

Project part-financed by the
European Union (European
Regional Development Fund)

The Interreg IVB
North Sea Region
Programme

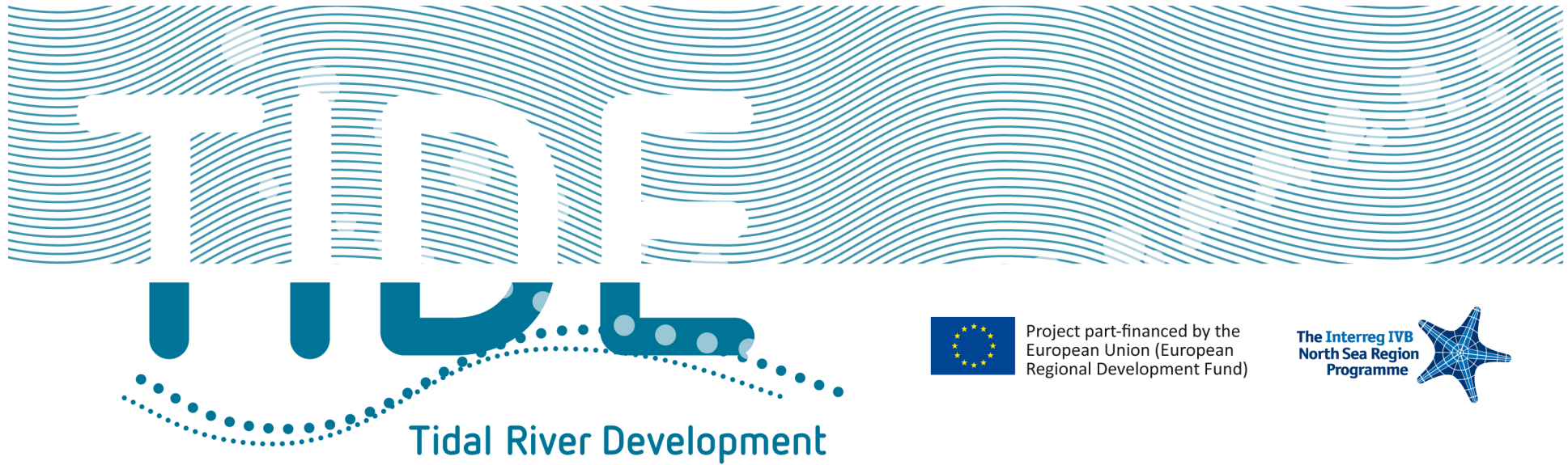


TIDE Presentation Pack



Table of contents

1.	Overview of the TIDE project	
	• The four estuaries	2-10
	• The TIDE project	11-34
	• Outcomes & recommendations	35-44
2.	Estuary functioning	
	• Zonation & historical development	45-55
	• Hydrogeomorphology	56-67
	• Ecology	68-80
	• Ecosystem services	81-98
3.	Governance	
	• General background	99-110
	• Uses & conflicts	111-117
	• Challenges, visions & recommendations	118-127
4.	Management measures	
	• Approach	128-135
	• Examples	136-155
	• Database & messages	156-157



Project part-financed by the
European Union (European
Regional Development Fund)

The Interreg IVB
North Sea Region
Programme



The TIDE Project: An overview

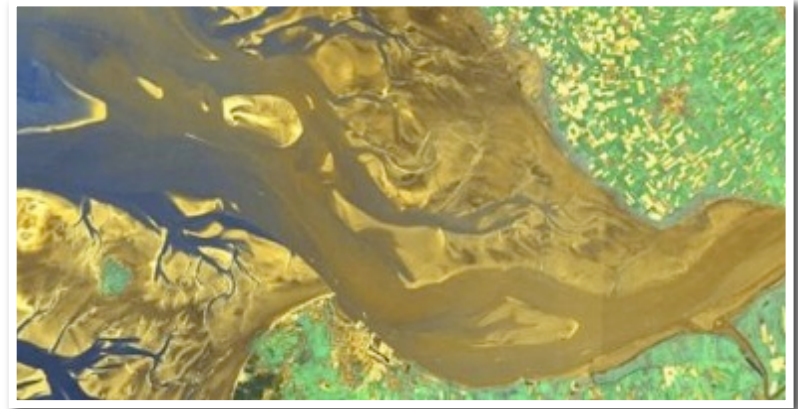
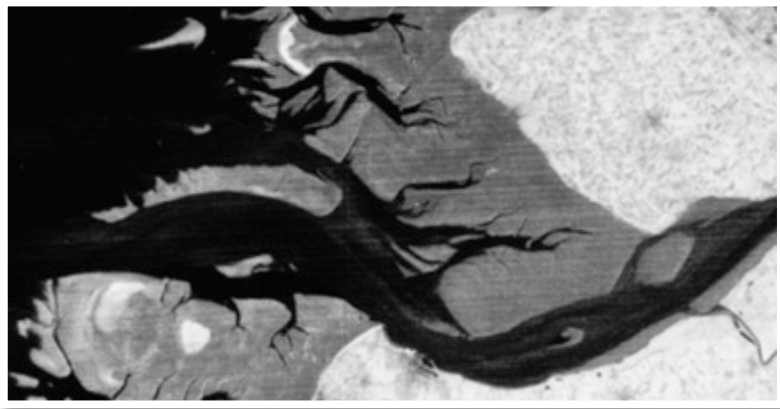
- Presenter -

Estuaries are highly dynamic systems



Elbe estuary

Estuaries are changing...



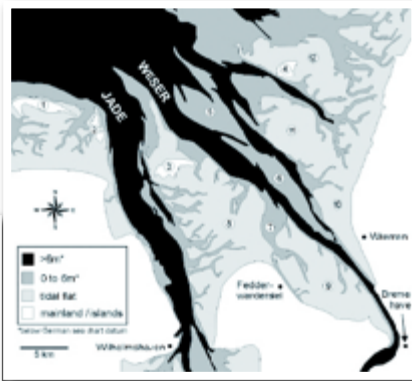
Elbe estuary

... and they are being changed.



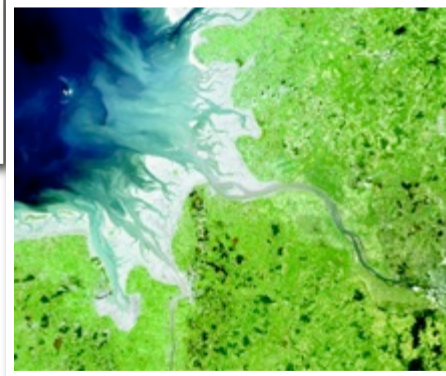
Four estuaries... one project

Scheldt | NL, BE



Weser | DE

Elbe | DE



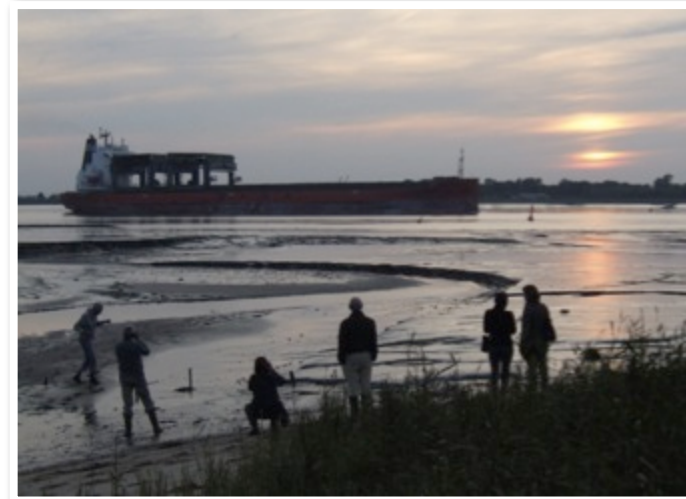
Humber | GB

€ 3.7 million, 50% financed by ERDF
 INTERREG IV B North Sea Region Programme
 January 2010 - June 2013



Similar challenges

- Fairways to important seaports
- Endangered estuarine ecosystem functions
- Increased sediment transport
- Legal and economic framework: EU Directive
- Economic prosperity, port development
- Climate change



Weser estuary



Scheldt estuary

TIDE

Tidal River Development

Similar challenges: Diverse uses



Example
Elbe estuary

Similar challenges: Endangered ecosystem functions

Flood regulation, coastal protection, water purification, plant and animal habitats



Czeck R, KÜFOG, BSU

Weser estuary

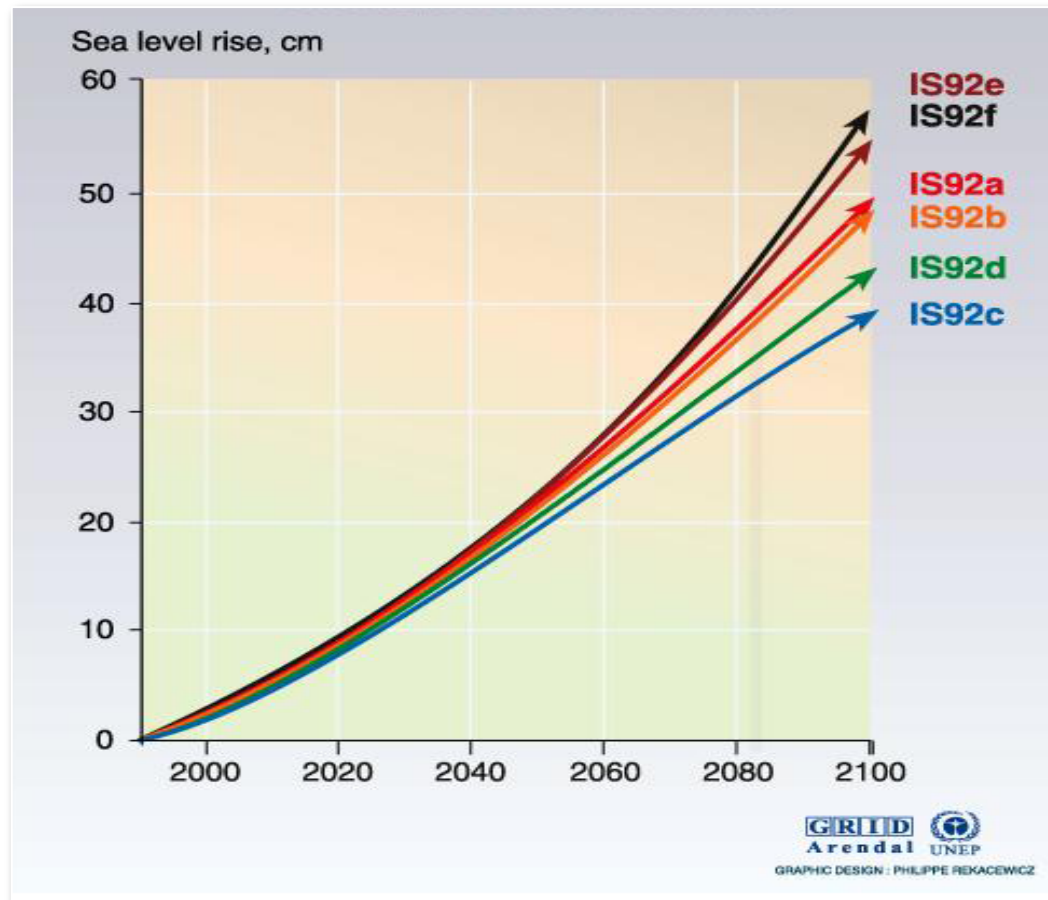


Elbe estuary



Humber estuary

Similar challenges: Climate change



- Sea level rise
- Gradient of water levels
- Freshwater discharge
- Salinity
- ...

Similar challenges: Sedimentation

Increasing sediment transport, requiring more maintenance dredging and improved sediment management



Elbe estuary



Scheldt estuary



TIDE partners



Hamburg Port Authority
(Lead Partner)



Flemish Authorities,
Department of Mobility and
Public Works



Lower Saxony Water
Management, Coastal
Defence & Nature
Conservation Agency



Port of
Antwerp
Antwerp Port Authority



Free Hanseatic City of
Bremen



Universiteit
Antwerpen
University of Antwerp



Universität Bremen
University of Bremen



Environment
Agency
Environment Agency



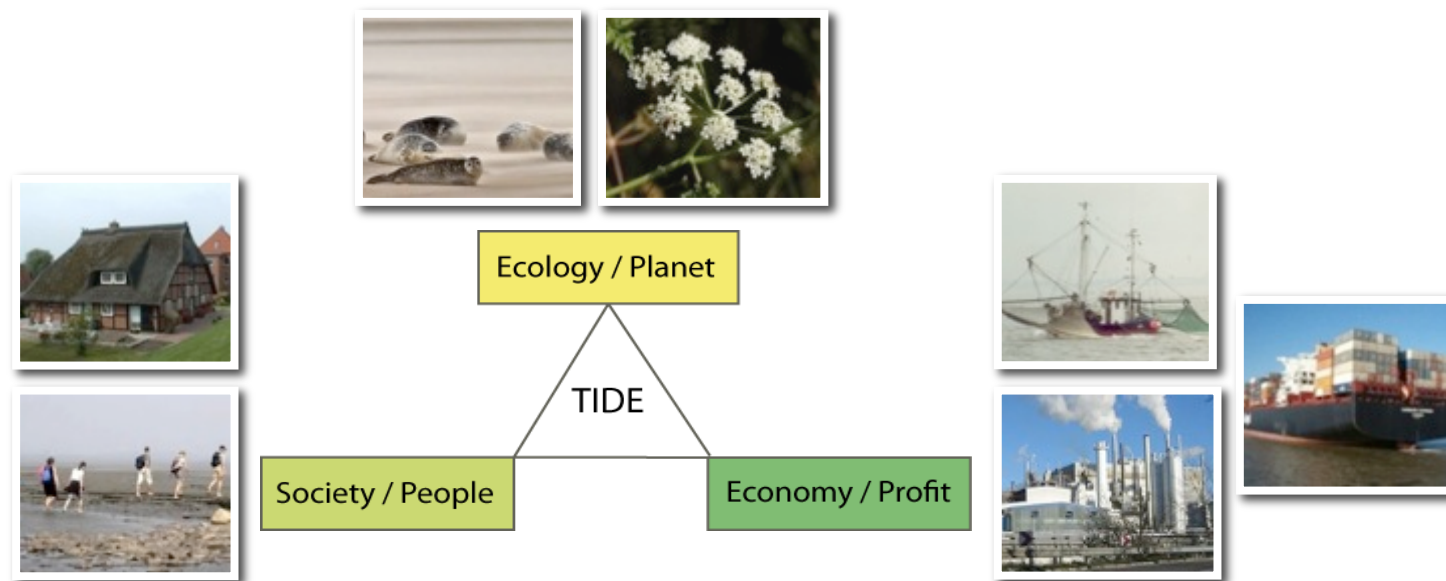
Rijkswaterstaat



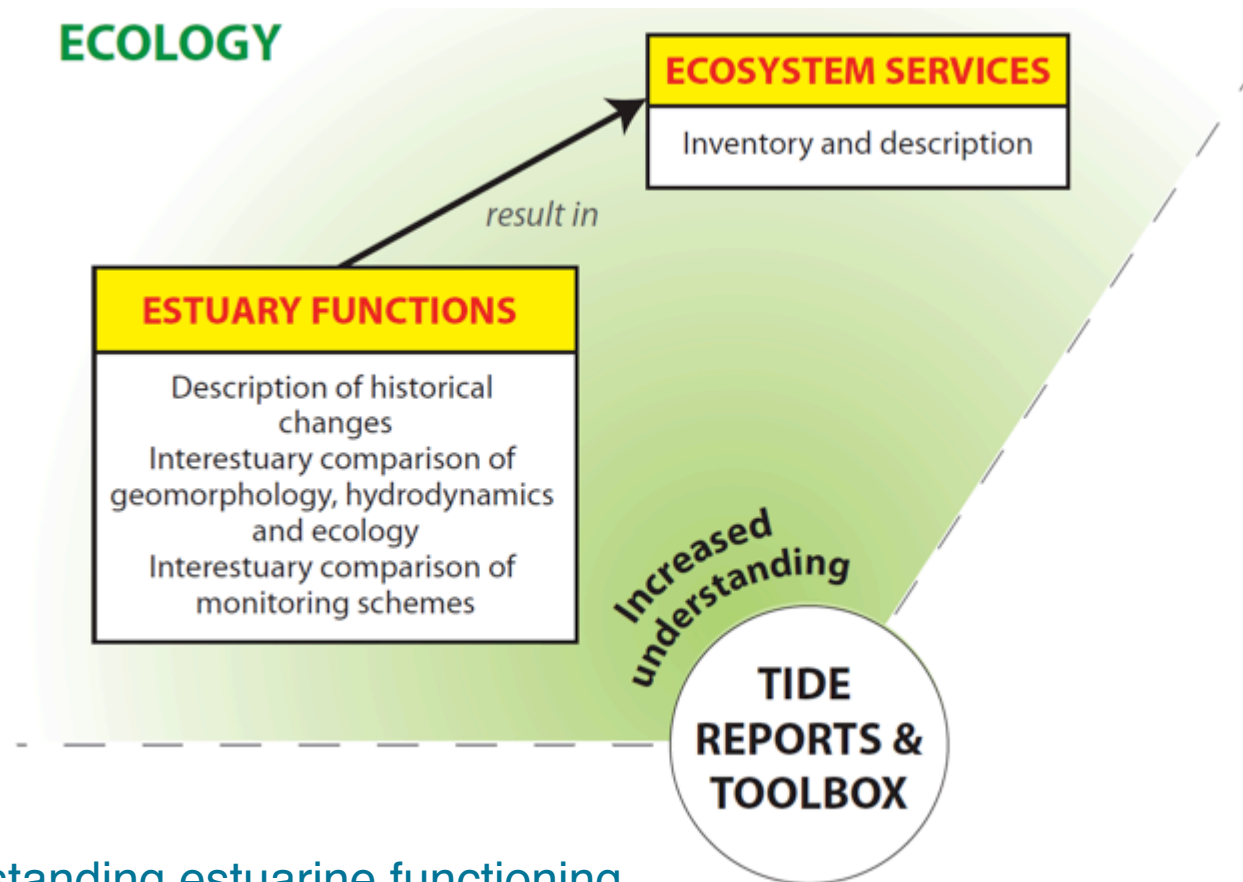
Institute of Estuarine &
Coastal Studies, Hull

TIDE objectives

- Improve estuarine understanding
- Develop concrete tools for estuary managers and stakeholders
- Give recommendations for integrated management of estuaries taking into account the whole estuary (ecology, economy, society)

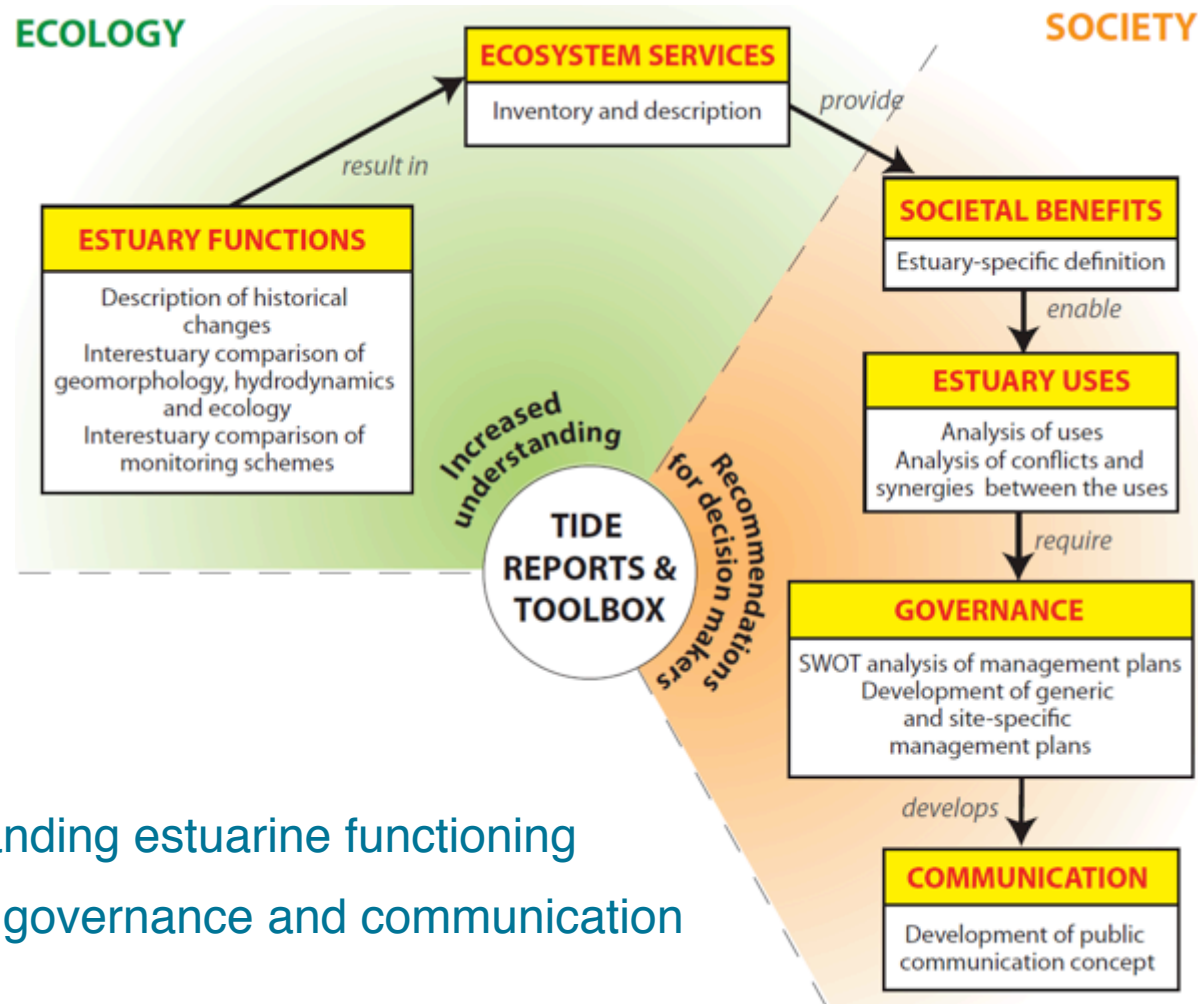


Understanding TIDE



- Understanding estuarine functioning

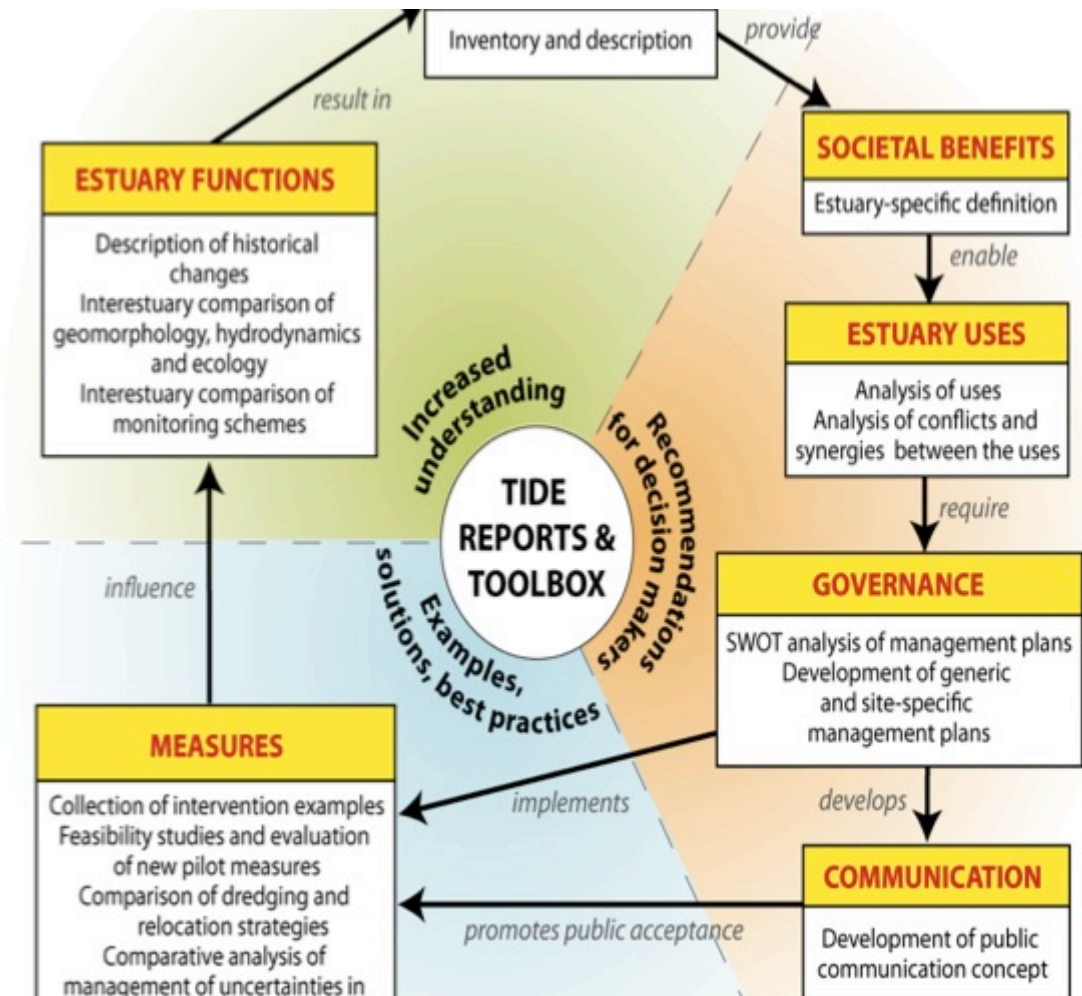
Understanding TIDE



- Understanding estuarine functioning
- Tools for governance and communication

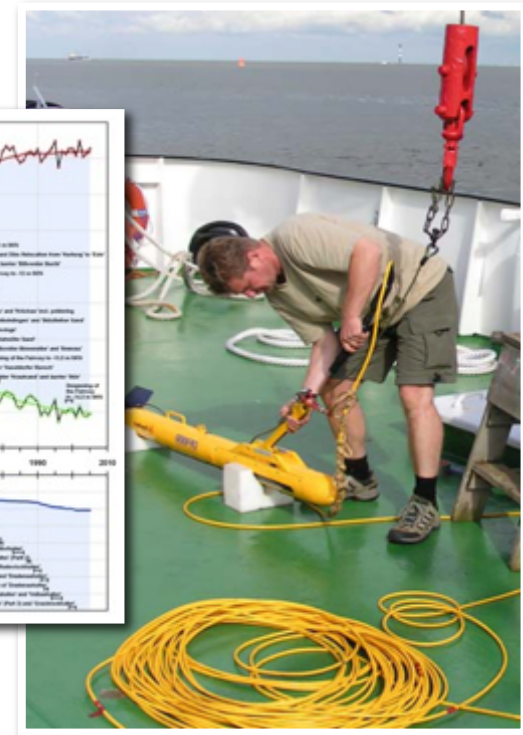
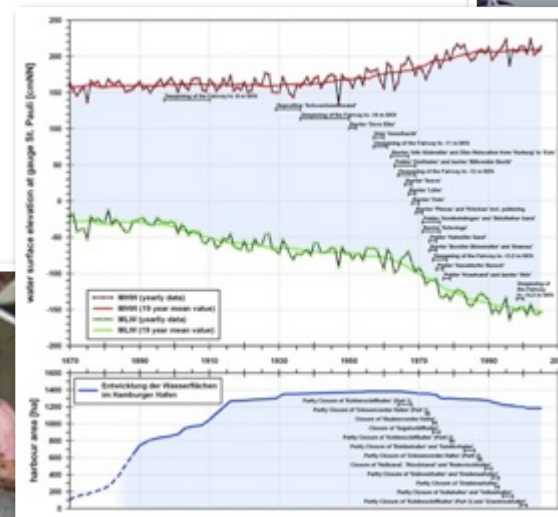
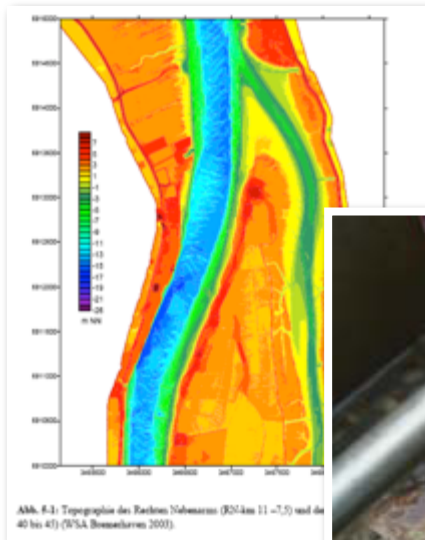
Understanding TIDE

- Understanding estuarine functioning
- Tools for governance and communication
- Management measures



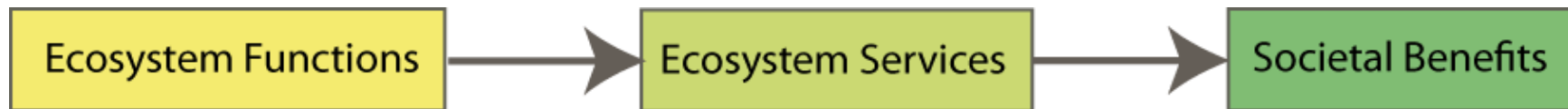
SCIENCE

Improve knowledge on estuary functioning, conduct inter-estuarine comparisons



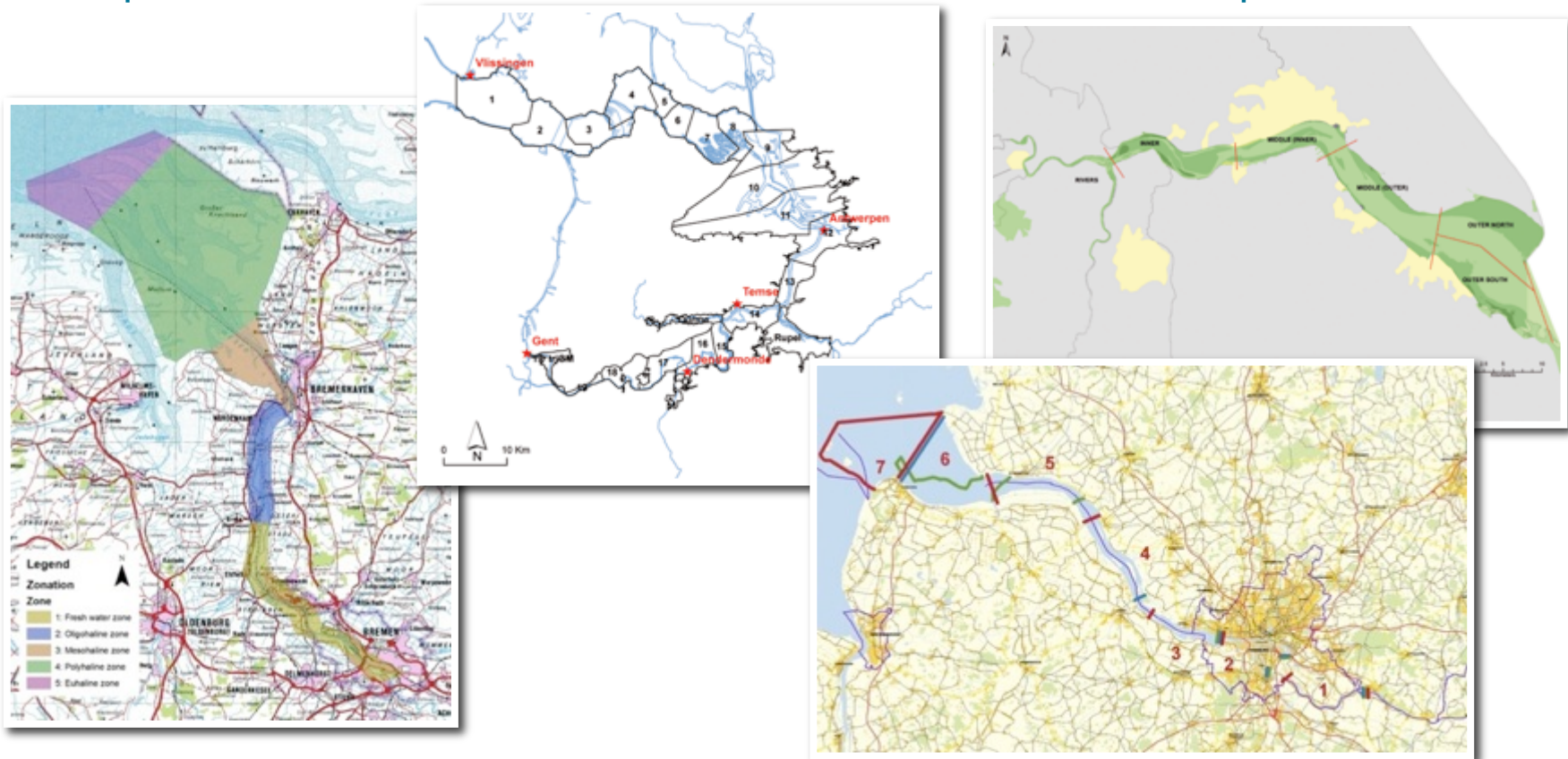
Ecosystem services approach

- The concept of ecosystem services is being recognised as having a high potential to link the different parts of the ecosystem and to tie it to the socio-economic system
- Explore underlying relations between ecosystem functions of estuaries, resulting ecosystem services and derived societal benefits
- Based on this knowledge, better understand the way in which human interventions affect these inter-relations



Estuary zonation based on salinity

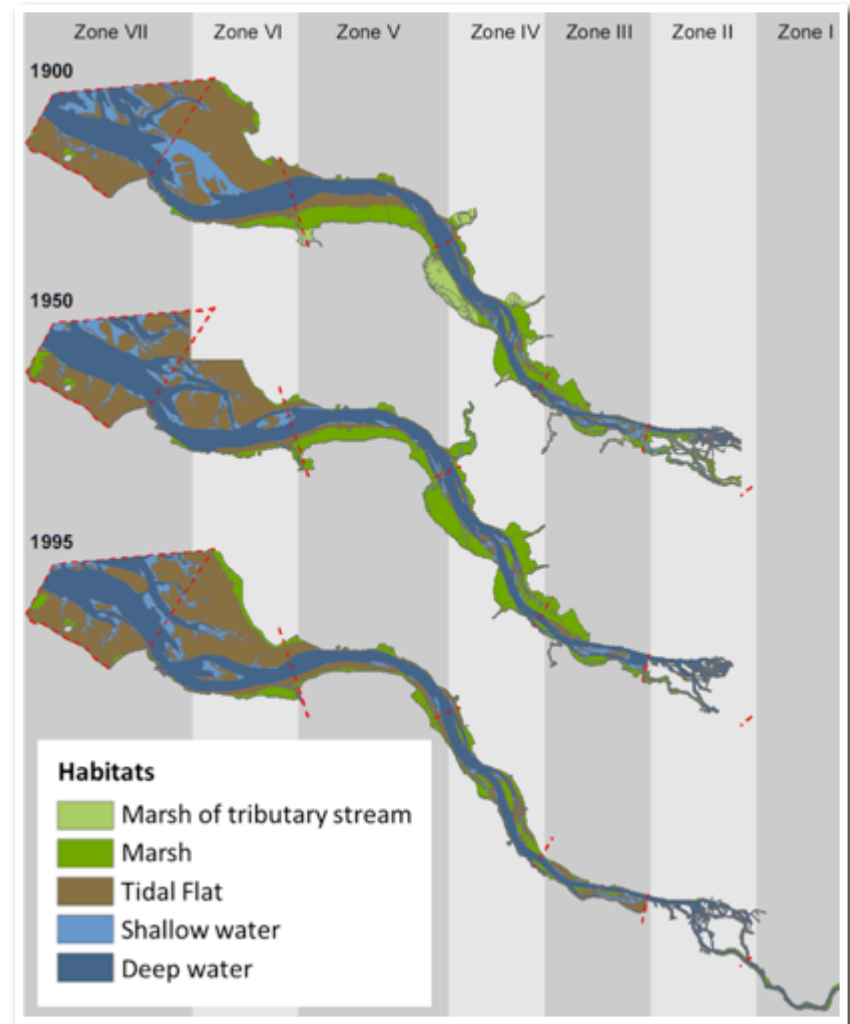
- Which zonation scheme is used within each estuary?
- Is it possible to define zones to be used for inter-estuarine comparisons?



Historical development

Describe and compare:

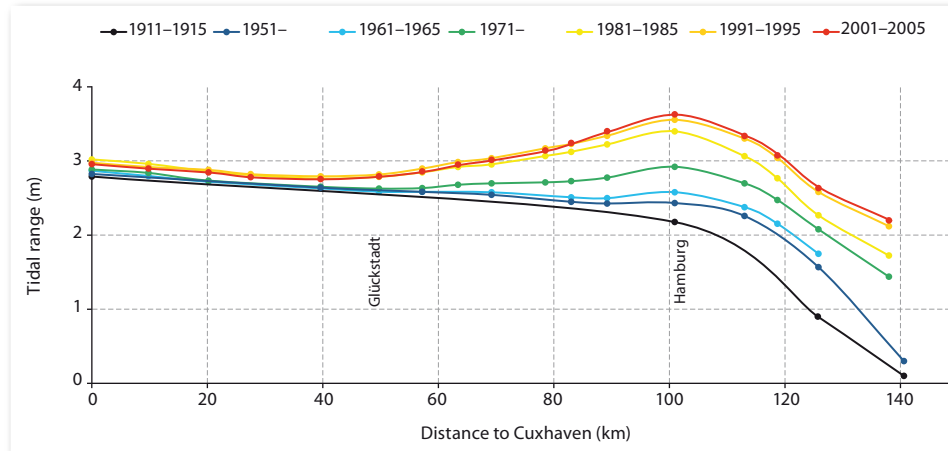
- Relevant changes and pressures
- Overview of human activities
- Tidal evolution
- Habitats



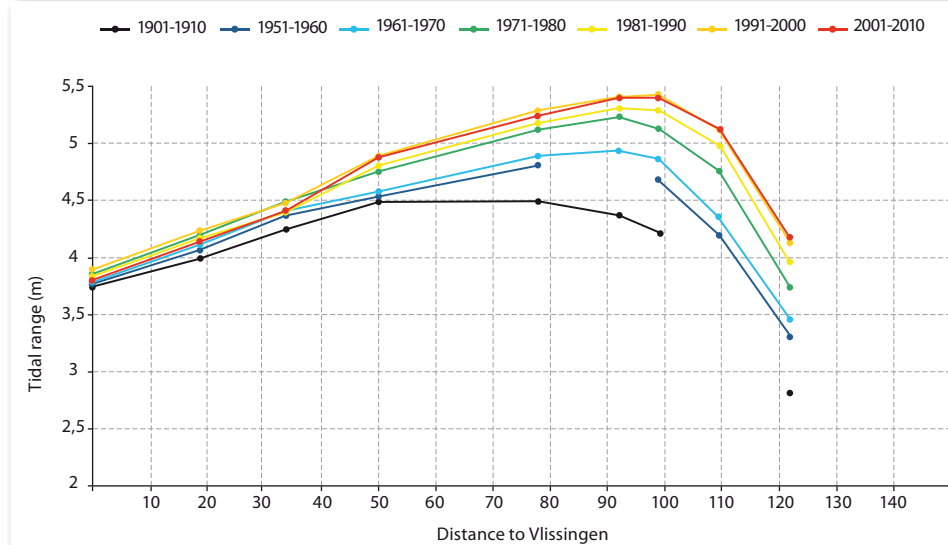
Habitat development
at the Elbe estuary

Changing estuary: tidal range

Development of the tidal range in the Elbe and the Scheldt during the last century

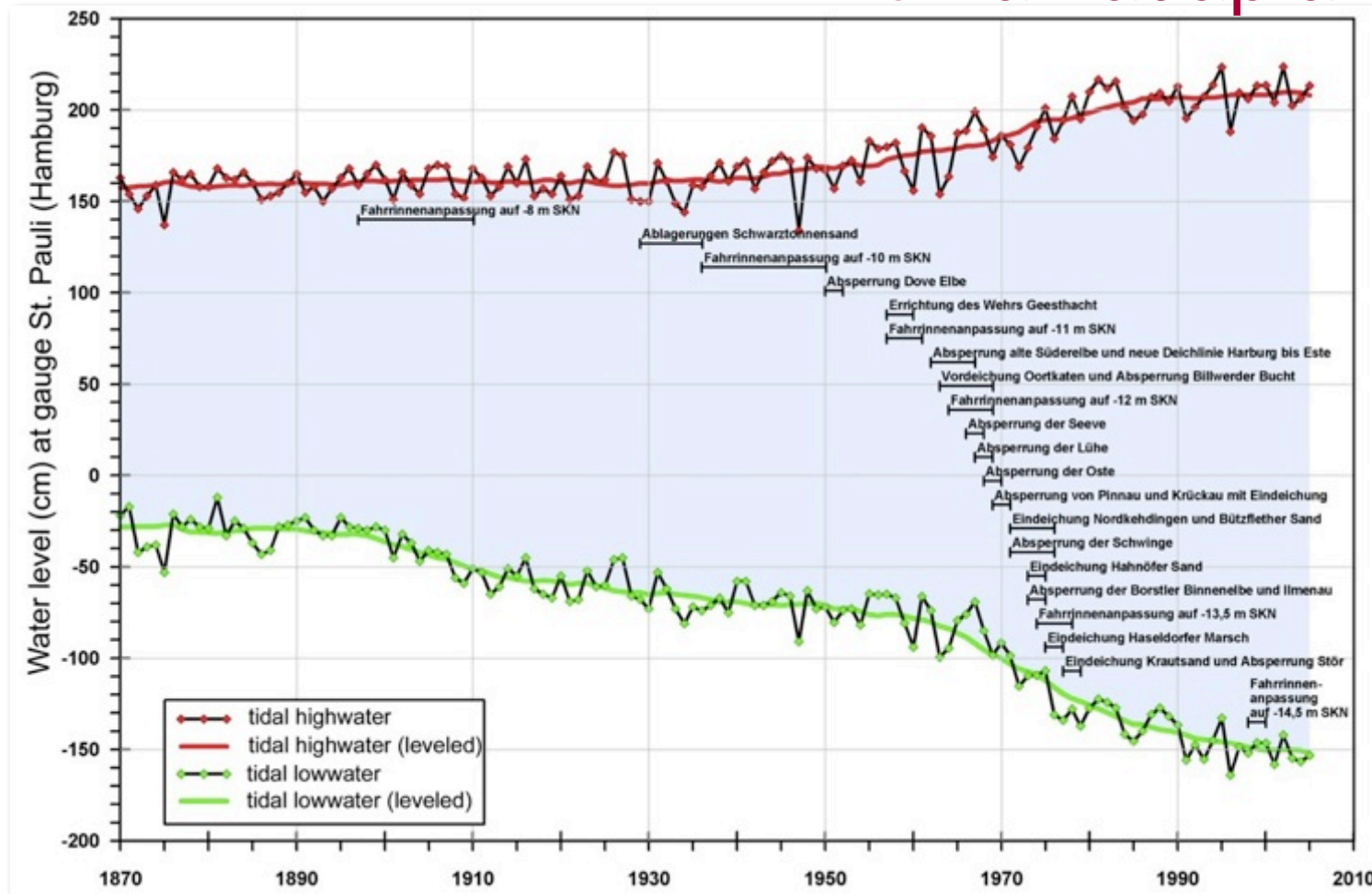


Elbe



Scheldt

Changing estuary: tidal range, human adaptations



Elbe

TIDE activities



GOVERNANCE

Improve effectiveness of policy mechanisms and instruments, bring together diverse stakeholders, realise integrated management and governance

Estuary management Inventory and SWOT analysis of management plans

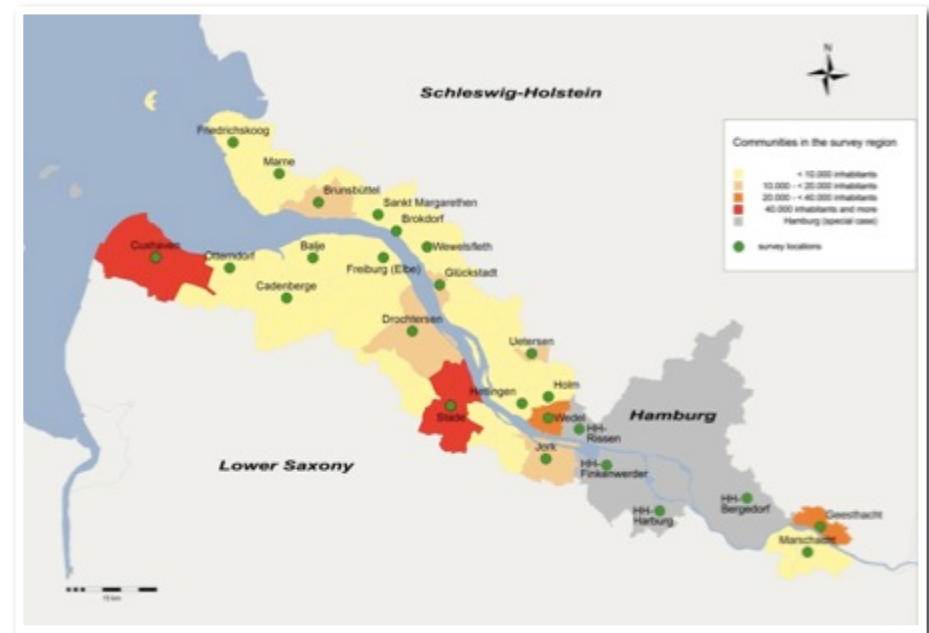
- Legislative drivers
- Management plans in each estuary (e.g. WFD)
- Recommendations

Location	Name of Plan	Focus / aims of the plans					SWOT				Status
		Conservation	Recreation	Flood Protection	Economy, Shipping & Ports	ICZM	Strength (Scope of Plan)	Weakness	Opportunities	Threats	
Elbe	Several plans inc River Basin Plan	X		(X)			Improving ecological status & inc. legally binding	No focus on tidal Elbe, non-holistic view on function	Cross-sector involvement & tie in to MSD	Focus on monitoring not functioning	Operational
Weser	River Basin Management Plan	X		X			Improving ecological status & inc. legally binding	No focus on tidal Weser, non-holistic view on function	Trans-boundary and sets targets	Focus on monitoring not functioning	Operational
Scheldt	River Basin Management Plan	X	X	X	X	x	Integrated	Difficulties in bilateral integration & establishment of measures	Increased knowledge	Costs & no clear timetable	Pre-operational
Humber	River Basin Management Plan	x		x			Improving ecological status & inc. legally binding	Not multi-sectoral & no estuary focus	Integration of WQ & conservation strands etc	Not fully integrated	Operational
Notes											

Estuary management Communication

Interrogation of 800 people about their perception of the Elbe estuary (Geesthacht, Harburg, Bergedorf, Stade, Uetersen, Brokdorf, Marne, Friedrichskoog, Cuxhaven, ...)

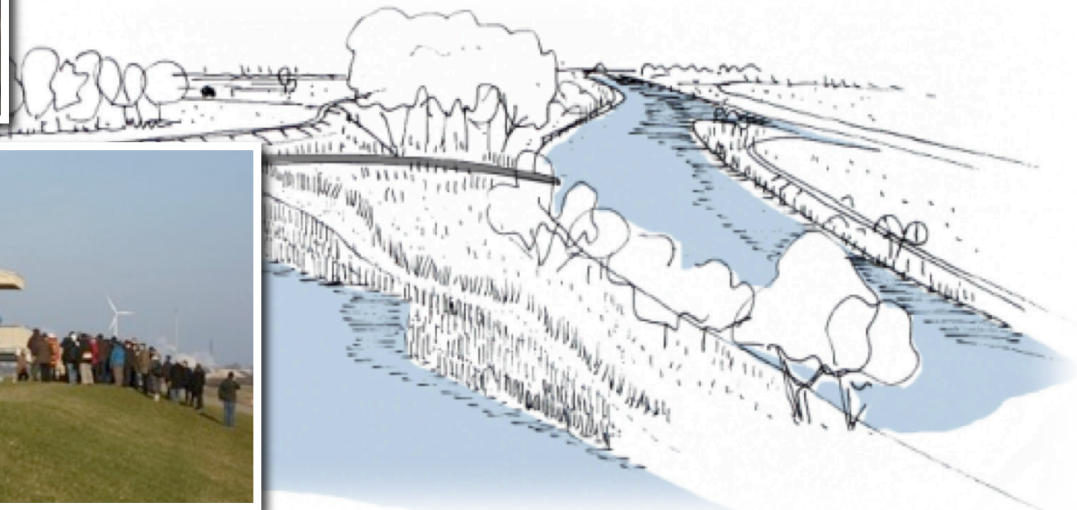
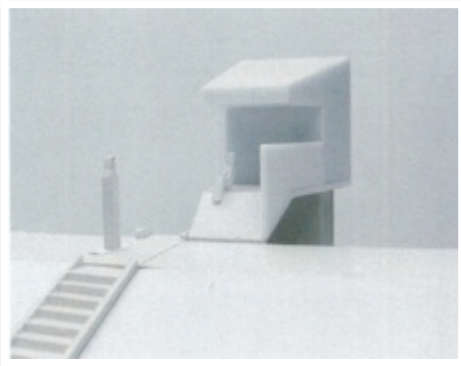
- How do you „use“ the Elbe?
- What does nature mean for you?
- What kind of conflicts can occur?
- How important is the harbour?
- What are your wishes for the future of the Elbe?
- Quiz in order to find out what people know about relevant Elbe topics
-



Estuary management Communication: means for acceptance and knowledge building



- Create positive experience
- Create awareness for tidal processes
- Communicate aims of the tidal Elbe concept



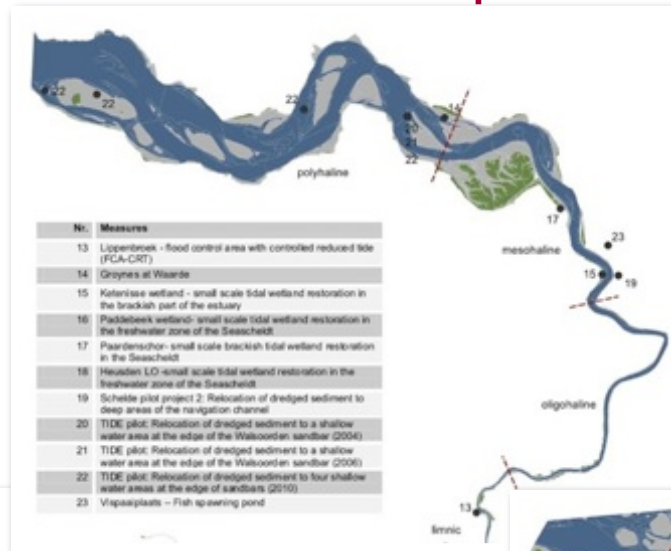
MANAGEMENT MEASURES

Compare, assess and plan mitigation measures and develop new management solutions

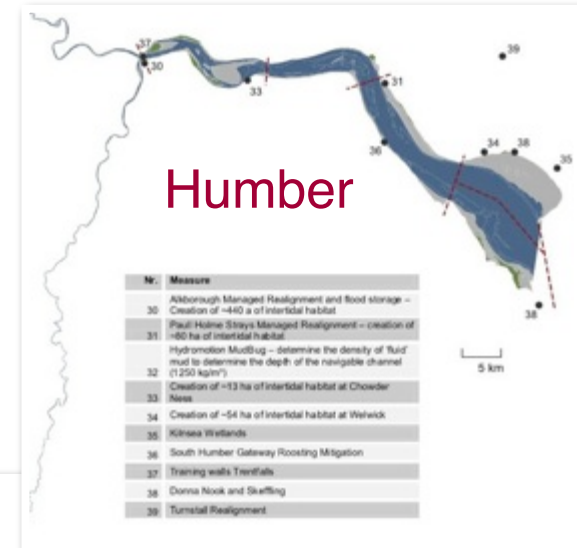


Database of measures Compilation & evaluation (39 measures)

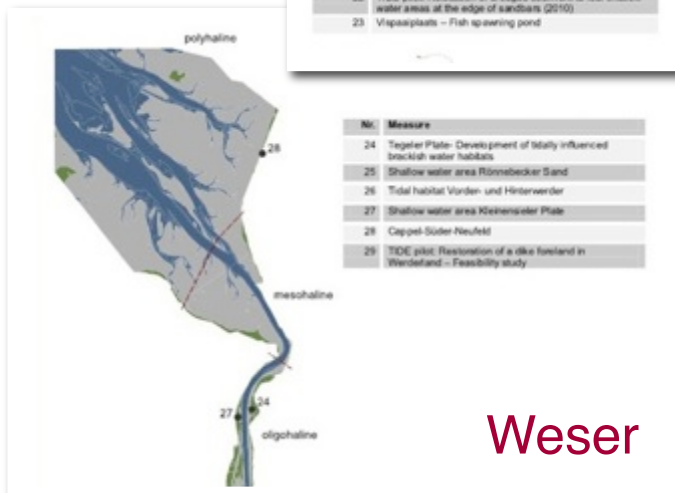
Scheldt



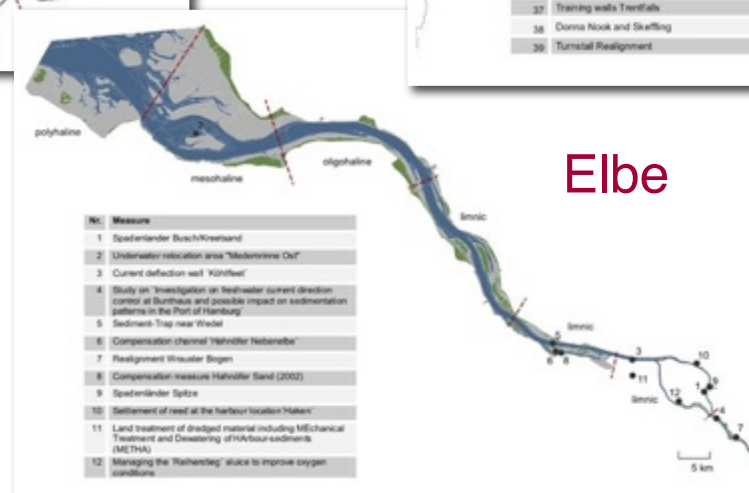
Humber



Weser



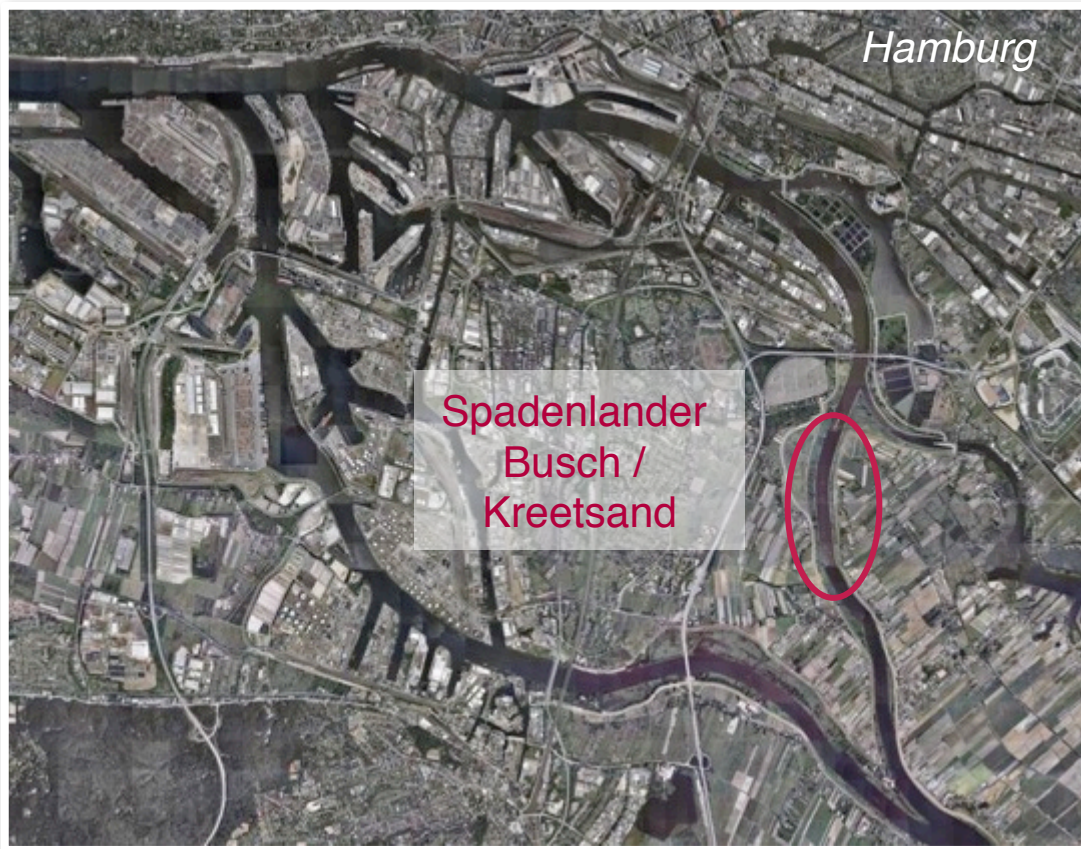
Elbe



Management measures

Elbe: Spadenlander Busch / Kreettsand

Tidal Volume: New shallow water area



Management measures

Elbe: Spadenlander Busch / Kreet sand



Kreet sand today

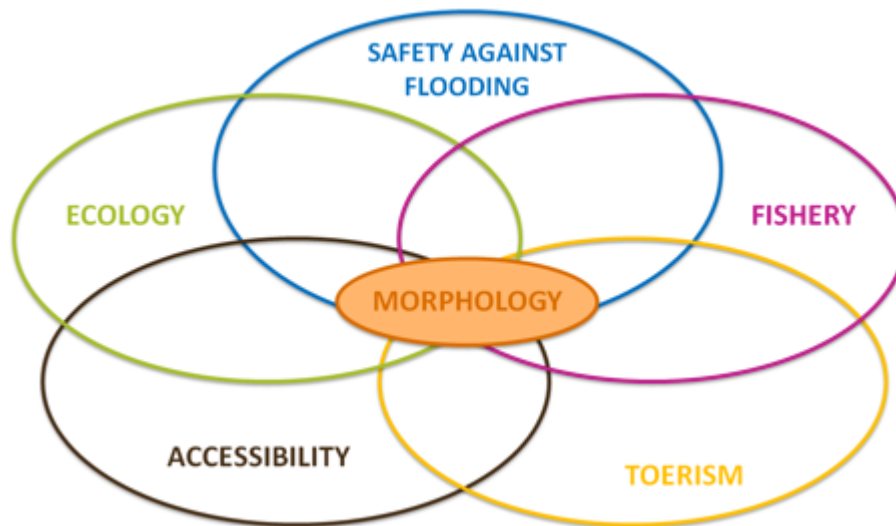
Kreet sand 2015



Management measures

Morphological management as a key to integrative holistic approach

Morphology can be seen as the foundation for different estuarine functions. A thoughtful management of morphology - working with natural dynamics - can create benefits for all estuarine functions.

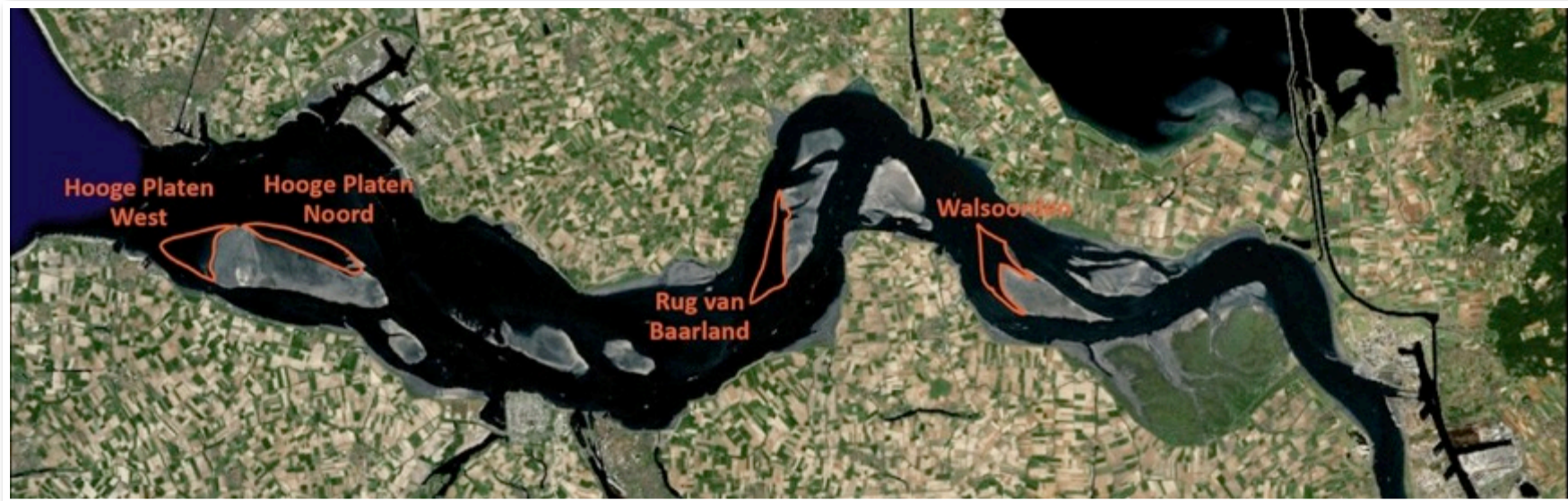


Tools for morphological management:

- Modification of hard bordering
- Construction of new (soft) structures
- Morphological dredging
- Morphological disposal of dredged material
- Combination of the above works

Management measures Scheldt: a new disposal strategy

Innovative sediment management, a win-win for port accessibility and nature?



Relocation of dredged sediments along sandbars

- Create ecological valuable habitat
- Maintain multiple channel system

Management measures Scheldt: flood control area

Lippenbroek (Zeeschelde)

- Located in freshwater tidal area
- Past: agricultural use
- Size: 10 ha
- Start: May 2006

Win-win situation:
flood protection and
valuable tidal nature
area

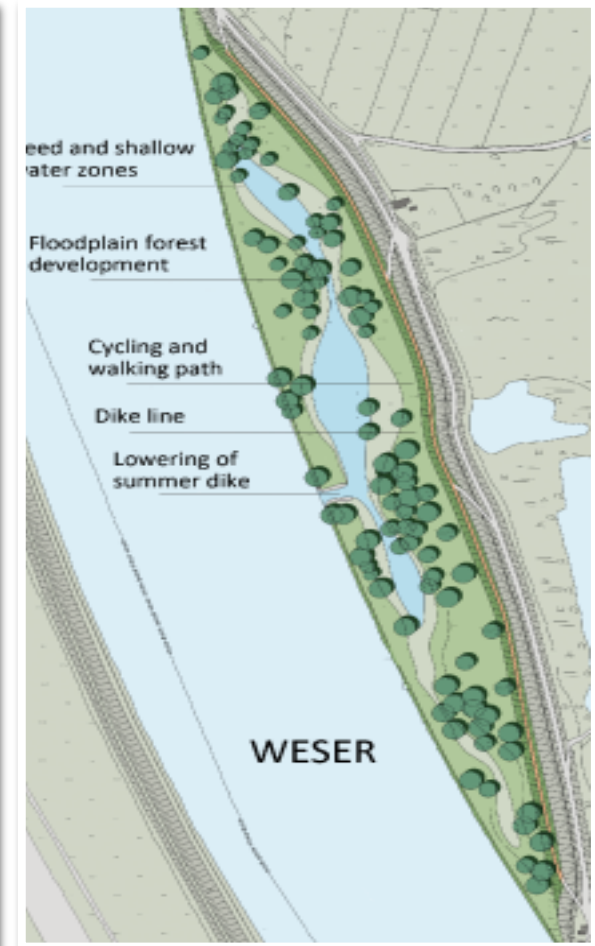


Management measures Weser: restoration of riverbanks

Goal: improvement of ecological conditions of the tidal Weser

Characteristics:

- 13 ha area
- Approx. 0.03 m above mTHW
- Approx. 4 m tidal amplitude
- Overflow dam (summer dyke)
- Main dyke to be enforced
- Agricultural use (greenlands)
- Natura 2000 areas adjacent



Management measures Humber: flood defence & creation of intertidal habitat

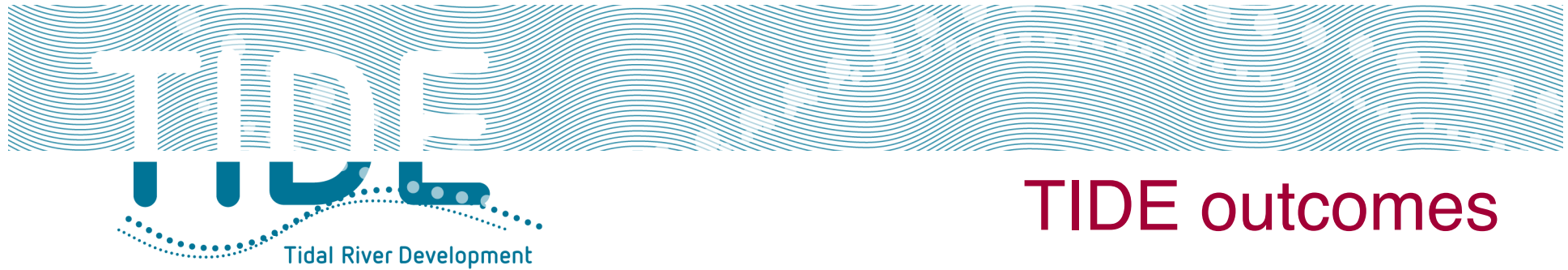


Goals: creation of intertidal habitat to offset coastal squeeze losses and flood storage



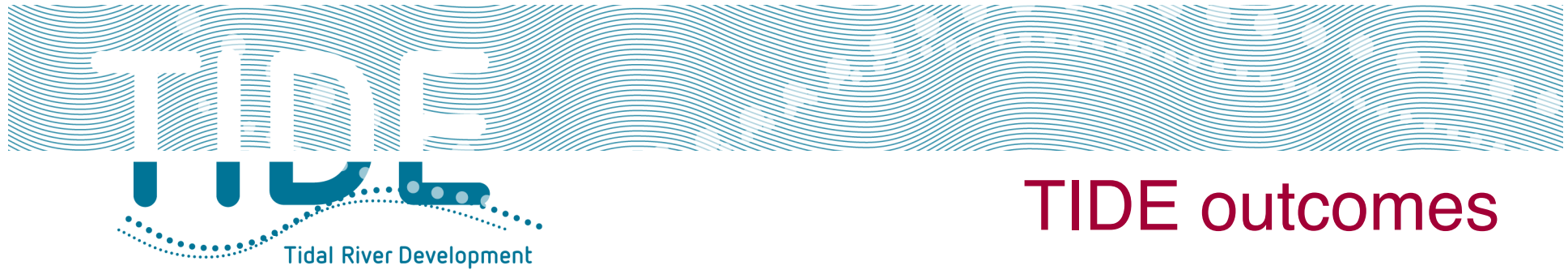
Characteristics:

- 440 ha, 170 ha intertidal
- Reduction in water levels upstream of up to 150 mm
- 1500 m embankment lowering to act as spillway in extreme events
- Site breached in 2006
- Natura 2000 compensation



SCIENTIFIC EXCHANGE AND BUILD UP OF EXPERTISE

- Compilation of information on Elbe, Humber, Scheldt and Weser estuaries:
 - Characteristics and functioning
 - Historical development
 - Management instruments and legal framework
 - Catalogue of evaluated measures
- Identification of similarities and differences:
 - TIDE estuaries have certain basic processes, structures and demands in common, but each estuary is unique in its functional characteristics and dynamics.
- Improved understanding of basic processes, structures and demands
- Defined zonation approach appropriate for estuarine comparison



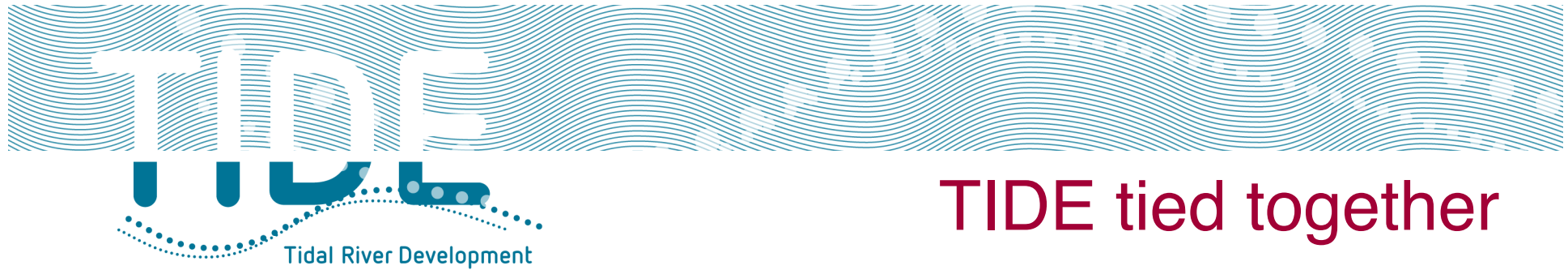
PRACTICAL TOOLS

- Checklists and recommendations (e.g. communication strategies)
- Methodologies related to hydromorphological topics (e.g. cubage technique)
- Templates which can be download (e.g. conflict matrix)
- A generic roadmap and decision support system 'EPSS '
- A downloadable app for the estimation of bird disturbance
- A catalogue of evaluated management measures
- Examples of good practices (e.g. morphological disposal along sandbars)
- ...



TIDE tied together

The main objective of estuarine management is to maintain and protect the natural ecology while safeguarding the delivery of benefits for society. As such, estuarine management is the responsibility of all stakeholders.

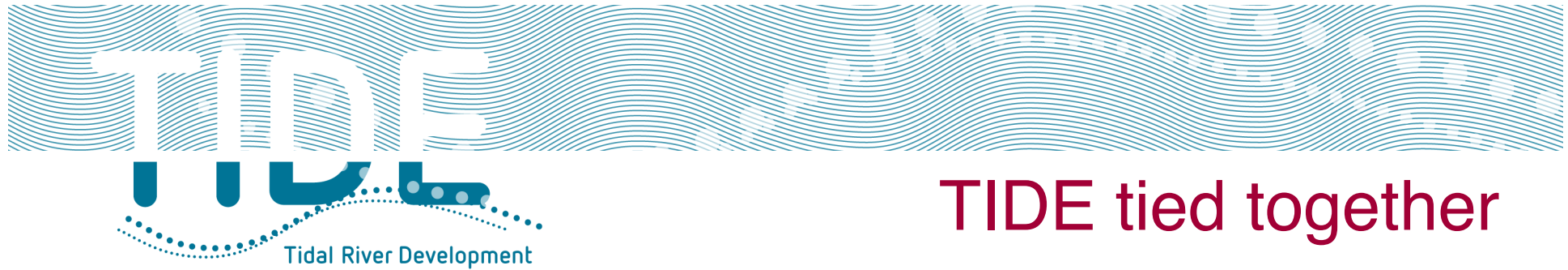


1. Understanding the basic estuarine processes, structures and demands requires:

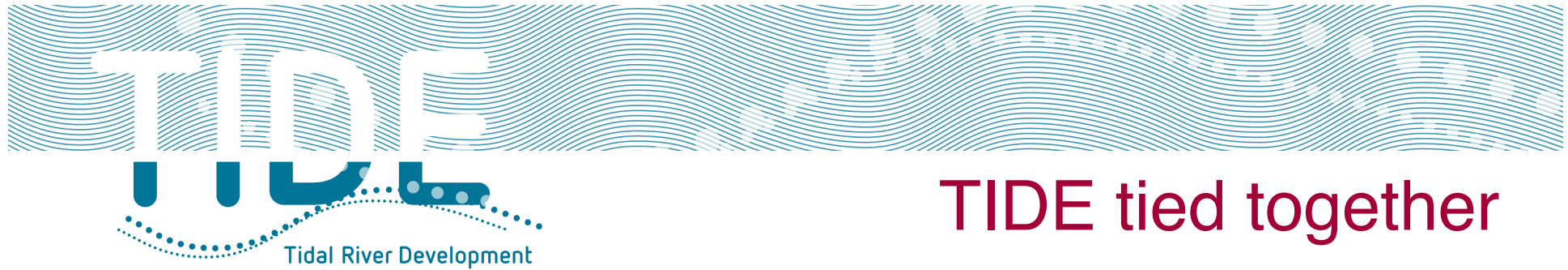
- Analysis of historical development and implications for habitat development
- Use of appropriate techniques to compare estuaries and consider interactions between morphology, hydrology and ecology
- Dissemination of knowledge to stakeholders, managers and policy makers

2. The ecosystem services approach shows the socioeconomic value of estuaries. Its application requires identification of:

- Societal benefits delivered by ecosystem services
- Ecosystem services delivery with spatial and seasonal variability among habitats and between systems
- Linkages with inland river systems and the hinterland



3. Management initiatives and governance should ensure that societal benefits are obtained by jointly developing opportunities and resolving conflicts between uses and users. This requires:
 - Considering the ecosystem as a whole when making decisions and implementing management measures (i.e. ecosystem approach)
 - Using site-specific management initiatives to accommodate both natural and human systems, being aware of shifting baselines caused by global changes
 - Identifying ‘What occurs where among estuarine users?’ and ‘Where are there opportunities and conflicts?’
 - Combining the ecosystem services and conflict matrix approaches to produce effective adaptive management
4. Successful implementation of management plans and measures requires an effective communication strategy for all stakeholders in order to win acceptance.



5. The success of any management strategy or measure depends on a monitoring strategy that is integrated, cost-effective, science based and target-oriented. It requires:
 - Defining monitoring objectives and methods explicitly beforehand
 - Achieve synergies between monitoring programmes and ensuring the greatest use of data and databases
 - Objectively appraising the effectiveness of the project in achieving its goals
6. As estuaries are dynamic systems, they need an adaptive management that accommodates natural development and anthropogenic demands and changes.
7. Exchange of expertise in order to learn from other disciplines and estuaries to effect successful and sustainable estuarine management.

An integrated management approach should:

- Apply the ecosystem approach
- Use the ecosystem services approach to measure and communicate changes with can deliver societal benefits
- Accumulate and share knowledge of estuary structure and functioning
- Use best practices from similar cases
- Follow a holistic approach and consider the system as a whole
- Apply a thoughtful management of morphology
- Practice adaptive management
- Employ an appropriate and adaptive monitoring strategy
- Apply an appropriate communication strategy

Access TIDE outcomes via an interactive website: the TIDE toolbox
www.tide-toolbox.eu

Start »

TIDE toolbox

Guiding Estuarine Management

Due to their high dynamics and various uses the management of estuaries demands an integrated approach taking into account estuarine functioning, appropriate governance and the implementation of measures based on knowledge and experience. TIDE offers a selection of tools and recommendations.

Functioning »
Increased understanding

- Ecology
- Hydrogeomorphology
- Ecosystem Services

Governance »
Recommendations for decision makers

- Management plans
- Estuary Uses
- Communication

Measures »
Examples, solutions and good practice

- Pilot studies
- Feasibility studies
- Evaluations

Integrated Management »

Provides (top), Influences (left), Implements/promotes (right)

Give us feedback »

www.tide-project.eu

Project part-financed by the European Union (European Regional Development Fund)

The Interreg IVB North Sea Region Programme

Disclaimer:
The authors are solely responsible for the content of this report. Material included herein does not represent the opinion of the European Community and the European Commission is not responsible for any use that might be made of it.

The screenshot displays the TIDE toolbox website. On the left is a navigation menu with the following items:

- » Start
- » About TIDE toolbox
- » Glossary
- » Management issues
- » TIDE tools
- » Reports
- » Management measures
- » Links

The main content area features a header with the TIDE toolbox logo and an aerial photograph of an estuary. Below the header is a navigation list:

- » Start
- » About TIDE toolbox
- » Glossary
- » Management issues
- » TIDE tools
- » Reports
- » Management measures
- » Links

Below the navigation list are several icons and logos: a thumbs-up icon for 'Give us feedback', the website URL 'www.tide.project.eu', the European Union flag with the text 'Project part-financed by the European Union (European Regional Development Fund)', and the Interreg IVB North Sea Region Programme logo.

The central focus is the 'TIDE toolbox' section, titled 'Guiding Estuarine Management'. It includes a paragraph: 'Due to their high dynamics and various uses the management of estuaries demands an integrated approach taking into account estuarine functioning, appropriate governance and the implementation of measures based on knowledge and experience. TIDE offers a selection of tools and recommendations.'

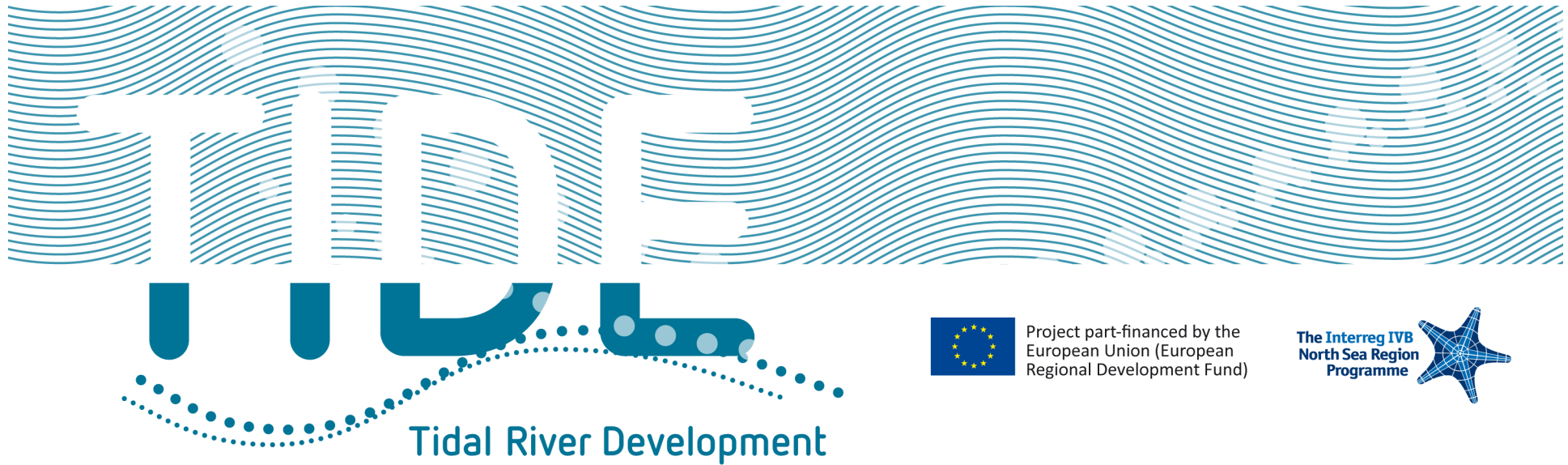
Below this text is a Venn diagram illustrating the 'Integrated Management' process. It consists of three overlapping circles:

- Functioning** (Green circle): Increased understanding
 - Ecology
 - Hydrogeomorphology
 - Ecosystem Services
- Governance** (Red circle): Recommendations for decision makers
 - Management plans
 - Estuary Uses
 - Communication
- Measures** (Blue circle): Examples, solutions and good practice
 - Pilot studies
 - Feasibility studies
 - Evaluations

The central intersection of all three circles is labeled 'Integrated Management'. Arrows indicate relationships: 'Provides' from Functioning to Governance, 'Influences' from Functioning to Measures, and 'Implements/promotes' from Measures to Governance.

A disclaimer at the bottom states: 'The authors are solely responsible for the content of this report. Material included herein does not represent the opinion of the European Community and the European Commission is not responsible for any use that might be made of it.'

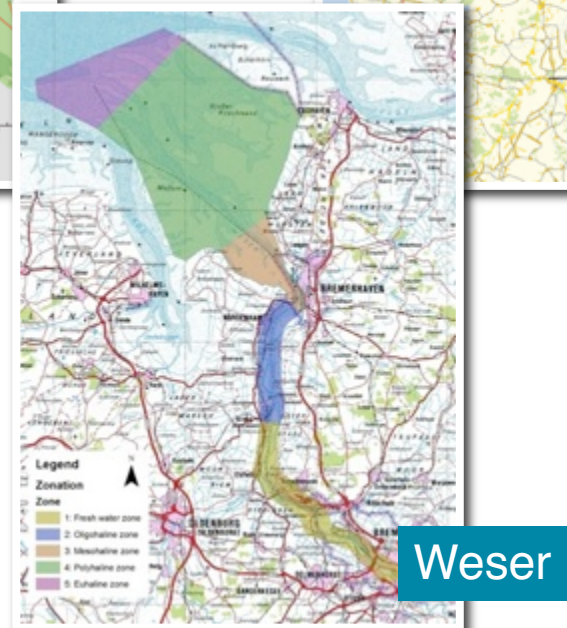
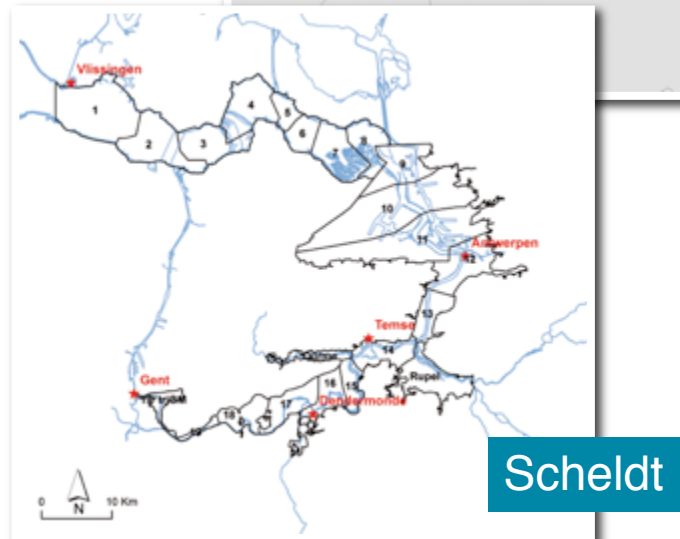
- Support estuarine managers in their daily work
- Provide information for interested people and organisations
- Show relationship between estuary functioning, governance and appropriate management measures
- Share our knowledge and experience
- Give recommendations
- Provide tools



An in-depth look at estuarine functioning

Coordinator: Patrick Meire, University of Antwerp

Selected examples of existing zonation

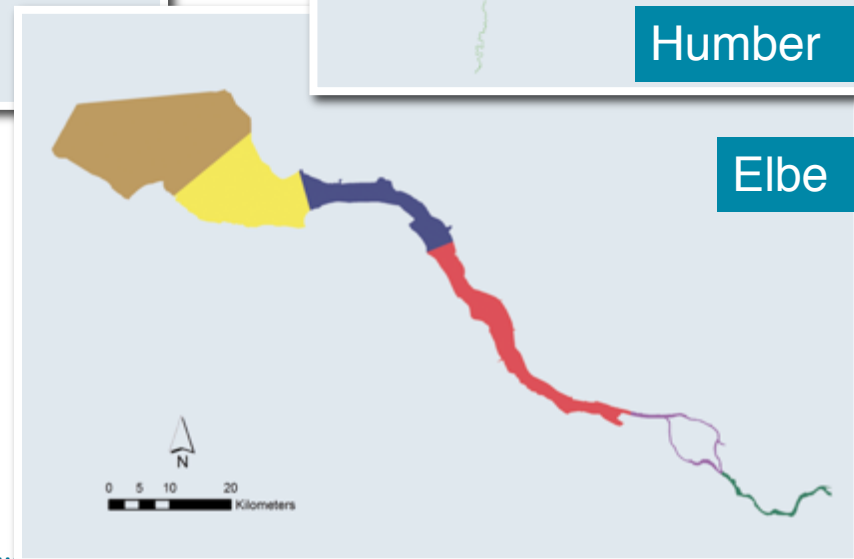
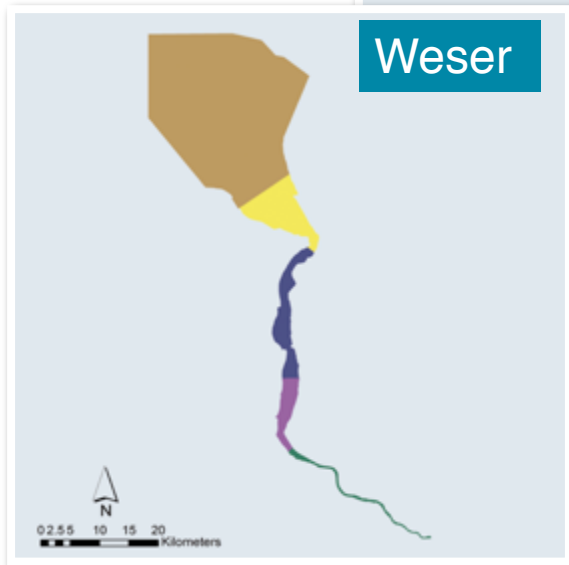
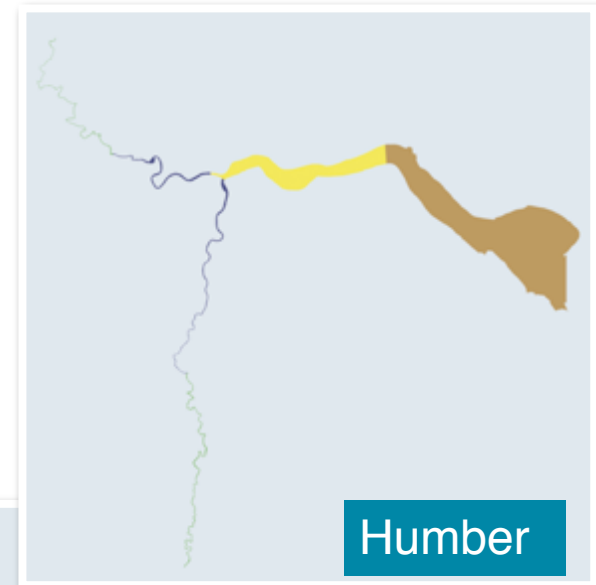
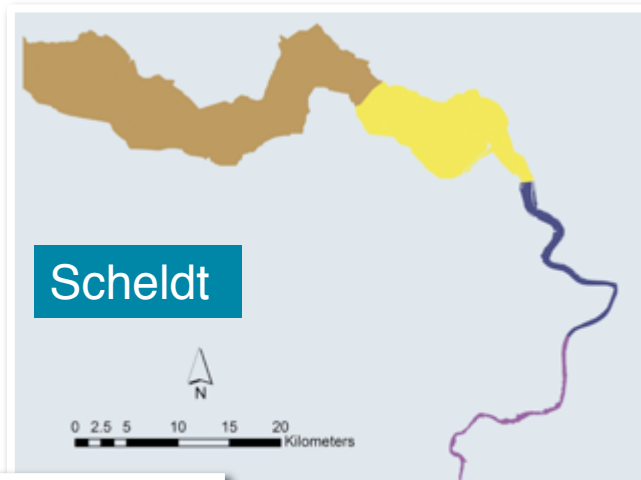


TIDE

Tidal River Development

TIDE zonation

- Polyhaline
- Mesohaline
- Oligohaline
- Freshwater 3
- Freshwater 2
- Freshwater 1

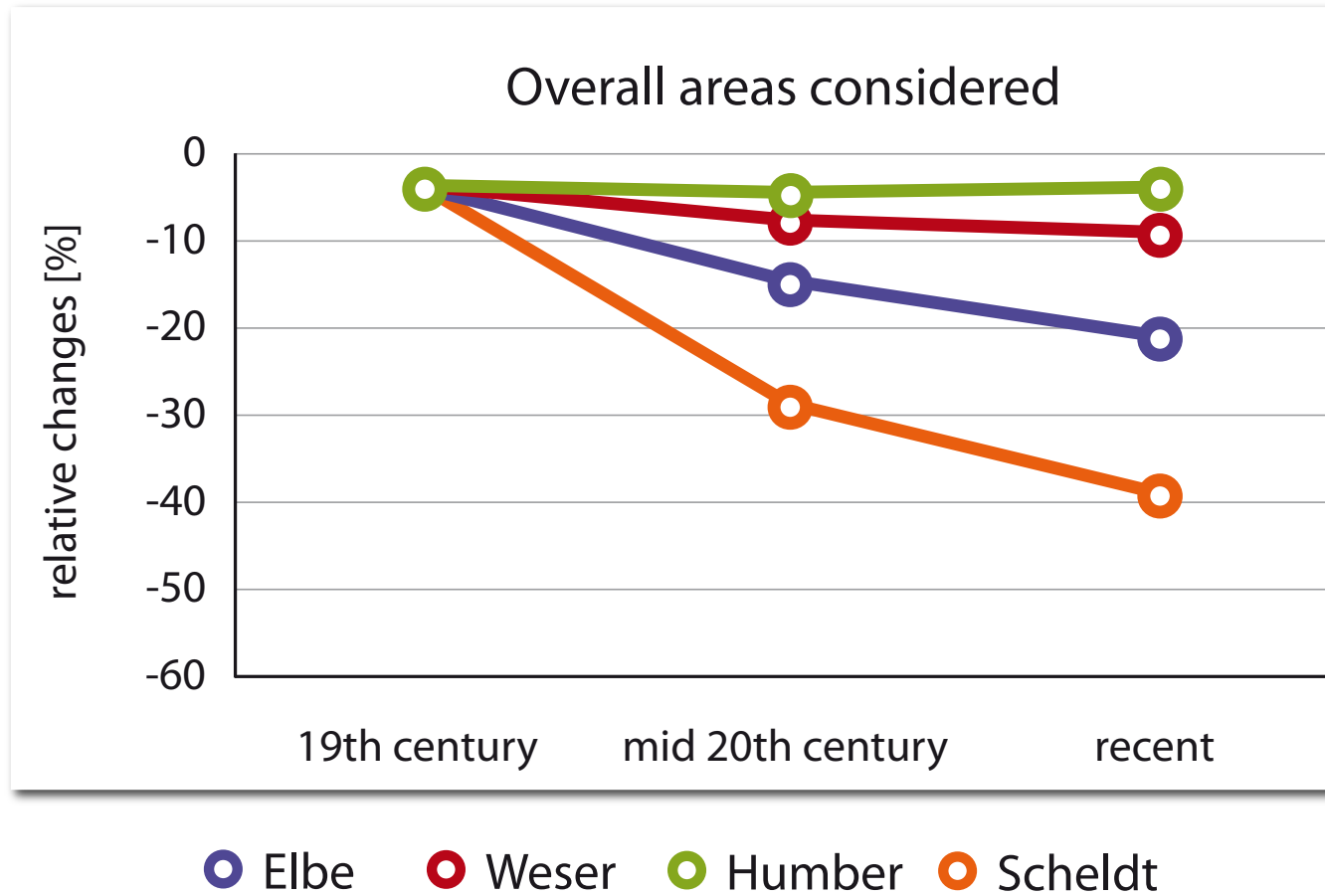


Historical evolution

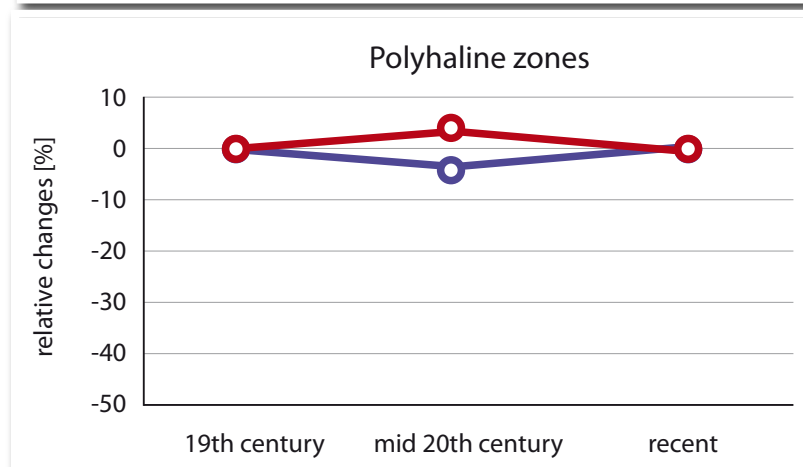
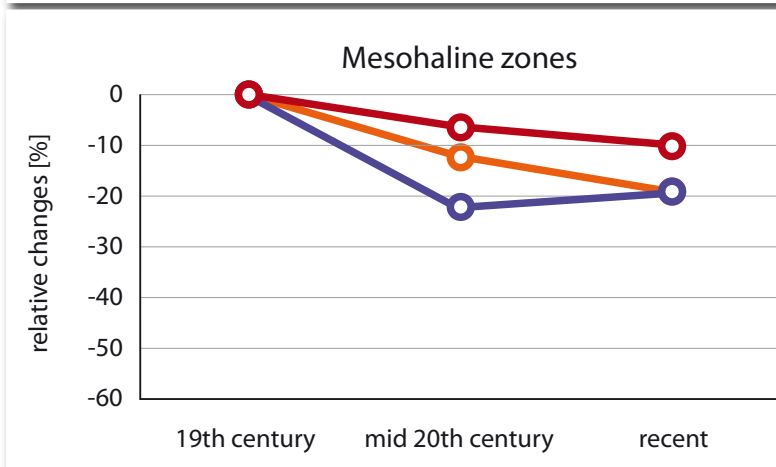
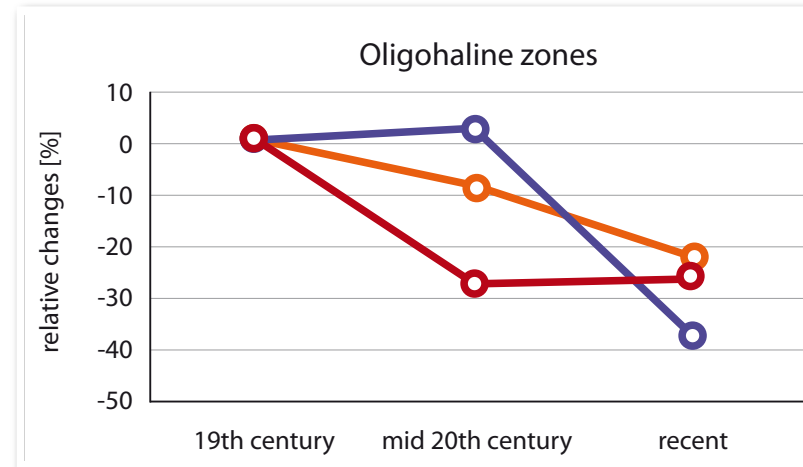
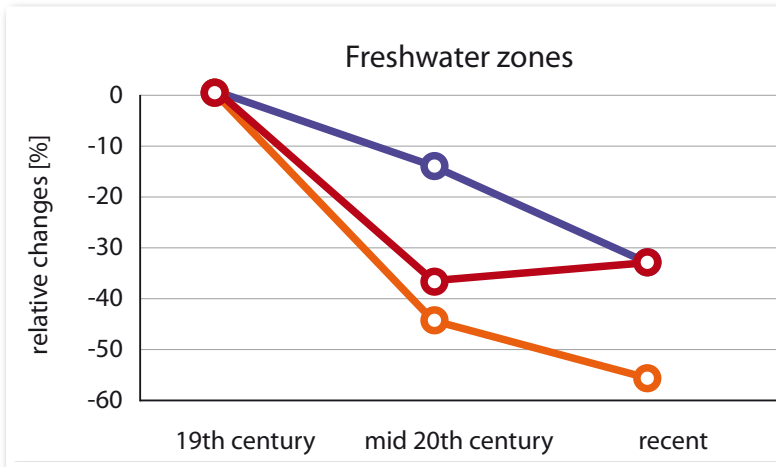
The hydrogeomorphology of estuaries was affected by:

- Straightening and deepening
- Building dykes
- Claiming land for agriculture and habitation
- Protecting shorelines
- Isolating / cutting off tributaries and side channels

Spatial changes



Spatial changes



● Elbe ● Weser ● Scheldt

Spatial changes

Humber

- Overall size of estuary greatly reduced during 18th and 19th centuries through land claims for agriculture and port development
- More recently: relatively stable (20th century)
- Highest losses occurred in the oligohaline zone

Scheldt

- More than 50% of freshwater area has disappeared
- Mesohaline zone: loss is less than 20%

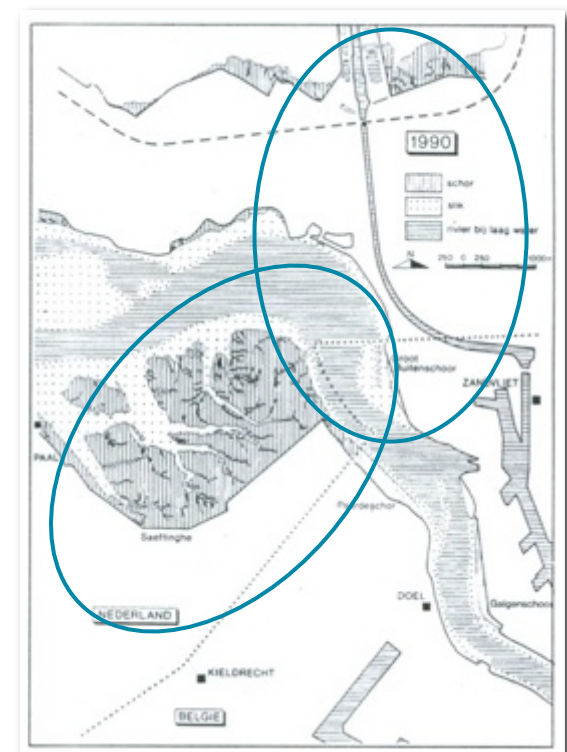
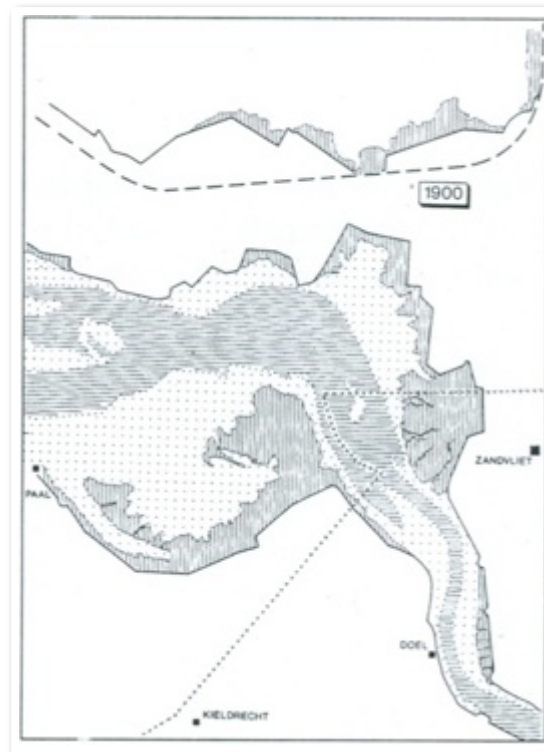
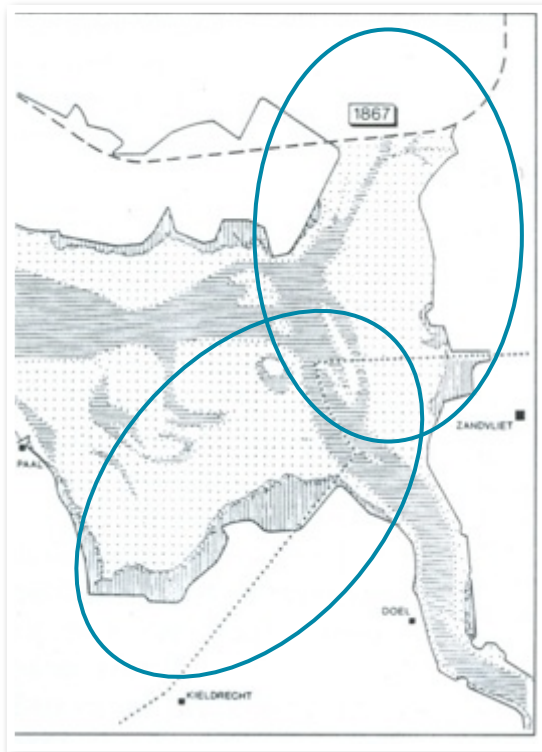
Elbe

- 16% of the area was lost in the last century
- Highest loss in freshwater zone
- Polyhaline zone has remained stable

Weser

- Total loss of 4%, more than one third in freshwater zone
- No substantial change in polyhaline zone

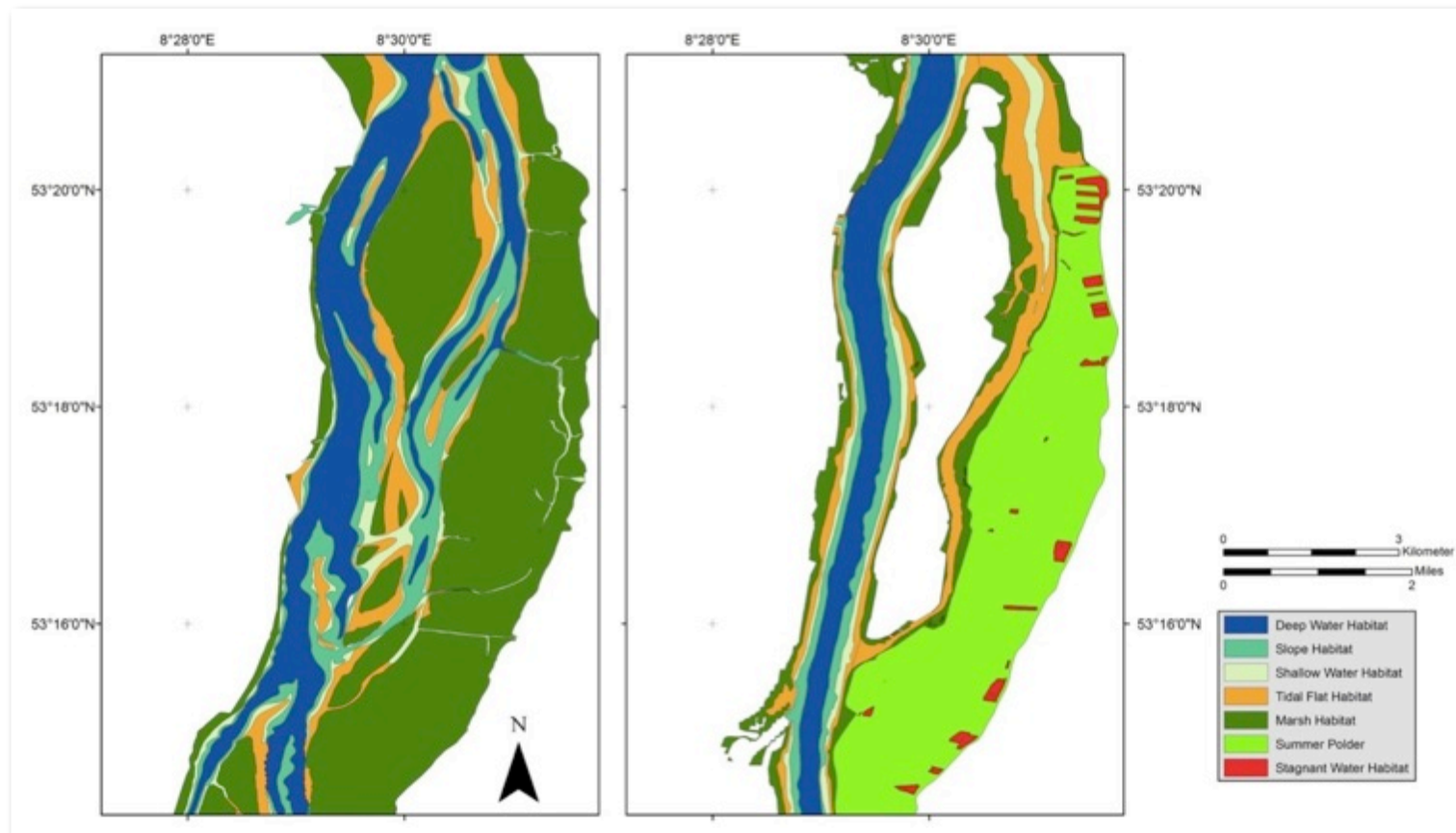
Changes in the Scheldt estuary Dutch-Belgian border 1867-1990



Changes in habitat patterns Weser - Harrier Sand

End of 19th century

Recent



Key messages

- Habitat loss is apparent, mainly in intertidal areas
- Losses upstream are significant, although small in area compared to downstream parts
- Upstream losses are sometimes relatively more important than downstream ones in terms of their ecological significance



The four TIDE estuaries

SUMMARY

- TIDE created its own consistent zonation approach for comparing the estuaries.
- All estuaries show highest losses of area in the inner estuary.
- The loss of estuarine area can be related to several anthropogenic impacts, e.g. isolation of tributaries, dyke construction, straightening and deepening.
- Changes in hydromorphological features have changed the abundance and distribution of certain habitats which are important for ecological functioning of the system.



Estuary functioning

Topics for interestuarine comparison

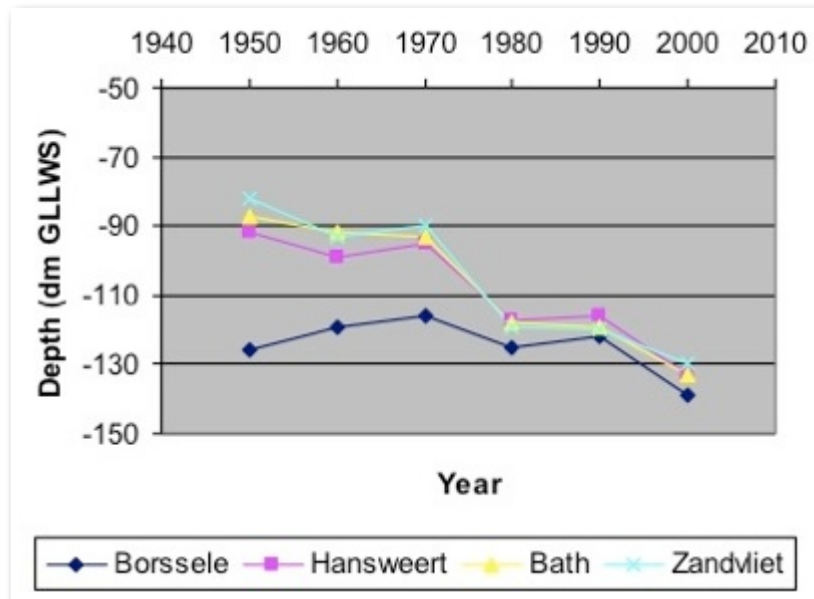
- Hydro-geomorphology
- Filtering functions
- Primary production
- Dissolved oxygen levels
- Habitat and bird distribution



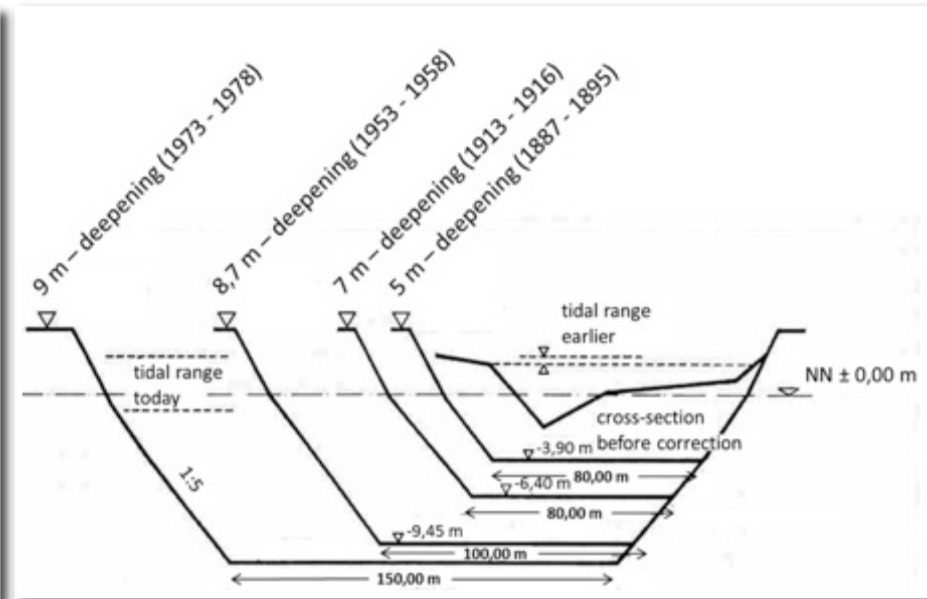
Tidal amplification in relation to morphology

- Which factors influence the amplification of the tide in an estuary?
- How can tidal amplification in an estuary be stopped or reduced?

Changes in morphology

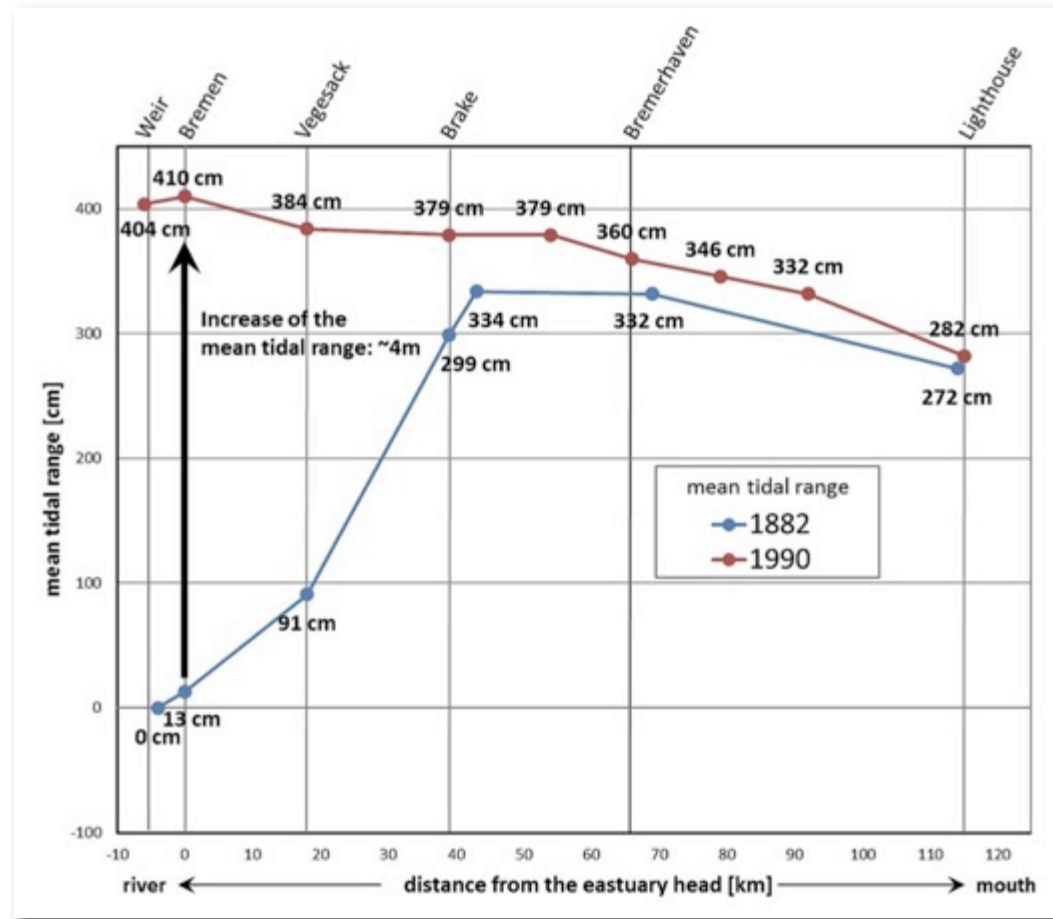


Deepening of the Scheldt estuary
1950 - Recent times

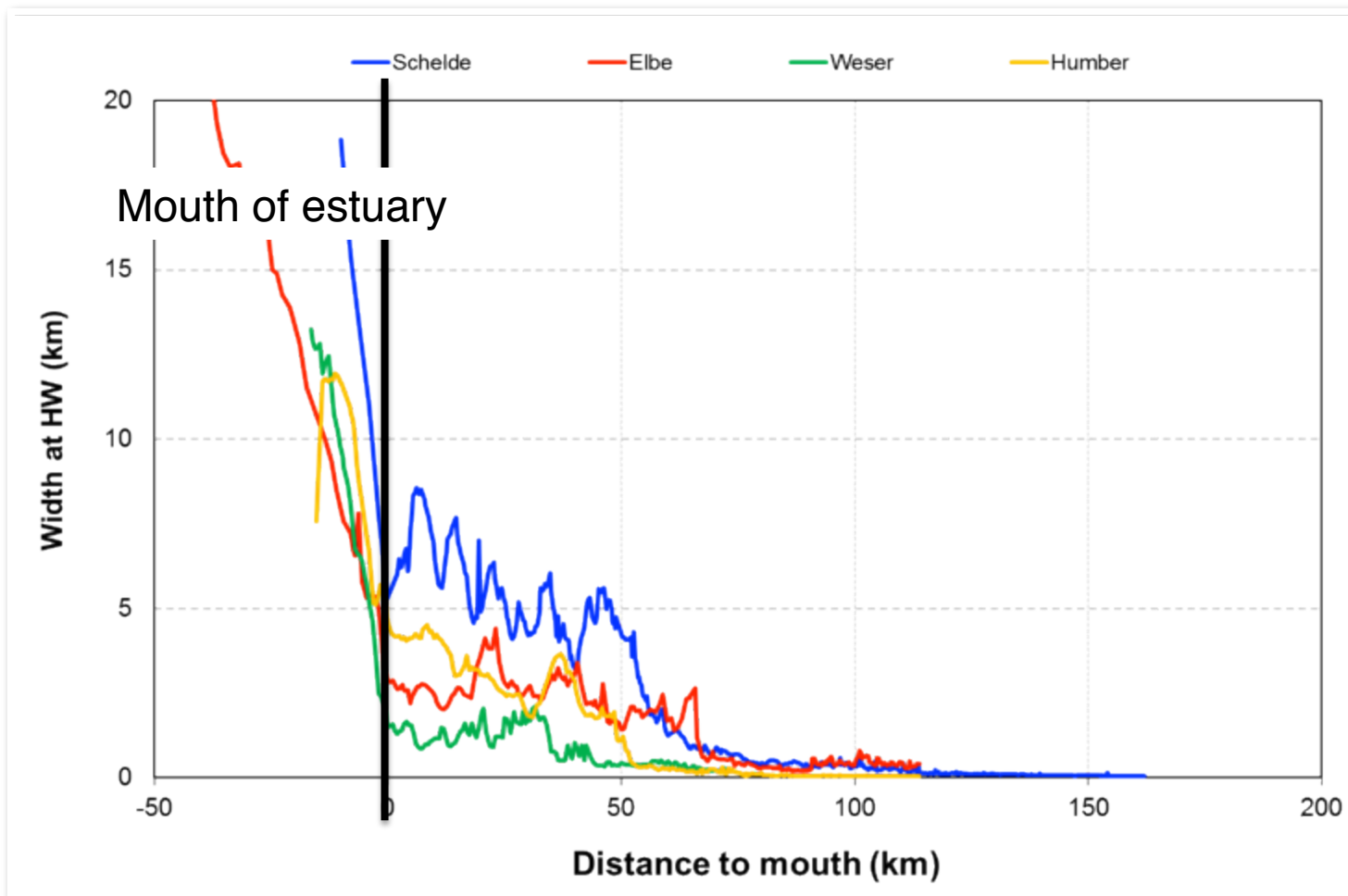


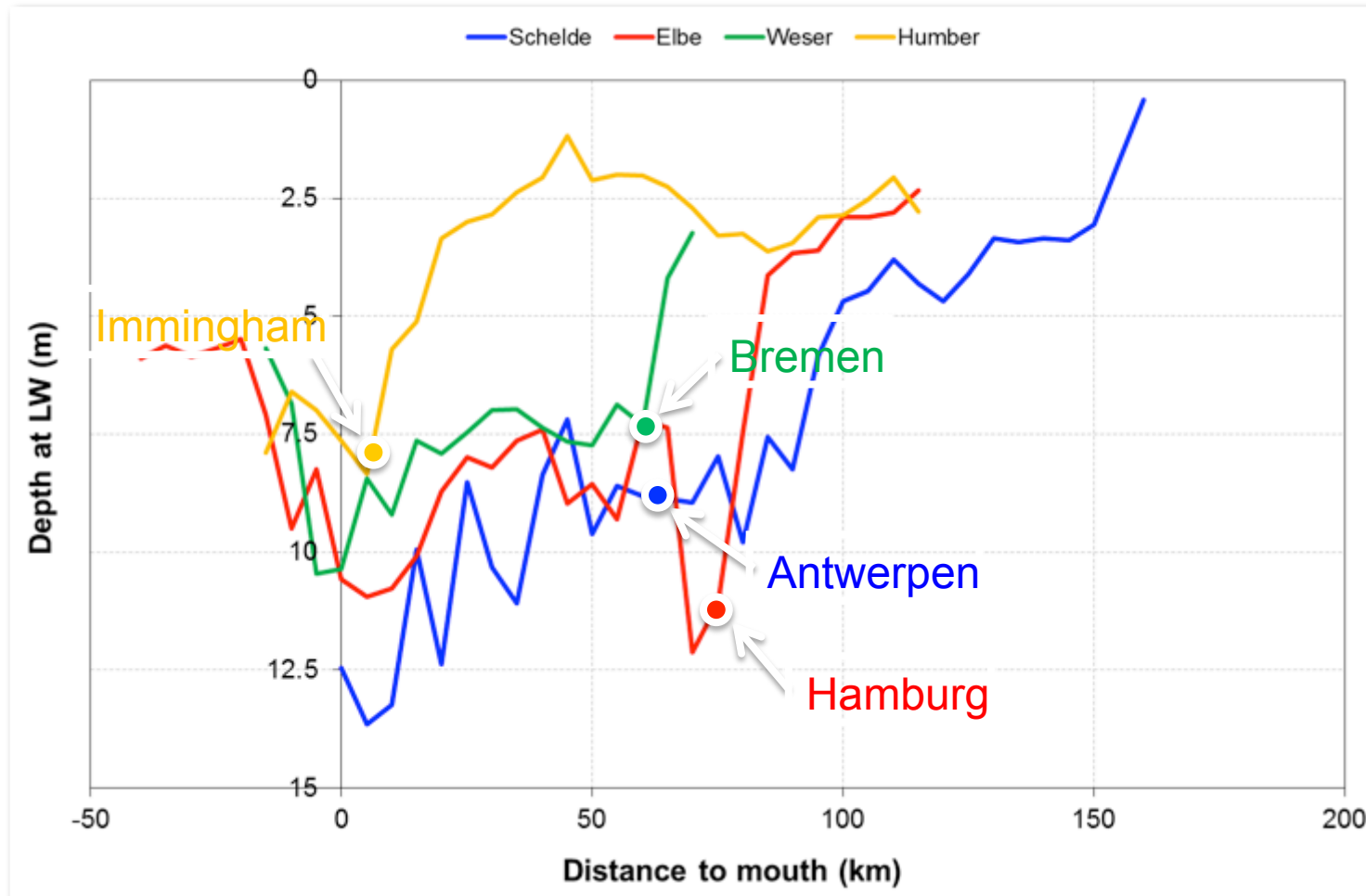
Deepening of a section of the lower Weser estuary
1880 - Recent times

Changes in tidal range in the Weser estuary

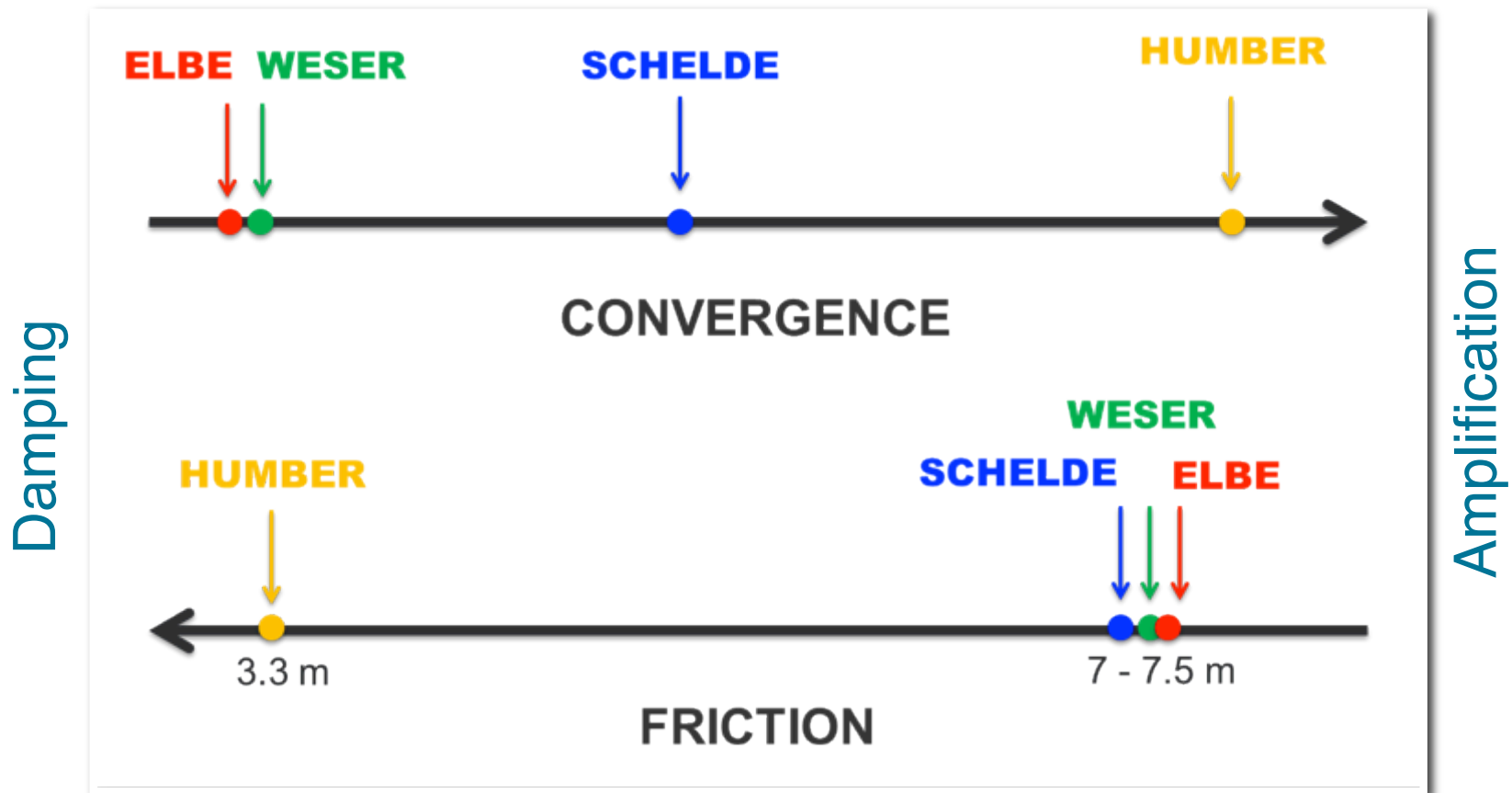


Convergence

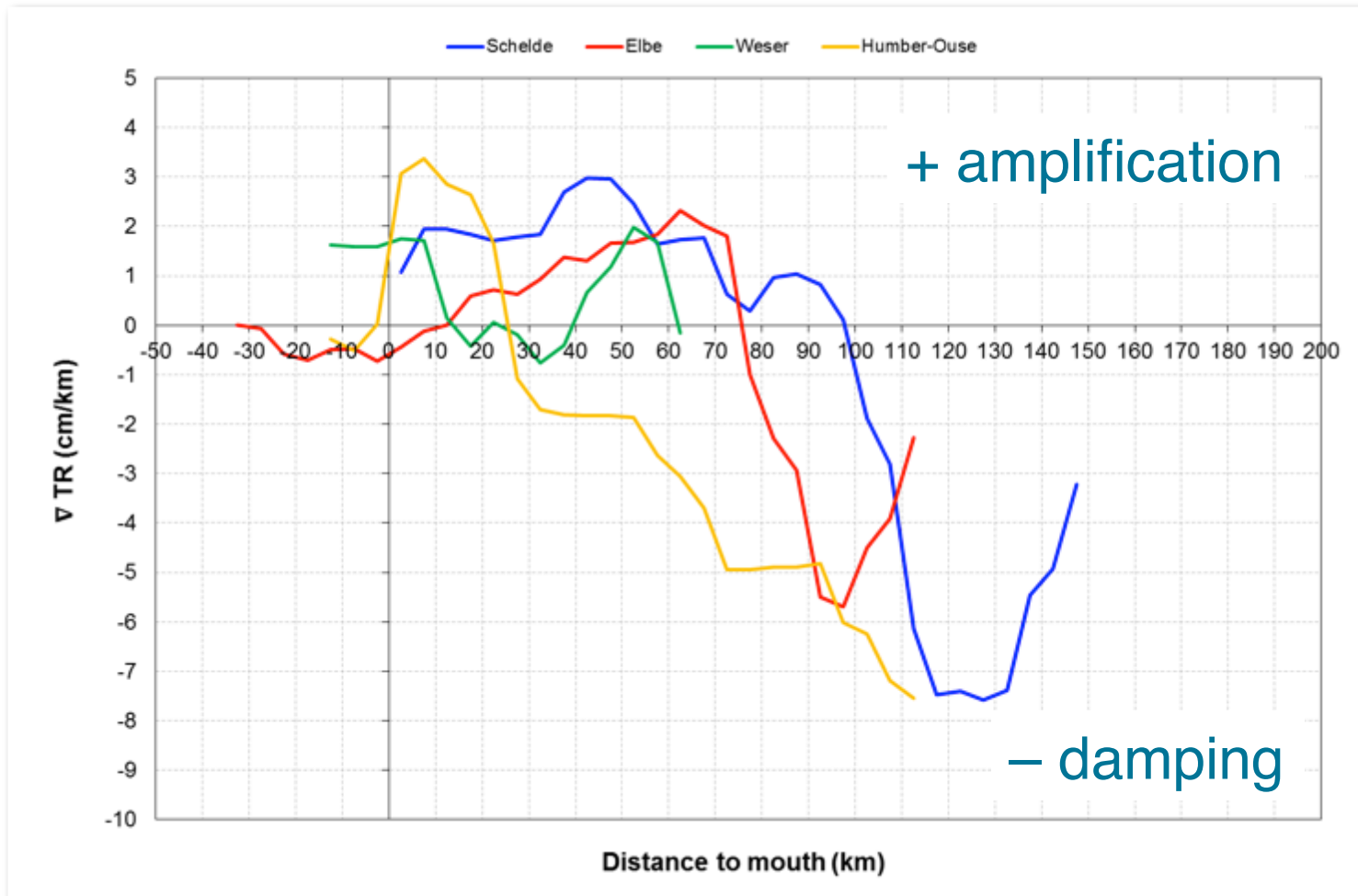




Convergence vs. friction



Tidal damping / amplification



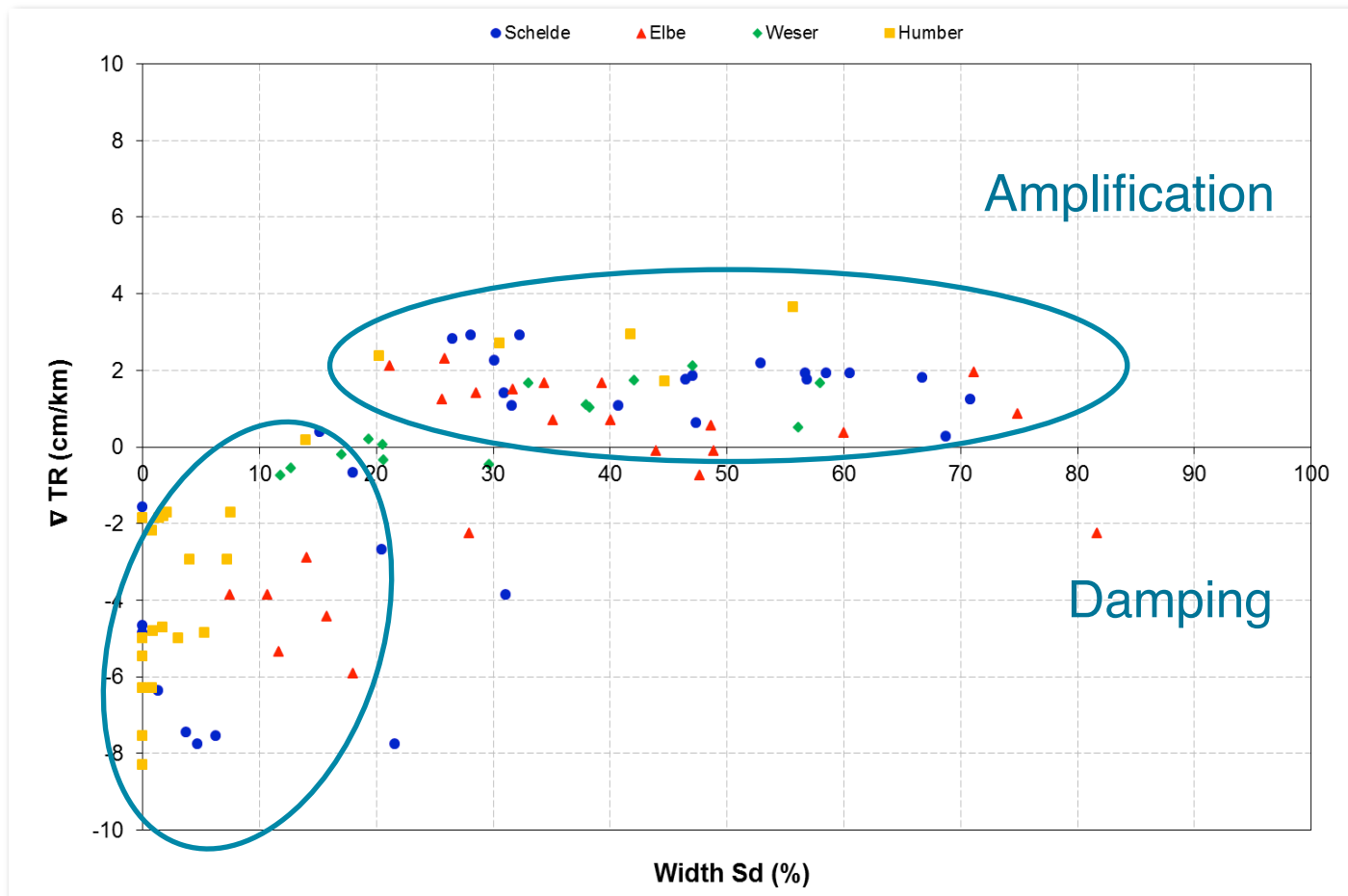
Tidal characteristics: Conclusions

- DAMPING < 4.2 - 7.7 m deep < AMPLIFICATION
- The more convergent the estuary, the smaller the critical estuary depth

BUT

- More estuaries needed in analysis
- Other proxies for friction needed
- Analyse not only tidal range, but also changes in high and low water levels

Habitats and the vertical tide (tidal range)



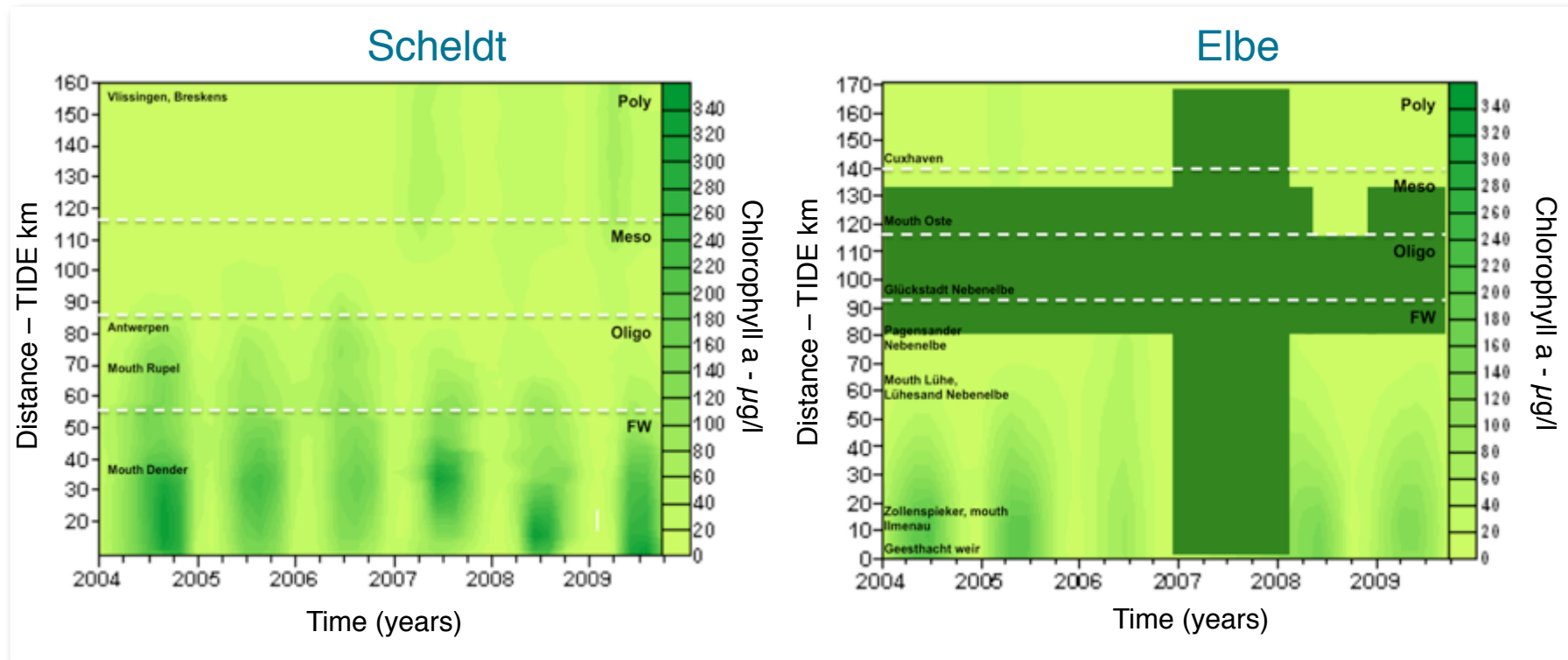
Hydro-geomorphological parameters

	Elbe	Weser	Humber	Scheldt
Maximum tidal range (mean tide) [m]	3,6	4,1	5	5,5
Tidal amplification				
Maximum TRx/TR0 (0 = mouth, x distance x until the mouth)	1,3	1,1	1,15	1,4
Maximum tidal range gradient [cm/km]	2,2	2	3,2	3
Tidal damping				
Minimum tidal range gradient [cm/km]	-5,5	-0,8	-7,5	-7,5
Maximum flood current [m/s]	1,3	1,3	1,9	1,5
Tidal asymmetry at the upstream border	1,6	1,4	-	1,7
Total freshwater discharge (mean) [m ³ /s]	722	331	209	107
Residence time of the water [days]				
High discharge	16	7	13	50
Mean discharge	29	11	27	92
Low discharge	63	27	69	247
Maximum difference in salinity between winter and summer	16	16	16	13
Estuary volume [billion m ³]	1,45	0,4	0,94	2,85
Estuary surface [ha]	24010	9977	15757	35424
Relative subtidal deep area [%]	37	25	23	49
Relative intertidal flat area [%]	20	31	23	26

Key messages

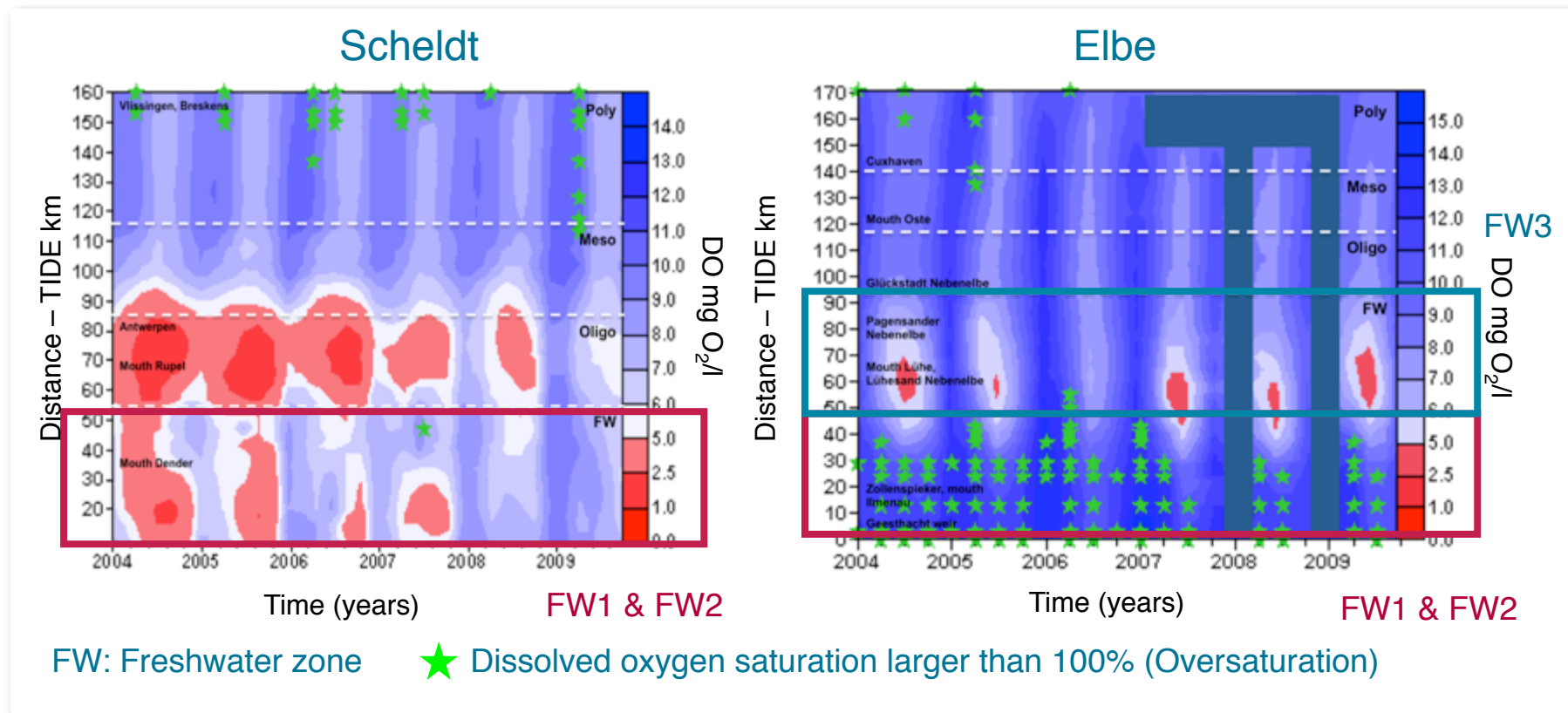
- Habitat loss has a significant impact on tidal propagation
 - Intertidal and subtidal areas are crucial habitats causing friction
- Changes in tidal characteristics are the driving force behind estuarine development.
- Management measures should aim at controlling tidal development and preventing a regime shift.
- Clear goals should be defined for tidal characteristics. Restoration of the intertidal is a key factor!
- In restoration projects: more important to pay attention to impact of realignment on tidal characteristics than on structural biodiversity. This should be taken into account in compensation schemes.

Algal biomass

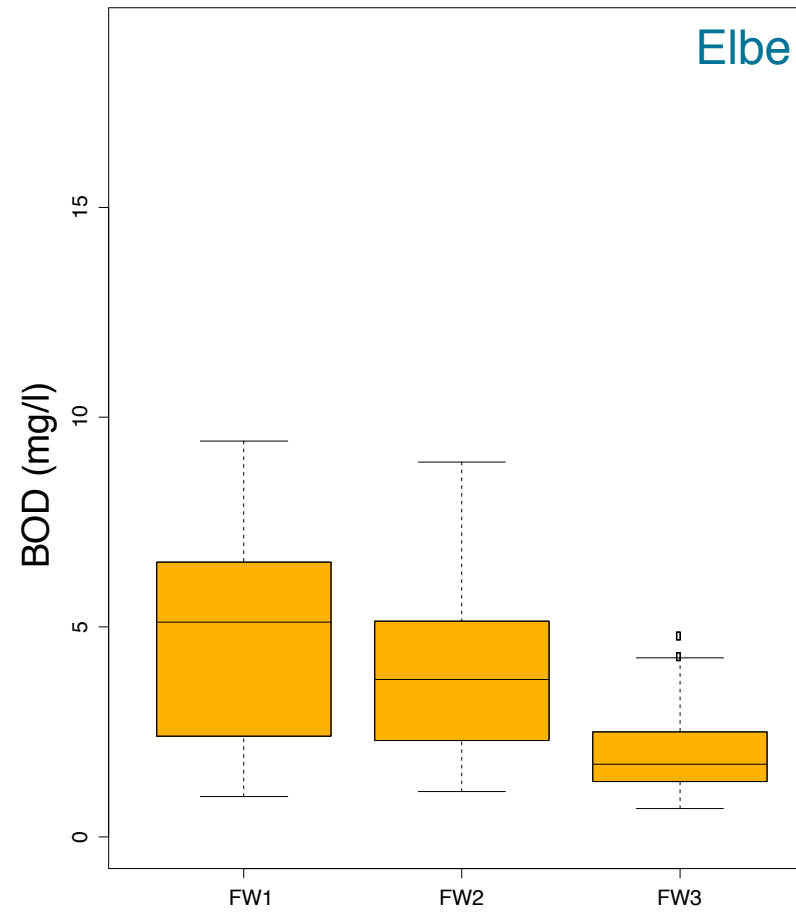
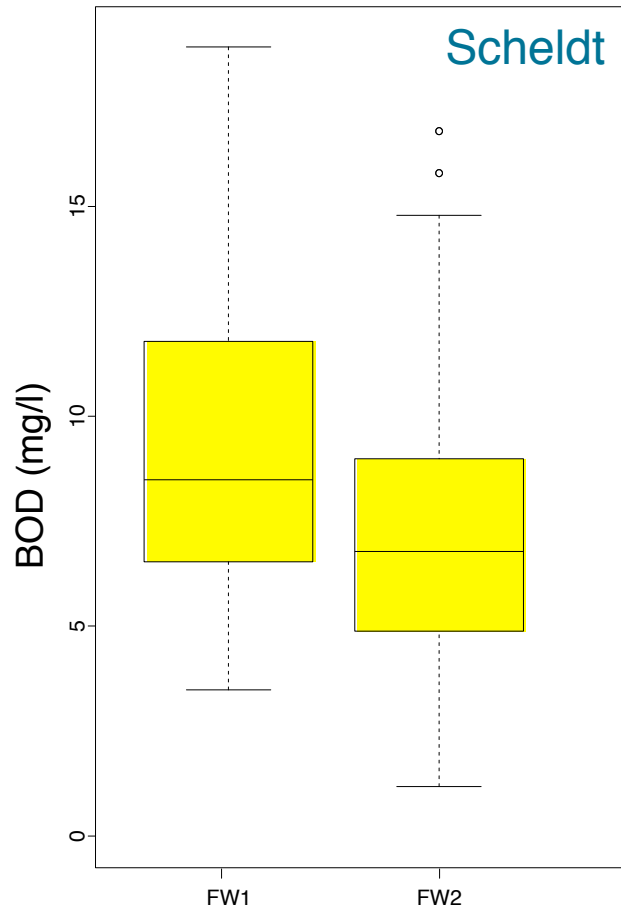


- Chlorophyll a highest upstream
- Chlorophyll a in Scheldt up to twice as high compared to Elbe
- Chlorophyll a proxy for biomass

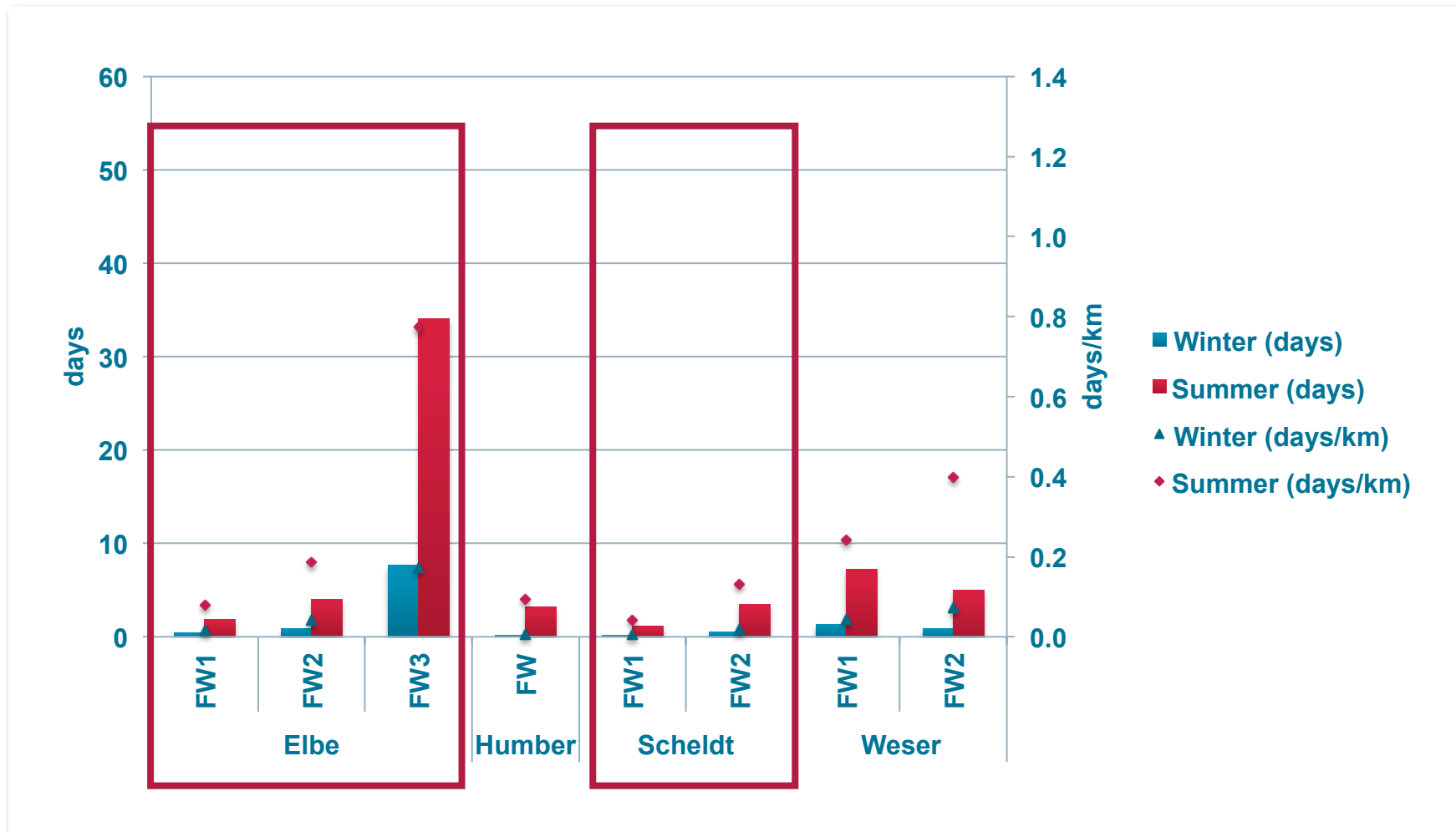
Primary production

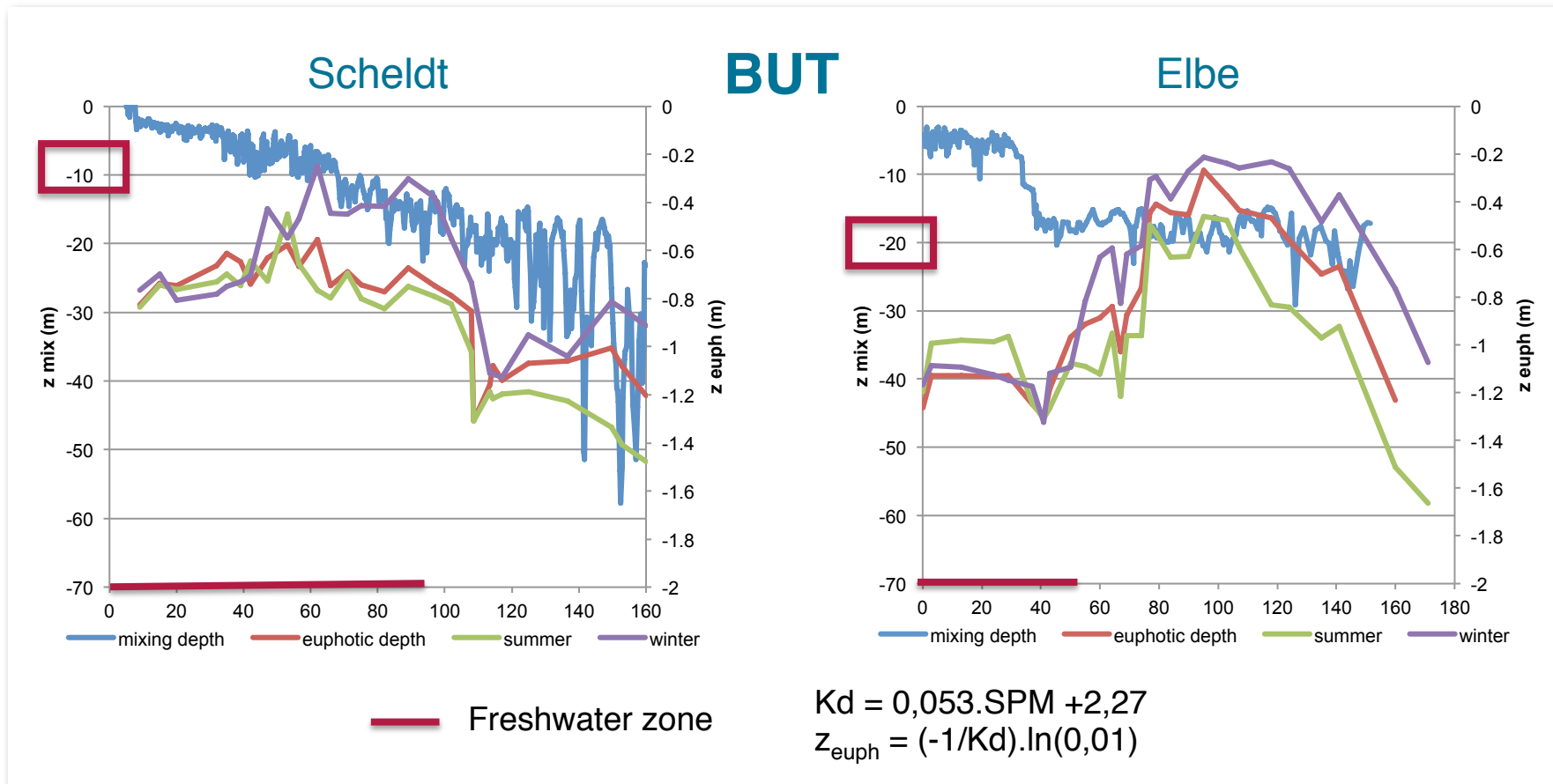


Biological Oxygen Demand

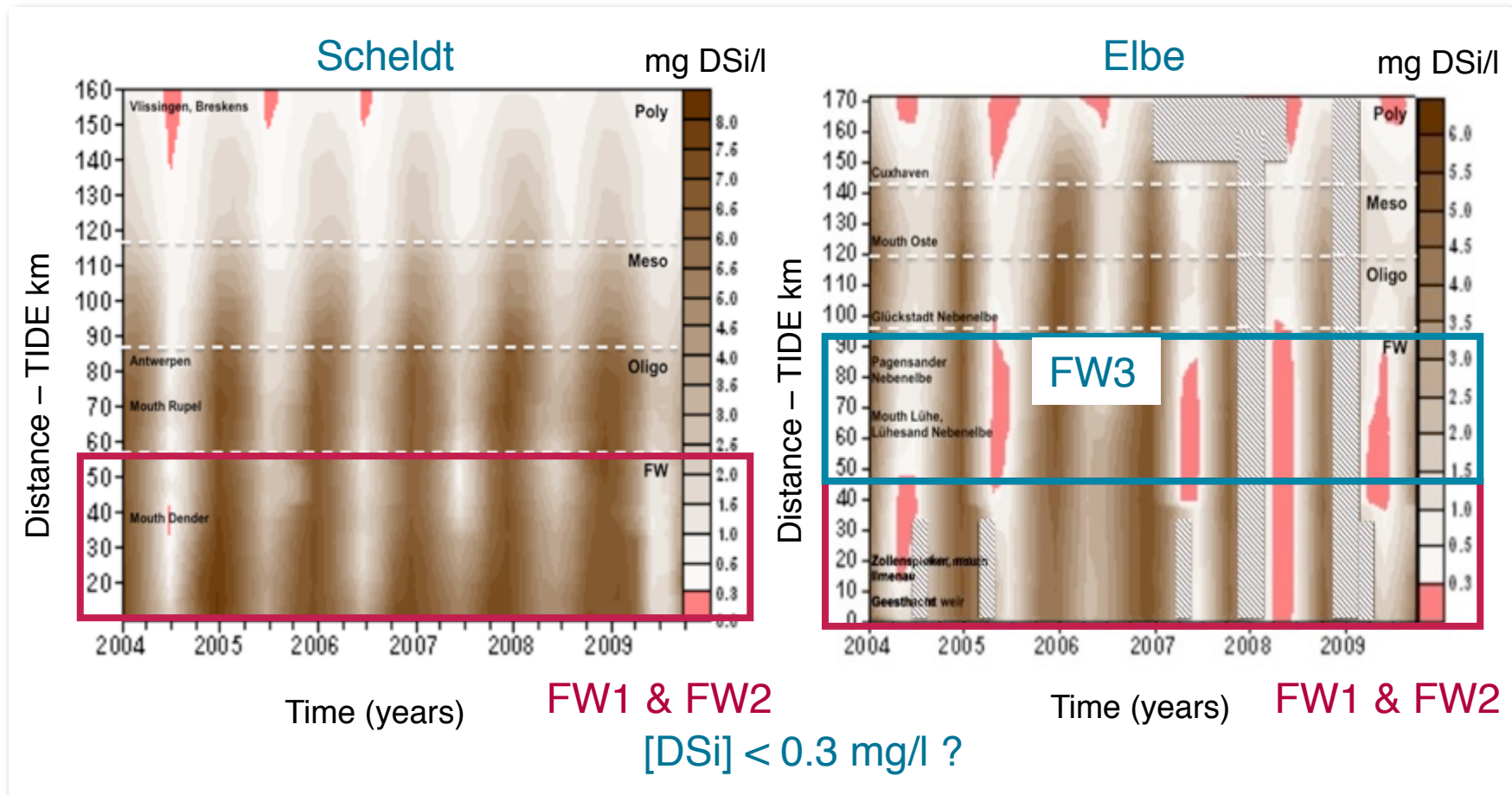


Residence time



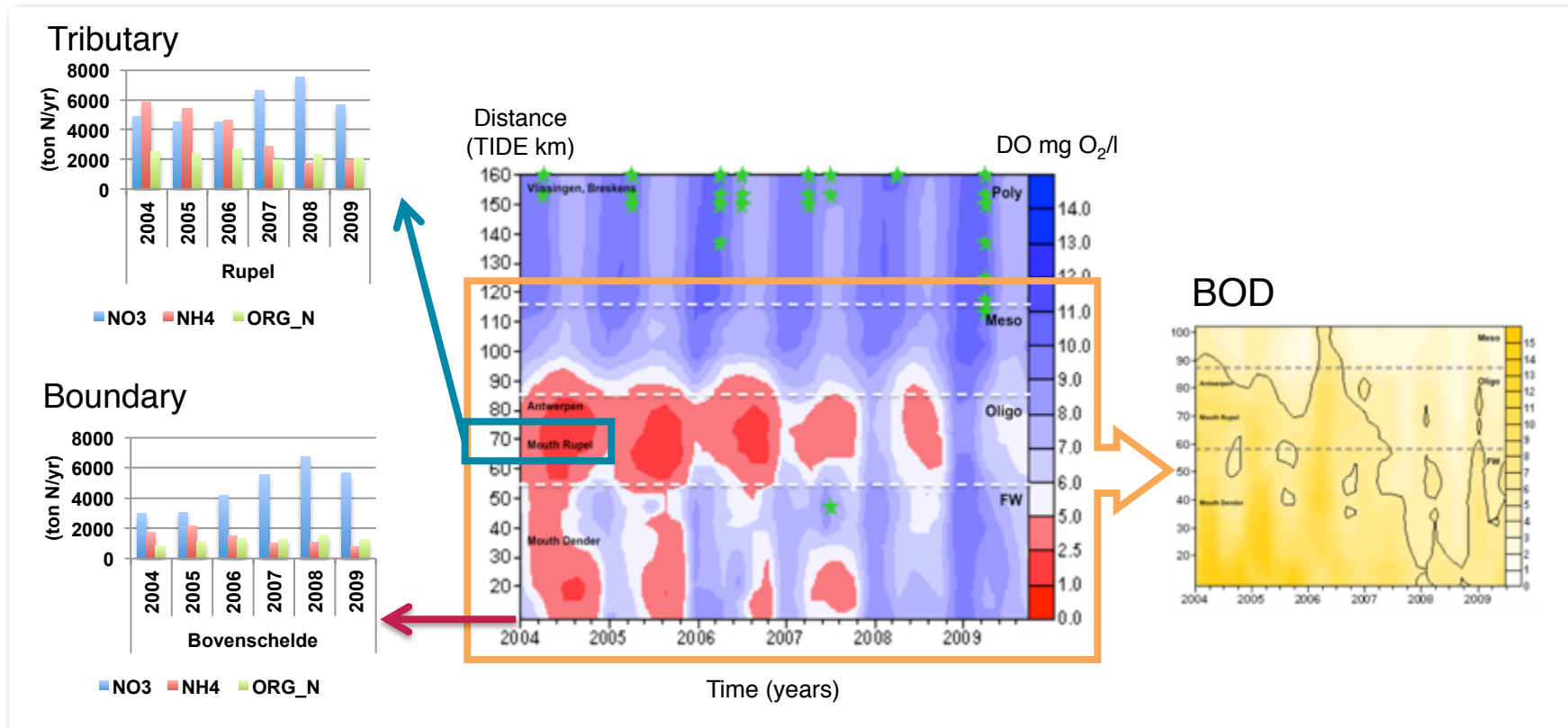


Dissolved silica limitation



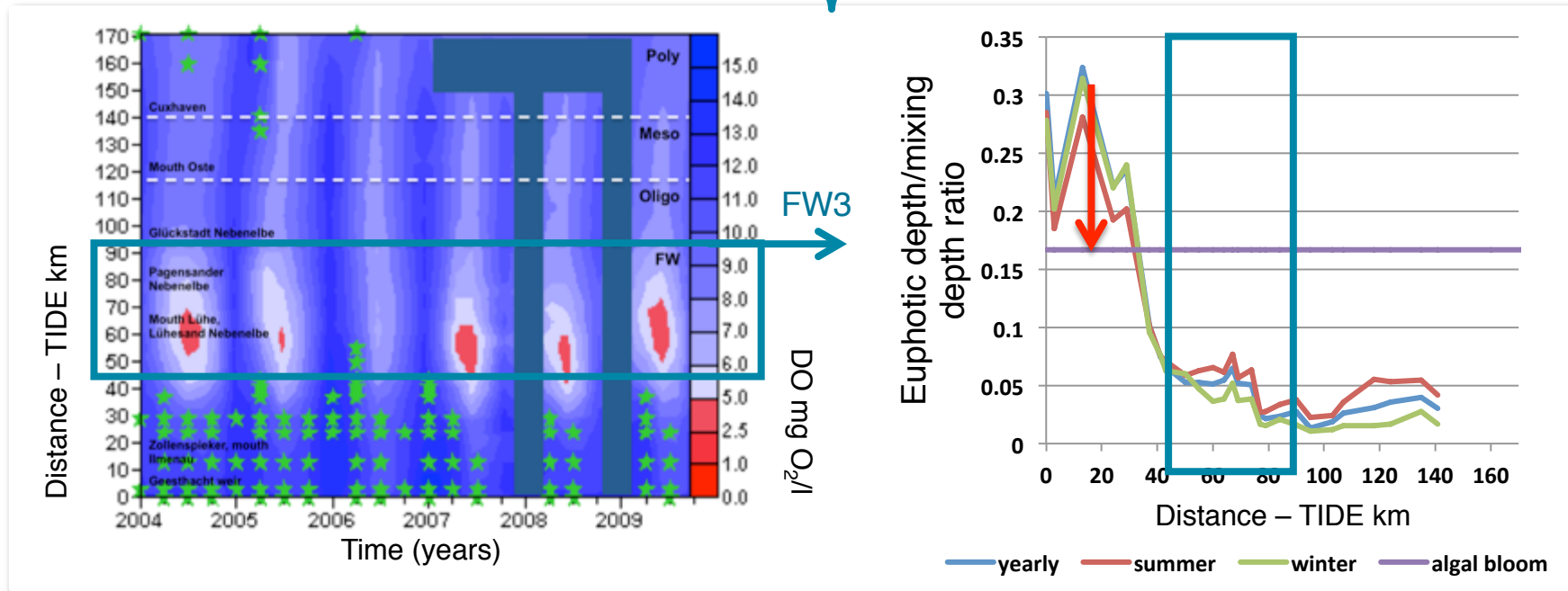
Dissolved oxygen levels

- DO sag in the Scheldt estuary can be attributed to water quality
- With recent improvements, DO sag became less critical (> 5mg/l)



Dissolved oxygen levels

DO sag can be related to morphology in the Elbe estuary



Filtering functions (nutrients)

Filter function (e.g. nutrients) is one of the most valuable ecosystem services provided by estuaries

With recent improvements in water quality, processes in the sediment gain importance



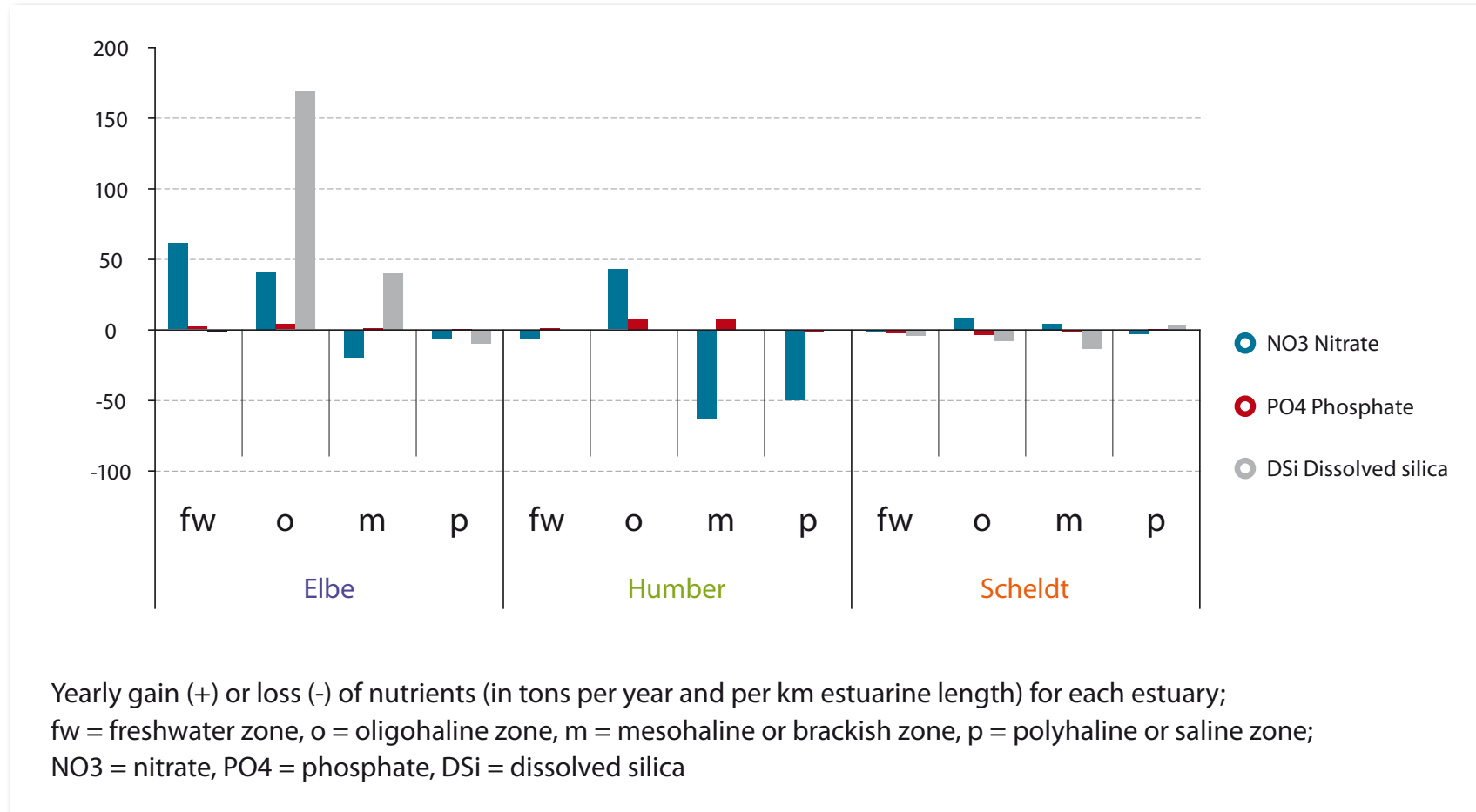
Intertidal habitat

Morphology appears to be able to change the functioning of the estuary (filter function for N decreases)



Geometry of the estuary

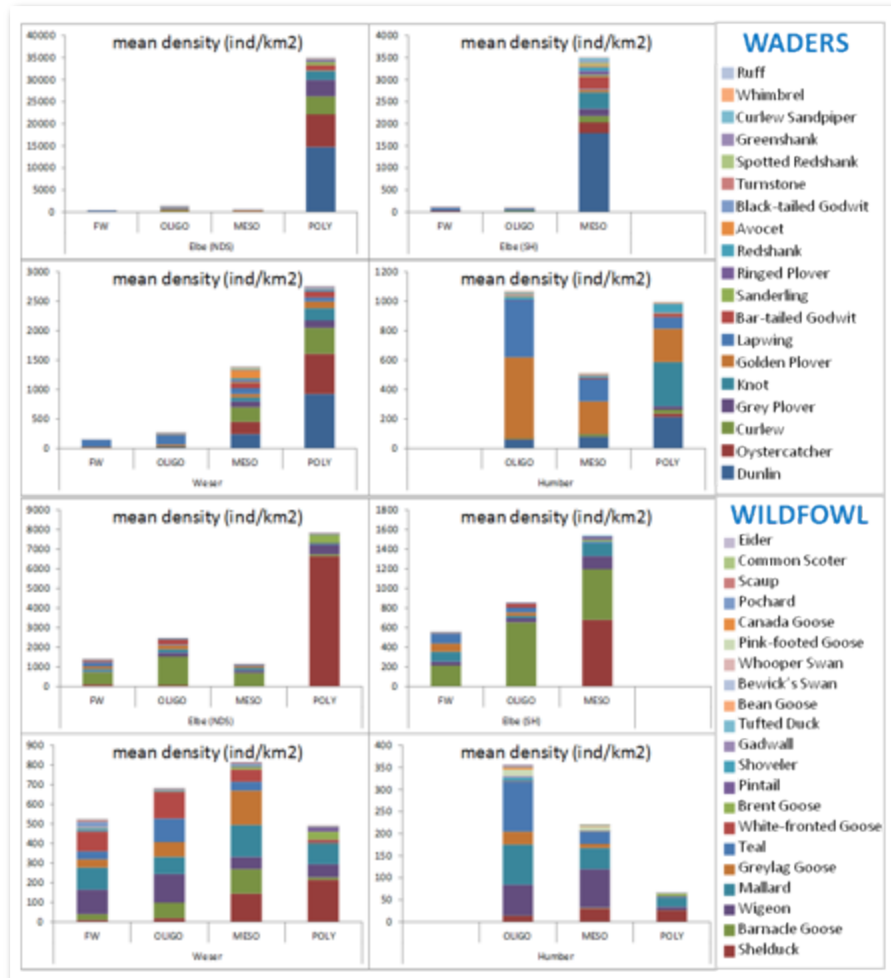
Yearly gain and loss of nutrients



Key messages

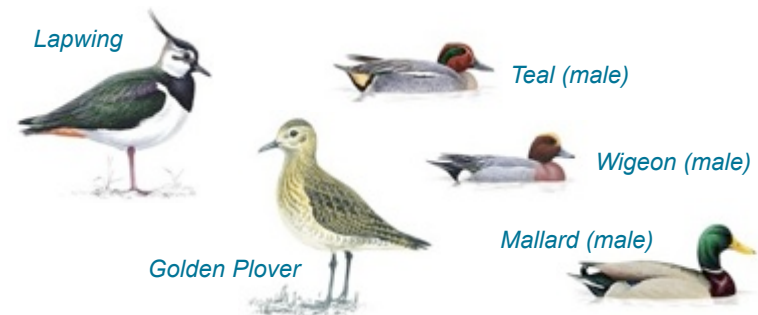
- Clear indications of interaction between residence time, shallow/intertidal area and Z_m/Z_e and their crucial role in productivity, filtering function and water quality
- Significant differences between estuaries in filtering function
- As water quality and filtering function are likely to be linked to morphology this should also be taken into account in management

Mean densities of waders and wildfowl



Analysis identified spatial factors to have a higher influence on bird density variability than temporal ones:

- Outer zones of estuaries support more diverse and dense bird assemblages. This is likely a result of greater availability of suitable habitats and proximity to adjacent coastal areas (e.g. Elbe)
- Locally, inner (oligohaline) areas may also be relevant in supporting abundant populations of some bird species (e.g. Lapwing, Golden Plover, Teal, Wigeon and Mallard in the Humber)





Waterbird disturbance and mitigation toolkit

- Tool for assessing likely disturbance impacts of a plan or project on waterbirds in Natura 2000 estuaries
- PC-based and interactive Android App versions available
 - Free PC-based Toolkit downloadable from TIDE Toolbox website
 - App available from Google Play (Search 'bird disturbance')
- For planners, construction managers and statutory agencies to assess high-level impacts and potential mitigation
- Includes multi-source visual and noise effects advice
- Developed by the Institute of Estuarine & Coastal Studies (IECS), University of Hull with Environment Agency match-funding

Ecosystem services

Result from:

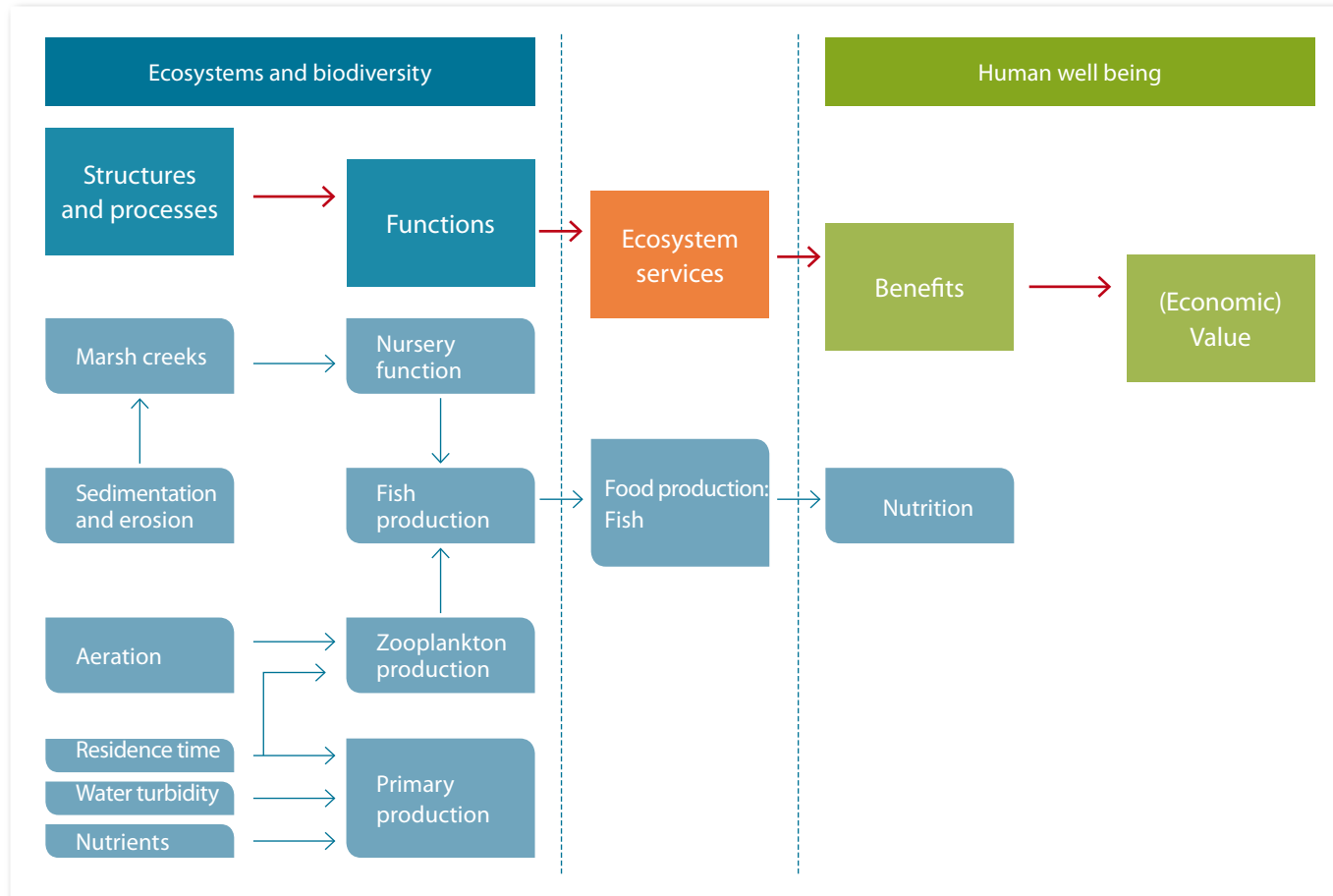
- **Ecosystem functions:** e.g. primary production, nutrient recycling, hydrodynamic conditions ...
- **Biophysical and –chemical Processes:** e.g. plant nutrient uptake, photosynthesis, mineral weathering, sedimentation, tidal pumping ...
- **Structure:** e.g. collection of habitats and species

Ecosystem services

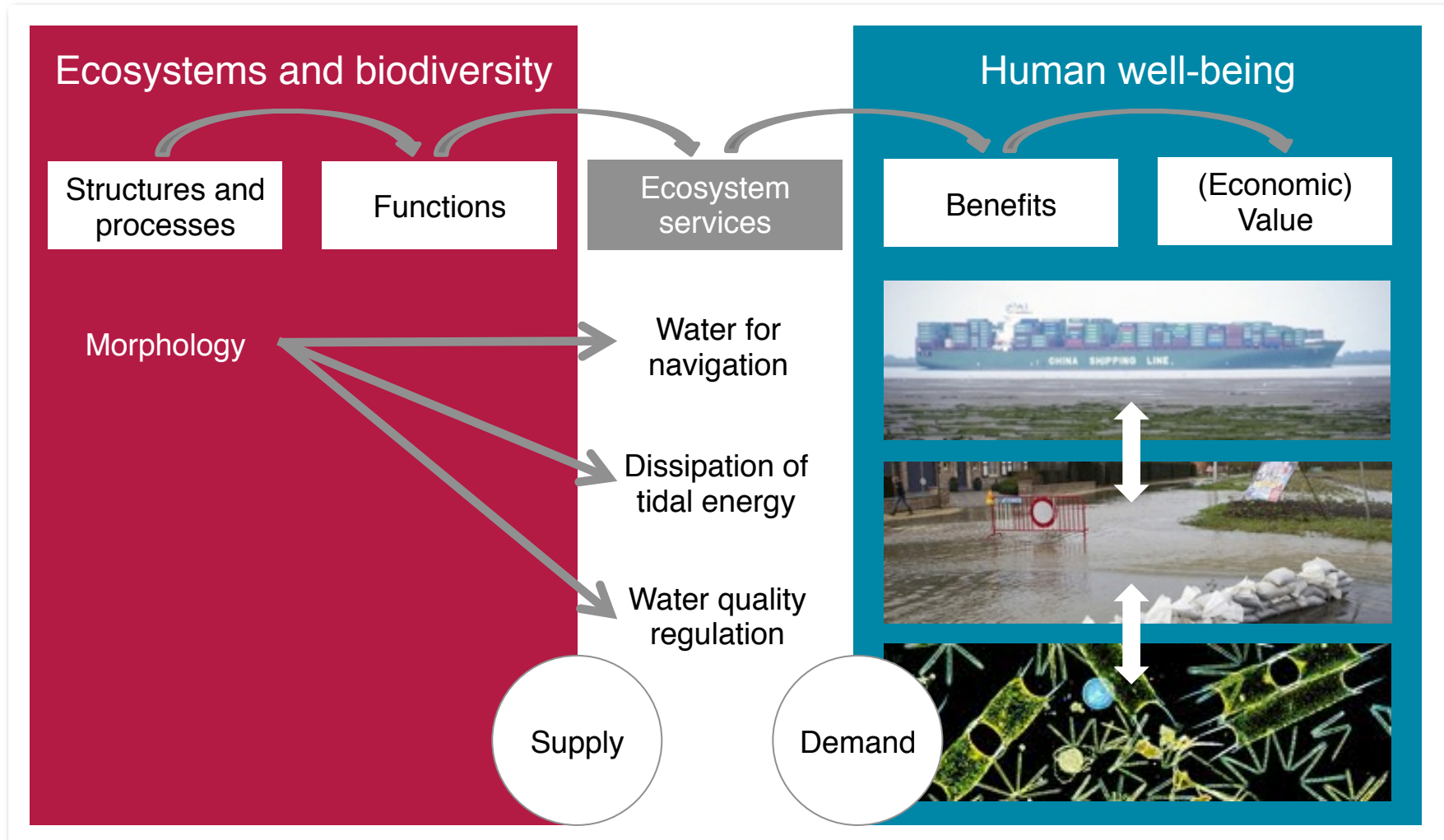
Ecosystem services fall into:

- **Provisioning services:** the products we derive from ecosystems, e.g. food, building materials, fibre, water, etc.
- **Regulating services:** the benefits obtained from the regulation of ecosystem processes, such as air quality and climate regulation or natural hazard regulation
- **Habitat services:** e.g. formation and maintaining of habitats and gene pools
- **Cultural services:** non-material benefits people obtain from nature, e.g, aesthetic, spiritual, educational and recreational

Ecosystem services



Pathway from ecosystem structures and processes to human well-being





Process

Define ecosystem services

- Pragmatic approach
- List of 44 ecosystem services

Demand survey

- Mainstream the concept among partners
- Determine most important ecosystem services to analyse → 20
- Score services (4 per estuary, 4 per salinity zone)
- Importance seen as the demand for an ecosystem service

Supply survey

- Link between services and natural structures
- Ecosystem services are delivered by habitats and species (Service Providing Units)
- Score how important each habitat is for supply of each service (4 per estuary, 4 per salinity)
- 12 scientific/professional respondents

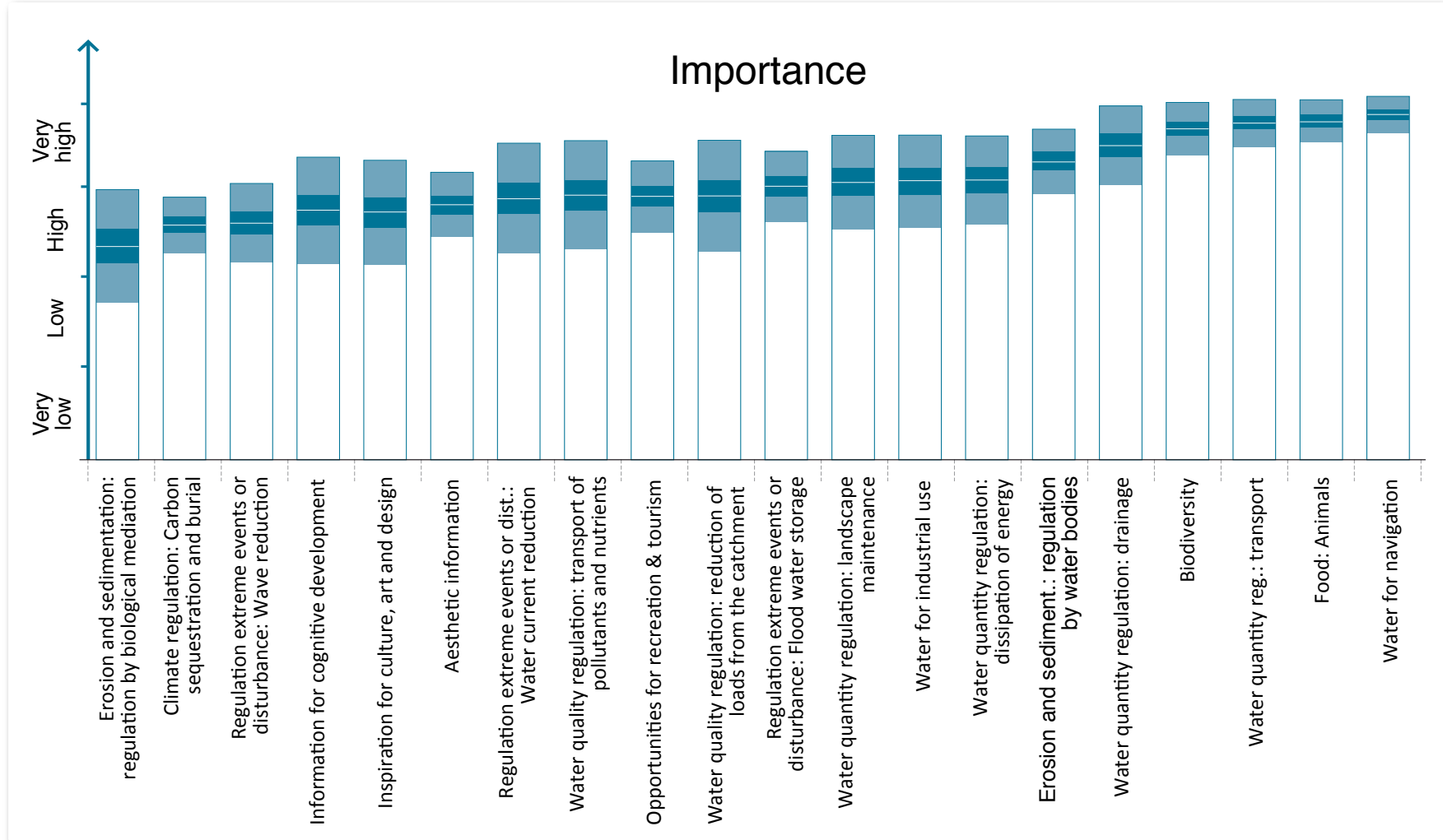


Selection of 20 'important' ecosystem services for TIDE

How essential are the services produced?

Important Ecosystem Services in TIDE estuariesz	Category
Food: Animals	Provisioning
Water for industrial use	Provisioning
Water for navigation	Provisioning
Climate regulation: Carbon sequestration and burial	Regulating
Regulation extreme events or disturbance: Flood water storage	Regulating
Regulation extreme events or disturbance: Water current reduction	Regulating
Regulation extreme events or disturbance: Wave reduction	Regulating
Water quantity regulation: drainage of river water	Regulating
Water quantity regulation: dissipation of tidal and river energy	Regulating
Water quantity regulation: landscape maintenance	Regulating
Water quantity regulation: transportation	Regulating
Water quality regulation: transport of pollutants and excess nutrients	Regulating
Water quality regulation: reduction of excess loads coming from the catchment	Regulating
Erosion and sedimentation regulation by water bodies	Regulating
Erosion and sedimentation regulation by biological mediation	Regulating
"Biodiversity"	Supporting
Aesthetic information	Cultural
Opportunities for recreation & tourism	Cultural
Inspiration for culture, art and design	Cultural
Information for cognitive development	Cultural

Ecosystem services demand





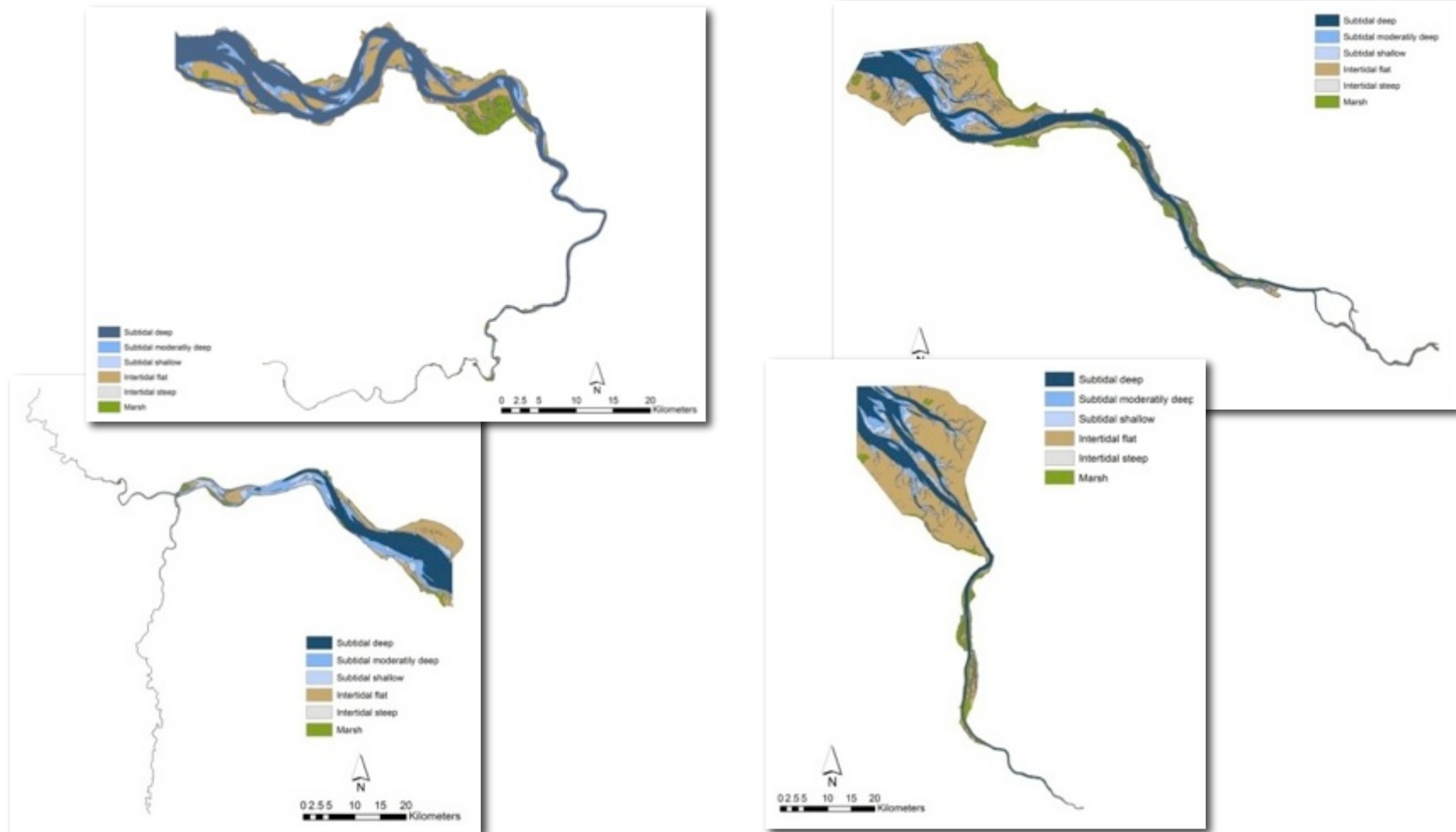
Ecosystem service supply per habitat type

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 moderately 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

Ecosystem service supply score per habitat type

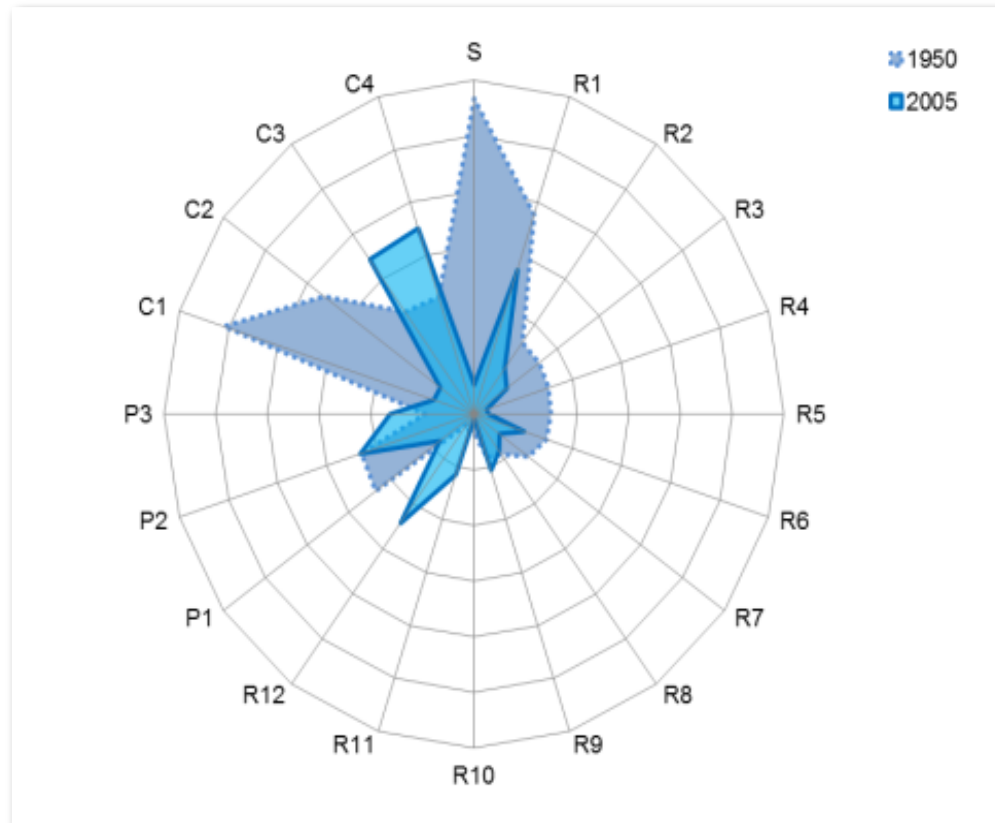
Define similar habitats



Ecosystem services supply

	Elbe	Weser	Humber	Scheldt	
Mean high water level	3	4	2	1	Safety, drainage
Tidal range	4	3	2	1	Safety, drainage
Tidal energy flux	4	3	2	1	Energy dissipation
Tidal amplification	3	4	1	2	
Tidal damping	2	4	1	3	
Maximum flood current	3	4	1	2	Erosion, sediment transport
Tidal asymmetry at the upstream border	2	3	?	1	Sediment transport
Freshwater discharge	1	2	3	4	Drainage, transport
River energy flux	1	2	4	3	Drainage, transport
Residence time of the water	2	4	3	1	Water quality, primary production
Difference in salinity between winter and summer	3	2	1	4	
Estuary volume	1	4	3	2	
Estuary surface	2	4	3	1	
Relative subtidal deep area	2	3	4	1	Navigation
Relative intertidal flat area	4	1	3	1	Food production, friction
Relative marsh area	2	1	4	3	Diversity, dike protection, sedimentation

Historical analysis



How has the delivery of ecosystem services changes over time?

Insight that loss of a single habitat results in the loss of a bundle of ecosystem services

Example: Weser 1950-2000

Quantifying and understanding underlying processes

- Derive measurable indicators of ecosystem services
- Try to quantify and understand underlying processes
 - Interestuarine comparison
 - Literature review

Ecosystem Service	“subservice”	indicator	measurement
Climate regulation			
	Carbon sequestration	Carbon burial	g C/m ² *y
	Microclimate regulation	Temperature buffering	Net heat flux
Waste treatment			
	N removal	Load reduction	% of input leaving estuary
Water quantity regulation			
	dissipation of tidal and river energy	Tidal damping	I

Key messages

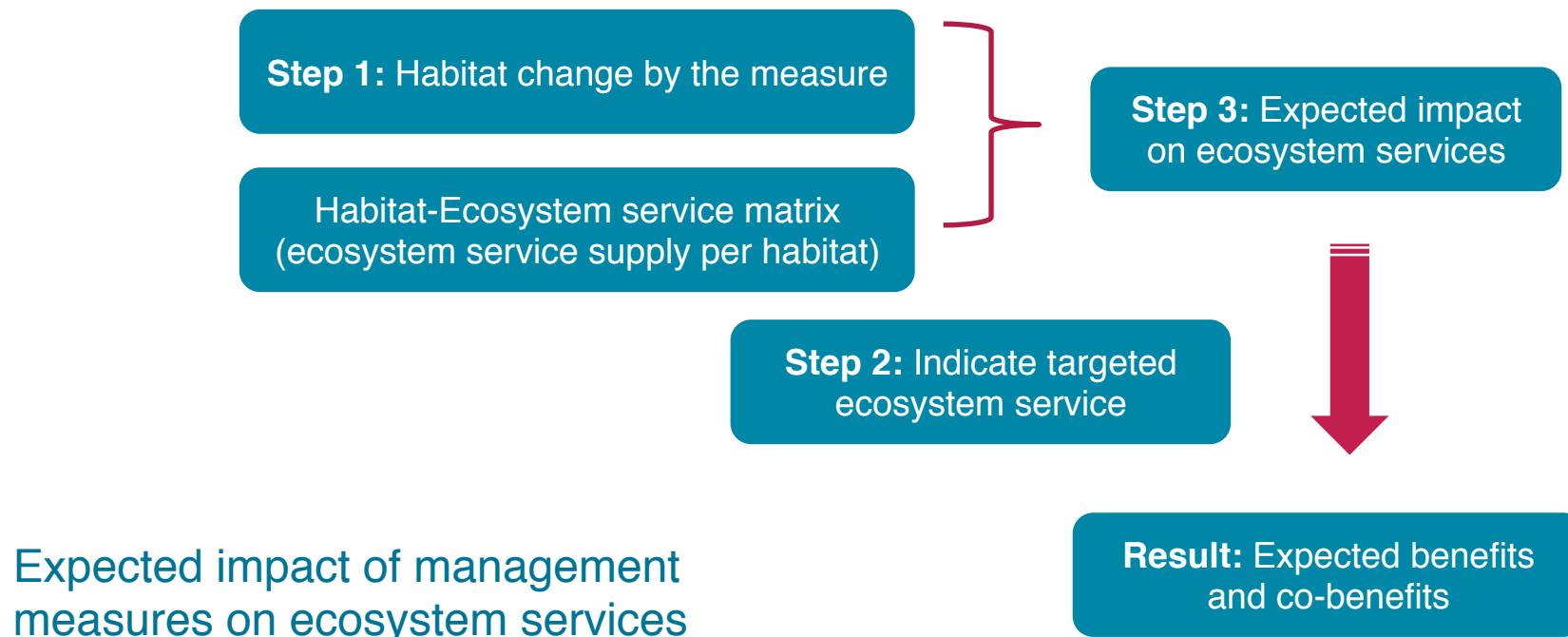
- Ecosystem service concept is good communication tool for interdisciplinary approach
- Ecosystem service approach gives clear framework for a qualitative assessment of importance of different habitats
- Ecosystem service concept gave better insight
 - into importance of intertidal areas for biodiversity AND supporting and regulating services
 - into real impact of changes in estuary
- Habitat loss resulted in a significant loss of regulating services

Loss of ecosystem services leads to economic loss!

From ecosystem services to management practice

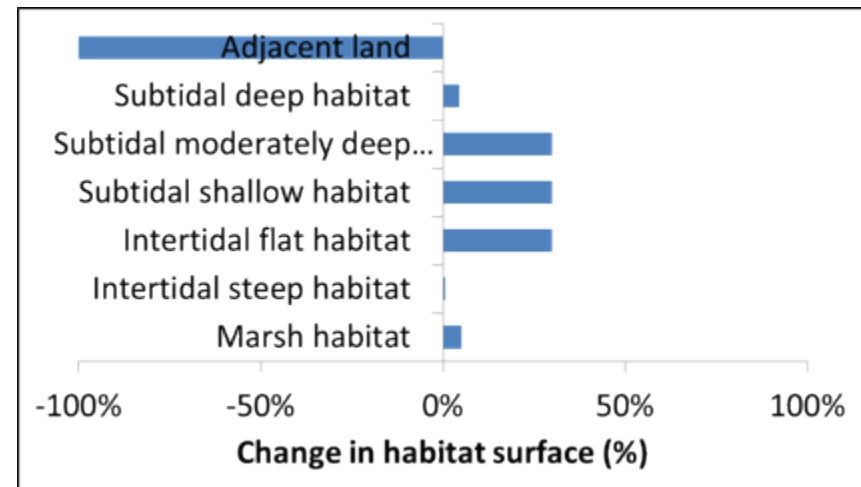
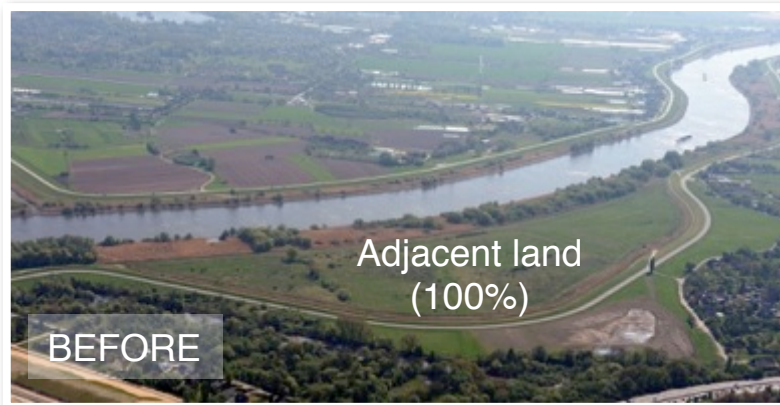
Can ES help us to decide on which measures, management to take?

APPROACH



Step 1: habitat change caused by measure

Example: Spadenlander Bush (in freshwater zone Elbe estuary)



Created habitats:

- Marsh (5%)
- Intertidal steep (0.5%)
- Intertidal flat (30%)
- Subtidal shallow (30%)
- Subtidal moderately deep (30%)
- Subtidal deep (4.5%)

Expected impact on ecosystem services

Step 2: Indicate targeted ecosystem service

Step 3: Expected impact per ecosystem service = habitat change (%) × ecosystem service supply score

Cat.	Ecosystem Service	Targeted?	Expected impact*
S	"Biodiversity"	0	2
R1	Erosion and sedimentation regulation by water bodies	0	2
R2	Water quality regulation: reduction of excess loads coming from the catchment	0	1
R3	Water quality regulation: transport of pollutants and excess nutrients	0	1
R4	Water quantity regulation: drainage of river water	0	0
R5	Erosion and sedimentation regulation by biological mediation	0	1
R6	Water quantity regulation: transportation	0	0
R7	Water quantity regulation: landscape maintenance	0	1
R8	Climate regulation: Carbon sequestration and burial	0	1
R9	Water quantity regulation: dissipation of tidal and river energy	1	1
R10	Regulation extreme events or disturbance: Wave reduction	0	0
R11	Regulation extreme events or disturbance: Water current reduction	0	0
R12	Regulation extreme events or disturbance: Flood water storage	0	1
P1	Water for industrial use	0	0
P2	Water for navigation	1	0
P3	Food: Animals	0	0
C1	Aesthetic information	0	1
C2	Inspiration for culture, art and design	0	2
C3	Information for cognitive development	0	2
C4	Opportunities for recreation & tourism	0	1

Legend: expected impact

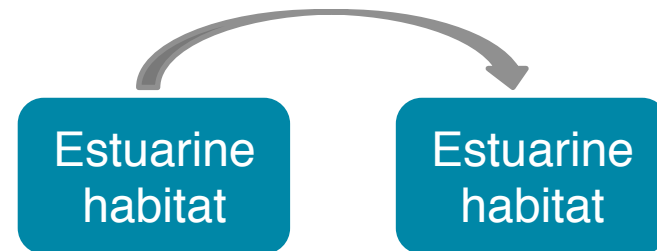
3	very positive
2	positive
1	slightly positive
0	neutral
-1	slightly negative
-2	negative
-3	very negative

Many co-benefits!
(i.e. Ecosystem service not targeted, but positive expected impact)

Conclusions



Many benefits and co-benefits regarding estuarine ecosystem services



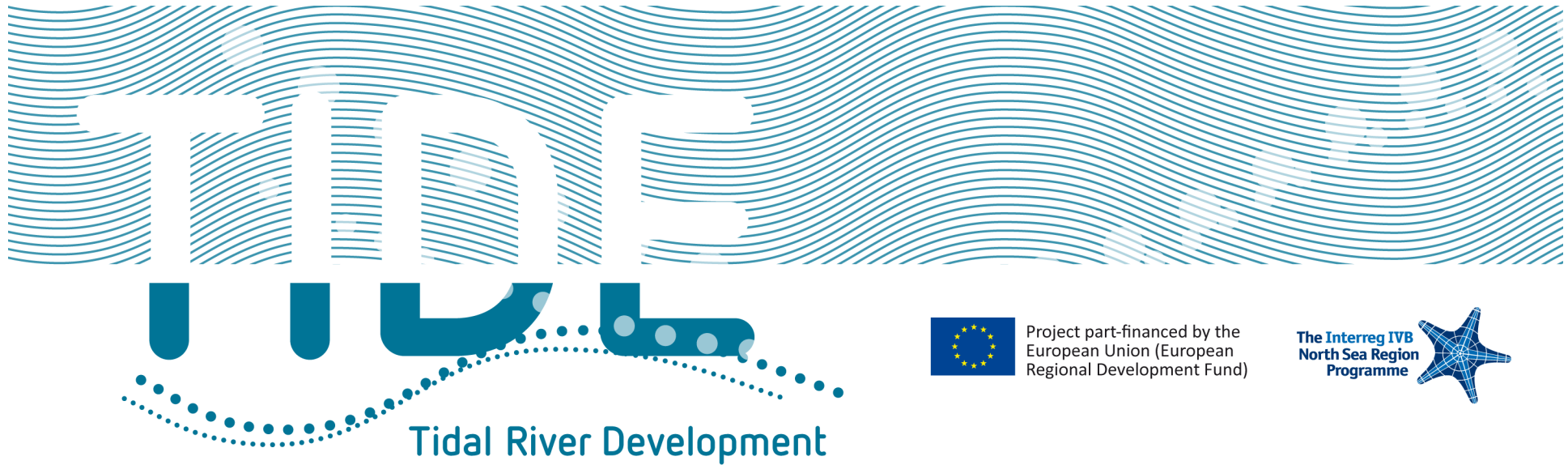
Positive and negative effects on estuarine ecosystem services, depending on importance of involved habitat type

REMARKS

- Assumption: linear surface-supply relationship
- Limited to the estuary and estuarine ES (effects lost adjacent land not included!)
- Limited to the boundaries of the measure (effects only in the project site)

Key messages

- Underlying processes of ecosystem services have high variability (cross-system, temporally and spatially)
- A mean doesn't say anything, only the range
- It is very important to know the factors influencing these numbers (need for site specific, tailor-made research)
- Numbers are for existing situations
- Beware of measurement inconsistencies



A detailed look at estuarine management and governance

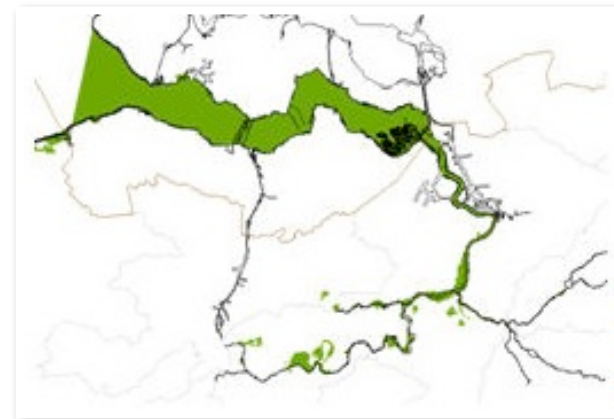
Coordinator: Mike Elliott, IECS, University of Hull

Management initiatives and governance

Scheldt Estuary Management Plans



European Marine Sites (SAC & SPA) in the International River Basin District Scheldt



Scheldt Estuary European Marine Site



Implementation of the Water Framework Directive and the Floods Directive in Flanders

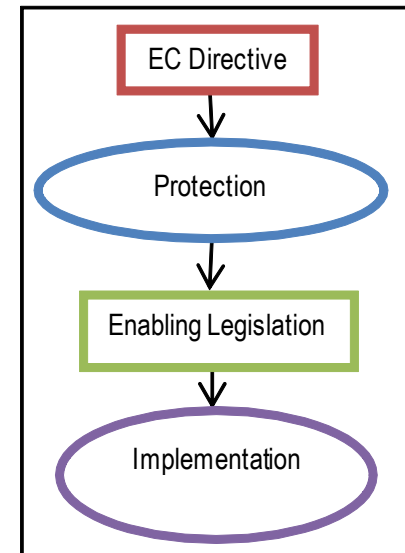
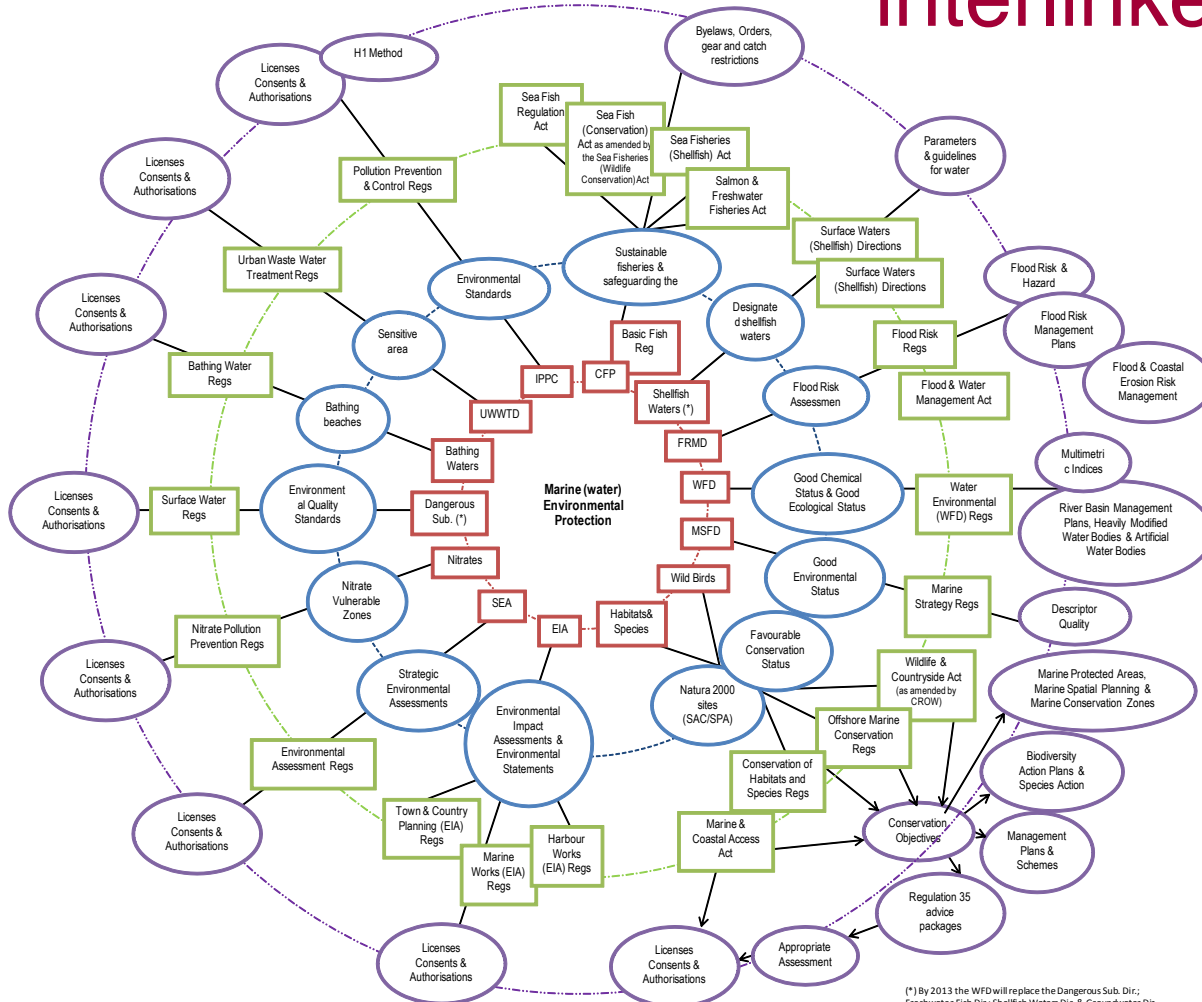


International River Basin District of the Scheldt

Legislative drivers and sectoral plan review

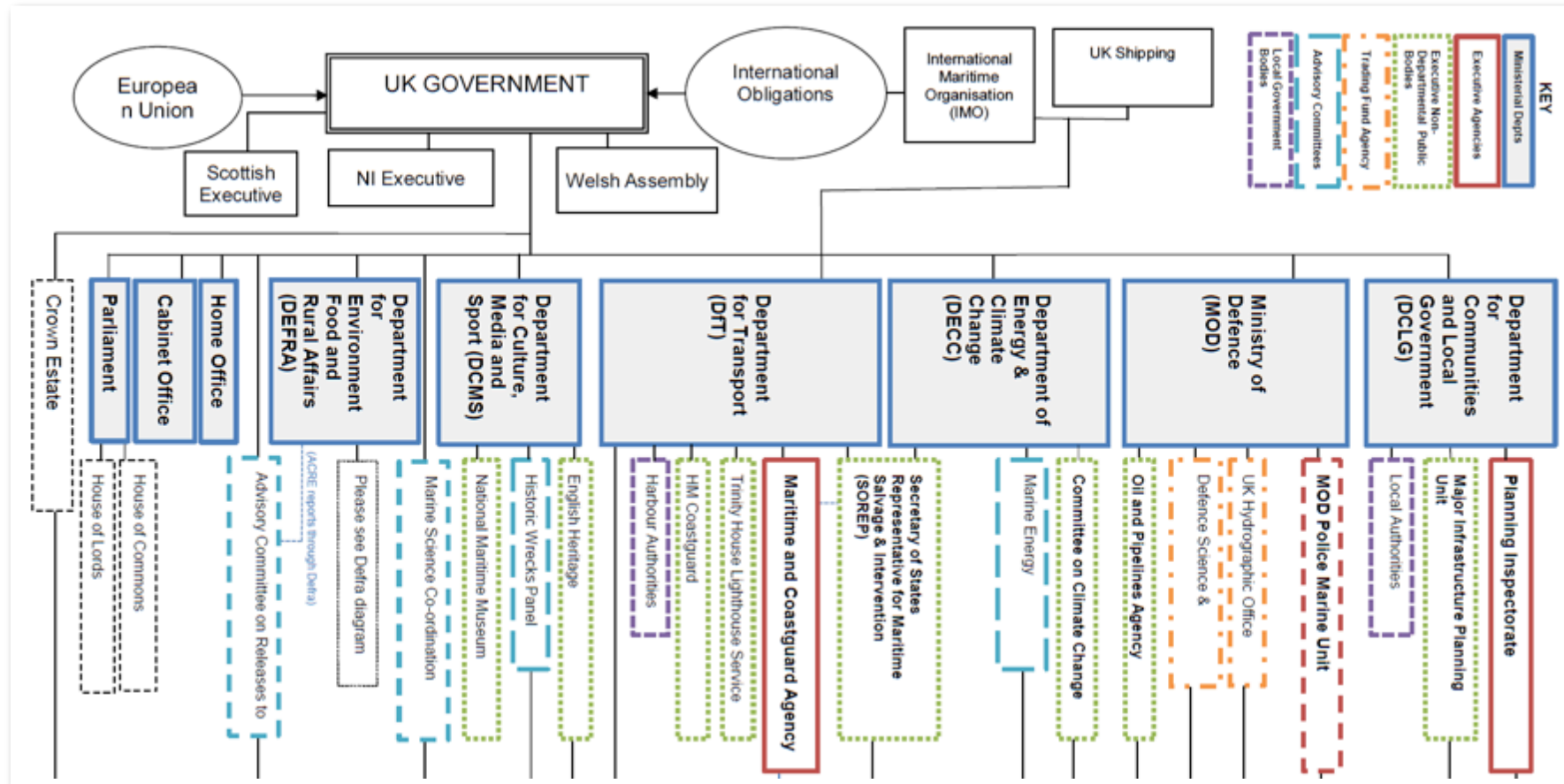
- Identified management drivers and plans across the four TIDE estuaries
 - Estuary management plans
 - Water quality directives (WFD & UWWTD)
 - Nature conservation directives and habitat management plans (Habitats & Species Directives, Wild Birds Directive, CHaMPS)
 - Flood protection and coastal protection directives and shoreline management plans (Flood Risk Management Directive)
 - Integrated coastal zone management (MSP & CMD)
 - European Marine Sites Management Plan
 - Fish and Shell fisheries Management
 - Navigation, ports and pollution prevention directives and port development plans
 - Economic development (incl. agriculture, forestry, tourism)
- SWOT analysis of management plans
- Documented key organisations with management responsibilities

Estuarine/marine governance interlinked instruments



(*) By 2013 the WFD will replace the Dangerous Sub. Dir.; Freshwater Fish Dir.; Shellfish Waters Dir. & Groundwater Dir.

Relevant management institutions - Humber estuary



© Mike Elliott, IECS



Things to be managed (and by whom)

- Habitats (nature conservation agencies)
- Environmental quality (EPA-type organisations)
- Water space usage (port authorities)
- Navigation (port authorities)
- Infrastructure (municipalities/federal state)
- Energy extraction (private companies)
- Biological extractions (fisheries bodies)
- Estuarine water extraction (private energy companies)
- Upstream water abstraction (water supply companies)
- Land space usage (municipalities/federal state)
- Erosion and flooding control (EPA, municipalities, etc.)
- Industry (EPA and private companies)
- Recreation and tourism (agencies)

Example Humber Estuary Management Scheme

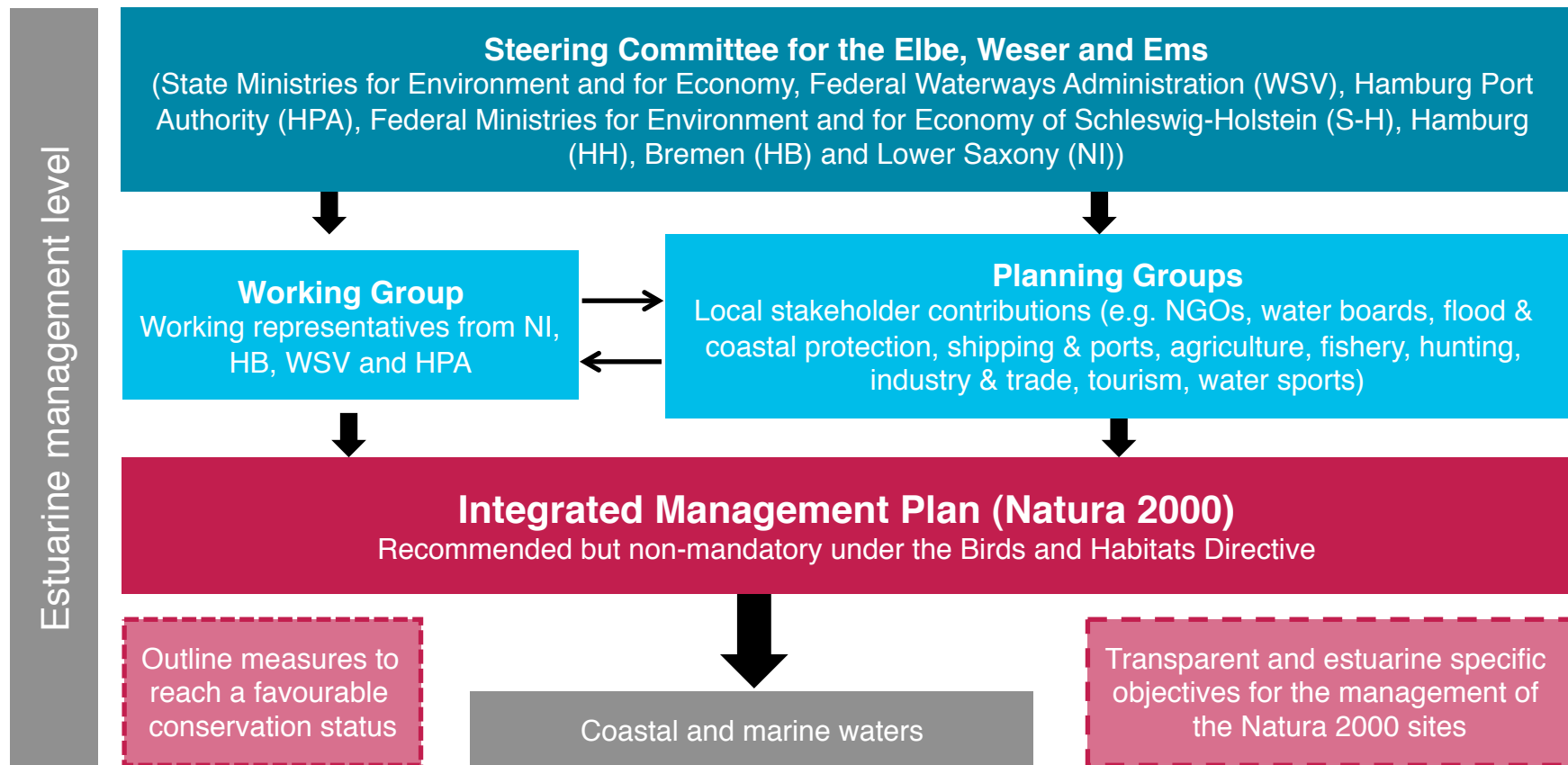
Our Vision for the Humber



On a clear day you will see from the top of the Humber Bridge's towers:

- An unpolluted estuary
- A healthy fishery
- Thriving wildlife with an expanded inter-tidal habitat
- Flood defences that provide an assured level of protection in harmony with the estuary's natural processes
- Prosperous ports, industry and agriculture, which have minimised their environmental impacts and benefit from the diverse and healthy Humber
- A landscape with outstanding archaeological and historic features enhanced by the Environment Agency's activities
- A tourist economy that benefits from the Humber but is sensitive to its wildlife and historic riches
- A vibrant community that understands, cares for and enjoys the Humber.

Implementation of Natura 2000 management plans in German estuaries



SWOT analysis

internal

Strengths

- What are the highlights of the management plan?
- Are unique (or unusual) resources being drawn upon (and, if so, what are they)?
- What factors would be central in the management plan approach being adopted or transferred to plans in the future?

Weaknesses

- What aspects of the management plan could be improved?
- What apparent pitfalls within the management plans have led to limited implementation?

external

Opportunities

- Does the management plan provide opportunities to incorporate future changes?
- Will opportunities arrive by changes in relation to 'new' technology, environmental changes or changes in government policy or societal wishes?

Threats

- Is the management plan threatened by funding, long term vision or political will?

SWOT analysis

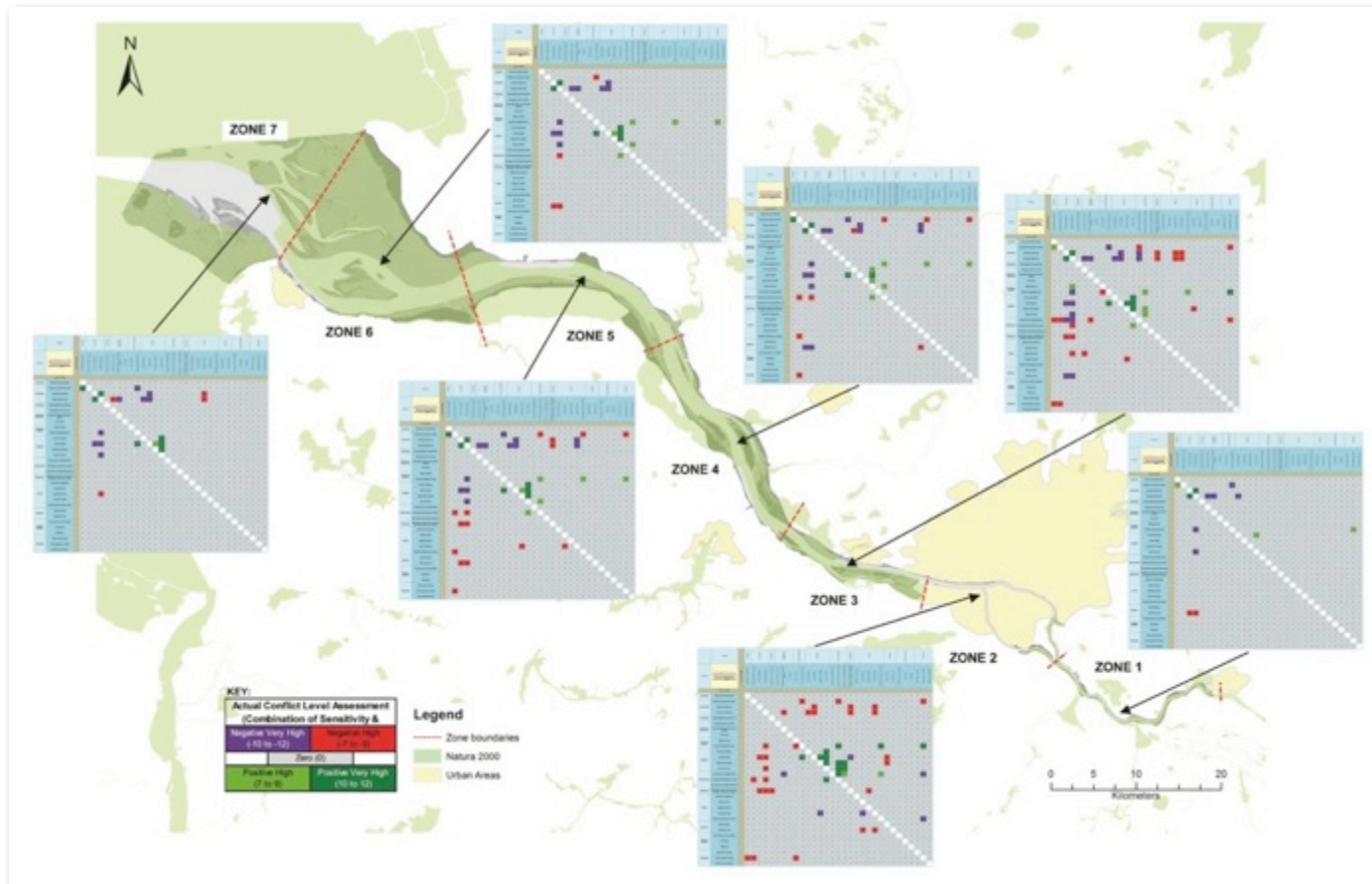
Estuary	Good/Best Practice	Issue
Weser	Stakeholder groups founded in Lower Saxony and Bremen on regional level to contribute to WFD implementation and set up list of non-binding measures referring to tidal section of the river Weser and plans to be updated every six years.	No extended focus on tidal sections of rivers within each estuary RBMP. WFD offers a solid basis for appropriate implementation.
Elbe	Stakeholder working groups wrote non-legally binding lists of measures for tidal section of Elbe, allowing further integration of other issues like ports, shipping and agriculture into implementation of WFD. (Plan to be updated every six years).	Continuous control of the accomplishment of the WFD targets is necessary.
Schelde	The RBMPs give greater awareness to nature conservation, recreation, ICZM, shipping and ports than plans in other three estuaries.	
Humber	A good network of advisory and stakeholder groups for the Humber feeding into the RBMP for the estuary.	

SWOT analysis

Common strengths, weaknesses, opportunities and threats identified within the management plans of the four TIDE estuaries



Conflict matrix approach



Key conflict areas identified for each zone for each estuary.
Elbe example (green shading indicates Natura 2000 extent, yellow urban zones).

Typology of conflicts

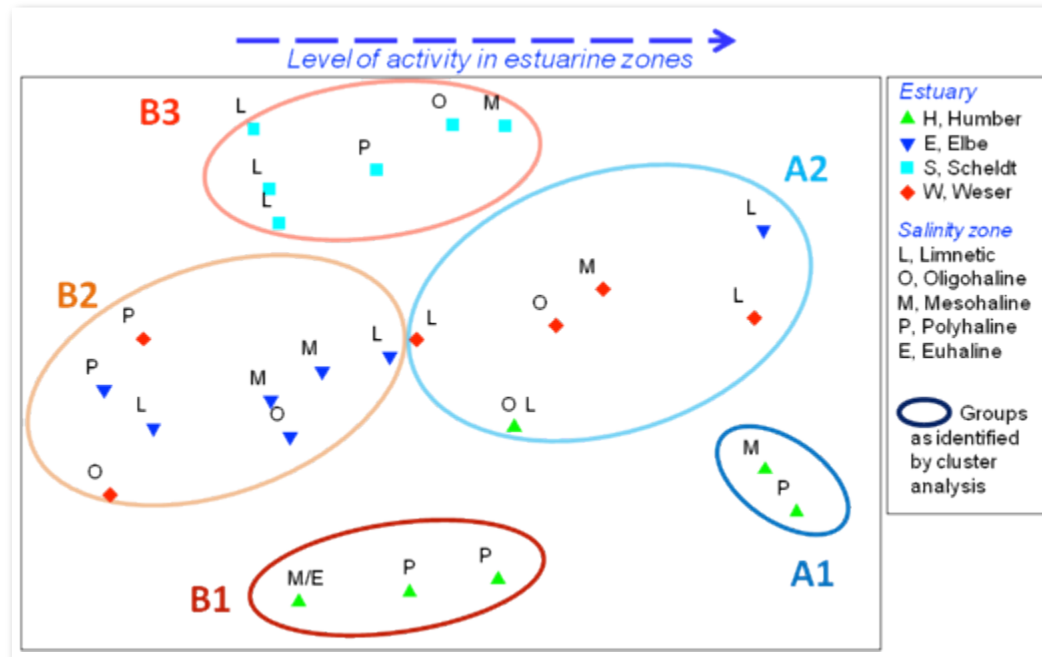
CONFLICTS

Impact of		Impact On		Score
Category	Activity	Category	Activity	
Conservation	Protected subtidal area	Navigation	Capital dredging	-7
Conservation	Protected subtidal area	Navigation	Maintenance dredging	-7
Conservation	Protected intertidal area	Access (e.g. disturbance)	Recreational access on the banks & intertidal	-9
Access (e.g. disturbance)	Recreational access on the banks & intertidal	Conservation	Protected intertidal area	-8
Flood/Coast protection	Flood bank (dyke/gabion/wall)	Conservation	Protected intertidal area	-8
Navigation	Capital dredging	Conservation	Protected subtidal area	-7
Navigation	Capital dredging	Conservation	Protected intertidal area	-7
Navigation	Maintenance dredging	Conservation	Protected subtidal area	-7

SYNERGISMS

Impact of		Impact On		Score
Category	Activity	Category	Activity	
Conservation	Protected subtidal area	Conservation	Protected intertidal area	9
Conservation	Protected intertidal area	Conservation	Protected subtidal area	10
Flood/coast protection	Flood bank (dyke/gabion/wall)	Ports & Harbours	Port related activity adjacent to system	7
Flood/coast protection	Flood bank (dyke/gabion/wall)	Industry	Industrial activity adjacent to system	7
Flood/coast protection	Flood bank (dyke/gabion/wall)	Residential	Housing adjacent to system	8
Navigation	Channel stabilisation	Navigation	Vessel movement	8
Navigation	Capital dredging	Navigation	Vessel movement	7
Navigation	Maintenance dredging	Navigation	Vessel movement	9

MDS ordination and cluster analysis



A: higher activities level, in particular in *Port & harbour* and *Industry* compared to **B**

A1 (Zone 3 & 4, Humber): highest activities level, in particular high *Port & harbour*, *Infrastructure on bed or in water column*, and *Tidal/current energy device (industry)*, but no *Channel stabilisation*

A2 (mostly Weser): Higher *Water abstraction for Agriculture, Industry* and presence of *Drinking Water Abstraction* (absent in all other groups)

B1 (Humber, Zones 2, 5, 6): Low *Channel stabilisation (Navigation)*, *Recreational access on water*, *Landscape feature* and no *Port land claim*, *Industrial discharge* and *Water abstraction (Industry)*

B2 (mostly Elbe): lowest activity level overall, no *Port activities*, low *Recreational access to banks/intertidal*, *Infrastructure on bed* and *Residential housing*, but high *Landscape feature provision*.

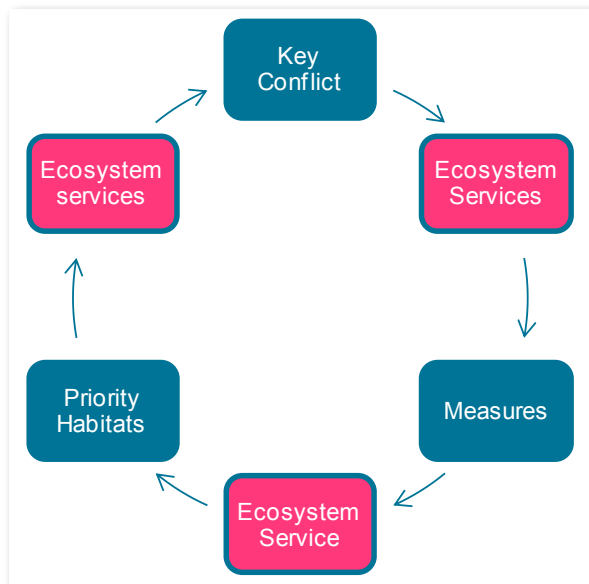
B3 (Scheldt): High *Commercial access*, *Aggregate extraction (Industry)* and *Channel Stabilisation (Navigation)*, but low *Capital dredging (Navigation)* and no *Archaeology/ Historical protected site*

Conflict matrix findings: Estuary use and planning

- **Weser estuary:** has most numerous conflicts (29), however only 4 (14%) are potentially severe.
- **Humber estuary:** has marginally lower number of moderate to high conflicts (24) but considerably greater number of severe interactions (9 or 38%).
- **Elbe estuary:** considerably less moderate to high conflicts (12) but highest percentage (42%) of those ranked most severe (5).
- **Scheldt estuary:** very few moderate to severe conflicts and low proportion of these are actually severe.

Weser issues, although more numerous, are generally less severe than other estuaries, and the Elbe, whilst having relatively few issues, faces a larger proportion of severe ones. Whilst there are synergisms identified for all estuaries, the Scheldt has many more and these tend to be more positive.

Conflict matrix findings: Measure implementation via ecosystem services



- Conflict matrix approach of value, particularly when used with measures tools and ecosystem services approach.
- This allows ecosystem services to provide common currency to determine relative values of management options once areas of key conflict are determined, leading to appropriate management measure delivery.
- Conflict matrix proforma and user guide provided as a TIDE tool for download.

What are the main challenges facing our estuaries?

Climatic and ecological deterioration

- Climate change including sea level rises
- Bank erosion
- Reducing rainfall and reduced water flow
- Loss of vegetation
- Eutrophication and nutrient enrichment from diverse sources
- Acid sulphate sediments
- Hydrocarbons
- Catchment drainage management needs to be coordinated
- Agricultural applications and fertilisers
- Poor water quality

What are the main challenges facing our estuaries?

Increasing development pressures

-  Rapid urban development and human pressures
-  Increased industry
-  Non nutrient pollution
-  Inappropriate development
-  Huge population growth and overcrowding
-  Multiple, competing uses
-  Managing recreational areas for increased population
-  Increased boat traffic and pollution
-  Illegal hunting and invasive species
-  Overfishing
-  No long-term sustainable focus



Your vision for an estuary?

Ecologically restored habitat:

- ✓ Maintained biodiversity and abundance of wildlife
- ✓ Clean water and healthy flora and fauna
- ✓ Intrinsic ecological values
- ✓ Ecosystem functioning well to provide ecological services
- ✓ Preserved connectivity
- ✓ Adaptable system accommodating to future pressures

Healthy functioning ecosystem serving the community:

- ✓ Healthy waters for community recreation
- ✓ Alive estuary that people can use (not just look at)
- ✓ Provides access for recreation and tourism
- ✓ Safe, resilient and accessible facilities and opportunities for the community to recognise cultural and social values

Effectively managed human development and impacts:

- ✓ Urban and population impacts managed
- ✓ Restricted residential and industrial development
- ✓ Opportunities for built environment and industry to exist sustainably
- ✓ Restricted ecological areas and reduced recreation areas
- ✓ Developments to have no impact on estuarine systems
- ✓ Incorporate urban, industrial and agricultural values into management
- ✓ Sustainable agriculture with more effective systems to reduce impacts

Your vision for an estuary?

Improved environmental management across the catchment:

- ✓ Effective management to cope with industrial and urban development
- ✓ Nutrients reduced and no eutrophication symptoms
- ✓ Eliminate human effects
- ✓ Estuaries managed and reshaped to cope with future impacts such as sea level rise

Better governance of estuarine systems

- ✓ Simplified, effective, holistic management systems with clear roles and responsibilities
- ✓ Community, government and stakeholders collaborating
- ✓ Indigenous management and experience recognised

Recognition and awareness of the value of healthy ecosystems:

- ✓ Create community awareness and support action
- ✓ Opportunities for learning, education and awareness

How to measure the end point?

How do you know you've reached it?

What indices can you use?

Are the objectives SMART (specific, measureable, achievable, realistic, time-bounded)?

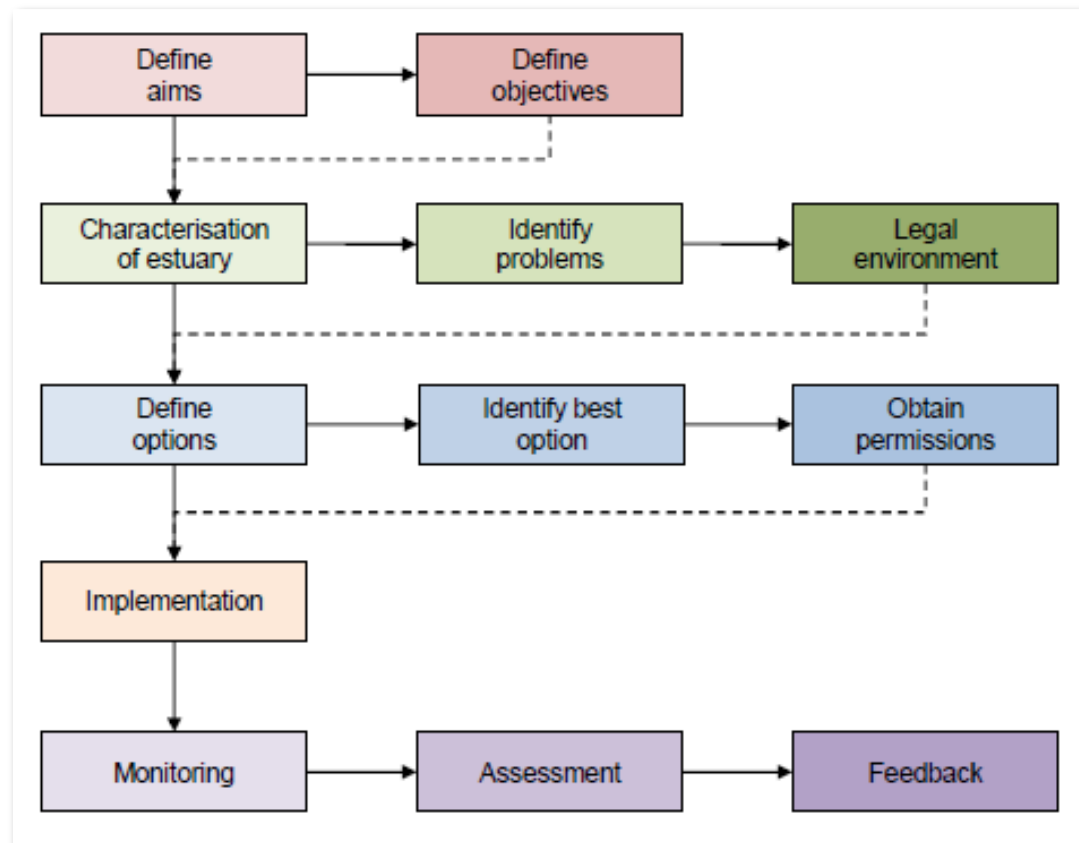
Bottlenecks	Showstoppers	Trainwrecks
<p>Lack of clear objectives No stakeholder forum Poor scientific understanding Poor advice Confusing planning system Manageable hazards Poor communication</p>	<p>Complex regulation Poor knowledge Poor training Overlapping designation Conflicting designation Sectoral management Poor administration Economic prerogative Lack of technologies Lack of tools Increasing governance Slow planning system Non-integrated planning system Manageable hazards</p>	<p>Intransigence Lack of funding Legal challenges Political will Unwillingness to adopt joint aims/vision Inflexible planning system Unmanageable hazards Lack of permissions Cultural conflicts Iconic ecology Ethically immoral</p>

Recipe for integrated management

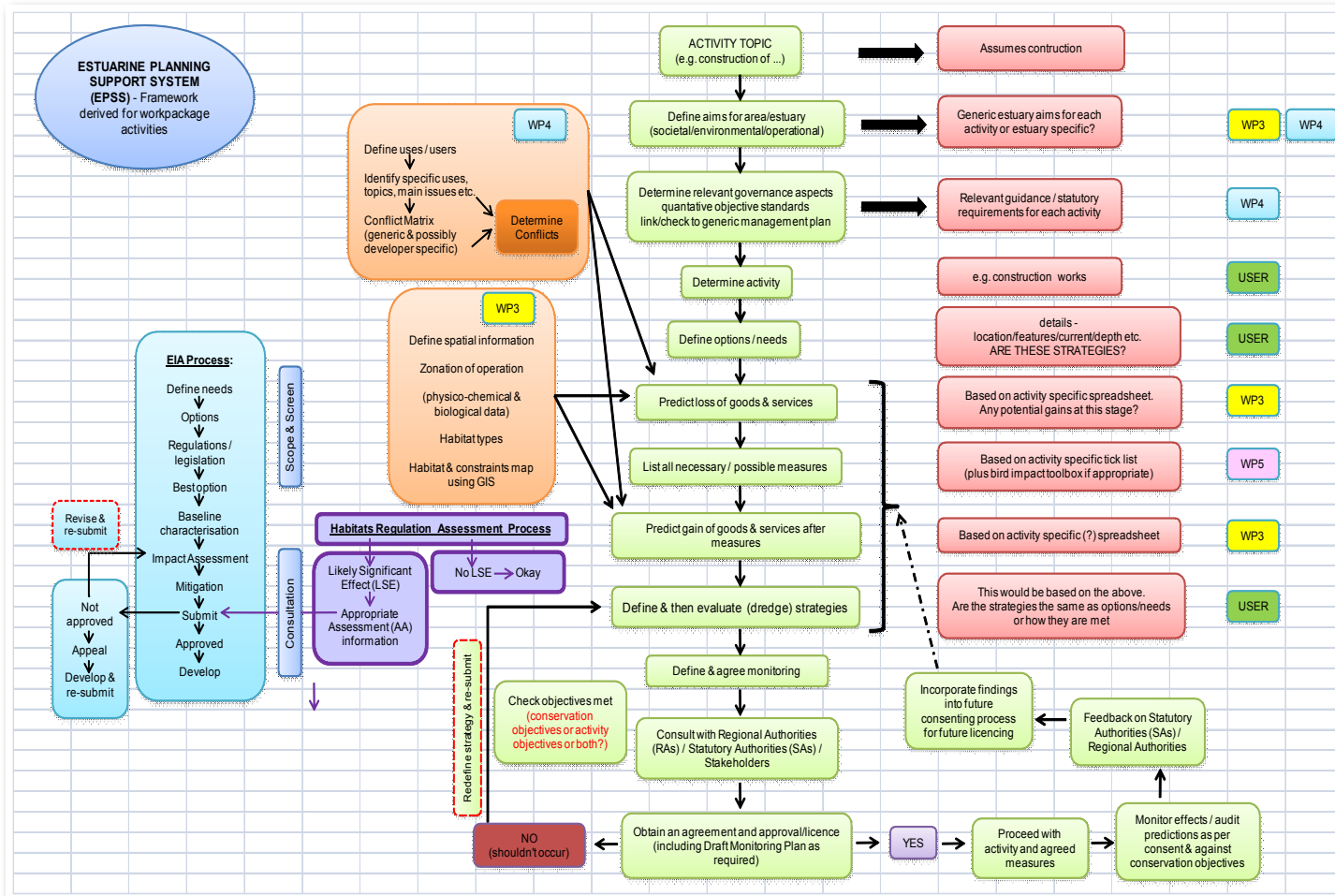
- Needing an understanding of ecological structure and functioning
- Leading to describing ecosystem services
- Leading to providing societal benefits
- Defined by historical evolution and estuarine comparisons
- To show how ecosystem services are delivered
- Requiring management initiatives and governance to ensure societal benefits are obtained
- Within a multiuser system: what occurs where among estuarine users?
- Leading to conflicts amongst users
- Requiring resolution of conflicts
- Requiring management measures
- Communicated by dissemination and information

TIDE Tool: Estuary Planning Support System EPSS

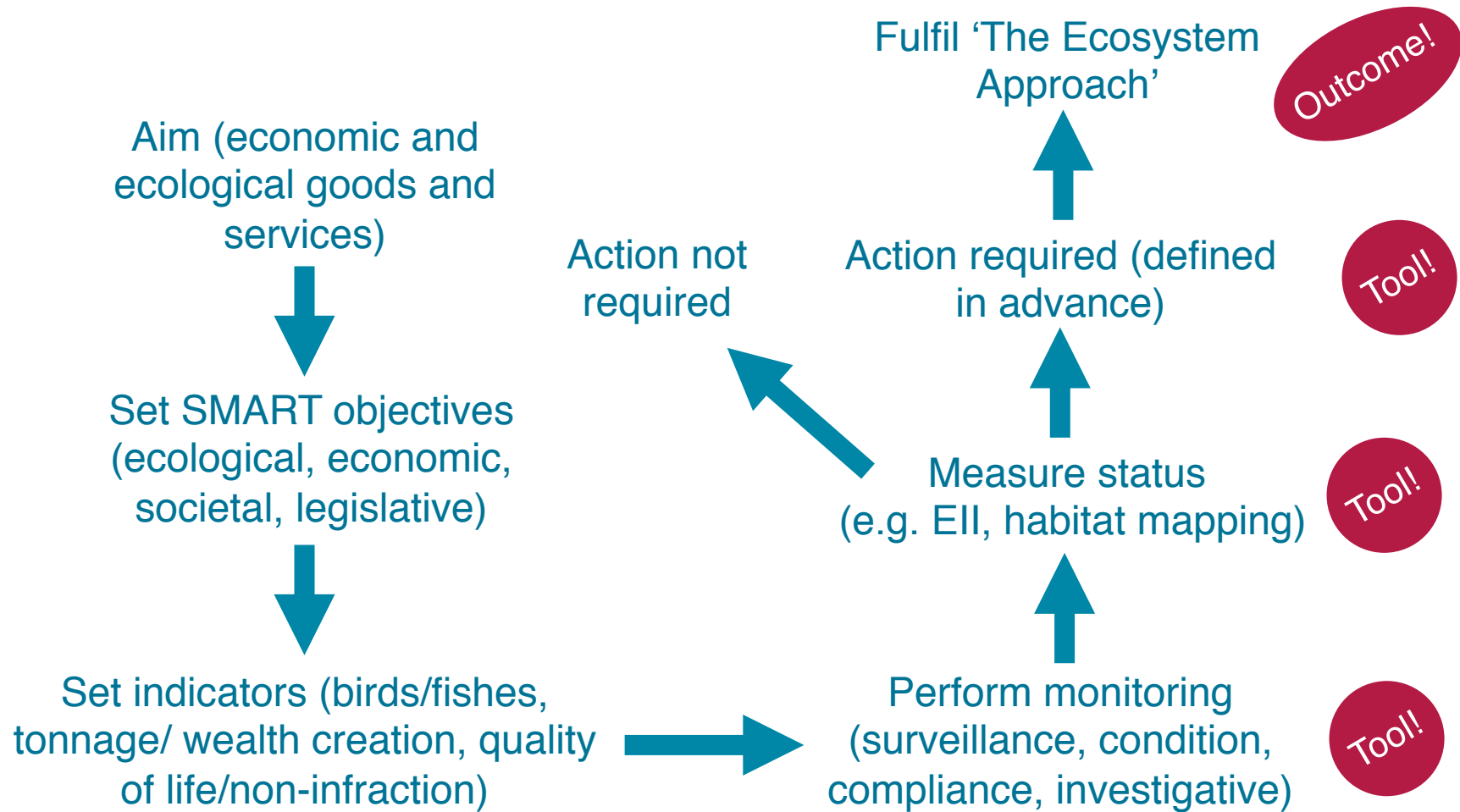
- Representation of a generic integrated estuarine management process
- 5 main stages linked through series of steps to guide user through process of estuarine management
- Links are available to take user to specific tools and outputs from TIDE project
- Further information from each stage of the EPSS is available by clicking on the boxes in the flowchart



EPSS: a generic tool for setting up plans



Science for management





Conclusions: Integration of findings from TIDE and other projects



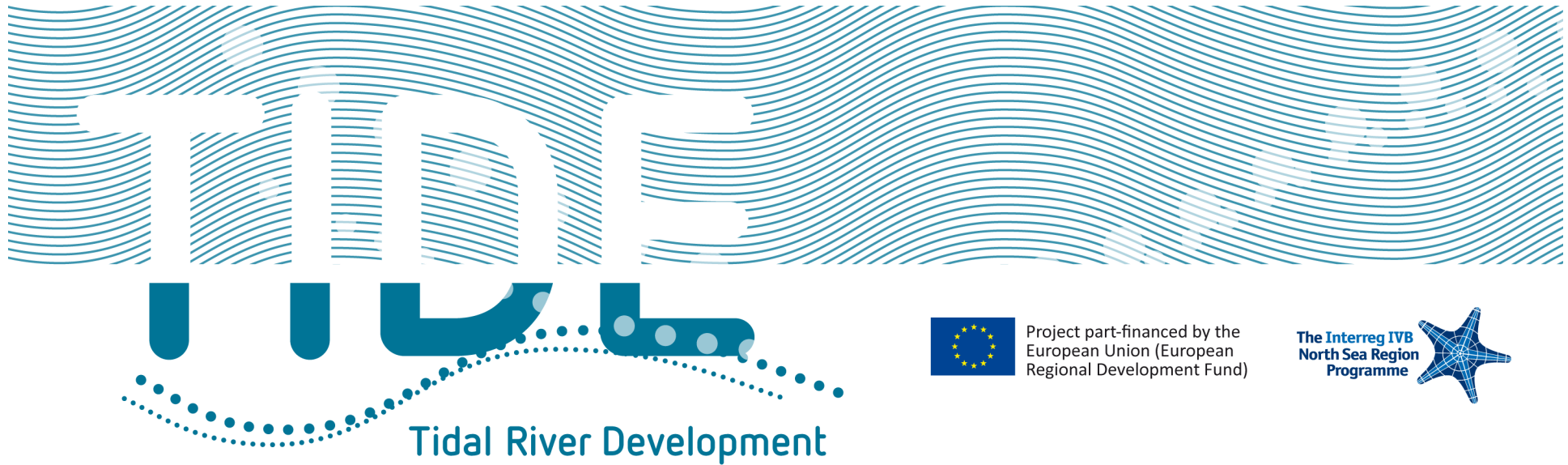
- All estuaries are different for management ... **but** all estuaries have similar features/paradigms.
- All approaches to management are similar ... **but** need to be modified for site-specificity.
- Management requires data, knowledge and expertise ... **but** must manage in the absence of them.
- All sectors have different constraints and perspectives ... **but** prevailing governance requires integration.
- Underlying governance is the same ... **but** has been implemented differently at local/regional/national levels.
- All areas have conflicts ... **but** conflict resolution requires compromise.
- Tools are available and/or can be created ... **but** need 'road testing' for other estuaries.
- All estuaries have similar economic and societal constraints ... **but** not all players are aware of this.

Key messages

- Clear objectives in fulfilling the ecosystem approach: ‘triple wins’ for ecology, society and economy.
- Determine problems (footprint) and then address/solve/mitigate/compensate
- Don’t assume activities automatically lead to pressures or impacts (negates mitigation and compensation)
- Good business relies on good ecology/biology/husbandry
- Essence is connectivity (good water conditions, ecological well-being, conditions fit-for-purpose)
- Vertical and horizontal integration, across sectors and states with harmonised governance and feedback mechanisms
- Ability to agree on future scenarios and manage to moving baselines
- Monitoring/modelling/management - adaptive systems

Key messages

- From Exogenic Unmanaged Pressure(s) and Endogenic Managed Pressure(s) to achieve ecological and socio-economic carrying capacity
- To protect and enhance ecosystem services and deliver societal benefits
- To achieve and manage ecological and socio-economic connectivity via a nested DPSIR/DPSWR/DPSEEC approach
- To use ecological and economic valuation for communication and management decisions
- Within a sustainable management framework (10-tenets, using governance ‘as a servant not a master’)
- To separate (and use properly) Environmental and Regulatory Impact Assessment
- Ensure sustainability - but for what/who/how/when?



A detailed look at management measures

Coordinator: Wilfried Heiber, NLWKN

TIDE work on management measures

APPROACH

- Making experiences gained through planning, realisation and monitoring of mitigation measures in estuaries available to managers
- Giving examples of successful management measures
- Supporting the future process of development and implementation of management measures in large estuaries



Collection and selection of measure examples: Categorisation

Measure Category	Development Target
Hydrology/ Morphology	Measure to reduce tidal energy, tidal range, tidal asymmetry and tidal pumping effects
	Measure for flood protection
	Measure to improve morphological conditions
	Measure to decrease the need for dredging
Biology/Ecology	Measure to develop and/or to protect specific habitats
	Measure to develop and/or protect specific species
	Other measure to develop natural gradients and processes, transition and connection
Physical/ Chemical Quality	Measure to prevent introduction of or to fight invasive species
	Measure to reduce pollutant loading (point and diffuse sources)
	Measure to reduce nutrient loading (point and diffuse sources)
	Measure to improve oxygen conditions
	Measure to reduce physical loading (e.g. heat input by cooling water entries)
	Other measure to improve self-purifying power

Collection and selection of measure examples: Categorisation

Measure category	TIDE estuary				Total (%)
	Weser	Elbe	Humber	Scheldt	
Biology/Ecology	6	6	8	7	27 (64)
Hydrology/Morphology	-	5	2	5	12 (29)
Physical/Chemical Quality	-	3	-	-	03 (07)
Total	6	14	10	12	42* (100)

Selection result:

- 39* measures from Weser, Elbe, Humber and Scheldt
- Instructive
- Well documented

* 3 of 39 measure were put in 2 categories

Measure examples: Analysis approach

- Effectiveness according to development targets (degree of target achievement)
- Impact on ecosystem services
- Conflict potential and synergistic effects regarding uses
- Conflicts and synergistic effects regarding WFD
- Conflicts and synergistic effects regarding Natura 2000
- ‘Crux of the matter’: frame conditions and positive and negative lessons, gaps of knowledge

Measure examples: Degree of target achievement

TIDE estuary	Degree of target achievement			
	high	medium	low	not clear yet
Weser	6	-	-	-
Hydrology/Morphology	-	-	-	-
Biology/Ecology	6	-	-	-
Physical/Chemical Quality	-	-	-	-
Elbe	4	5	2	3
Hydrology/Morphology	1	1	1	2
Biology/Ecology	2	3	-	1
Physical/Chemical quality	1	1	1	-
Humber	2	4	-	4
Hydrology/Morphology	1	1	-	-
Biology/Ecology	1	3	-	4
Physical/Chemical Quality	-	-	-	-
Scheldt	8	3	-	1
Hydrology/Morphology	2	2	-	1
Biology/Ecology	6	1	-	-
Physical/Chemical quality	-	-	-	-
Total	20	12	2	8

Measure examples: Impacts on ecosystem services

Estuary	Measure	Zone	Categ.	Ecosystem services																
				S	R1	R2	R3	R4	R5	R6	R7	R8	R9	R10	R11	R12				
Elbe	Spadenlander Busch	Fresh	HB	3	3	1	1	1	1	0	1	1	1	0	1	1	1	1		
Elbe	Medemrinne Ost	Meso	H	1	1	0	1	0	0	0	0	0	0	1	0	0	0	0		
Elbe	Current deflection wall	Fresh	H	1	1	0	1	0	0	0	0	0	0	0	0	0	0	0		
Elbe	Current direction control	Fresh	H	1	1	0	1	0	0	0	0	0	0	0	0	0	0	0		
Elbe	Sediment trap Weidel	Fresh	H	1	1	0	1	0	0	0	0	0	0	0	0	0	0	0		
Elbe	Hakenlöcher Habersbarbe	Fresh	HB	0	0	1	0	-1	0	-1	-1	-1	-1	0	0	0	0	0		
Elbe	Wasser Bogen	Fresh	B	1	3	0	2	0	2	0	1	1	0	0	0	0	0	0		
Elbe	Hakenlöcher Sand	Fresh	B	1	1	0	1	0	1	1	1	1	1	0	0	0	0	0		
Elbe	Spadenlander Spitze	Fresh	B	1	1	0	2	0	2	0	1	1	0	0	0	0	0	0		
Elbe	Boed settlement Haken	Fresh	B	2	1	0	2	0	2	0	-1	1	1	0	0	0	0	0		
Elbe	MEFRA	Fresh	B	1	1	0	1	0	0	0	0	0	0	0	0	0	0	0		
Elbe	Managing Rehrerweg dike	Fresh	B	1	1	0	1	0	1	0	0	0	0	0	0	0	0	0		
Schelde	Vogelsteek	Fresh	HB	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		
Schelde	Giljes Waarde	Meso	B	1	1	0	1	0	1	1	1	1	1	0	0	0	0	0		
Schelde	Ketelvoertland	Meso	B	2	1	0	1	0	1	1	1	1	1	0	0	0	0	0		
Schelde	Panelschilveiland	Fresh	B	1	1	0	1	0	1	1	1	1	1	0	0	0	0	0		
Schelde	Panelschilveiland	Meso	B	2	2	0	2	0	2	2	2	2	2	1	0	0	0	0		
Schelde	Huizen LD wandland	Fresh	B	1	1	0	2	0	2	0	1	1	0	0	0	0	0	0		
Schelde	Sediment relocation Ketevlak	Meso	H	1	1	0	1	0	1	0	0	0	0	0	0	0	0	0		
Schelde	Waksoorden 2004	Meso	B	1	1	0	1	1	1	2	0	0	0	0	0	0	0	0		
Schelde	Waksoorden 2006	Meso	B	1	1	0	1	0	1	0	1	0	0	0	0	0	0	0		
Schelde	Sandbars 2010	Poly	B	0	1	2	0	1	2	1	0	1	0	2	2	1	0	0		
Schelde	Fish pond	Meso	B	1	1	2	1	1	0	2	1	0	0	0	0	0	0	0		
Weaver	Begler Plate	Oligo	B	2	2	0	2	0	2	0	2	2	2	0	0	0	0	0		
Weaver	Shallow water area Nieuwrecker Land	Fresh	HB	1	1	0	1	0	1	2	0	1	1	1	0	0	0	0		
Weaver	Vorder- und Hinterwaller	Fresh	HB	1	2	1	1	1	2	0	1	1	1	0	0	0	0	0		
Weaver	Kleinwater Plate	Fresh	B	1	1	0	2	0	2	0	1	1	2	0	0	0	0	0		
Weaver	Capoff Sider-Neufeld	Poly	B	1	1	0	1	0	1	1	2	1	0	0	0	0	0	0		
Weaver	Wiederland	Poly	B	1	1	0	1	0	1	0	1	1	1	0	0	0	0	0		
Humber	Albionough SM	Meso	HB	1	2	0	0	0	2	0	1	1	1	0	0	0	0	0		
Humber	PMS SM	Poly	B	1	1	0	1	0	1	0	1	1	1	0	0	0	0	0		
Humber	Mullag SM	B	1	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0		
Humber	Chowen River APP near dike	Meso	B	1	1	0	0	0	1	1	1	0	0	0	0	0	0	0		
Humber	Wicks at Dings Creek at Grimsby	B	1	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0		
Humber	Wolwick	B	2	2	0	2	0	2	1	1	1	0	0	0	0	0	0	0		
Humber	Beacon Lagoon	B	1	1	0	1	0	1	0	1	0	0	0	0	0	0	0	0		

Legend: expected impact*

3	very positive
2	positive
1	slightly positive
0	neutral
-1	slightly negative
-2	negative
-3	very negative
X	Targeted ES

Estuary	Measure	Zone	Categ.	Ecosystem services																
				S	R1	R2	R3	R4	R5	R6	R7	R8	R9	R10	R11	R12				
Elbe	Spadenlander Busch	Fresh	HB	3	3	1	1	1	1	1	0	1	1	1	1	0	1	1		
Elbe	Medemrinne Ost	Meso	H	1	1	0	1	0	0	0	1	0	0	0	0	0	0	0		
Elbe	Current deflection wall	Fresh	H	1	1	0	1	0	0	0	0	0	0	0	0	0	0	0		
Elbe	Current direction control	Fresh	H	1	1	0	1	0	0	0	0	0	0	0	0	0	0	0		

- Targeted ES indicated by orange boxes:
- Habitat services (S)
 - Provisioning services (P)
 - Regulating services (R)
 - Cultural services (C)

Measure examples: Effects regarding WFD and Natura 2000

Indication of measures with very positive and positive effects on main pressures
(classification by measure categories)

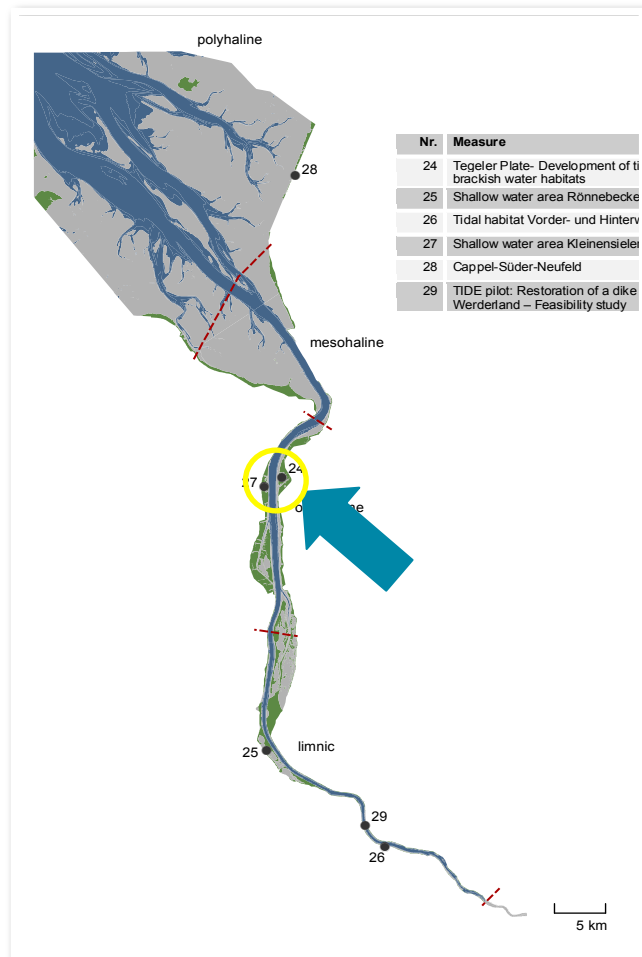
Measure category	Percentage of pressures positively affected by measure (%)
Hydrology/Morphology	21
Biology/Ecology	67
Physical/Chemical Quality	14

Water Framework Directive (WFD)

Measure category	Percentage of conservation objectives positively or very positively affected by measure (%)
Hydrology/Morphology	16
Biology/Ecology	78
Physical/Chemical Quality	37

Natura 2000

Tegeler Plate Example



Nr.	Measure
24	Tegeler Plate- Development of tidally influenced brackish water habitats
25	Shallow water area Rönnebecke Sand
26	Tidal habitat Vorder- und Hinterwerder
27	Shallow water area Kleinensieler Plate
28	Cappel-Süder-Neufeld
29	TIDE pilot: Restoration of a dike foreland in Werderland – Feasibility study

Measure Category: Biology/Ecology

Estuary: Weser

Salinity zone: Oligohaline

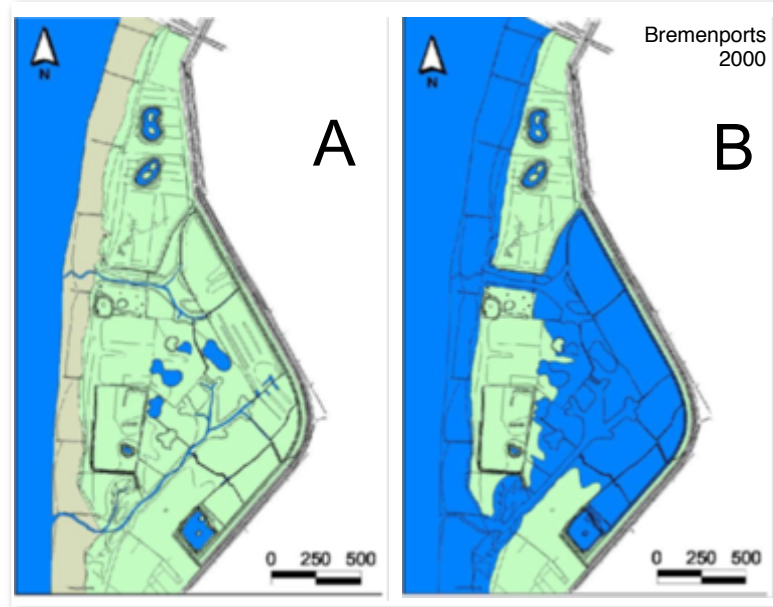
Area: 210 ha

Measure status: Implemented

Responsible: Bremenports GmbH und Co. KG

Legislative driver: Compensation measure (port extension)

Tegeler Plate Example: Development targets



Different water levels on the Tegeler Plate
A: tidal low water
B: spring tide high water

- Tidally influenced habitats (mudflat and shallow water areas, creeks, reed) with species rich vegetation and fauna
- Specific water regime conditions as well as soil formation and sedimentation processes
- Improvement of the natural scenery

Example: Tegeler Plate

Bremenports 2000

1993



2001



Structure diversity on the Tegeler Plate before and after implementation of management measure

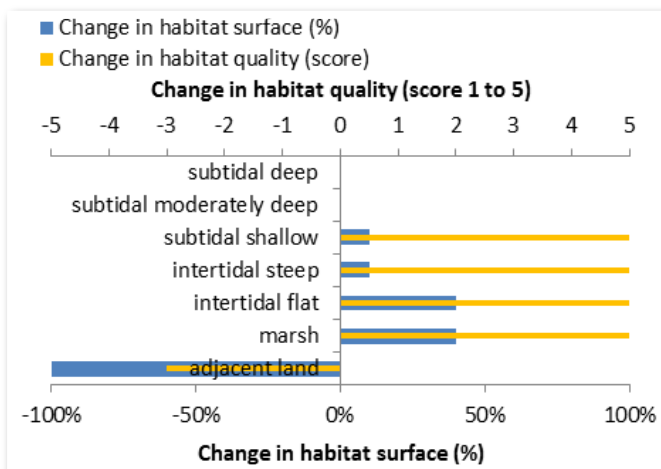
Tegeler Plate Example: Monitoring



Monitoring:

- Structure of the project area
- Sediment distribution and attributes
- Water levels and basic hydrological parameters
- Vegetation
- Breeding and migrant birds
- Fish fauna
- Terrestrial invertebrate fauna
- Aquatic benthic fauna

Tegeler Plate Example: Impact on ecosystem services



Surface and quality habitat change after implementation of management measure

1. Expected impact on ES supply in the measure site
2. Expected impact on different beneficiaries, each as a consequence of the measure

Tegeler Plate- Development of tidally influenced brackish water habitats		
Cat.	Ecosystem Service	Score
S	"Biodiversity"	3
R1	Erosion and sedimentation regulation by water bodies	3
R2	Water quality regulation: reduction of excess loads coming from the catchment	2
R3	Water quality regulation: transport of pollutants and excess nutrients	0
R4	Water quantity regulation: drainage of river water	0
R5	Erosion and sedimentation regulation by biological mediation	2
R6	Water quantity regulation: transportation	0
R7	Water quantity regulation: landscape maintenance	3
R8	Climate regulation: Carbon sequestration and burial	3
R9	Water quantity regulation: dissipation of tidal and river energy	2
R10	Regulation extreme events or disturbance: Wave reduction	2
R11	Regulation extreme events or disturbance: Water current reduction	2
R12	Regulation extreme events or disturbance: Flood water storage	3
P1	Water for industrial use	0
P2	Water for navigation	0
P3	Food: Animals	1
C1	Aesthetic information	3
C2	Inspiration for culture, art and design	3
C3	Information for cognitive development	3
C4	Opportunities for recreation & tourism	2

Beneficiaries:	
Direct users	0
Indirect users	2
Future users	3
Local users	3
Regional users	2
Global users	1

Legend: expected impact*	
3	very positive
2	positive
1	slightly positive
0	neutral
-1	slightly negative
-2	negative
-3	very negative

*: Indicative screening based on ES-supply surveys and estimated impact of measures on habitat quality and quantity. Quantitative socio-economic conclusions require local supply and demand data to complement this assessment.

Tegeler Plate Example: Synergistic effects & conflicts with WFD

Measure effects on main pressures on the oligohaline zone of the Weser estuary

Indicator	Code	Main pressures oligohaline zone Weser	Effect?					Description
			--	-	0	+	++	
S.I.	-	Habitat loss and degradation during the last 100 years: Subtidal					X	As a result of measure implementation, additional subtidal areas were created.
S.I.	1.1	Habitat loss and degradation during the last 100 years: Intertidal					X	As a result of measure implementation, additional intertidal areas were created.
S.I.	1.4/ 1.5	Gross change in morphology/hydrographic regime during the last about 100 years				X		Natural erosion and sedimentation processes were promoted.
D.I.	1.3	Land claim during the last about 100 years					X	Due to measure implementation, the tidal influence on the project area was increased and the Tegeler Plate - formerly used for agricultural purposes- was nearly completely left to natural succession.
D.I.	2.6	Capital dredging			X			
D.I.	2.4	Maintenance dredging					X	Due to measure implementation, the Tegeler Plate provides additional sedimentation area. As a consequence, this leads by trend to less maintenance effort in the river

Tegeler Plate Example: Synergistic effects & conflicts with Natura 2000

Specifications for entire investigation area of IBP Weser	Effect of measure 24 on conservation objectives?		
	positive effect	no effect	negative effect
Conservation and development of specific functions and processes of estuaries and (tidal) floodplains to reach favourable abiotic conditions and typical hydromorphological structures			
Conservation and development of favourable water structures and water bed dynamics	++		
Development of evenly distributed and reduced current energy and tidal parameters	+		
Conservation and development of favourable gradients of specific aspects regarding estuaries and (tidal) floodplains (e.g. salinity, sediments,	++		

Natura 2000-objectives with specifications for entire investigation area of the Integrated Management Plan Weser (IBP Weser) (extraction of 13 objectives)

Natura 2000 objectives with specifications for operational area 2 (extraction of 11 objectives)

Operational area 2: Oligohaline zone in the lower Weser (Weser-km 40 - 65)				
Specifications for operational area 2	Effect of measure 24 on conservation objectives?			Short explanation
	positive effect	no effect	negative effect	
Conservation and development of specific estuarine habitats and (tidal) floodplains and their dynamic changes				
Development, enlargement and upgrade of shallow water zones with moderate current climate	+			Subtidal shallow water areas were created on the Tegeler Plate.
Development of passable shore structures	++			Due to measure implementation, tidal influence on the project area was considerably increased and about 100 ha of additional

Alkborough Example



Nr.	Measure
30	Alkborough Managed Realignment and flood storage – Creation of ~440 ha of intertidal habitat
31	Pauli Holme Strays Managed Realignment – creation of ~80 ha of intertidal habitat
32	Hydromotion MudBug – determine the density of 'fluid' mud to determine the depth of the navigable channel (1250 kg/m ³)
33	Creation of ~13 ha of intertidal habitat at Chowder Ness

Measure Category: Hydrology/
Morphology

Estuary: Humber

Salinity zone: Oligohaline

Area: 440 ha

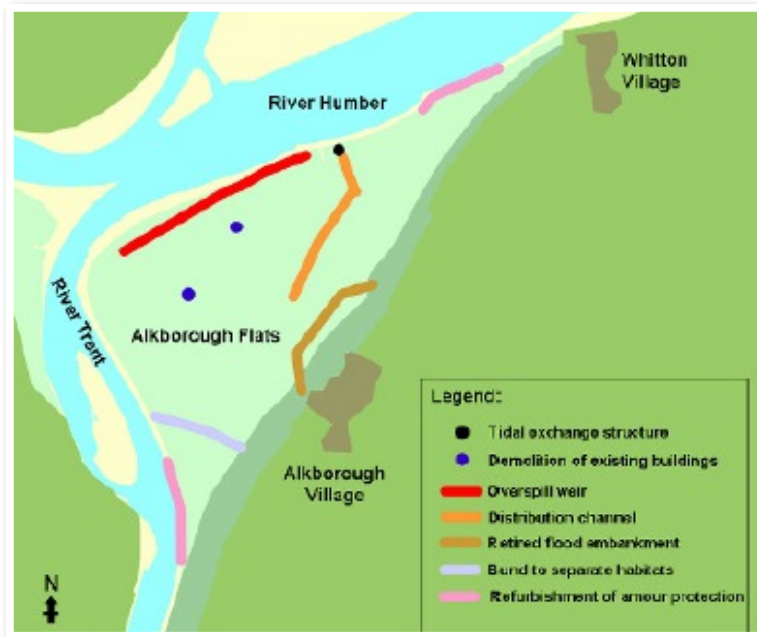
Measure status: Implemented

Responsible: Environment Agency
(UK)

Driver: Humber Flood Risk

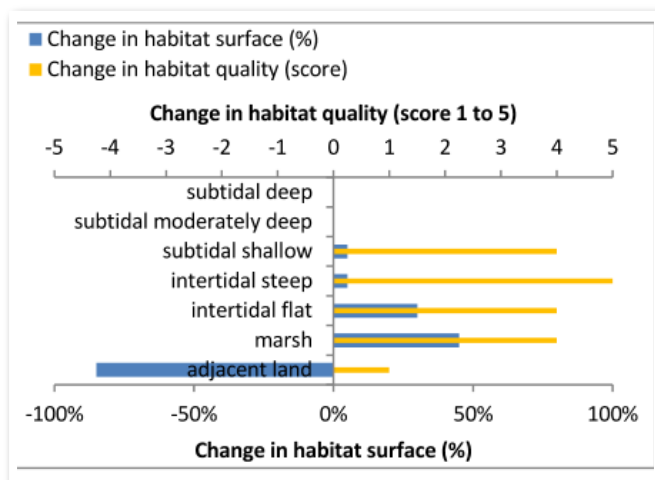
Management Strategy, Natura 2000

Alkborough Example: Development targets



- Flood defence (reducing high tide levels in the upper estuary - primary aim)
- Creation of new intertidal habitats to offset those lost through coastal squeeze within the estuary

Alkborough Example: Impact on ecosystem services



Surface and quality habitat change after implementation of management measure

1. Expected impact on ES supply in the measure site
2. Expected impact on different beneficiaries, each as a consequence of the measure

Alkborough Managed Realignment and flood storage – Creation of ~440 a of intertidal habitat

Cat.	Ecosystem Service	Score
S	*Biodiversity*	3
R1	Erosion and sedimentation regulation by water bodies	2
R2	Water quality regulation: reduction of excess loads coming from the catchment	2
R3	Water quality regulation: transport of pollutants and excess nutrients	0
R4	Water quantity regulation: drainage of river water	0
R5	Erosion and sedimentation regulation by biological mediation	2
R6	Water quantity regulation: transportation	0
R7	Water quantity regulation: landscape maintenance	2
R8	Climate regulation: Carbon sequestration and burial	2
R9	Water quantity regulation: dissipation of tidal and river energy	1
R10	Regulation extreme events or disturbance: Wave reduction	1
R11	Regulation extreme events or disturbance: Water current reduction	1
R12	Regulation extreme events or disturbance: Flood water storage	1
P1	Water for industrial use	0
P2	Water for navigation	0
P3	Food: Animals	0
C1	Aesthetic information	2
C2	Inspiration for culture, art and design	2
C3	Information for cognitive development	2
C4	Opportunities for recreation & tourism	2

Beneficiaries:	
Direct users	0
Indirect users	2
Future users	3
Local users	2
Regional users	1
Global users	1

Legend: expected impact*

3	very positive
2	positive
1	slightly positive
0	neutral
-1	slightly negative
-2	negative
-3	very negative

*: Indicative screening based on ES-supply surveys and estimated impact of measures on habitat quality and quantity. Quantitative sock



Alkborough Example: Synergistic effects & conflicts with WFD and Natura 2000

Indicator	code	Main pressures oligohaline zone Humber	Effect?					Description
			--	-	0	+	++	
S.I.	1.4	Gross change in morphology during the last 100 years.					X	The land was originally reclaimed from the estuary; the creation of the site effectively restores the balance.
S.I.	3.1/3.2	Decrease of water and sediment chemical quality				X		

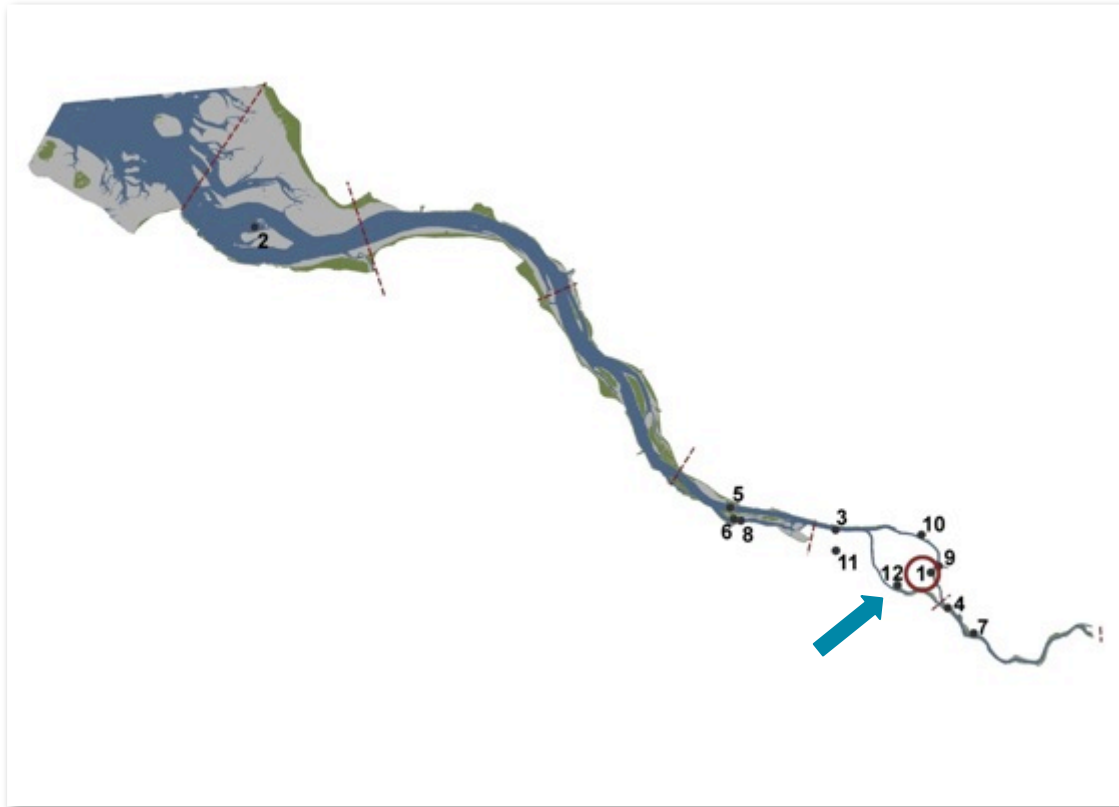
S.I. = state indicator;
D.I. = driver indicator

Measure effects on main pressures (WFD)

Conservation objectives (Humber)	Specification	Effect?					Short explanation
		--	-	0	+	++	
Protected Habitats: Estuary	Intertidal wetland (brackish)					X	Newly created intertidal habitat in Internationally Designated Nature Conservation Site.

Measure effects on conservation objectives on the oligohaline zone of the Humber estuary

Spadenlander Busch Example



Measure Category:
Hydrology/Morphology
Estuary: Elbe
Salinity zone: Limnic
Area: 47 ha
Measure status: Currently
under construction
(2012-2015)
Responsible: Hamburg
Port Authority
Driver: RESMC, Natura
2000

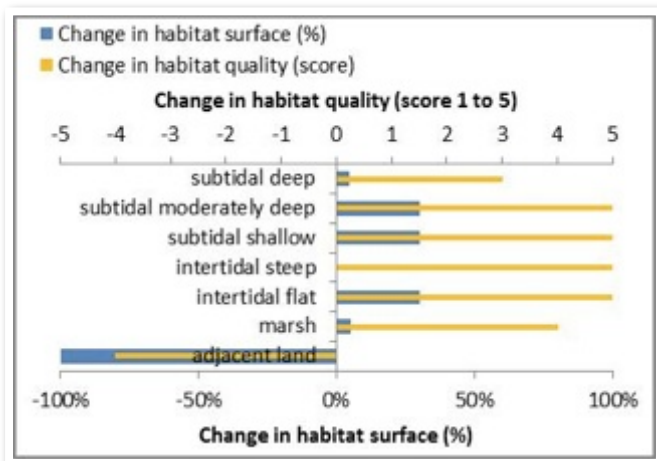
Spadenlander Busch Example: Development targets



Former spoil area is transformed into area influenced by tide in order to:

- Weaken the effect of “tidal pumping”
- Develop new ecologically valuable habitats

Spadenlander Busch Example: Impact on ecosystem services



Surface and quality habitat change after implementation of management measure

1. Expected impact on ES supply in the measure site
2. Expected impact on different beneficiaries, each as a consequence of the measure

Spadenlander Busch/Kreetsand			Beneficiaries:	
Cat.	Ecosystem Service	Score		
S	"Biodiversity"	3	Direct users	0
R1	Erosion and sedimentation regulation by water bodies	3	Indirect users	2
R2	Water quality regulation: reduction of excess loads coming from the catchment	1	Future users	3
R3	Water quality regulation: transport of pollutants and excess nutrients	1	Local users	2
R4	Water quantity regulation: drainage of river water	1	Regional users	2
R5	Erosion and sedimentation regulation by biological mediation	1	Global users	1
R6	Water quantity regulation: transportation	0		
R7	Water quantity regulation: landscape maintenance	1		
R8	Climate regulation: Carbon sequestration and burial	1		
R9	Water quantity regulation: dissipation of tidal and river energy	1		
R10	Regulation extreme events or disturbance: Wave reduction	0		
R11	Regulation extreme events or disturbance: Water current reduction	1		
R12	Regulation extreme events or disturbance: Flood water storage	1		
P1	Water for industrial use	1		
P2	Water for navigation	0		
P3	Food: Animals	0		
C1	Aesthetic information	2		
C2	Inspiration for culture, art and design	3		
C3	Information for cognitive development	3		
C4	Opportunities for recreation & tourism	2		

Legend: expected impact*	
3	very positive
2	positive
1	slightly positive
0	neutral
-1	slightly negative
-2	negative
-3	very negative

*: Indicative screening based on ES-supply surveys and estimated impact of measures on habitat quality and quantity. Quantitative socio-economic conclusions require local supply and demand data to complement this assessment.



Spadenlander Busch Example: Synergistic effects & conflicts with WFD and Natura 2000

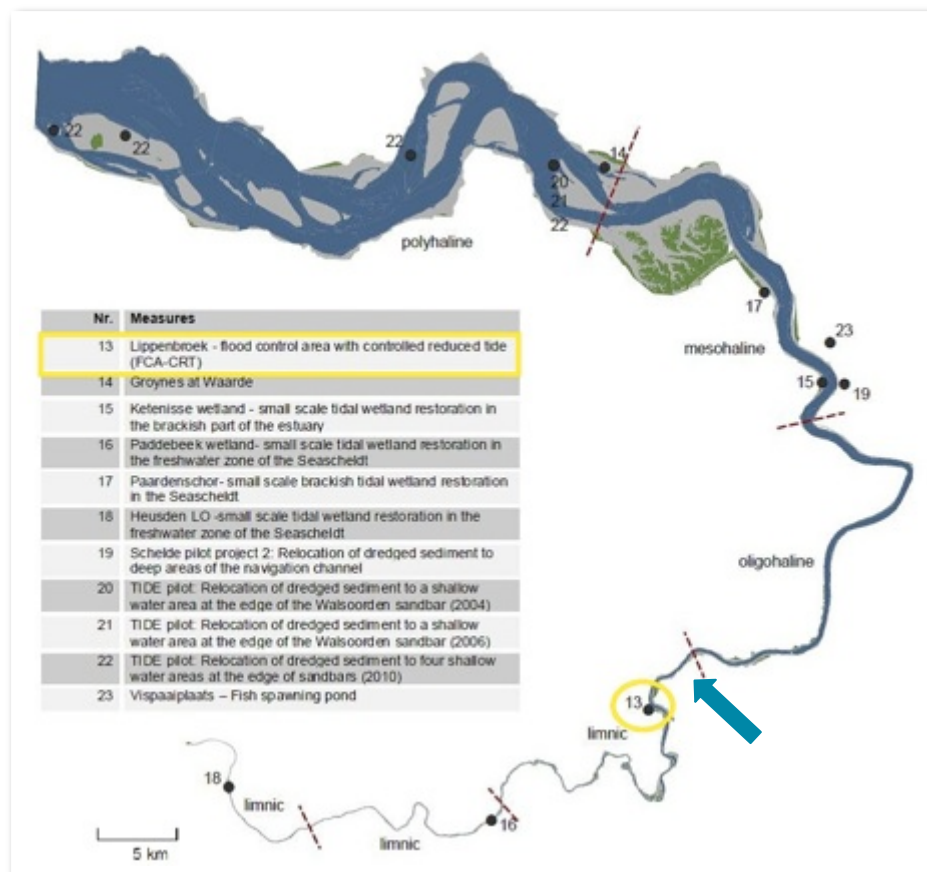
Measure effects on main pressures (WFD)

Indicator Group	Code	Main pressures freshwater zone Elbe	Effect?					Description: Effects of the measure Spadenlander Busch
			--	-	0	+	++	
S.I.	-	Habitat loss and degradation during the last about 100 years: Subtidal				+	Creation of new sub- and intertidal area	
S.I.	1.1	Habitat loss and degradation during the last about 100 years: Intertidal				+		
S.I.	1.4/ 1.5	Gross change in morphology/hydrographic regime during the last about 100 years				+	Attempt to influence the hydrodynamic system in a beneficial manner	
S.I.	3.1/3.2	Decrease of water and sediment chemical quality			0		-	
D.I.	2.3	Discharge of nutrients or harmful substances			0		-	
D.I.	1.3	Land claim during the last about 100 years				+	Creation of new sub- and intertidal area	
D.I.	2.6	Capital dredging				x	Could lower the bad side effects of capital dredging	

Measure effects on conservation objectives (Natura 2000)

Operational area (zone)	Natura 2000 conservation objectives	Effect of Measure on conservation objectives			Description
		Positive	No effect	Negative	
2	Reestablishment of natural sediment- and tidal-dynamics	+			
2	Development of alluvial forests and species-rich aggregates of tidal reeds and tall herb communities	+			
2	Development of a network of step-stone habitats for the 'Elbe Water Dropwort' (<i>Oenanthe conioides</i>)	+			
2	Conservation and development of adequate rest-habitats for migratory fish and lamprey species along their route	+			
2	Conservation of relevant functions for bird protection, esp. in the nature protected areas Westerweiden for roosting goose and Holzhafen for roosting ducks.		+		
2	Strengthening the NATURA 2000 network, particularly the construction of an ecological valuable bypass to avoid the Port of Hamburg.	+			

Lippenbroek Example



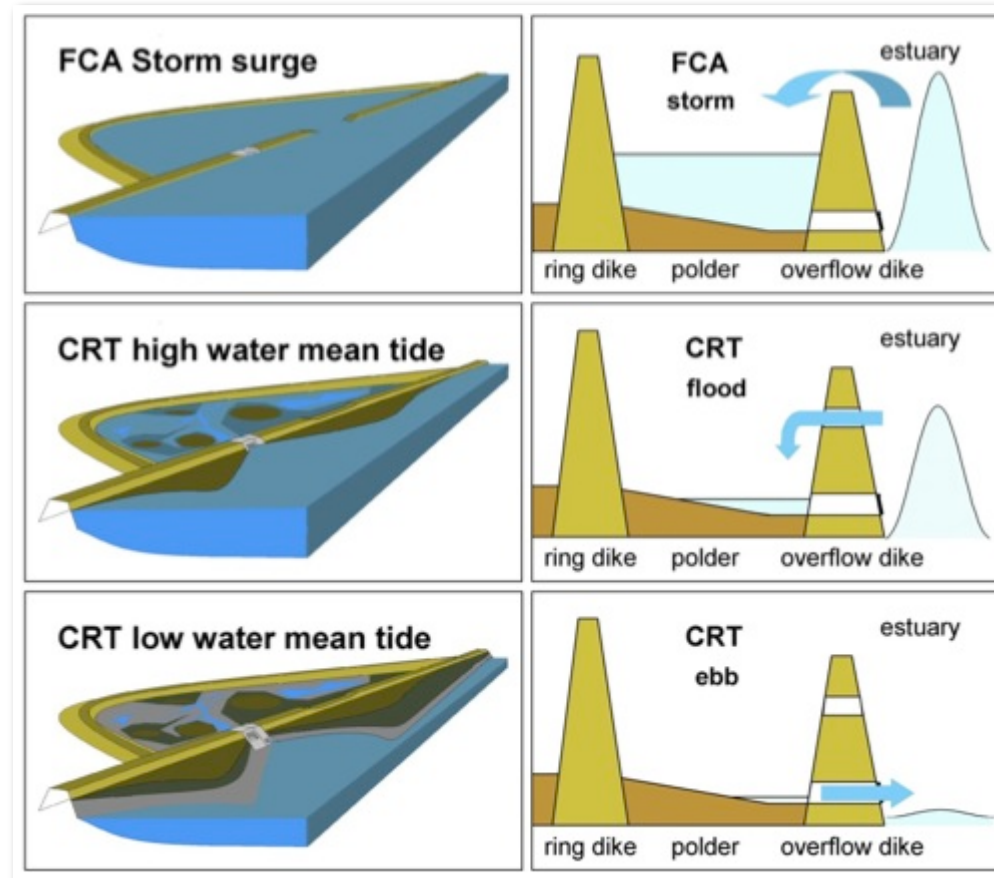
Measure Category: Hydrology/
Morphology and Biology/Ecology
Estuary: Scheldt
Salinity zone: Limnic
Area: 10 ha
Measure status: Implemented
Responsible: Waterwegen en
Zeekanaal NV

Lippenbroek Example: Development targets



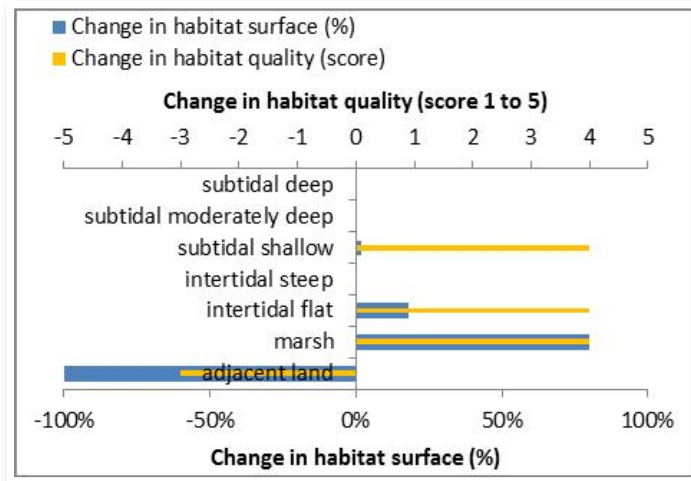
- Aim to combine water storage during extreme high tides and estuarine wetland restoration
- First functional Flood Control Area with Controlled Reduced Tide (FCA-CRT)

Lippenbroek Example



Functioning of a Flood Control Area (FCA) with Controlled Reduced Tide (CRT)

Lippenbroek Example: Impact on ecosystem services



Surface and quality habitat change after implementation of management measure

1. Expected impact on ES supply in the measure site
2. Expected impact on different beneficiaries, each as a consequence of the measure

Lippenbroek - flood control area with controlled reduced tide (FCA-CRT)		
Cat.	Ecosystem Service	Score
S	"Biodiversity"	3
R1	Erosion and sedimentation regulation by water bodies	3
R2	Water quality regulation: reduction of excess loads coming from the catchment	3
R3	Water quality regulation: transport of pollutants and excess nutrients	0
R4	Water quantity regulation: drainage of river water	0
R5	Erosion and sedimentation regulation by biological mediation	2
R6	Water quantity regulation: transportation	0
R7	Water quantity regulation: landscape maintenance	2
R8	Climate regulation: Carbon sequestration and burial	3
R9	Water quantity regulation: dissipation of tidal and river energy	0
(R10)	(Regulation extreme events or disturbance: Wave reduction)	1
(R11)	(Regulation extreme events or disturbance: Water current reduction)	1
R12	Regulation extreme events or disturbance: Flood water storage	3
P1	Water for industrial use	0
P2	Water for navigation	0
P3	Food: Animals	0
C1	Aesthetic information	3
C2	Inspiration for culture, art and design	2
C3	Information for cognitive development	2
C4	Opportunities for recreation & tourism	2

Beneficiaries:	
Direct users	0
Indirect users	2
Future users	3
Local users	3
Regional users	2
Global users	1

Legend: expected impact*	
3	very positive
2	positive
1	slightly positive
0	neutral
-1	slightly negative
-2	negative
-3	very negative

*: Indicative screening based on ES-supply surveys and estimated impact of measures on habitat quality and quantity. Quantitative socio-economic conclusions require local supply and demand data to complement this assessment.

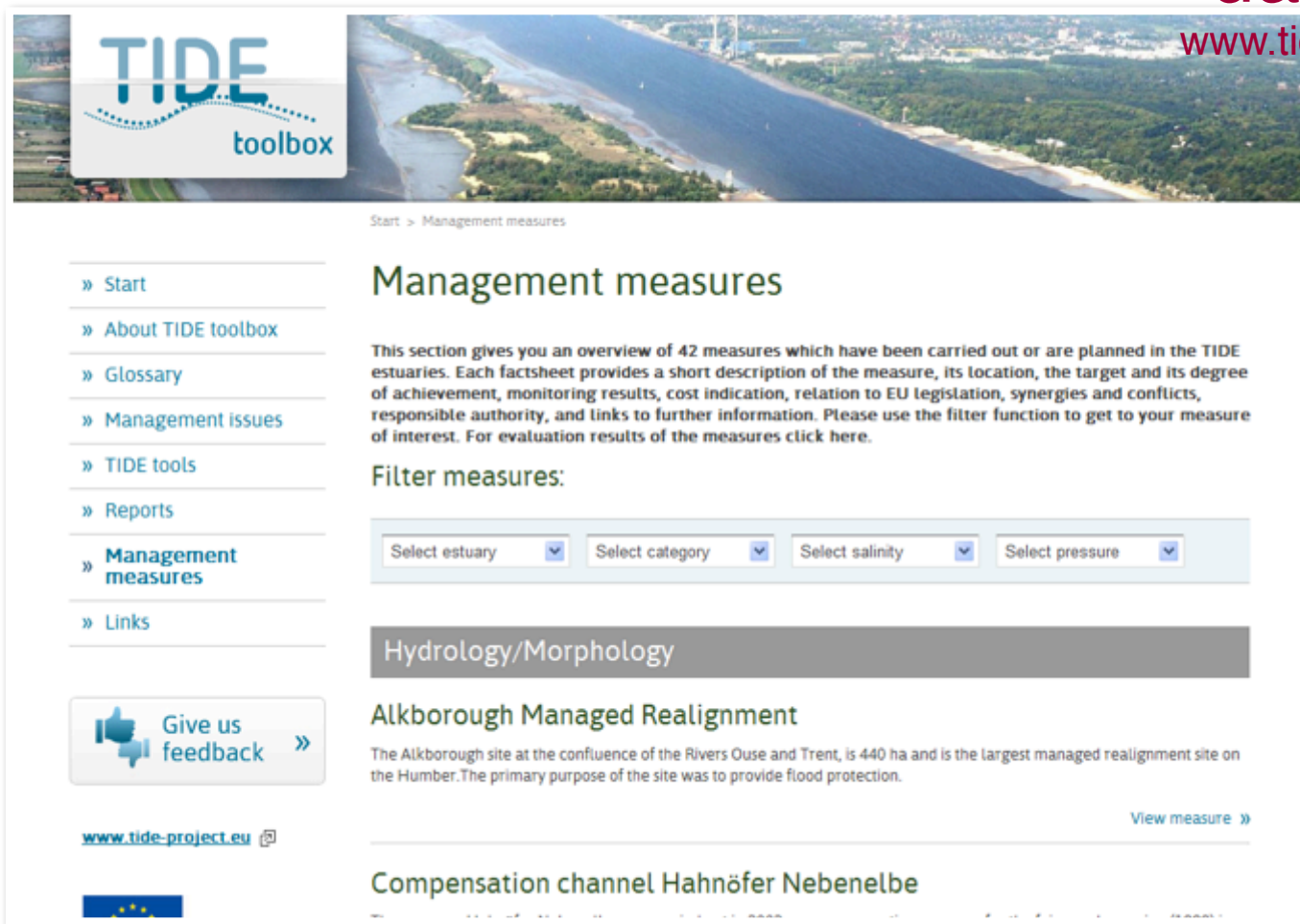
Lippenbroek Example: Synergistic effects & conflicts with WFD and Natura 2000

Indicator	code	Main pressures freshwater zone Scheldt	Effect?					Description
			--	-	0	+	++	
S.I.	1.1	Habitat loss and degradation during the last about 100 years: Intertidal					X	Restoration of intertidal ecosystems.
S.I.	1.5	Gross change of the hydrographic regime during the last about 100 years					X	At larger scale, a FCA-CRT can contribute to the hydrographic regime of the estuary (eg. water storage capacity and safety function)
S.I.	3.1/ 3.2	Decrease of water and sediment chemical quality					X	Nutrient processing and aeration in a CRT can improve water and sediment quality (at larger scale).

Measure effects on main pressures (WFD)

CO	Details	Effect?					Description
		--	-	0	+	++	
HD: Scheldt- and Durme-estuary from the Dutch boarder to Ghent (BE2300006)	Tidal freshwater wetland					X	Newly created freshwater tidal wetland in the protected area BE2300006, and quality improvement for this type of habitat.
BD: Durme and the mid streams from the Scheldt (BE2301235)	Birds					X	In total, 98 species were inventoried, of which 30% aquatic bentivores (19 species), 54% wetland generalists (11 species), 8% terrestrial species (18 species) and 8% forest species (13 species).

Measure effects on conservation objectives (Natura 2000)



The screenshot shows the 'Management measures' page of the TIDE toolbox. The page features a navigation menu on the left with options like 'Start', 'About TIDE toolbox', 'Glossary', 'Management issues', 'TIDE tools', 'Reports', 'Management measures' (highlighted), and 'Links'. Below the menu is a 'Give us feedback' button. The main content area is titled 'Management measures' and includes an introductory paragraph, a 'Filter measures' section with dropdown menus for 'Select estuary', 'Select category', 'Select salinity', and 'Select pressure', and a list of measures. The first measure listed is 'Alkborough Managed Realignment', with a brief description and a 'View measure' link. The second measure is 'Compensation channel Hahnöfer Nebelbe'. The website footer includes the URL 'www.tide-project.eu' and the European Union flag.

Key messages

- System based analysis: what have to be the crucial objectives of the management measure?
- Approach: working with the system
- Analysis of synergies, co-benefits, conflicts
- Formulation of precise targets which can be checked by monitoring
- Target oriented measure monitoring programme
- Communication concept



Thanks for your attention !





Thanks for your attention !

