

Large-scale future maintenance of the Dutch coast; Learning from nature

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TNO | Knowledge for business



Presentation

- Introduction
- Long-term coastal evolution
- Natural sediment supply
- Nourishments
- Conclusions

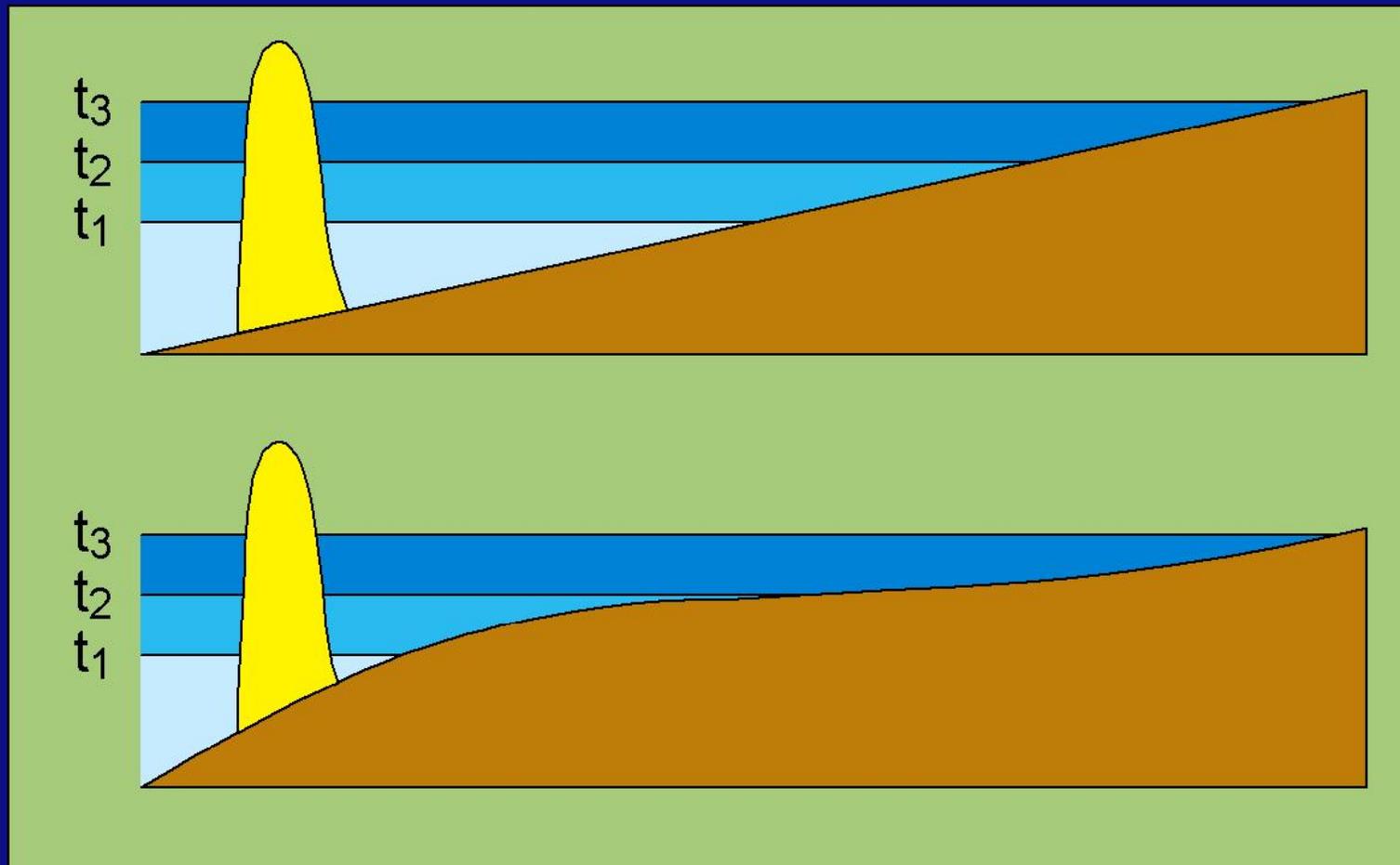
Introduction

Goal:

1. Putting coastal maintenance into the right perspective
 - *long-term natural evolution*
2. Connecting daily practice to long-term coastal evolution
 - *anticipating future accelerated sea-level rise*

Accommodation space (= demand !)

basal topography + relative sea level



Long-term coastal evolution

supply > demand :

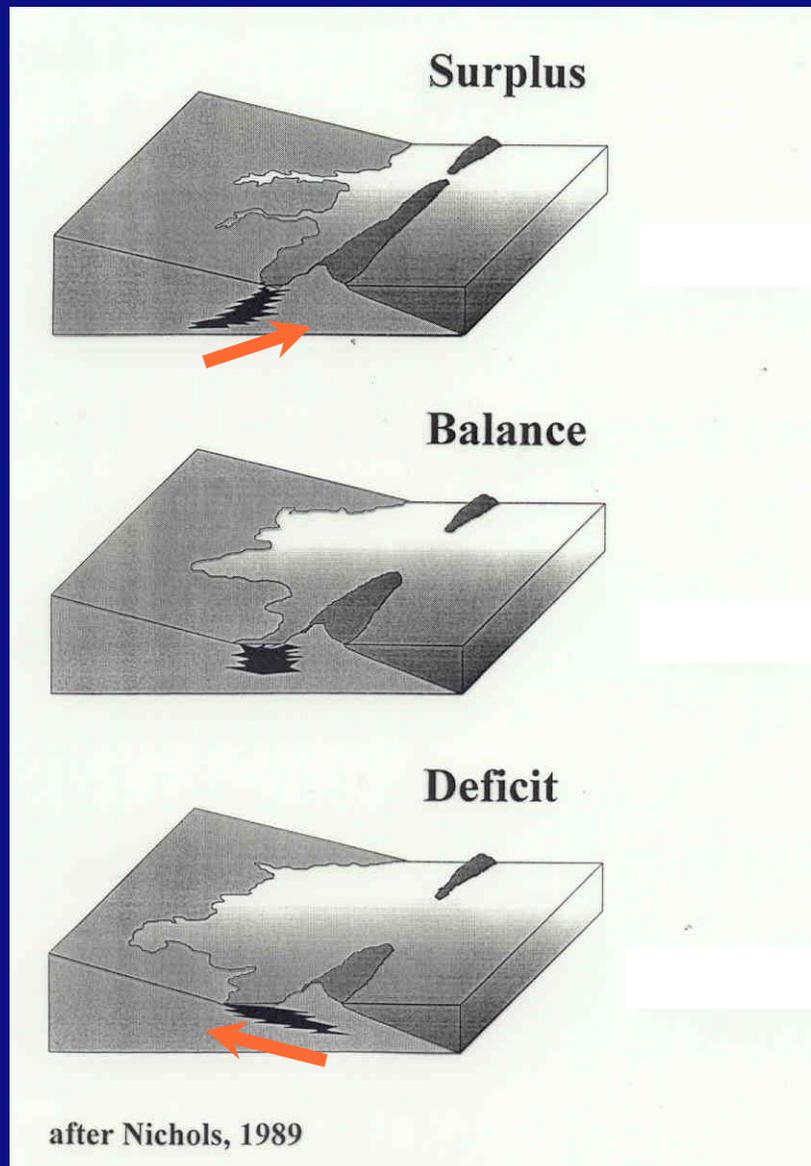
regression

supply = demand :

stable

supply < demand :

transgression



Future changes in balance:

1. topography is fixed
2. RSLR: accelerates (predictions)

Increasing accommodation space

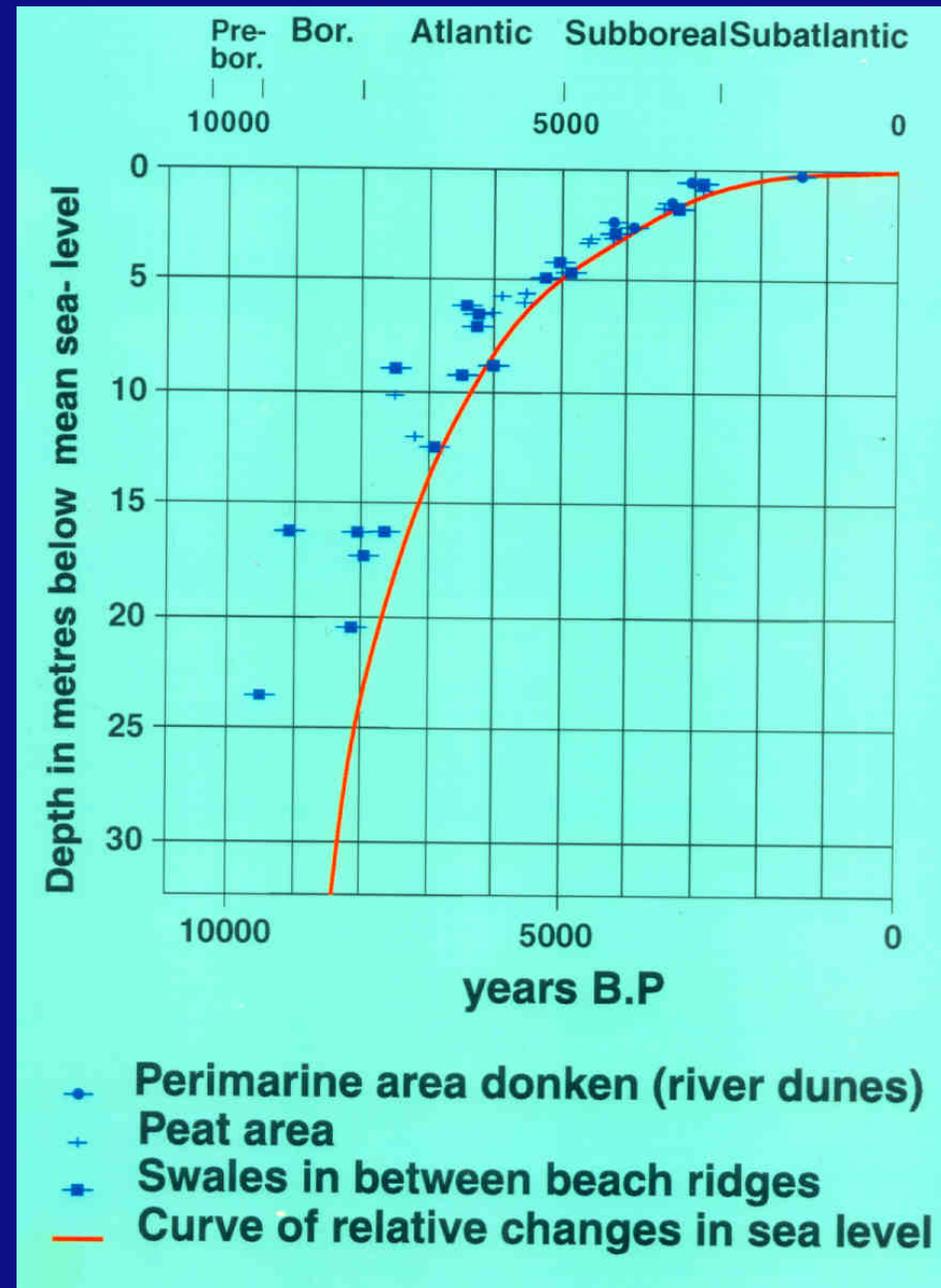
sediment supply ???

Long-term coastal evolution

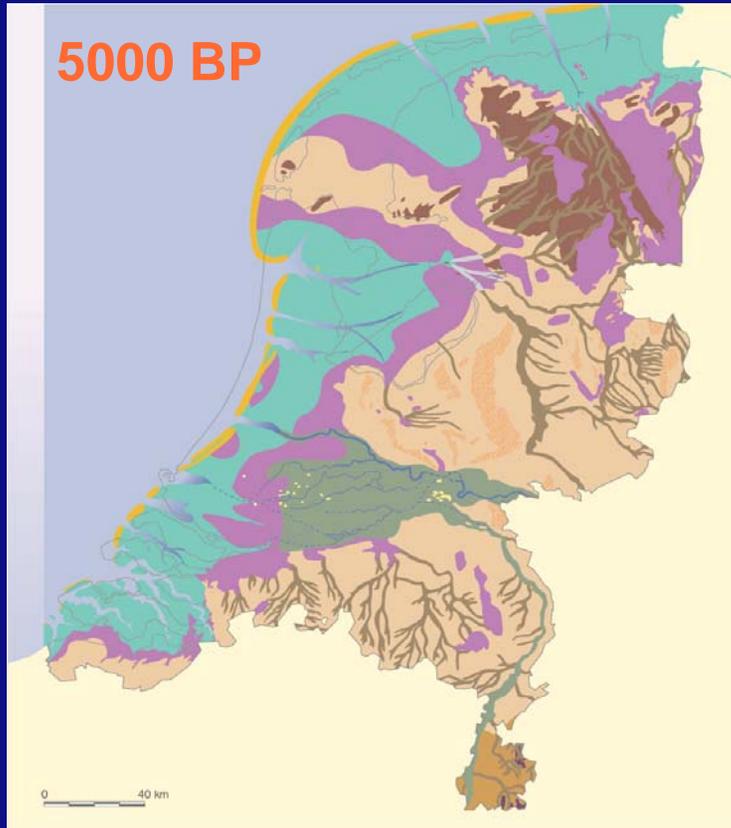
examples from The Netherlands

Relative sea-level rise

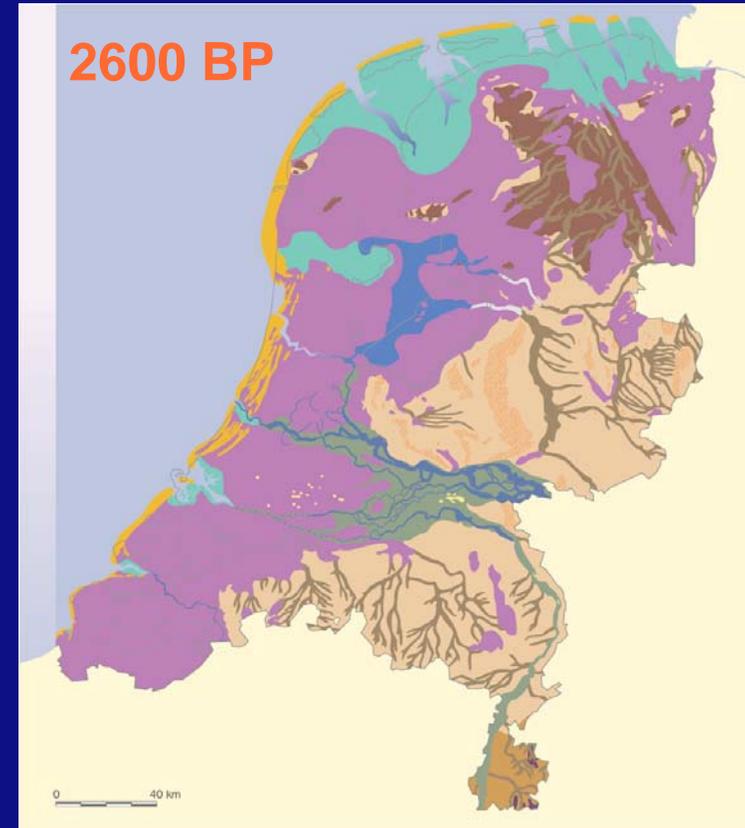
- trendcurve
- absolute sea-level rise
- land subsidence



Paleo-geography The Netherlands



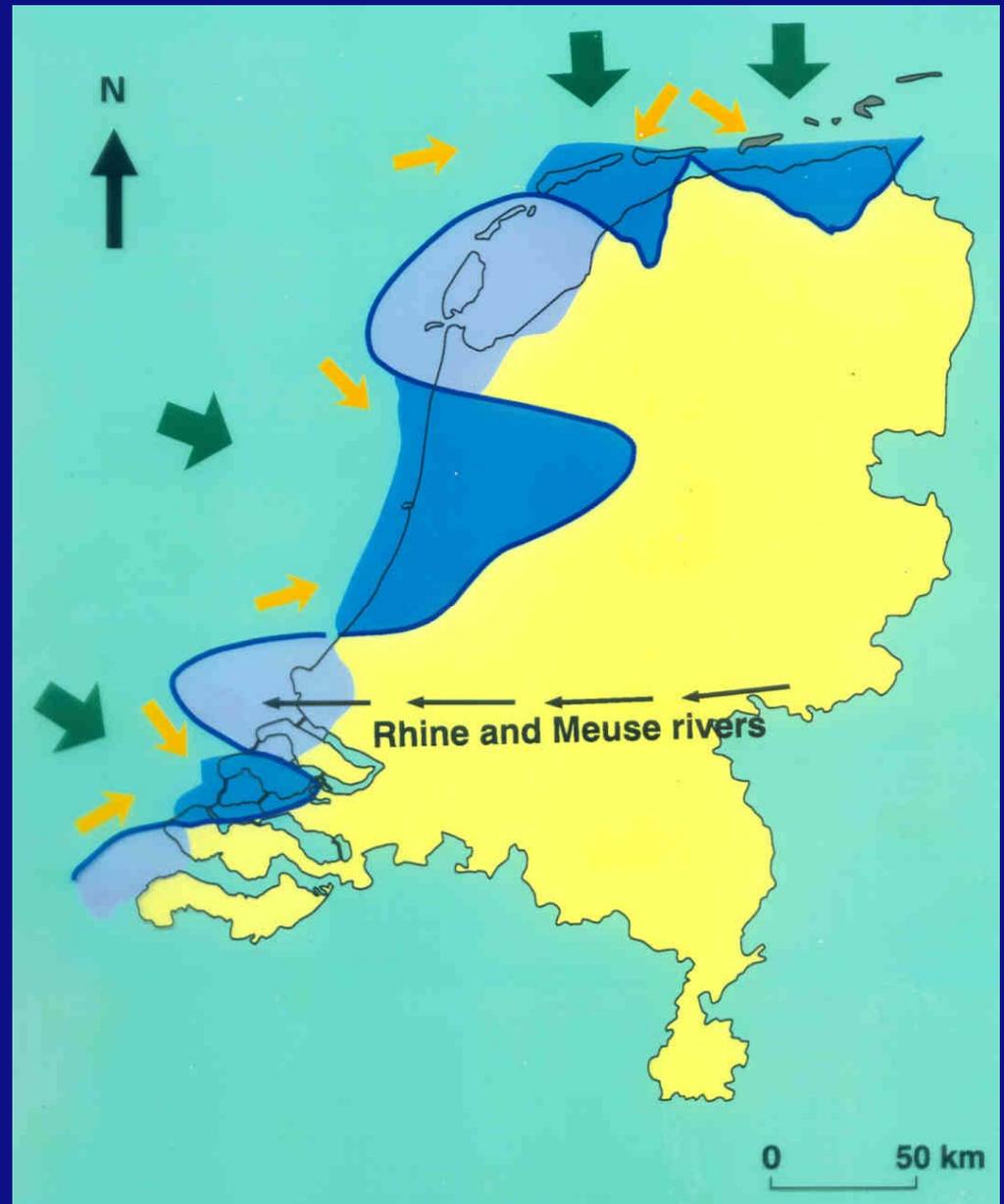
demand > supply

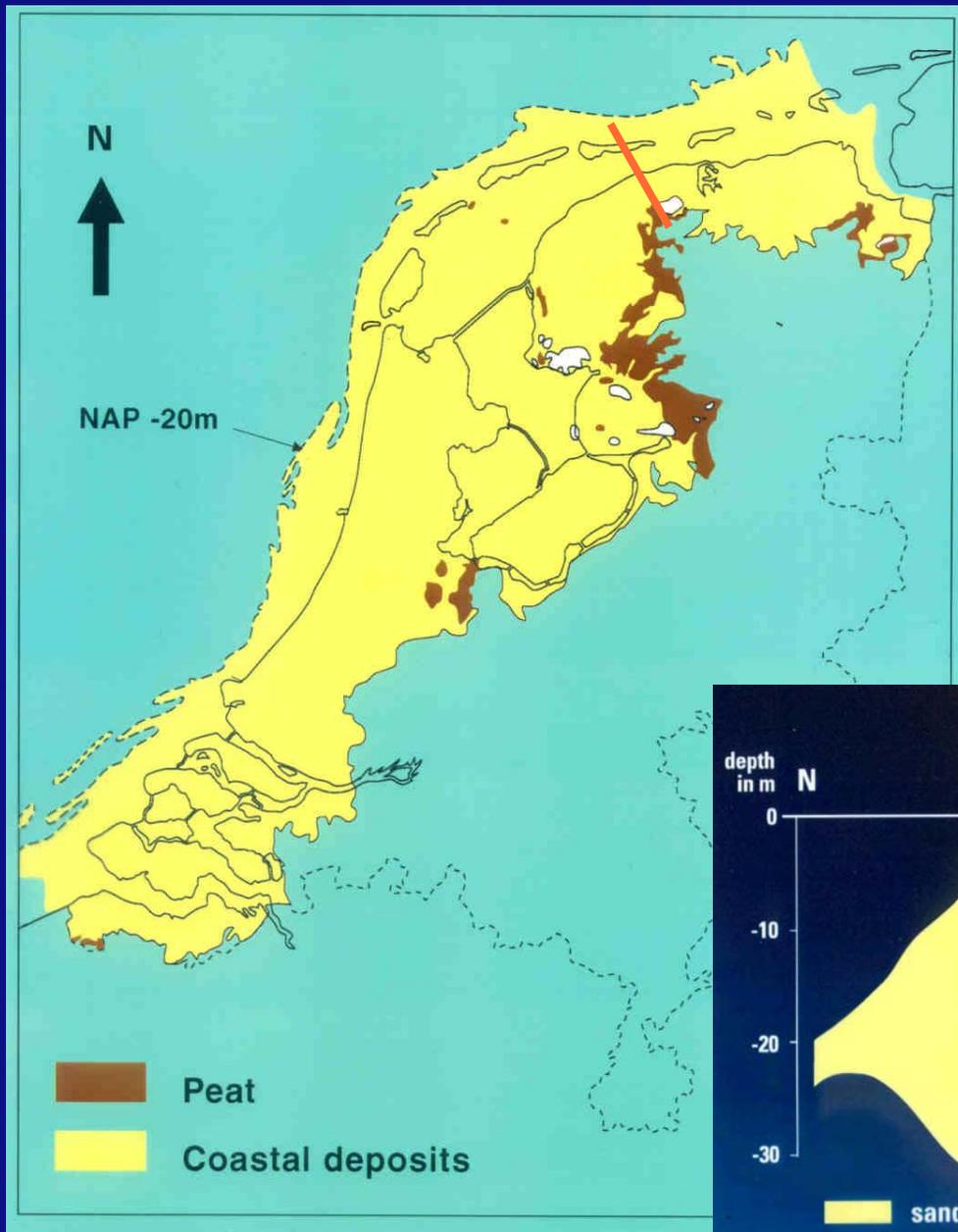


demand < supply

Holocene sediment budget *Sources & sinks*

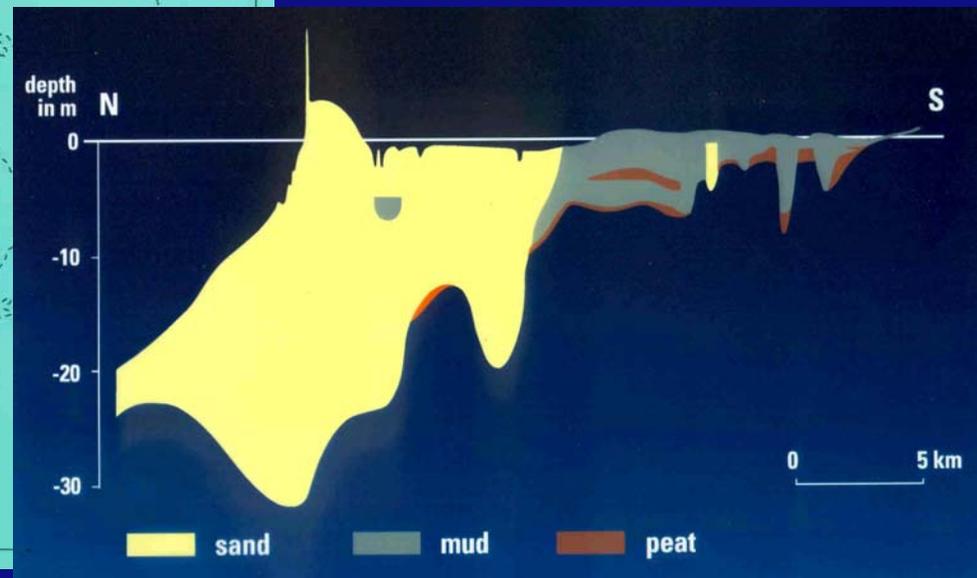
- sinks:
 - coastal plain deposits :
tidal basins
barriers
- sources:
 - North Sea floor
 - Pleistocene headlands
 - rivers
 - older coastal deposits





Sink: coastal plain

- Tidal basins
- Estuaries
- Beach barriers



Total volume Holocene coastal deposits

(in billion m³)

lithology	volume	percentage
sand	151 - 157	67 -70 %
mud	59 - 65	26 - 29 %
peat	11	5 %
Total	226	100 %

Holocene sediment budget

Infilling with time

period	percentage	volume (billion m ³)	volume / yr (million m ³)
Atlantic (8000-5000 BP)	60 %	136	41
Subboreal (5000-2900 BP)	30 %	67	27
Subatlantic (since 2900 BP)	10 %	23	7

Conclusion:

**No longer
natural
large-scale
sediment accumulation
!!!**

“The Hague, we have a problem !”

Keeping up by nourishing sand



What is nourishing ?

- Compensation of sand deficits
- Feeding of sediment fluxes
- Building a sand buffer

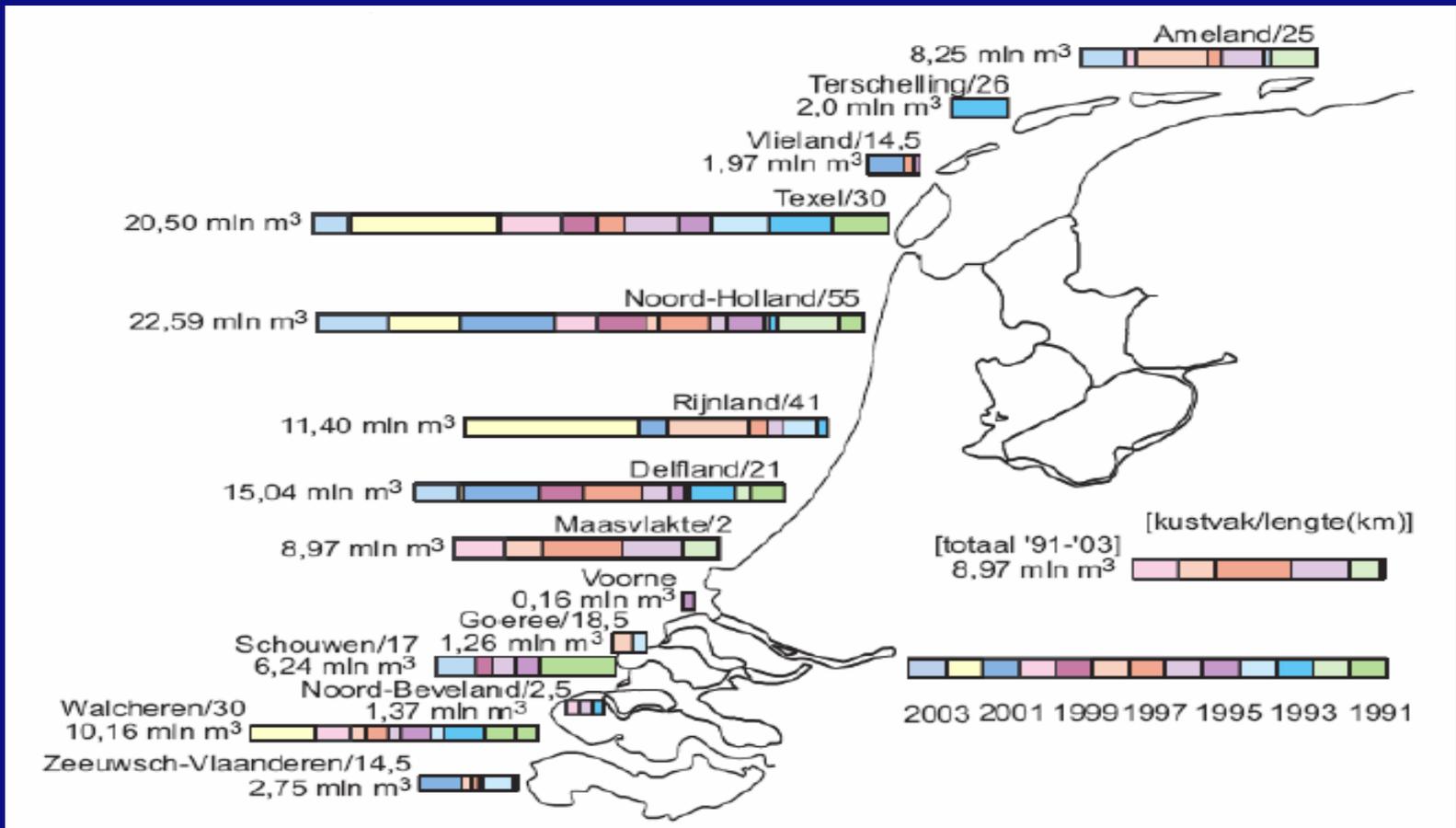
- Land reclamation ?

Why nourishing sand ?

- Flexible
- Tailor-made
- Relatively cheap
- Swift reaction to unexpected changes

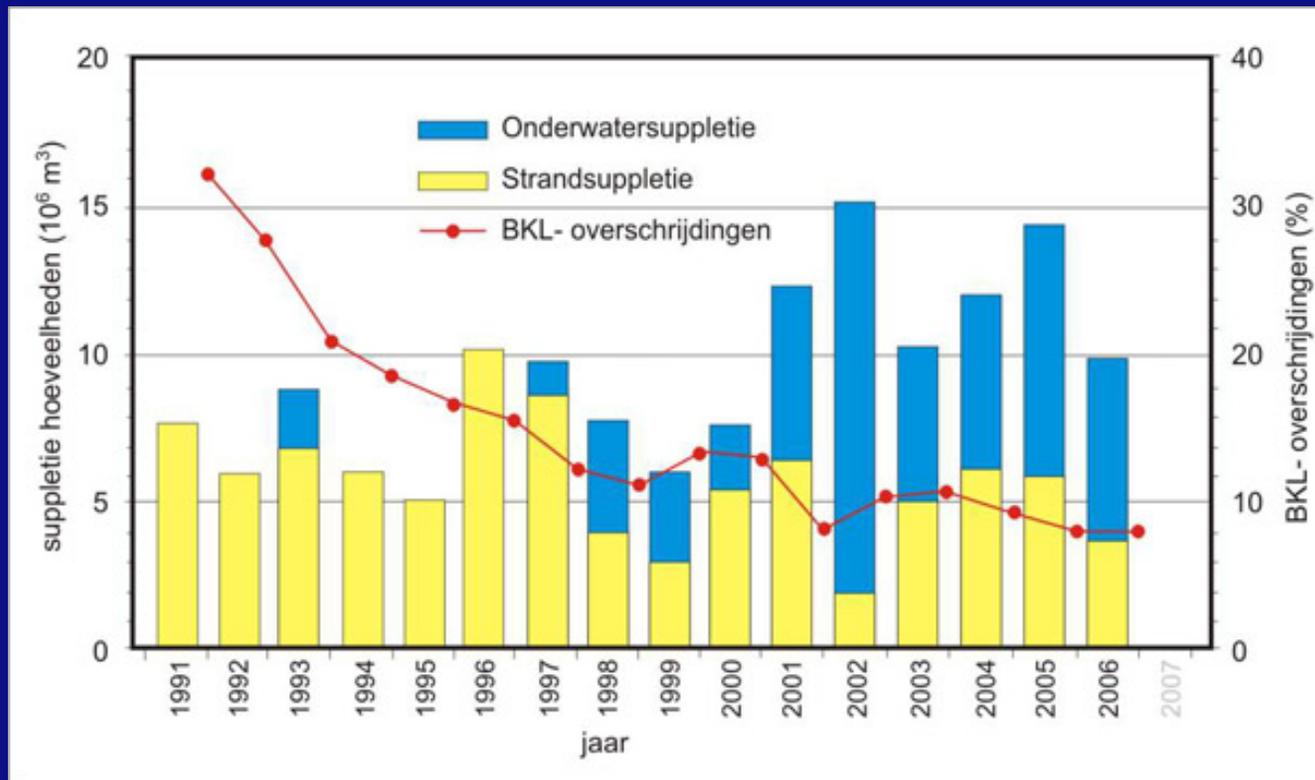
- Sandy system by origin
- Using natural processes
- Redistribution within system:
 - *accumulation in tidal basins*

Nourishments 1991-2003; 112 Mm³



Results of nourishment policy

- Sand deficit in bar zone and beach much smaller



Growing dunes !



Noordwijk aan Zee



Katwijk aan Zee



Wassenaar

Future ; problems? (1)

1. Large-scale sand extraction North Sea bed:
 - ecological impact?
2. Sediment import Wadden Sea will continue !
 - Impact closure Zuiderzee
 - relative sea-level rise
3. Changing boundary conditions
 - Accelerating rise in sea level
 - Land subsidence
 - Stronger storms; more erosion?
 - Increasing number of storms; frequency?

We better keep our sand buffer topped up!

Concluding remarks

Nourishing sand is a continuation of natural long-term evolution with other means

- We are helping Mother Nature !
- It works !
- Plenty of sand in the North Sea

- Raising the coastal plain?
 - *We have got time, but don't wait too long!*

