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University of Antwerp

Ecosystem services of estuarine and coastal areas: the basis for restoration and an integrated approach?

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University of Antwerp – Department of Biology
Ecosystem Management Research Group (ECOBE)

Date (optional)

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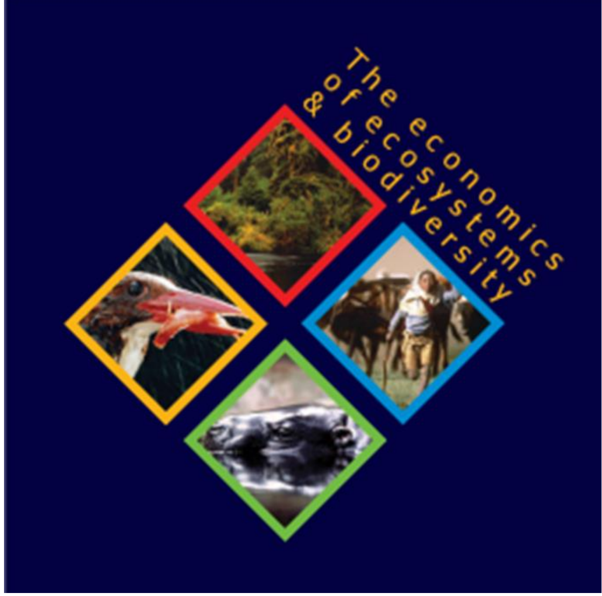
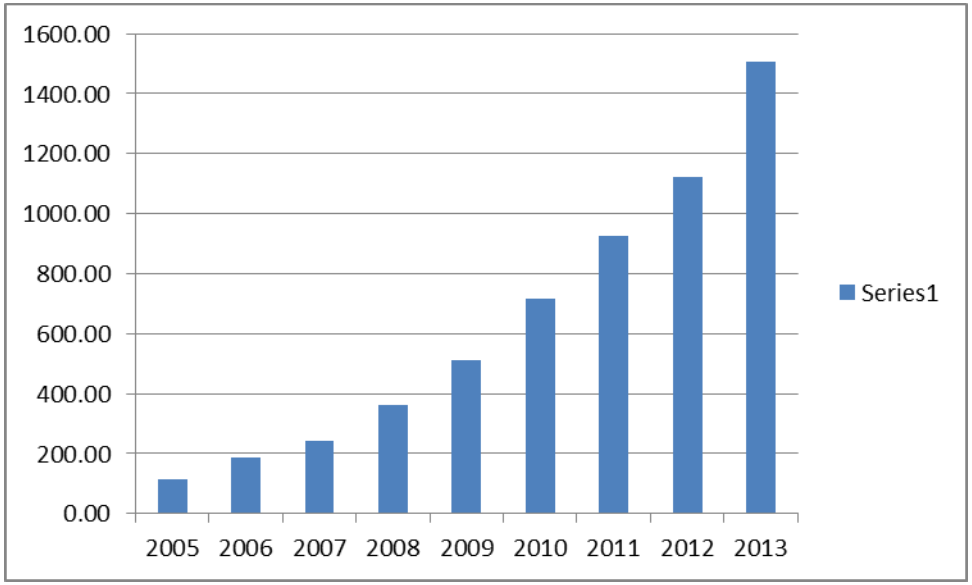
What are ecosystem services?



"***The direct and indirect contributions of ecosystems to human well being***" (TEEB, 2010)

PART 1: Intro

The concept of ecosystem services received increasing attention the last 20 years and is becoming a “buzz word”.



Number of publications dealing with “ecosystem services” in web of science between 2005 and 2013

➔ **Why did this simple concept receives so much attention?**

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Why are ecosystem services important?

1. It is a unifying concept which makes it possible to
   1. Make clear to a broader public what are the benefits we get from ecosystems
   2. Make a link between ecology and economy as ES can be valued in economic terms

Why are ecosystem services important?

1. It is a unifying concept which makes it possible to
   1. Make clear to a broader public what the benefits are we get from ecosystems
   2. Make a link between ecology and economy as ES can be valued in economic terms
2. It is being taken up by several major international organisations
   1. EU, WB, UN,….

What are the ES from estuaries?

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Ecosystems and biodiversity

Structures and processes

Functions

Human well being

Benefits

(Economic) Value

Animal food

Channels

Morphology

Salt marshes

Ecosystems and biodiversity

Structures and processes

Functions

Morphology

Salt marshes

Agricultural land

Animal food

Human well being

Benefits

(Economic) Value

Ecosystems and biodiversity

Structures and processes

Functions

Raw materials: Platform for building

Human well being

Benefits

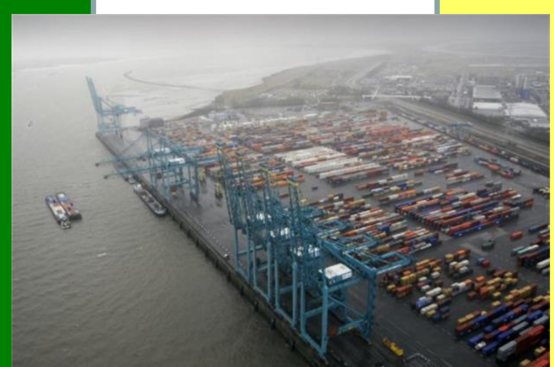
(Economic) Value

Morphology

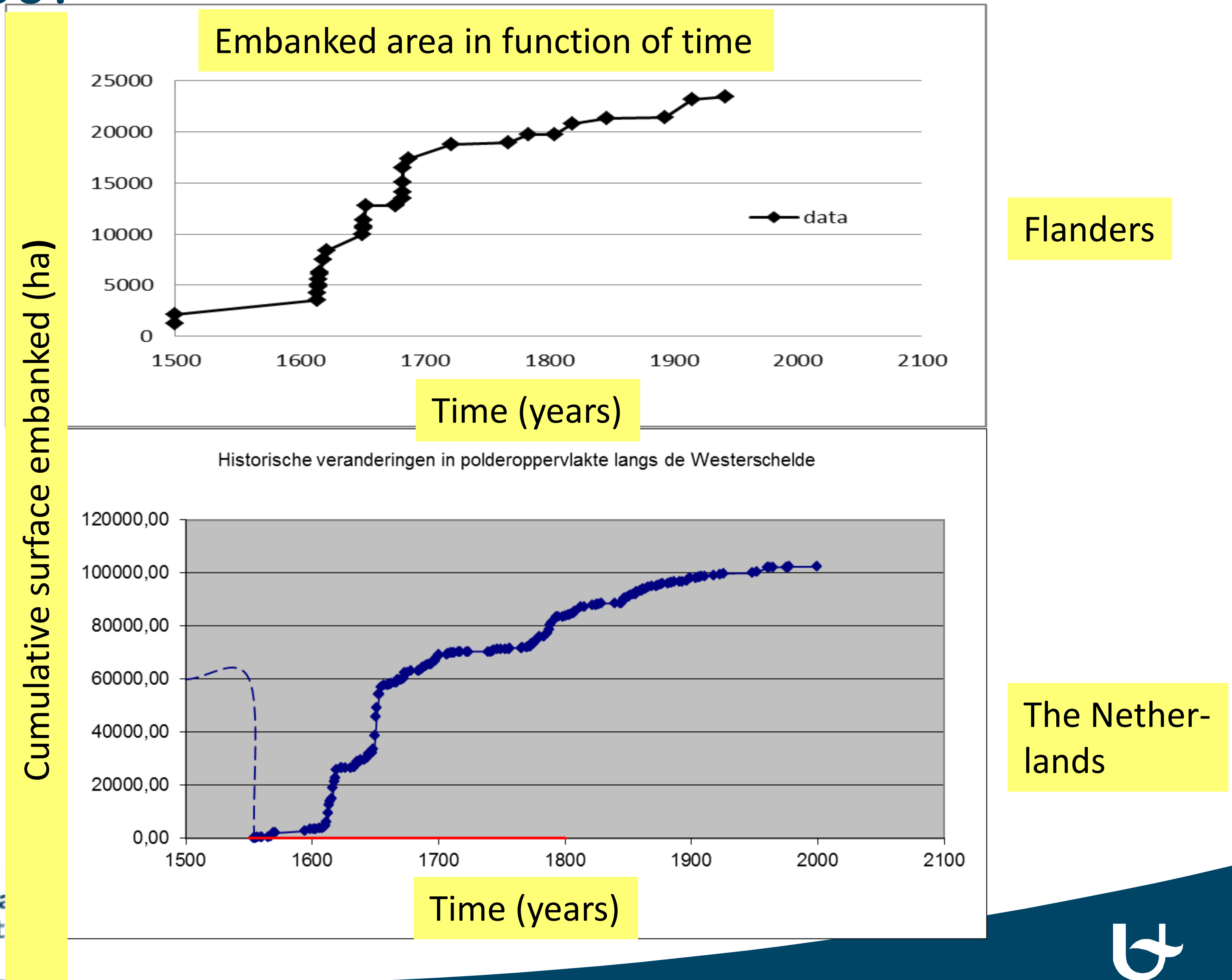
Salt marshes

Tidal Flats

Industrial/harbor area



Embanked area of Schelde estuary: 150.000 ha since 1500!



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Ecosystems and biodiversity

Human well being

Structures and processes

Functions

Water for navigation

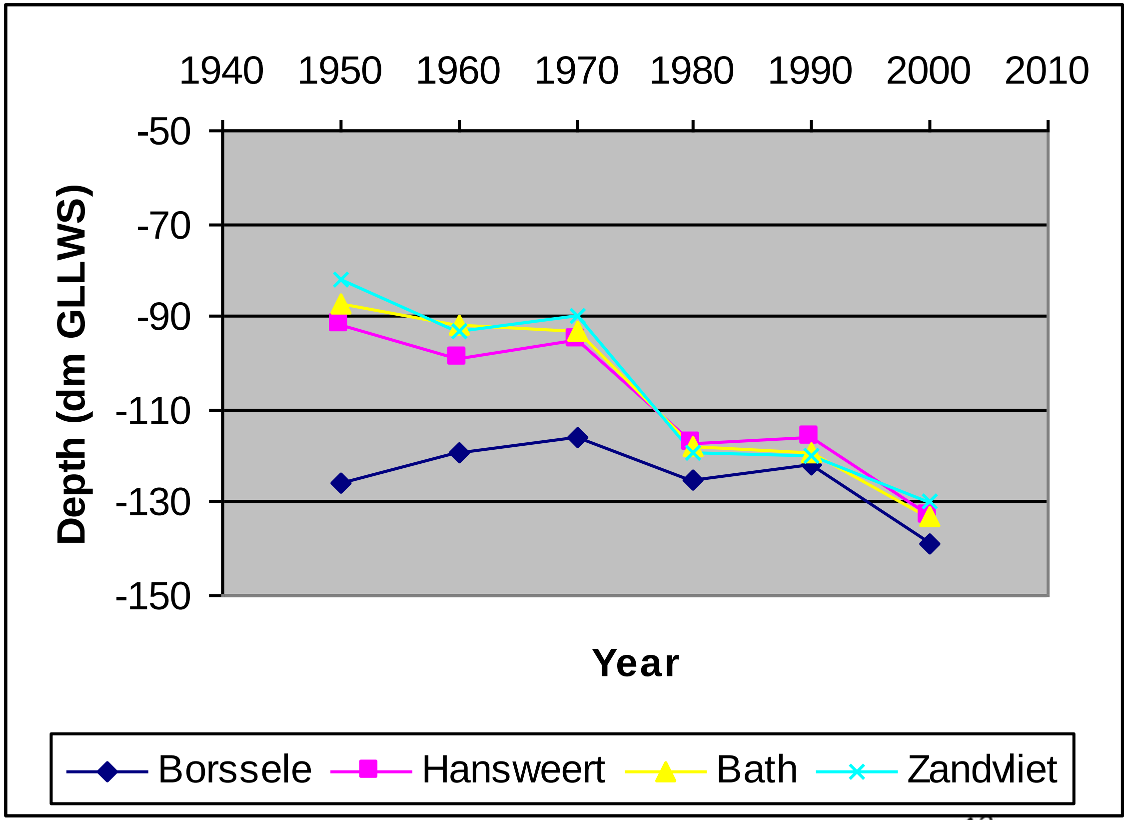
Benefits

(Economic) Value

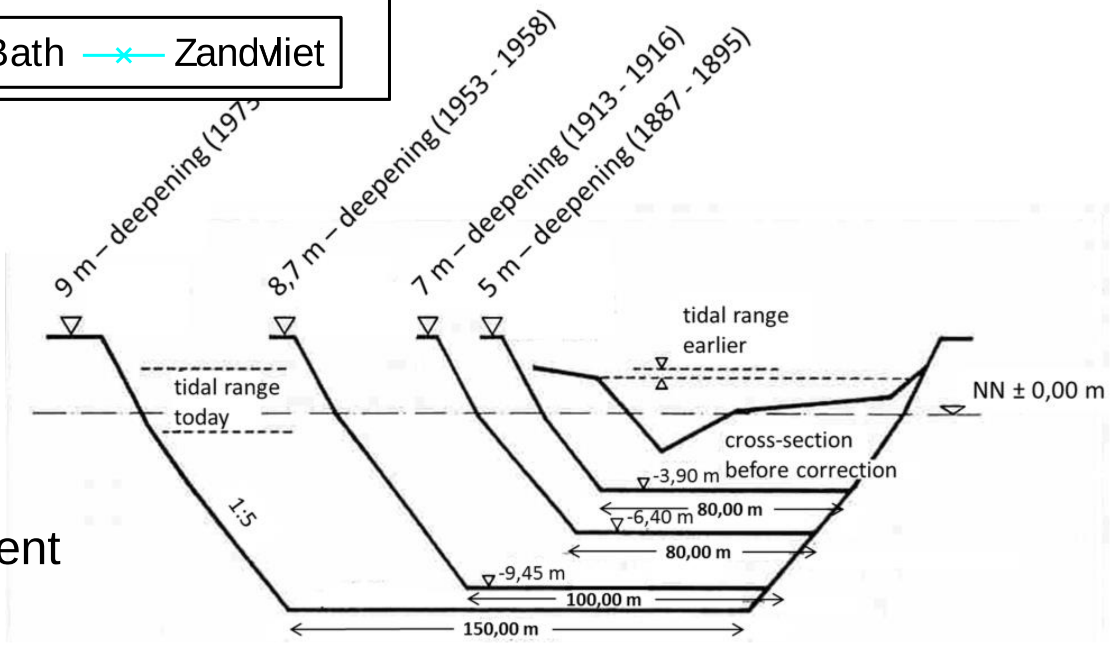
Channels

Morphology

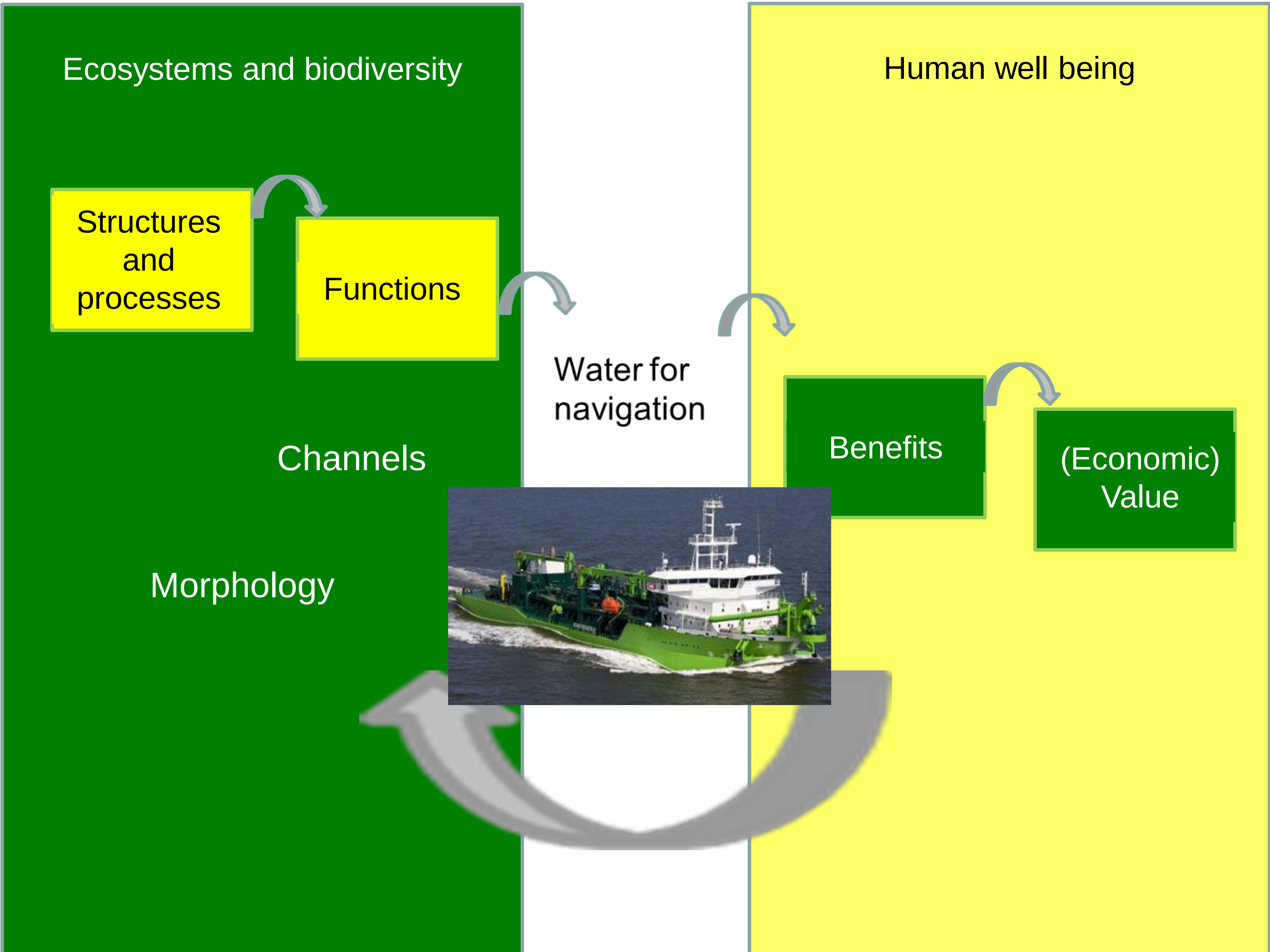

CHINA SHIPPING LINE

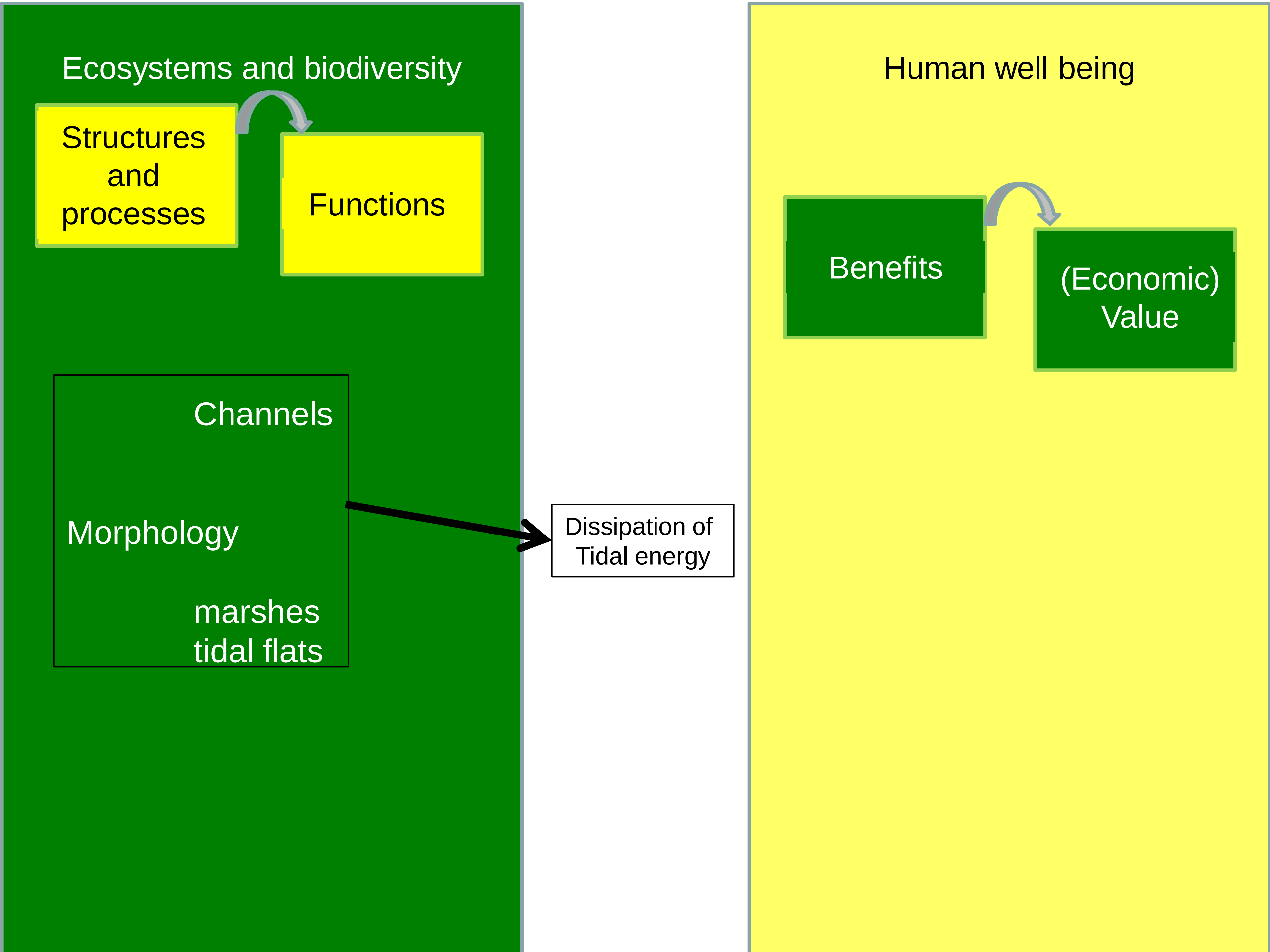


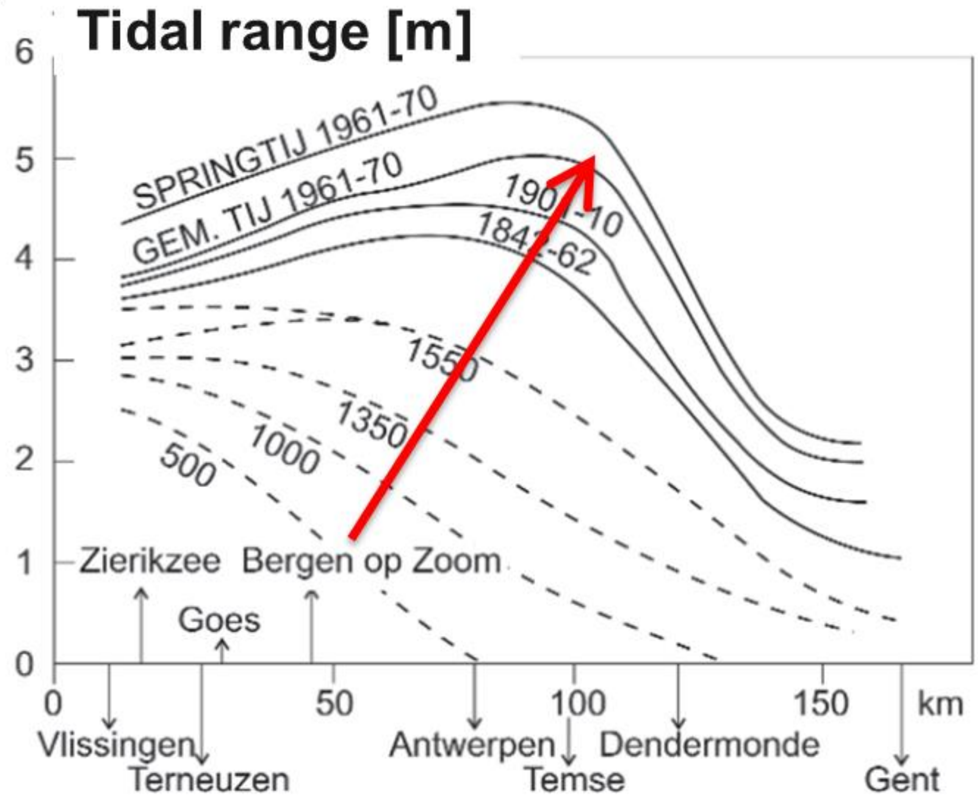
Deepening:
Schelde estuary
1950 – recent times



Deepening:
Section Lower Weser 1880 – recent times


Ecosystems and biodiversity
Human well being
Structures and processes
Functions
Water for navigation
Benefits
(Economic) Value
Channels
Morphology

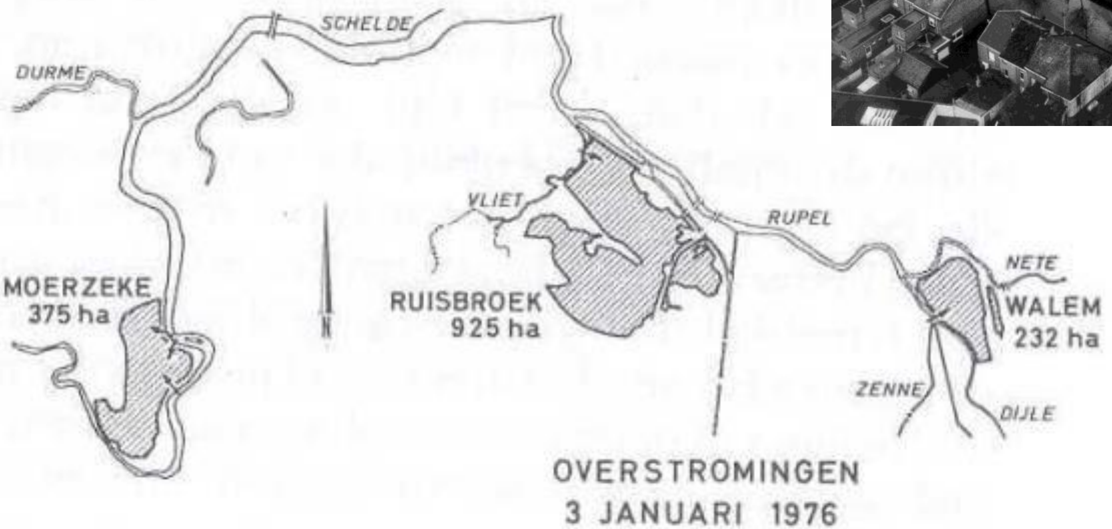

Ecosystems and biodiversity
Structures and processes
Functions
Channels
Morphology
marshes
tidal flats
Dissipation of Tidal energy
Human well being
Benefits
(Economic) Value



Source: Coen (2008)

Sealevel rise in combination with morphological changes in the estuary resulted in an amplification of the tides!

Ruisbroek 1977

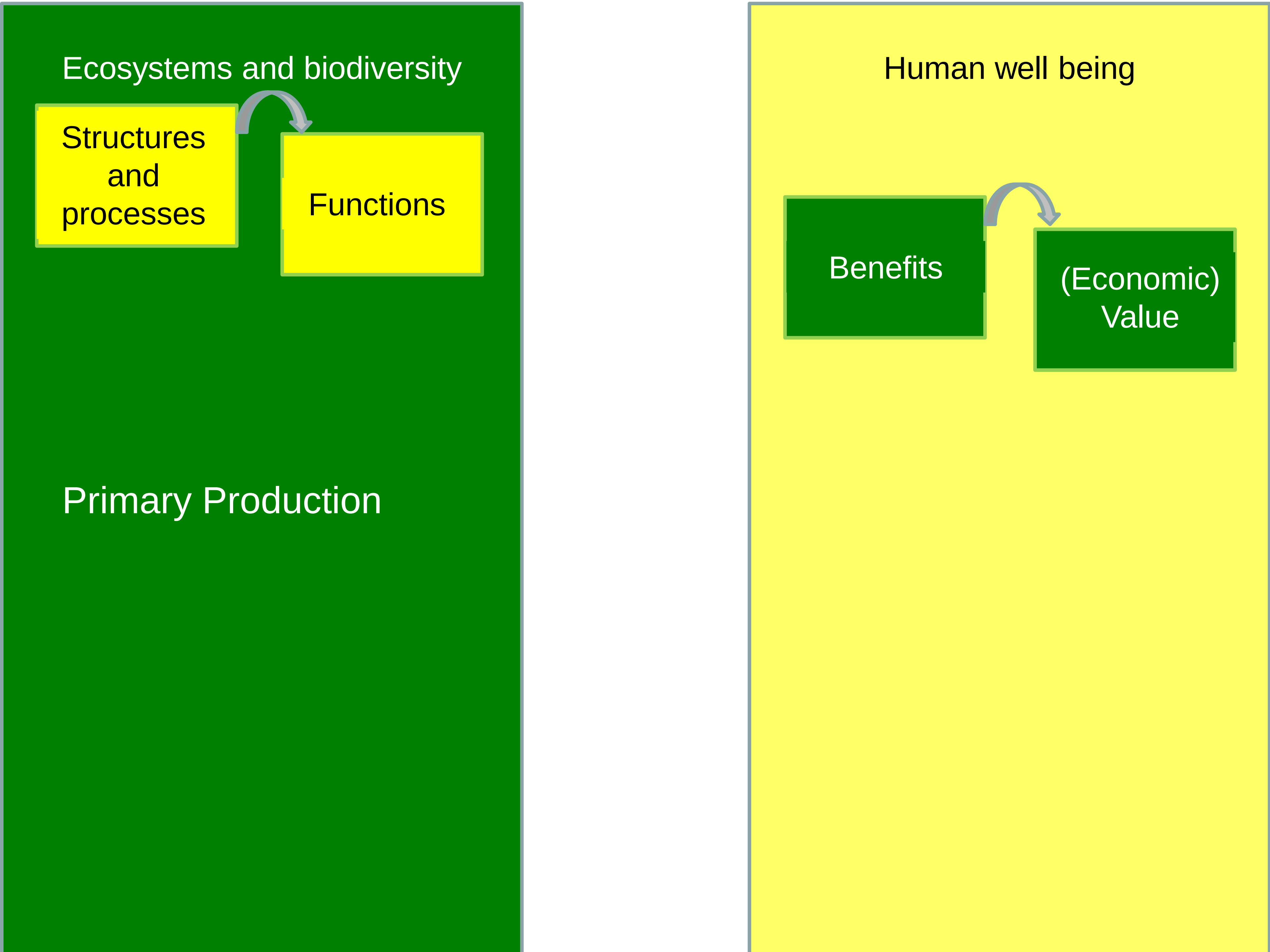


Key Message

Habitat loss has a significant impact on the tidal propagation

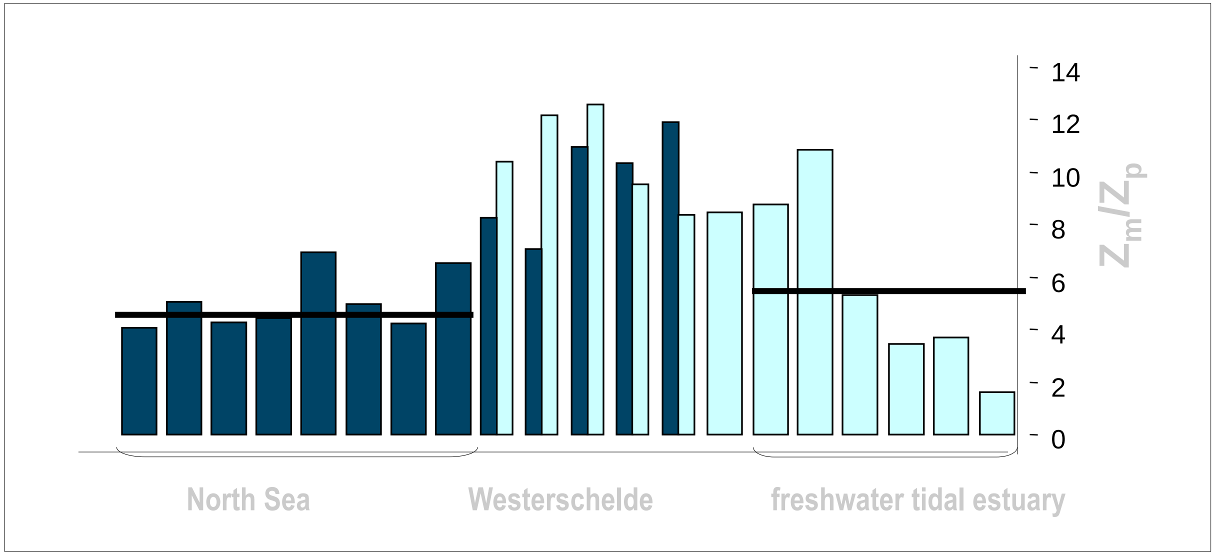
- Intertidal and subtidal areas are crucial habitats causing friction
- channel depth, relative surface intertidal area, covergence length scale, bed roughness

Changes in the tidal characteristics are the driving force behind estuarine development

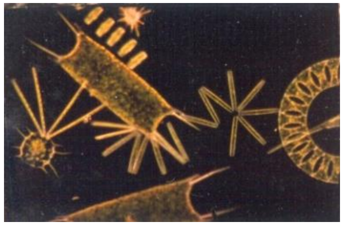

Ecosystems and biodiversity
Structures and processes
Functions
Primary Production
Human well being
Benefits
(Economic) Value

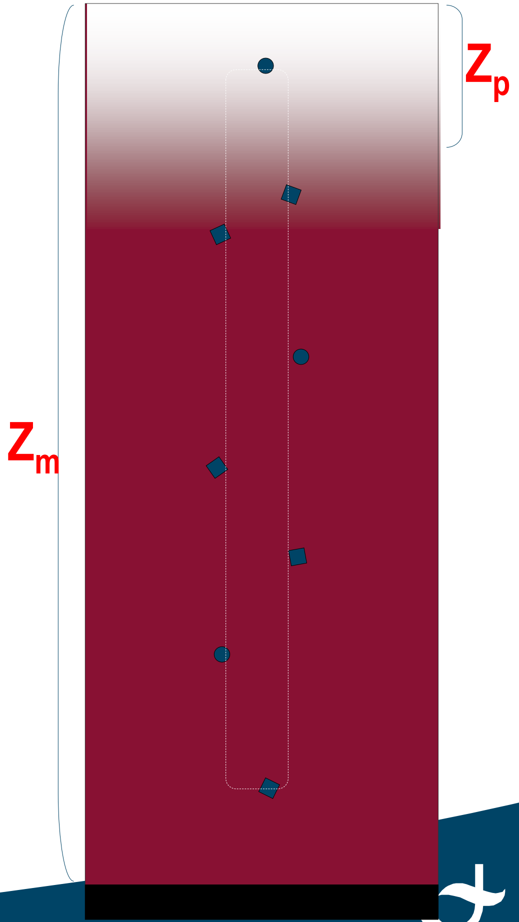
Primary production

North Sea	Schelde estuary	
	Westerschelde	freshwater tidal estuary
(Reid *et al*. 1990)	(Soetaert *et al*. 1994)	(this study)
200 g C m^{-2} $year^{-1}$	41 g C m^{-2} $year^{-1}$	260 g C m^{-2} $year^{-1}$



Kromkamp & Peene (1995) *Mar. Ecol. Progr. Ser.* 121: 249-259 and this study





PRIMARY PRODUCTION DEPENDS ON MORPHOLOGY

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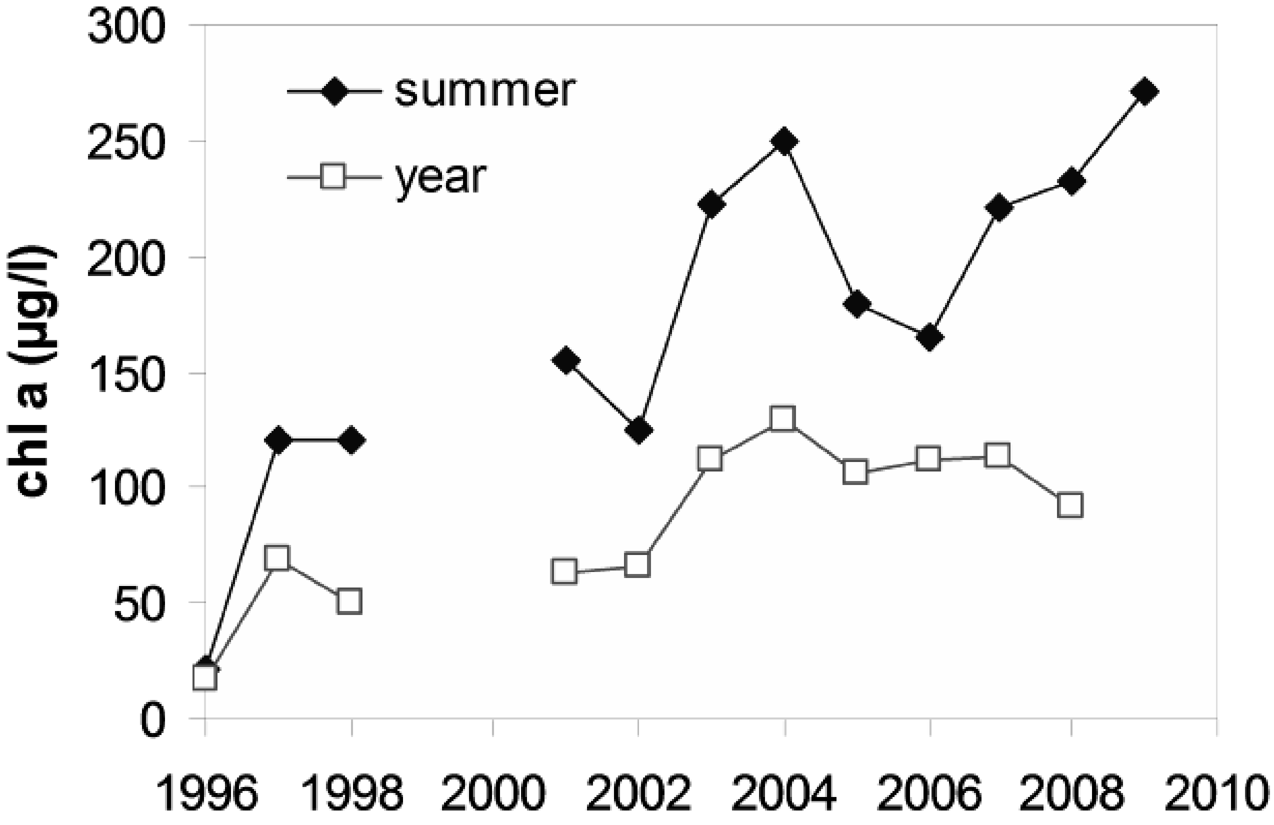
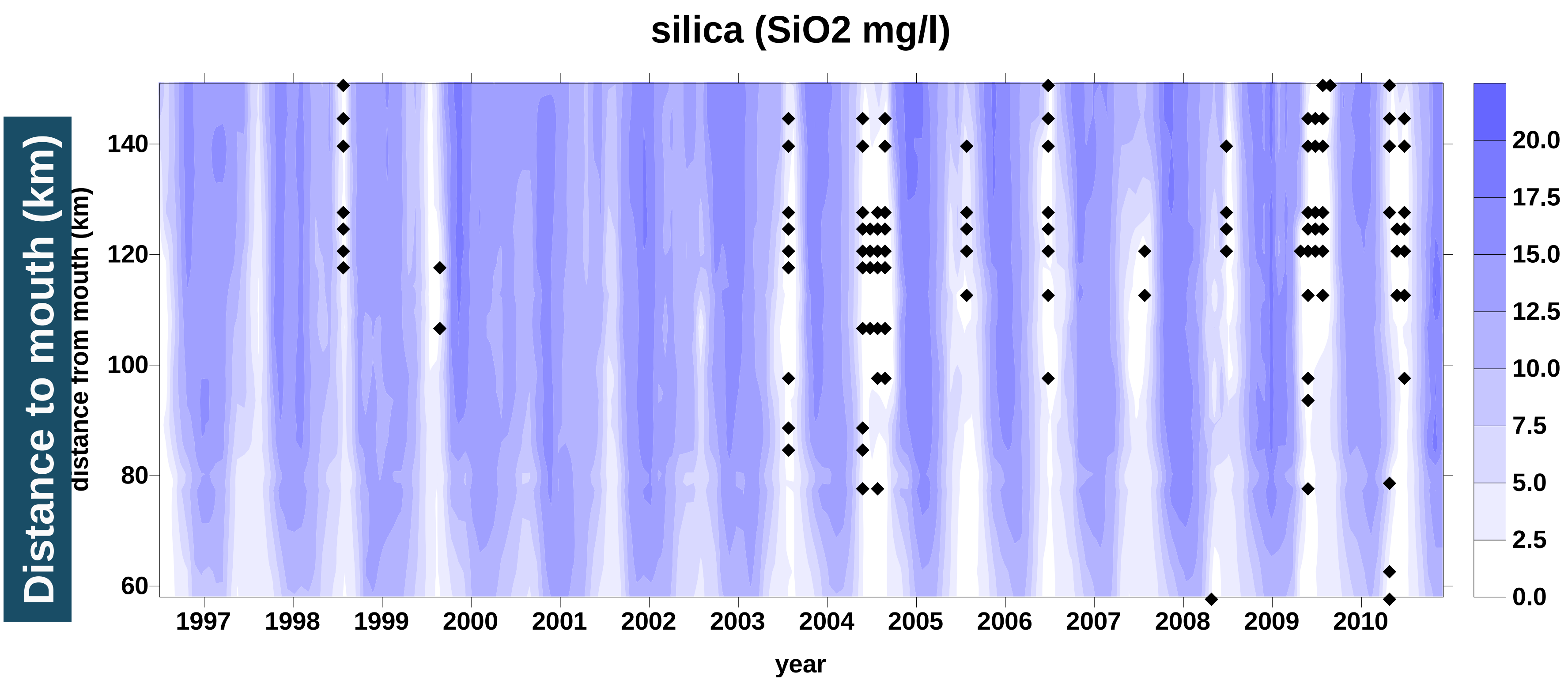
Primary Production in Zeeschelde



Primary production also depends on water quality

NEW PROBLEMS?



FREQUENT DSI DEPLETION

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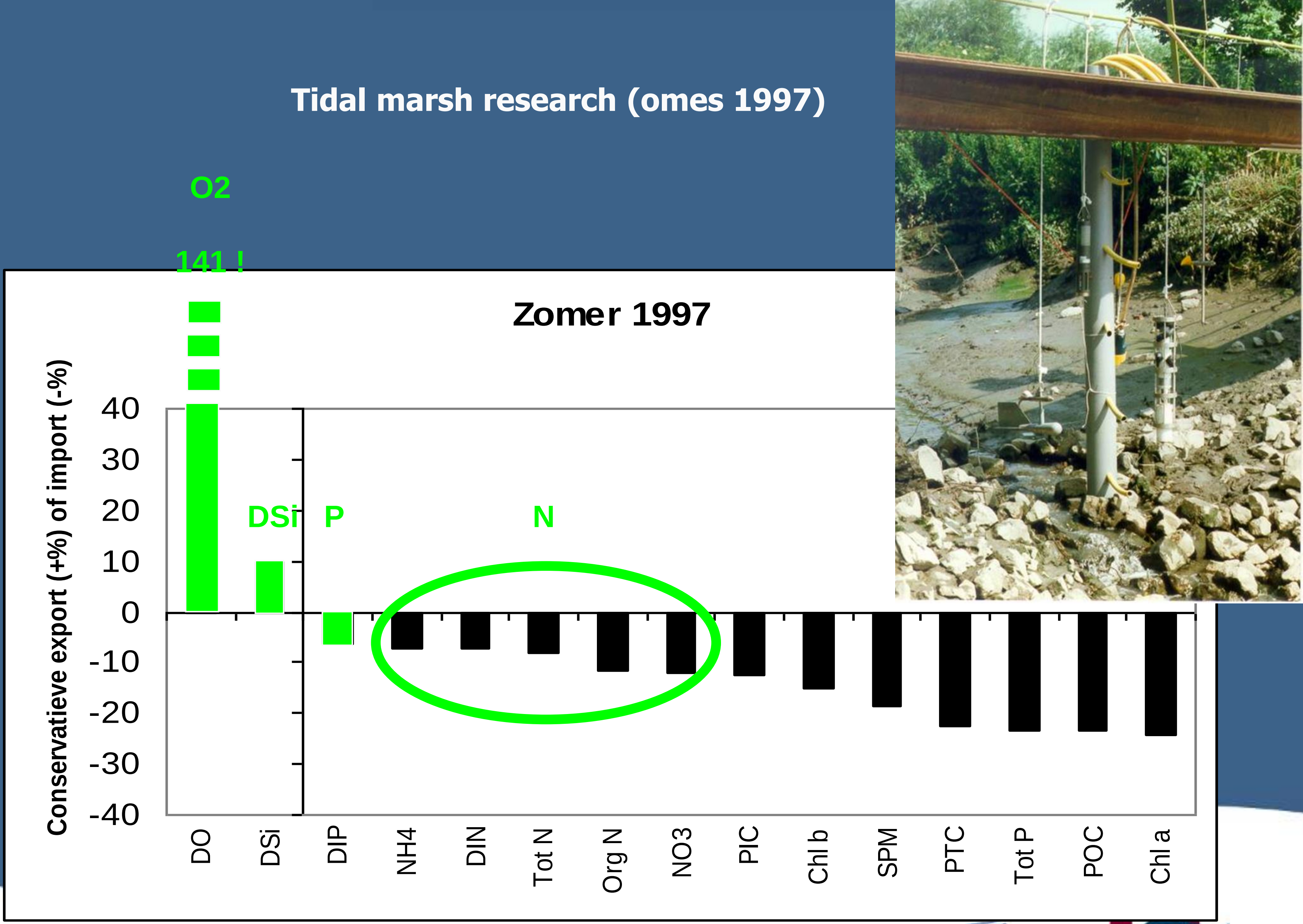
Tidal marsh research (omes 1997)



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et al., 2008

Key Message

- Primary production as a crucial ecological process is dependent on:
  - Morphology and changes lead to less favourable Zm/Zp ratio, decreasing PM
  - Correct stoichiometry of nutrients and if unbalanced this causes major problems. Also habitat availability if crucial

Ecosystems and biodiversity

Structures and processes

Functions

Morphology

Water for navigation

Human well being

Benefits

(Economic) Value

Ecosystems and biodiversity

Structures and processes → Functions

Morphology

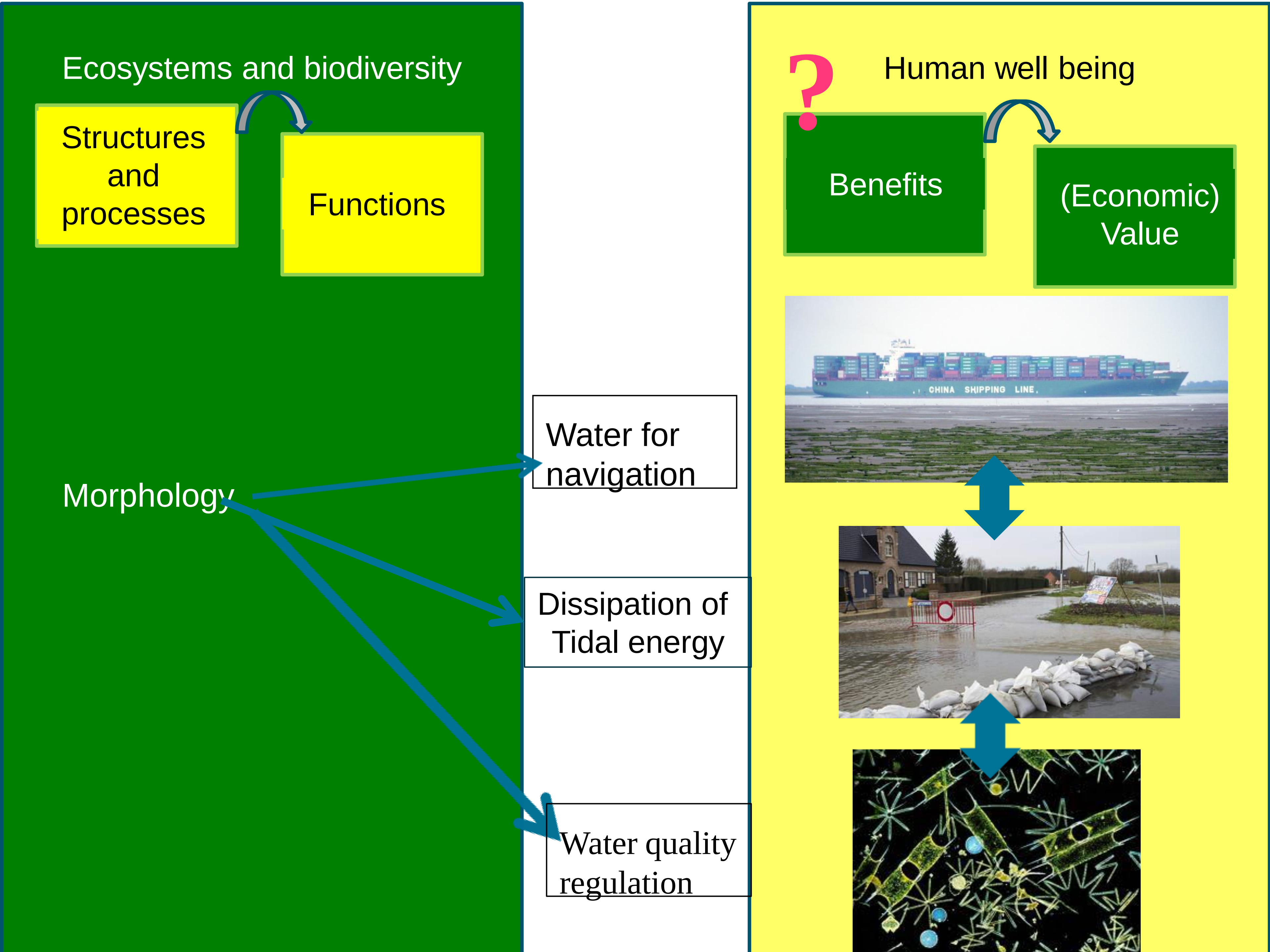
→ Water for navigation

→ Dissipation of Tidal energy

Human well being

?

Benefits → (Economic) Value


Ecosystems and biodiversity
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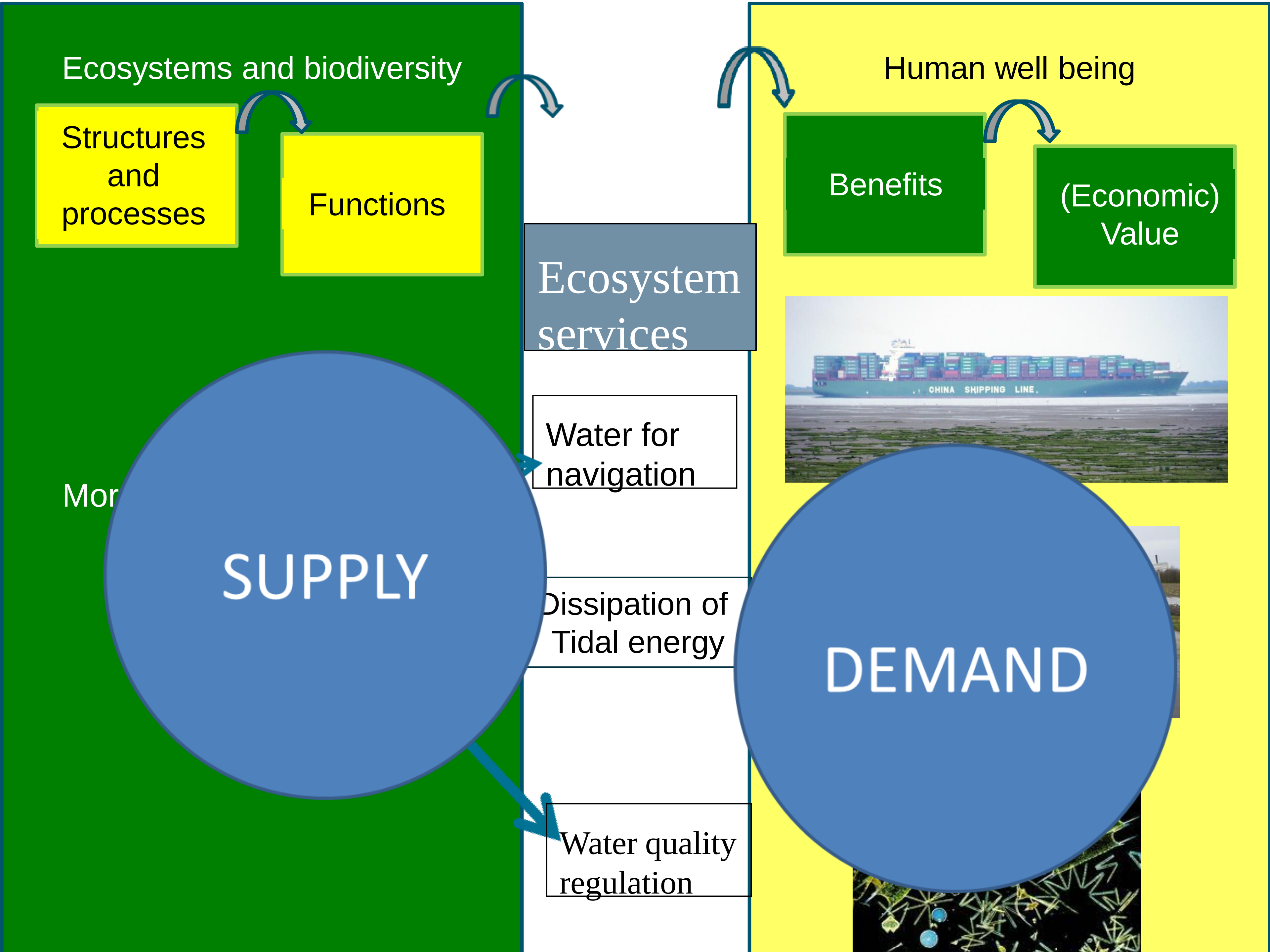
CHINA SHIPPING LINE
Morphology
Water for navigation
Dissipation of Tidal energy
Water quality regulation


Ecosystems and biodiversity
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(Economic) Value
Water for navigation
CHINA SHIPPING LINE
SUPPLY
Dissipation of Tidal energy
Water quality regulation
DEMAND

An integrated strategy

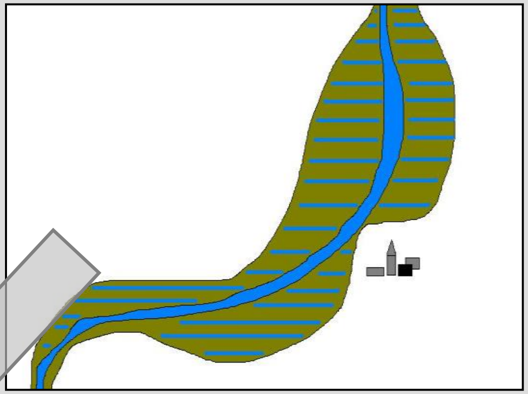
- Requires:
  - Understanding the demand of ecosystem services
  - Quantification of ES == supply of ES

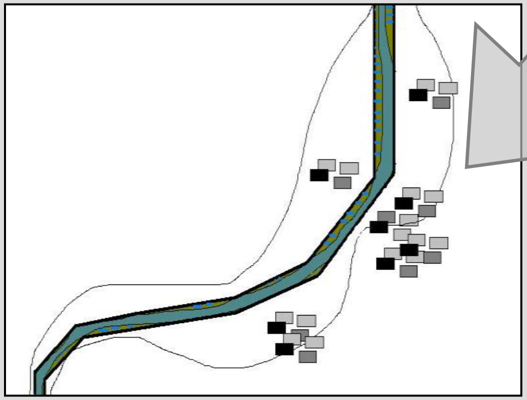
➔ determine conservation objectives!

- What biodiversity we need to have (structural approach)?
- Which and how much services the ecosystem must deliver (functional approach)?

Schelde: disturbed estuary

Driving forces:
- Dredging & embankments
- Pollution
- Climate change





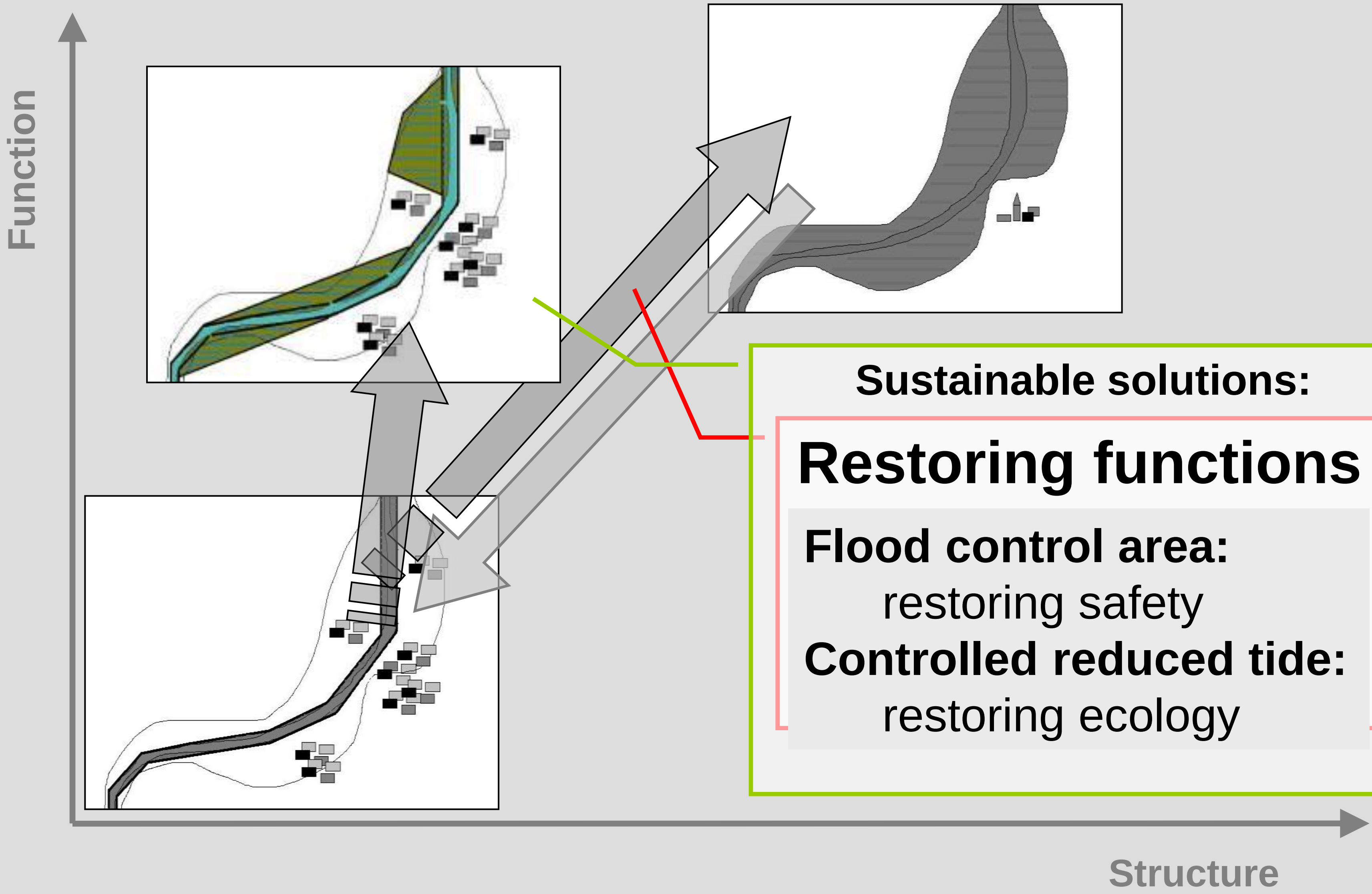
Function

loss of
ecosystem functions

Impact on:
- safety
- economy
- ecology

Structure

Schelde: solutions?



Sustainable solutions:

Restoring functions

Flood control area:
restoring safety

Controlled reduced tide:
restoring ecology

Ecosystem services: Supply

Habitat-ES matrix: ES-supply score per habitat type

Score	Habitat has...in supply of ES
1	no importance
2	very low importance
3	moderate importance
4	Importance
5	Essential importance

	Marsh	Intertidal steep	Intertidal flat	Subtidal shallow	Subtidal moderatiey deep	Subtidal deep
"Biodiversity"	5	3	5	4	3	3
Erosion and sedimentation regulation by water bodies	4	2	5	5	4	4
Erosion and sedimentation regulation by biological mediation	4	2	4	3	1	1
Water quality regulation: reduction of excess loads coming from the catchment	5	2	3	3	2	2
Water quality regulation: transport of pollutants and excess nutrients	2	2	2	3	3	4
Water quantity regulation: drainage of river water	2	2	3	2	2	2
Water quantity regulation: transportation	1	1	1	1	3	5
Water quantity regulation: landscape maintenance	4	2	3	3	2	1
Water quantity regulation: dissipation of tidal and river energy	2	2	3	3	3	1
Climate regulation: Carbon sequestration and burial	4	2	3	3	2	1
Regulation extreme events or disturbance: Wave reduction	3	3	3	2	1	1
Regulation extreme events or disturbance: Water current reduction	3	2	3	3	2	1
Regulation extreme events or disturbance: Flood water storage	4	3	3	2	2	1
Water for industrial use	2	2	1	2	3	3
Water for navigation	1	1	1	1	3	4
Food: Animals	3	2	2	2	2	2
Aesthetic information	4	3	4	3	3	3
Inspiration for culture, art and design	4	3	4	4	4	4
Information for cognitive development	4	4	4	4	4	4
Opportunities for recreation & tourism	3	2	3	3	4	4

An integrated strategy

- Requires:
  - Understanding the demand of ecosystem services
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→ determine conservation objectives!

- What biodiversity we need to have (structural approach)?
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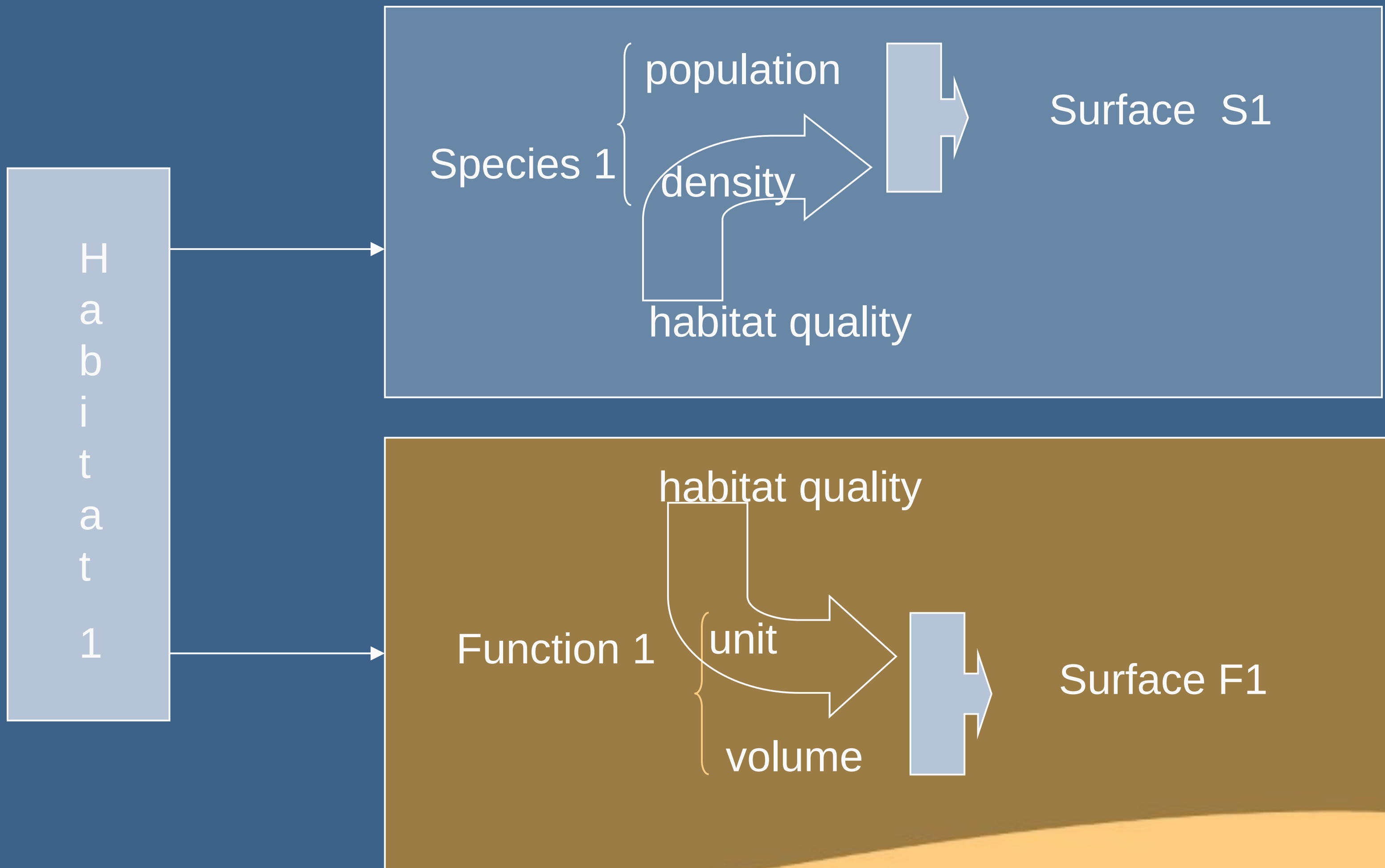
An integrated strategy

- Goals for ecosystem services, THE DEMAND for ES, can be:
  - A volume of water that can be stored on marshes (➔ safety)
  - Amount of primary production needed to sustain the nursery function
  - Retention of nutrients
  - Buffering tidal energy

An integrated strategy

- Understanding and quantification of ES
- Formulation of objectives
- **The calculation of habitats surface needed**
  - **Safety**
  - **Tidal dissipation**
  - **Nutrient removal**
  - **Si delivery to sustain primary production**
  - **Populations of several target species**
- Measures to maintain or restore habitats

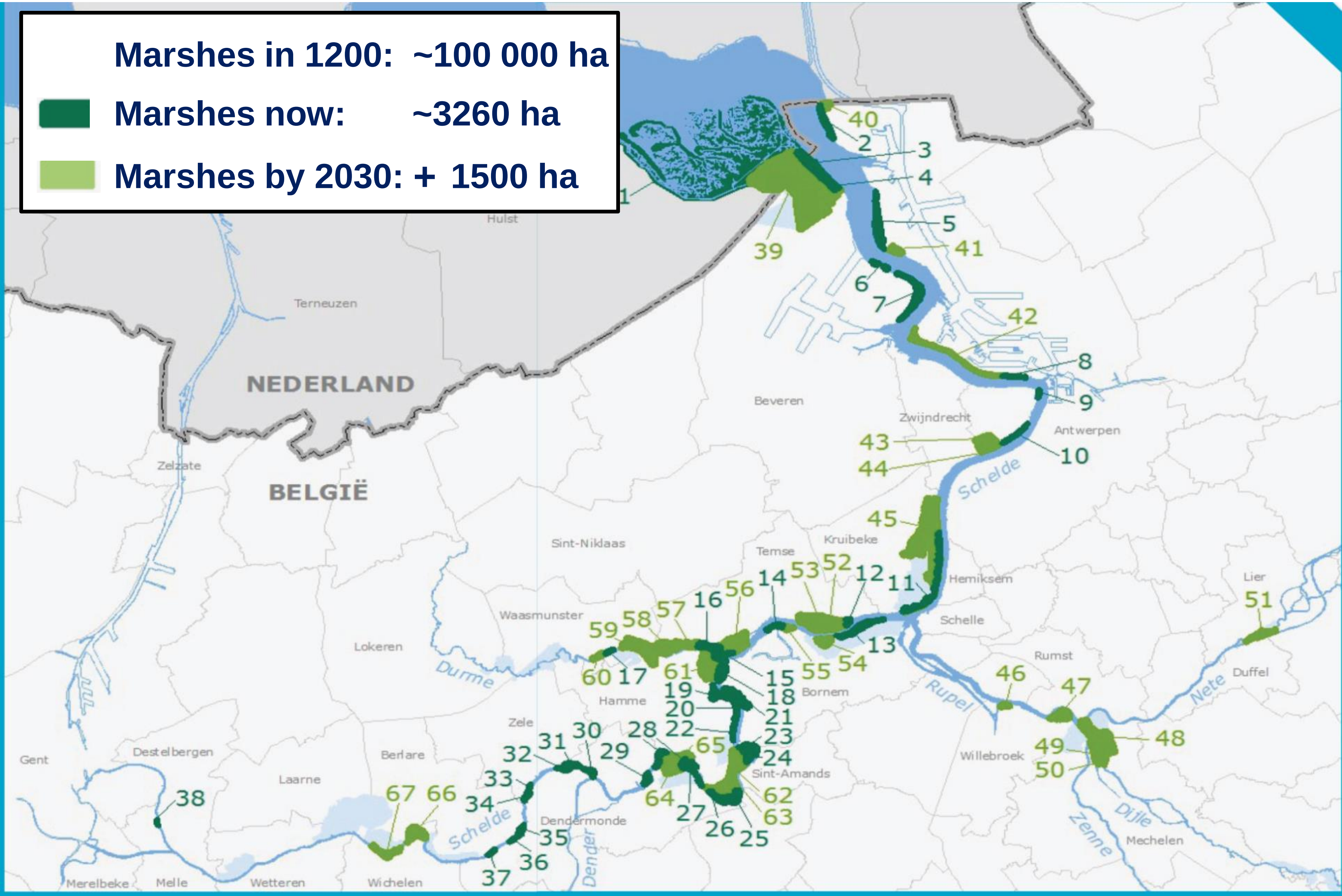
Conservation Objectives (CO)



Final CO: → Max (surface S1,..Sn; F1,…,Fm)

→ Habitat quality

Intertidal marsh creation to solve estuarine problems

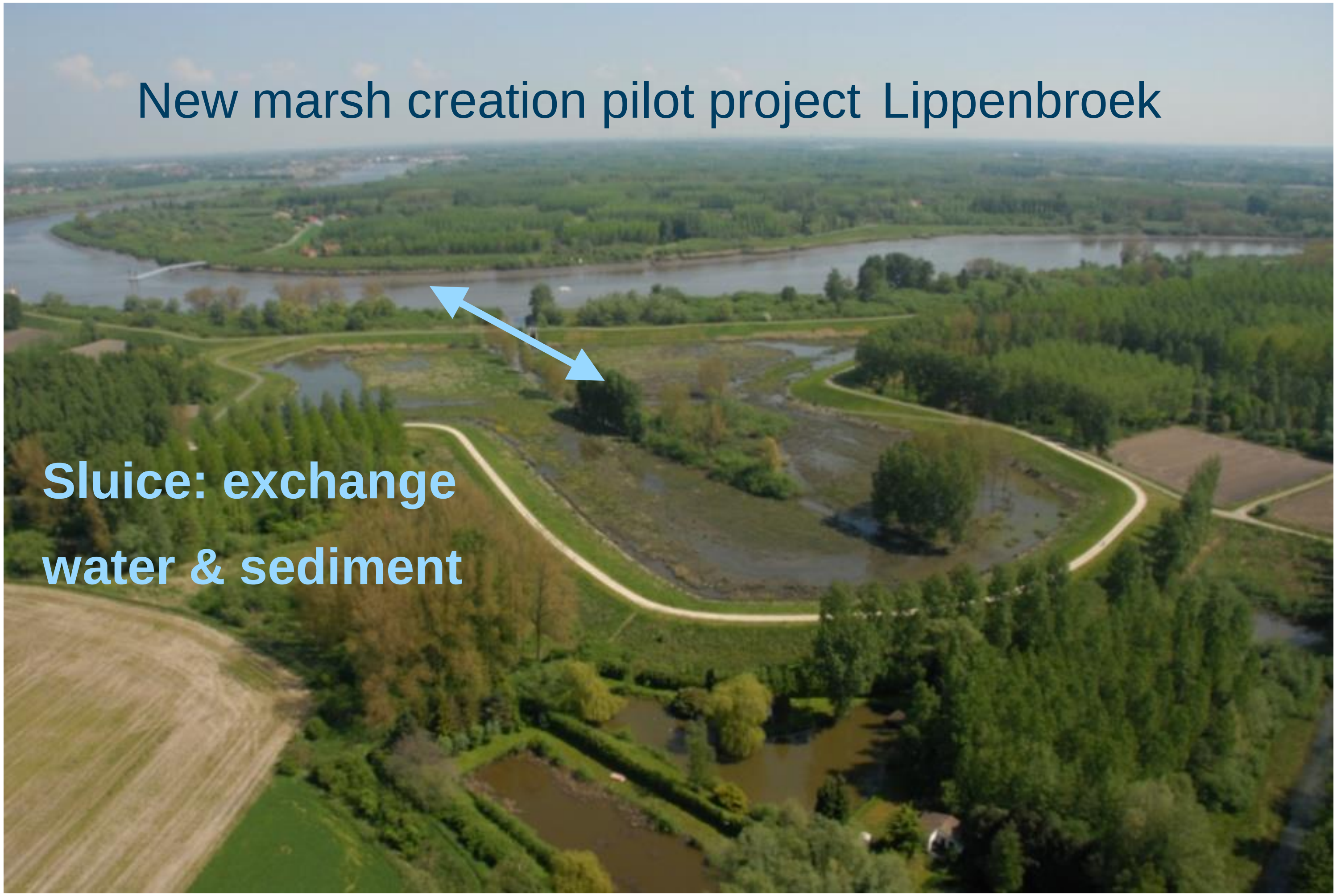


Some examples

Goal: flood control ➔ storing water

Goal: water quality ➔ reducing nutrient load and increasing Si concentration to achieve good stoichiometry!

Intertidal marsh creation to solve estuarine problems



Water quality: Silica

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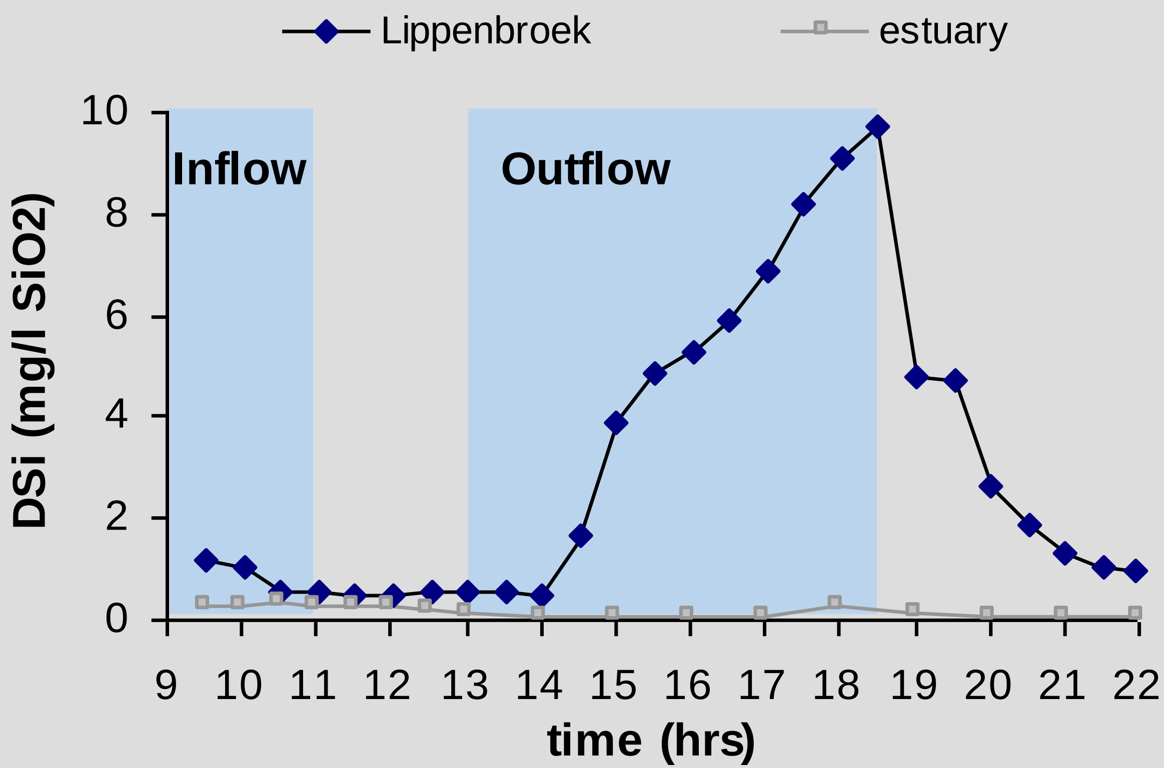

Vegetation: colonisation of bare sites

Phragmites australis

Ranunculus repens

Salix sp.

Typha latifolia

Lythrum salicaria

Iris pseudacorus

Callitriche sp.

Veronica beccabunga

Alisma plantago-aquatica

Colonising species (40)

Low inundation frequency:

30 species

-Wetland + ruderal species

-Salix and Phragmites potentially dominant

Averaged inundation frequency:

27 species

-Ruderal + wetland species

-Salix, Phragmites, Typha: pot. dominant

-**High inundation frequency:**

10 species

- typical wetland species

- Typha potentially dominant


Some examples

Goal: flood control → storing water

Goal: water quality → reducing nutrient load and increasing Si concentration to achieve good stoichiometry!

Goal: dissipation of tidal energy

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Some examples

- Goal: flood control → storing water
- Goal: water quality → reducing nutrient load and increasing Si concentration to achieve good stoichiometry!
- Goal: dissipation of tidal energy

- Work is now oriented towards finding more optimal combination of measures based on cost/effectiveness analysis

Conclusions

conclusions

- Ecosystems deliver services to society:
  - Ecosystem services
- But are therefore dependent on the presence of species and habitats and their performance.

- → not delivering these services has a high cost for society

Conclusions

- Can we improve ecosystem services to achieve sustainability?
- ➔ YES, IF
- We have a good understanding of the impact of past management on the present state of the system and the ecological services in particular
- We have a clear definition of goals describing the amount of ecosystems services the system is expected to deliver (volumes of water to store, nutrient retention, attenuation of the tide,….)

Conclusions

- Can we improve ecosystem services to achieve sustainability?

- ➔ YES, IF

- We can translate required services into surfaces of habitat required

- We can find the right spatial configuration of the habitats
- The big economic value of ecological services is widely accepted
- We are able to make estuarine and coastal management plans in an integrated way so that both economic and ecological services are optimized.

- Essential is bringing all elements together in a truly integrated plan, that is decided by the government and that is implemented based on very intensive stakeholder participation where the overall goal of the plan is reconciled with some local intersts
- Managing ES of estuaries and coasts is the key to protect the biodiversity and not vice versa!!

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