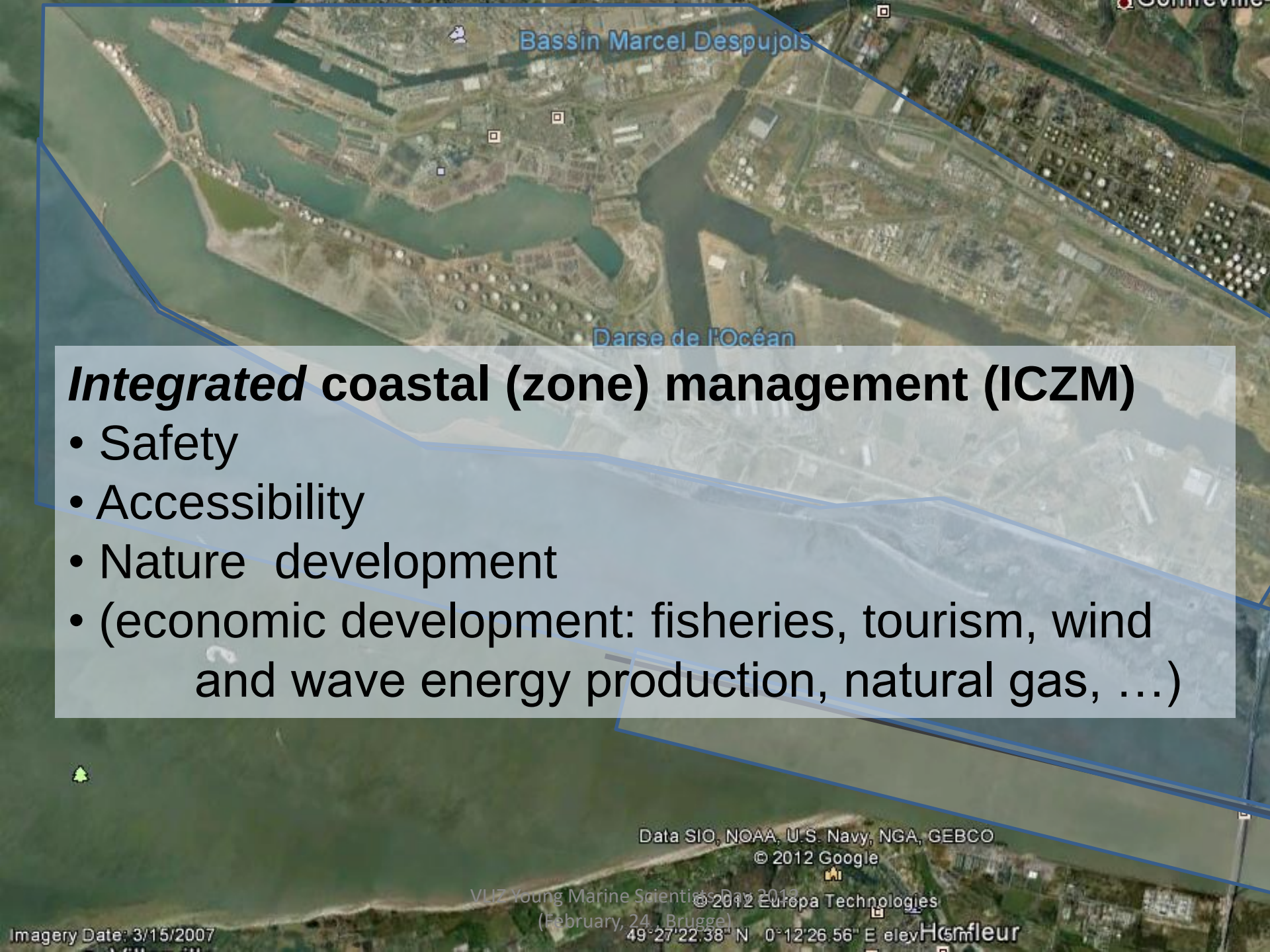
"Why do we love the sea?

Because it makes us think of things we like to think"*.

Jean Berlamont,
Hydraulics Laboratory, dept. civil engineering, KU Leuven

*After Robert Henri (1865 – 1929)



***Integrated* coastal (zone) management (ICZM)**

- Safety
- Accessibility
- Nature development
- (economic development: fisheries, tourism, wind and wave energy production, natural gas, …)

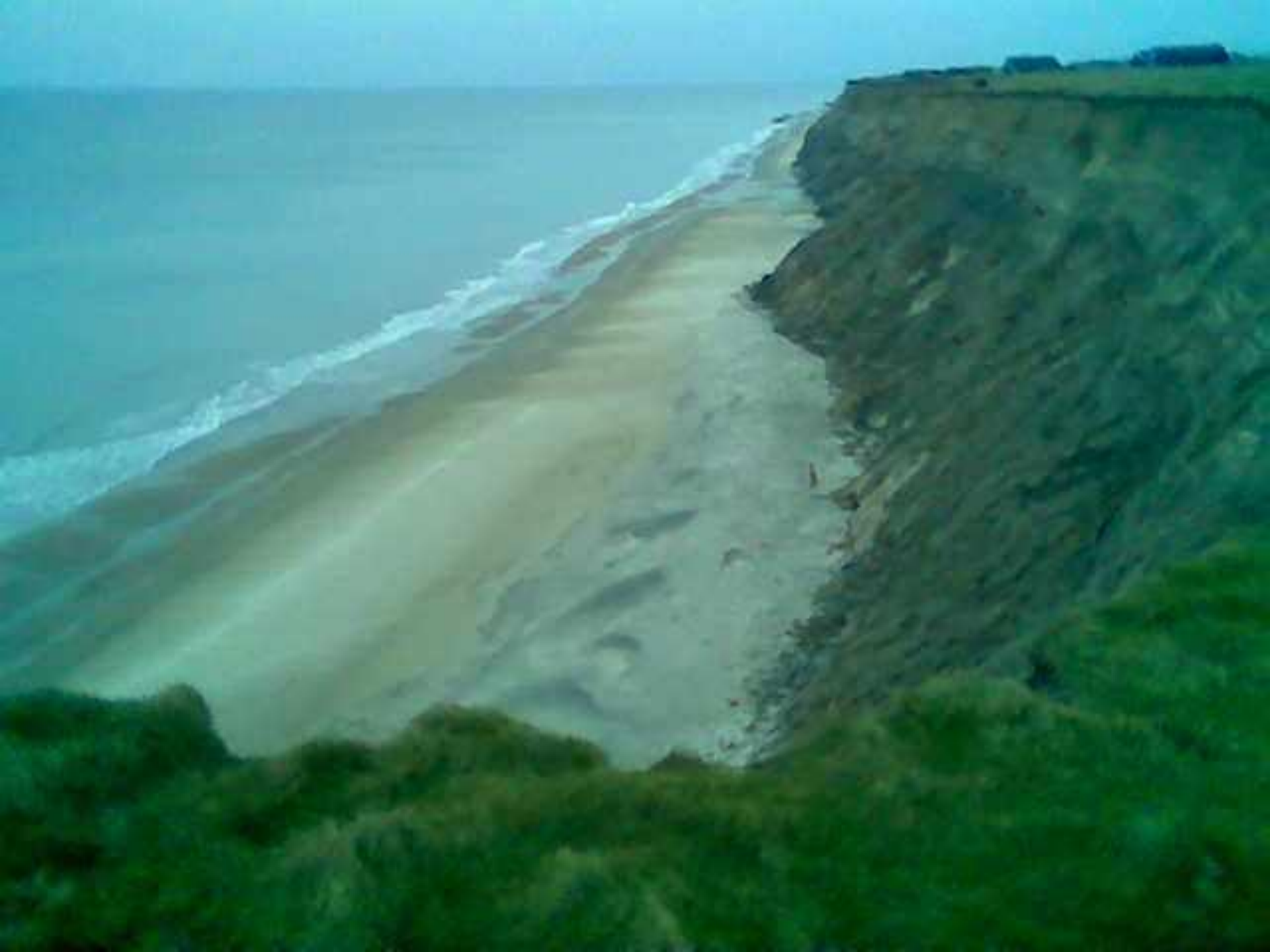
1. Safety

Claudia Vermaut

Foto R. Verbeke


Zeebrugge
Oostende
Bruges
Nieuwpoort
30 %!
Image © 2012 DigitalGlobe
© 2012 Google
Image © 2012 Aerodata International Surveys
Data SIO, NOAA, U.S. Navy, NGA, GEBCO
West-Vlaanderen
51°10'43.93" N 2°58'05.36" E elev 1 m
Google earth
Eye alt 61.56 km


Coastal erosion (Suriname)



Integrated master plan for the coast

T = 1000 y
TAW + 7 m
Significant wave height 5 m

1953: T = 250 y
1976: T = 50 y

"Paradigm shift"

- "*Zacht waar het kan, hard waar het moet*"
- Avoid flooding at any time anywhere <>
  Reduce risk/ damage to acceptable level
  (T = 1000 y), while avoiding large scale flooding

Overview of the planned coastal protection works

COASTAL ZONE COASTAL	PROTECTION MEASURE
De Panne	dune nourishment + beach nourishment
St. Idesbald - Koksijde	beach nourishment
Koksijde	dune nourishment + reconstruction of road
Harbour of Nieuwpoort	storm surge barrier
Middelkerke – Westende	beach nourishment + storm return wall around casino
Raversijde – Mariakerke	beach nourishment + storm return wall
Oostende center	beach nourishment + stilling wave basin
Harbour of Oostende	storm return wall
East Bank of Oostende	beach nourishment
De Haan-Wenduine	beach nourishment + storm return wall
Harbour of Blankenberge	storm return wall + erosion resistant slopes
Blankenberge	beach nourishment
Harbour of Zeebrugge	storm return wall + erosion resistant slopes
Knokke-Heist	beach nourishment
Zwin International dyke	

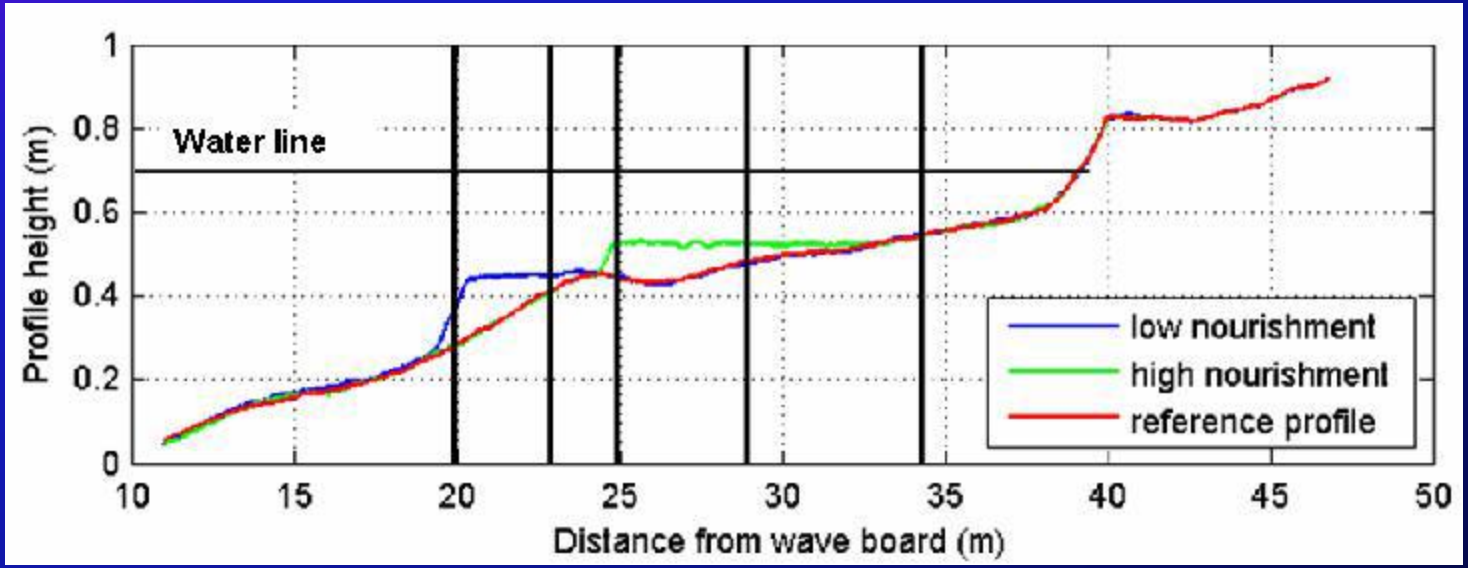
AN INTEGRATED MASTER PLAN FOR FLANDERS FUTURE COASTAL SAFETY
TINA MERTENS1, KOEN TROUW1, JONAS VERMANDER1, TOON VERWAEST2, ANNELIES BOLLE3, JULIEN DE ROUCK

VLIZ Young Marine Scientists Day 2012
(February, 24 , Brugge)

Beach nourishment


“Dynamic preservation”
Dune nourishment

Shore face nourishment



EXPERIMENTAL STUDY INVESTIGATING VARIOUS SHOREFACE NOURISHMENT DESIGNS

D.J.R. Walstra1,2, C.W. Hoyng3, P.K. Tonnon1, L.C. Van Rijn1,4

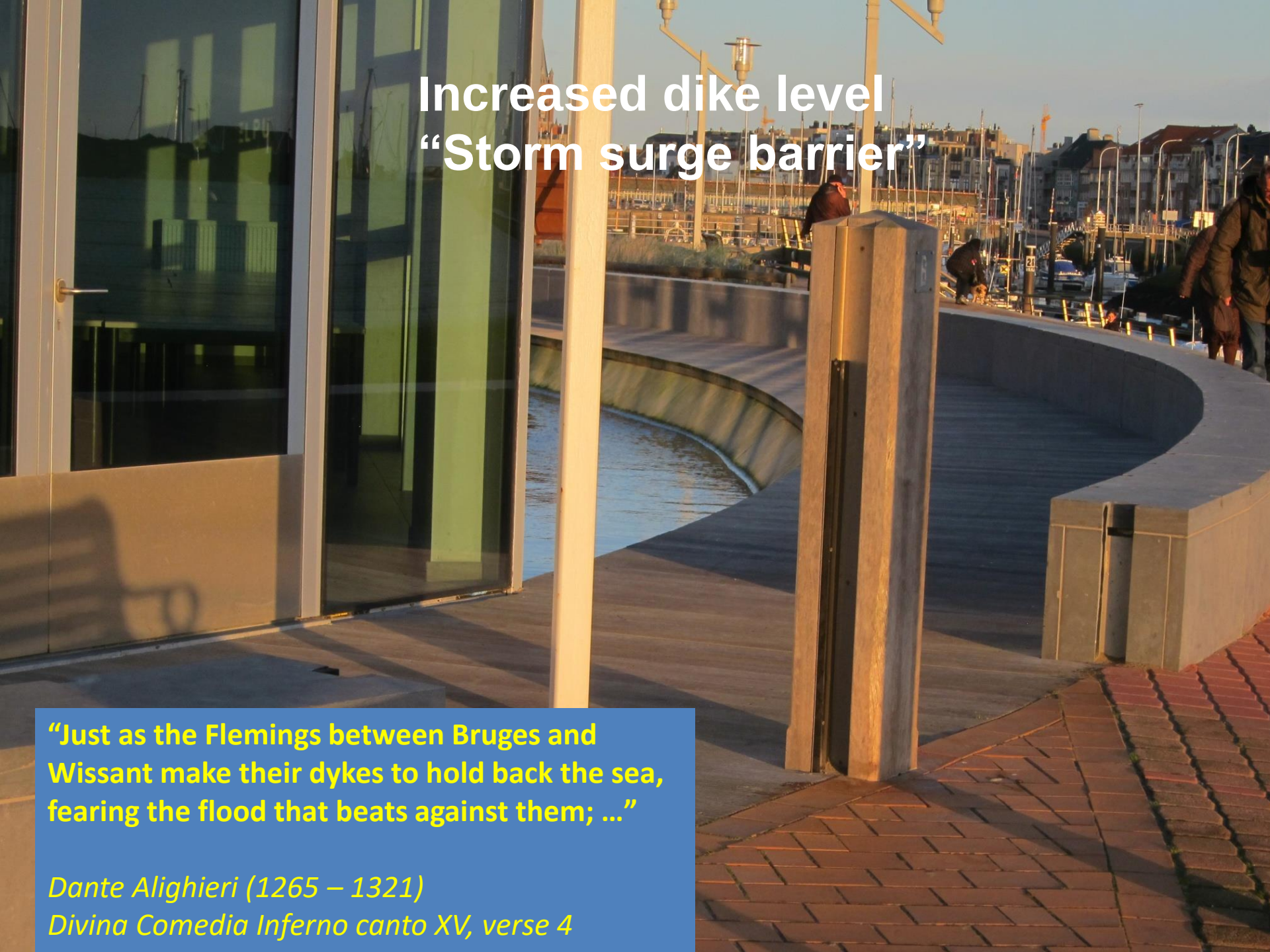
Storm surge barrier

“artist impression” van de stormvloedkering te Oosterweel (Antwerpen) … + 80 + 80 + 80 + … (1981)

Storm surge barrier Lunaplattte Weser

Thames

Nieuwe waterweg



Increased dike level
"Storm surge barrier"

"Just as the Flemings between Bruges and Wissant make their dykes to hold back the sea, fearing the flood that beats against them; …"

Dante Alighieri (1265 – 1321)
Divina Comedia Inferno canto XV, verse 4

Increased dike level
"Storm surge barrier"

"Just as the Flemings between Bruges and Wissant make their dykes to hold back the sea, fearing the flood that beats against them; …"

Dante Alighieri (1265 – 1321)
Divina Comedia Inferno canto XV, verse 4

Increased dike level
“Storm surge barrier”

“Just as the Flemings between Bruges and Wissant make their dykes to hold back the sea, fearing the flood that beats against them; …”

Dante Alighieri (1265 – 1321)
Divina Comedia Inferno canto XV, verse 4

AN INTEGRATED MASTER PLAN FOR FLANDERS FUTURE COASTAL SAFETY

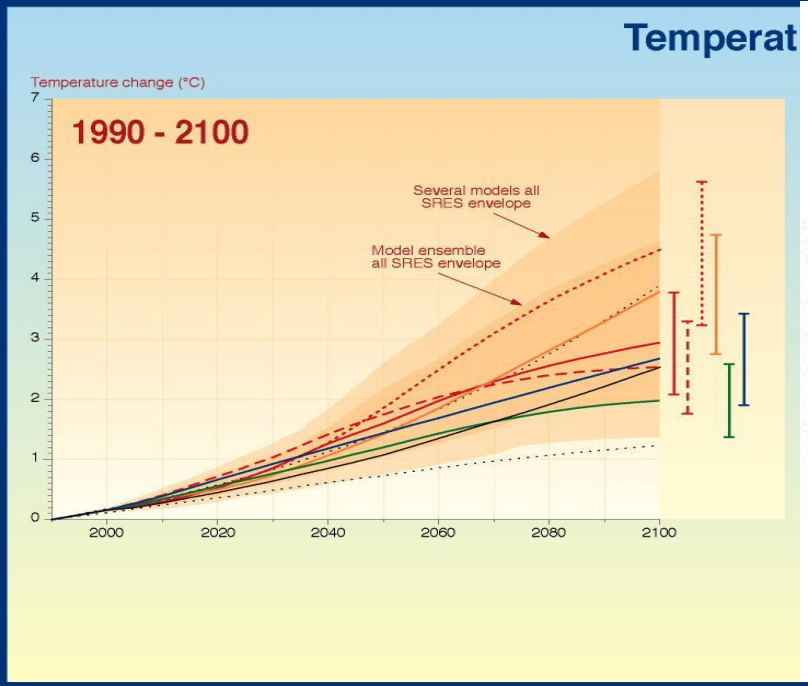
TINA MERTENS1, KOEN TROUW1, JONAS VERMANDER1, TOON VERWAEST2, ANNELIES BOLLE3, JULIEN DE ROUCk

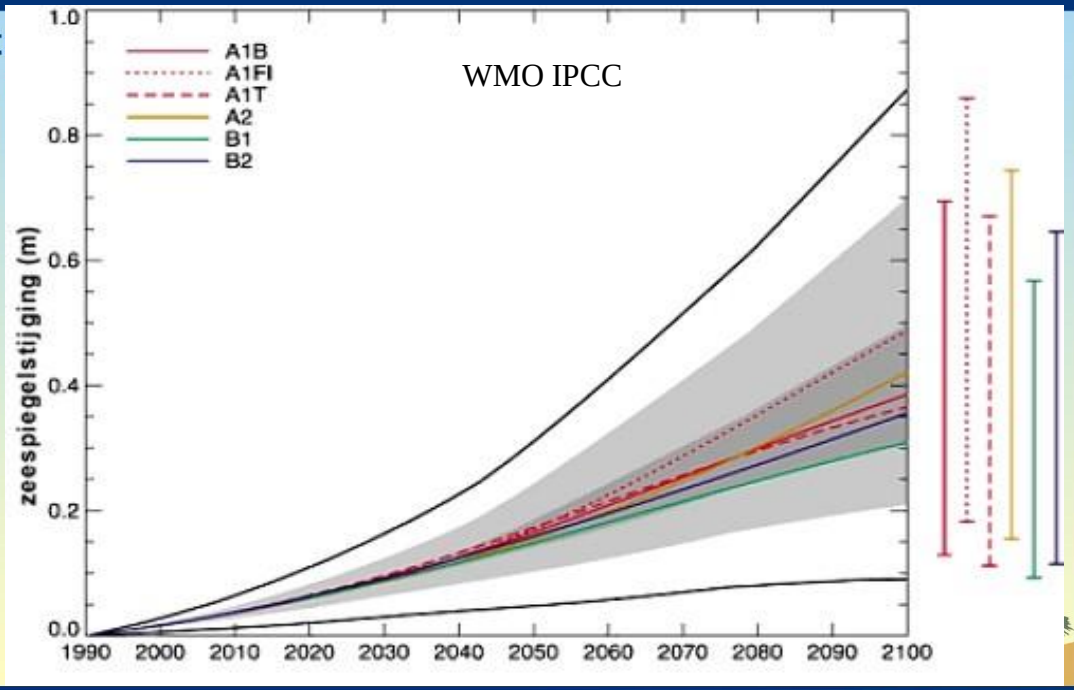
VLIZ Young Marine Scientists Day 2012
(February, 24 , Brugge)

Integrated coastal and maritime plan for Ostend, Design of Soft and Hard Coastal Protection Measures, S. Gysens, J. De Rouck, K. Trouw, A. Bolle, M. Willems
Coastal Engineering, 2010

Challenge: sea level rise

Effect of climate change on mean sea level/ wave climate





WG1 TS FIGURE 22

4000 m * 3.5 10-4(1/°C)*0.5 (°C) = 0.7 m!

Average Monthly Arctic Sea Ice Extent
December 1979 to 2011

Knowledge gaps / Research challenges

- Effect of climate change on mean sea level/ wave climate
- Overtopping discharges? 1 l/m,s?
- Forces/ damage due to overtopping discharges
- Current & wave prediction outside calibration range
- Risk assessment/ uncertainty modelling
- Adaptive designs





Innovative technologies for safer
European coasts in a changing climate

THESEUS

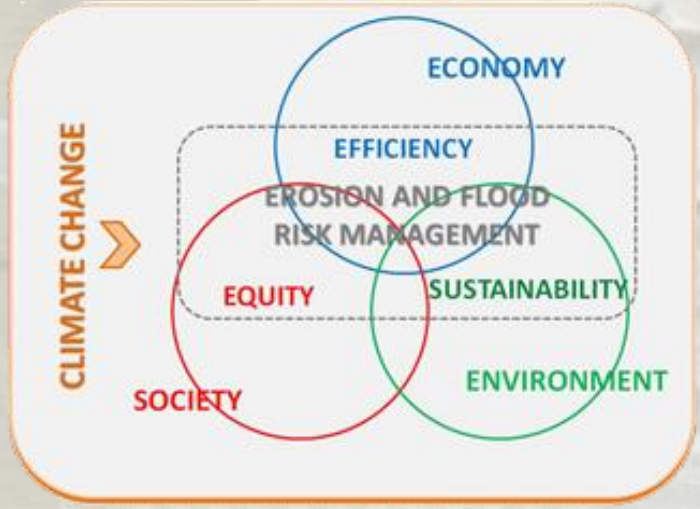
Period: 2011-2014

31 EU partners from 18 countries

Aims:

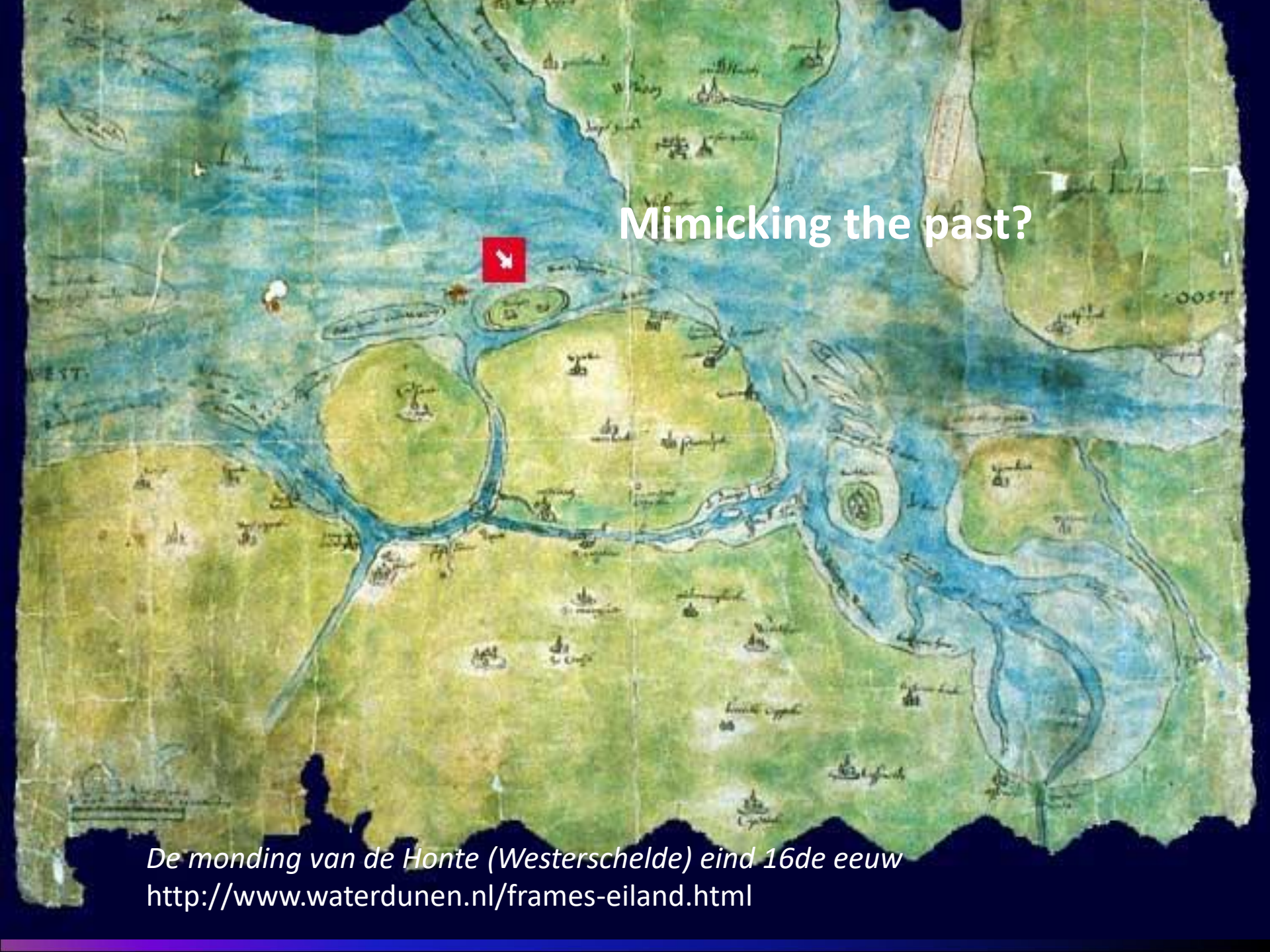
Provide a sound worldwide applicable approach to mitigate coastal risk

Develop real solutions for improving and preserving the safety of people, economies and habitats



The **Flanders Bays 2100** project combines **safety** with four other key pillars:
Sustainability: the sea as an important source of sustainable energy.
Attraction: an attractive coast for tourists and inhabitants.
Naturalness: sufficient space for nature on the coast.
Evolution: the coast must offer room for economic development now and in the future.

Minimize the line of defence!



De monding van de Honte (Westerschelde) eind 16de eeuw
http://www.waterdunen.nl/frames-eiland.html

2. Accessibility of harbours

Challenges: sediment mechanics

Nautical Bottom Research

Aim:

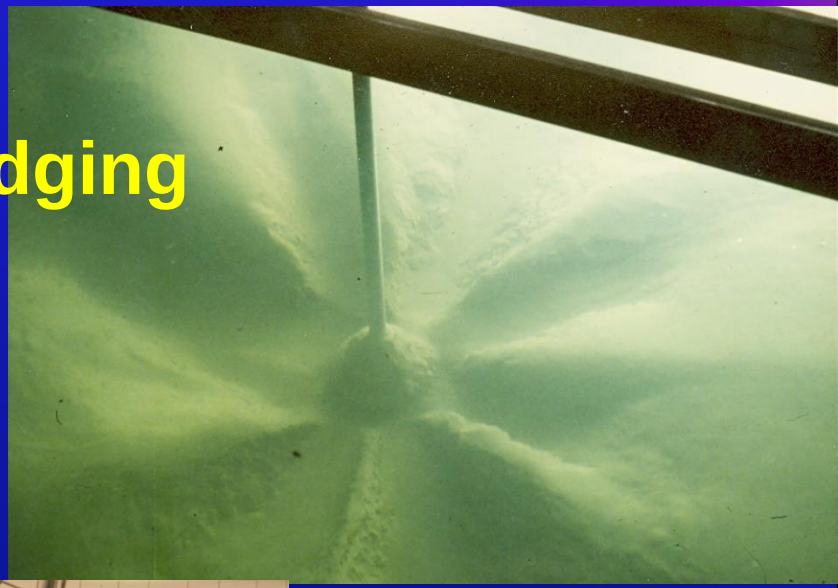
- Testing and innovating of in-situ survey techniques to determine the navigation resistance for a ship moving over a fluid mud bottom by means of CFD modelling & experiments in the Sludge Test Tank @ WL Borgerhout

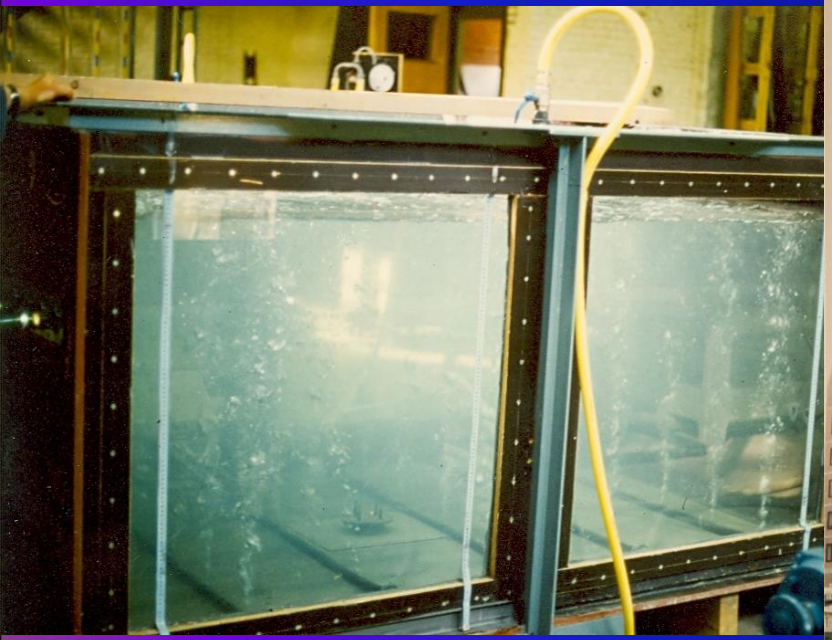
Reducing maintenance dredging
Mud trap Zeebrugge?

Reducing Maintenance dredging

Mud pumping station?

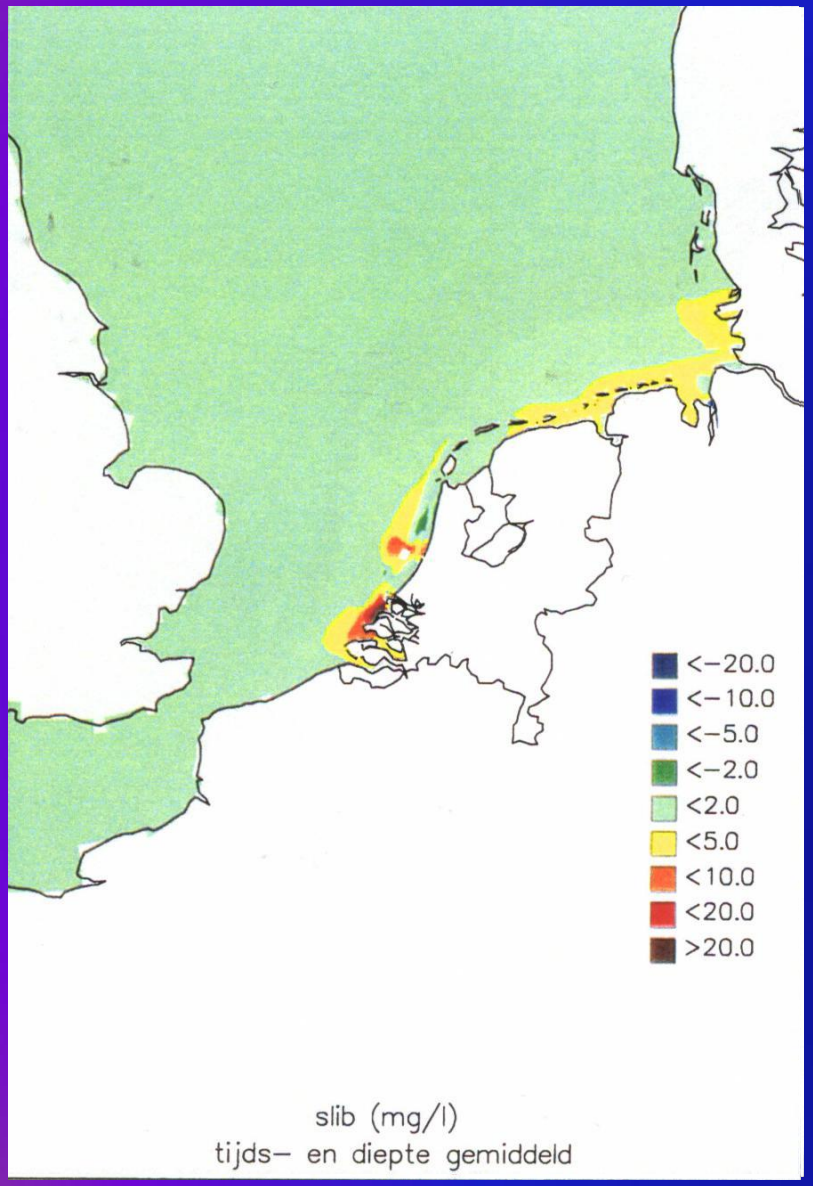
Air bubble screen?

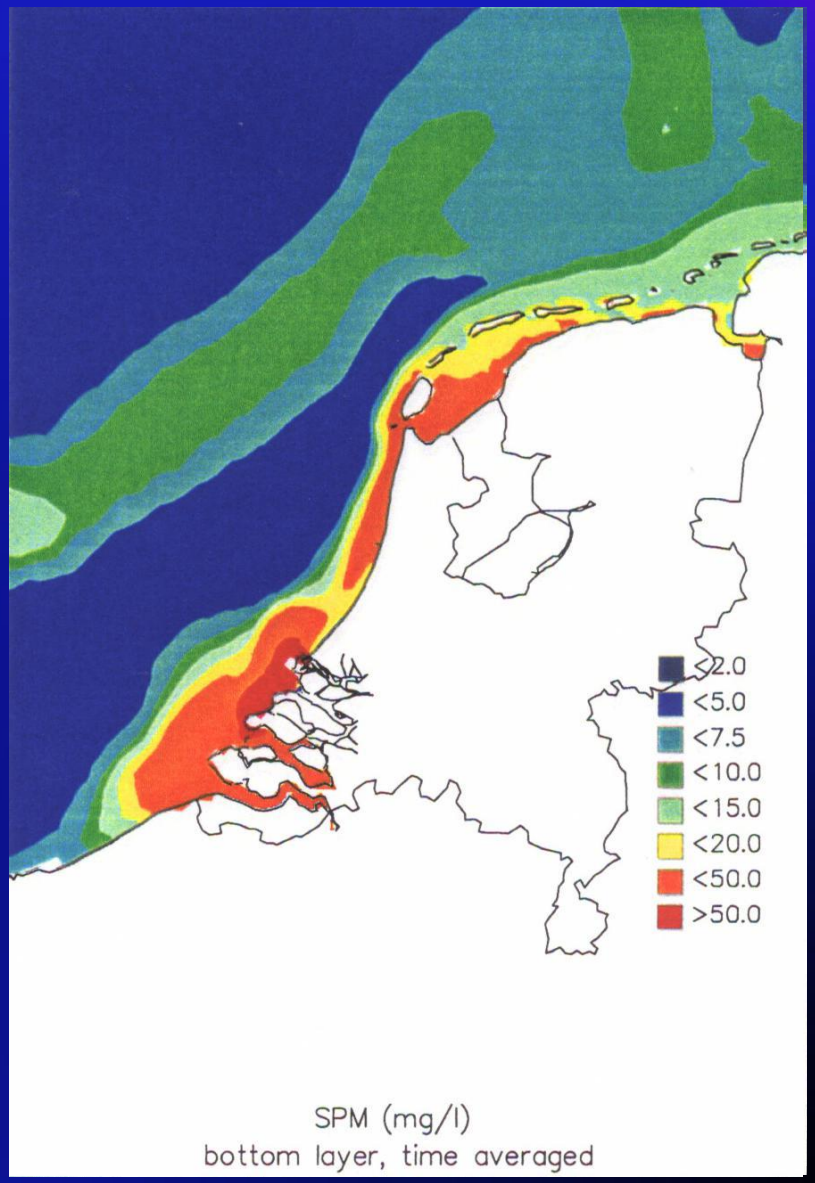




Reducing maintenance dredging
Sand trap off the Zwin entrance

Environmental impact assessment (MER): Flyland project (NL)





Knowledge gaps / Research challenges

- Behaviour and fate of cohesive sediments (COSINUS)
- Distributed data (satellite or airborne remote sensing)
- Morphological models (long term)
- Physical scale models
- Numerical models
- Composite modelling

Nature development
Nature restauration

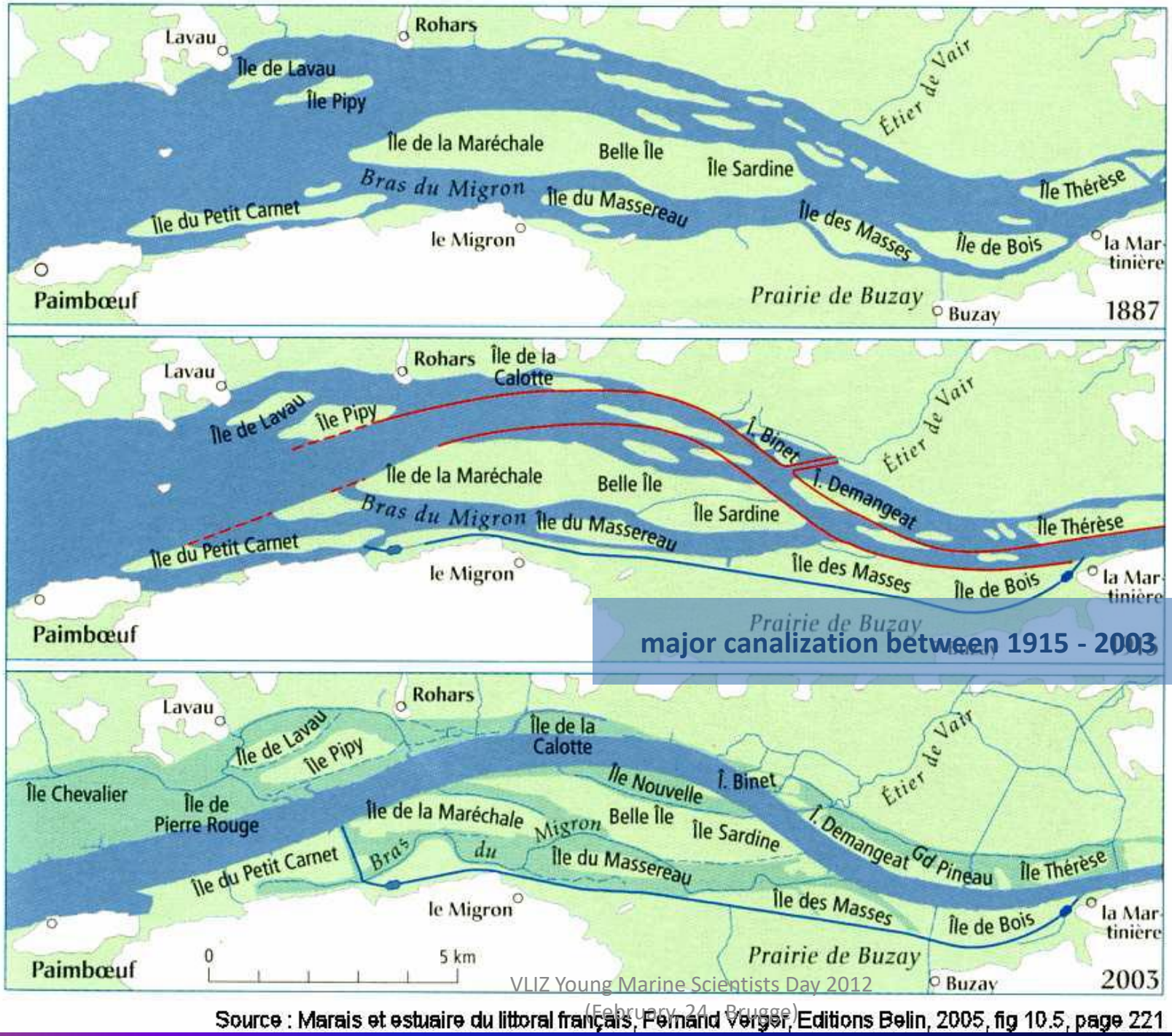
- Biodiversity
- Nursery function
- Intertidal flats


Zwin
Zwin
Image © 2011 Aerodata International Surveys
Data SIO, NOAA, U.S. Navy, NGA, GEBCO
© 2011 Google
Imagery Date: 4/8/2007
elev 1 m

(February, 24 , Brugge)


Le Havre
© 2012 Google
3/15/2007
49°26'44.64" N 0°16'57.21" E elev 3 m

Loire



major canalization between 1915 - 2003

Source : Marais et estuaire du littoral français, Pernand Verger, Editions Belin, 2005, fig 10.5, page 221


Sites potentiels pour la recréation
de la vasière expérimentale


Mont Saint-Michel (France)

Mont Saint-Michel (France)

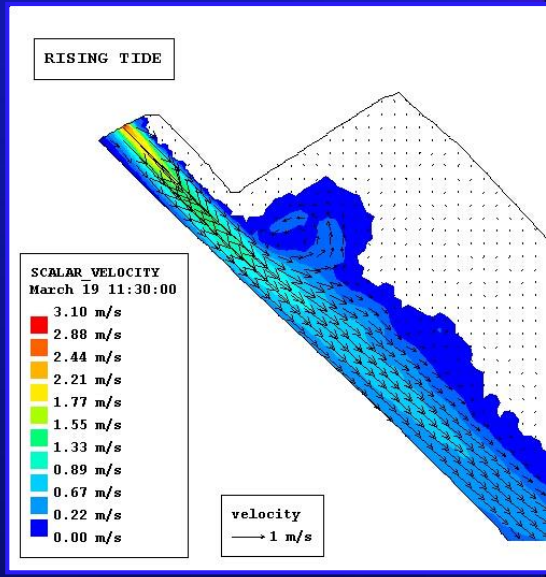
Knowledge gaps/ research challenges

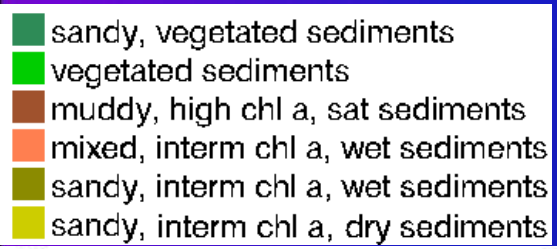
- **(Distributed) data collection (satellite or airborne remote sensing)**
- Physical scale models
- Numerical models
- Composite modelling
- Morphological models (long term)

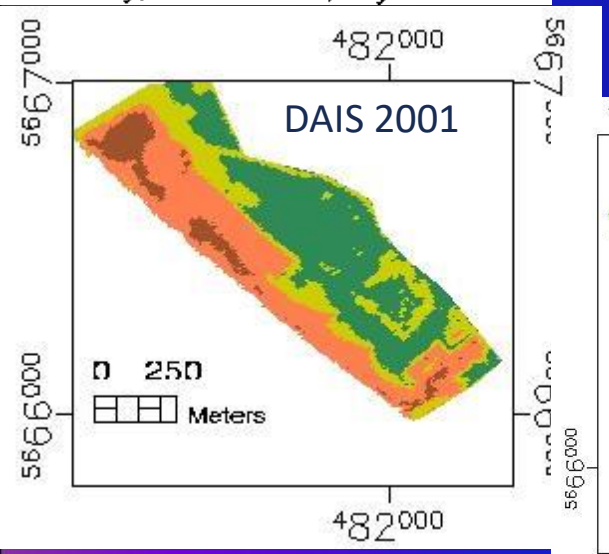
Remote sensing, intertidal flat

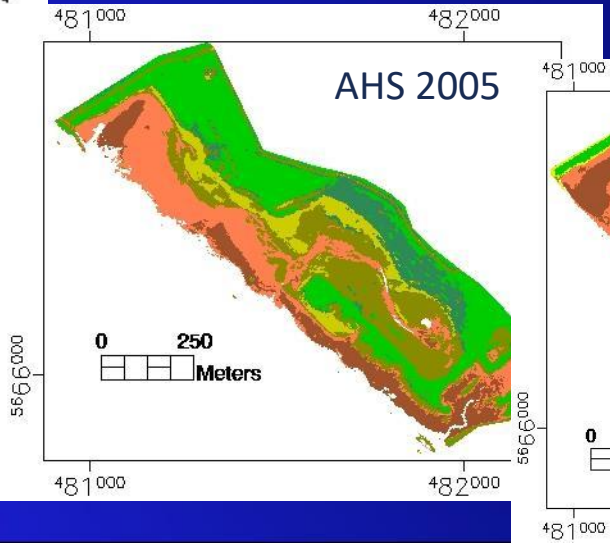
Sediment properties (sand, mud, water content, biological activity)

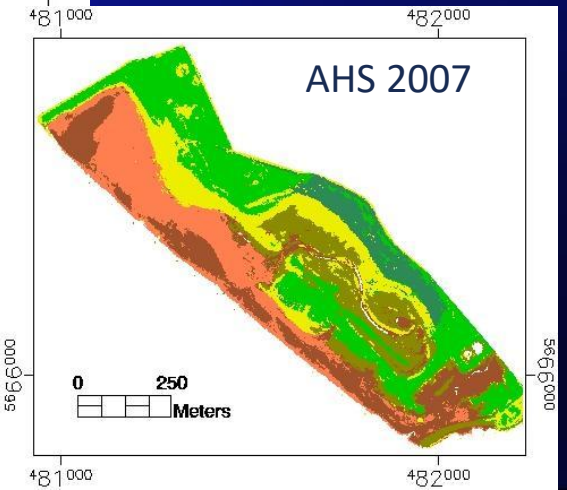
Numerical modelling hydro- and sediment dynamics:











Ground measurements (Molenplaat, Schelde)

SEDIMENT TYPE UNSUPERVISED CLASSIFICATION OF THE MOLENPLAAT, WESTERSCHELDE ESTUARY, THE NETHERLANDS

Stefanie Adam[1], Ilse Vitse[1], Chris Johannsen[2] and Jaak Monbaliu[1]

1. Katholieke Universiteit Leuven, Laboratory for Hydraulics, Department of Civil Engineering, 3011 Heverlee, Belgium; stefanie.adam(at)bwk.kuleuven.be

2. Purdue University, Department of Agronomy, West-Lafayette, Indiana 47907-2054, USA

ABSTRACT

Sediment stability or erosion resistance of intertidal zones depends on sediment physical characteristics and on biological factors.

Obtaining accurate data on the basic biological, chemical and physical processes in sediments is expensive and difficult.

Remote sensing methods can produce detailed information on ecological functioning in a cost effective manner.

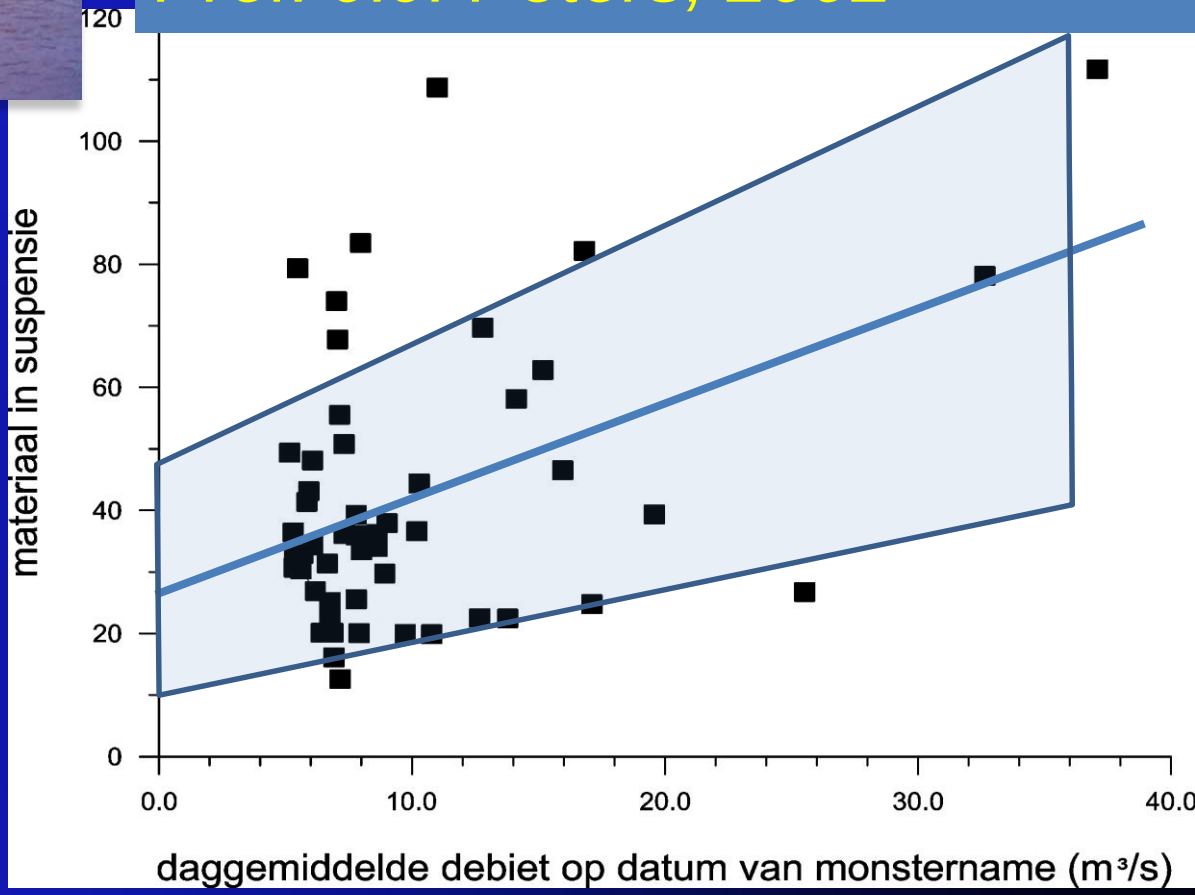
A hyperspectral image of the Molenplaat, an intertidal flat in the Westerschelde estuary, the Netherlands, was acquired with the HyMap sensor in June 2004. The goal of this research is to per-form, analyse and evaluate unsupervised classification methods for sediment types on

VLIZ Young Marine Scientists Day 2012
(February 24, Brugge)

Ground measurements
Mud banks, coast Surinam

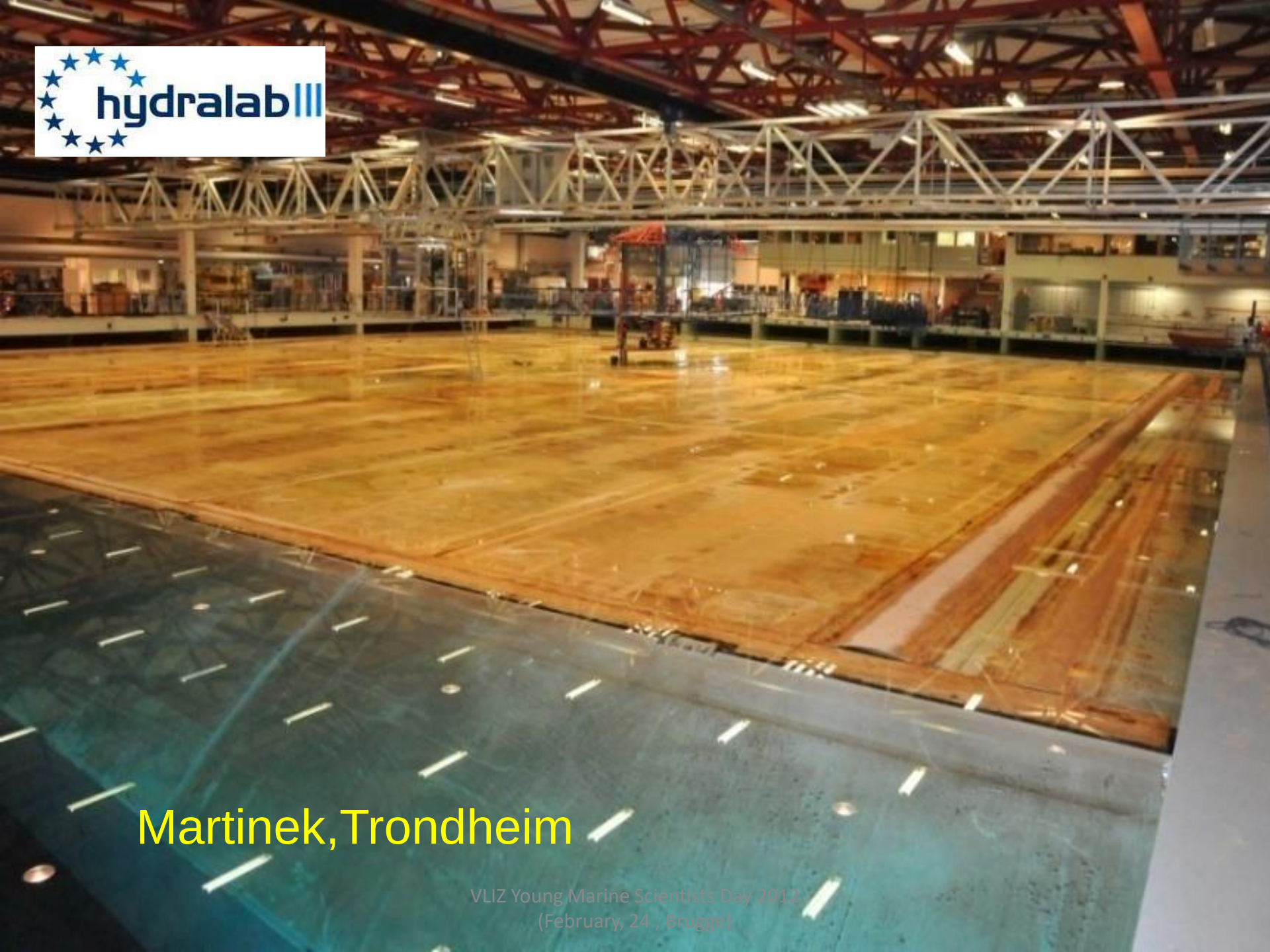
"If you are happy,
and you want to remain happy,
don't try to measure sediment transport"
Prof. J.J. Peters, 2002

Sediment transport measurements in the River Scheldt (Temse)

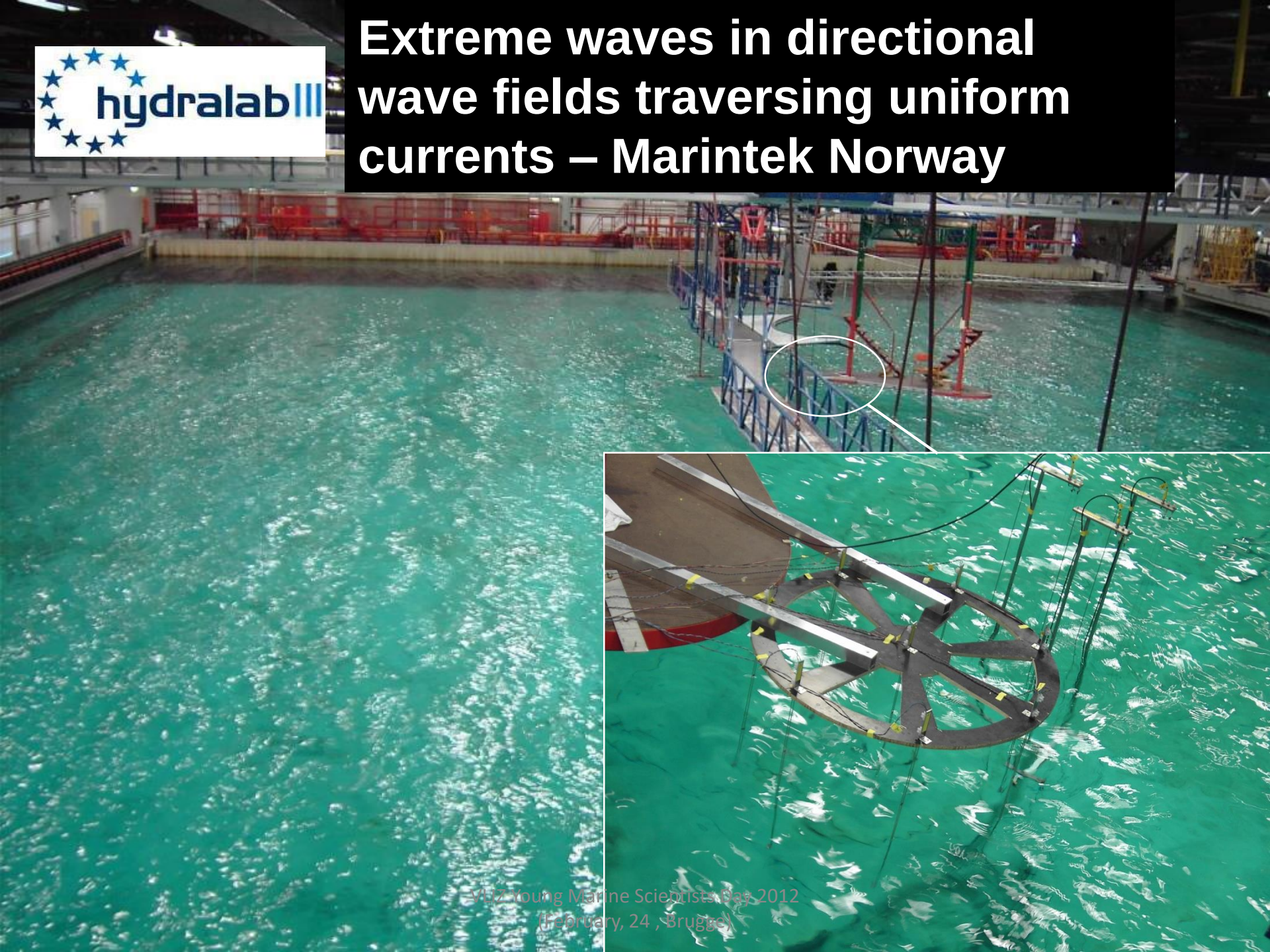


Knowledge gaps/ research challenges

- (Distributed) data collection
  (satellite or airborne remote sensing)
- **Physical scale models**
- Numerical models
- Composite modelling
- Morphological models (long term)

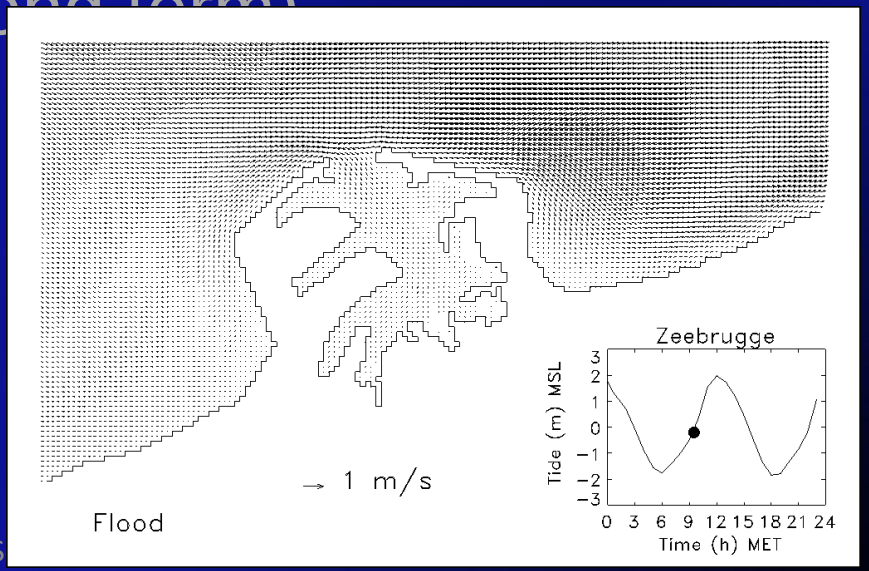

hydralab III
Martinek, Trondheim

Extreme waves in directional wave fields traversing uniform currents – Marintek Norway



Knowledge gaps/ research challenges

- (Distributed) data collection (satellite or airborne remote sensing)
- Physical scale models
- **Numerical models**
- Composite modelling
- Morphological models (long term)



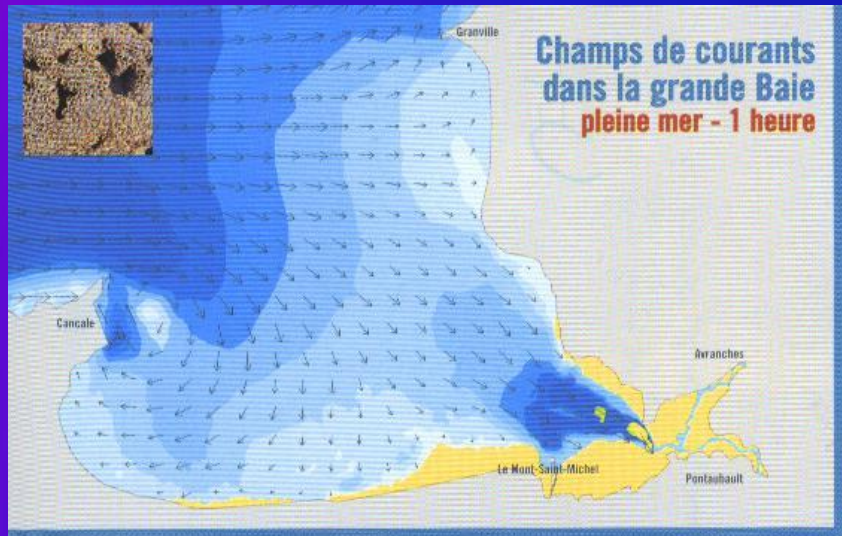
It is impossible to *measure* the effect of one individual parameter on the results, without the effect of all other, known or unknown influencing parameters.

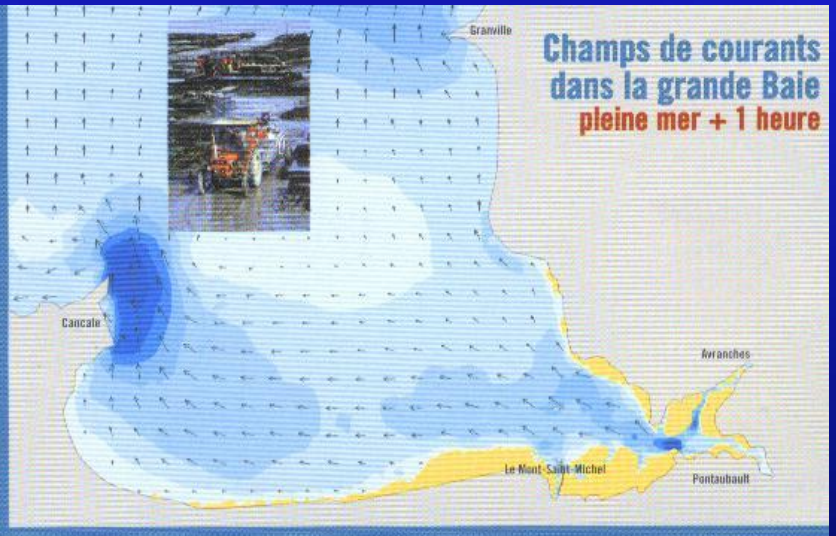
That's why we use models which describe the different processes.

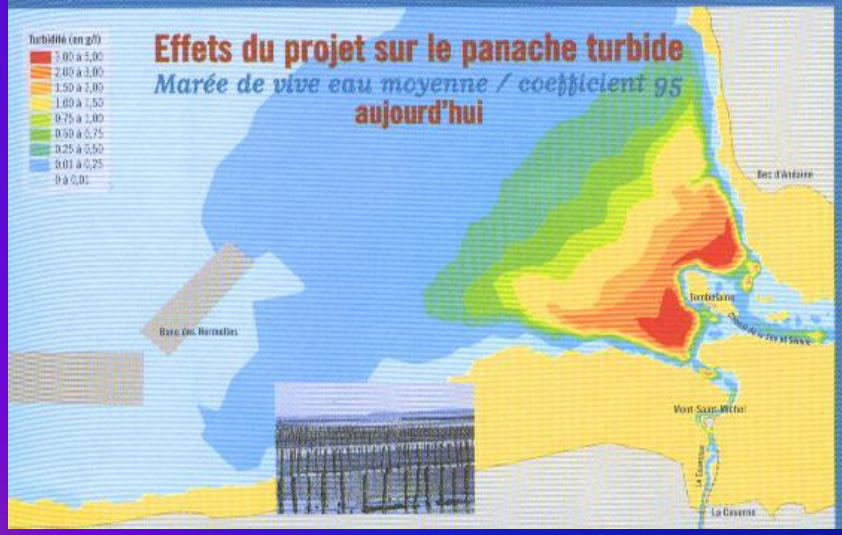
Knowledge gaps/ research challenges

- (Distributed) data collection (satellite or airborne remote sensing)
- Physical scale models
- Numerical models
- **Composite modelling**
- Morphological models (long term)

Baie de Mont Saint-Michel (F)







VLIZ Young Marine Scientists Day 2012
(February, 24 , Brugge)

Sogreah Grenoble

Knowledge gaps/ research challenges

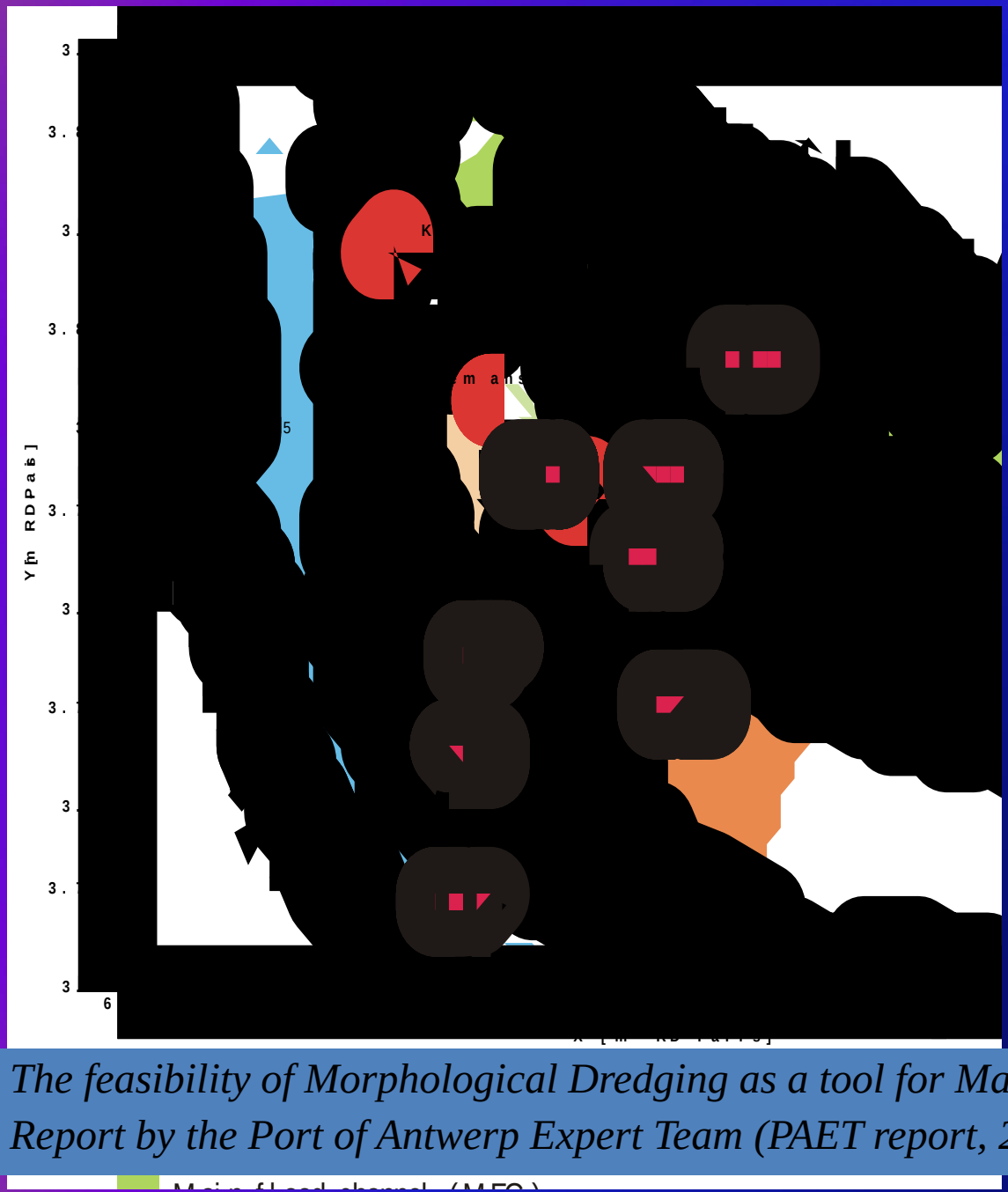
- (Distributed) data collection (satellite or airborne remote sensing)
- Physical scale models
- Numerical models
- Composite modelling
- **Morphological models (long term)**

Need for morphological modelling for the prediction of long term natural and antropogenic changes

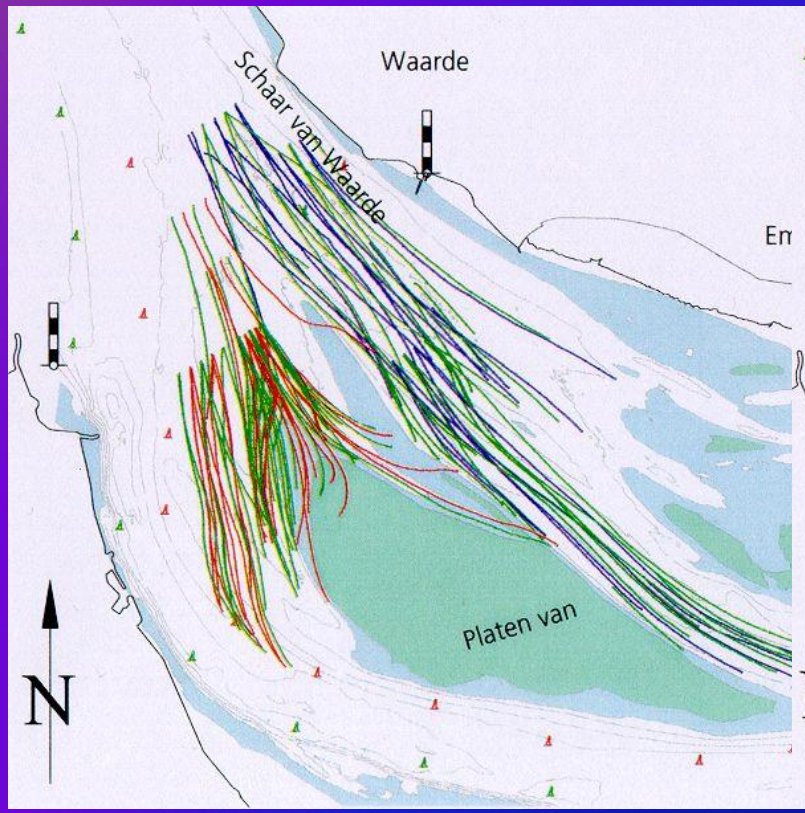
- estuaries — navigable channels, wetlands, shores, tidal flats, …
- harbours — siltation, accumulation of pollutants
- coastal morphology — beaches, sea defences, …
- dredge spoil deposits — under water, on land

Environmental impact assessment
morphology >> ecology
equilibrium state >> dynamics
- spatially detailed information
- time horizon of the prediction
- different time and space scales

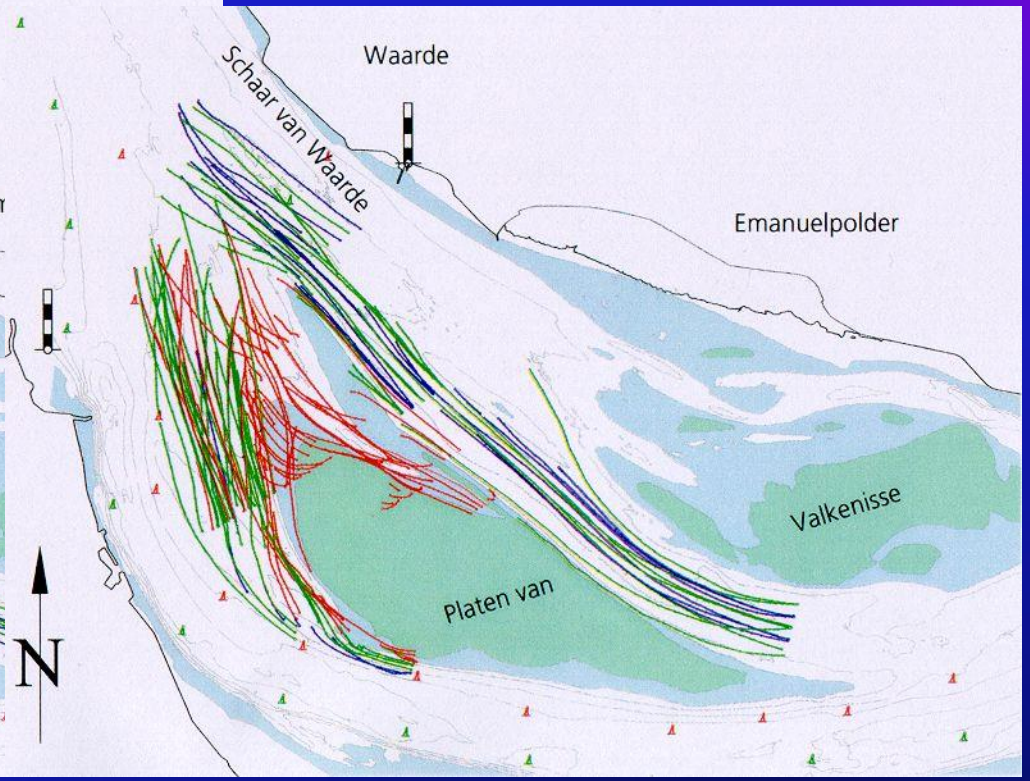
Precautionary principle: *"if you can not proof that there will be no harmful effects…".*



The feasibility of Morphological Dredging as a tool for Managing the Westerschelde
Report by the Port of Antwerp Expert Team (PAET report, 2003)



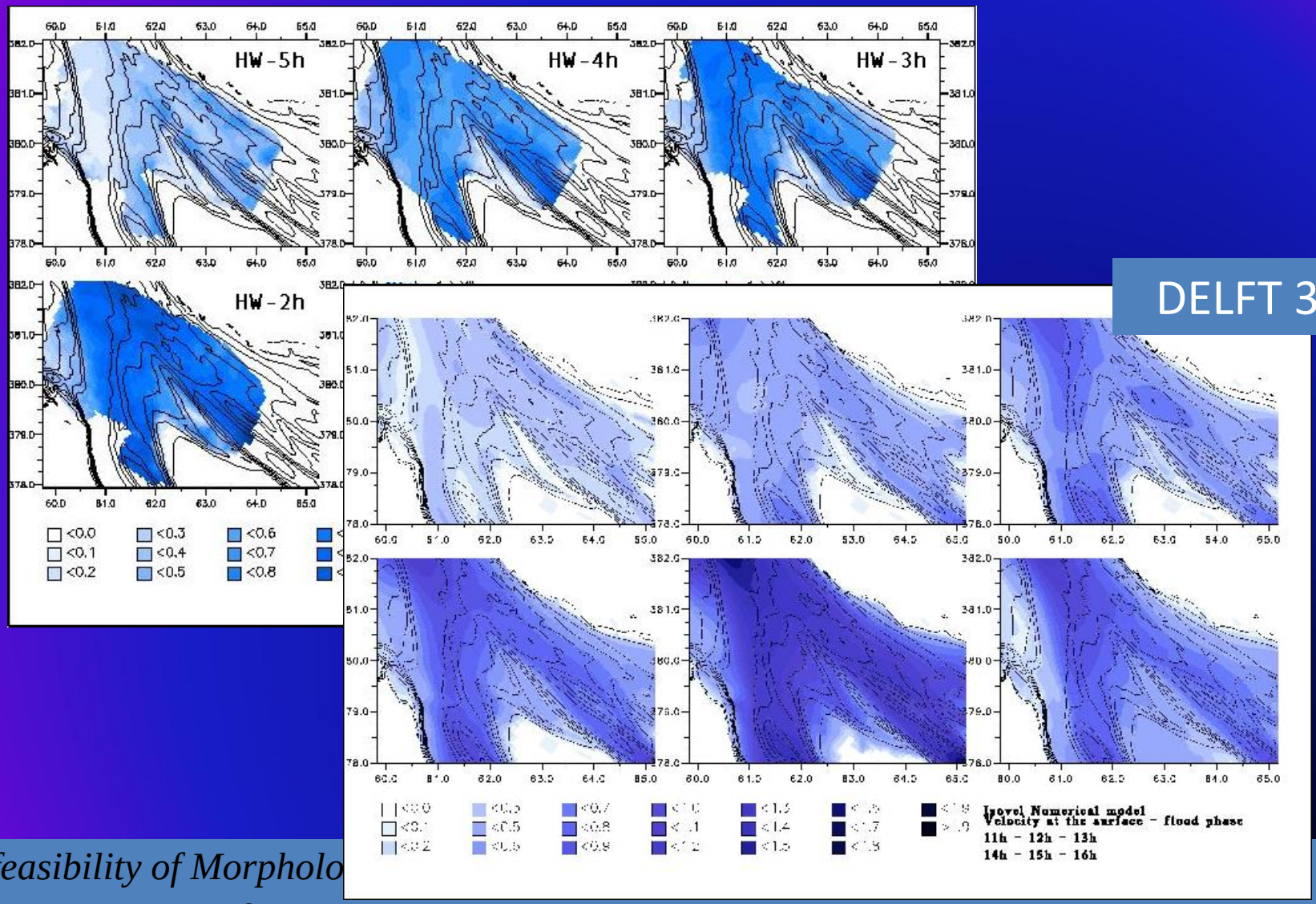
Overview of float tracks
(flood phase)



Overview of float tracks
(ebb phase)

The feasibility of Morphological Dredging as a tool for Managing the Westerschelde
Report by the Port of Antwerp Expert Team (PAET report, 2003)

Isovel lines in the scale/ numerical model during flood

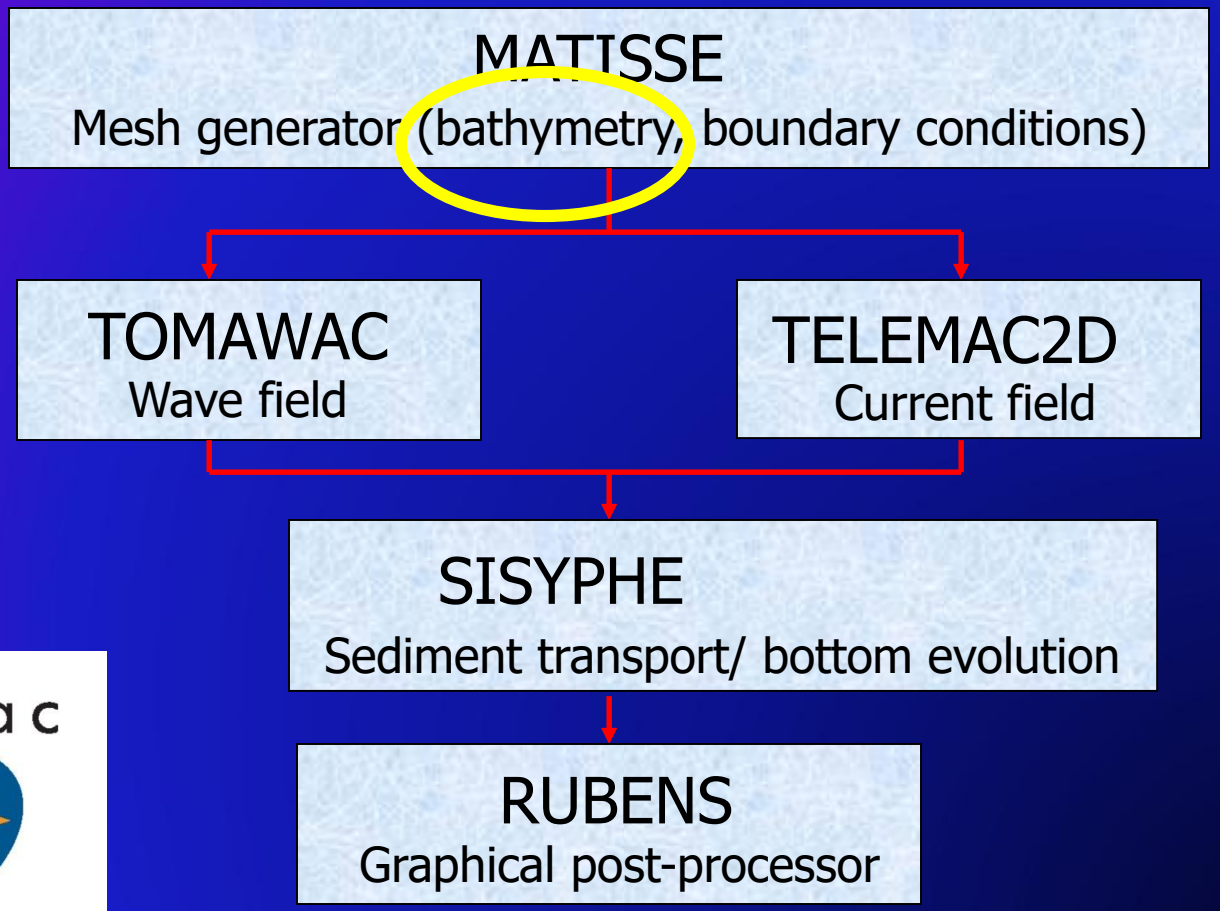


The feasibility of Morpholo

Report by the Port of Antwerp Expert Team (PAET report, 2003)

The TELEMAC system:

long-term simulations for morphological changes studies



telemac

Bathymetry

"My course is set for an uncharted sea"
Dante Alighieri, Paradise

- *Coherent* data sets, sufficiently detailed
- historical data for validation?
- Data for sand banks? Mud flats? Wetlands?
  Data have never been collected for this purpose,
  but for navigation, dredging purpose…

The NOWESP database

Universität Hamburg
DER FORSCHUNG | DER LEHRE | DER BILDUNG

NOWESP

North-west European Shelf Programme (1993-1996)

Historical data from the north-west European shelf were compiled and evaluated (Van Leussen et al., 1996, NOWESP, 1994, 1995, 1996).

- the acquisition of the relevant data sets,
- the organization of the data sets in the NOWESP Research Data Base,
- the merging of the specific data sets for ten main state variables used in NOWESP
- and the provision of data products for the analysis within NOWESP.

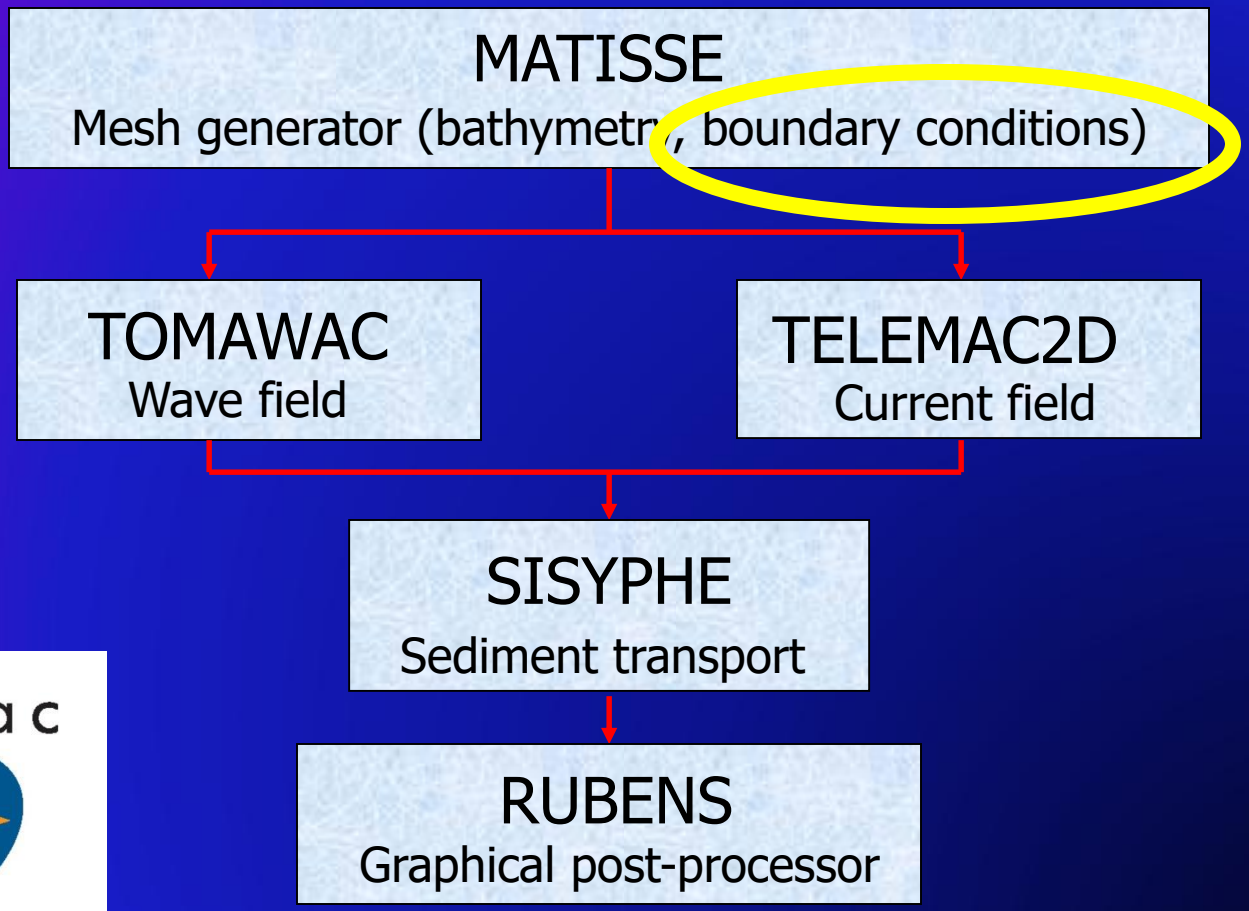
NOWESP provided data sets for ten state variables
temperature, salinity, phosphate, nitrate, nitrite, ammonium, silicate, chlorophyll, suspended particulate matter,, zooplankton (only in time series data) as:

- Merged data sets of the nine state variables for the whole area.
- Gridded data sets for the same nine state variables on a grid of 20 km by 20 km.
- Time series at eight sites on the shelf.

The data sets can be obtained from the server of the Institut für Meereskunde Hamburg

The TELEMAC system:

long-term simulations for morphological changes studies



telemac

Boundary conditions

- **at the horizontal boundaries of the flow field**
  not (only) water level but velocity field/ **fluxes**

- **at the bottom boundary of the flow field**
  need for more spatially distributed data on the bed properties and (initial) sediment availability

- **at the free surface of the flow field**
  traditional free surface b.c. may result in unrealistic high *Ri* values at the free surface(too much buoyancy damping)

FIELD_AC

FLUXES, INTERACTIONS AND ENVIRONMENT AT THE LAND-OCEAN BOUNDARY. DOWNSCALING, ASSIMILATION AND COUPLING

SEVENTH FRAMEWORK PROGRAMME

PROJECT STRUCTURE

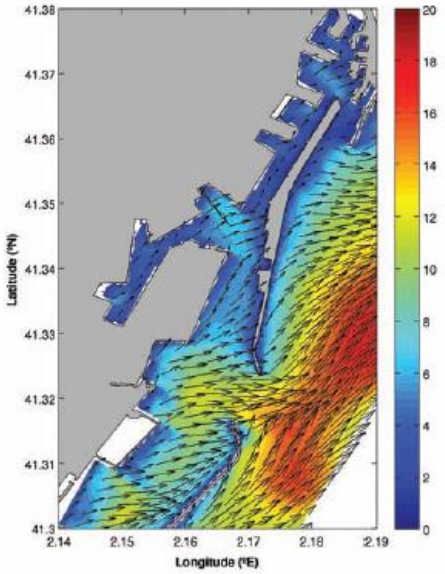
1. DOWN-STREAMING GMES SERVICES TO COASTAL-ZONE END-USERS
   Led by UPC

2. BOUNDARY FLUXES
   Led by KUL

3. FIELD EVIDENCE AND PREDICTION LIMITS
   Led by GKSS

4. METEO-OCEANOGRAPHIC MODELLING TOOLS
   Led by NERC-POL

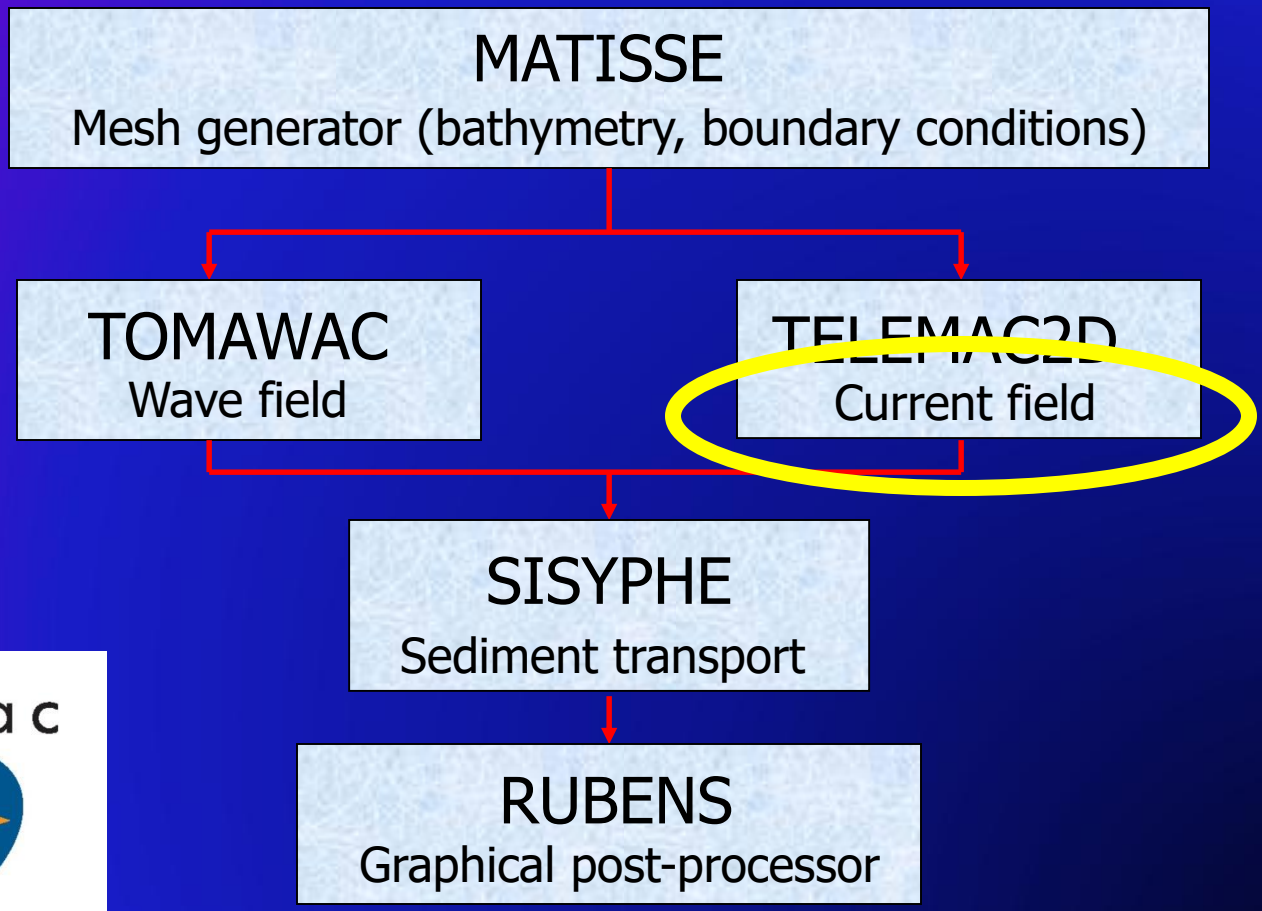
5. INTERACTIONS AND COUPLING IN RESTRICTED DOMAINS
   Led by ISMAR



FIELD_AC assesses the quality of coastal scale oceanographic predictions. It specifically includes free-surface waves and continental discharges, with emphasis on coupling and high resolution.

The TELEMAC system:

Knowledge gaps/ research challenges



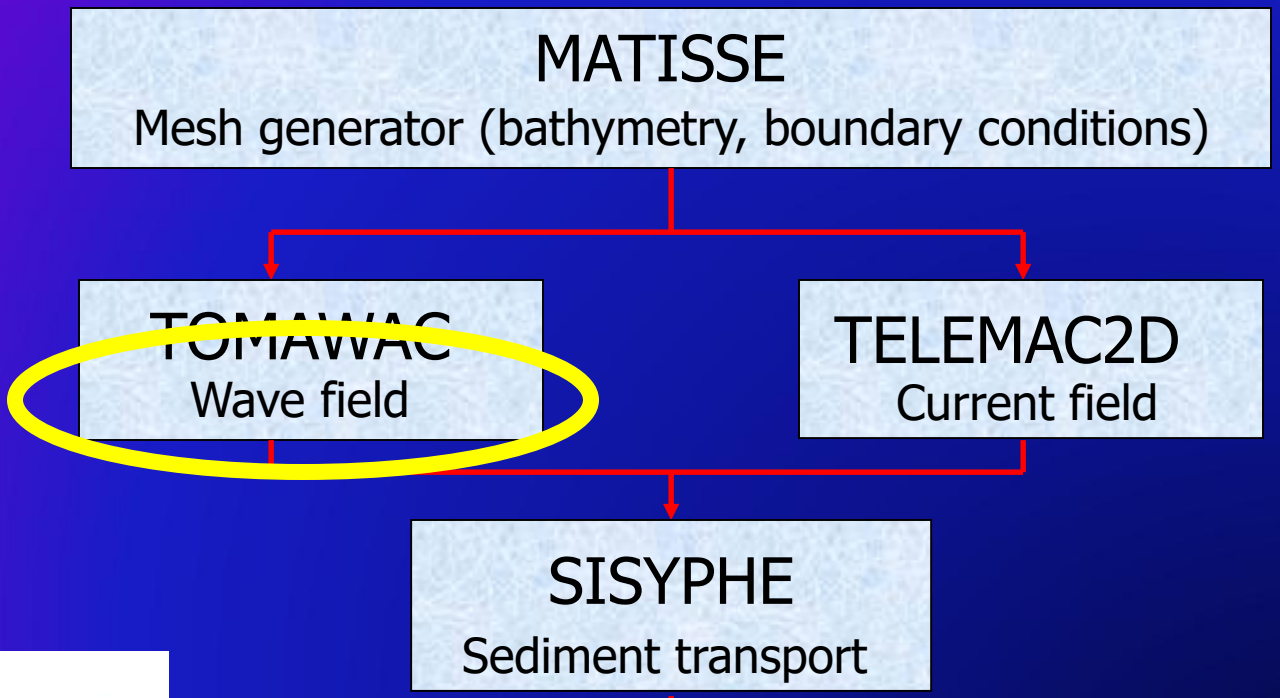
Current field

"There is a tide in the affairs of men,
We must take the current when it serves"
W. Shakespeare Julius Cesaer, 4, 3, 218.

- ***direction*** of current velocity is very important (sediment transport)
- "fairly good agreement" of flow field can lead to large errors in sediment transport
- near-bed flow field and turbulence
- turbulence damping due to suspended sediments (Toorman, 2004)

The TELEMAC system:

long-term simulations for morphological changes studies

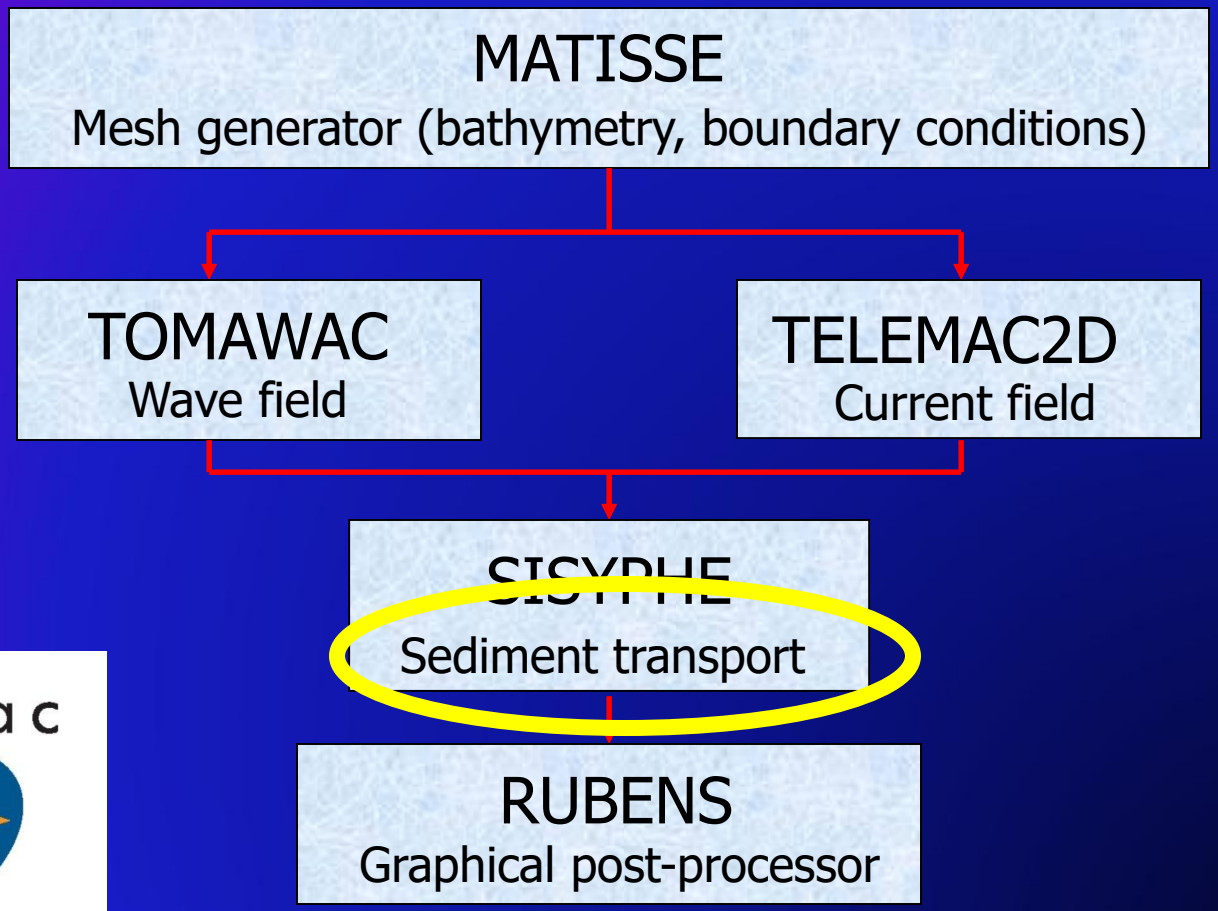


Wind fields, drag coefficient

2/3 variability between different models due to forcing meteo (NOMADS)

The TELEMAC system:

long-term simulations for morphological changes studies



telemac

SISYPHE

Bottom evolution equation

$$\frac{\partial Z_f}{\partial t} + \mathrm{Div}(Q_s) = 0$$

Z_f = bottom depth
Q_S = solid volume transport

Current induced transport:

- Meyer - Peter formula (bed load)
- Einstein – Brown formula (bed load)
- Engelund – H

Current and

- Bijker formul
- The Soulsby

"Transport of sediment is one of the most important and difficult classes of processes encountered by the hydraulic engineer"

A. Papanicolaou et al.,
Jnl Hydraulic Engineering, ASCE, January, 2008

non cohesive
sediment transport predictor

- Unsteady flow?
- formulas give transport capacity < > actual transport rates
- 1D approach vs. interaction with morphology (2D and 3D)
- measurements? (Heisenberg?)

Morphological calculations

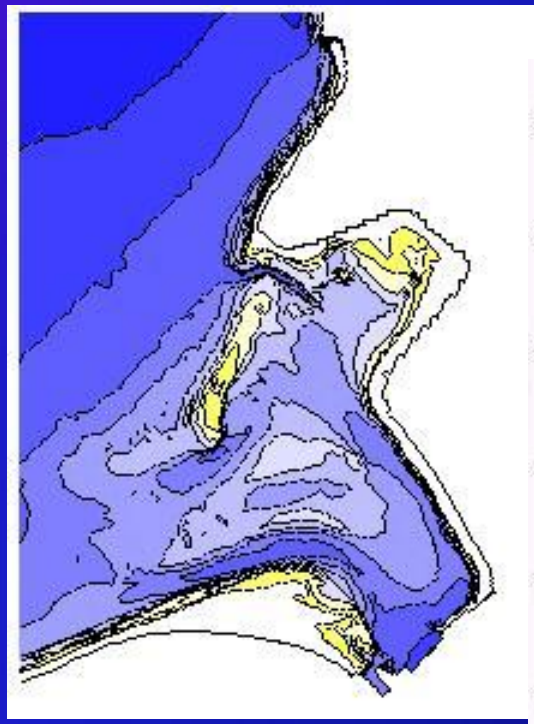
- direction of transport in some cases sensitive
- Sed. tspt. is a process with an important memory
- Small errors in predicted morphological changes (caused by wrong (inaccurate) modelling of hydrodynamics or sed. tspt), influence (local) currents, (direction of) sediment transport, morphology,… can grow rapidly.

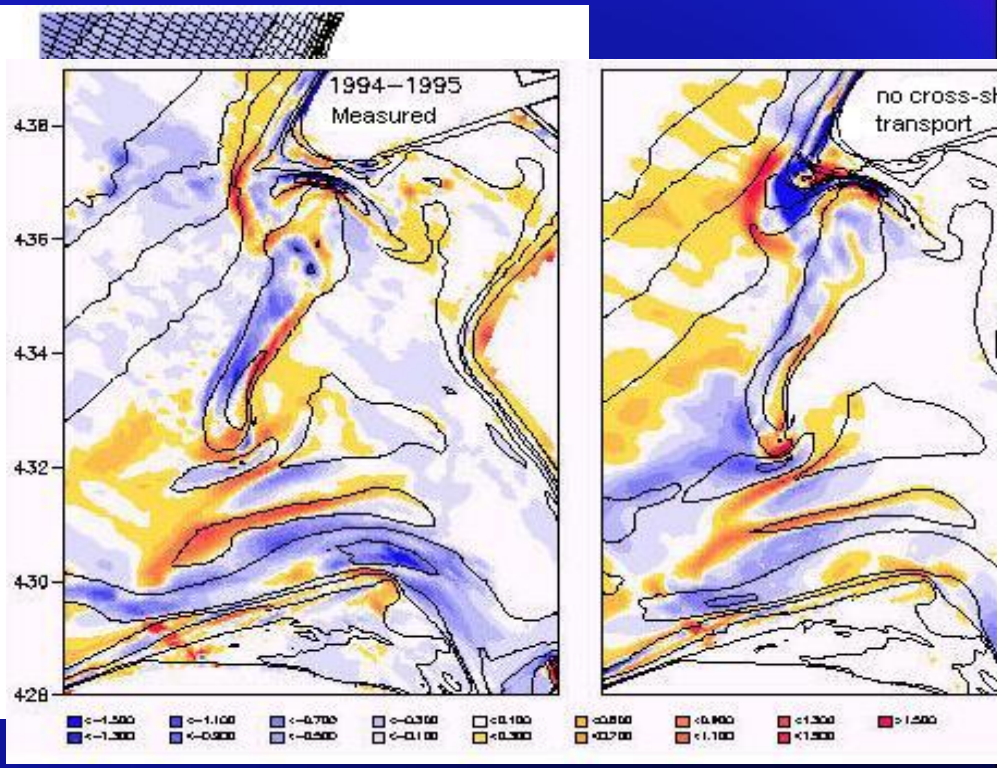
  Even if all processes are modelled well, errors can be introduced and grow rapidly due to limited knowledge or necessary simplifications of B.C.... (K. Trouw, 2004)

long term prediction >> divergence? Chaotic behaviour?

“fairly good agreement” maybe, is not good enough

DELFT 3D





Measured and computed depth changes 1994-1995


"Why do we love the sea?
because it makes us think of things we like to think".
The coast faces a lot of challenges
Safety, economy, nature developmen
Identify knowledge gaps
Research challenges
Salvador Dali

Conclusions

- Integrated approach is needed.
- Need for estimating side effects of measures or collateral damage
- (morphological) effects can take years to materialize
- Side effects can happen on other places and times than where and when intervention was done
- Models are usefull, but “models are only models”
- Long term morphological modelling is yet impossble

Conclusions

- The interpretation of model results is equally important as the production of modelling results. It takes time, care and expert knowledge.
- It is equally important to know what we don't know than to know what we do know, but often, we do not know what we do not know (D. Rumsfeld, 2002).
- Need for research
- Need for good and well managed (distributed) data (Vliz)


Velvet, 2008