Sand Mining and Nourishment

A field geologist perspective

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Main Uses of Marine Aggregates

- Construction production industry
  (aggregate in concrete, road base, harbour construction,….)
- Land reclamation ('fill-up' sand)
- Beach nourishment and shore protection
- Infrastructure of society

@Eastern Daily Press

Physical disturbance of the NS area

% Area	Source	Area
54	Fishing	309 204 km^2
0.03	Aggregate extraction	180 km^2
0.01	Dredging disposal	72 km^2
0.001	Waste disposal	5.5 km^2
0.001	Sludge disposal	5.5 km^2
0.05	Platforms	313 km^2
0.05	Well heads	300 km^2
1.5	Pipelines	8374 km^2
1.27	Cables	7322 km^2
0.05	Wrecks	284 km^2
0.0001	Cuttings disposal	0.5 km^2
56.95	Total	327 000 km^2

Physical disturbance of the seabed in the North Sea in **1986** data. (Data supplied by the Institute of OVshore Engineering – IOE, Heriot-Watt University, Edinburgh; OSCOM 13: Report of the Thirteenth Meeting of the Oslo Commission, 1987.)
Source: De Groot 1996.

Resource Origin

Sand and Gravel deposits on the continental shelf can be either *relict* or *modern*

✓ ***Relict*** **deposits are deposited under different hydrodynamic and sedimentological regimes during low level stands (i.e river or coastal bank deposits)**

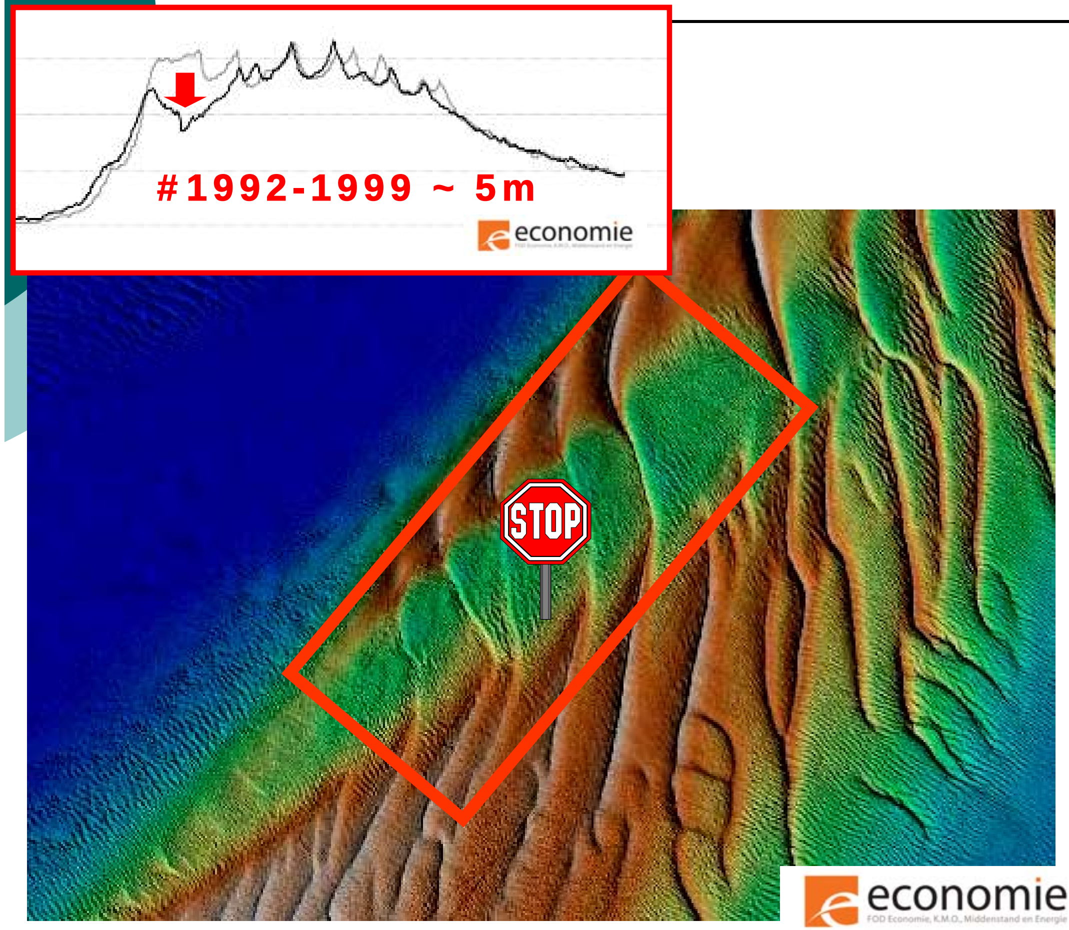
- **sand and gravel sheets (mostly thin)**
- **relict bank and drowned beaches**
- **buried palaeovalleys**

✓ ***Modern*** **deposits have been deposited and are controlled by the present hydrological and sedimentological regime**

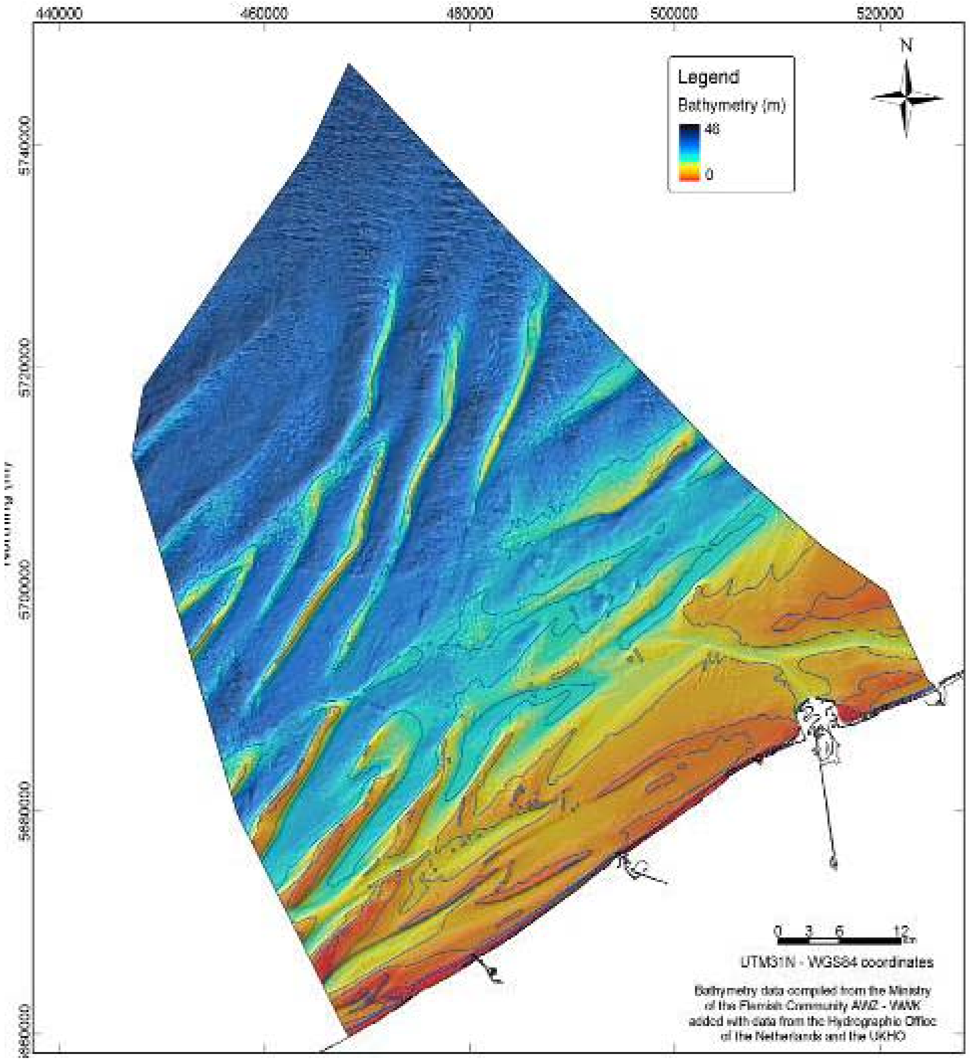
- **banks (gravel or (mainly) sand)**
- **bedform fields**

Velegrakis *et al.* *accepted*

Sustainable exploitation?



1979-1991: 1 10^6 m^3/yr
1991-nu: 2 10^6 m^3/yr, still 75% heaviliy concentrated
NL: since 1991 > 20 10^6 m^3/yr



Sustainable exploitation => Sustainable development ? - guidelines

(Ref. Wellmer & Becker-Platen 2002)

ecology

same priority

economy social justice

Renewable resources

Use of renewable resources:
The rate of consumption should not exceed the rate at which they are regenerated

Non-renewable resources

Use of non-renewable resources:
The consumption should not exceed the amount that can be replaced by functionally equivalent renewable resources or by attaining a higher efficiency in the use of renewable or non-renewable resources

Resilience of the system

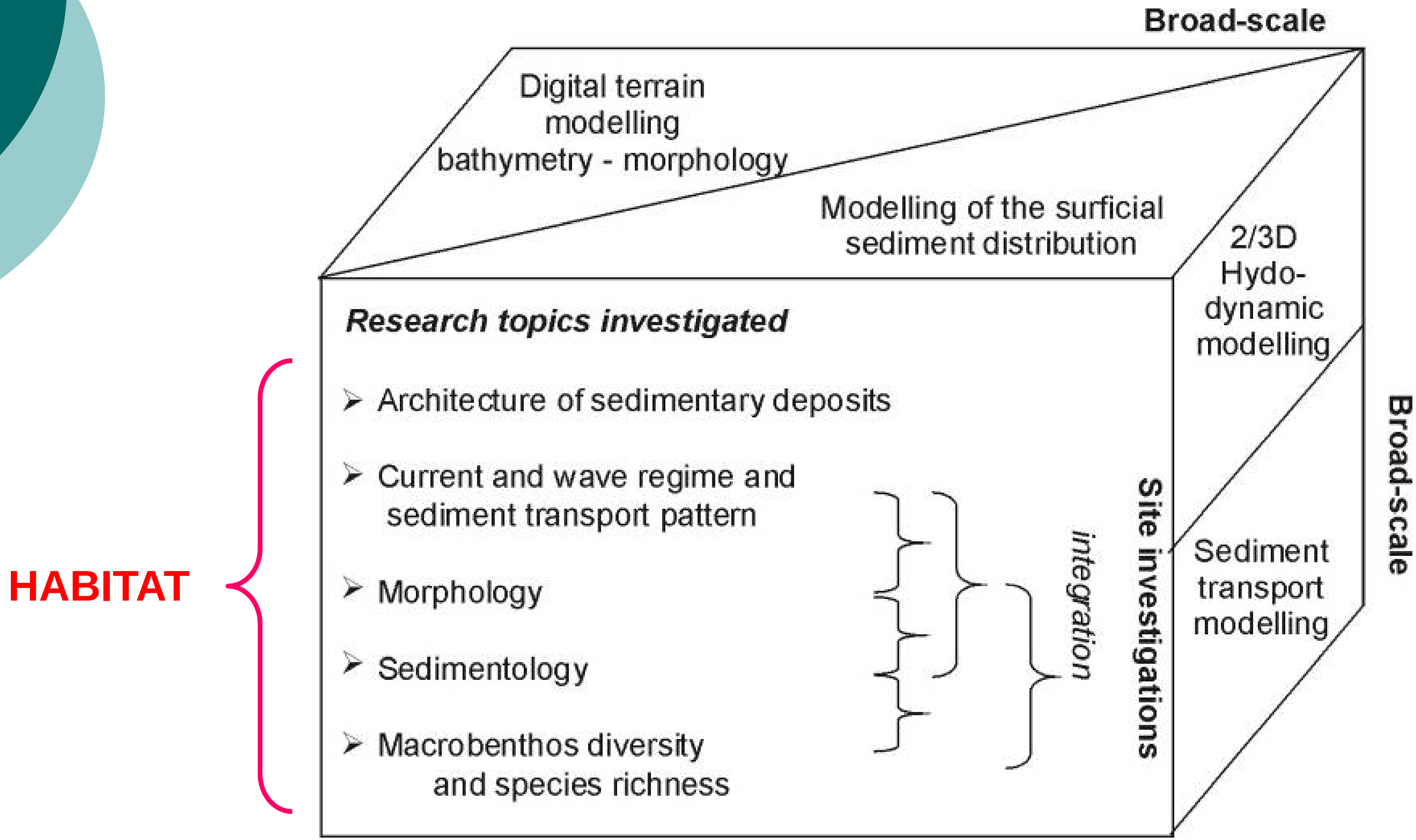
Material and energy input into the environment should not exceed the capacity of the environment to absorb them with minimal detrimental effects

Carying capacity of the Earth's system

The rate of anthropogenic input and environmental interference should be measured against the time required for natural processes to react and cope with environmental change

All of these issues are utmost difficult to address in the marine environment

Need for research integration



Need for adequate tools

Multidisciplinary research needed!

	Geology	Morphology	Sedimentology	Sediment dynamics	Biology/Ecology
Knowledge / Data need	Resource availibility (sufficient Q cover) Good characterisation of subsoil strata (homogeneity of the subsurface layers) Resource origin	Volume calculations Fine-scale Morphometric analysis Bedforms	Spatial distribution Quality mapping << industry needs	Fine-scale hydrodynamics 2D/3D (currents + waves) Sediment transport (bedload/suspended) Sediment balance (erosion/deposition) +grain-size	Identification of ecologically sensitive areas Habitat characterisation
Tools / Innovation need	VHR Seismics	High frequency Acoustics	High frequency Acoustics	High frequency Acoustics/Optics/EM	High frequency Acoustics
	Sensor improvement				
	+ Coring+Geotechnics	+ Video/Still	+ Sampling+Geotechnics	+ Sampling	+ Video/Sampling
		Monitoring – adequate time series – good reference framework			
	Predictive modelling – long-term				
Most challenging: dealing with uncertainty					

Need for sound modelling approaches

- *Boundary conditions, seafloor conditions, parameters from **real data***
  << In situ & remote sensing

- Hydrodynamic Model
  - Coupling of different models (currents + waves) (beach+shelf+estuary)
  - Fine-scale 2D/3D

- Combination Models - Measurements
  - hydrodynamic model - ADCP meas. → validation
  - hydrodynamic model - satellite images → mud transport NS
  - hydrodynamic model – LISST, OBS → flocculation

- Coupled sand-mud models / erodibility of sediments!

- Morphodynamic modelling

- Idealised modelling for impact assessments

Need for a strategic framework

Detailed resource and environmental maps, both on a large- and small-scale and **criteria** to avoid detrimental effects have been proposed

- grain-size maps	**TO**	*target the right quality*
- thickness and suitability of the Quaternary deposits		*ensure long-term availability*
- sediment transport/ erosion-deposition maps		*maximise the chance of regeneration* *minimise detrimental physical impact*
- maps on wave energy distribution		*evaluate a possible impact on the coast*
- maps on ecological functioning		*avoid sensitive areas or important habitats*
- (maps on other seabed users) (NA if zones are predefined)		

Capacity / resilience of the system ?

- need to quantify the **natural evolution** of the (sub)system

but is this possible within a anthropogenically steered environment ???

Relation MA extraction and biodiversity - Main problems

- No baseline information
- No historic reference points
- Significance of impacts on biodiversity?
- Cumulative impacts?
- Links between cause and effect?
- Impacts on habitats complexes, structure and function?
- Post-dredging recovery and restoration?
- Influence of site specific characteristics? and how to extrapolate?

After Gubbay 2003. Marine Aggregates and Biodiversity. Information, issues and gaps in understanding. WWF report, 24 p.

Impact of aggregate extraction – *case study Kwinte Bank*

The facts: *since 1999*
- **creation of a depression of 5 m, still extraction per time unit max 50 cm**
- **now depression to the north of the Kwinte Bank**
- **extraction up to 0.20 m³/m² (Marine Sand Fund)**

Geology
- locally, almost complete dredging of upper unit of the bank

Morphology
- +/- stabilisation of the sandbank after cessation of dredging, **no** regeneration
- recovery of the bedforms, though smaller in height (results Marine Sand Fund)

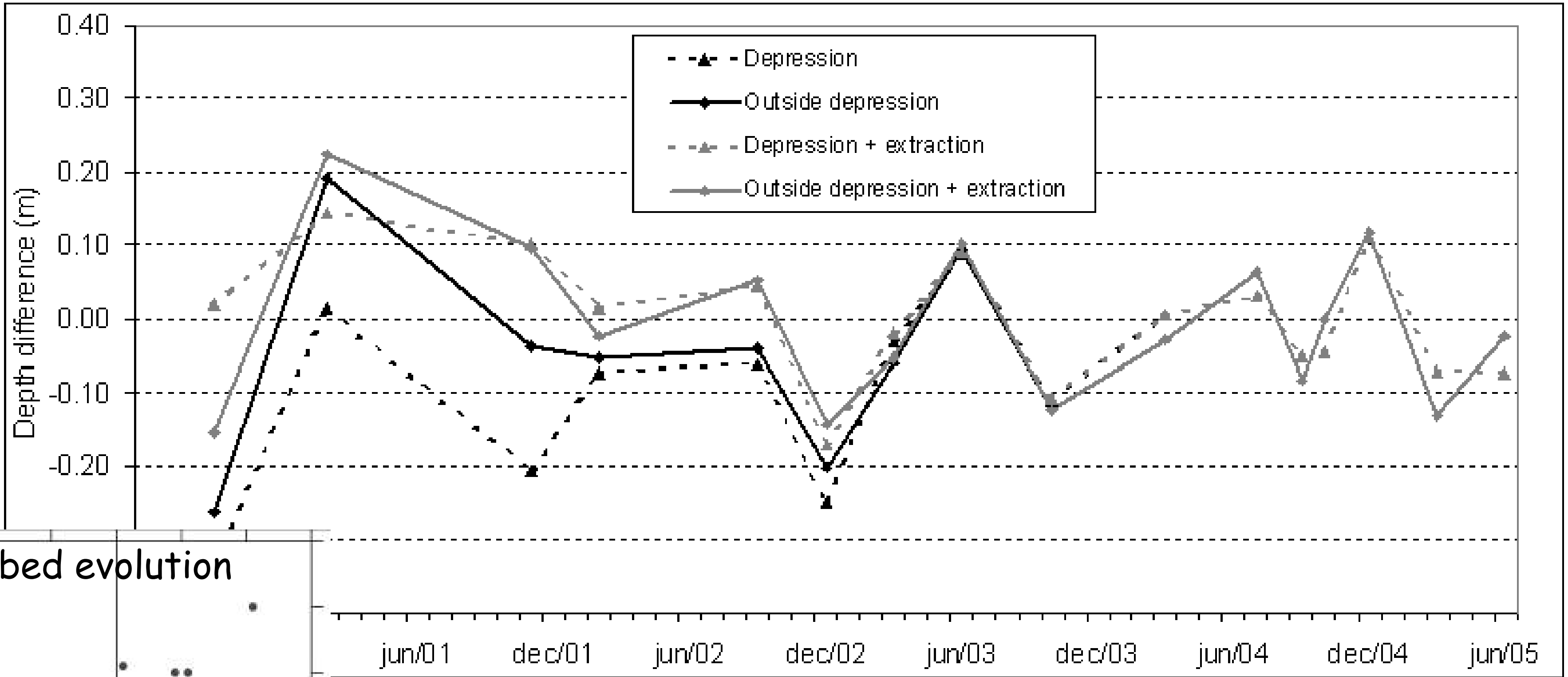
Sedimentology
- complex distribution; evolution similar as the swale sediments
- flood: depression acts as a corridor for shells; ebb: deposition of fines
- sediments seem to be only locally reworked; no major exchange of sediments

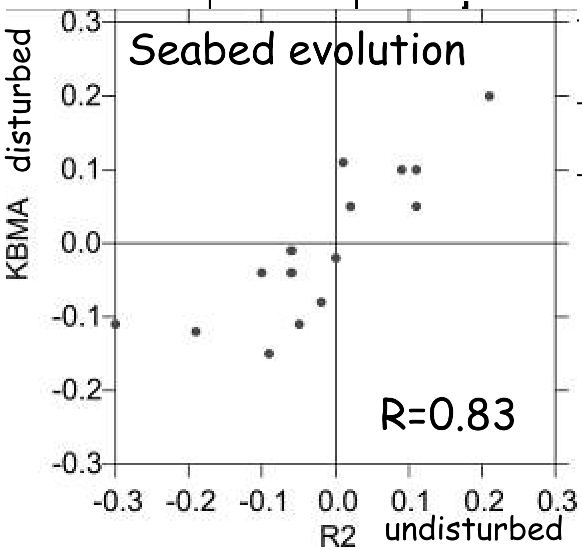
Sediment dynamics
- locally altered hydrodynamics and erosion-deposition pattern
- impact scenario's do not destabilise the sandbank, but merely indicate regeneration mechanism, BUT availability of sand?
- *impact of waves and storms on sediment transport ?*

Biology (Belspo SPEEK)
- limited macrobenthic life with lower biomass
- increase of opportunistic deposit feeding nematode species
- impact on harpacticoid copepode communities
- no recovery after 2 years
- *but, methodological constraints, no baseline and a wide habitat niche*

Impact on the coast?
- no scientific evidence yet available

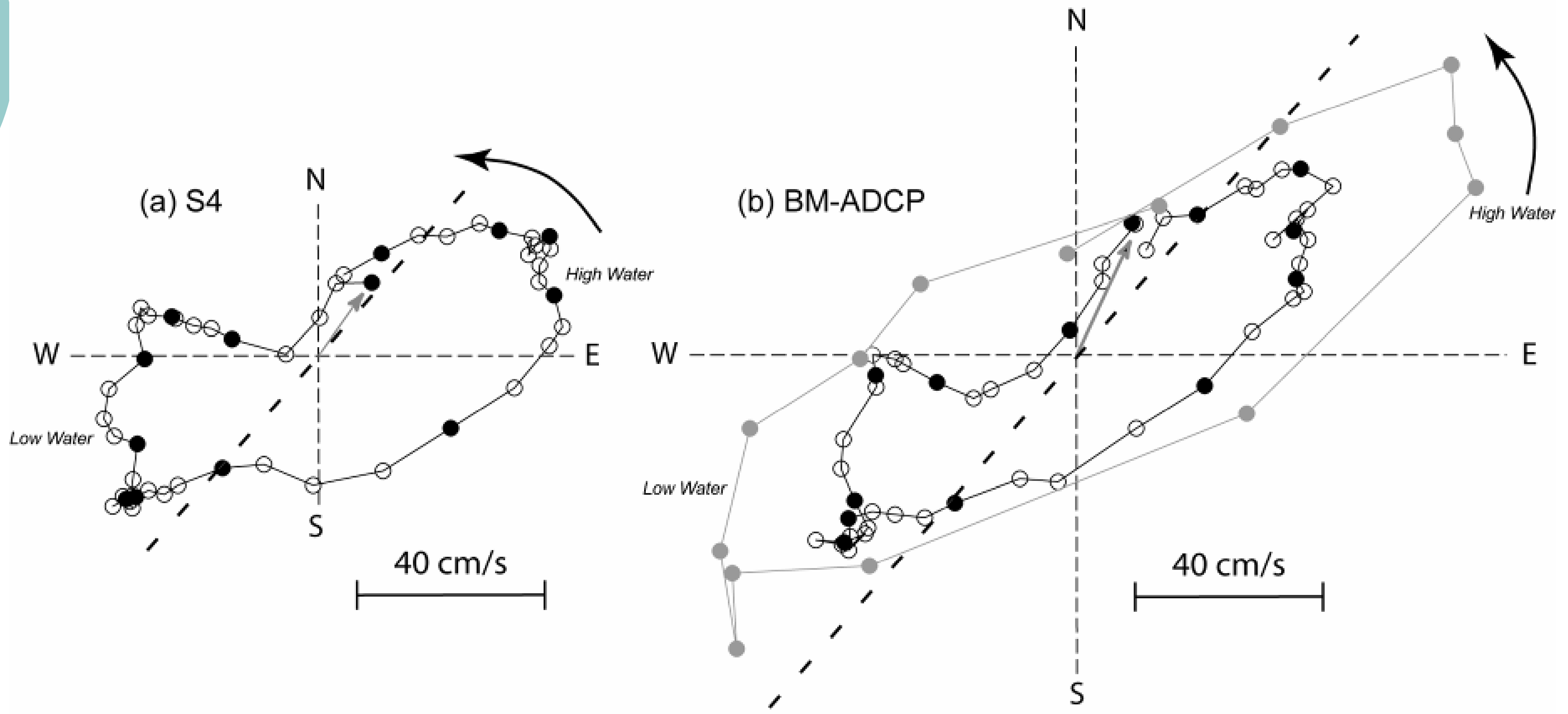
Morphological effects





Degrendele et al., accepted

Hydrodynamical effects

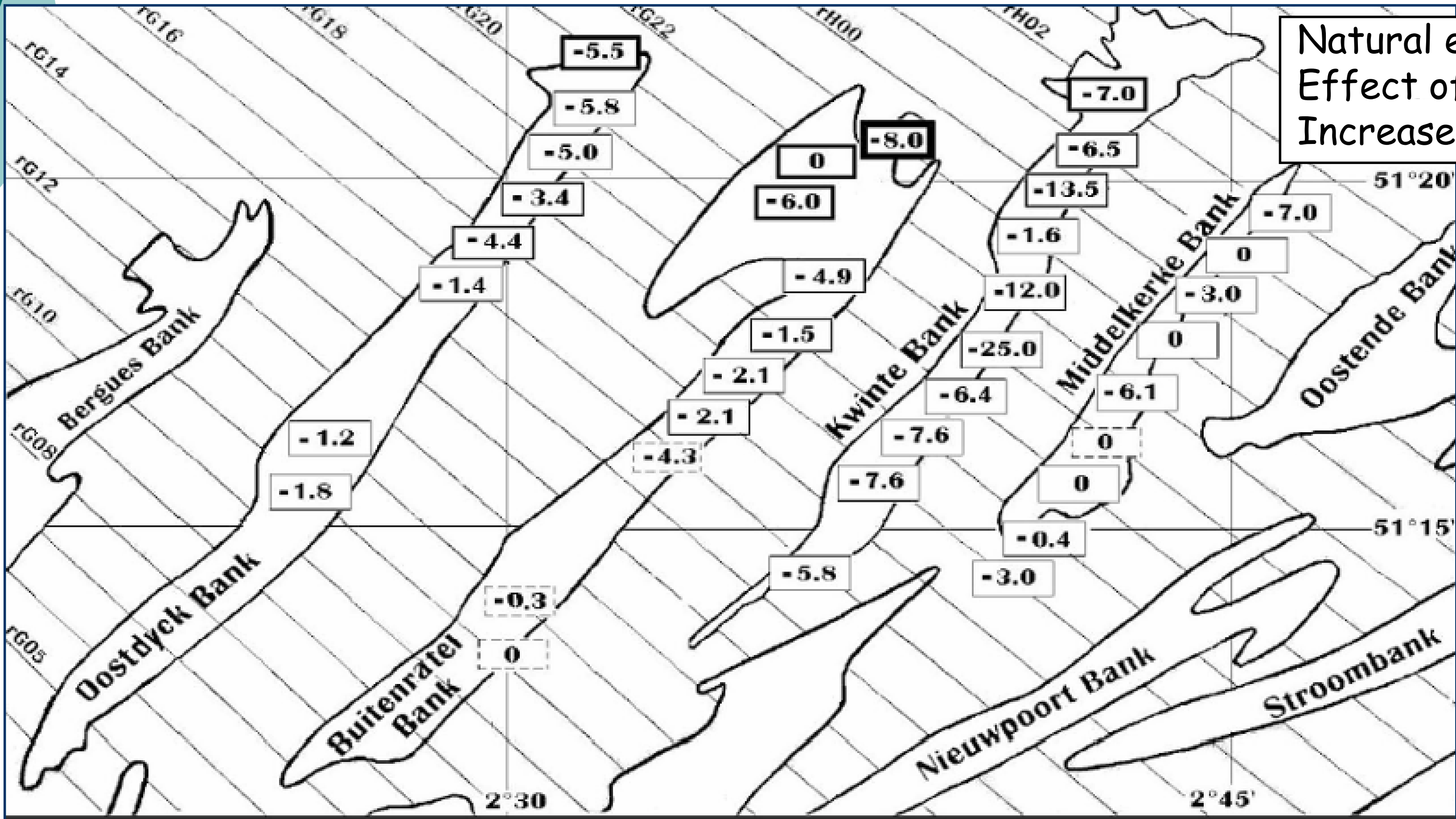


Garel, accepted

On the <u>short- to medium term</u>: impact rather local and only very slow to no regeneration
On the <u>long-term</u>: EROSION (De Moor, 2002; Norro et al. 2006)

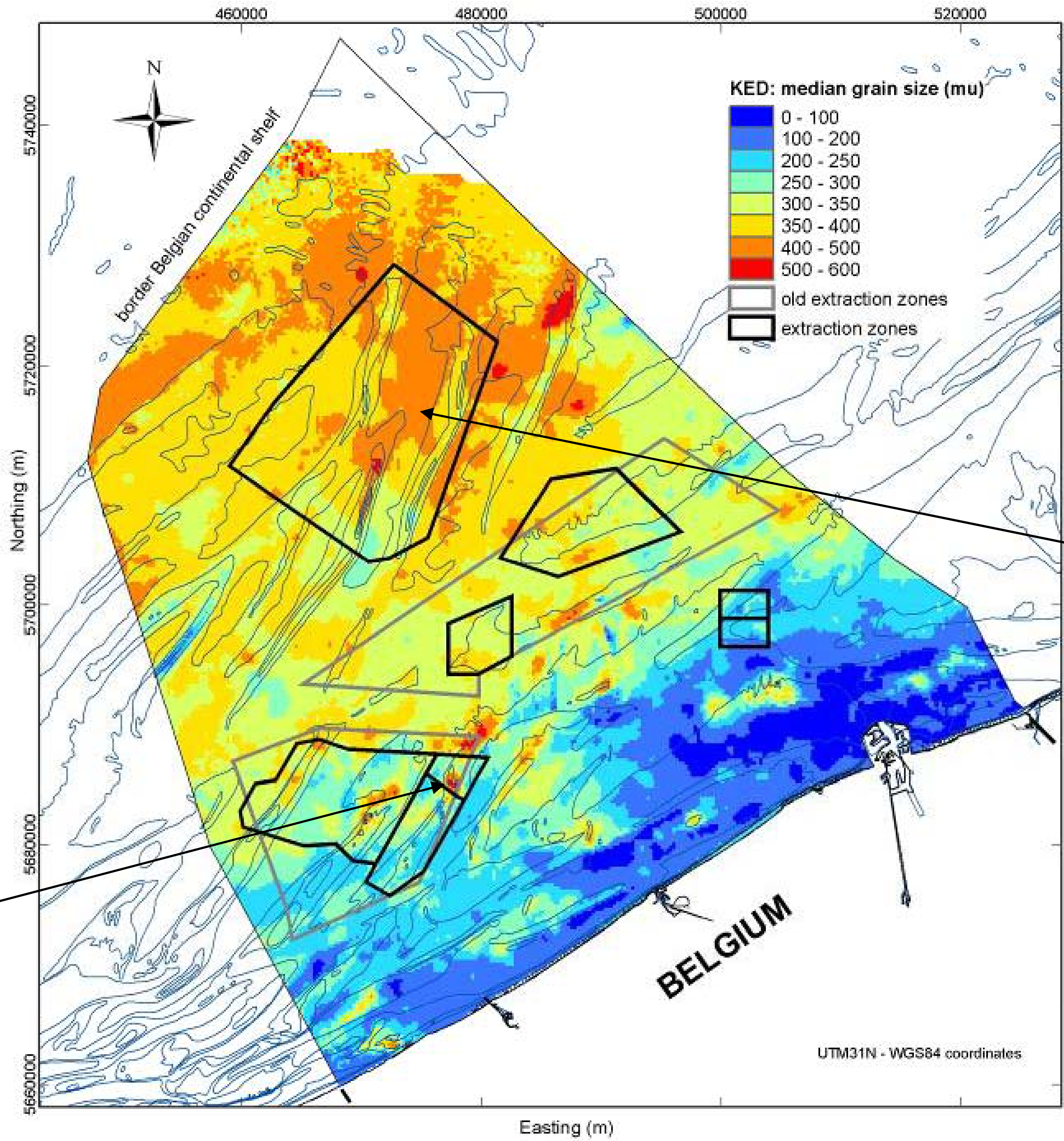
For the Kwinte Bank, preliminary modelling results (MUMM) calculate a mean volumetric loss of $-1.4 \pm 0.27\ 10^6\ m^3/yr$ whilst extraction is only around $0.9\ 10^6\ m^3/yr$

Imposes problems on monitoring strategies: issues on time- and space scales



Source: De Moor, 2002

Natural evolution?
Effect of waves?
Increased storminess?



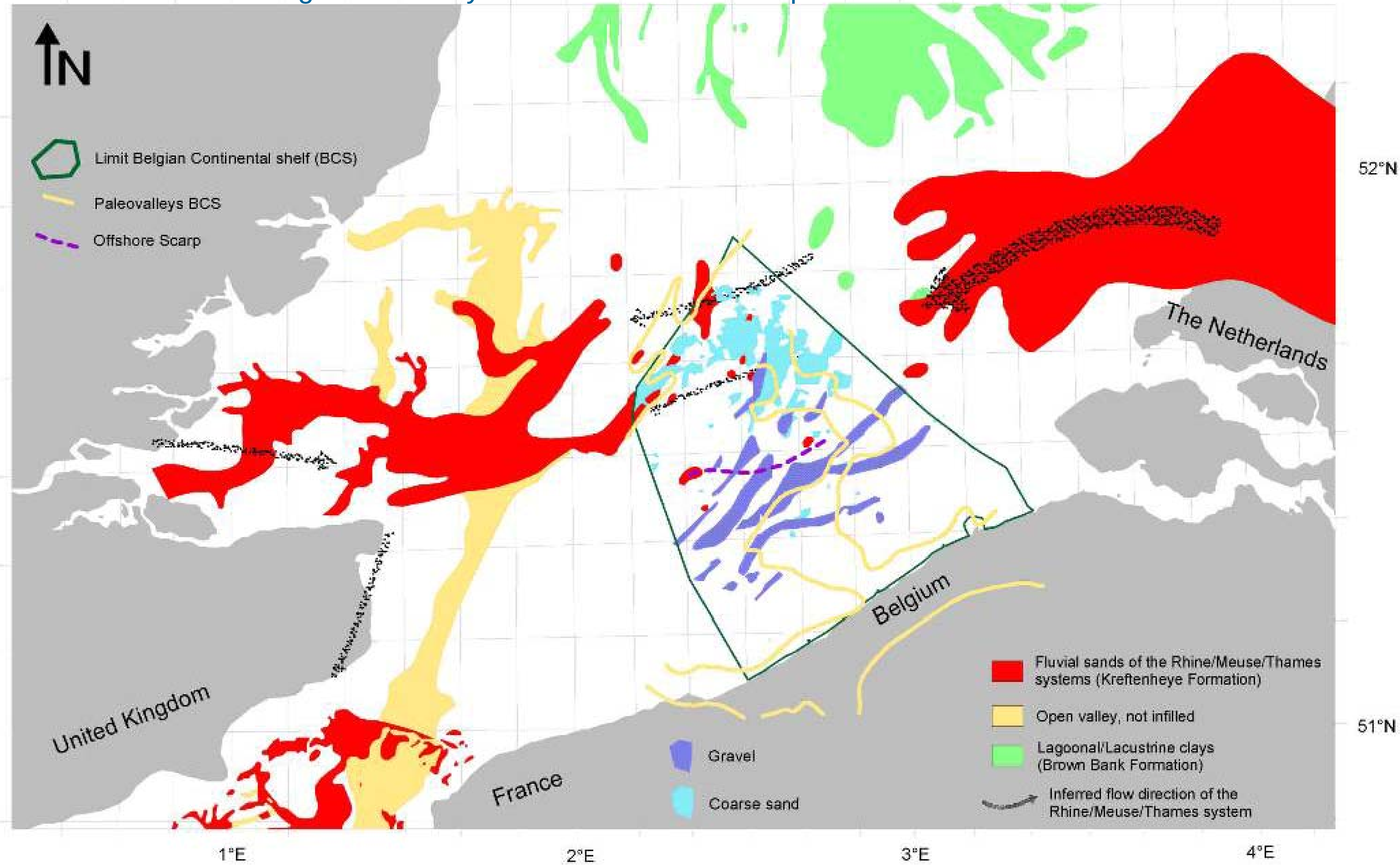
Kwinte Bank depression

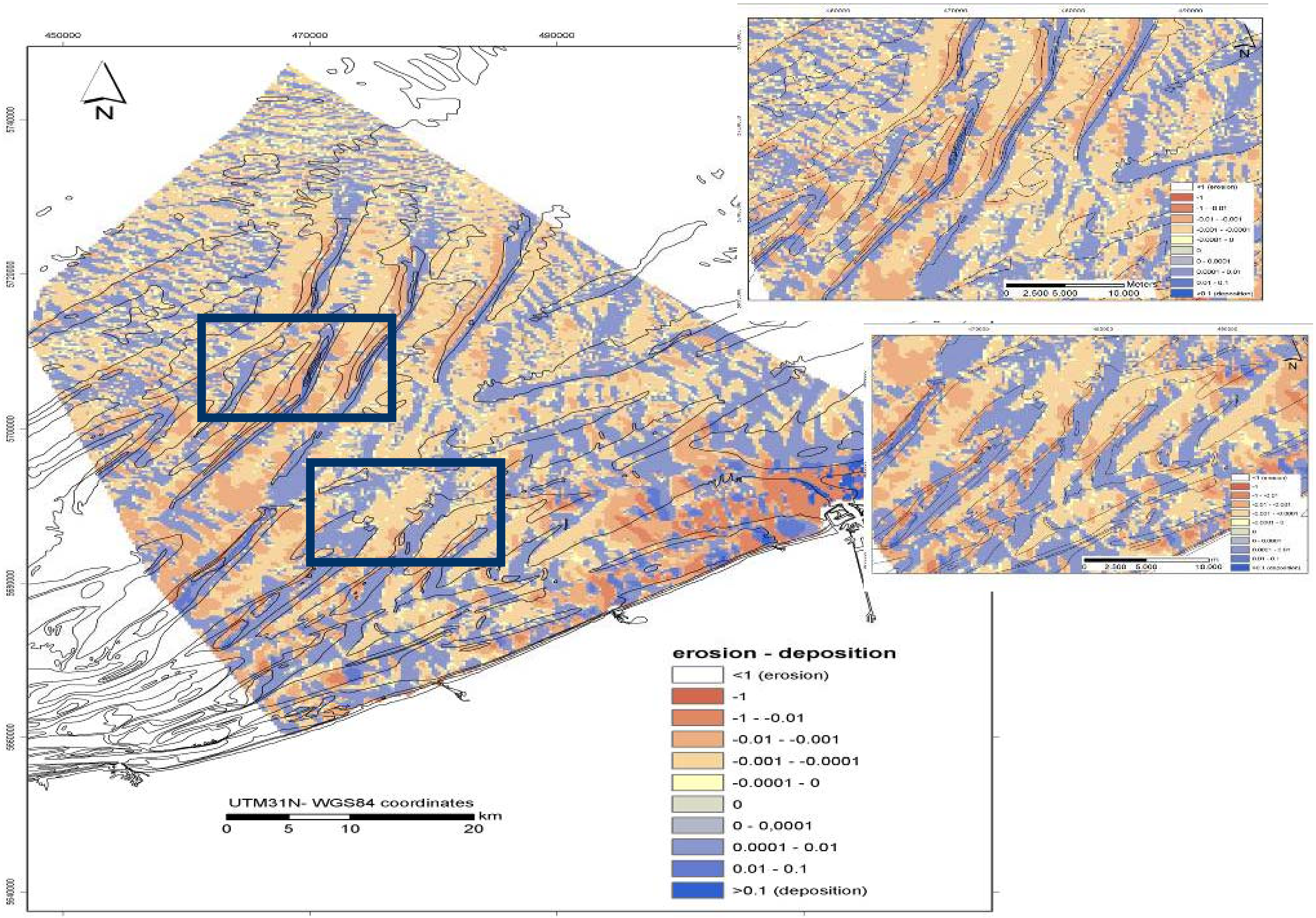
Area of interest for major beach nourishment project

Huge quantities of sediment will be taken in a short period of time

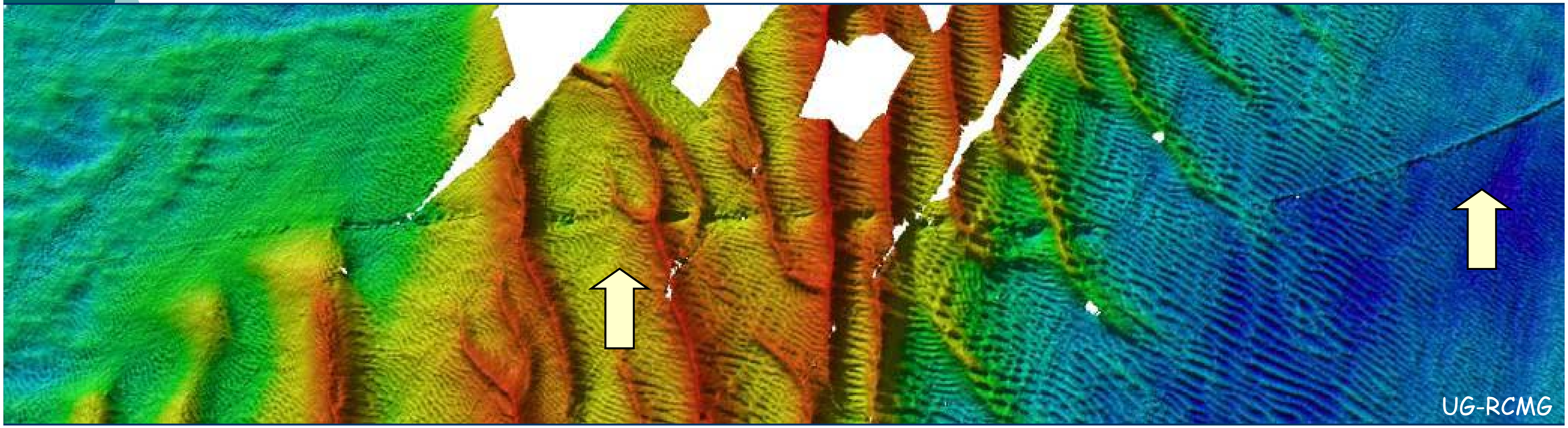
Coarse sand – gravel exploitation potential on the BCS ?

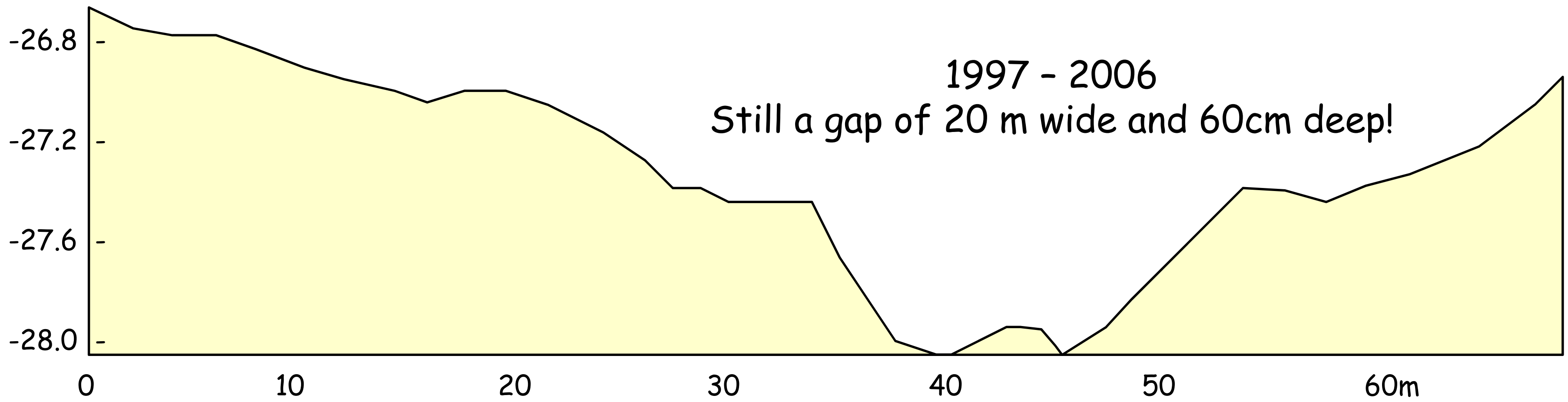
Knowledge on the occurrence and thickness of these deposits is difficult to predict and calls for research on their origin and the dynamics at the time of deposition



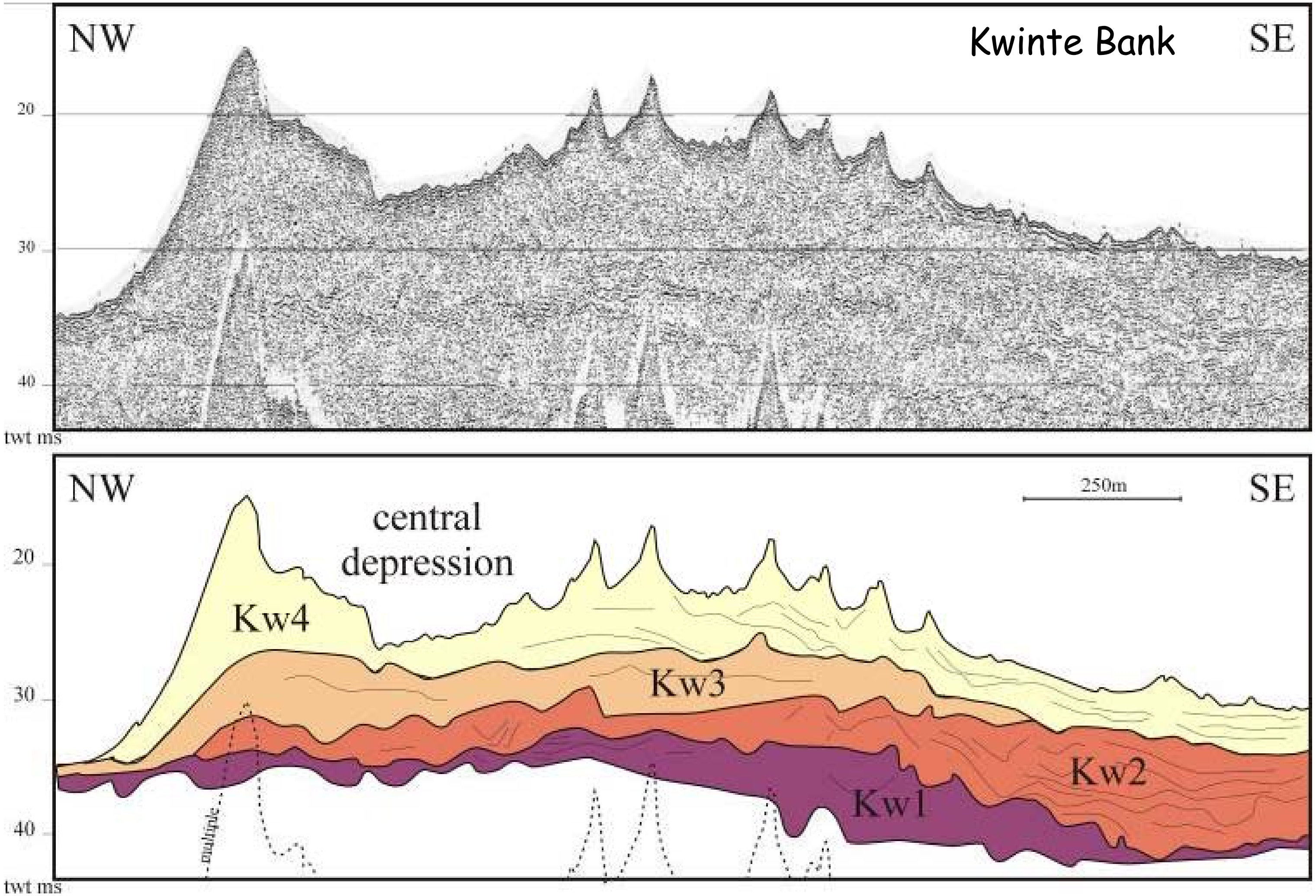

450000
470000
490000
N
erosion - deposition
<1 (erosion)
-1
-1 - -0.01
-0.01 - -0.001
-0.001 - -0.0001
-0.0001 - 0
0
0 - 0,0001
0.0001 - 0.01
0.01 - 0.1
>0.1 (deposition)
UTM31N- WGS84 coordinates
0
5
10
20
km
Meters
0
2.500
5.000
10.000

Natural evolution?



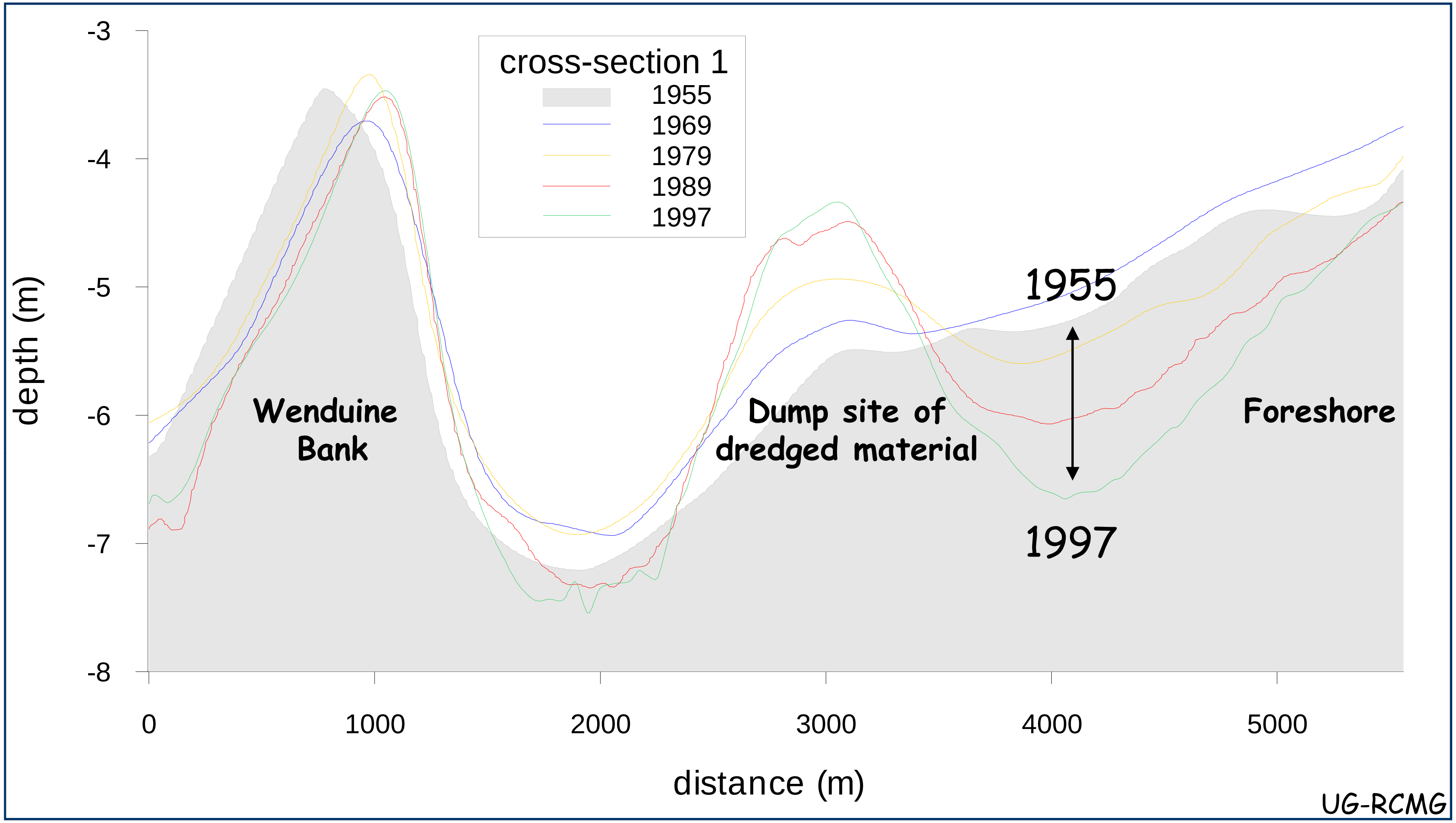


Future: A Resource 3D approach?



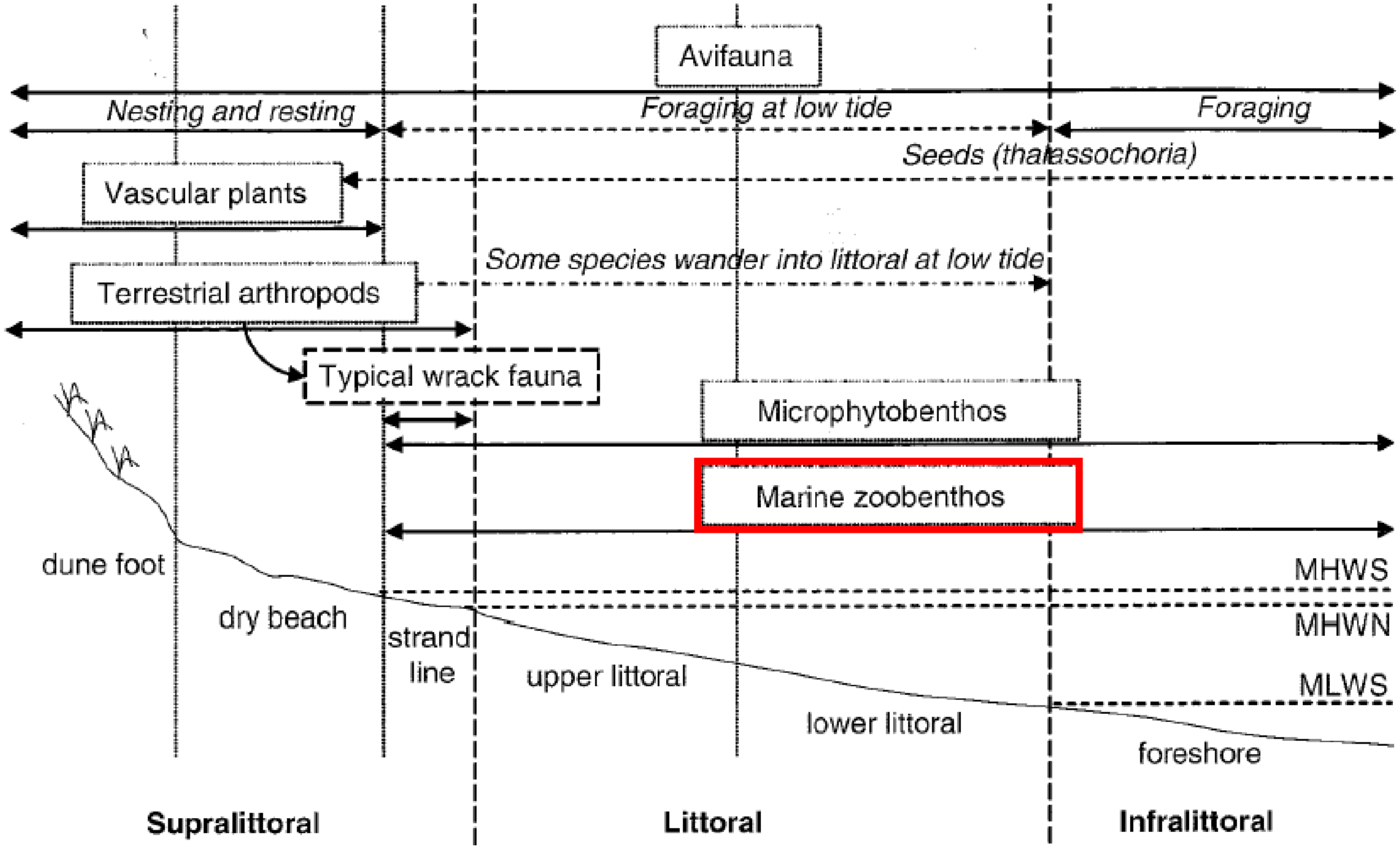
Bellec *et al.* *accepted*

Influence of human activities on the beach ecosystem



Bathymetry data: Flemish Authorities, Maritime Services & Coast

Sandy beach ecosystem



Speybroek et al., 2006
Review on ecological impacts of beach nourishments

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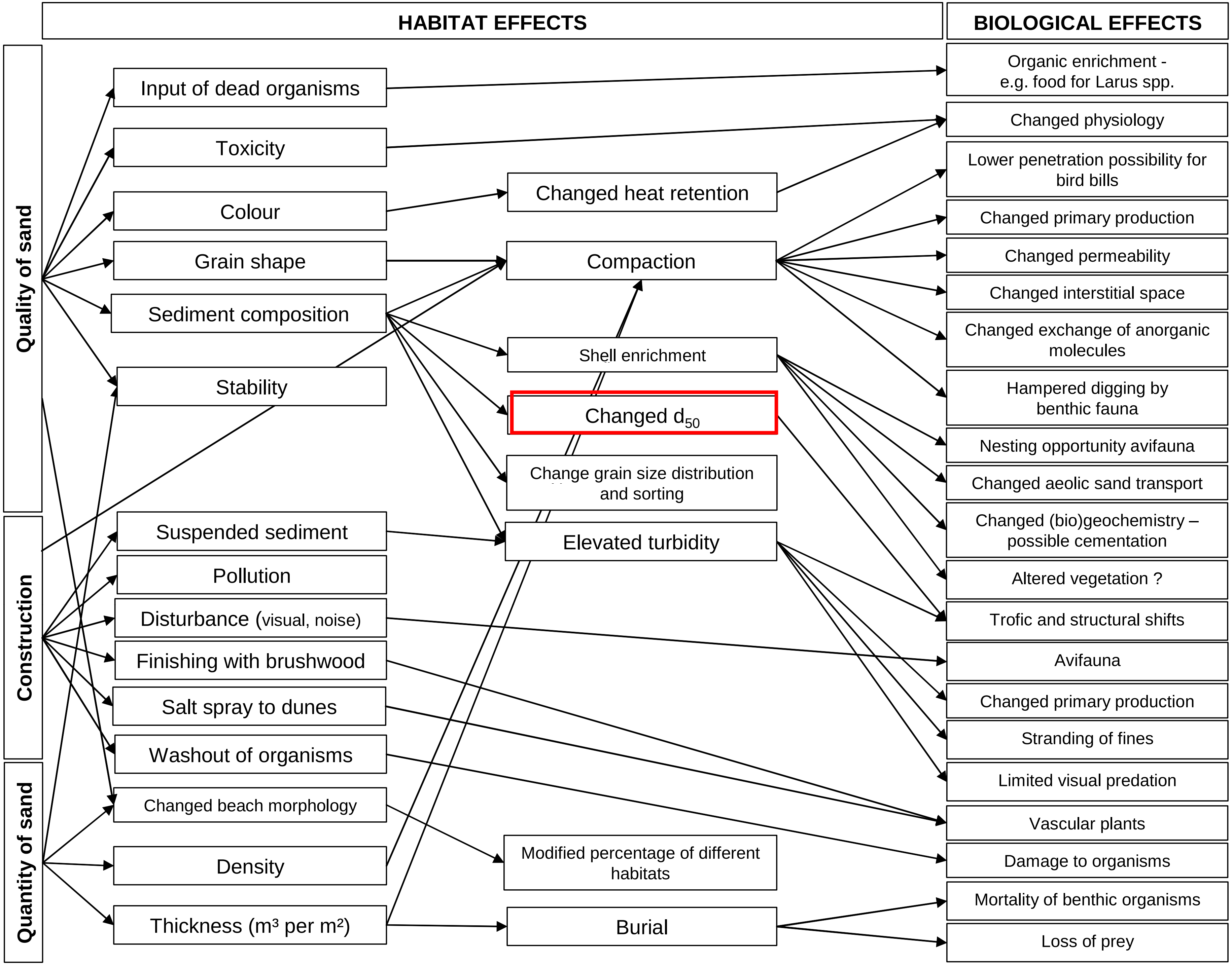
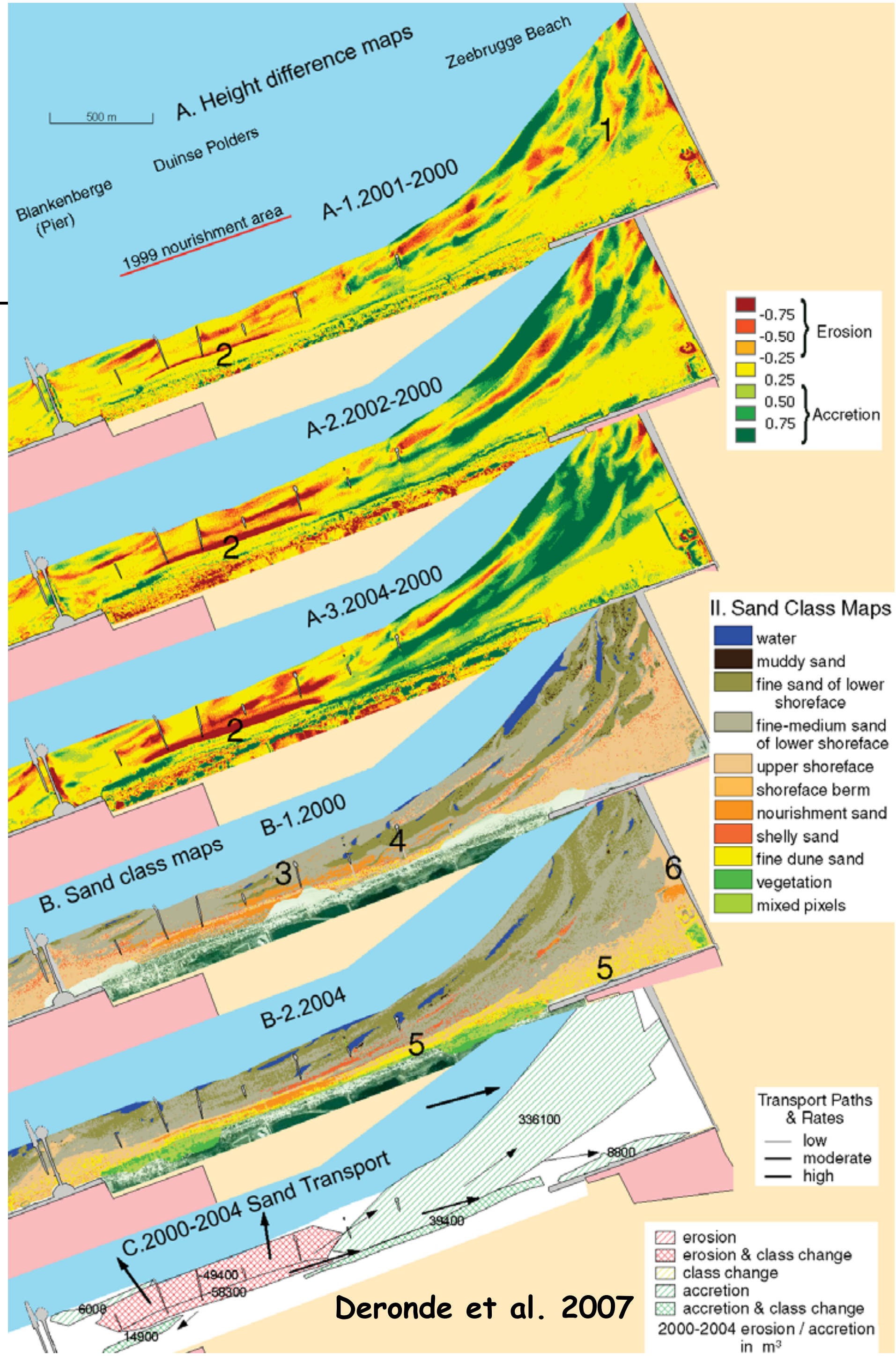


Future?

Nowadays, the integration of LiDAR and hyperspectral data allows studying the sediment dynamics and the behaviour of nourishment sands (Deronde et al., 2007).

In the subtidal, acoustic measurements allow a similar approach.

Integrating these datasets and with the increasing knowledge of the relation between the physical environment and some biological components and their valuation criteria, it becomes real to map, model and biological value the continuum of the dunefoot up to the seabed at high spatial and temporal scales.



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BELGIAN SCIENCE POLICY

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economie
FOD Economie, K.M.O., Middenstand en Energie

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