

About sediments and marine life: A clear cut and tight relationship?

Some snapshots to set the scene for the NCK theme day

Steven Degraer



My background

- PhD in Biology (Ghent University, 1999)
- Scientific career
 - 1994 – 2008
 - Ghent University: scientific collaborator
 - 2008 – ctd.:
 - Royal Belgian Institute of Natural Sciences: senior scientist
 - Ghent University: guest professor
- Scientific focus: benthic ecology of intertidal and shallow subtidal marine ecosystems
 - 1994 – 2008: soft sediment environments
 - 2008 – ctd.: hard substrate environments (among other topics)

Key messages

1. Benthos is abundant and can be found (nearly) everywhere.
2. Specific sediment types host specific benthic communities.
3. The sediment-benthos relationship can be used to predict what benthic fauna (and other fauna) to occur where.
4. Not only sediments drive benthos distribution patterns.
5. Sediment-benthos correlations do not equal cause-effect relationships.
6. On its turn, benthos activities impacts sediments.



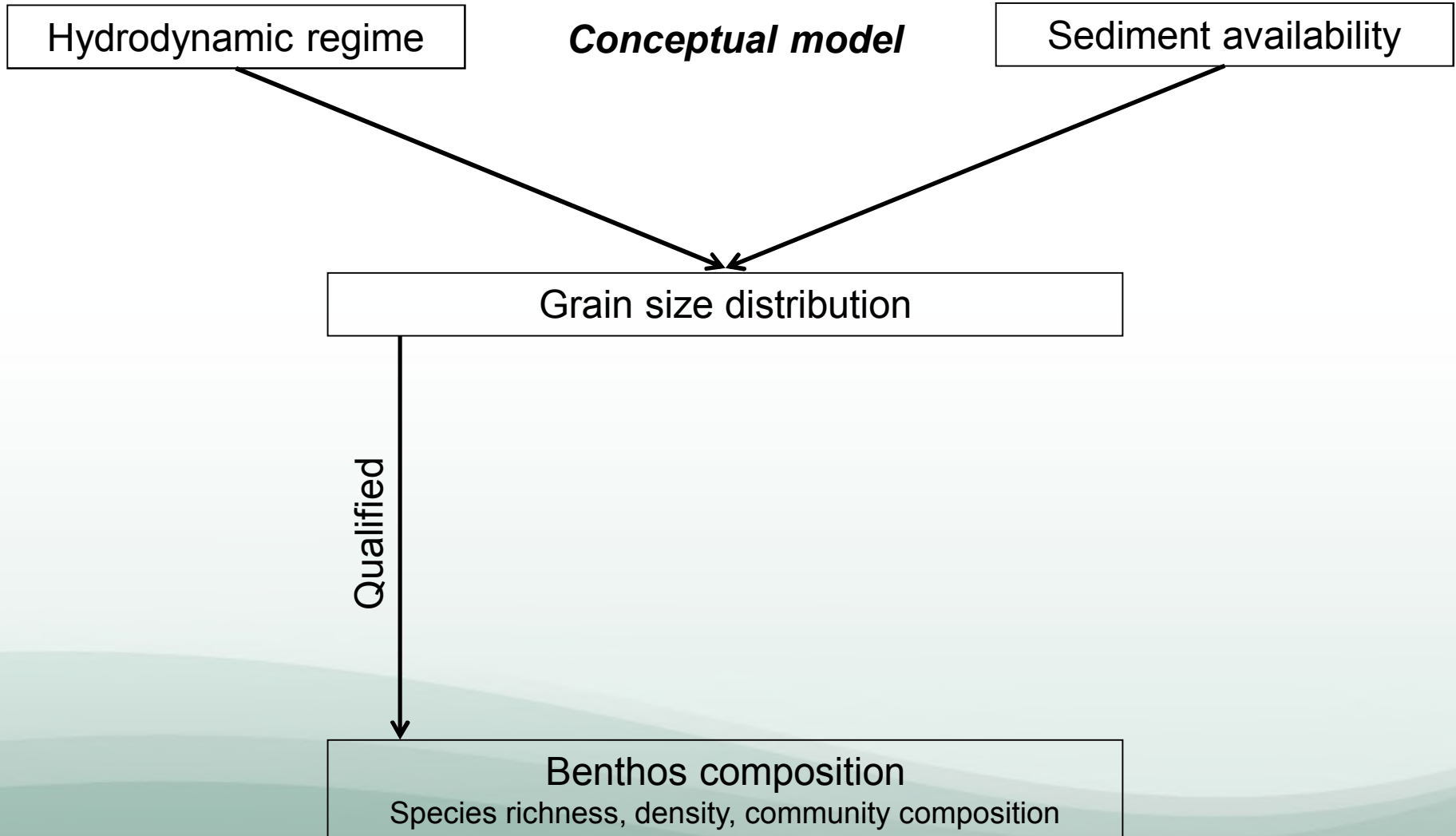
Benthos is numerous and can be found (nearly) everywhere

- Habitat type
 - Soft sediment and hard substrate benthos
- Position
 - Infauna, epibenthos and hyperbenthos
- Size
 - Microbenthos, meiobenthos, macrobenthos,...
- Macro-infauna Belgian part of the North Sea
 - 400+ species
 - Polychaetes, bivalves, amphipods, decapods,...

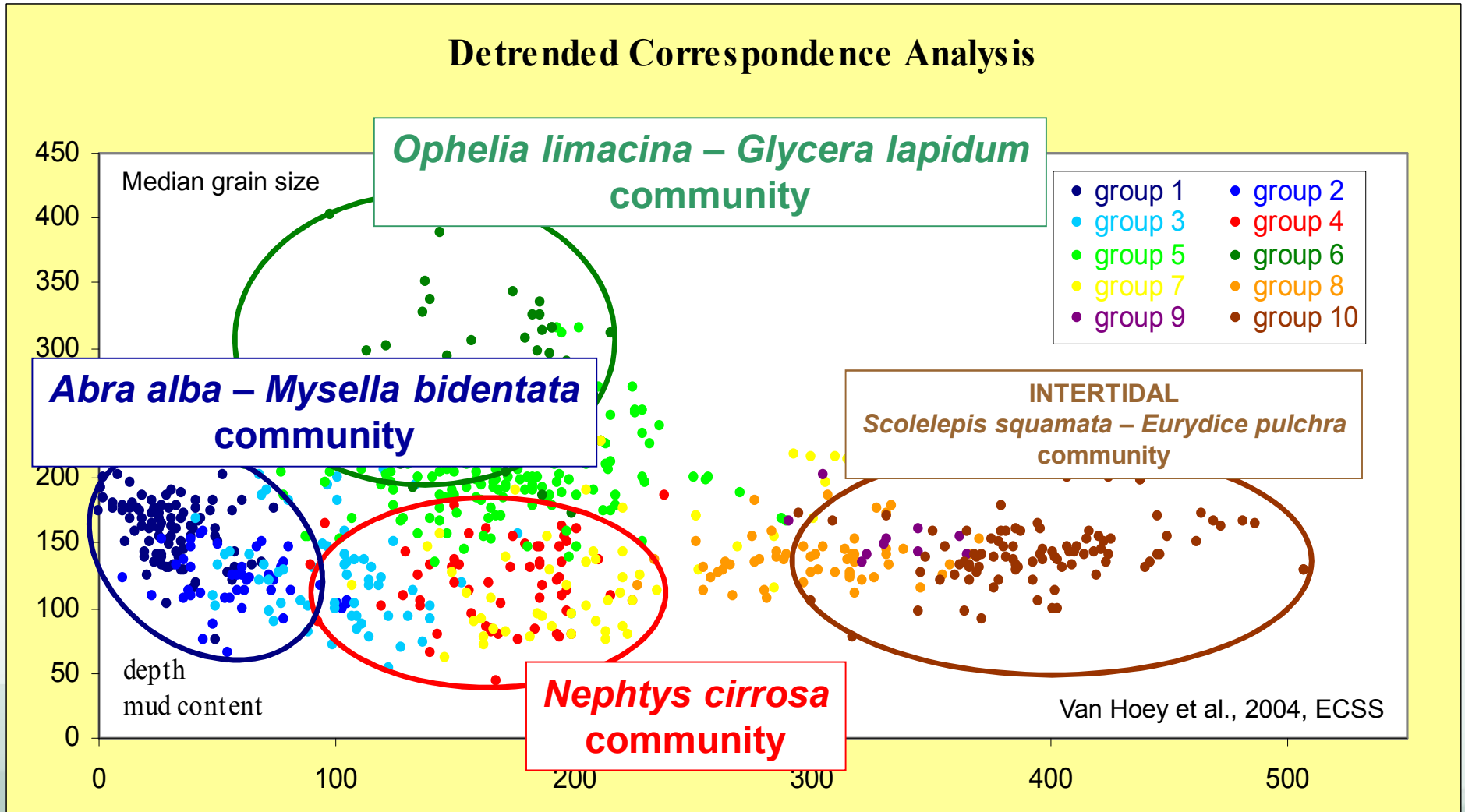
Mariene ongewervelden van het Belgisch deel van de Noordzee
Invertébrés marins de la partie belge de la mer du Nord



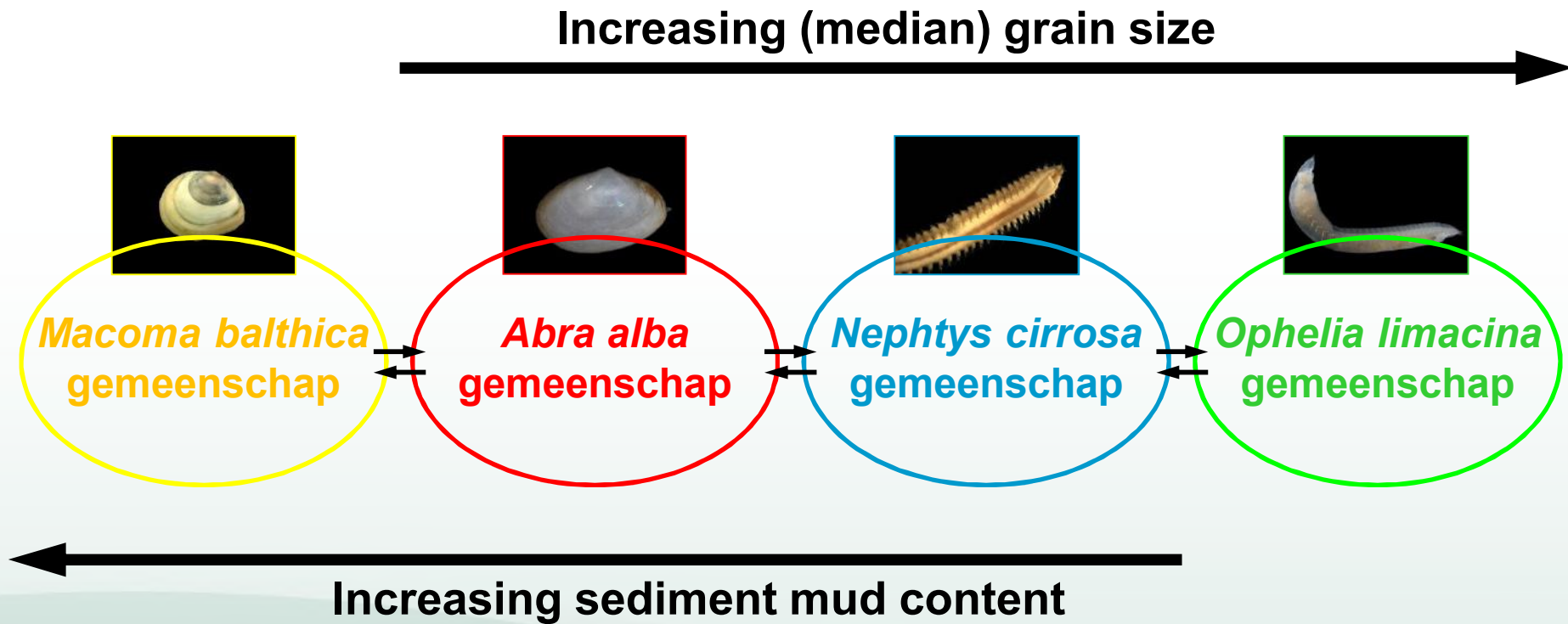
Sediment types and benthic communities



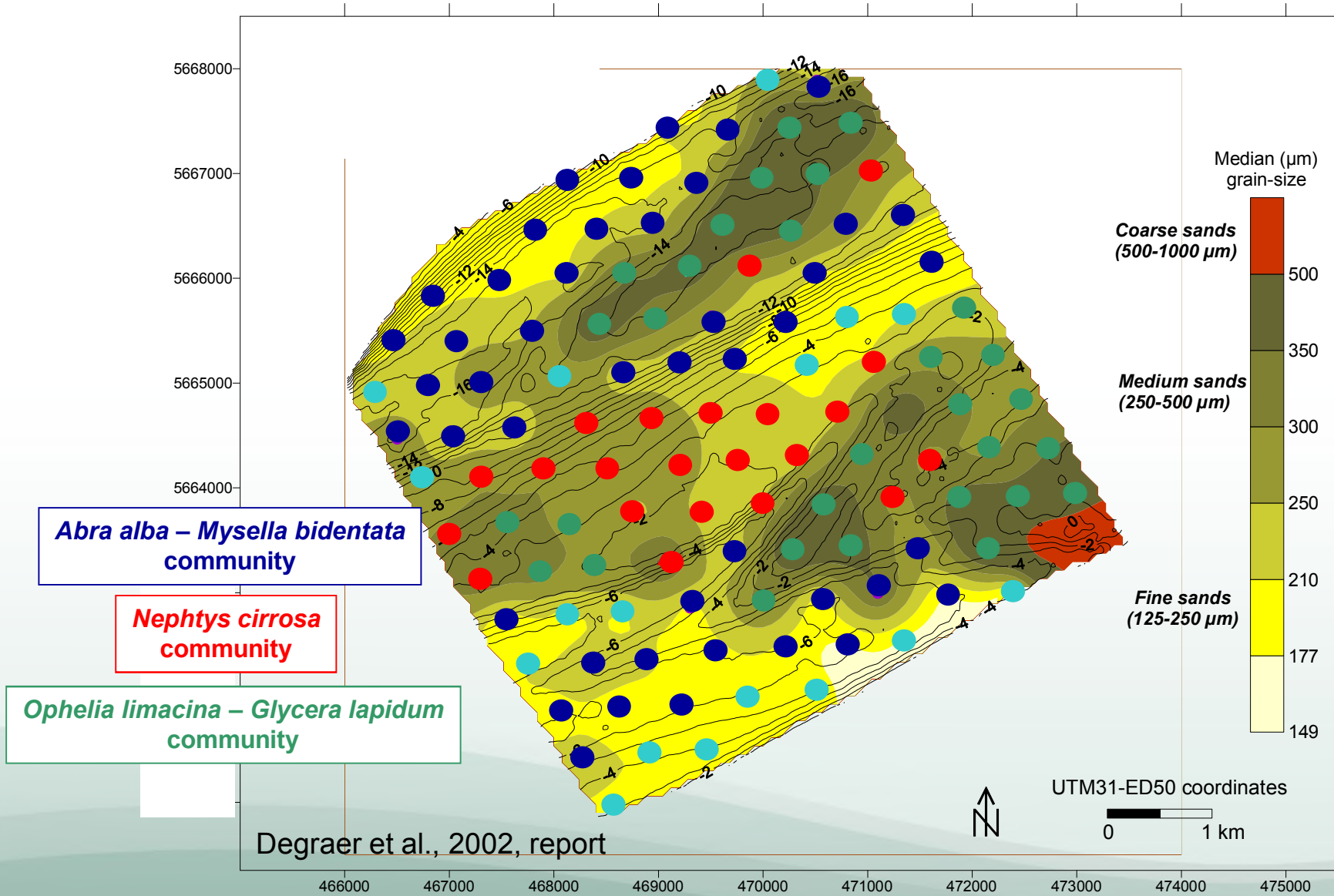
Sediment types and benthic communities



Sediment types and benthic communities

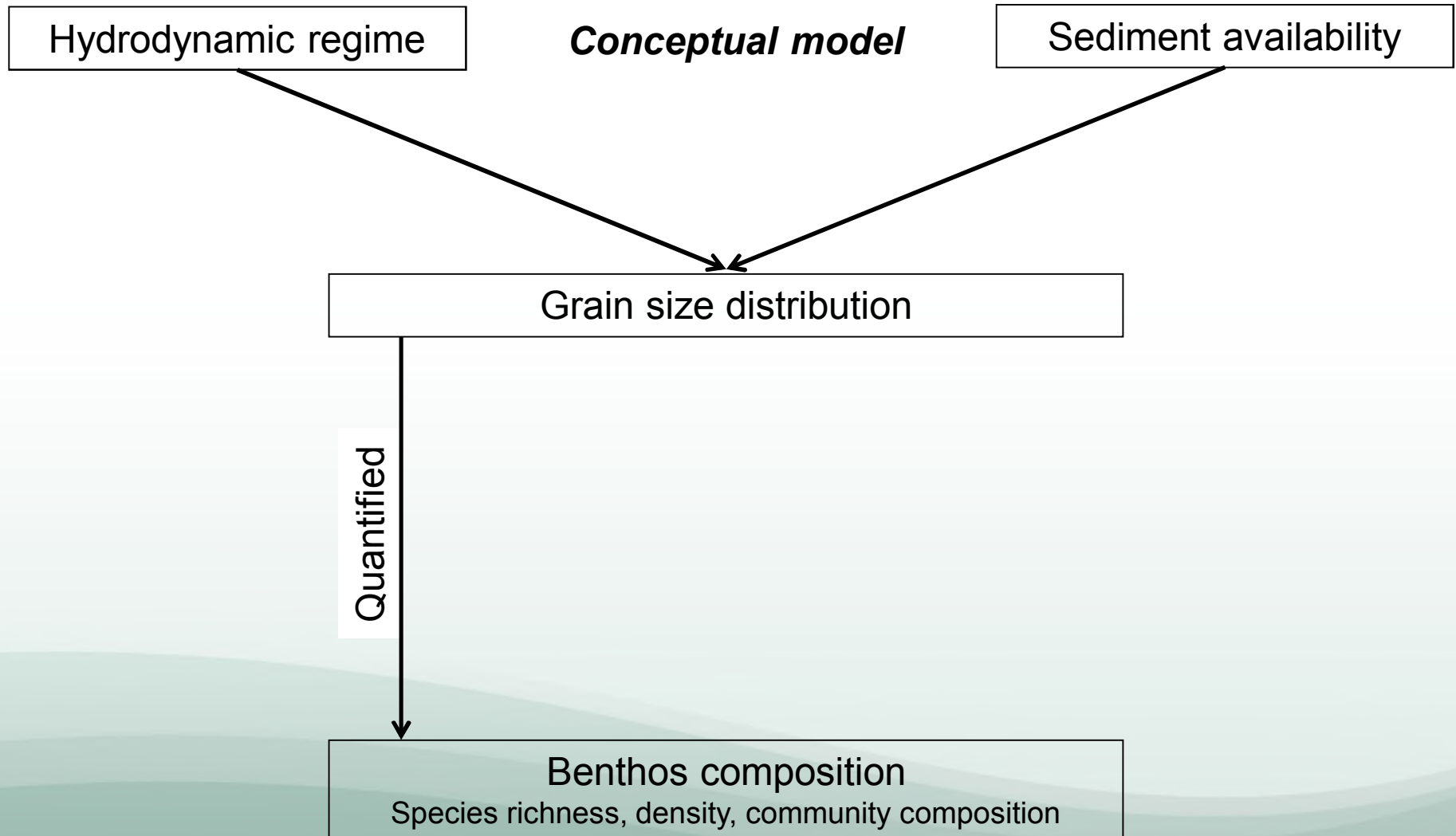


Sediment types and benthic communities



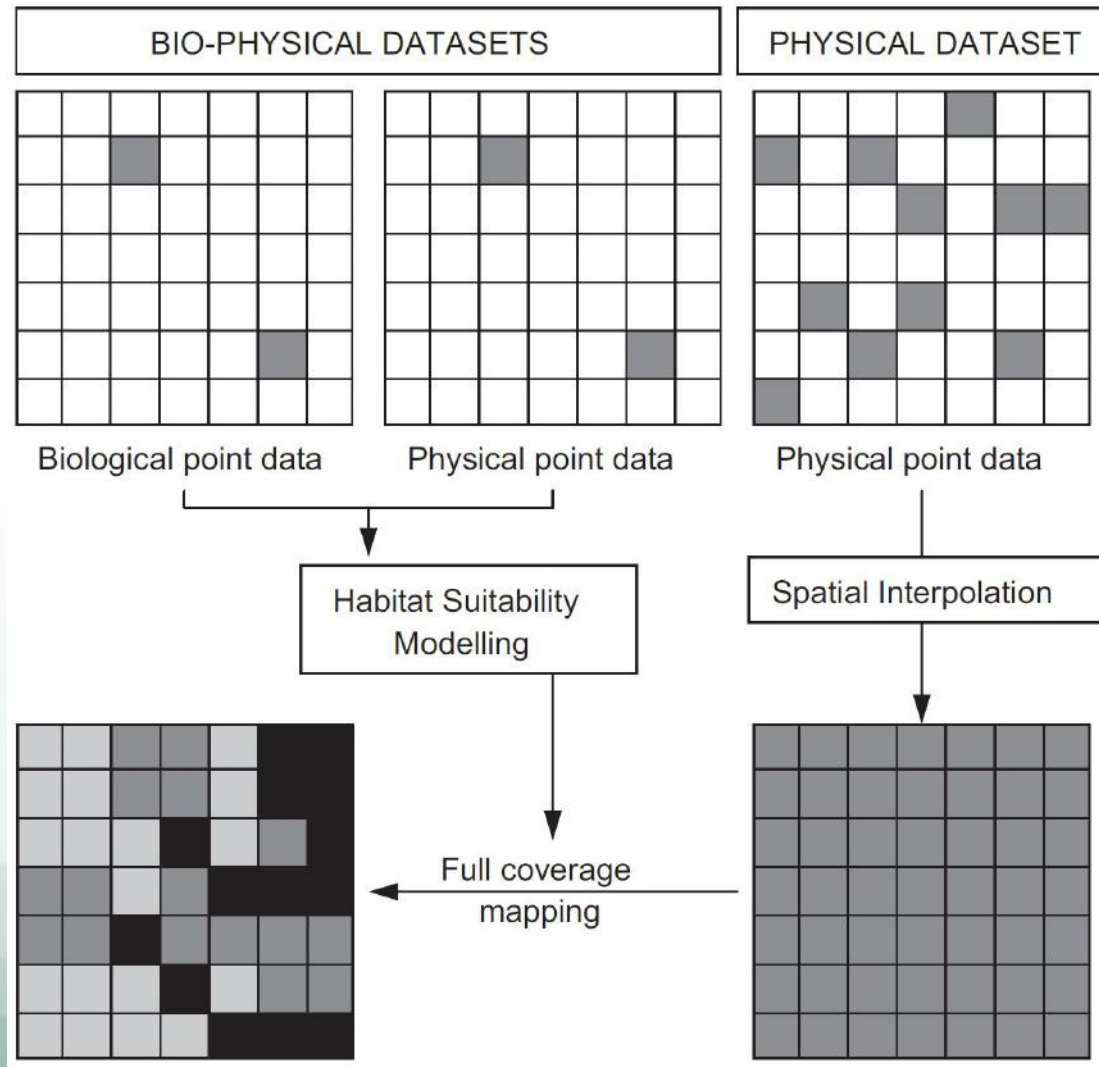
Sediment types and benthic communities

Habitat suitability modeling



Sediment types and benthic communities

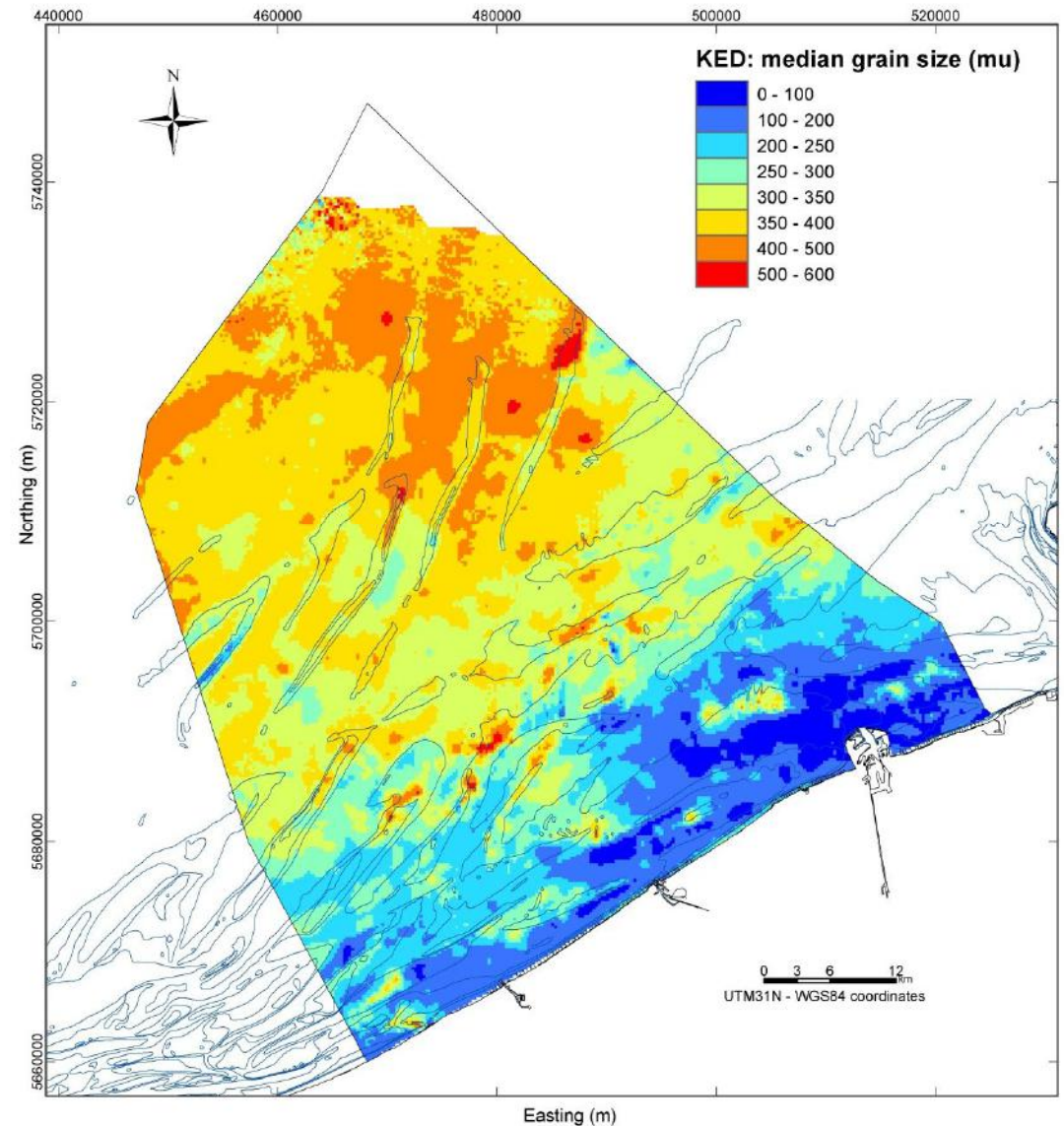
Habitat suitability modeling



Sediment types and benthic communities

Spatial interpolation of sediment distribution

- Belgian part of the North Sea
 - Muds, muddy sands, fine sands, medium sands, coarse sands to gravels
- High resolution maps of median grain size and mud content available



Sediment types and benthic communities

Habitat suitability modelling

Discriminant Function Analysis

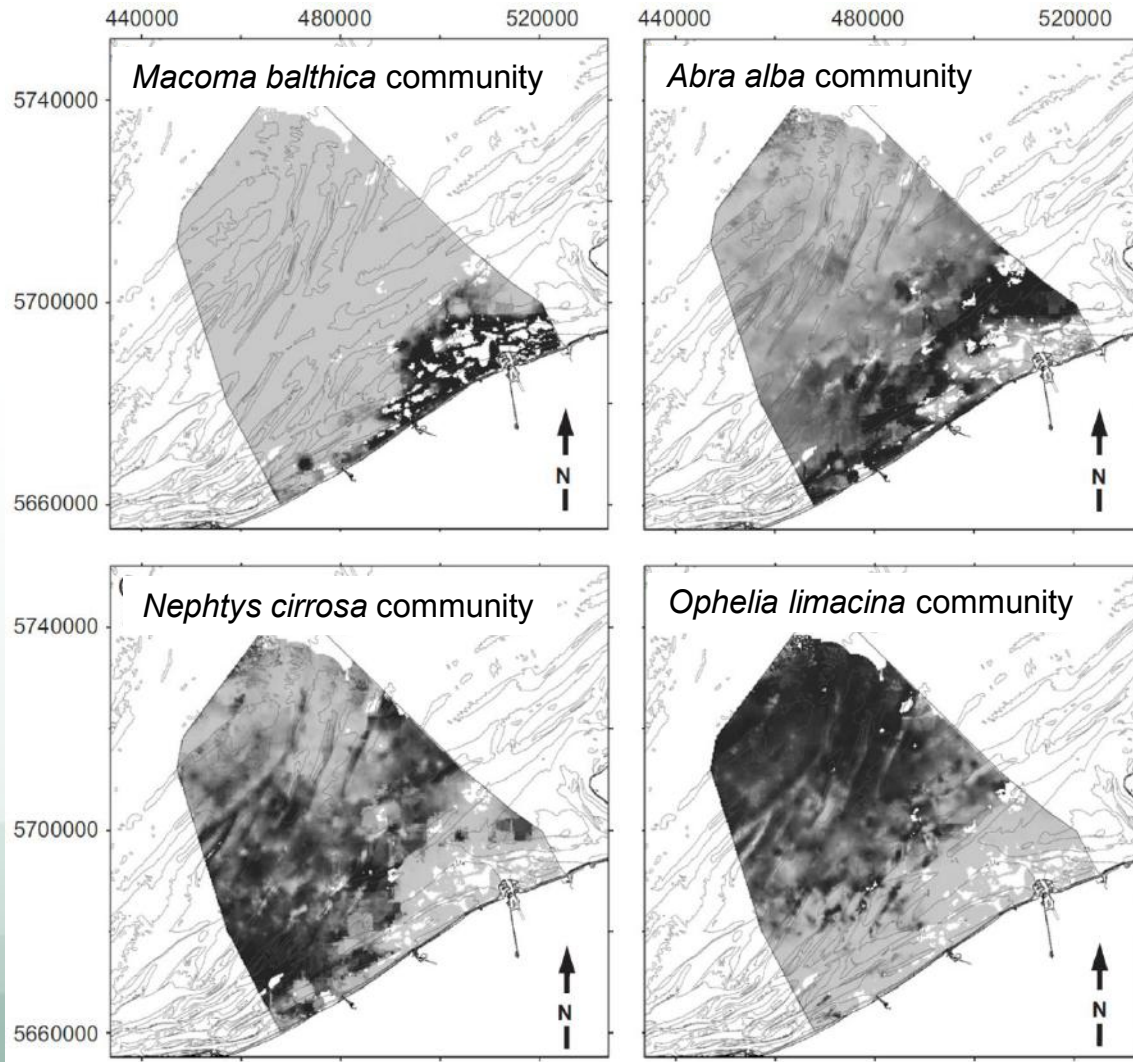
Community specific weights of all variables taken into the classification functions

	<i>Macoma balthica</i> community	<i>Abra alba</i> community	<i>Nephtys cirrosa</i> community	<i>Ophelia limacina</i> community
Median grain size	0.063	0.082	0.079	0.121
Log ₁₀ (mud content + 1)	17.685	13.421	7.541	11.457
Constant	-17.637	-15.716	-12.541	-27.323

Cases are classified to the community rendering the highest score, by applying $S_i = w_{i(\text{median grain size})} * (\text{median grain size}) + w_{i(\text{mud content})} * (\log_{10}(\text{mud content} + 1)) + \text{Constant}$, with $i = \text{community } i$.

Sediment types and benthic communities

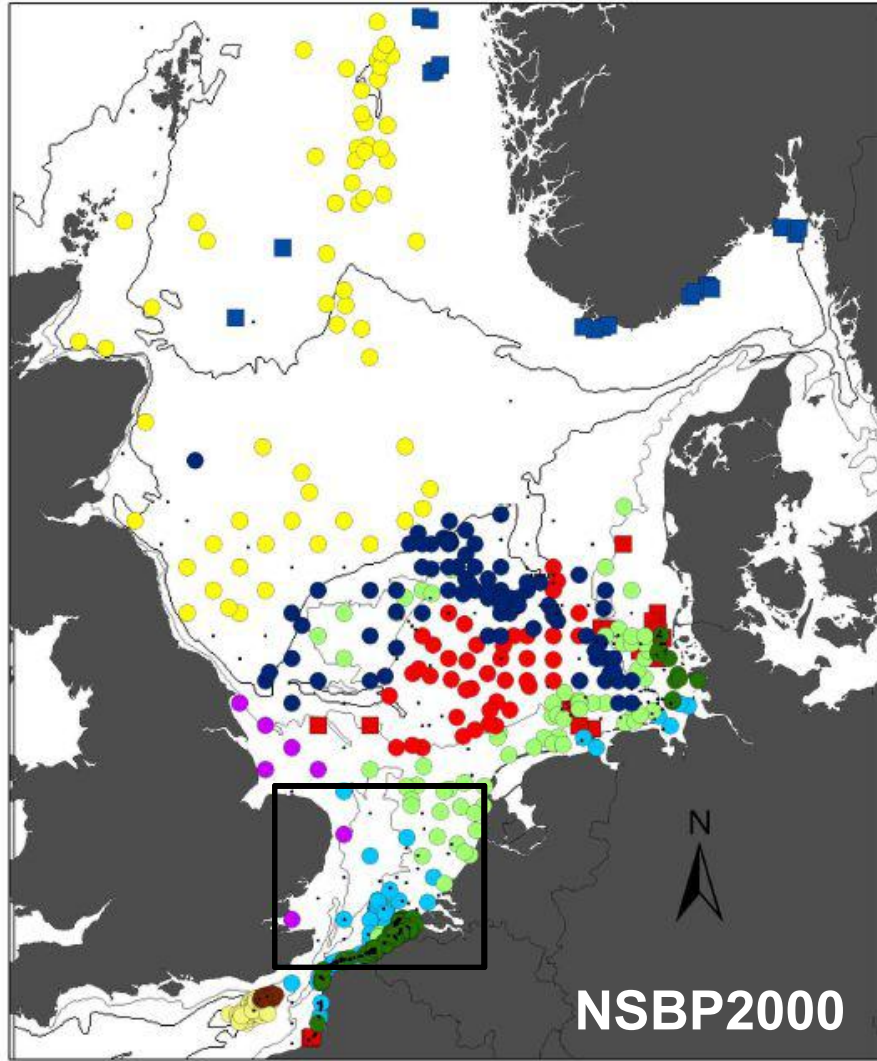
Habitat suitability mapping



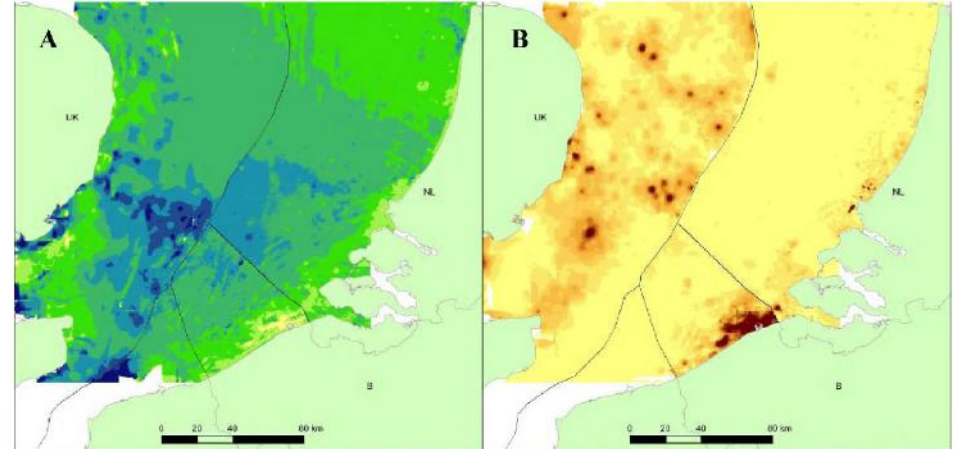
- Likelihood of occurrence
- Wider ecological relevance?
 - Reliable within domain, less reliable outside domain
 - Applicable to other ecosystem components?

Sediment types and benthic communities

Habitat suitability mapping outside model domain



Rees et al., 2007, ICES CRR

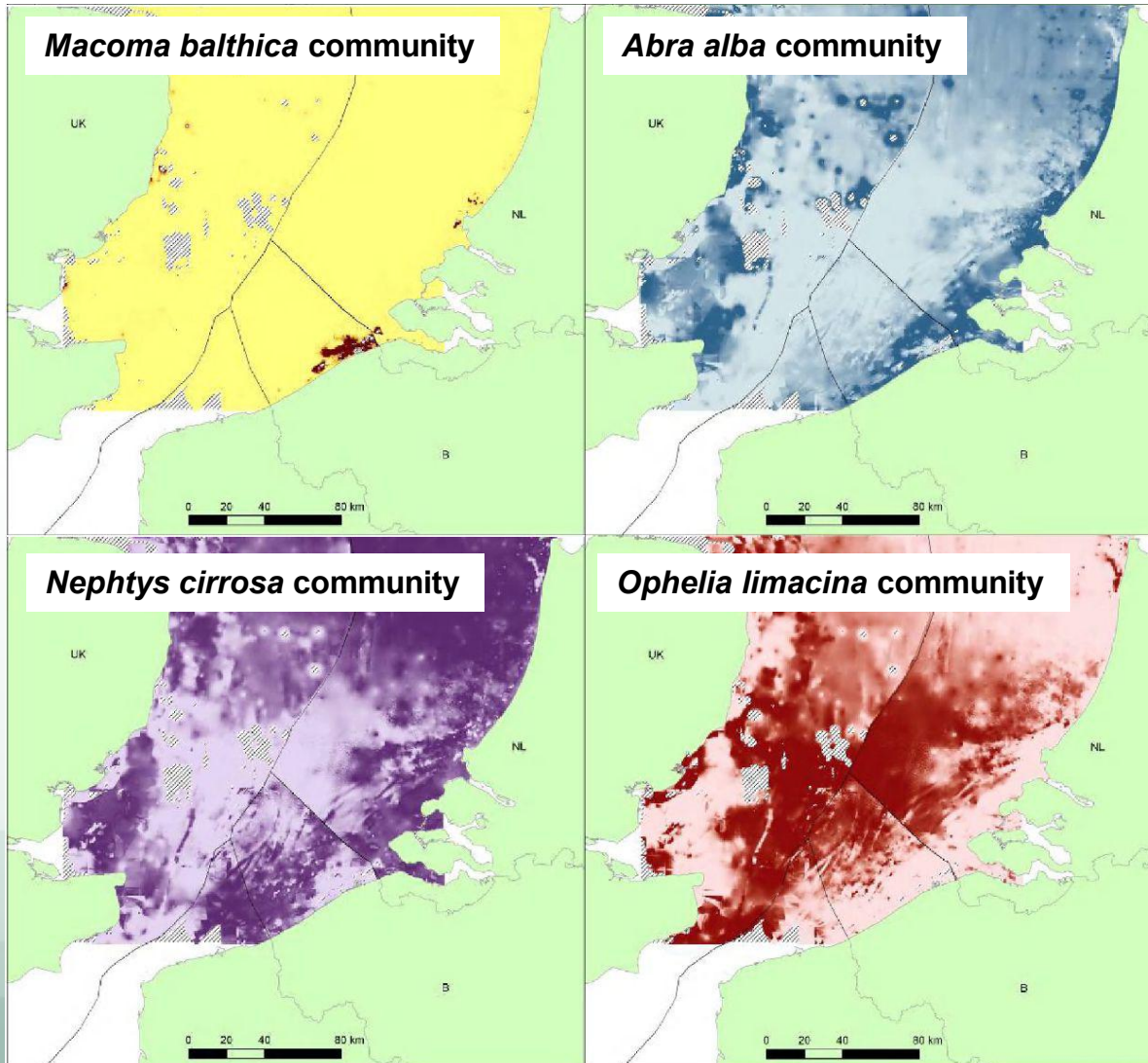


Verfaillie et al., 2006, PhD thesis

- High resolution maps
 - Median grain size
 - Mud content
- Similar macrobenthic communities in Southern Bight

Sediment types and benthic communities

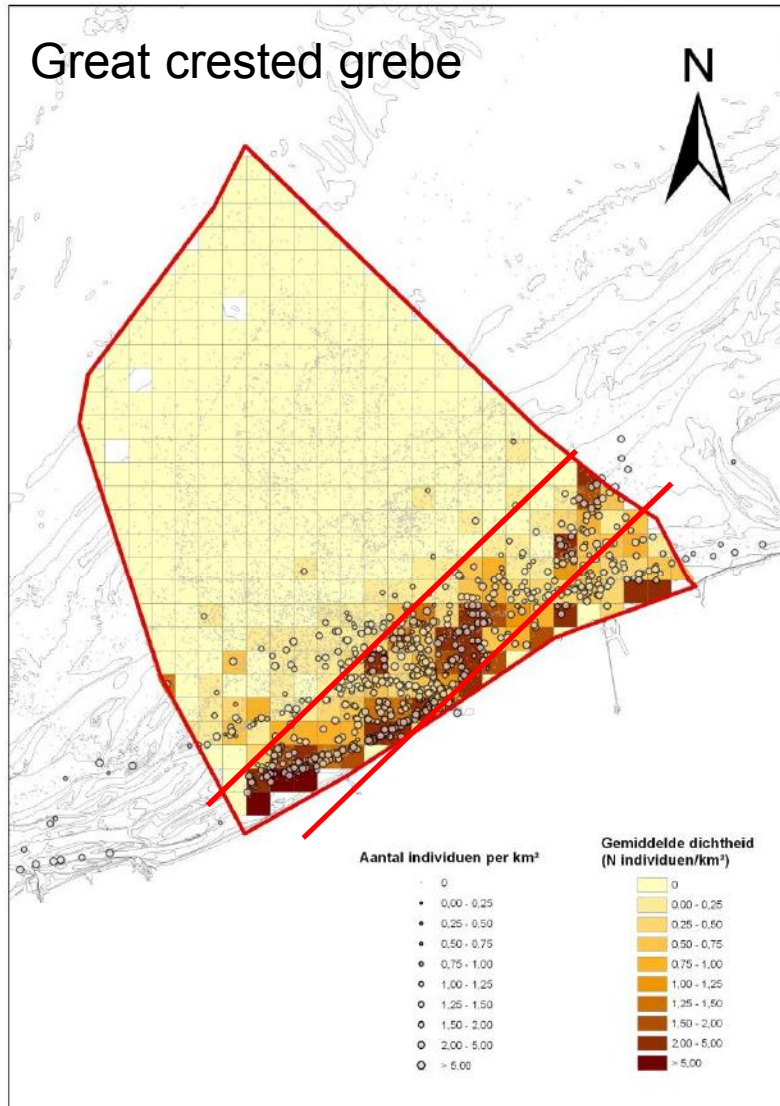
Habitat suitability mapping outside model domain



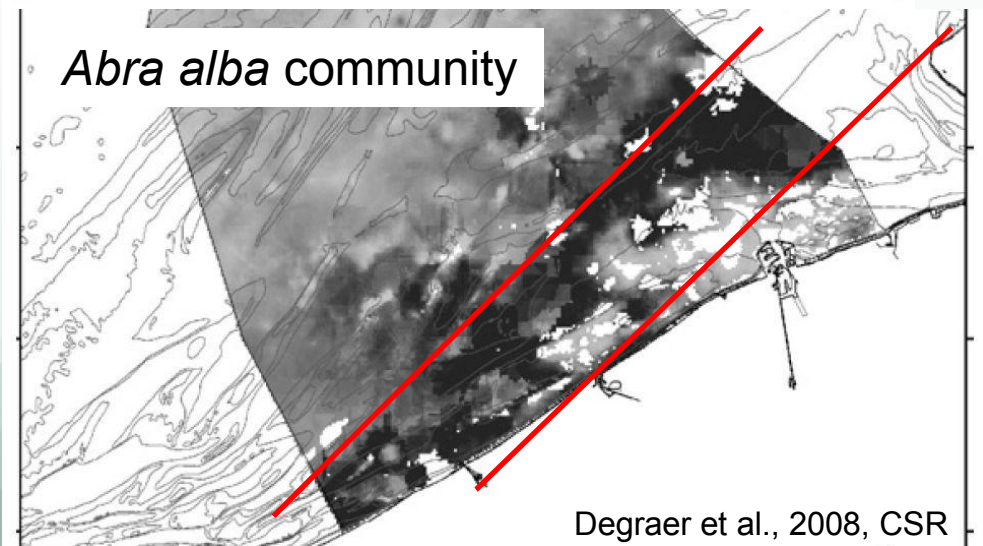
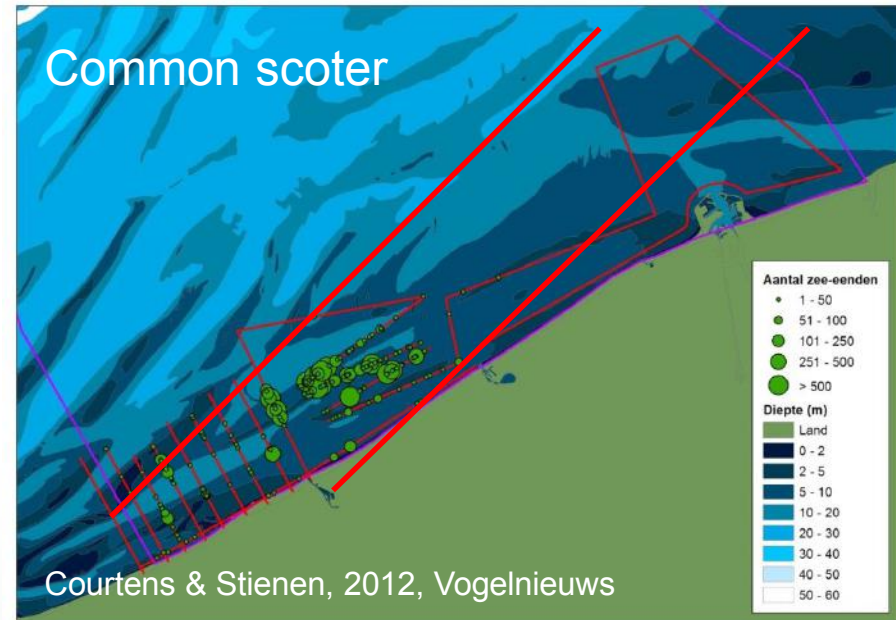
- Promising, yet with cross-border inconsistencies

Sediment-based habitat suitability

Also relevant for higher trophic level organisms?

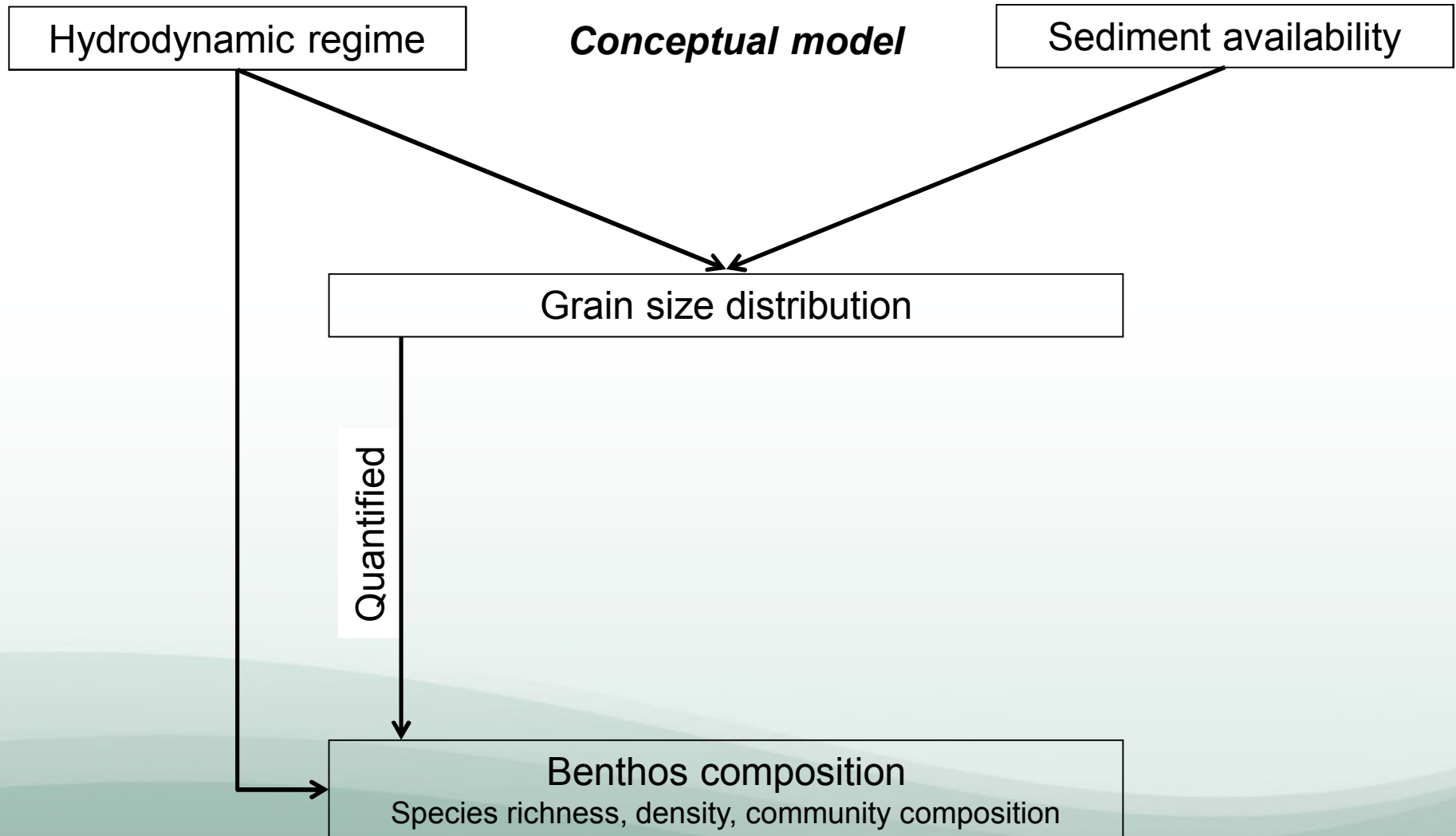


Degraer et al., 2010, report



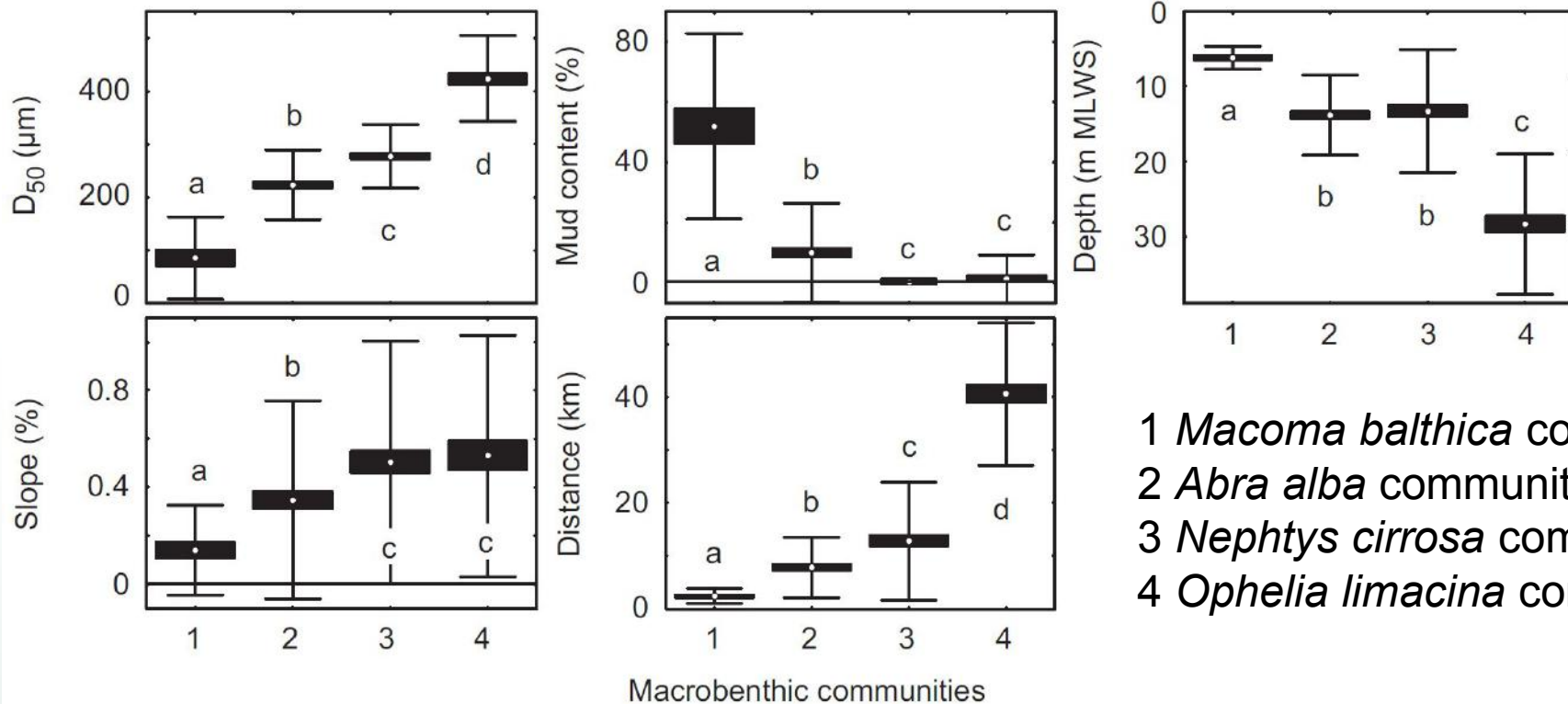
Habitat suitability

Not only sediments matter



Habitat suitability

Not only sediments matter

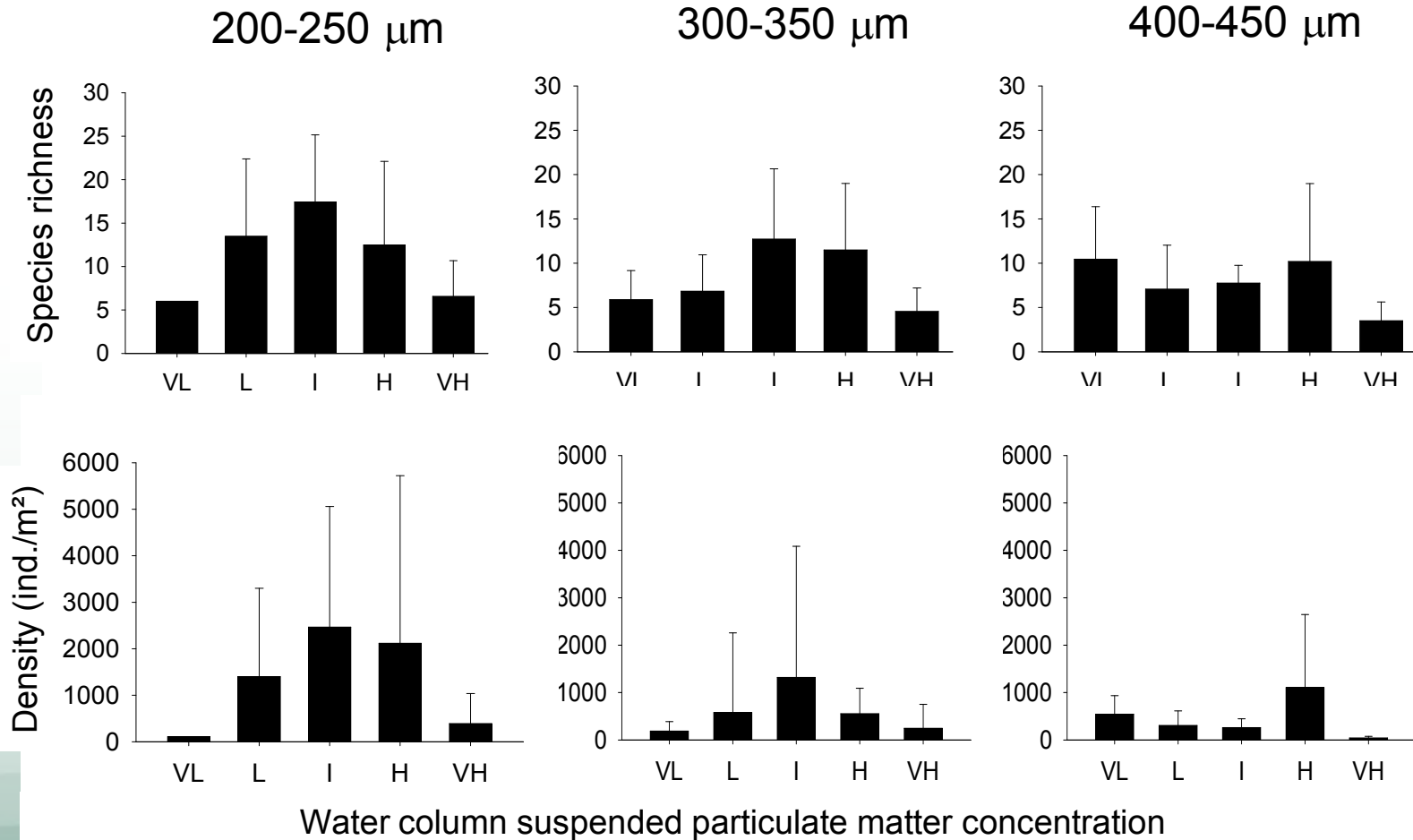


- 1 *Macoma balthica* community
- 2 *Abra alba* community
- 3 *Nephtys cirrosa* community
- 4 *Ophelia limacina* community

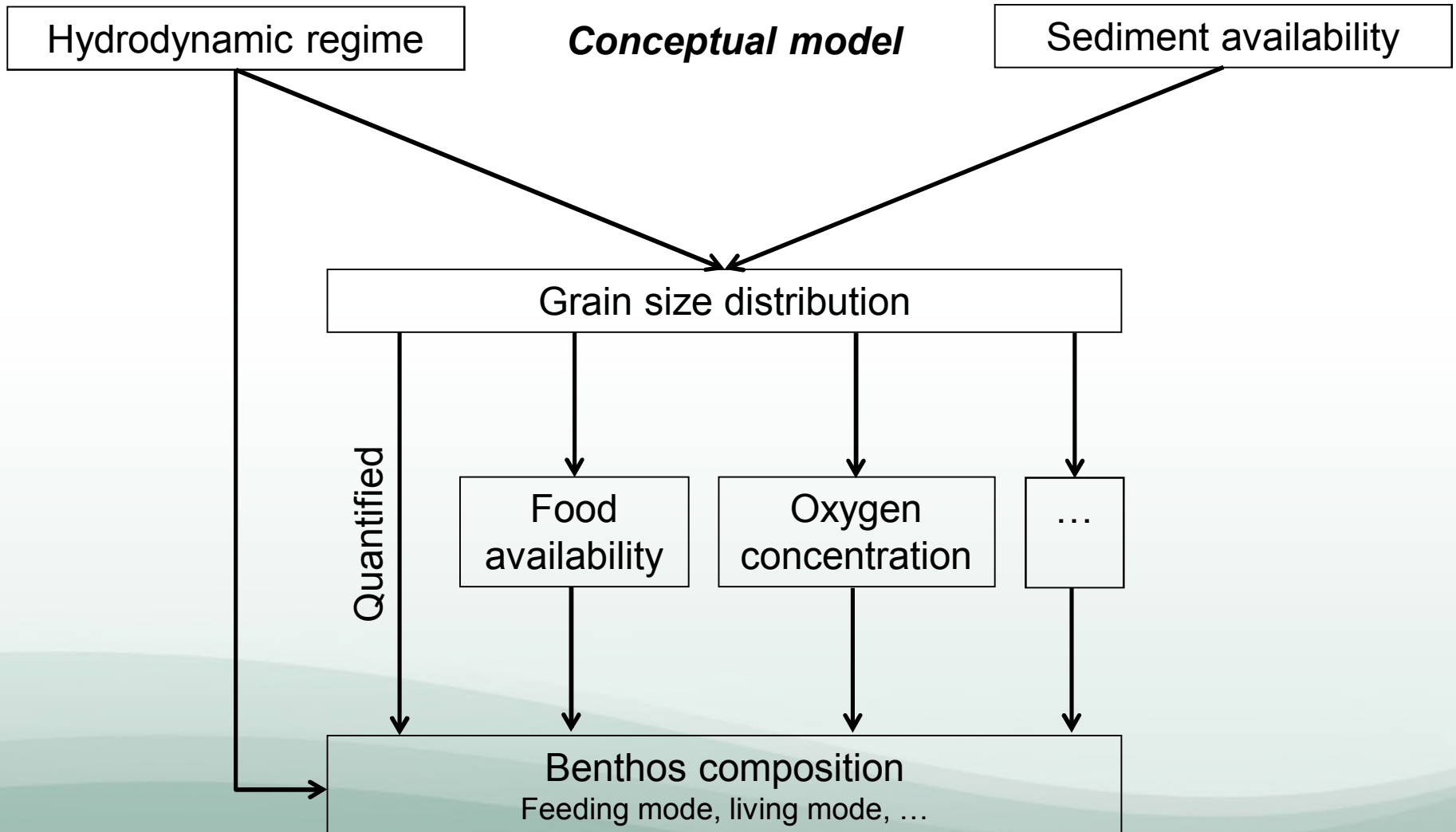
Habitat suitability

Not only sediments matter

Median grain size categories



Sediment-benthos correlations \neq cause-effect relationships



Correlation is not causation



Habitat needs determined by

- Substrate needs
- Oxygen needs
- Food needs

Example environmental drivers

- Grain size distribution
- Sediment oxygenation
- Organic matter concentration

Example traits

- Burrowing mode
- Breathing mode
- Feeding mode

Correlation is not causation

Example: burrowing mode

Echinocardium cordatum



Bulldozing does not work in muds.

Example: breathing mode



Lanice conchilega

Pumping down oxygen-rich surface water supplies the organism with oxygen in an oxygen-poor environment.

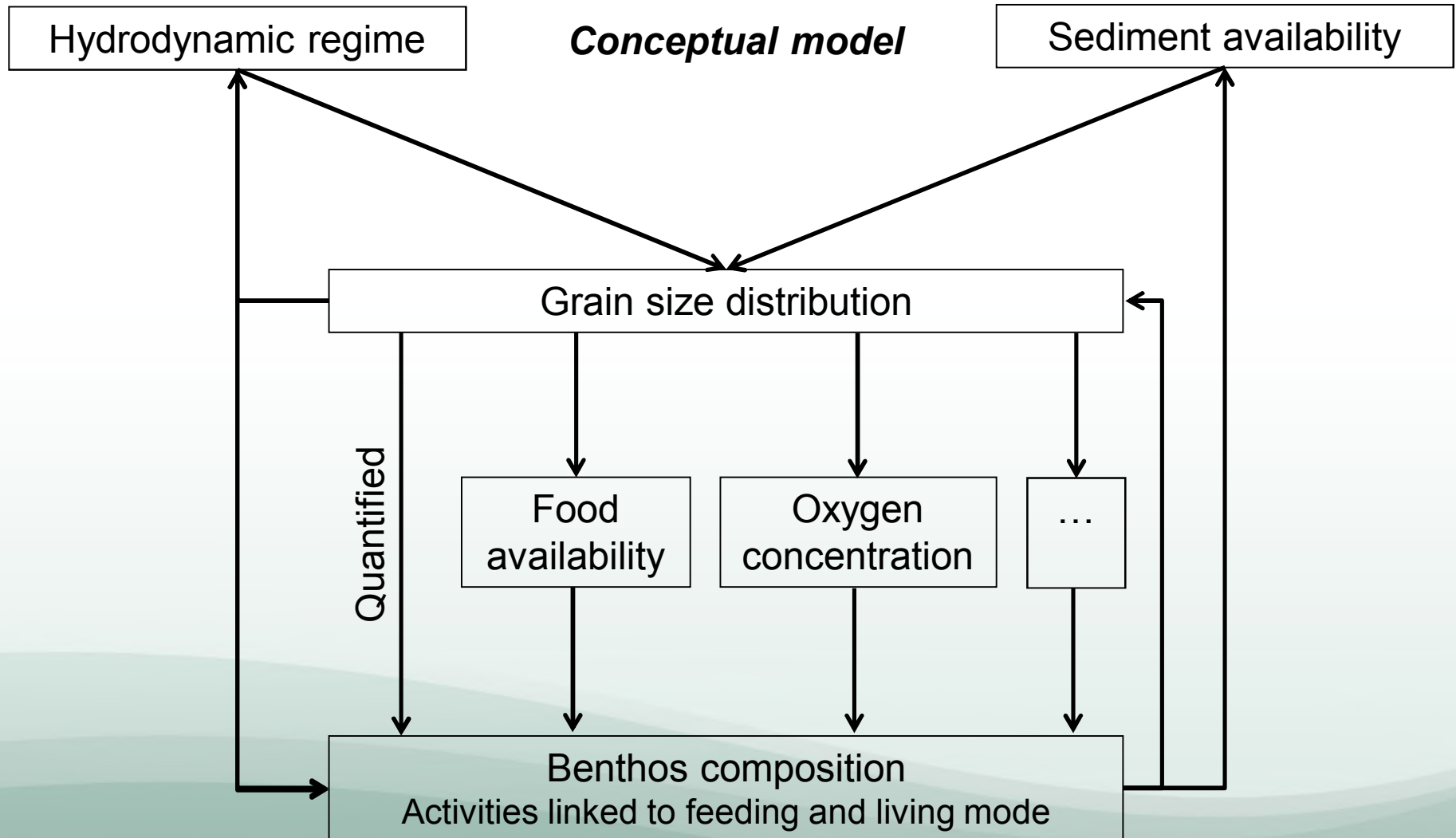
Example: feeding mode

Arenicola marina

Deposit feeding only possible in areas where organic matter and hence fines are being deposited.

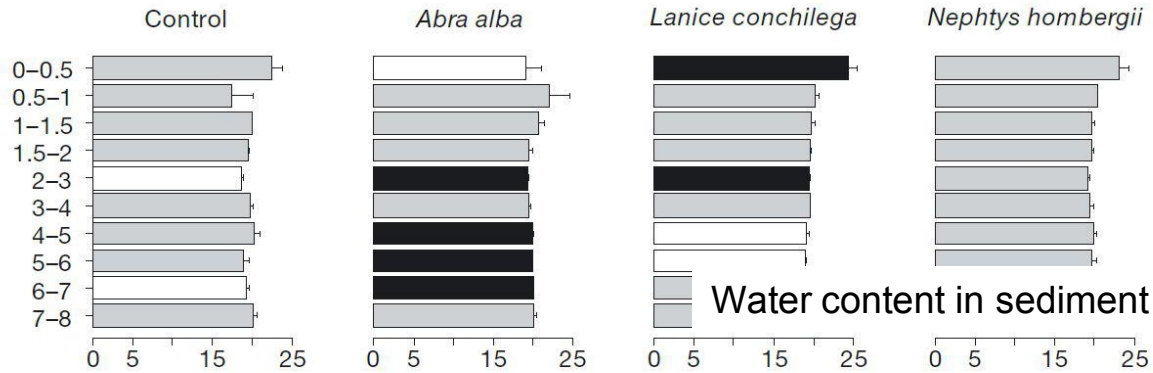
Sediment-benthos relation feedback loops

Benthos impacts sediments

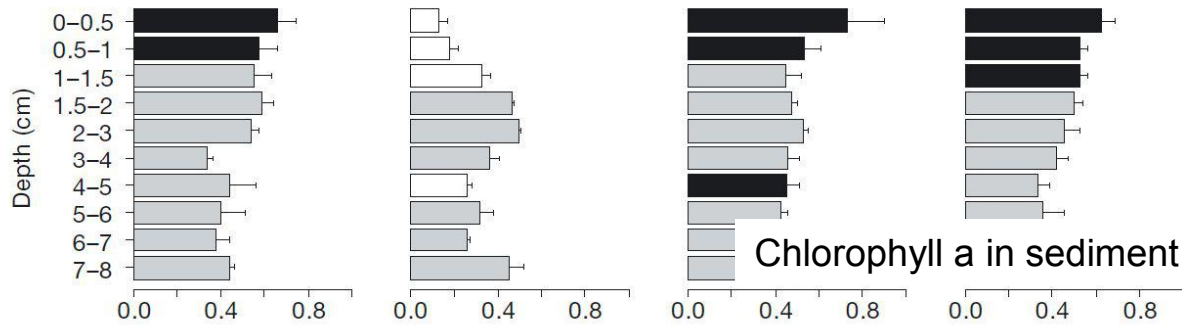


Sediment-benthos relation feedback loops

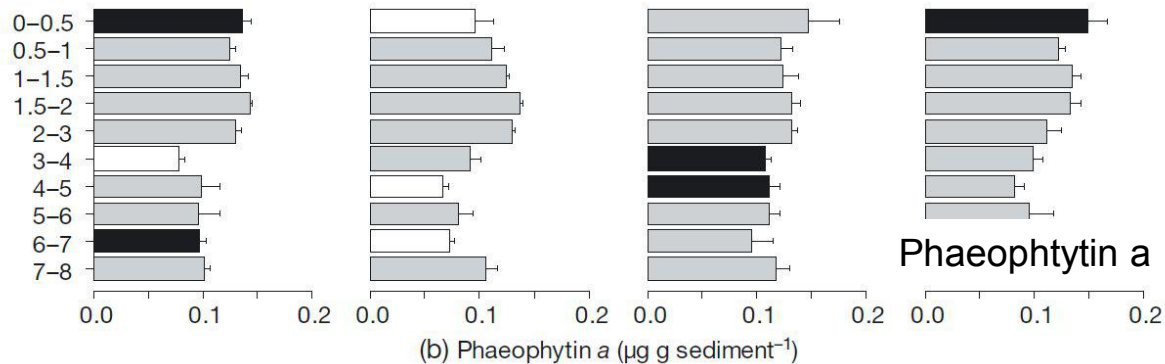
Benthos activities impact sediments



(a) Water content (%) of the sediment



(b) Chlorophyll a ($\mu\text{g g sediment}^{-1}$)



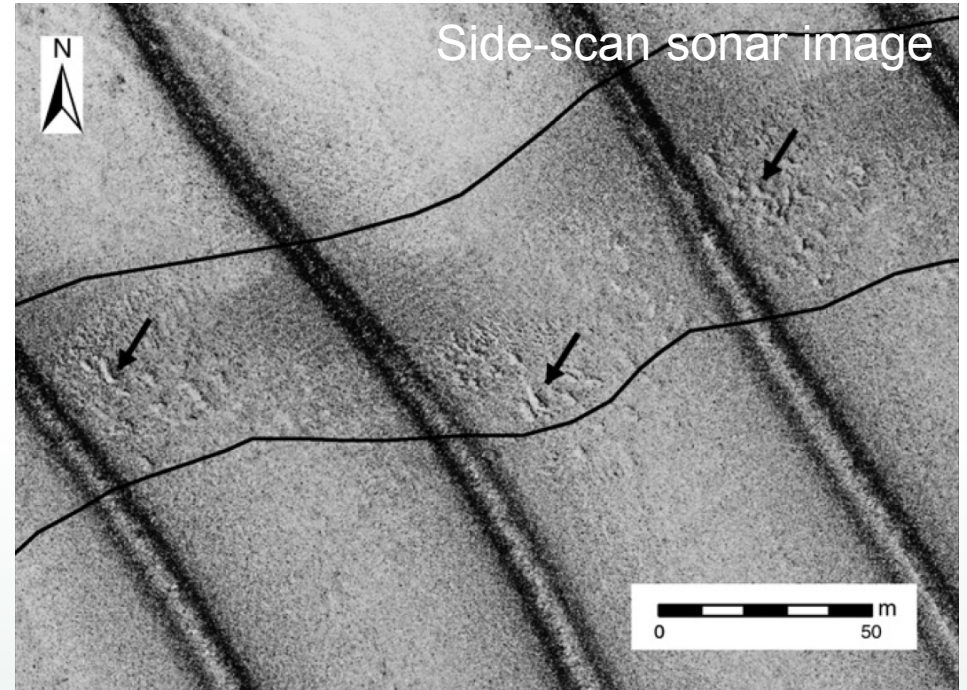
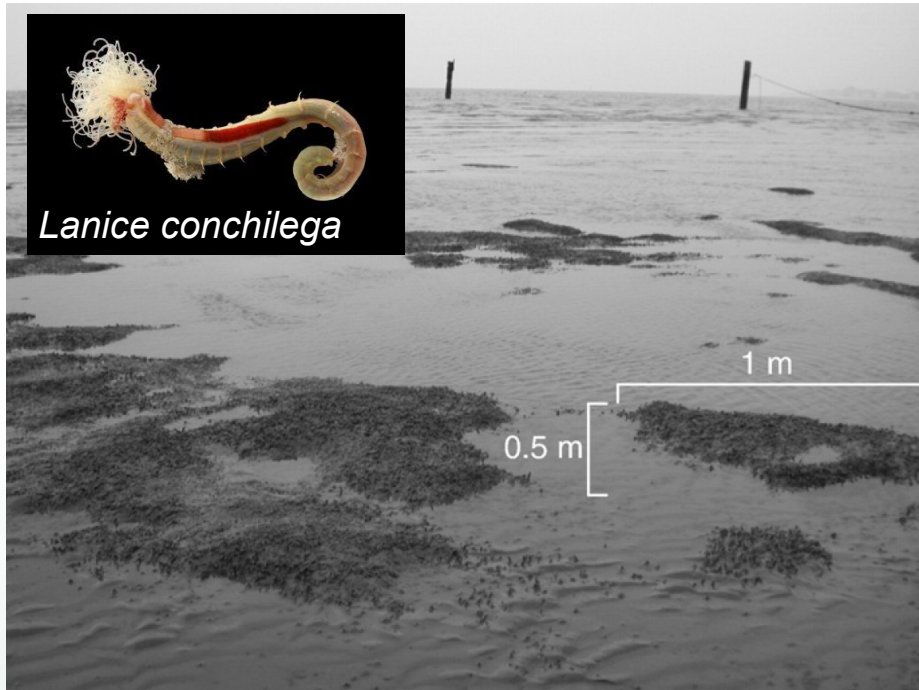
(b) Phaeophytin a ($\mu\text{g g sediment}^{-1}$)



- Surface deposit feeding
 - *Abra alba*
- Bio-irrigation
(~ sediment “flushing”)
 - *Lanice conchilega*
- Bioturbation
(~ sediment reworking)
 - *Nephtys hombergii*

Sediment-benthos relation feedback loops

Benthos activities impact sediments and its morphology



- Locally elevated sediments
- Higher sediment compaction
- More fines inside aggregations

Take home messages

1. Benthos is abundant and can be found (nearly) everywhere.
2. Specific sediment types host specific benthic communities.
3. The sediment-benthos relationship can be used to predict what benthic fauna (and other fauna) to occur where.
4. Not only sediments drive benthos distribution patterns.
5. Sediment-benthos correlations do not equal cause-effect relationships.
6. On its turn, benthos activities impacts sediments.



A dense collection of various marine organisms, including crabs, starfish, mollusks, and worms, arranged on a black background. The organisms are diverse in color and shape, ranging from small, translucent larvae to larger, more complex creatures like crabs and starfish. The word "QUESTIONS?" is overlaid in large, white, bold, sans-serif capital letters in the center of the image.

QUESTIONS?