Sediment Connectivity and Exchange in Ameland Inlet

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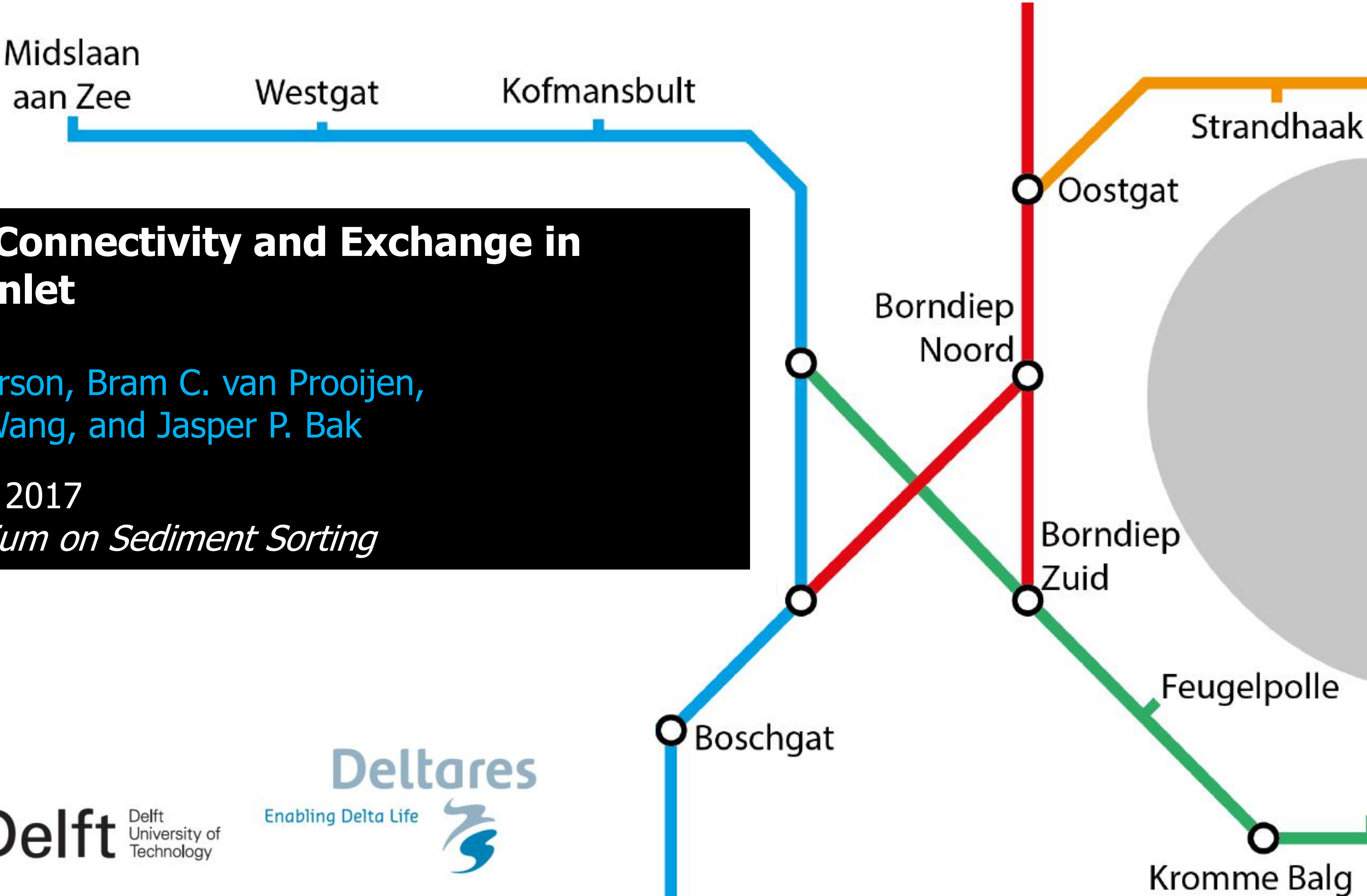

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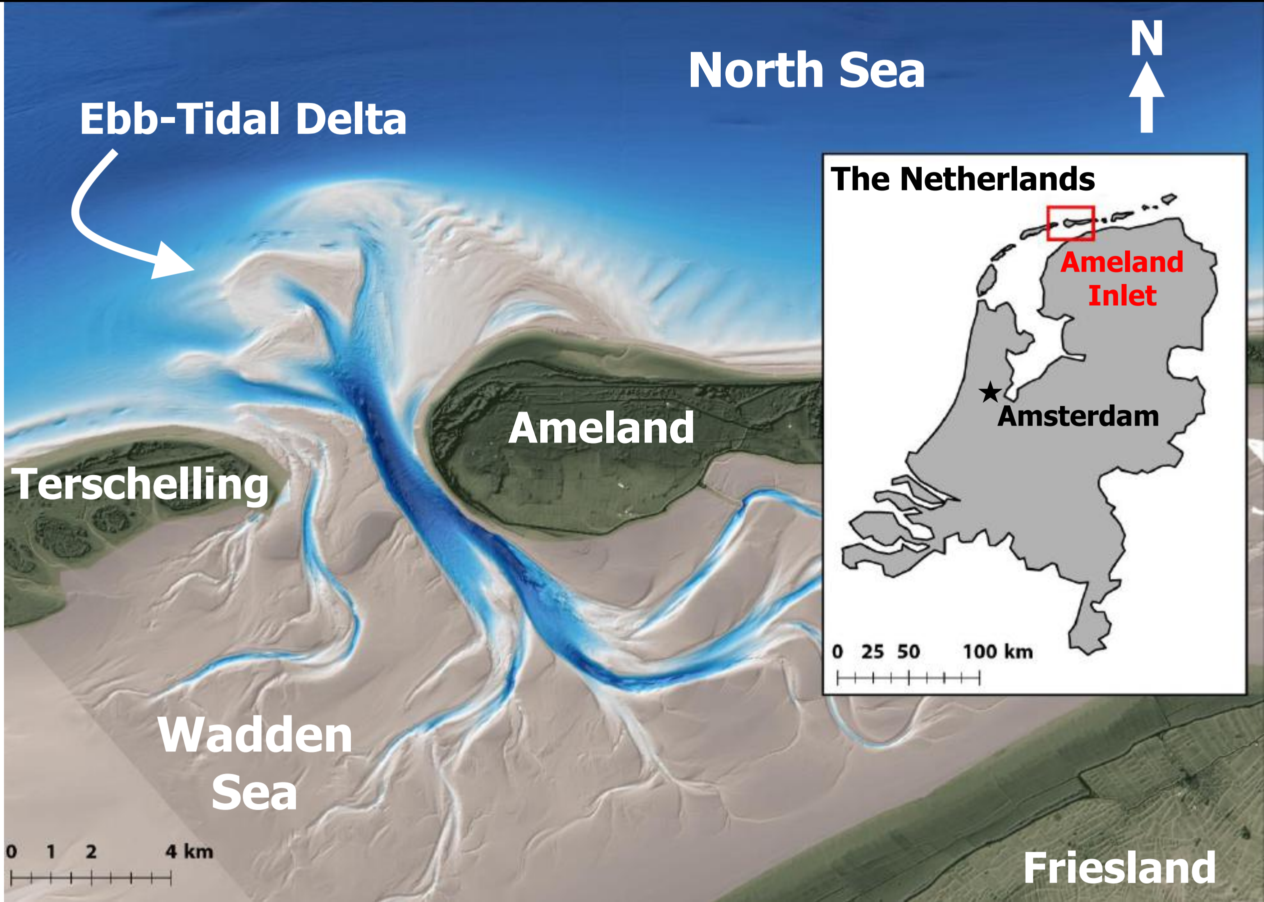
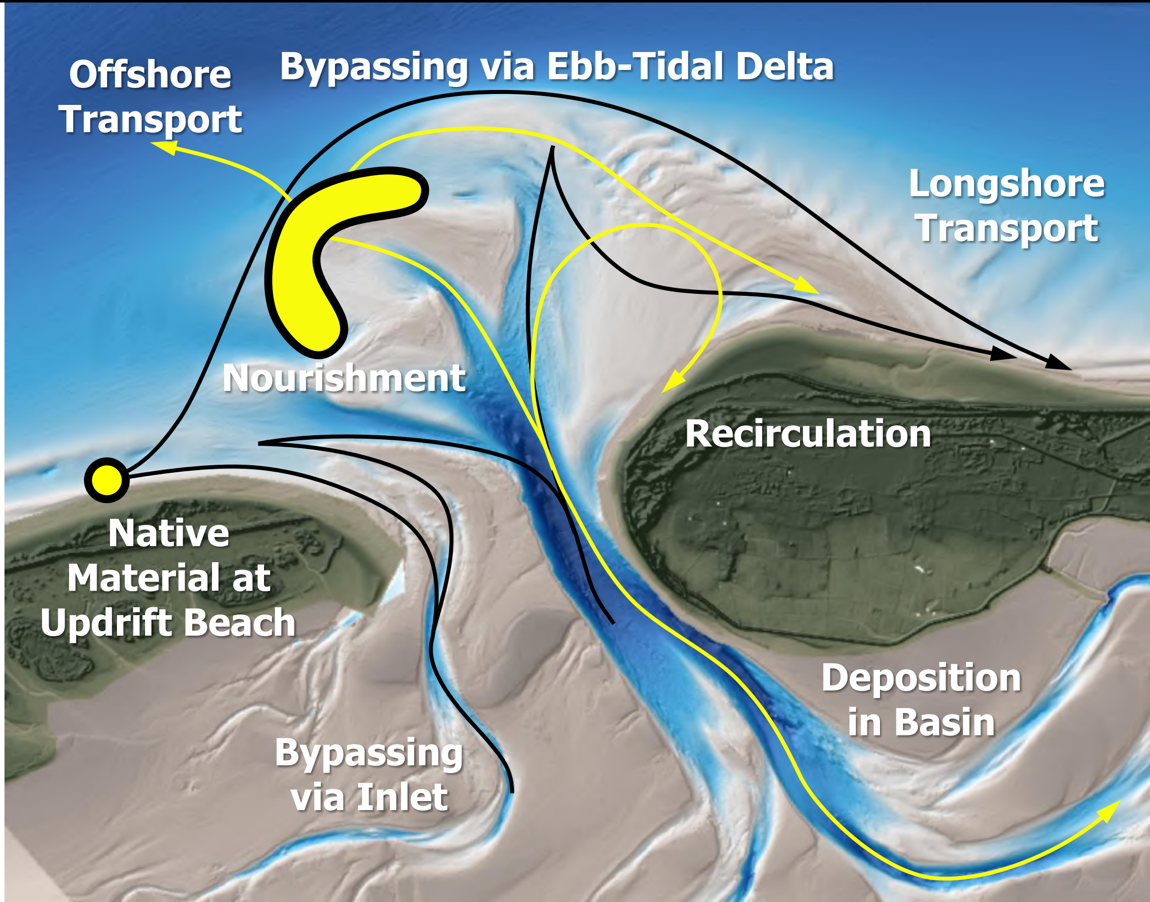
Study Site: Ameland Inlet (Netherlands)

- Flood safety and vital habitat depend on the fate of the Wadden Sea & Islands
  - Will tidal flats keep up with sea level rise?
  - Is Wadden Sea sed. getting coarser?
  - What effect do nourishments have?



Sediment Transport Pathways in Ameland Inlet

- How will the inlet respond to future changes?
- Fate depends on sediment transport pathways
- Pathways in turn depend on grain size, hydrodynamic forcing, morphology, and timescale



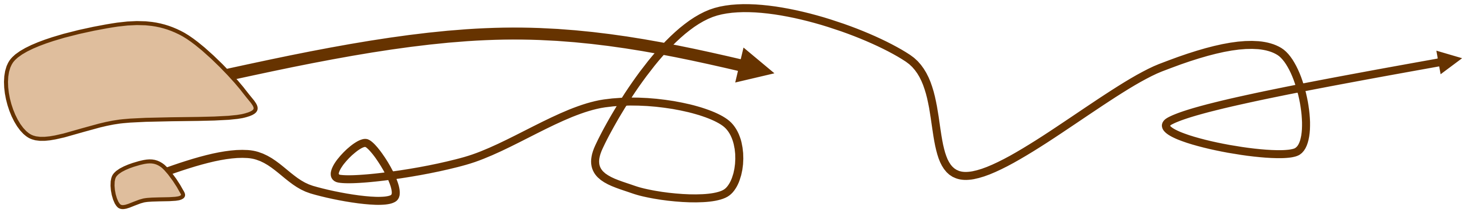
Sediment Connectivity

How do we define connectivity?

- The degree to which sediment can travel from point A to B
- Well-established concept in ecology, geomorphology, neurology

Potential applications

- Improve native system understanding
- Predict future scenarios (i.e. the fate of nourishments or sea level rise)
- Connect to benthic ecology



Interpreting Connectivity Using Graph Theory

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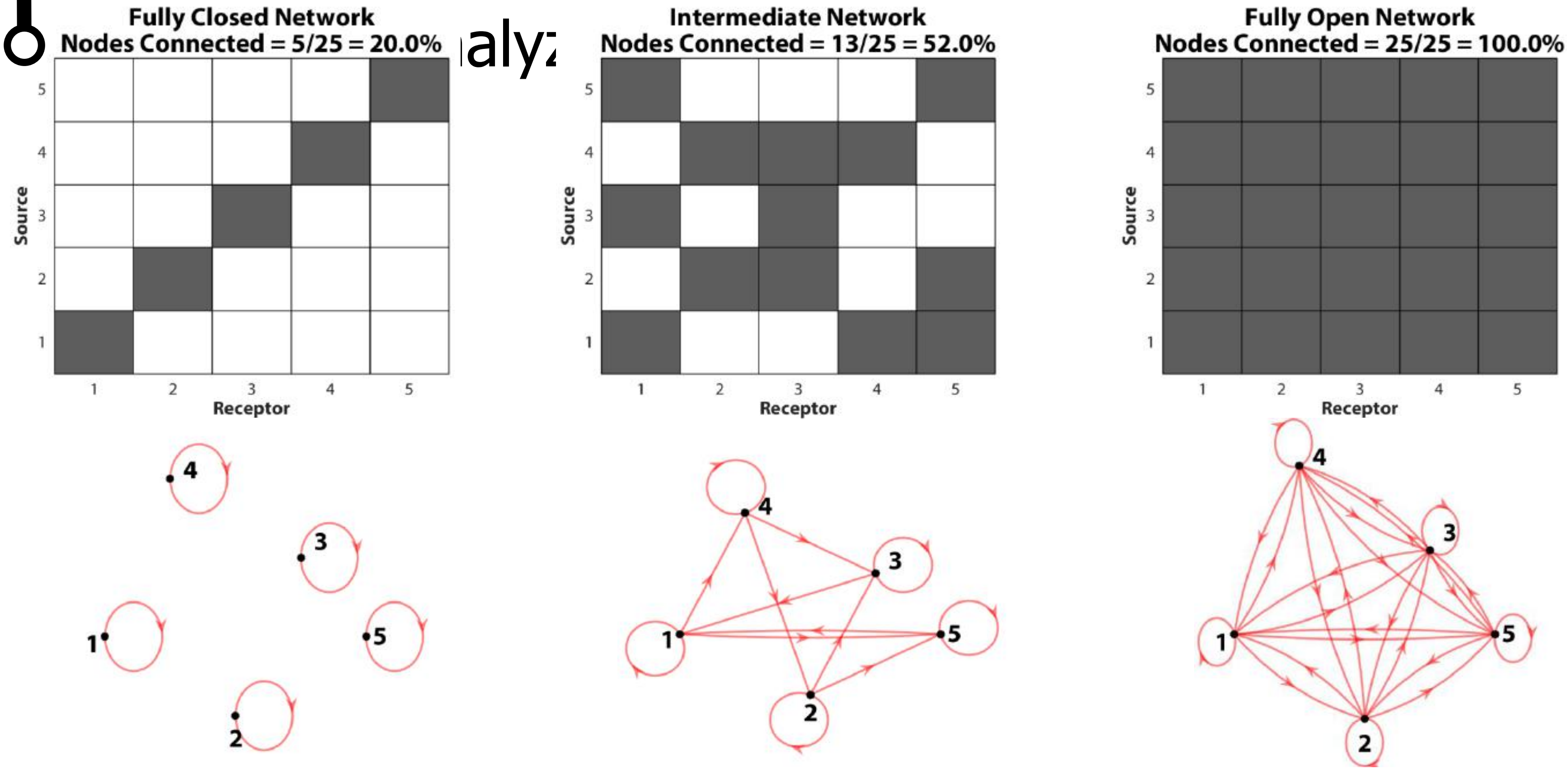
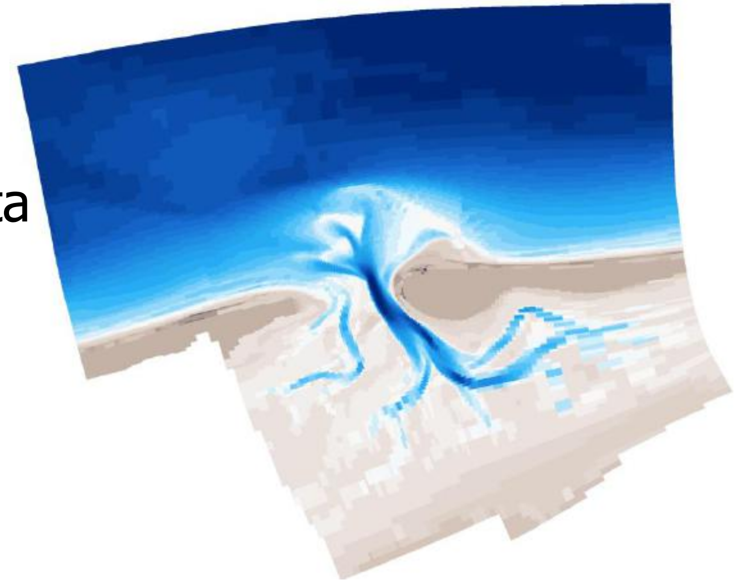


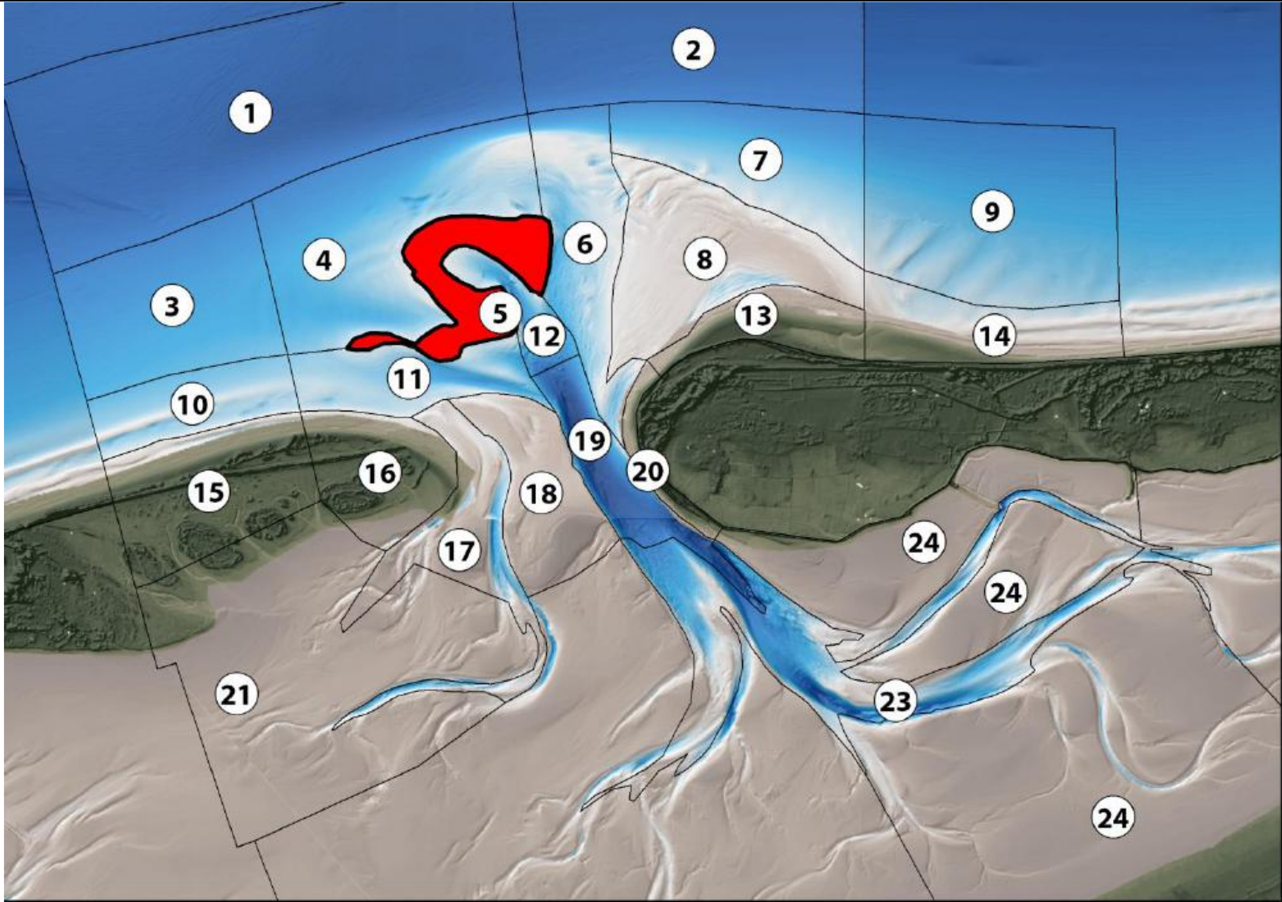
Morphodynamic Model Setup

- Delft3D morphodynamic model
  - 2D, schematized tidal forcing only
  - 40x30 km domain, highest resolution ≈ 80 m
  - 4 sediment classes
    - 100, 200, 300, 400 μm
    - Distributed according to measured data
  - 1.5 year morphological time



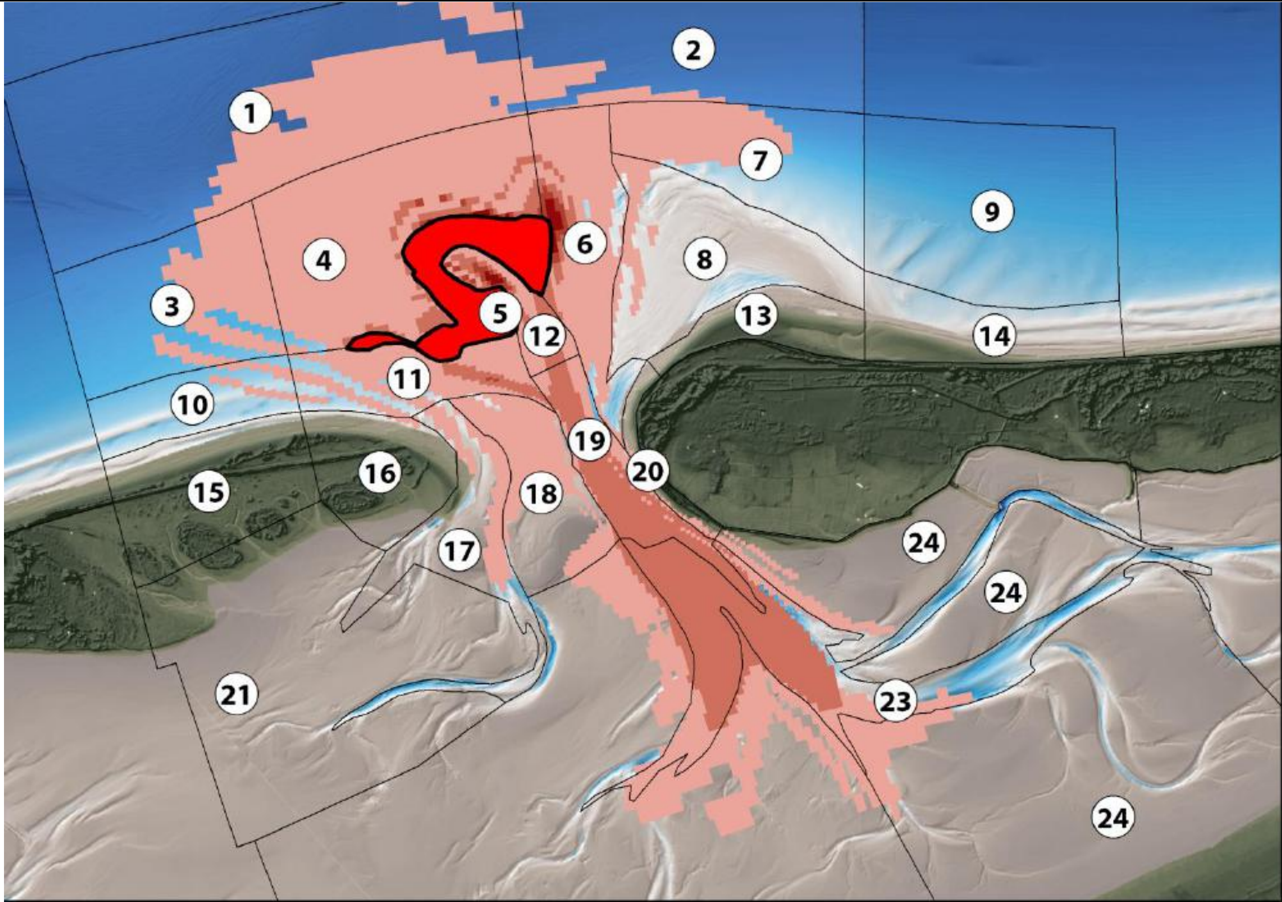
Methodology [1/4]

- Divide model domain into representative units
- Label sediment differently each for source unit
  - 4 background classes
  - 4 tracer classes



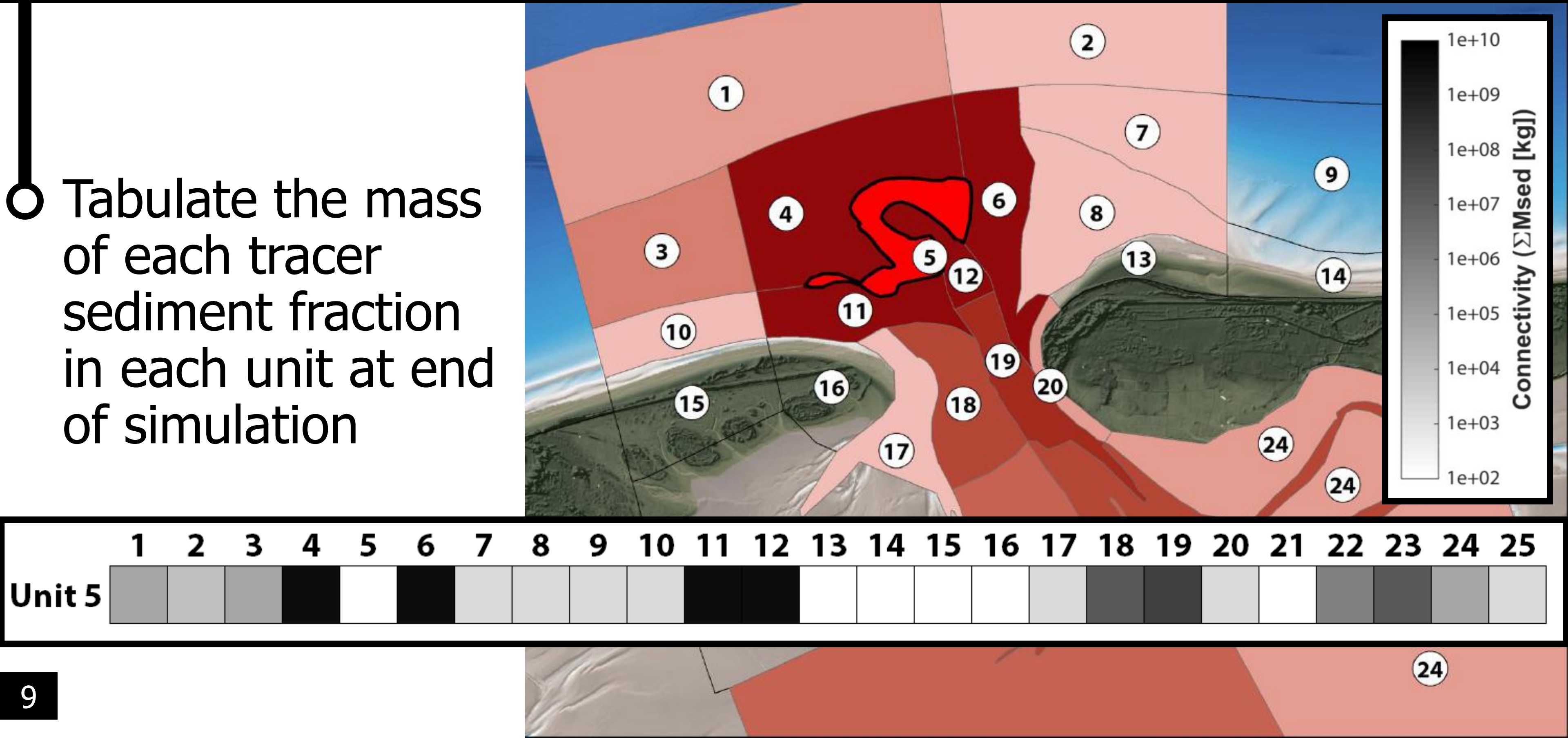
Methodology [2/4]

- Run Delft3D morphodynamic model
- Track tracer sediment as it moves through domain



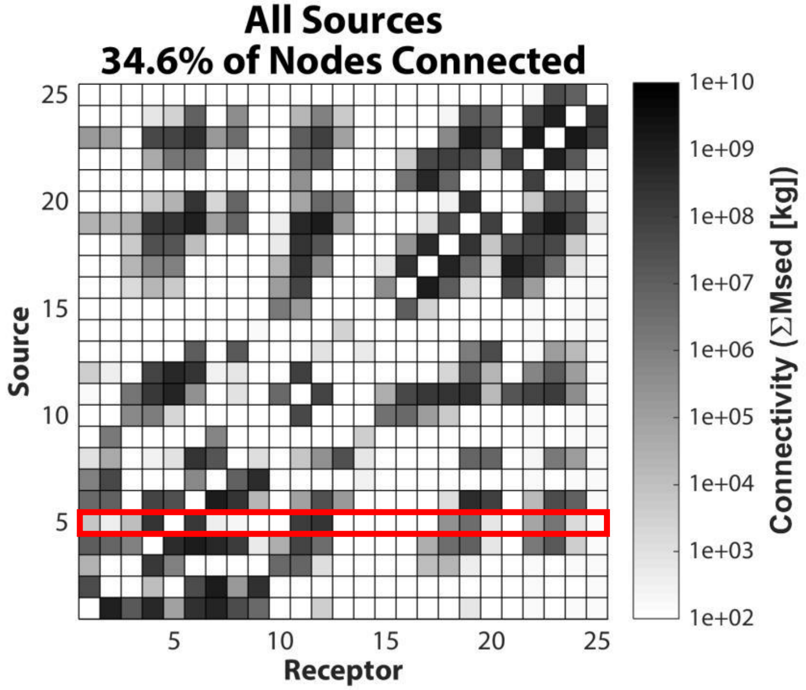
Methodology [3/4]

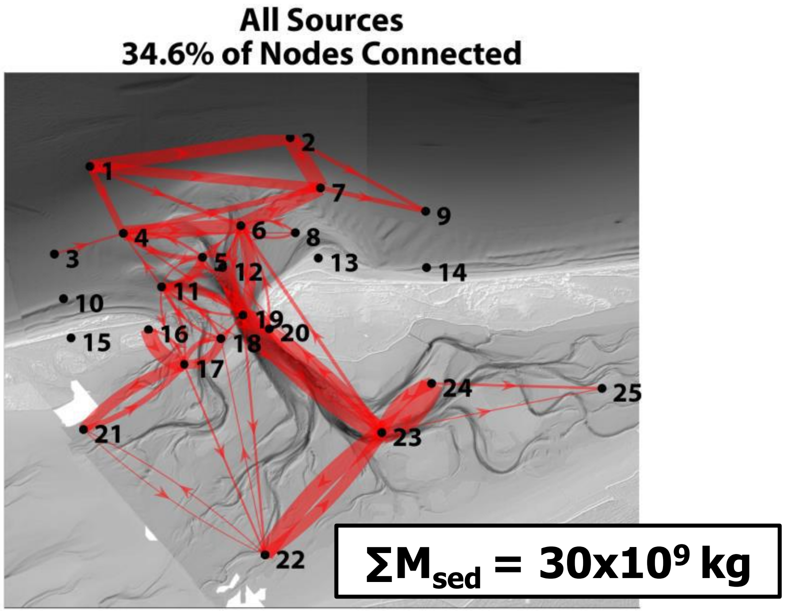
- Tabulate the mass of each tracer sediment fraction in each unit at end of simulation



Methodology [4/4]

- Include in adjacency matrix and network
- Repeat procedure for each source area

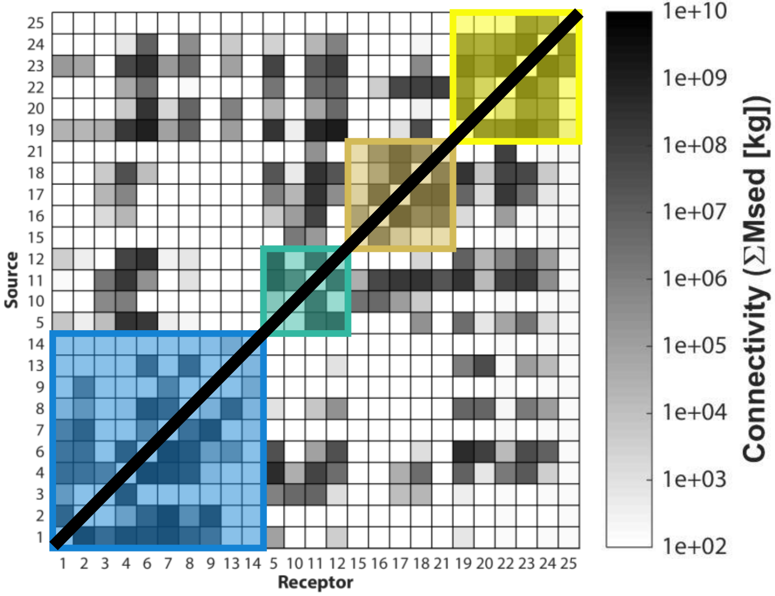


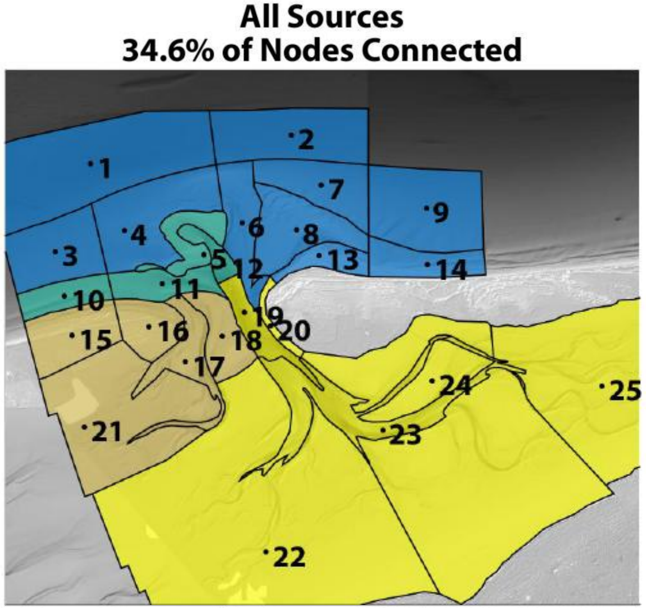


Preliminary Results [1/3]

Connectivity is highest with neighbouring units

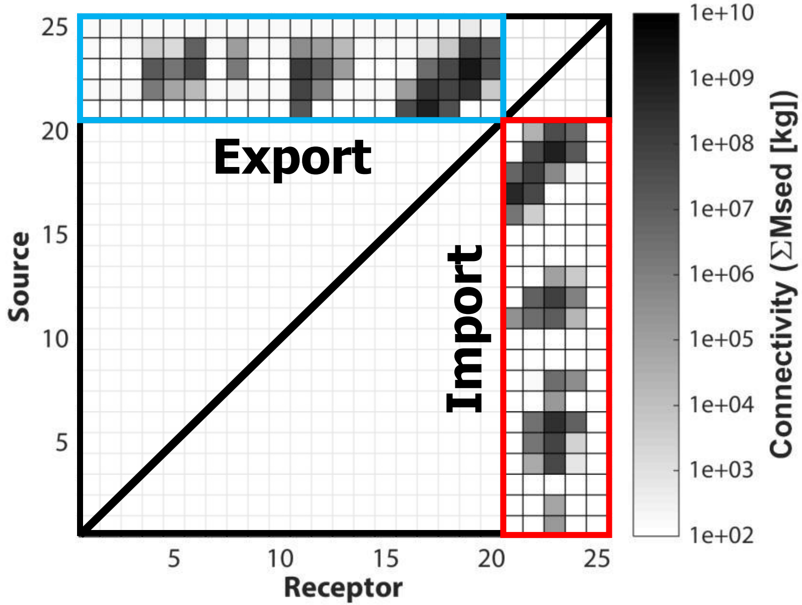
There are four key sediment-sharing "neighbourhoods"

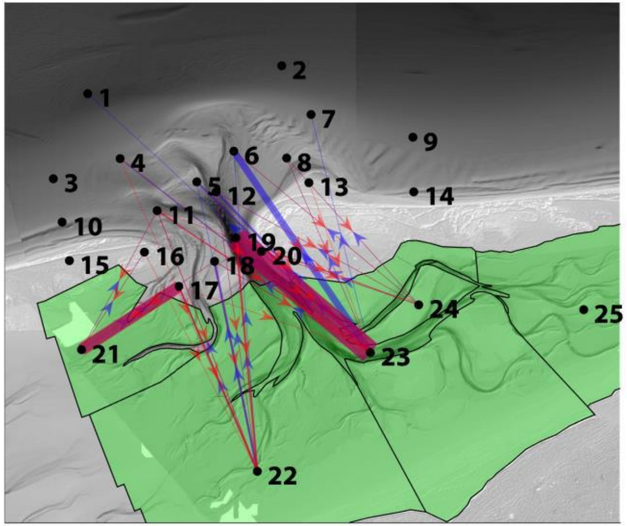




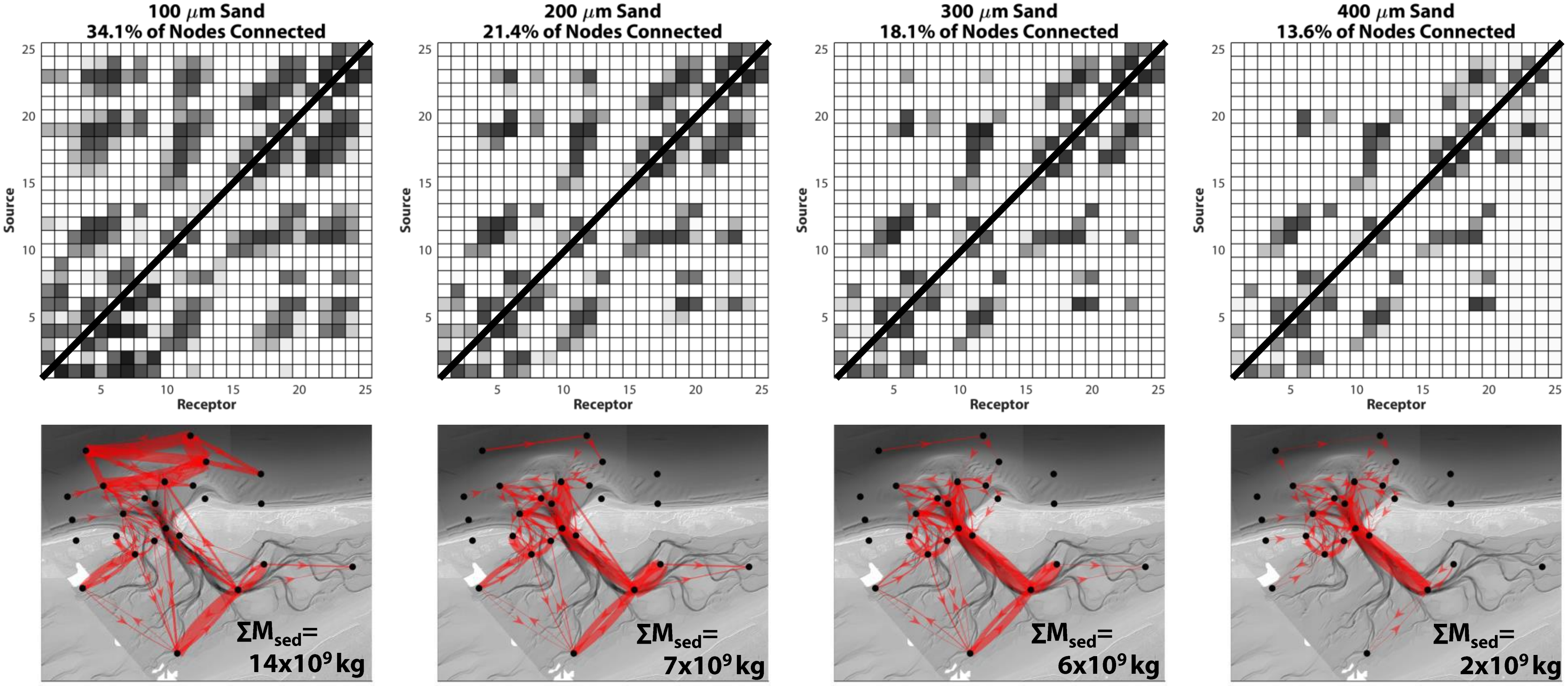
Preliminary Results [2/3]

- Asymmetry implies one-way paths and net transport
  - e.g. Basin Import ≈ 1.5x Basin Export



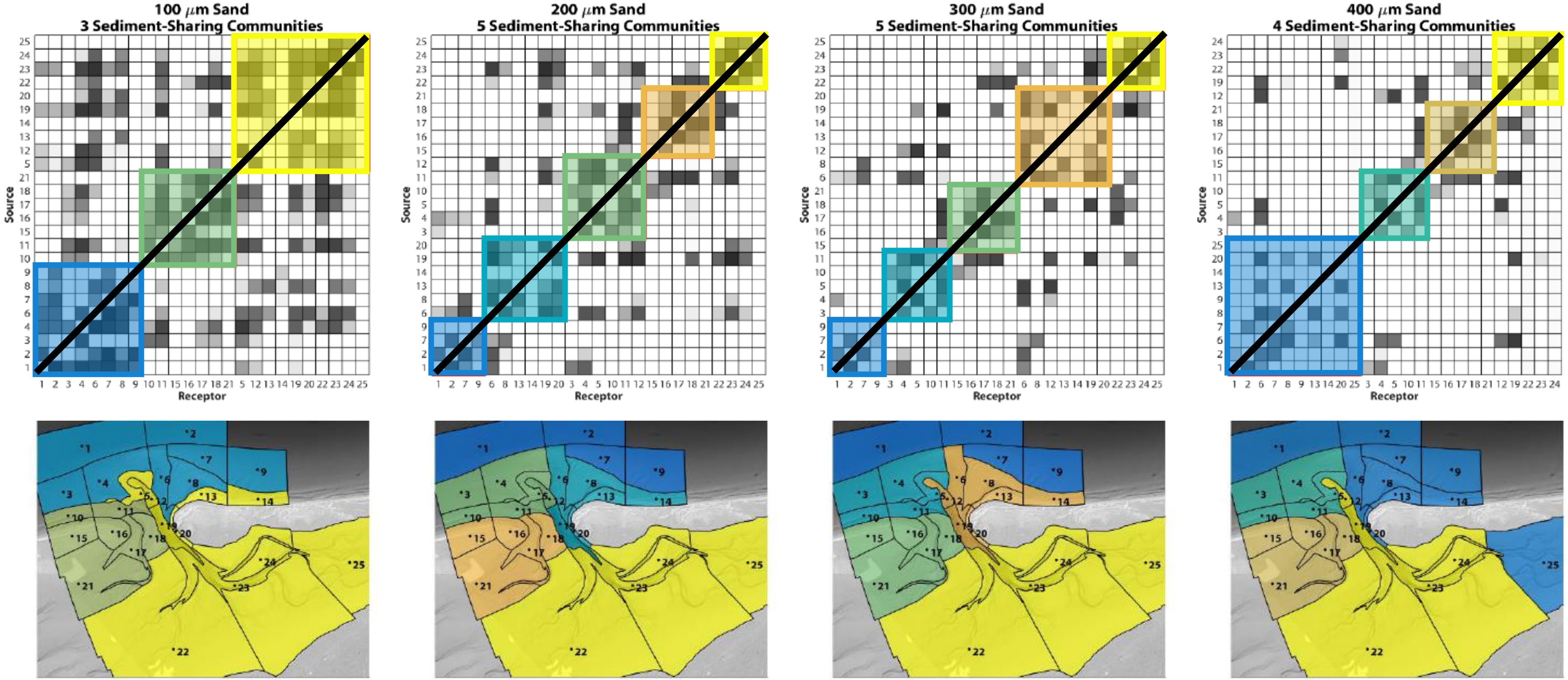


Preliminary Results [3/3]



Finer Sand → **Coarser Sand**

Sediment Sharing Communities & Grain Size



Finer Sand → **Coarser Sand**

So What?

With this framework, we can:

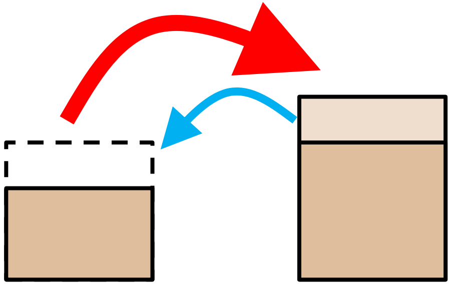
- **Quantify sediment transport pathways** across many different scenarios
- Better understand the **fate of nourishments** as a function of grain size
- **Anticipate future changes** in bed composition of the Wadden Sea
- Link sediment transport pathways to **benthic ecology**

What Next?

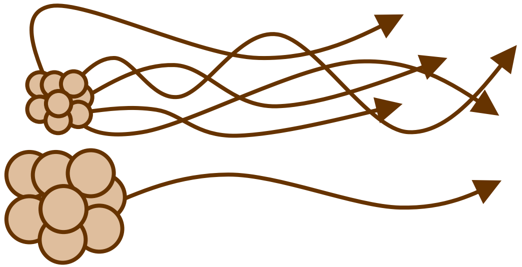
- Improvements to underlying model
  - Validation with field data
  - Include waves, wind-driven currents
- Analyze multiple scenarios:
  - Historical bathymetry/forcing
  - Nourishments & sea level rise
- Use particle tracking model

Conclusions

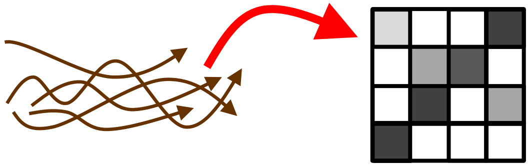
Asymmetries in connectivity (i.e. unidirectional transport) can be used to explain long-term erosional or depositional trends



Connectivity is inversely proportional to grain size, but also depends on sediment supply



Sediment connectivity provides a **quantitative framework for assessing sediment transport pathways** in coastal systems



Thank you for your time!

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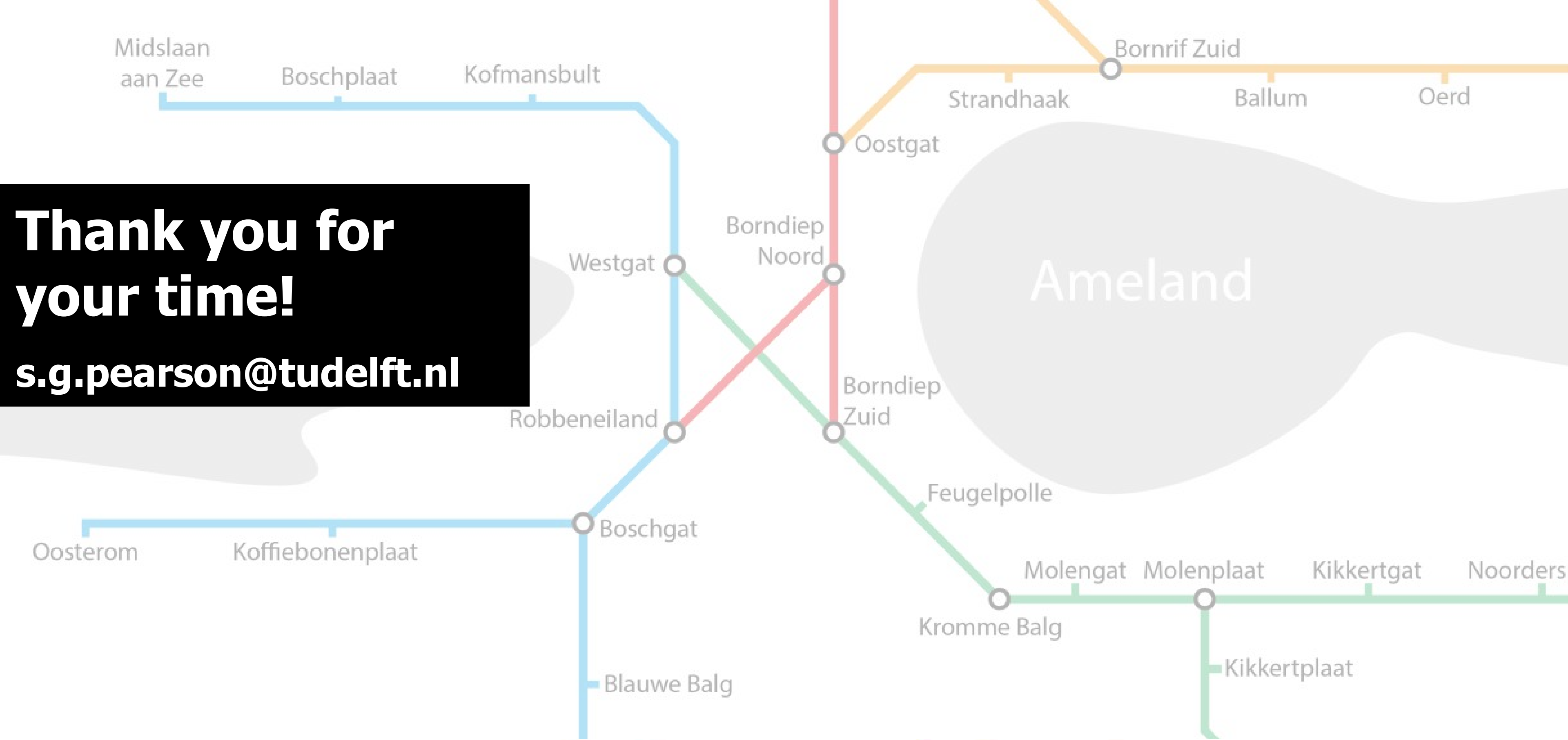

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