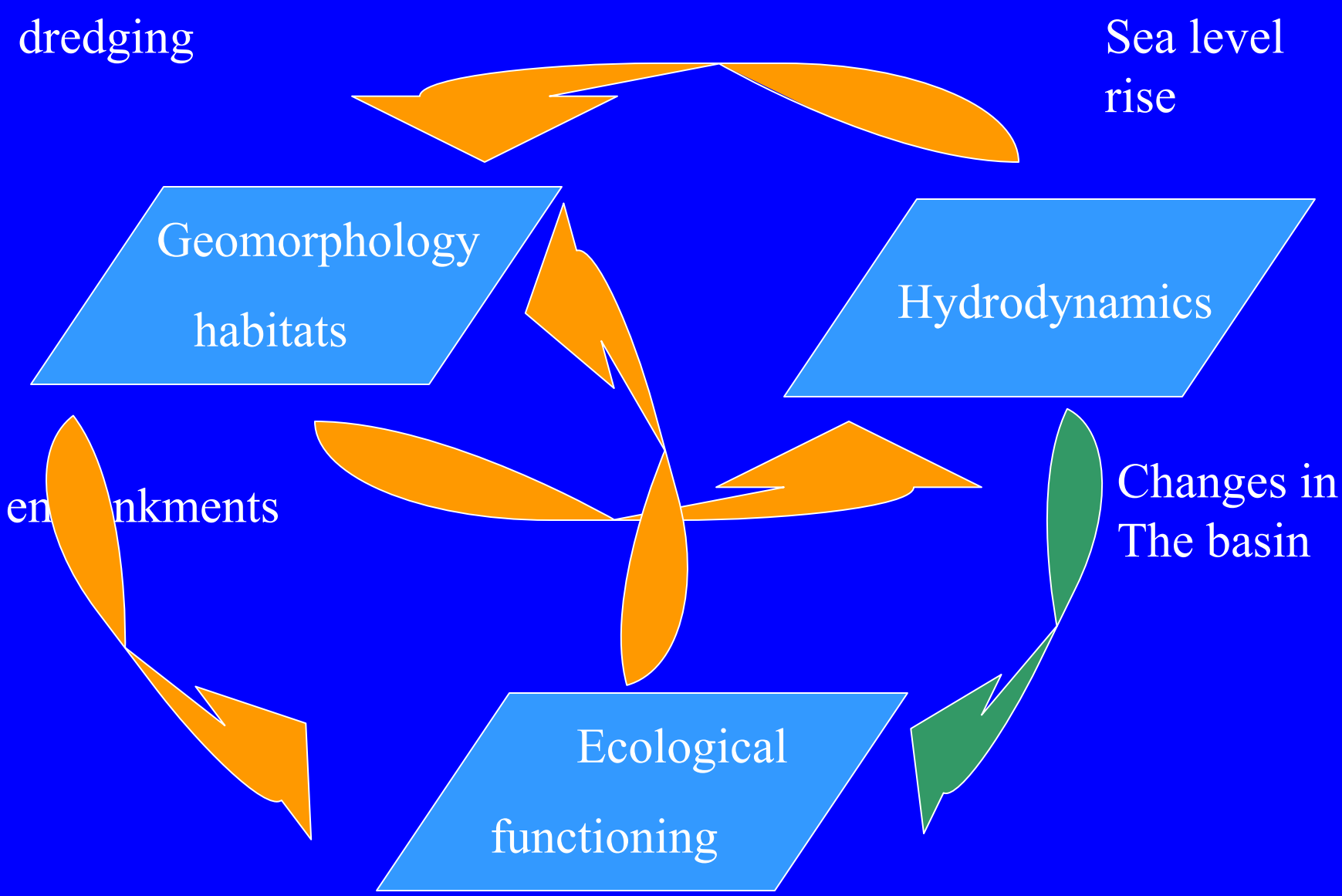
Data: S. Temmerman

Slope ↑, current speed ↑ ➔ marsh erosion ↑

Increase in high dynamic tidal flats



Courtesy Dick de Jong, RIKZ


dredging
Sea level rise
Geomorphology habitats
Hydrodynamics
Changes in The basin
Ecological functioning

Benthic biomas depends on sediment characteristics

Data Tom Ysebaert

Goods and services

- In recent years the concept of ecosystem health emerged, a concept that can be used to asses the state of an ecosystem and cn be used to build a reference for restoration.
- It is based on 3 mean focusses:
  - organisation
  - Vigor
  - Resilience
- Several ecosystem functions (goods & services) are associated with each focus

Proces/structure

Resilience
buffer for dynamical processes

Derived functions:

- water regulation and protection against flooding
  - Risks of flooding has increased significantly
  - ➔ present management:
    - Sigmaplan / Deltaplan
      - Heightening of dikes
      - Controlled inundation areas
      - Storm surge barrier

Resilience

Proces/structure

buffer for dynamical processes

Derived functions:

- sediment trap
  - Due to a lack of sedimentation areas, extremely high rates

➔ present managament:

- Dredging (up to 500.000 ton DW.y^{-1} removed from the area)
- NO link to sediment management in basin

- protection against erosion
  - Many dikes are not protected by marshes, this is solved by hard engineering

Proces/structure

Organisation
biodiversity / foodweb

Derived functions:

- trophic-dynamic regulations of populations
- habitat for resident and transient populations
- important habitat for global population
- nursery
- migration route

➔ severely impacted

➔ present management:

- "classical nature management"
  - Juridical measures
  - Species oriented measures
  - Vegetation management

➔ no impact at all on major problems like water quality

Vigor

Proces/structure

Nutrient cycle / primary production / behaviour of contaminants

Derived functions:

- regulation net transport of nutrients to North Sea
- regulation net transport contaminants to North Sea

✂➔ Yes but the overall effect is still small since the available surface of marshes decreased significantly and pelagical processes are limited by pollution and turbidity

- water treatment
- regulation gas exchange with the atmosphere
- climate regulation

Framework for restoration

- Estuary is in a spiral of negative developments leading to many problems
- Improving ecological functioning by:
  - providing habitat and enhancing biogeochemical functioning and primary productivity
  - Influencing geomorphological processes

✂➔ wetlands play a crucial role

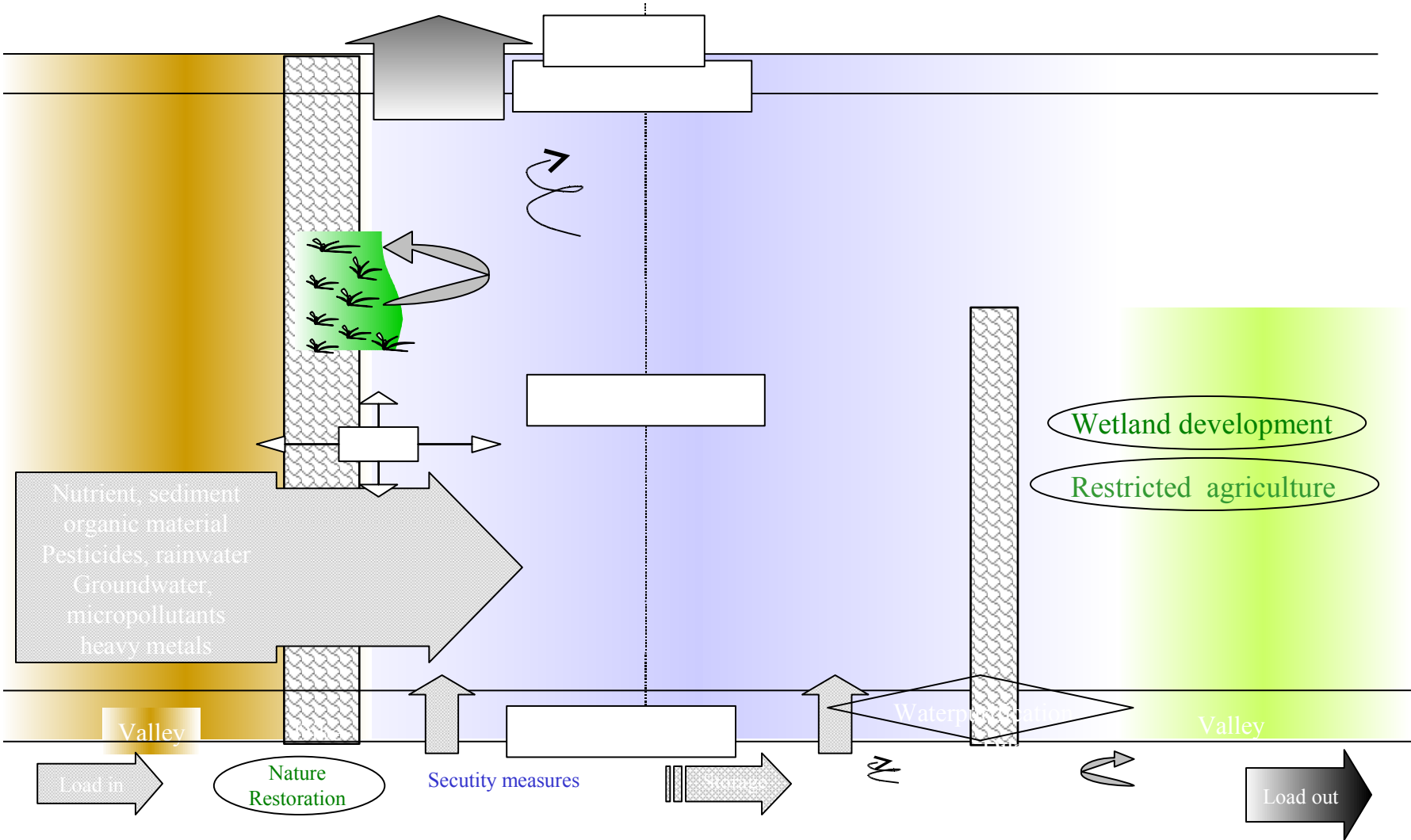
How ?

- How to device a management strategy maintaining or restoring goods and services and meanwhile fullfilling economic demands like deepening?

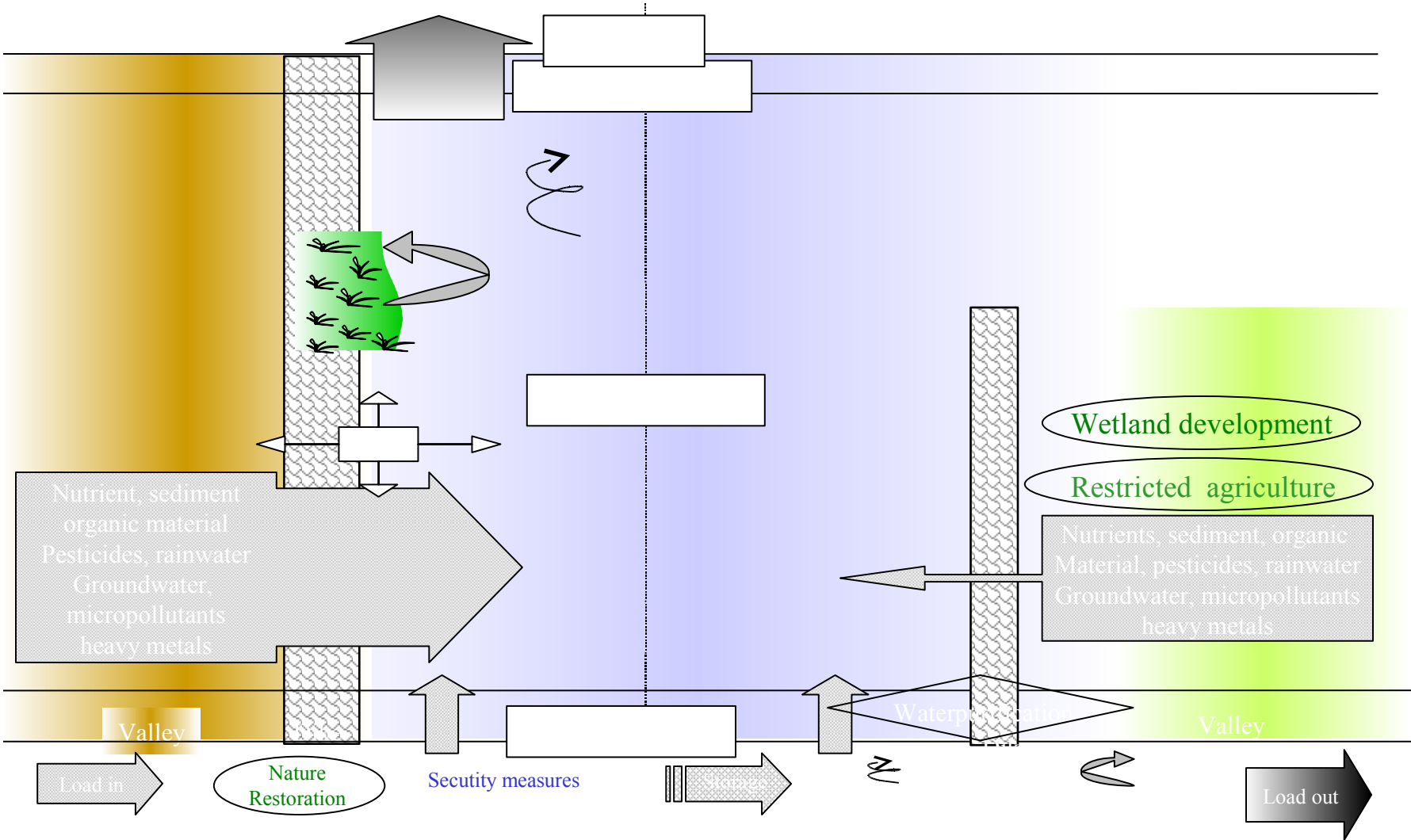
Goals

	01 VlRaa	02 VlHan	03 HanGr	04 GrBur	05 BurTm	06 TmDem	07 DemGt	08 Durme	09 ZeDNe	10 strSc
maximisation of buffer capacity discharge	0	0	0	0	+	+	++	++	++	++
maximisation tidal energy dissipation	+	++	++	++	++	+	+	+	+	0
Increase multichannel system	0	++	++	0	0	0	0	0	0	0
optimisation natural habitat processes	++	++	++	++	++	++	++	++	++	0
minimise turbidity	0	+	+	++	++	++	+	++	+	0
Optimisation C flux	0	0	0	0	0	0	0	0	0	++
optimisation N flux	0	0	+	+	+	++	++	++	++	++
Optimisation O2	0	0	0	+	++	++	+	++	+	++
Optimisation of P flux	0	0	0	0	0	0	+	+	+	++
Optimisation of Si flux	+					++	++	++		0
Optimisation of primary production	0	+	+	++	++	++	+	++	+	0
optimisation conditions for zoöplankton	0	+	+	+	++	++	++	++	++	0
optimisation conditions for benthos	+	++	++	++	++	++	++	++	++	0
Optimisation fishmigration	0	+	+	+	+	+	++	++	++	++
extension surface shallow low dynamic water	+	++	++	++	++	++	++	++	++	0
extension surface tidal flats	+	++	++	++	++	++	++	++	++	0
Reducing high dynamic areas	0	++	++	0	0	0	0	0	0	0
Extension surface marsh	+	++	+	+	++	+	++	+	++	0
Extension young marsh	+	++	++	++	++	++	++	0	0	0
Extension surface wetland	0	0	0	+	+	+	++	+	++	0

Conceptual model

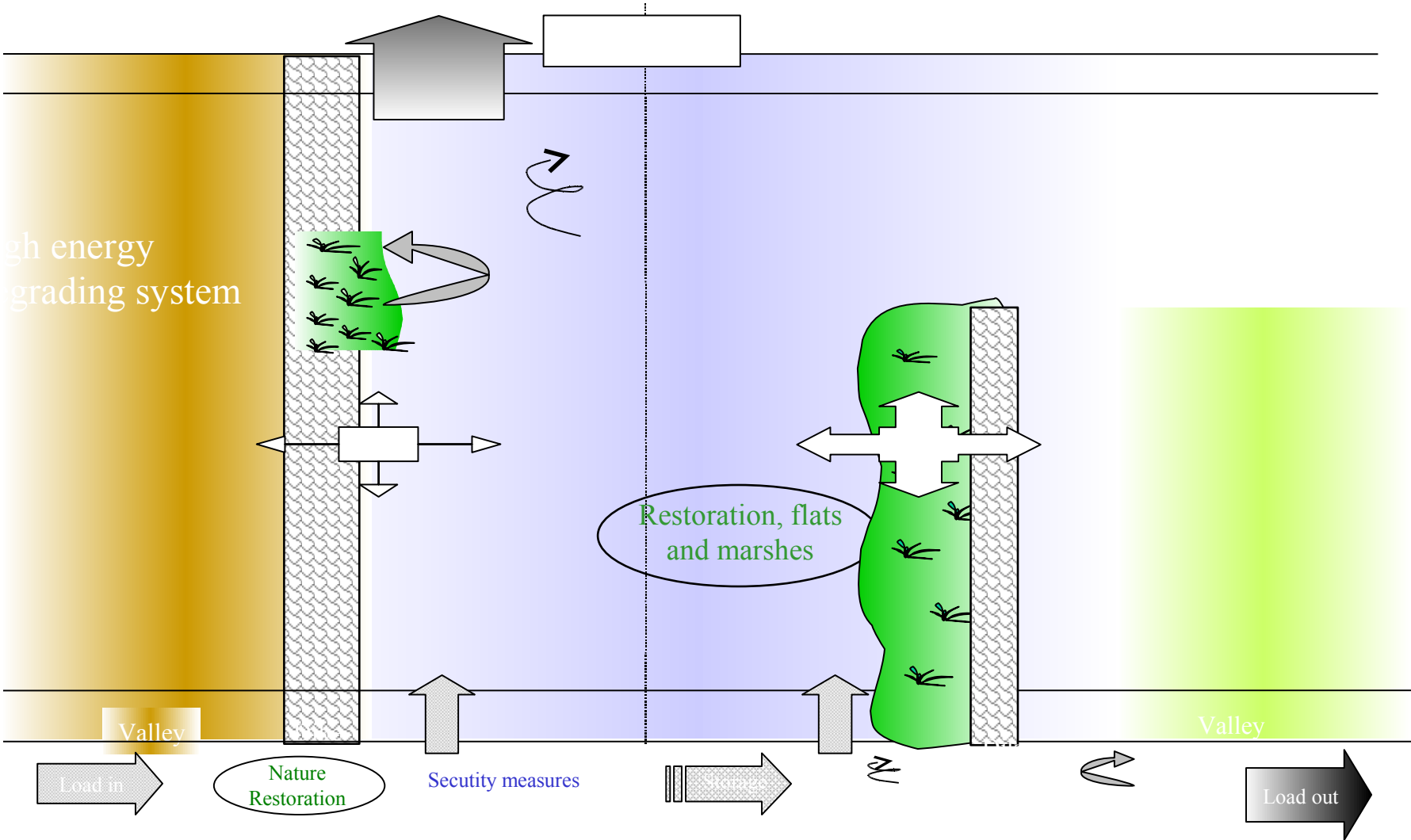


Conceptual model



Conceptual model

Restore habitats (morphology) within the estuary



Habitat restoration during maintenance

Use « soft » measures instead of « hard engineering »

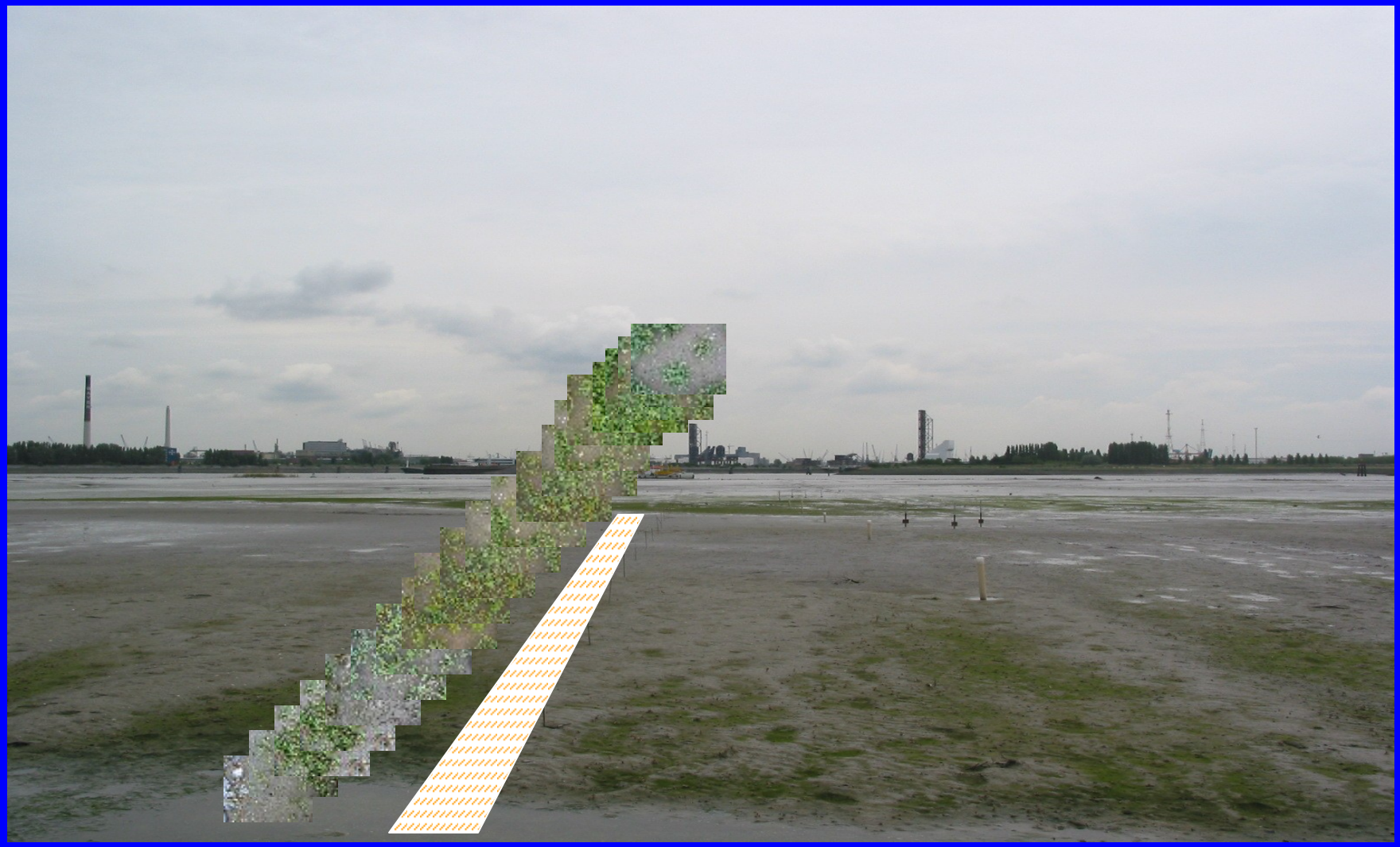
Projects carried out by the Flemish Administration of Waterways

Restoration of former raised site

Restoration of former raised sites

Projects carried out by the Flemish Administration of Waterways

Evolution in the Field



Evolution in the Field

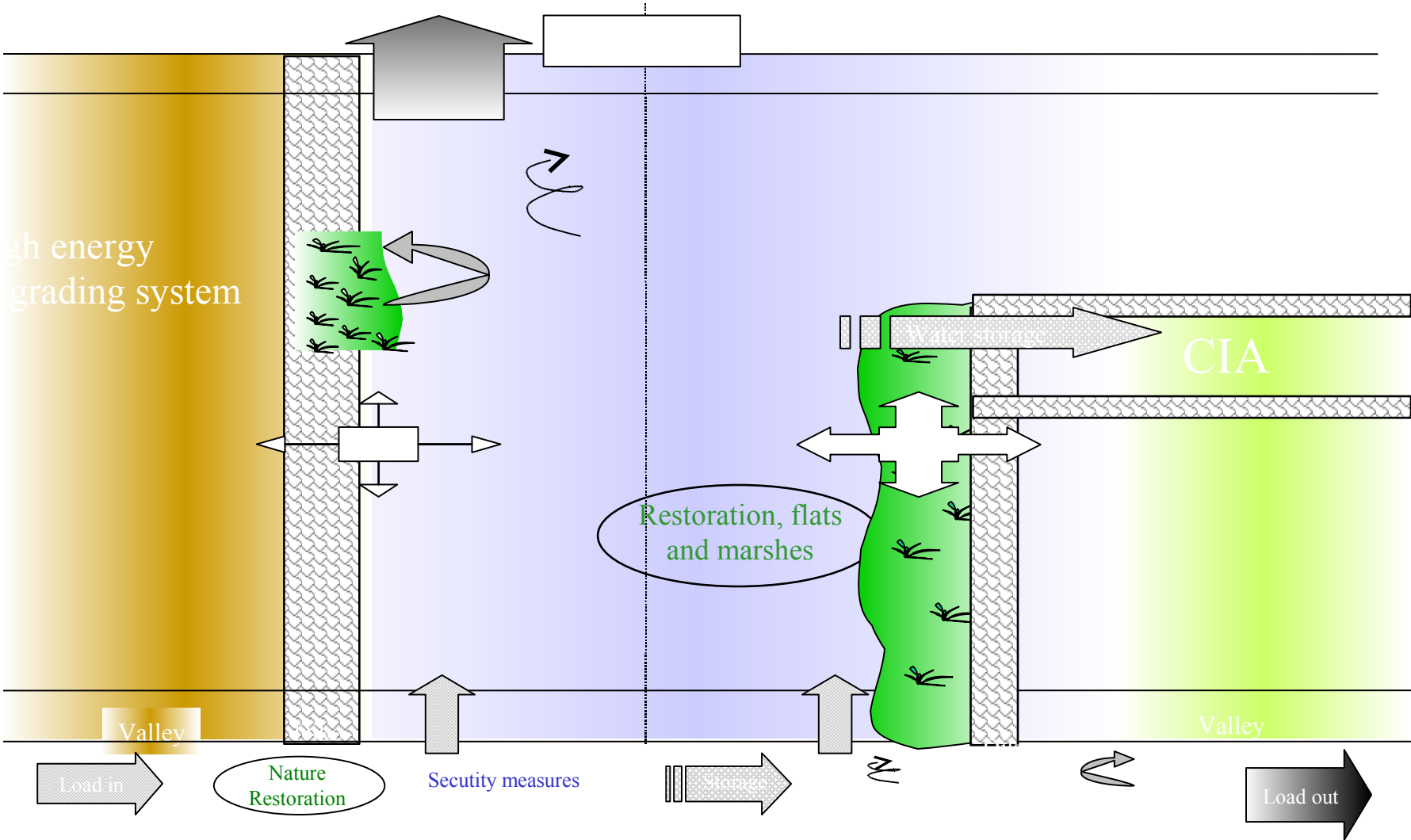
18/02/2003

06/05/2003

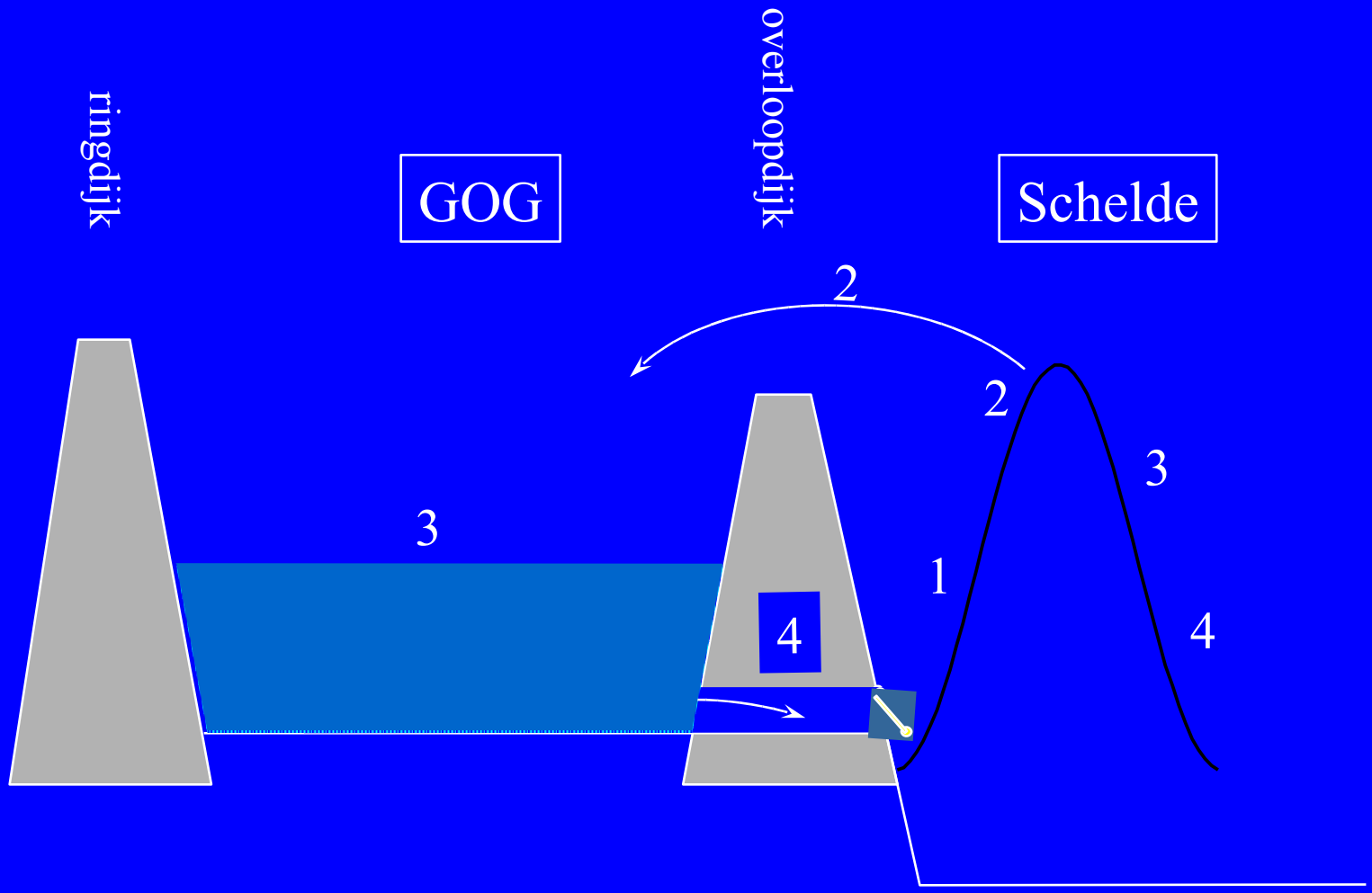
30/07/2003

Conceptual model

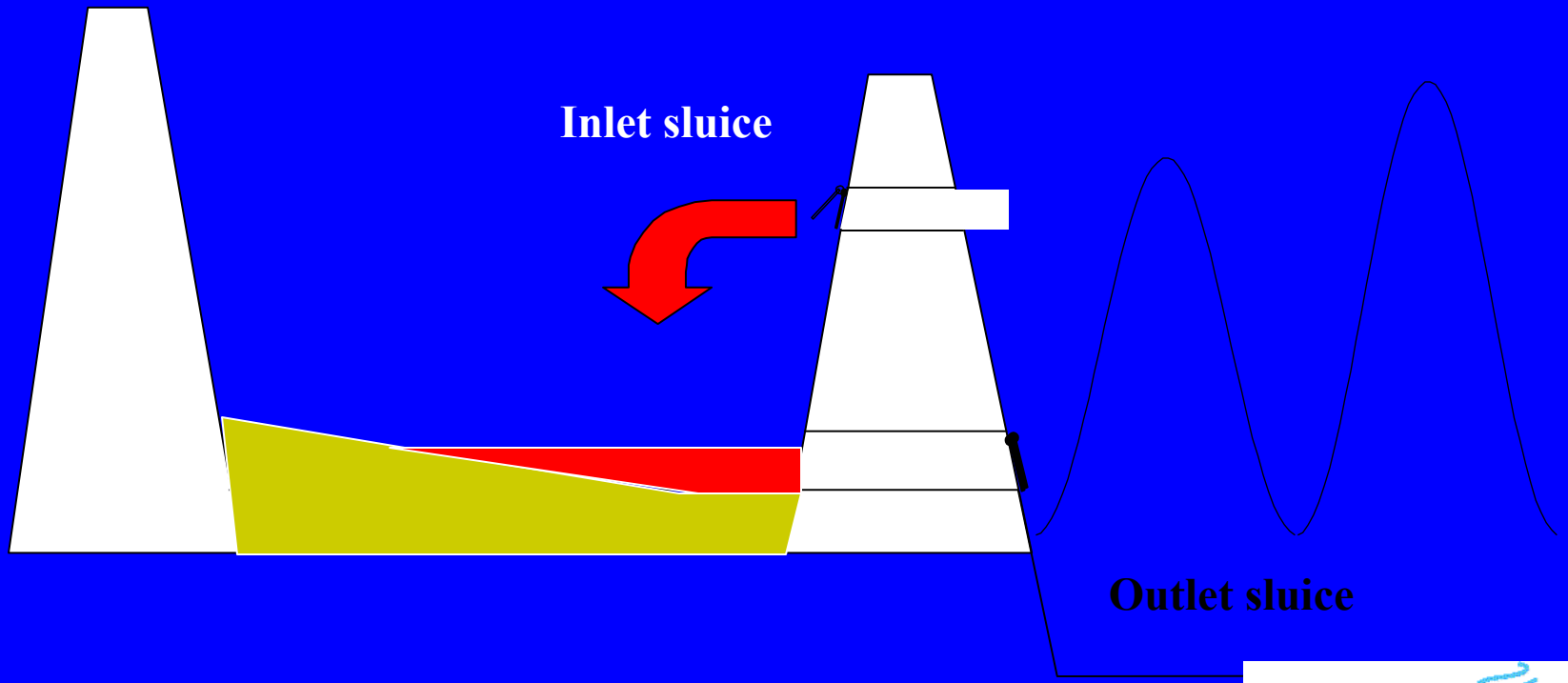
Restore habitats (morphology) within the estuary



Controled inudation area

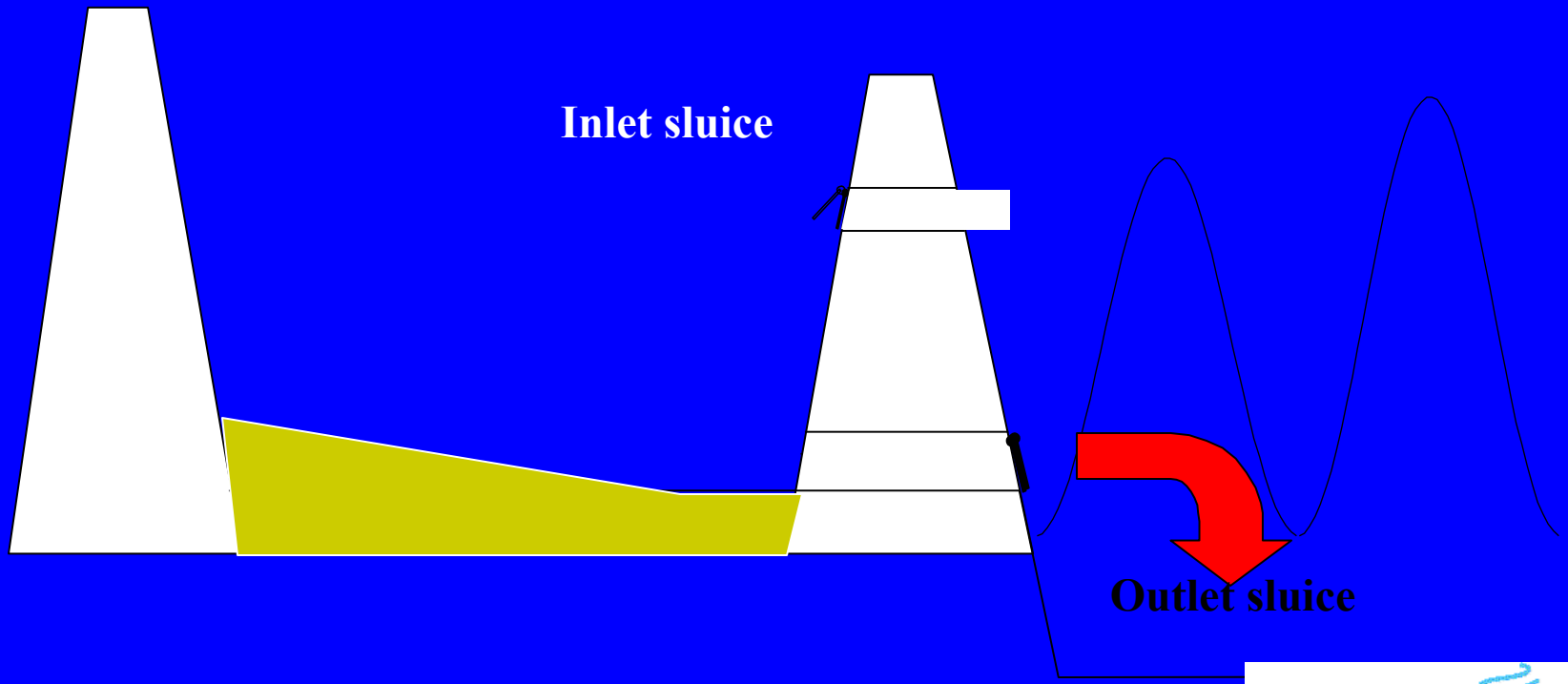


Principle CIA with Reduced Tide



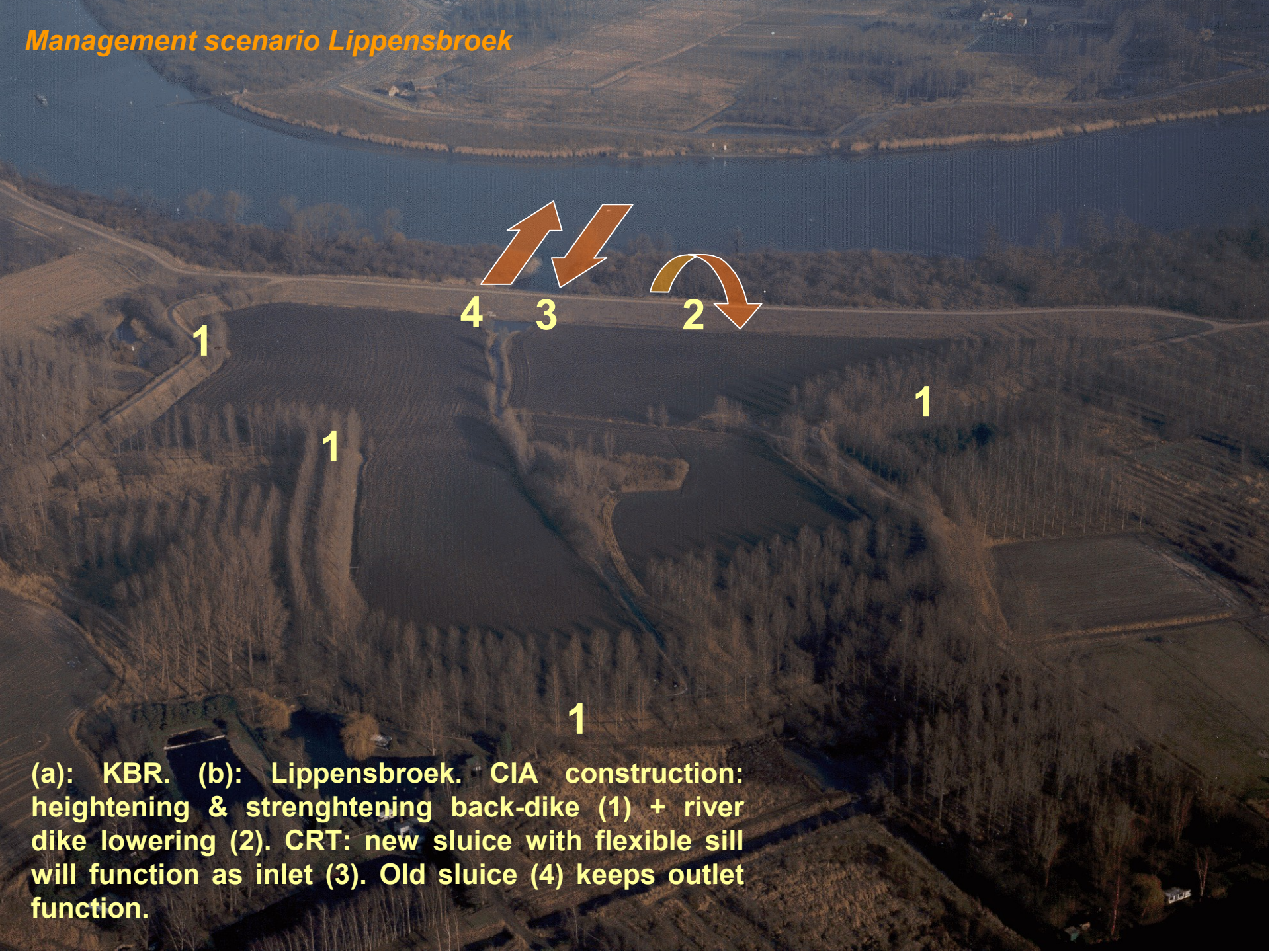
ECOSYSTEM MANAGEMENT RESEARCH GROUP

Principle CRT



ECOSYSTEM MANAGEMENT
RESEARCH GROUP

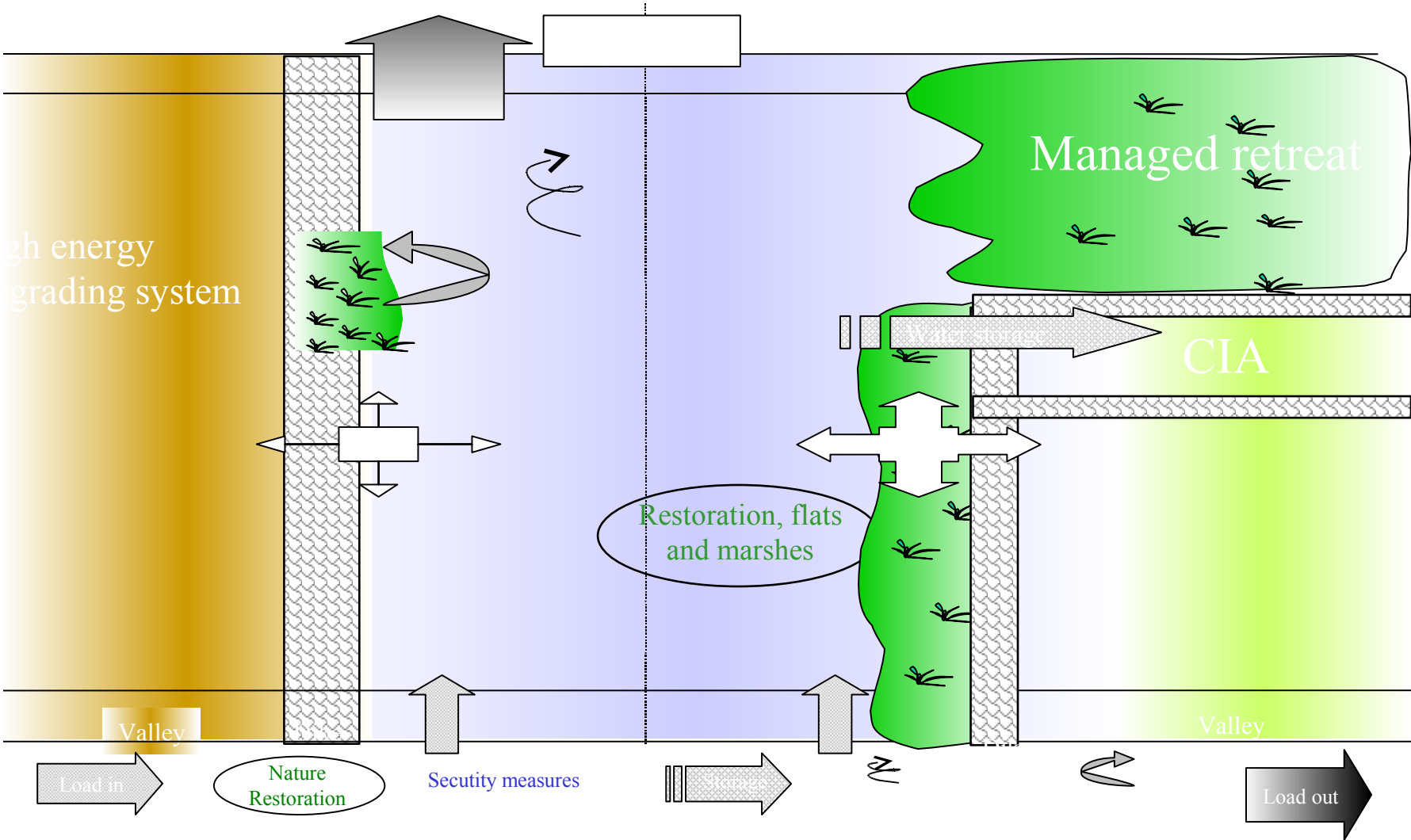
Management scenario Lippensbroek



(a): KBR. (b): Lippensbroek. CIA construction: heightening & strenghtening back-dike (1) + river dike lowering (2). CRT: new sluice with flexible sill will function as inlet (3). Old sluice (4) keeps outlet function.

Conceptual model

Restore habitats (morphology) within the estuary



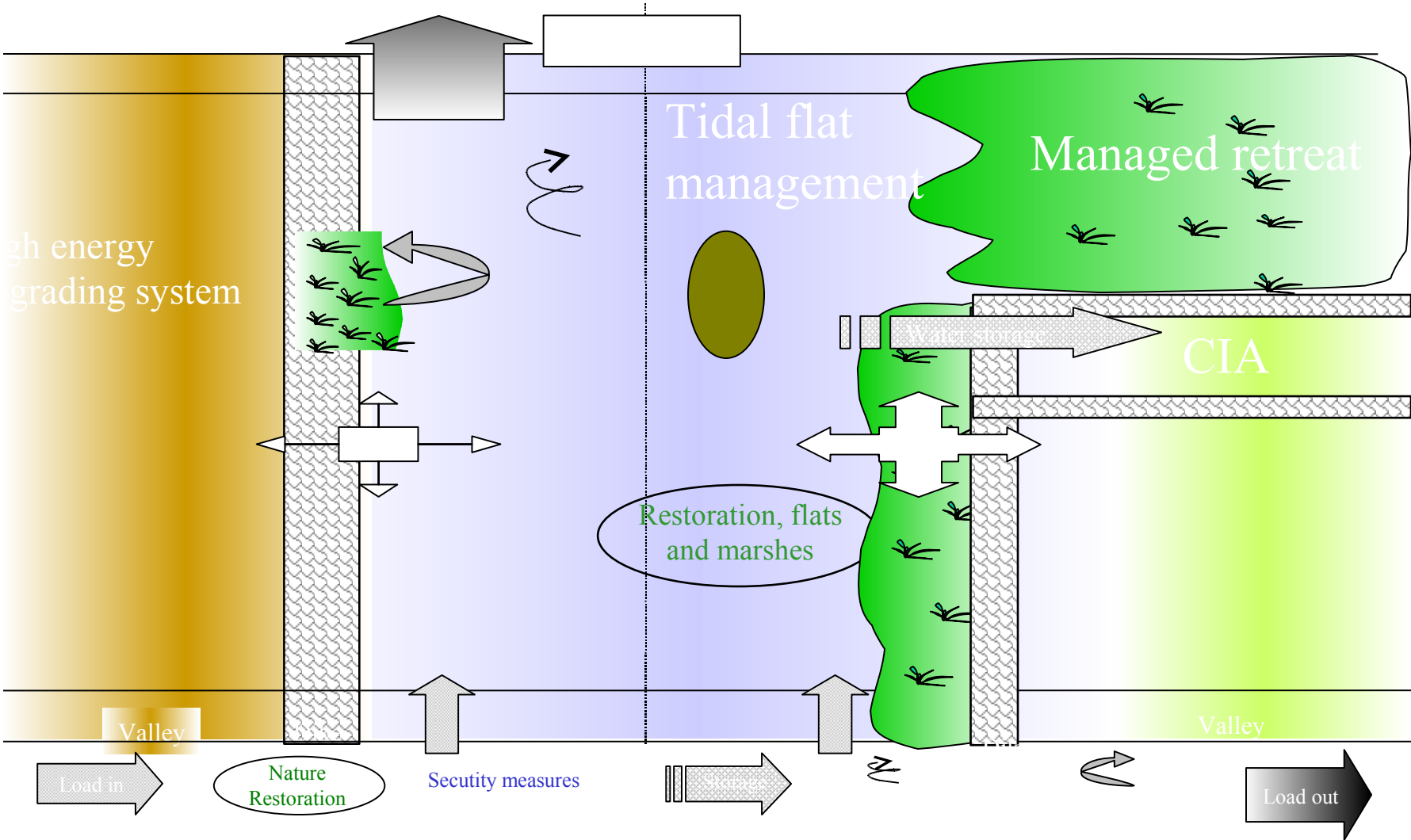
Managed retreat

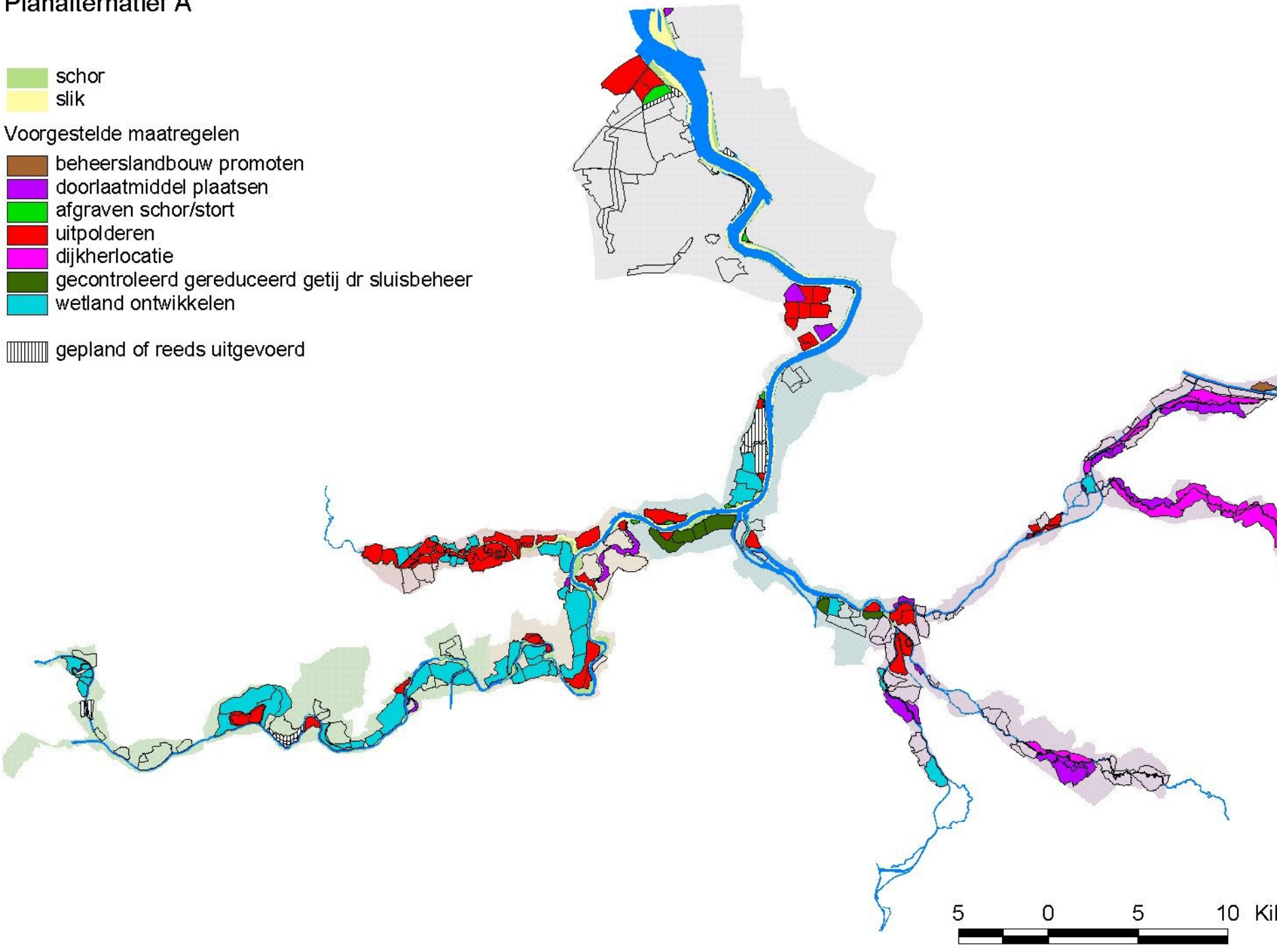
1990

1998

Conceptual model

Restore habitats (morphology) within the estuary




Planalternatief A
schor
slik
Voorgestelde maatregelen
beheerslandbouw promoten
doorlaatmiddel plaatsen
afgraven schor/stort
uitpolderen
dijkherlocatie
gecontroleerd gereduceerd getij dr sluisbeheer
wetland ontwikkelen
gepland of reeds uitgevoerd
5 0 5 10 Kil

Present situtation

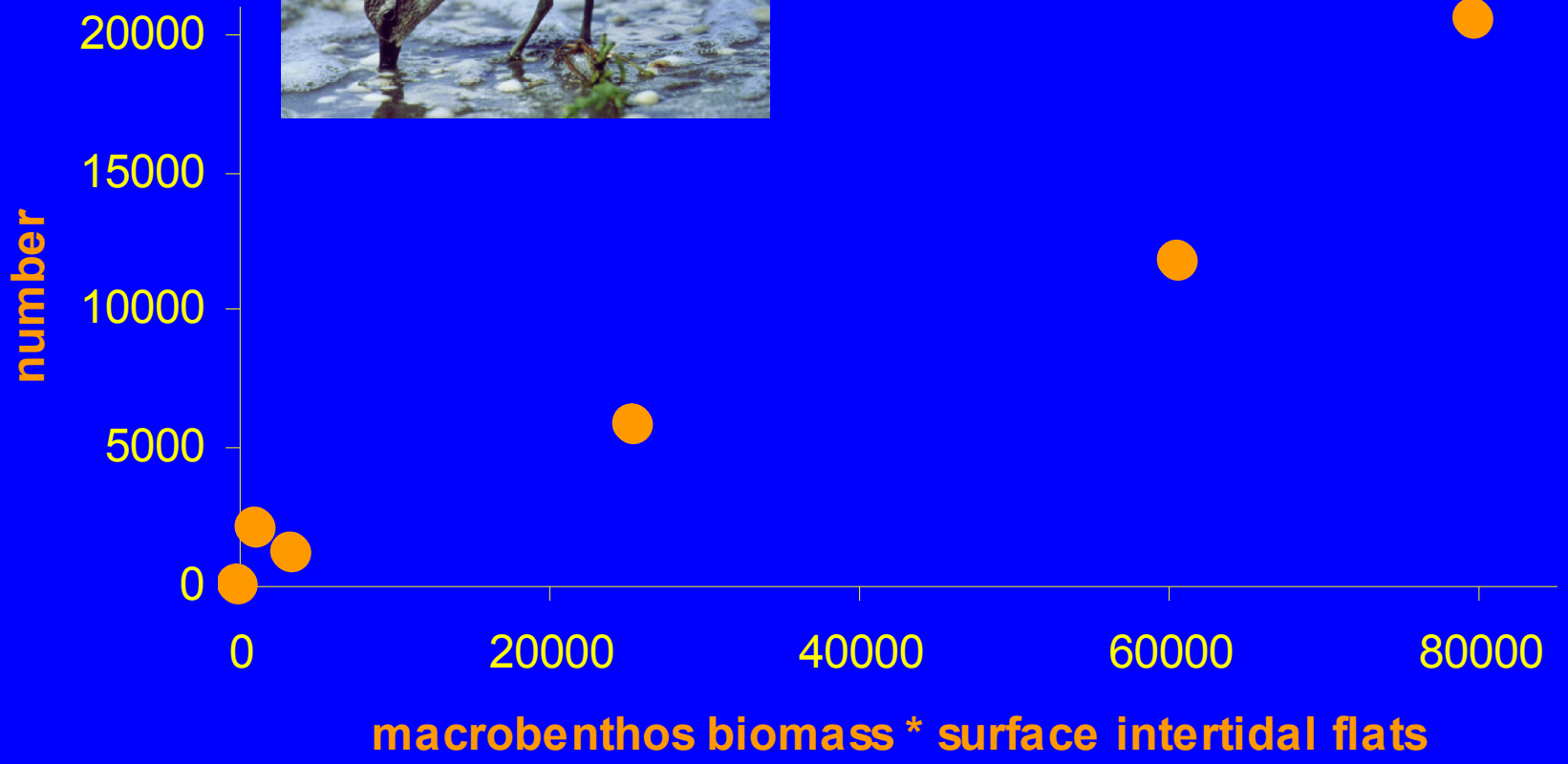
- PROSES: cooperation between the Netherlands and Flanders
- Flanders decided to carry out three major projects:
  - Wetland development of the Kalkense Meersen
  - Managed retreat of the Durme
  - Managed retreat of the Prosperpolder
  - 1800 ha of inundation areas linked with wetland development
- The Netherlands will decide soon

Conclusion

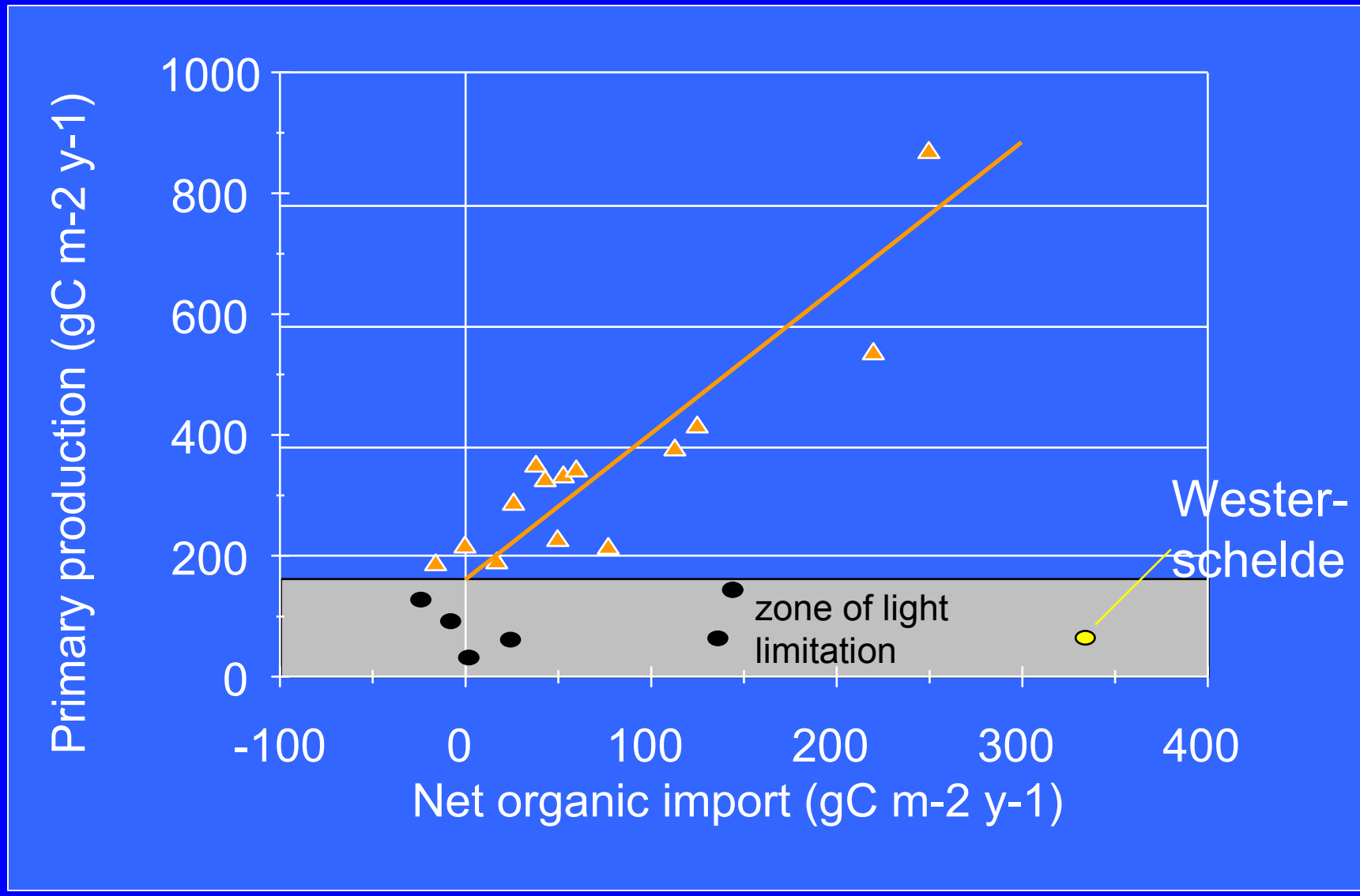
- Optimalisation of ecosystem goods and services is a most important goal in which natural habitats, wetlands, play a crucial role
- Restoration of wetlands should increase the possibilties of the system to absorb environmental changes (climate change) increase resilience, vigor and organisation of the system
- Where do what should be based on the understanding of the functioning of the system, which requires a lot of research, modelling but overall an integrated approach


Thanks for your attention

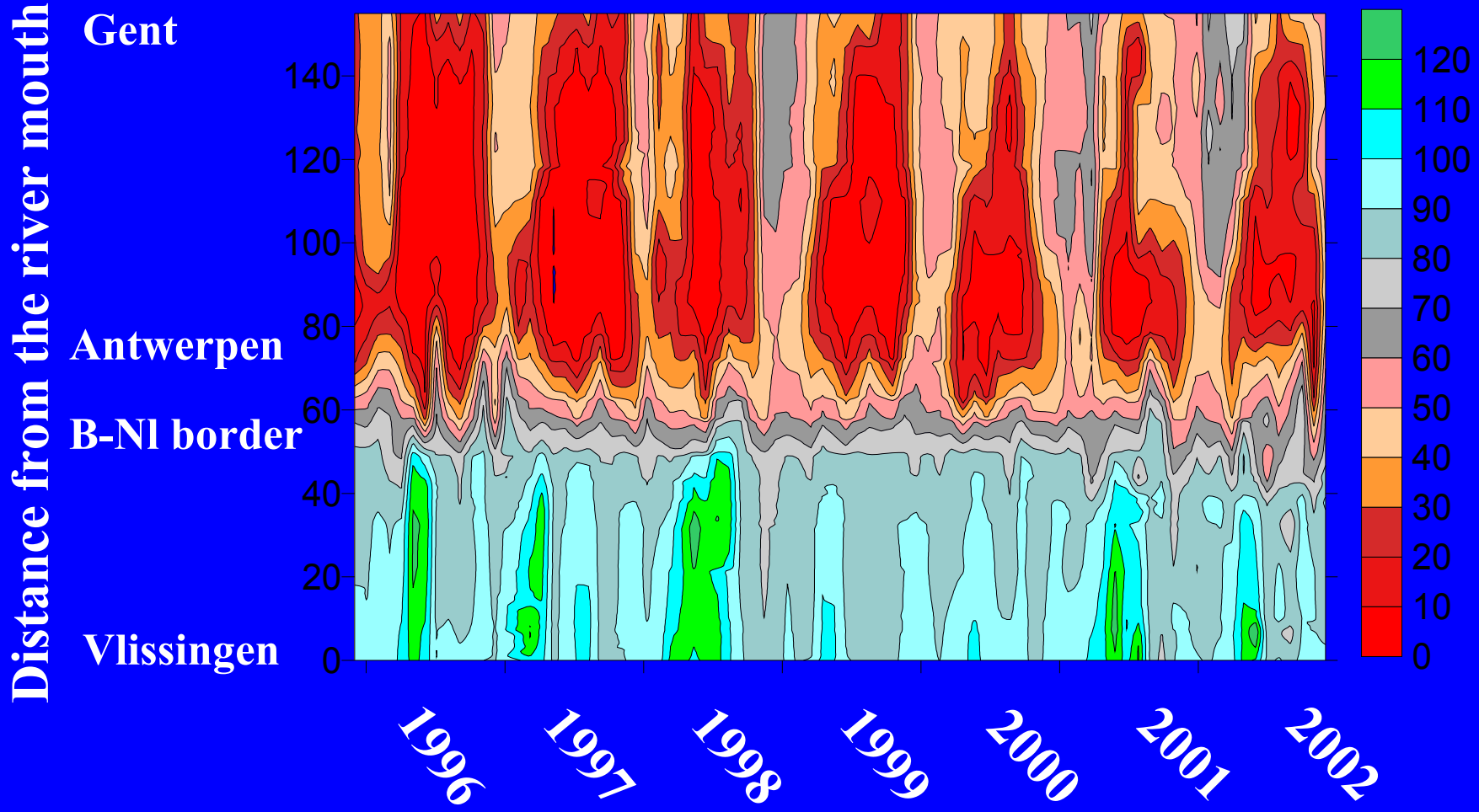
Benthos eating birds – habitat/food



Data Tom Ysebaert


Primary production (gC m-2 y-1)
1000
800
600
400
200
0
-100
0
100
200
300
400
Net organic import (gC m-2 y-1)
zone of light limitation
Wester-schelde

Oxygen saturation (%)



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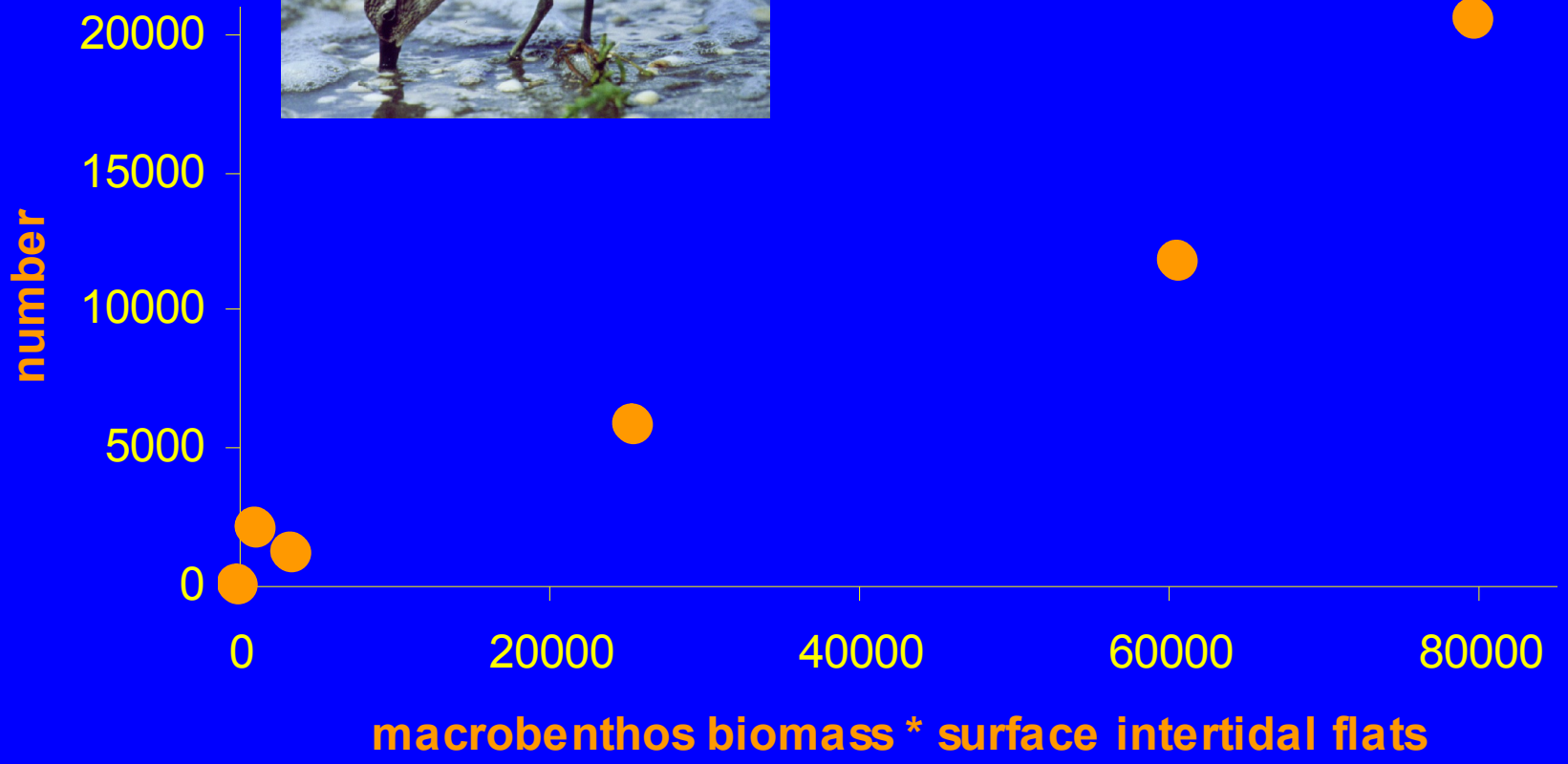
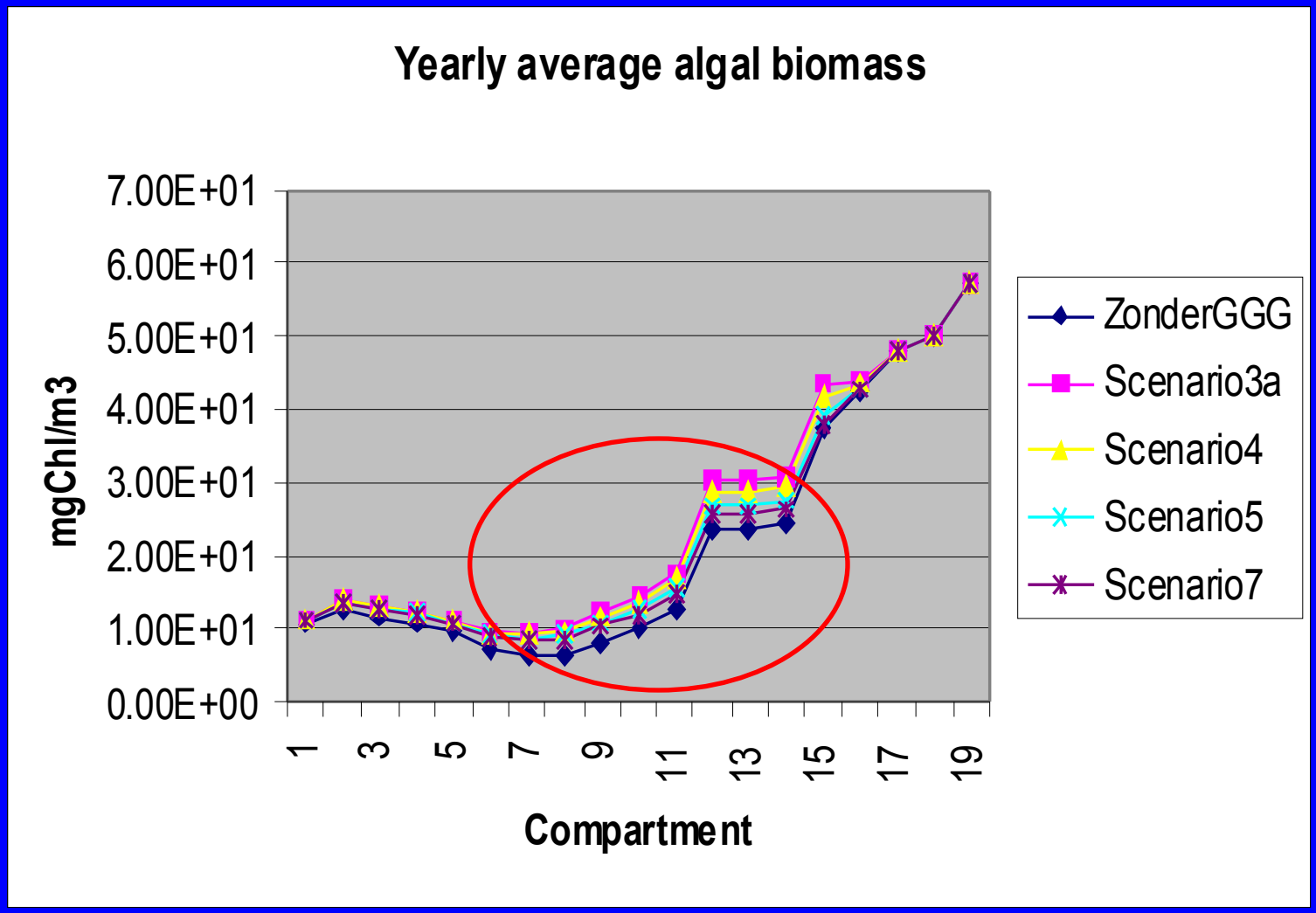
Benthos eating birds – habitat/food

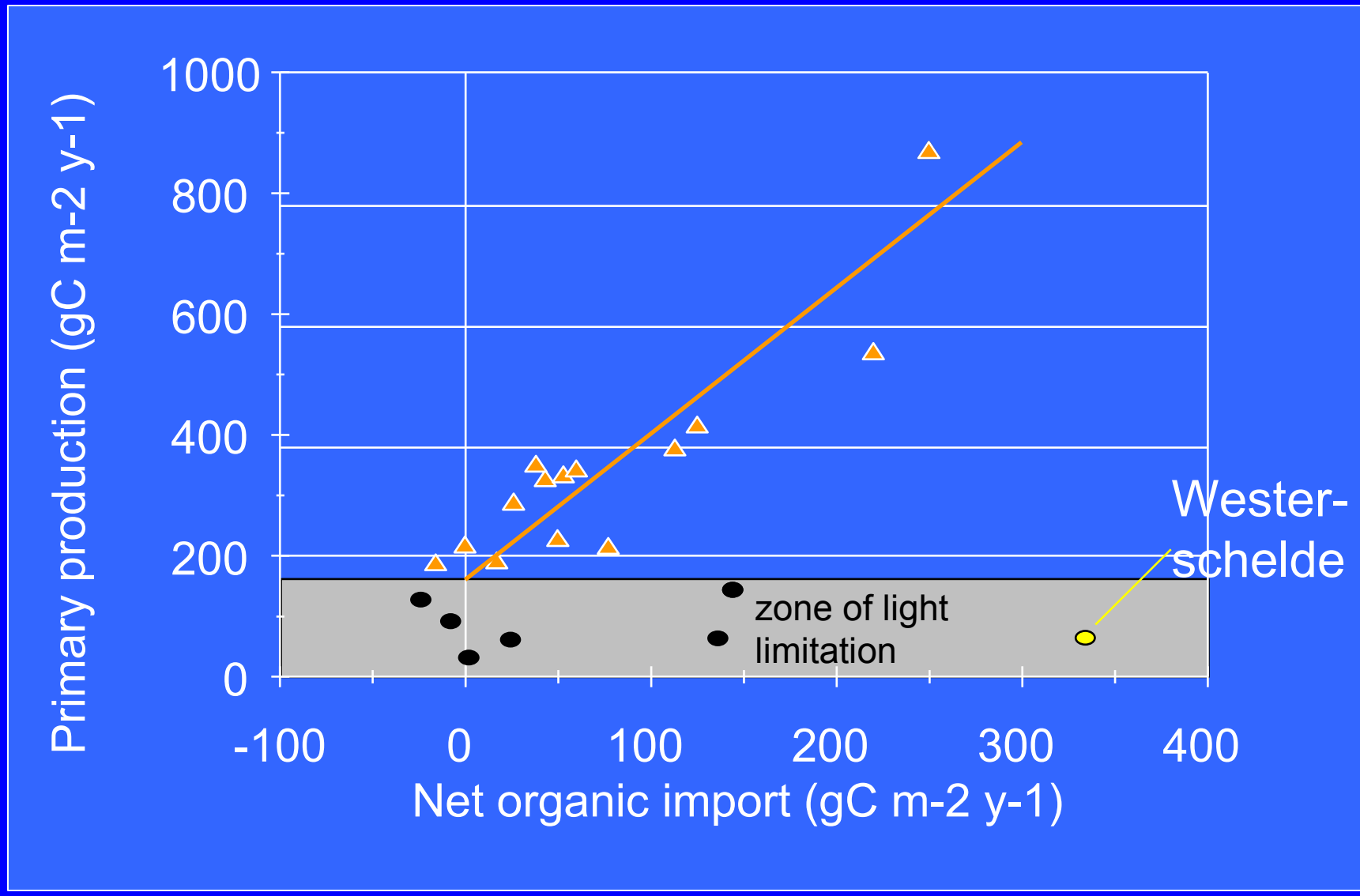


Data Tom Ysebaert

Phytoplankton primary production



Based on the OMES ecosystem model of the Schelde estuary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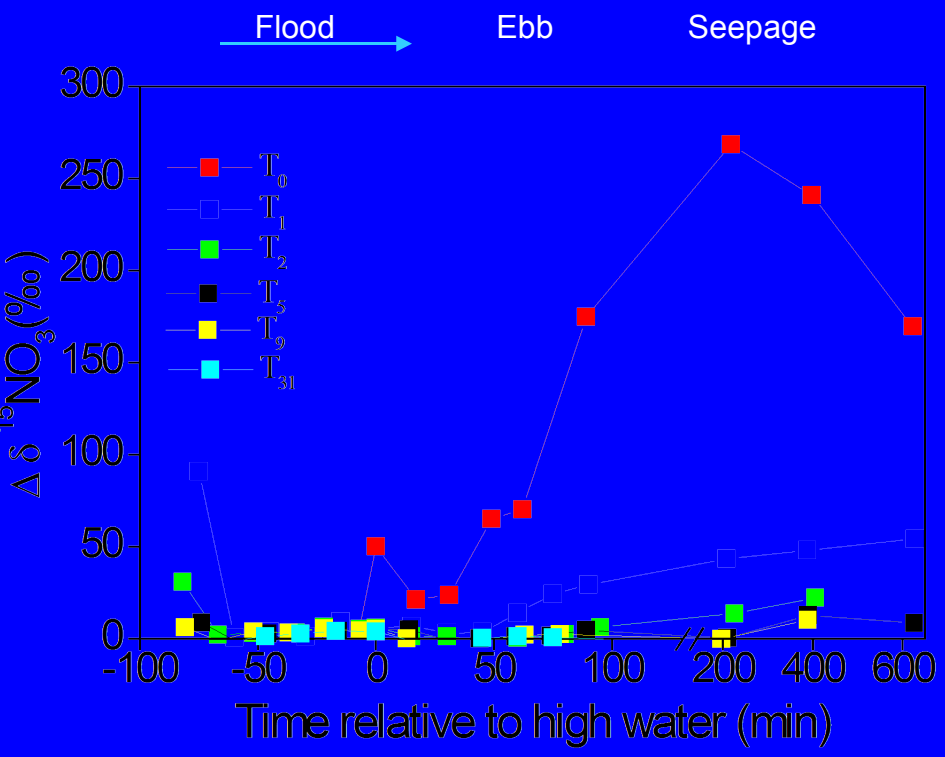
1000
800
600
400
200
0
-100
0
100
200
300
400
Net organic import (gC m-2 y-1)
zone of light limitation
Wester-schelde

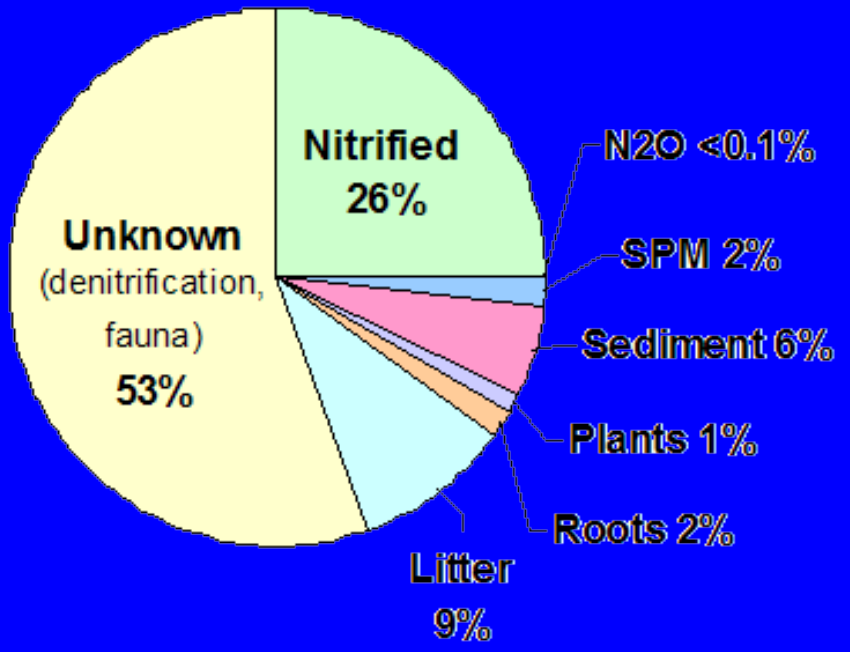
Biogeochemical functioning



Fate of ^{15}N after first tide:

69% exported as $^{15}NH_4^+$

Transformed:



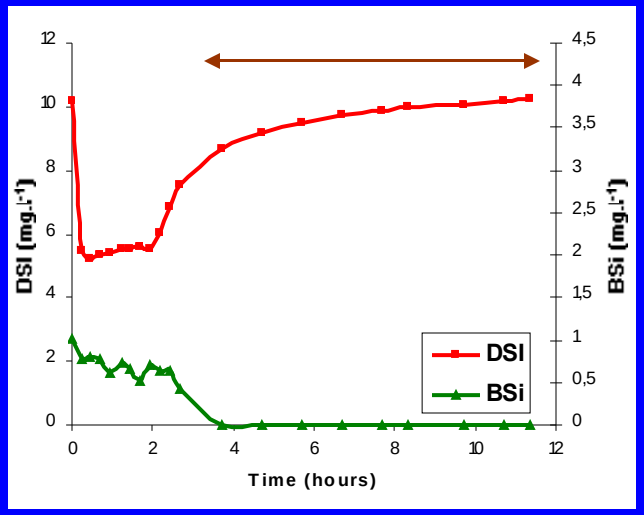
Nitrification rate

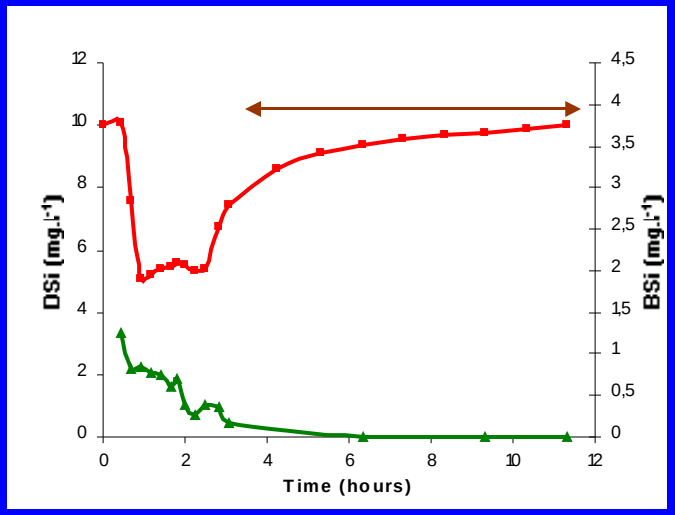
Whole ecosystem 1.49 µM h^{-1}

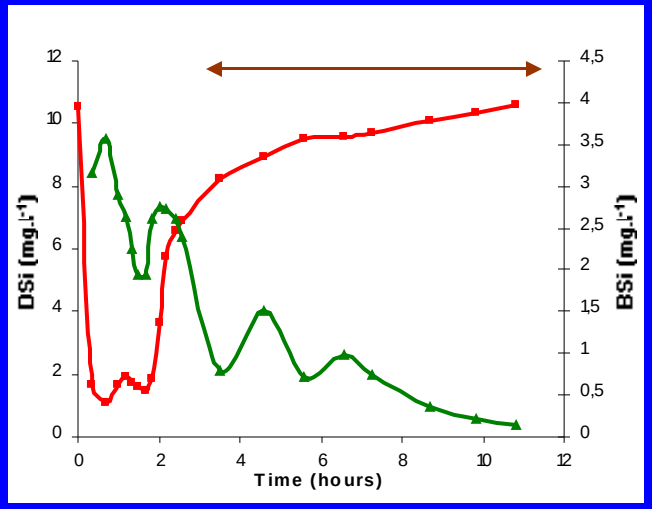
Water phase 0–0.67 µM h^{-1}

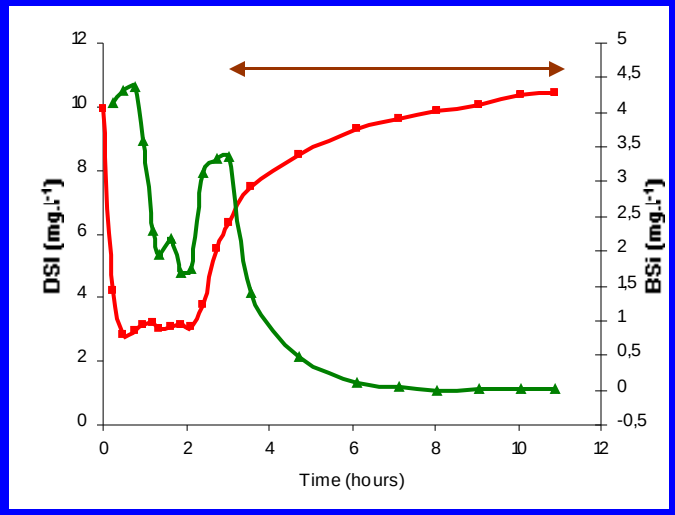
Courtesy by Britta Gribsholt of NIOO-CEMO

Tidal concentration patterns





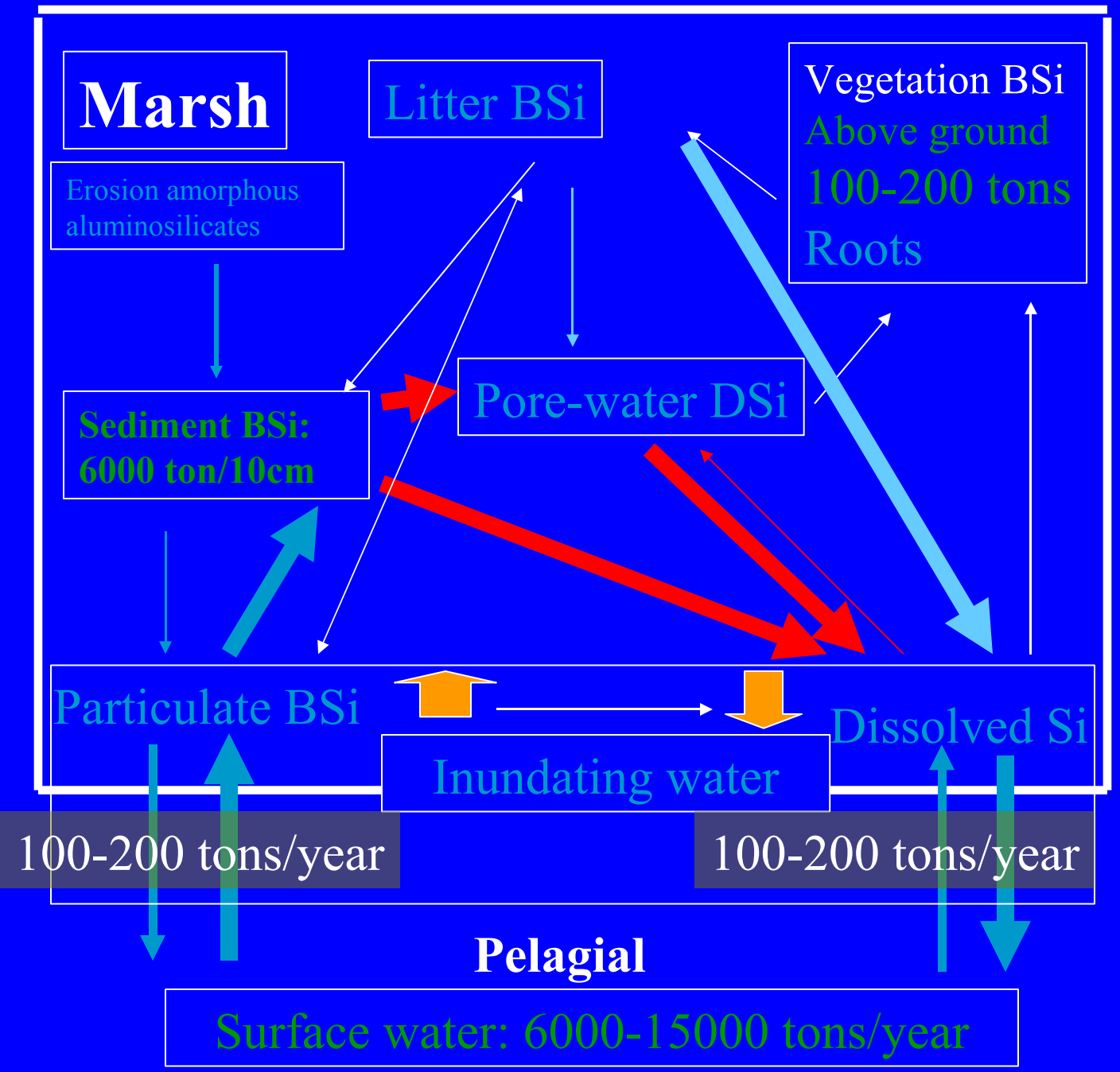




Bulk water

Dripple

Data Eric Struyf



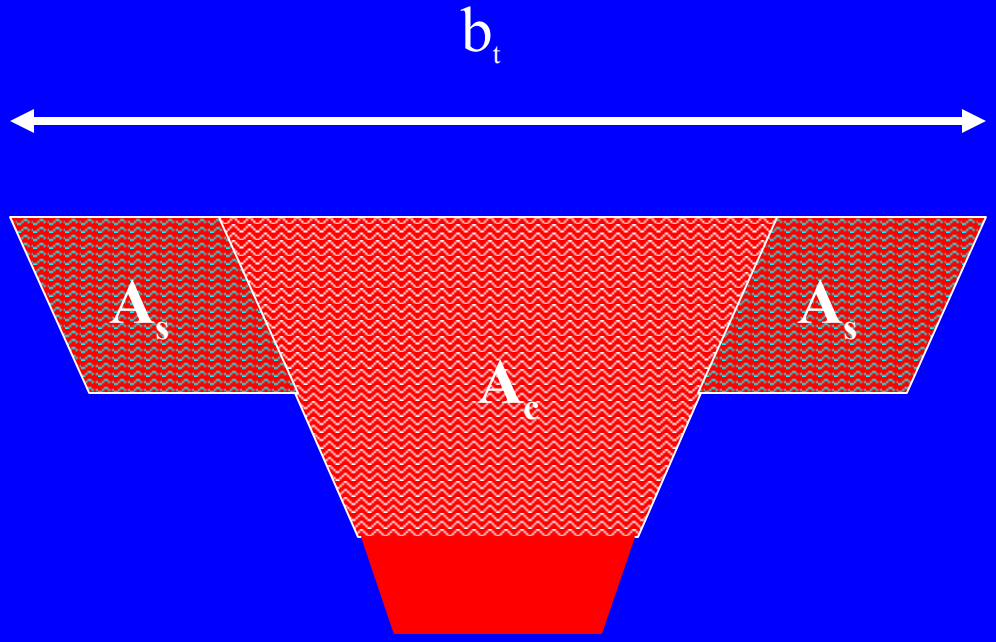
Ongoing work:

- mass-balances
- decomposition
- sediment-water interaction
- pore-water and roots

Data Eric Struyf

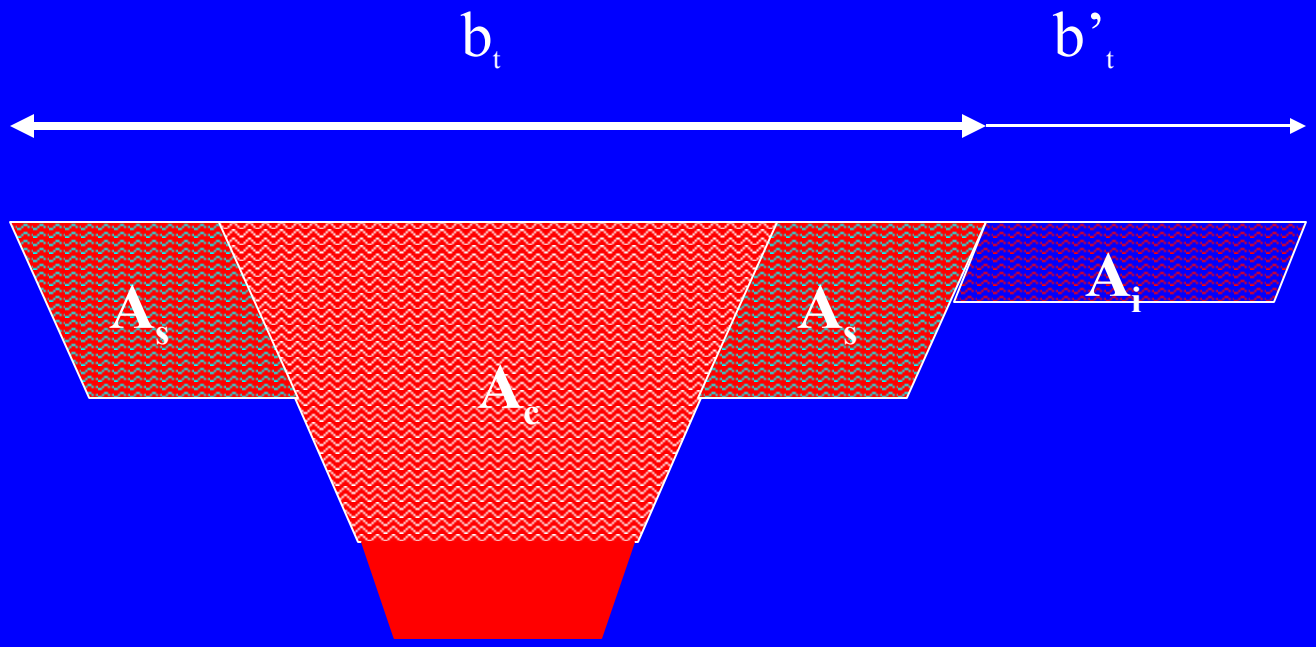
Interaction with geomorphology

Impact of shallow areas (A_s) and deepening



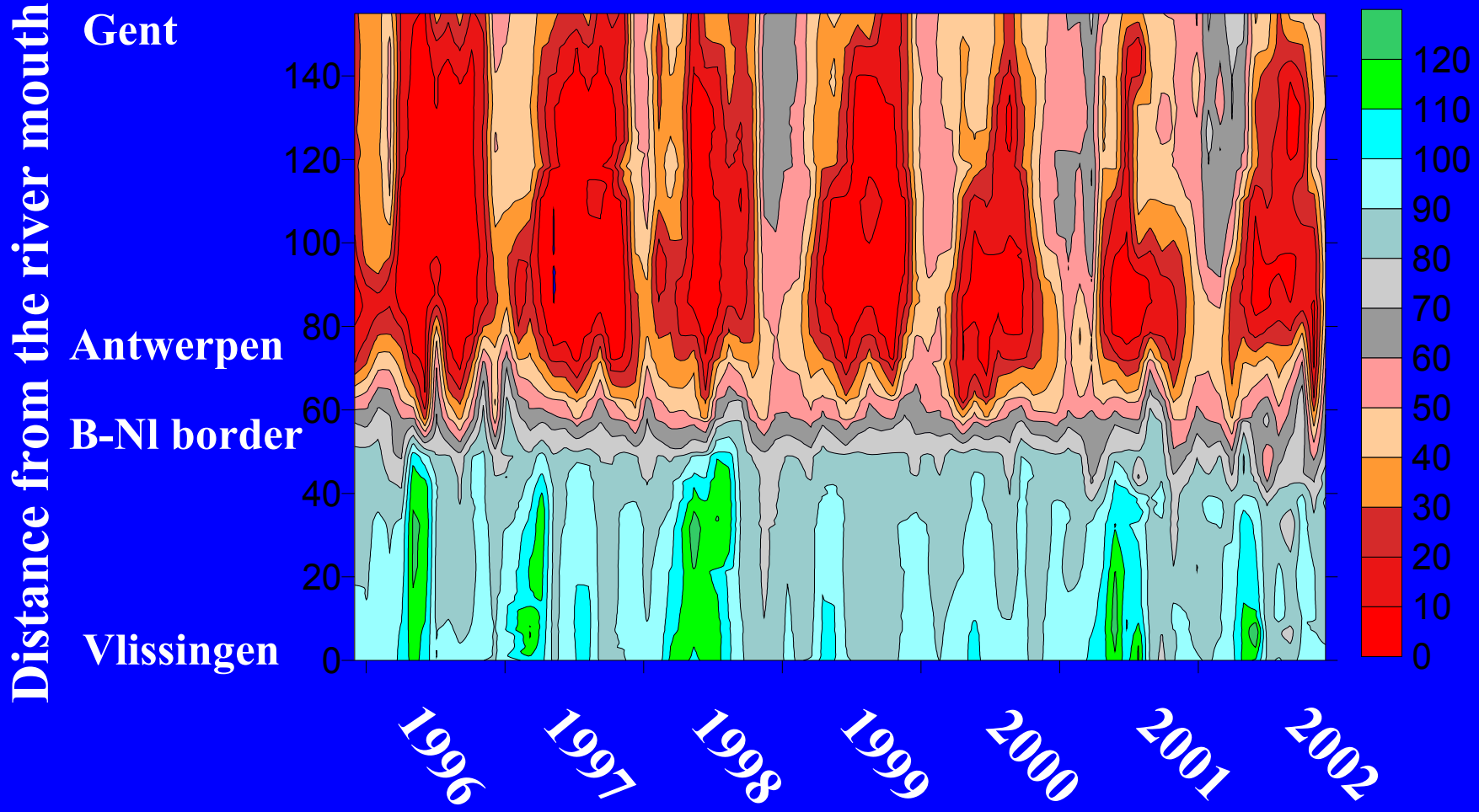
$$c = \sqrt{\frac{g * (A_c + 2A_s)}{b_t}}$$

Adding intertidal areas



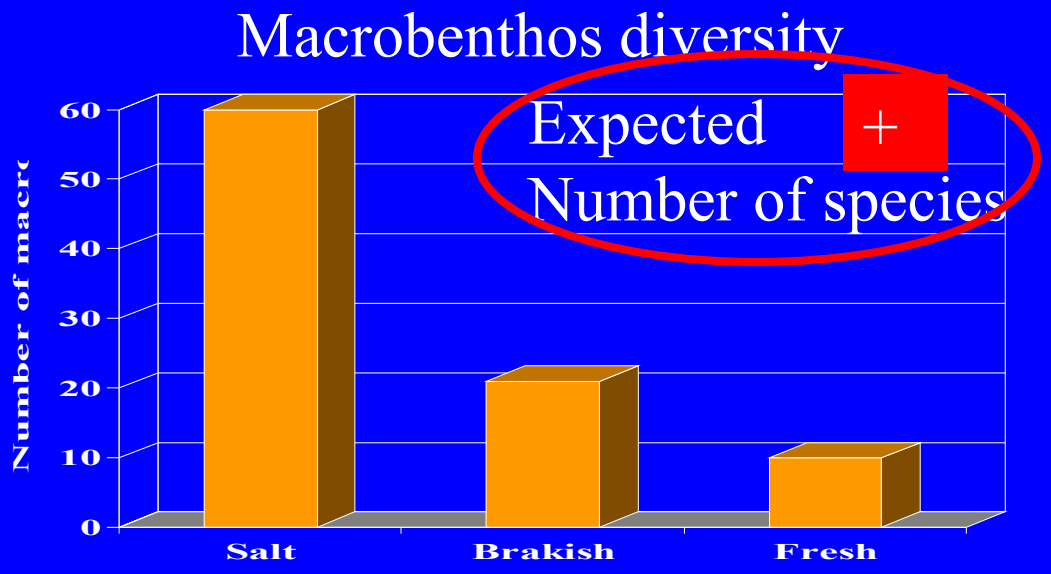
$$c = \sqrt{\frac{g*(A_c + 2A_s + A_i)}{(b_t + b'_t)}}$$

Oxygen saturation (%)



ECOSYSTEM MANAGEMENT RESEARCH GROUP

Biodiversity: strong decline



Impoverished communities of macrobenthos, fish, …

Water Quality
Paradox of the Schelde

	1974	1985
	(Billen et. al., 1985)	(Soetaert & Herman, 1995)
N import in estuary (tons)	**52.000**	**66.000**
N discharge into North Sea (tons)	**27.000**	**51.000**

Improving waterquality leads to increasing N discharge into the North Sea due to less denitrification in the more oxic water!