ICZM in a climate change perspective -important issues for the Baltic sea

Numerical modelling in support of shoreline management

Ida Brøker

DHI

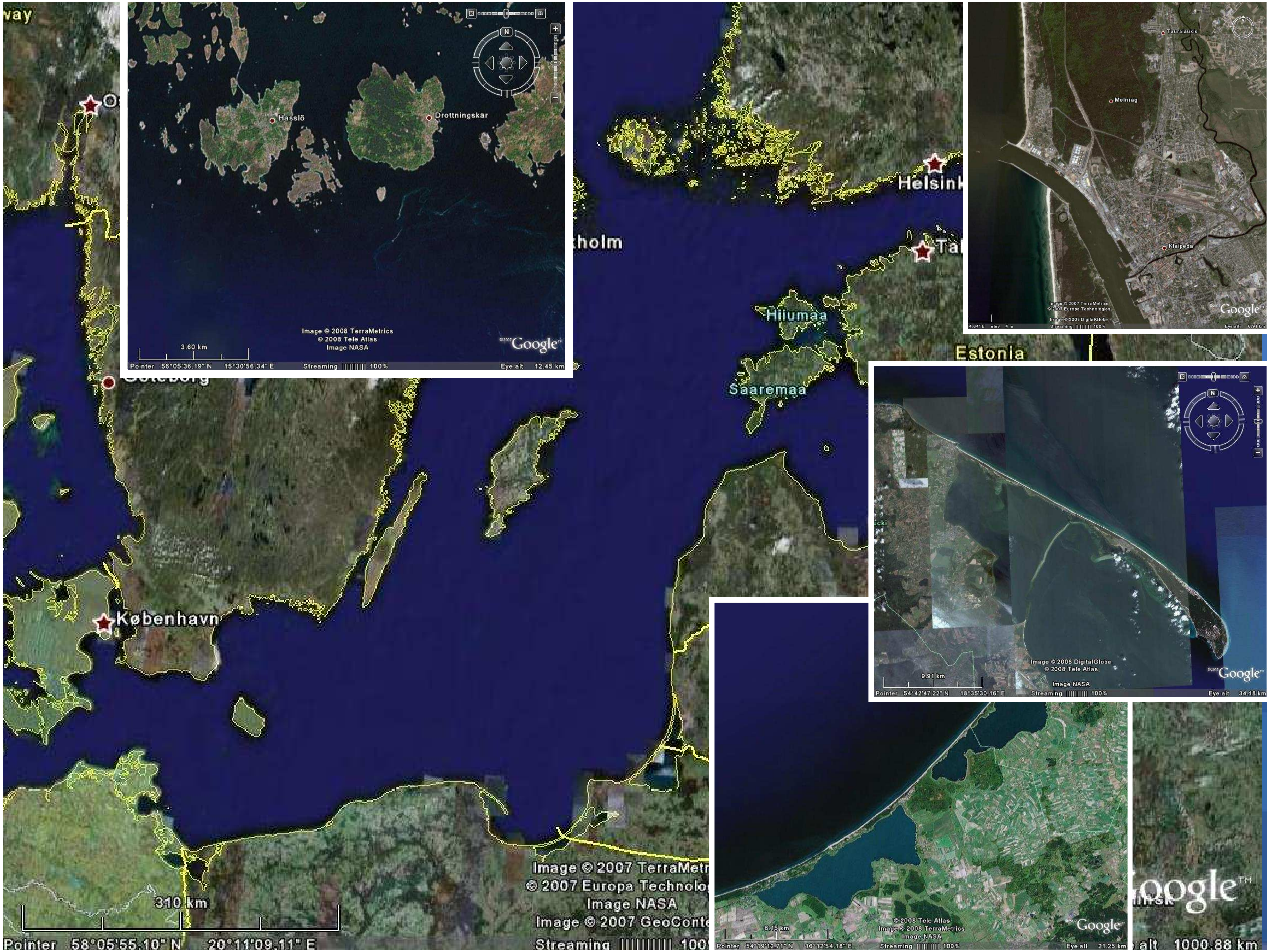
Hasslö
Drottningskär
Image © 2008 TerraMetrics
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Image NASA
3.60 km
Google
Pointer 56°05'36.19" N 15°30'56.34" E Streaming 100% Eye alt 12.45 km
Tauralaukis
Melnrag
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Estonia
København
Image © 2008 DigitalGlobe
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Image NASA
9.91 km
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Pointer 54°42'47.22" N 18°35'30.16" E Streaming 100% Eye alt 34.18 km
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Image NASA
6.15 km
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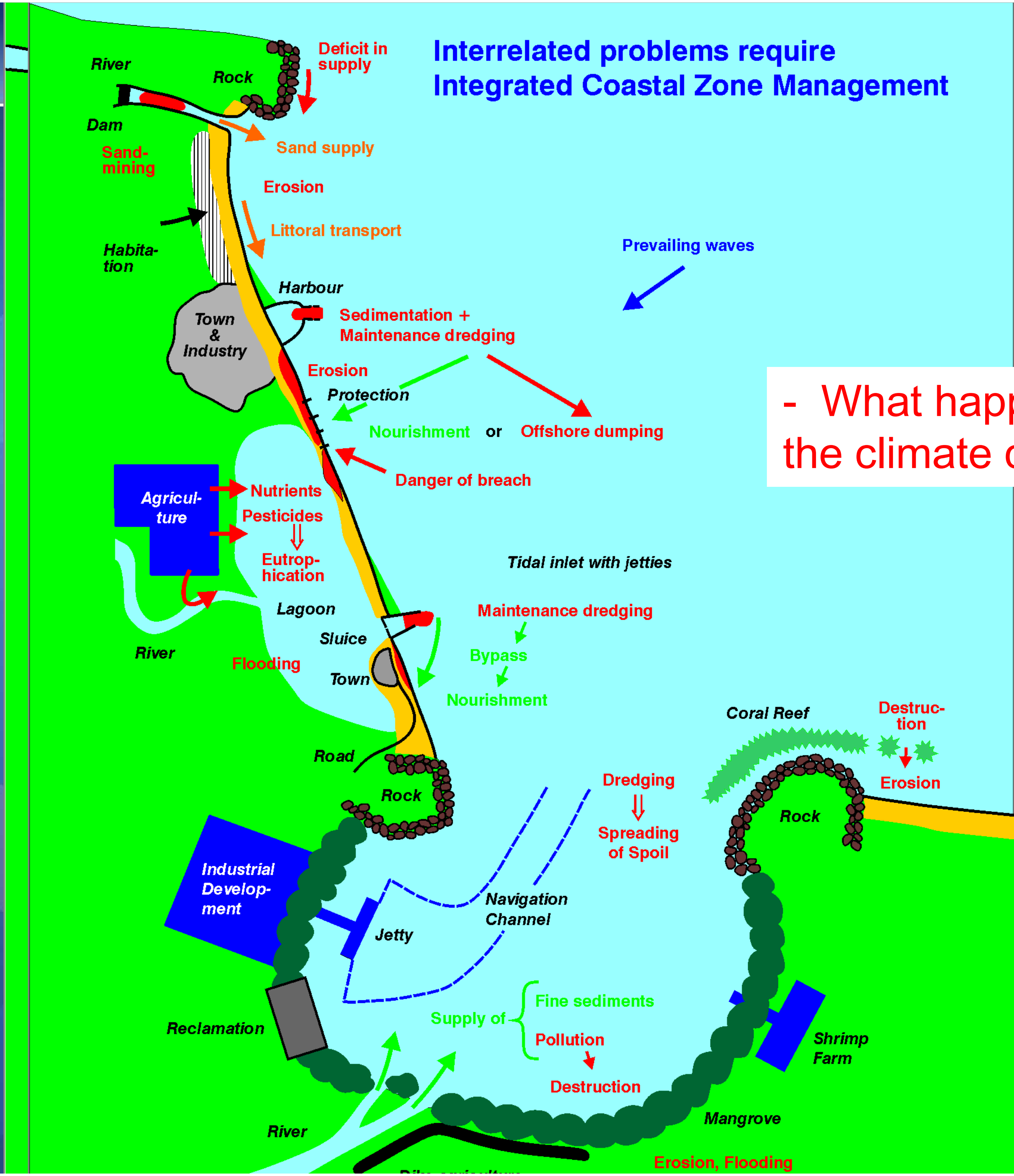
1000.88 km

Interrelated problems require Integrated Coastal Zone Management



- What happens if the climate change ?

Outline of presentation:

Examples of effects of climate changes on coastlines

modelling tools needed to quantify effects

- large scale, waves and hydrodynamics
- local scale, littoral drift and shoreline respons
- a shoreline model including dune erosion
- examples

-concluding remarks - research needs

Sea level rise

Example: Newbiggin Bay, UK (however, man-made !)

1-2 m subsidance due to mining under the seabed changed nice sandy beach into eroding bay

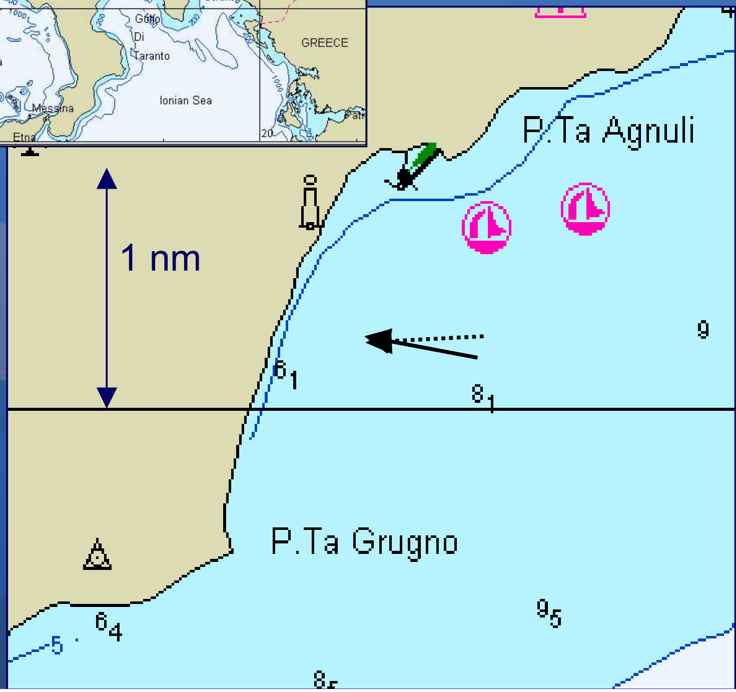
new protection:

breakwater

Newbiggin bay - ca.1900

Newbiggin bay - 2000

Example: Matinatta, Italy - the real thing

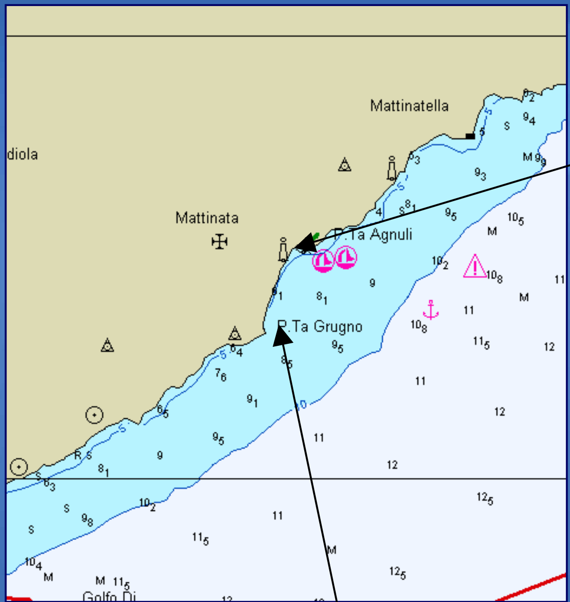


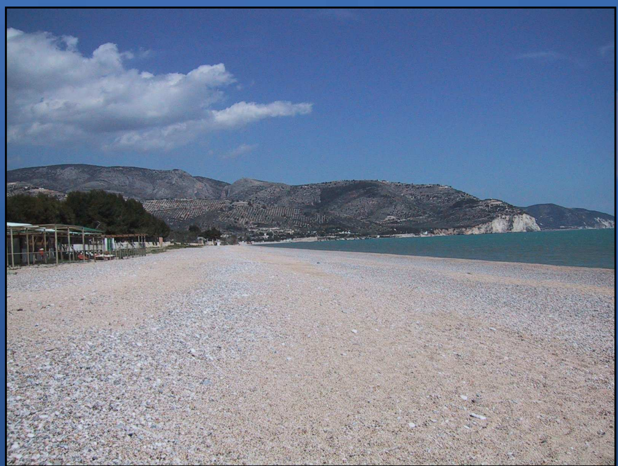
Slight anti-clockwise turning of pre-dominant wave direction

and

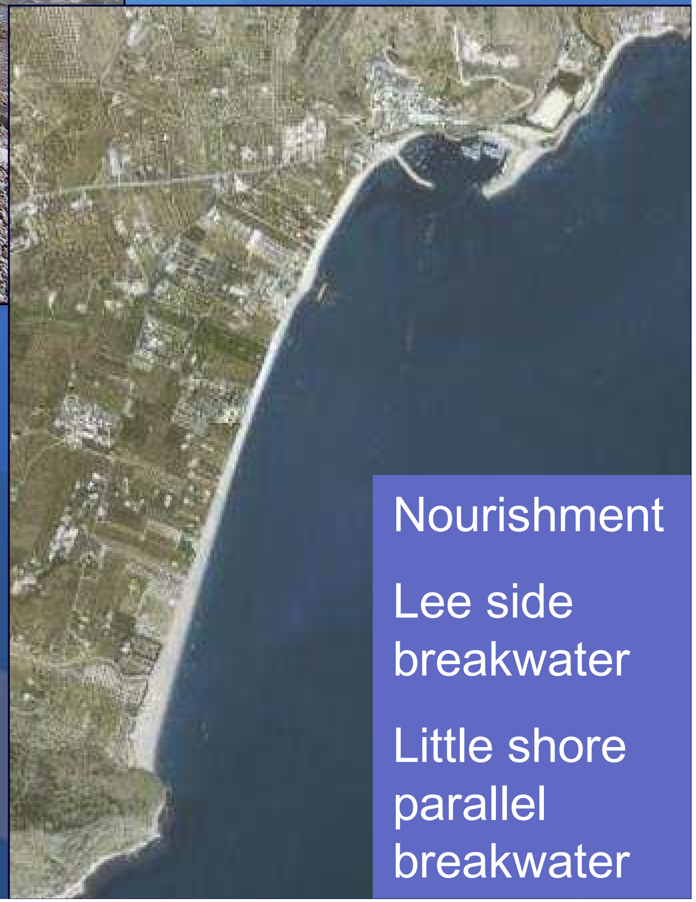
lack of supply of sediment due to decrease in rain fall

Example: Matinatta, Italy - continued





Anti-clockwise turning of the beach...

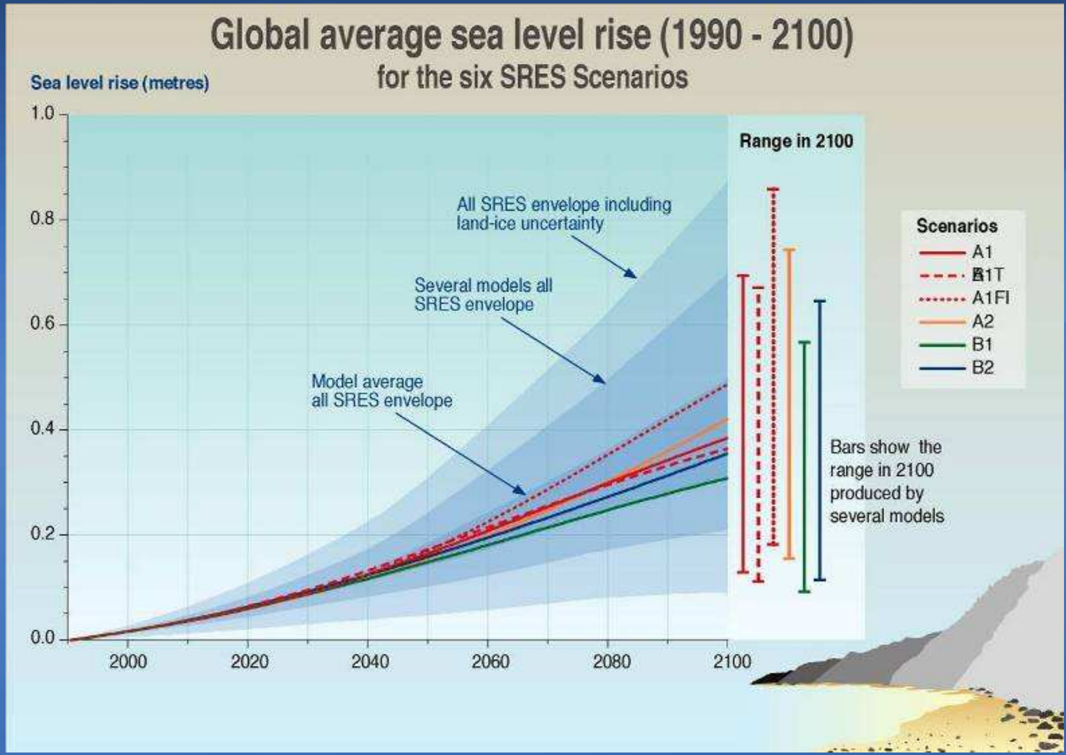


Nourishment

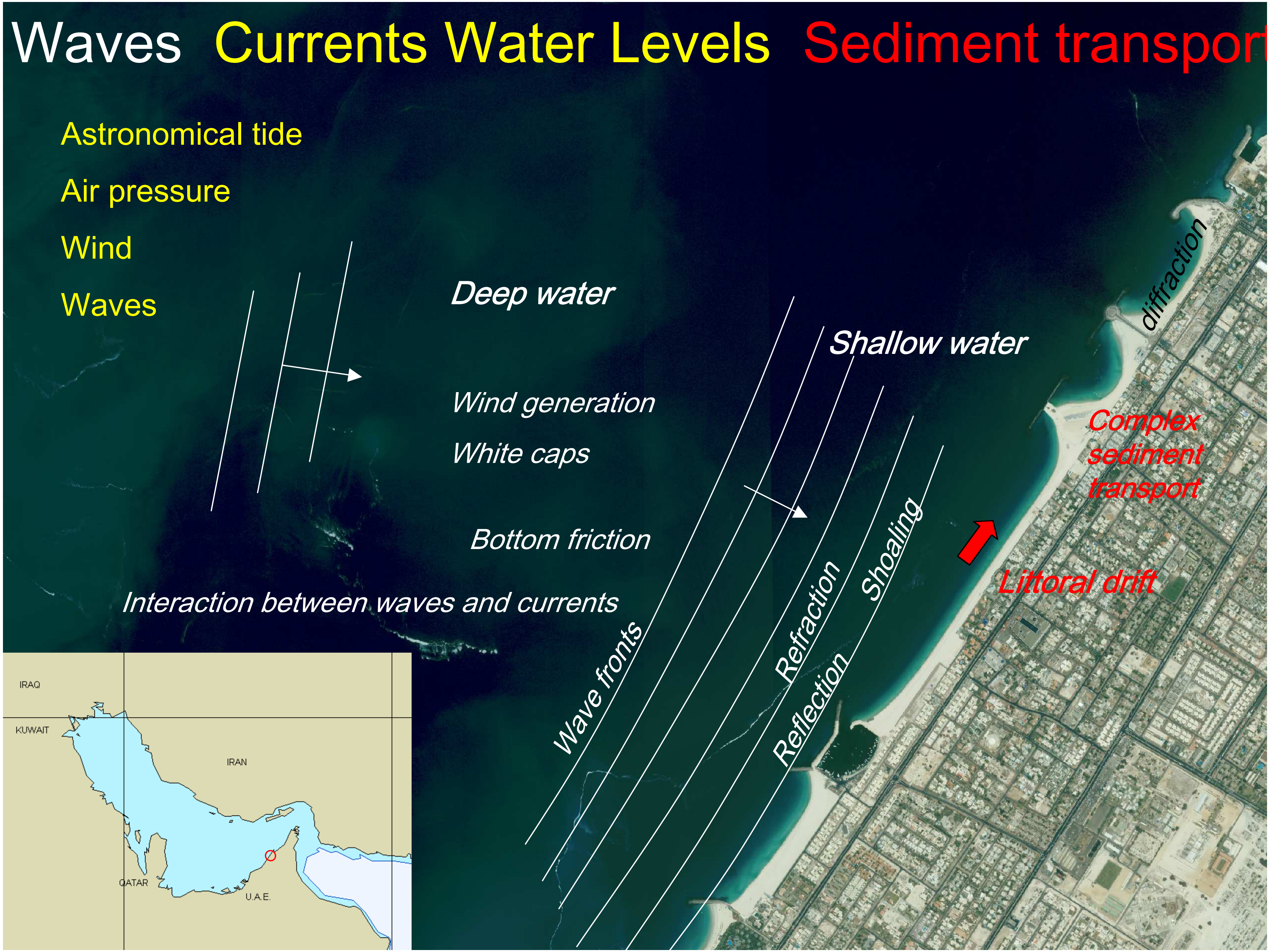
Lee side breakwater

Little shore parallel breakwater

IPCC scenarios



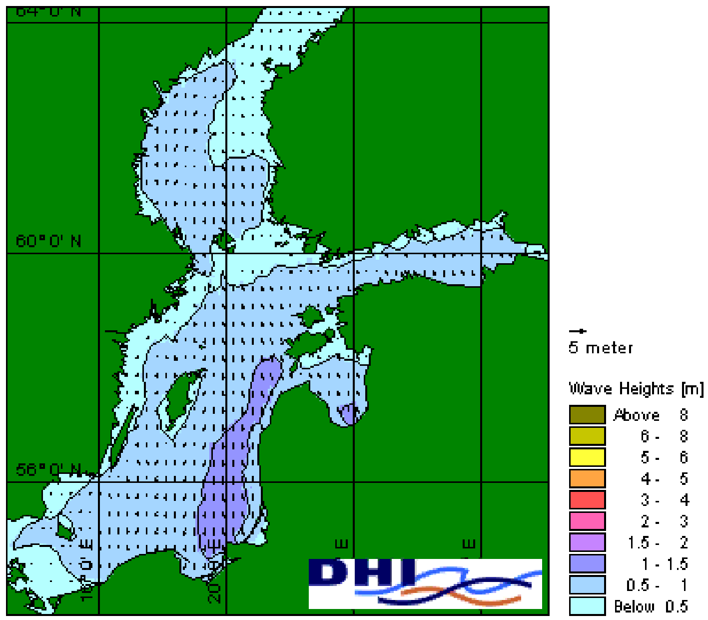
- 3 - 5° increased temperature
- Increased storm intensity
- Bigger waves (in the North sea) ~ 5%
- Water level increase ca. 40 cm in 100 years
- Increased storm surge ca. 10%.
- 25 % increase in rain intensity
- 10% increase in discharge in streams and rivers


Waves Currents Water Levels Sediment transport
Astronomical tide
Air pressure
Wind
Waves
Deep water
Wind generation
White caps
Bottom friction
Interaction between waves and currents
Shallow water
Wave fronts
Refraction
Reflection
Shoaling
diffraction
Complex sediment transport
Littoral drift
IRAQ
KUWAIT
IRAN
QATAR
U.A.E.

Metocean Data Hindcast/Forecast

Spectral Wave model

-wave heights
- wave periods
- wave directions



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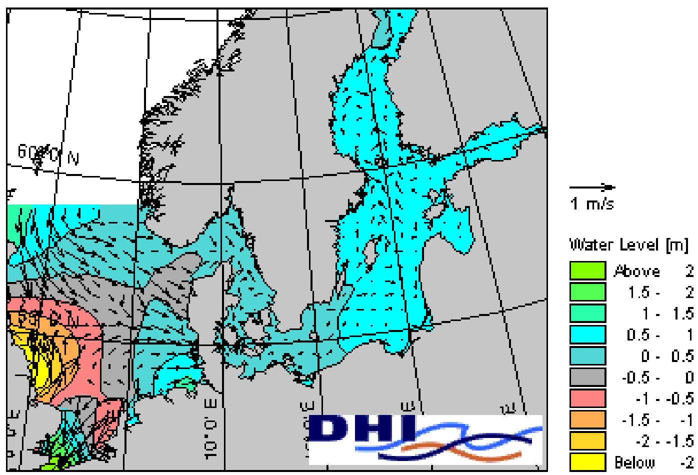
2D and 3D Hydrodynamic Flow Simulations (HD)
- water levels
- currents



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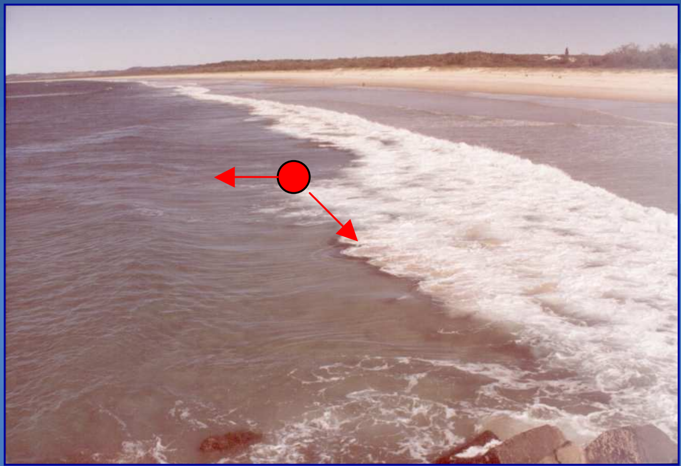
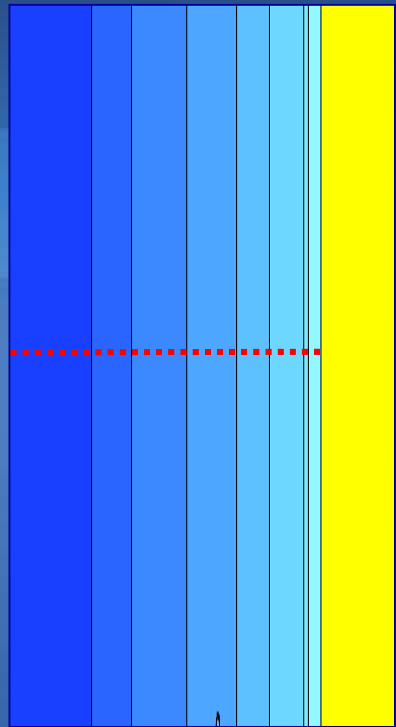
Models can be run in forecast and predict waves and water levels corresponding to various climate scenarios

-29/9

LITTORAL DRIFT AND SHORE LINE EVOLUTION MODELS





Littoral drift

shoreline evolution

structures:

groynes

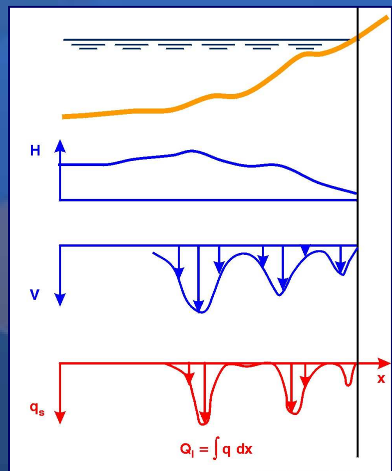
revetments

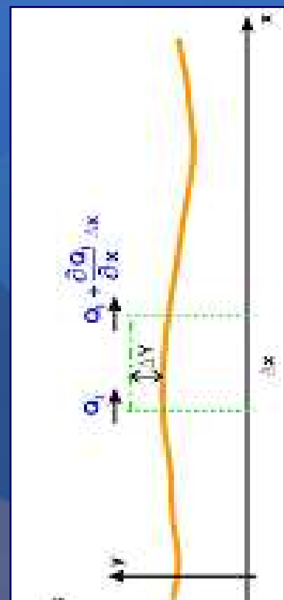
breakwaters

Sand transport model:

Waves and current at arbitrary angles
Intra-wave description of bed shear - stress and turbulence
Wave asymmetry
Turbulence from wave boundary layer, breaking and steady current
Quasi-3D current velocity profiles including undertow

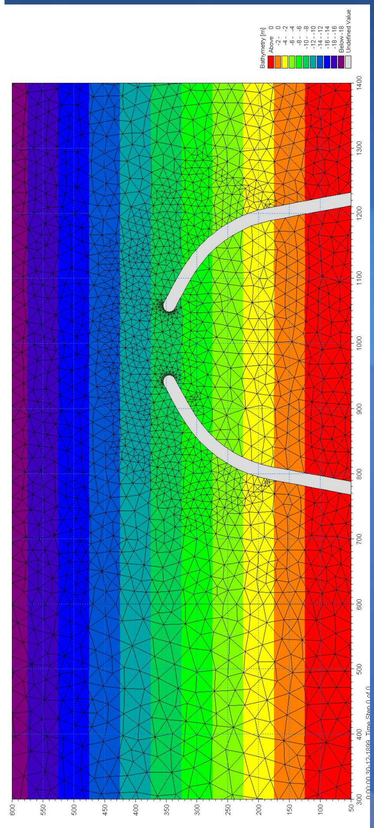
$Q_s + Q_b = f(H_{rms}, T, Diss, V, D, \gamma, d_{50}, \sigma)$

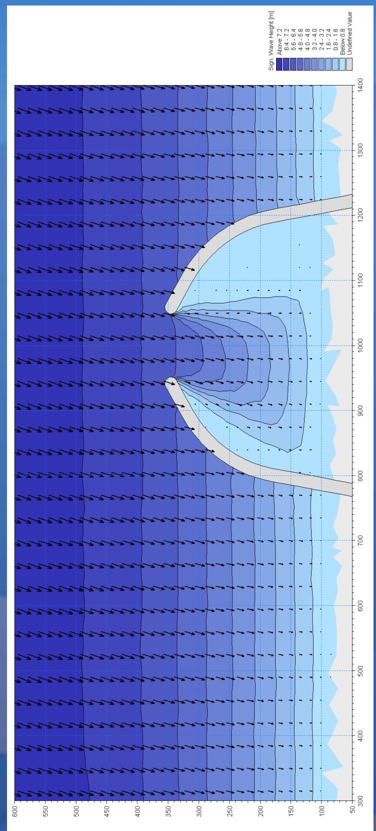




Area models, waves, hydrodynamics, sediment transport

Wave models

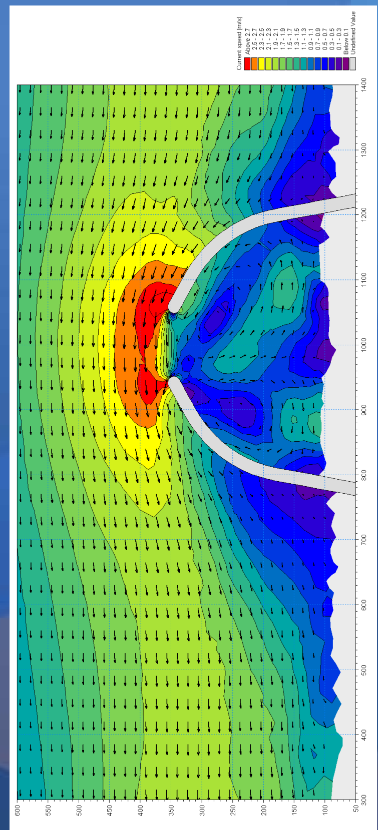




Hydrodynamic model

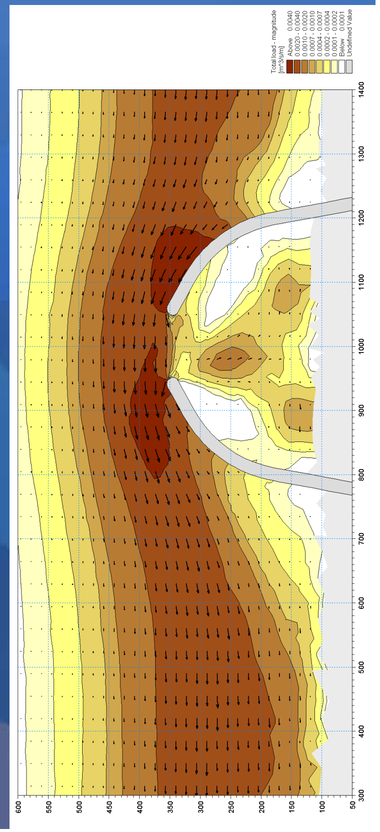
Depth integrated

Tidal, wind and wave driven currents



Sand transport model

Intra wave period deterministic model



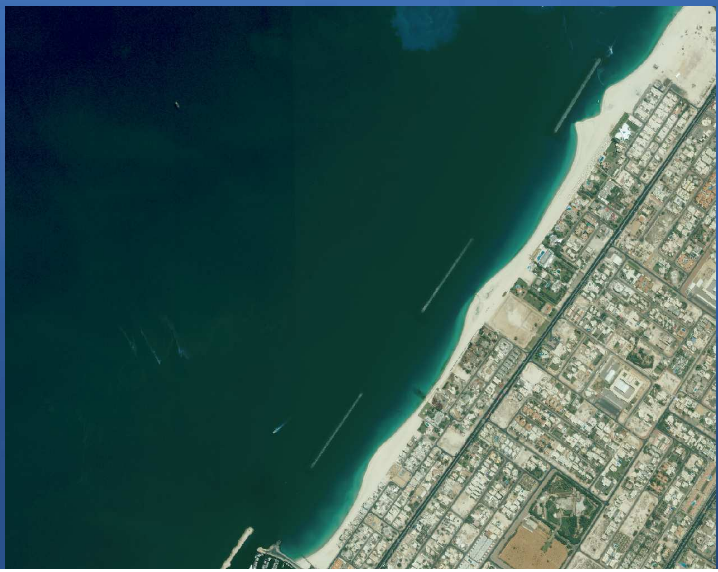
COASTAL AREA MORPHOLOGICAL MODELLING

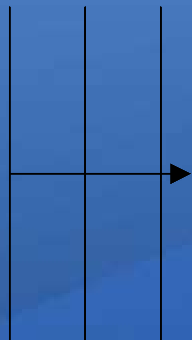
Example: Evolution behind shore parallel breakwaters

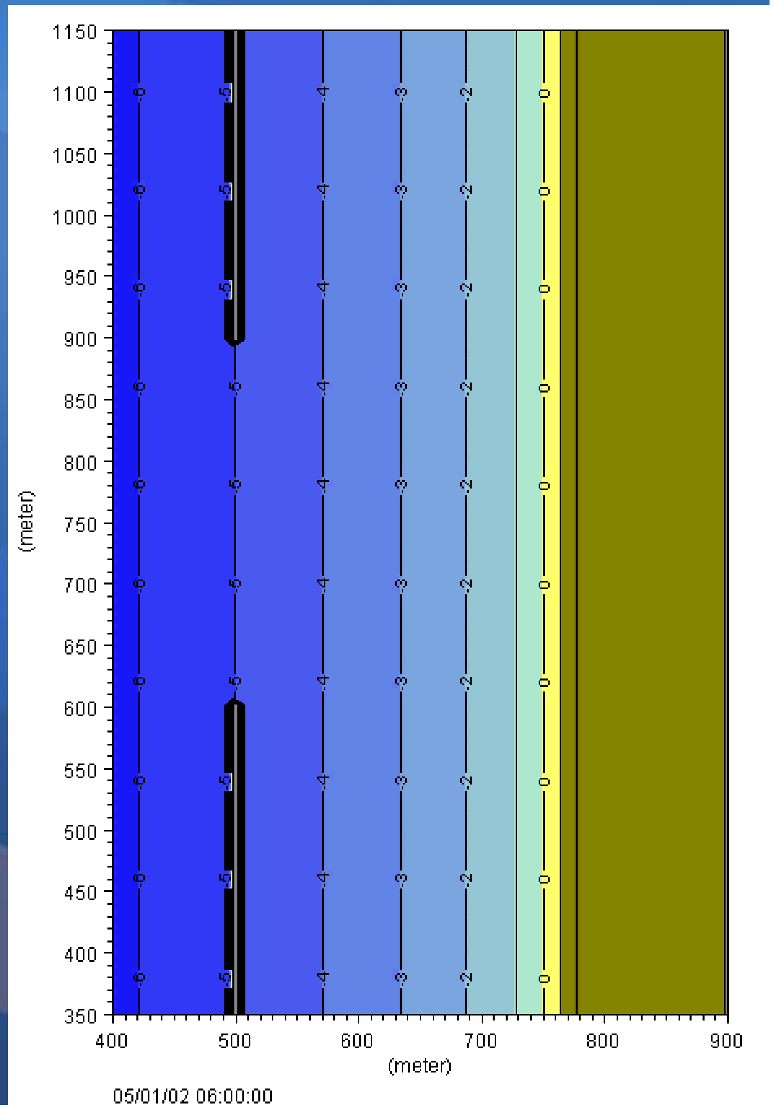
Sequence of modelling

- waves
- Currents
- sediment transport

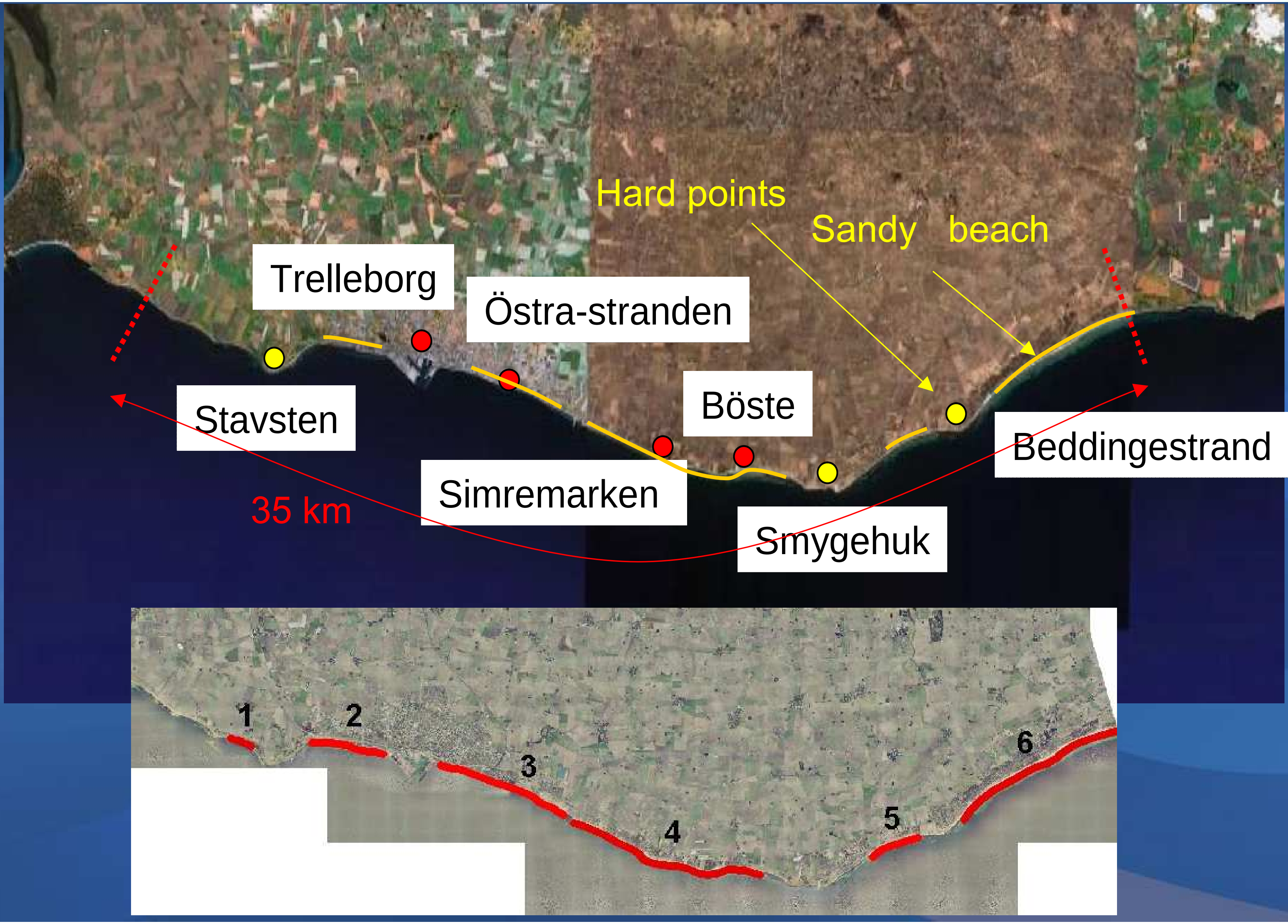
Including simutaneous updating of the bathymetry







Example: Trelleborg coastline



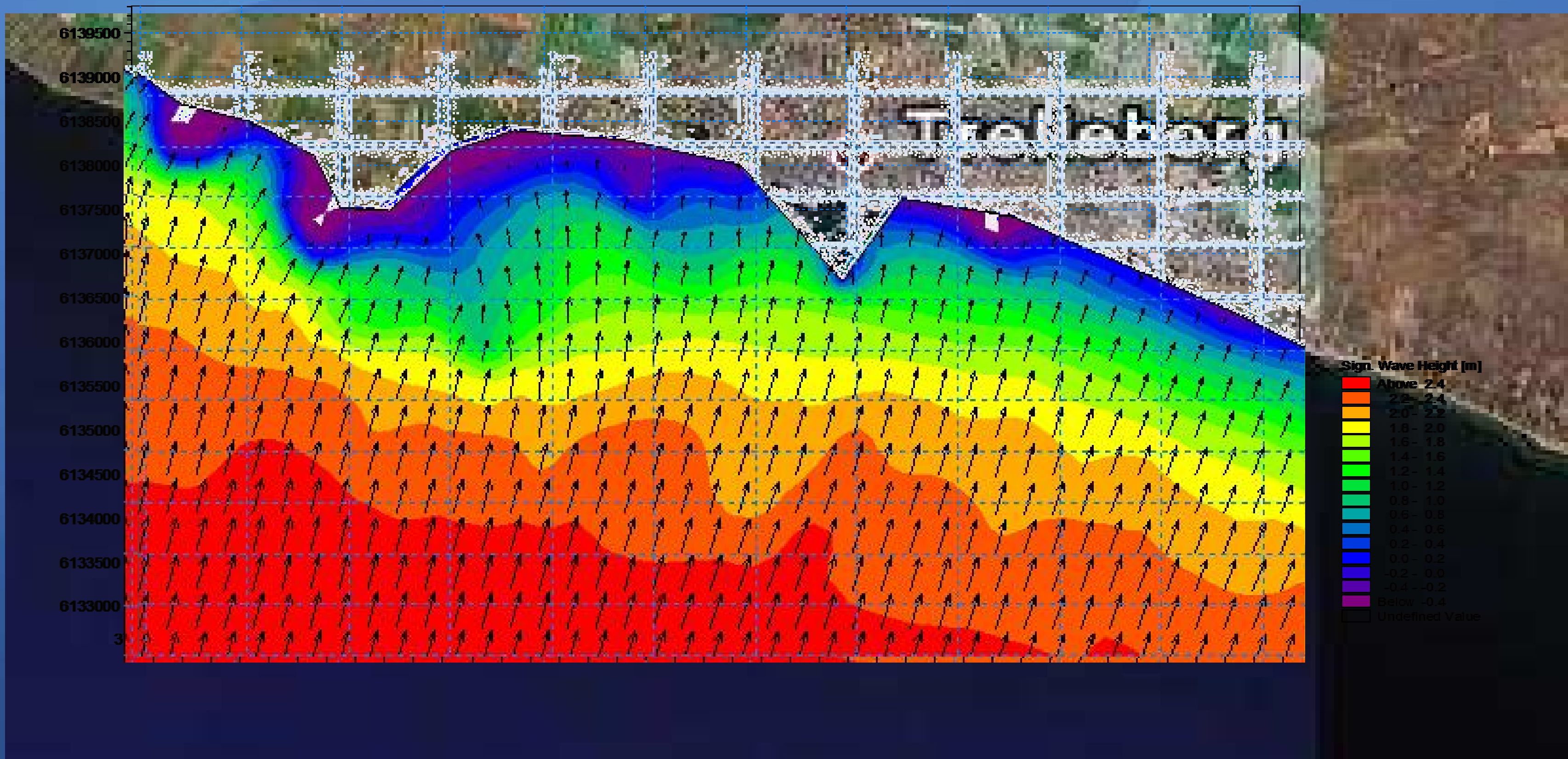
Wave Conditions

Mike21 Spectral Waves

Boundary conditions from a DHI baltic model

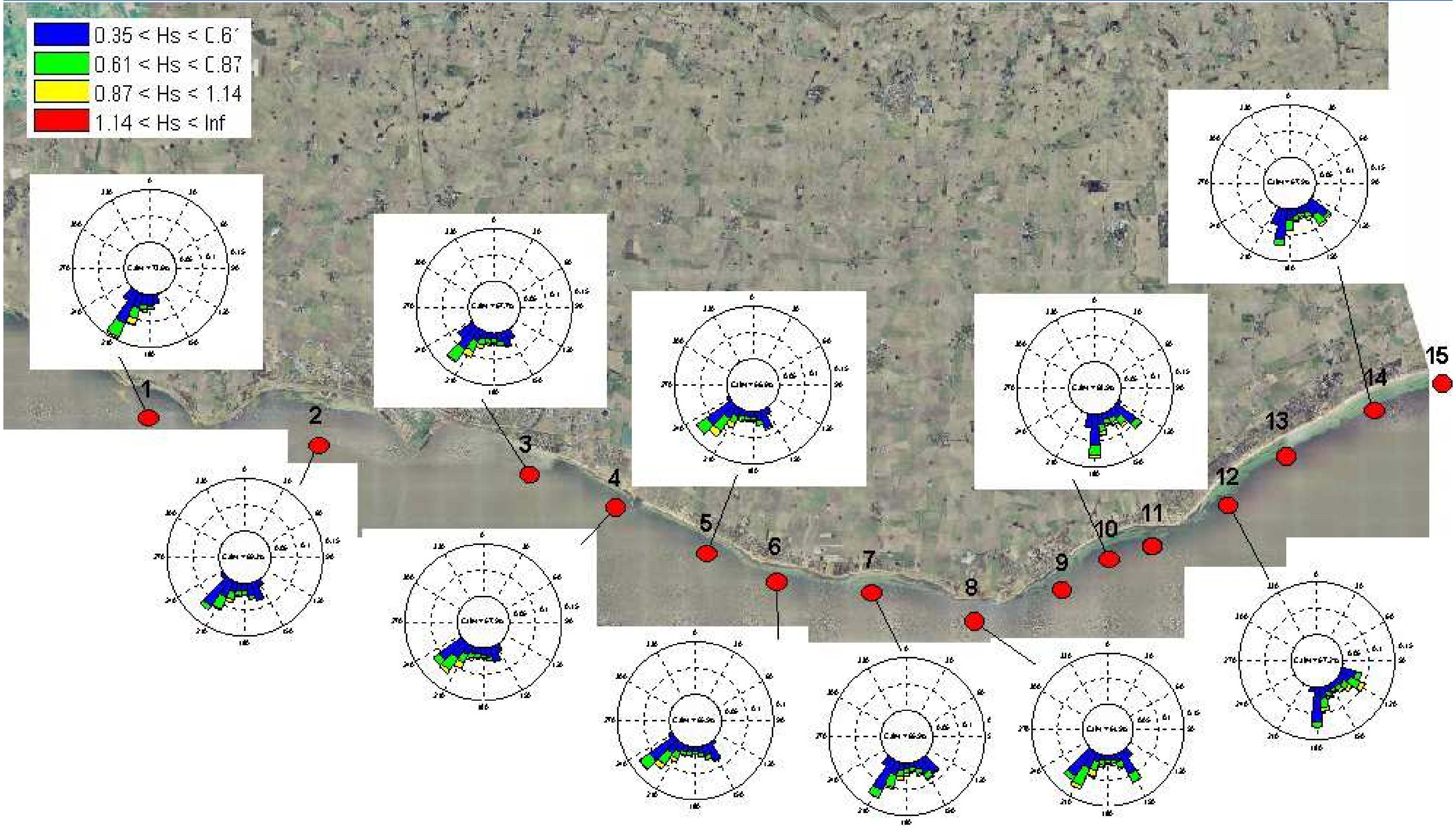
220 wave scenarios were simulated.

Nearshore statistics generated.

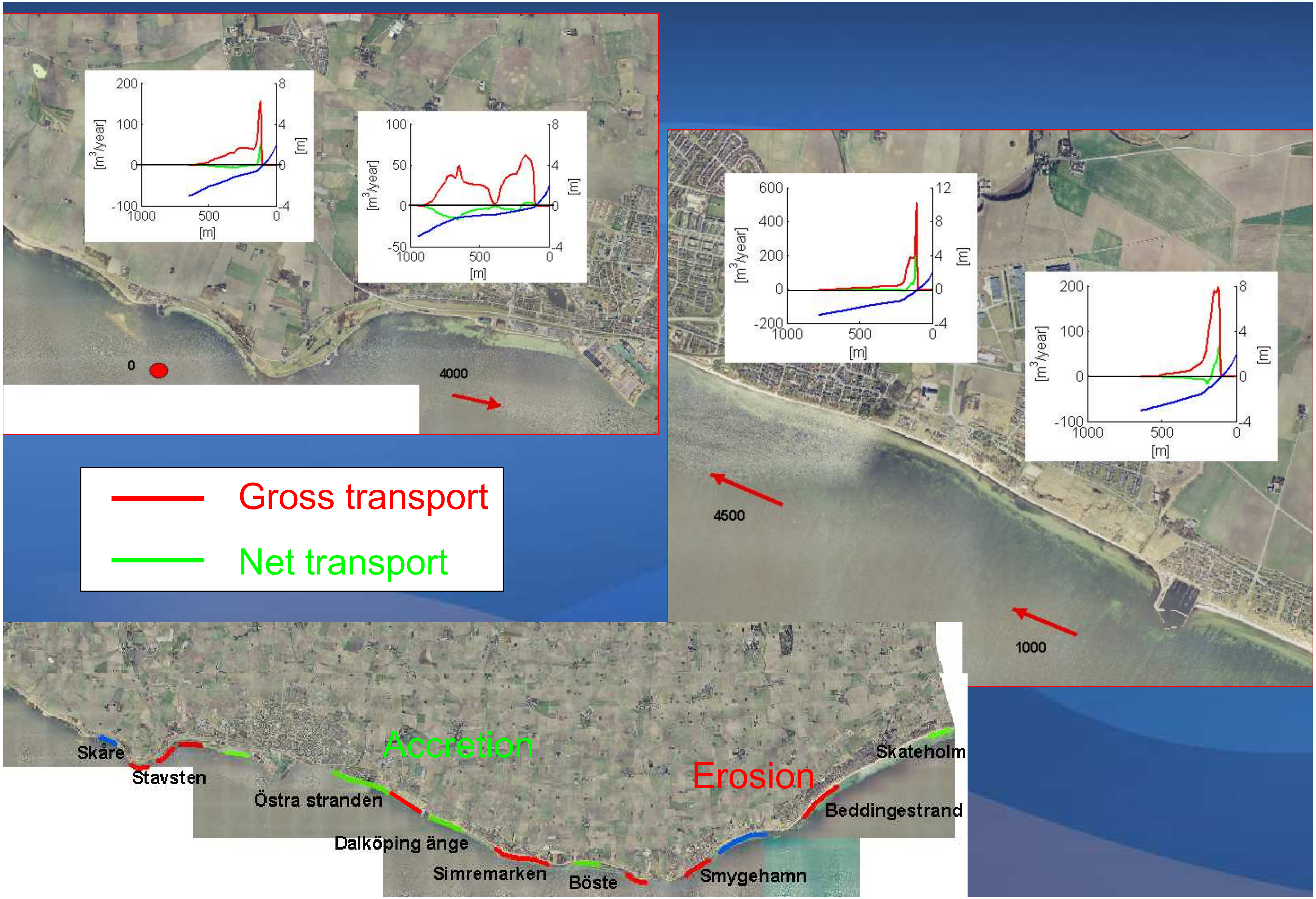


Wave Conditions Result

- Wave climate is relatively mild, dominant direction is SW.
- Point 8 has the roughest wave climate and point 2 the mildest



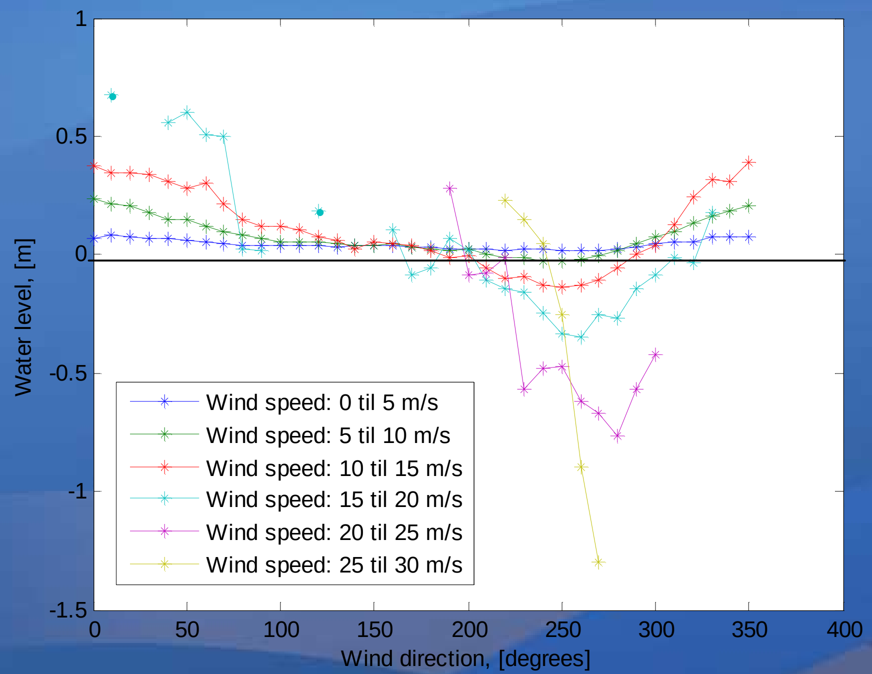
Longshore Sediment Transport Cell 1, 2 and 3



Water Level Conditions - surge and sea level rise

Strong wind from western directions push water to the eastern end of the baltic sea, giving low water levels at Trelleborg

Strong winds from eastern directions push water to the western end of the Baltic Sea, giving high water levels at Trelleborg



Not included: run-up and over topping

Data based on DHI's Baltic Sea Model

SMHI: combination of (IPCC) and the land uplift in Sweden lead to:

"high case" scenario: the sea level will rise 77cm in 100 years

"low case" scenario:the sea level will rise 31cm in 100 years

at Trelleborg

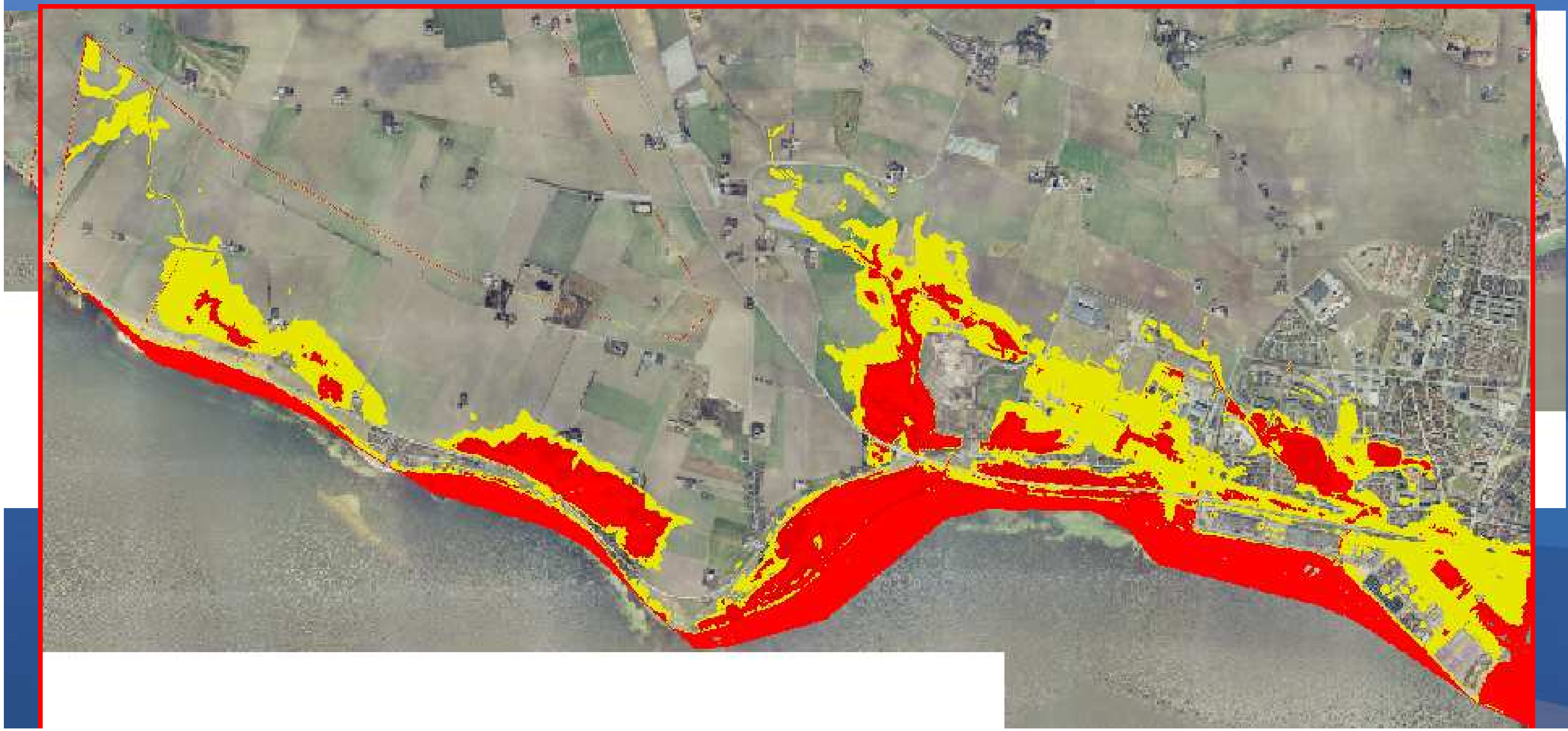
Future Risk of Flooding

Red areas:lower than a 1:50 50 year event today

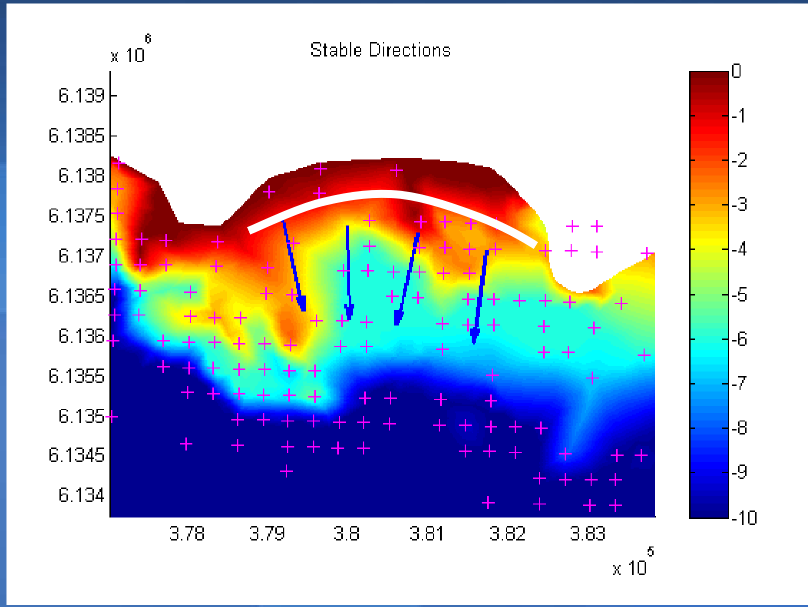
Yellow areas: lower than a 1:50 year event in 100 years

(The high case scenario has been used.) no account for increased storminess

Not included: run-up and over topping



Artifical Beach West of Trelleborg Harbour

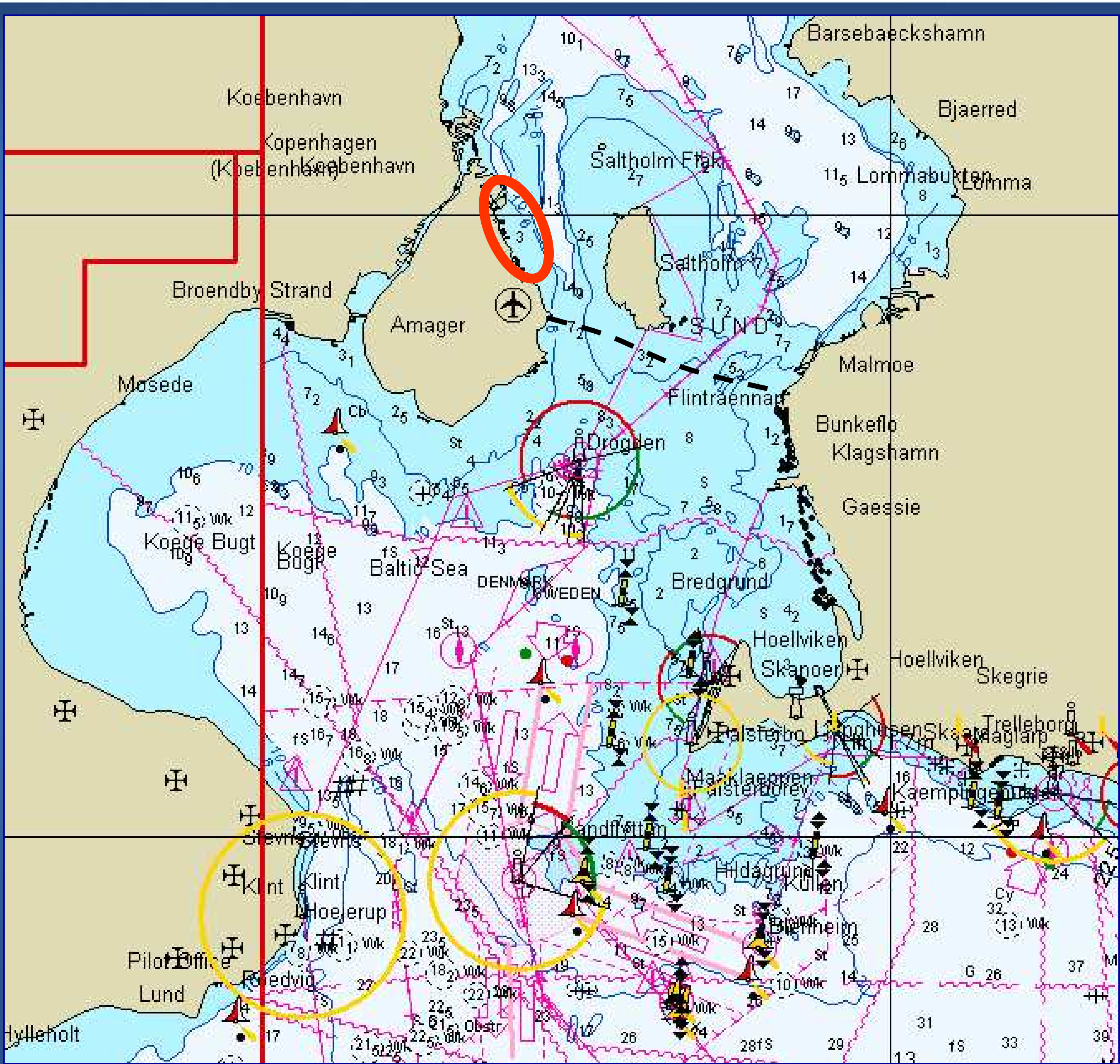


Criteria for new artificial beach:

1. Beach must be stable, i.e. loss of sand from beach due to natural erosion cannot be accepted.
2. Beach must be of good quality.
3. Water depth must be sufficient for bathing purposes.
4. Risk of accumulation of algae must be minimized.

It is concluded that it is possible to create an artificial beach with good quality west of the harbour, if the shoreline is moved forward into the Baltic Sea.

Amager beach park



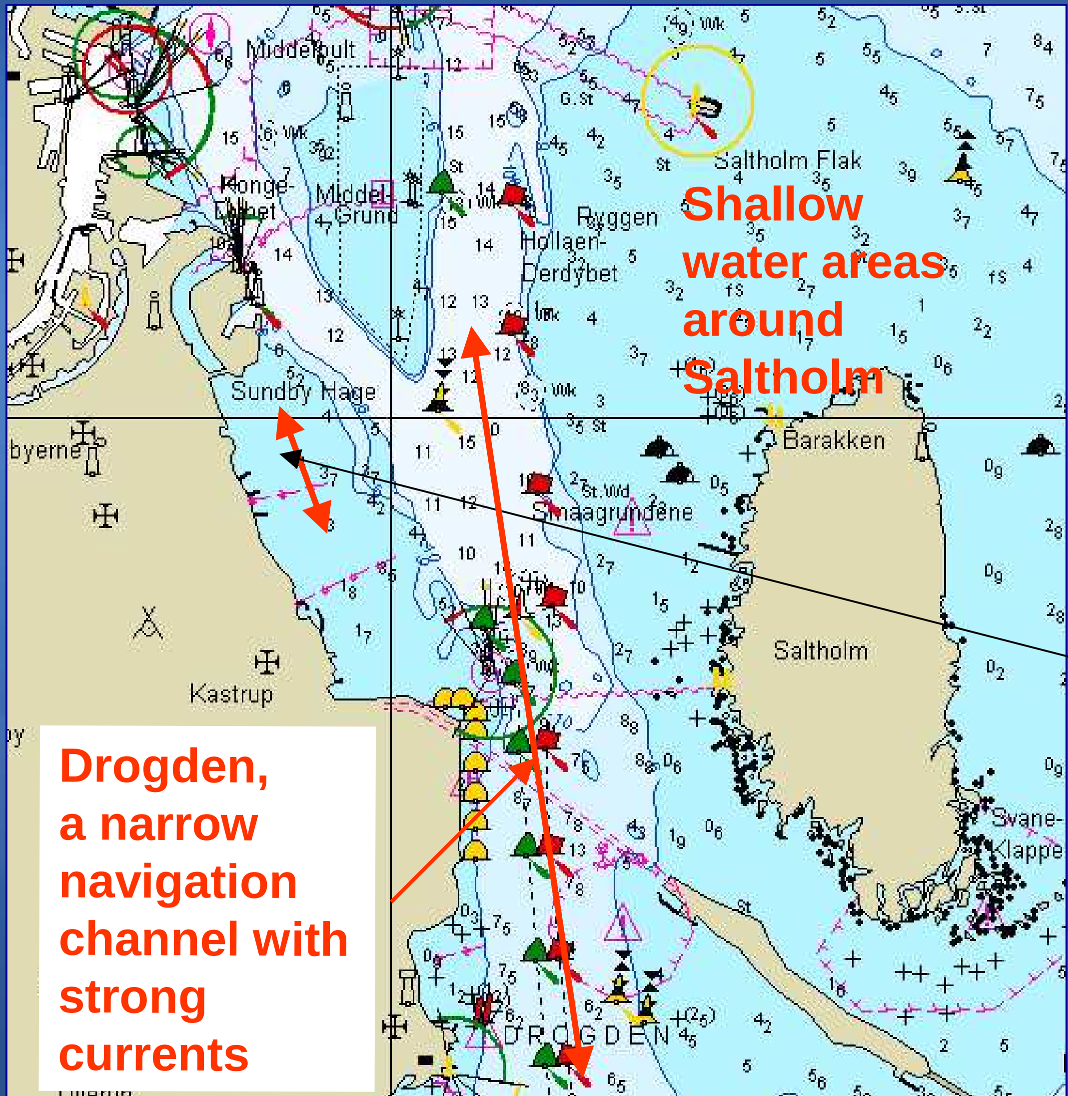
20 km

Conditions in 2004

Flat profile appox. 1:200 on the inner 200 m

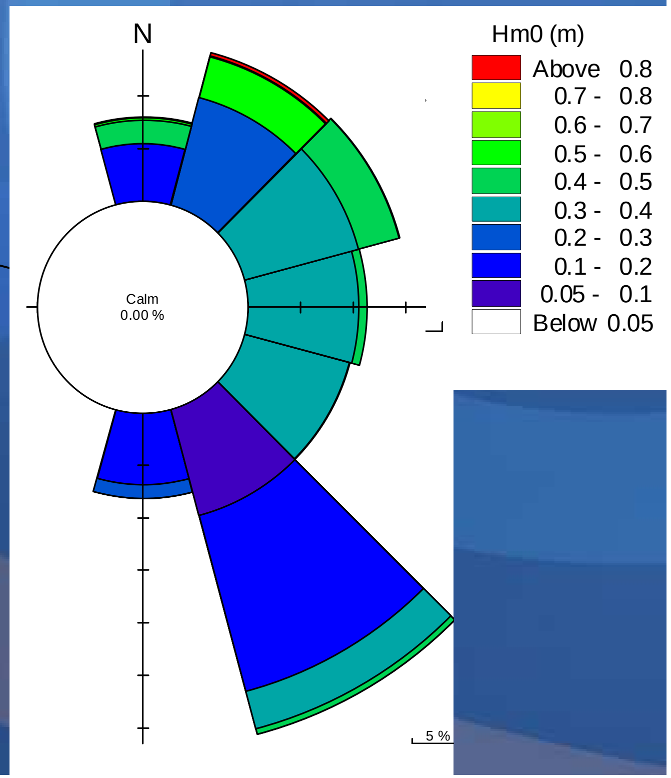
"beach" sand behind a wooded seawall, soft muddy bottom in front of wall

Conditions on the site



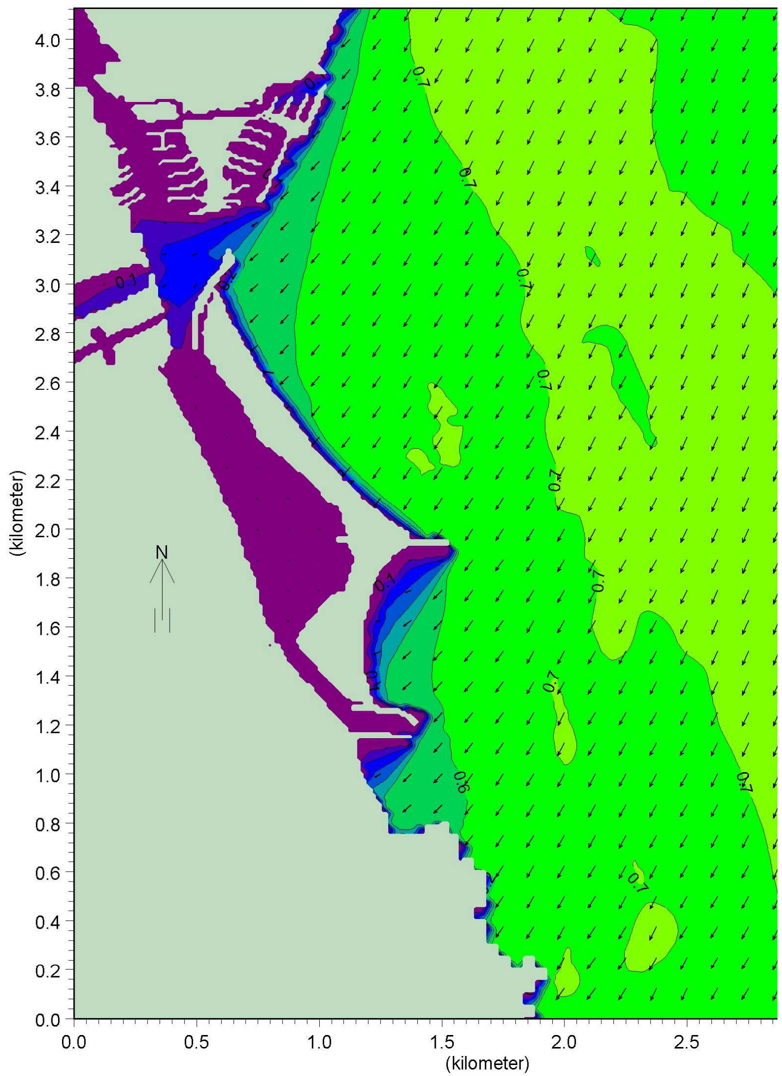
Extreme high water level: 1.25 m

Waves off the beach park

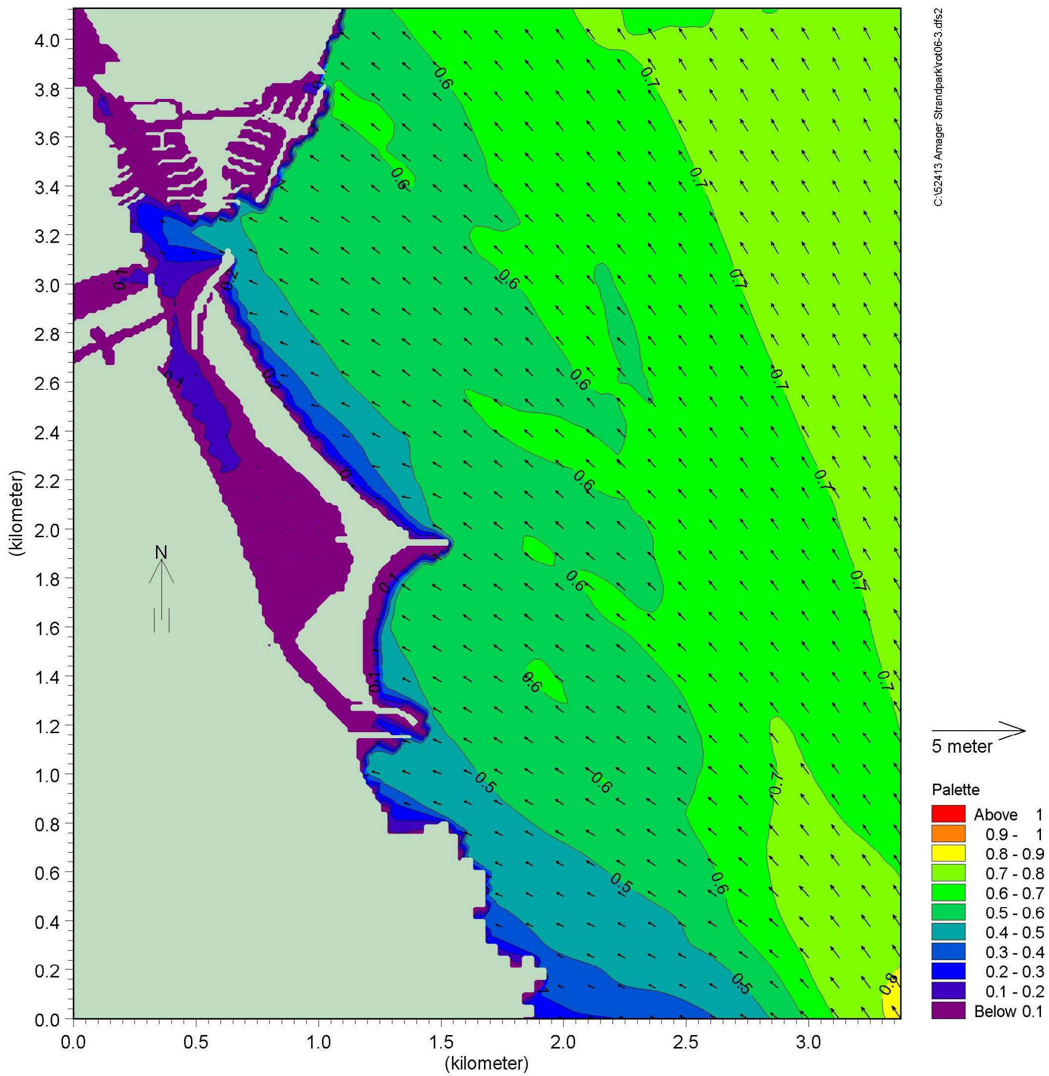


Wave modelling

Wind from NNE



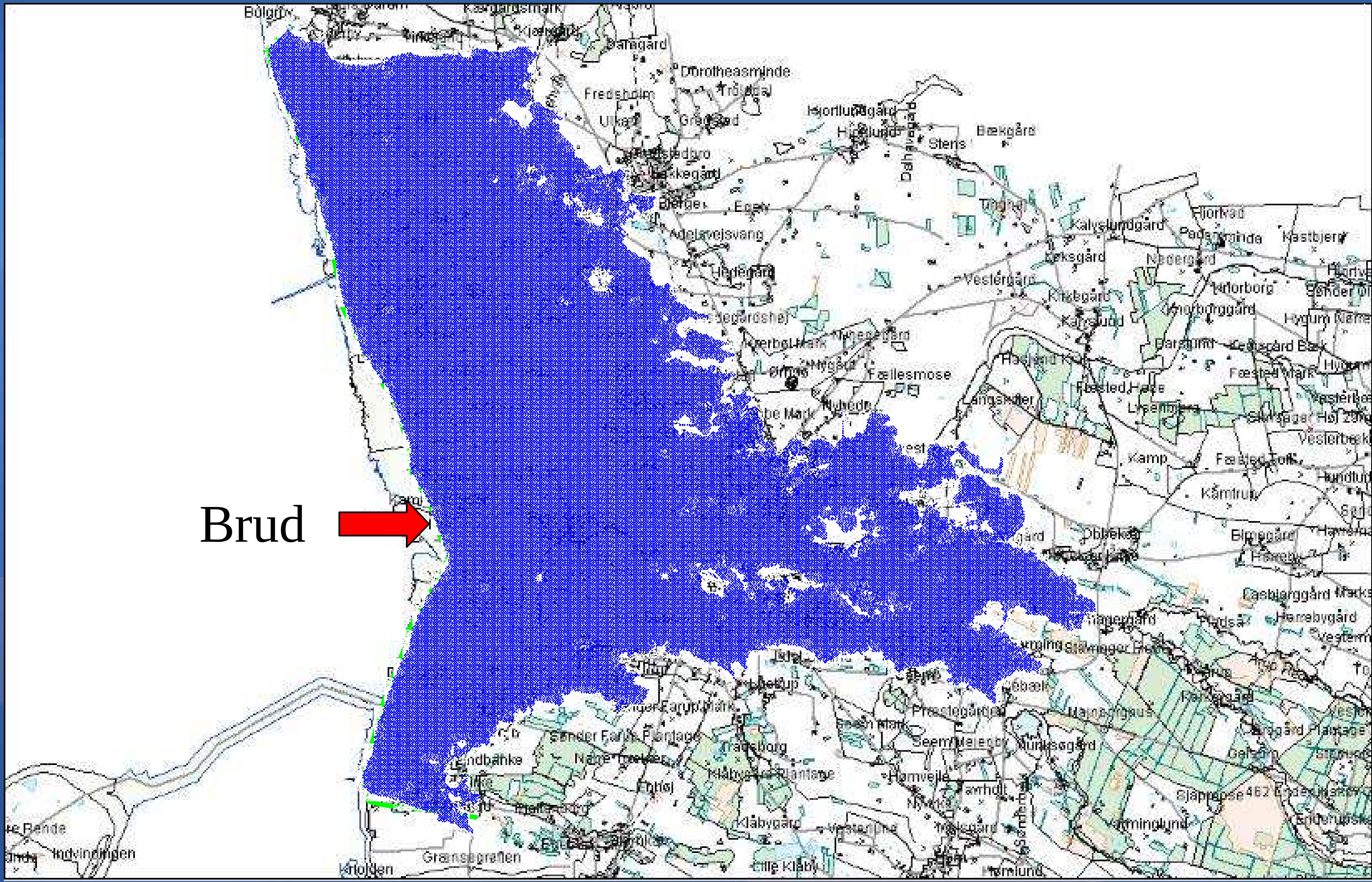
Wind from SSE



August 2005 – just after construction

An other example. Køge bay beach park

- another topic: Coastal flooding



Research needs

Further improvement of long term coastal morphological models

stable long term simulations - including the capacity to quantify shoreline instabilities for oblique incoming waves

Breaching of coastal dunes

- enhancement of the models to include the geotechnical processes involved in the breaching

- combination of run-up, overtopping, breaching and over land flooding

Use existing and improved tools in combination with climate scenarios, water level changes AND storminess to predict future evolution and assess risk


Thank you for your attention !