

Cascading effects in the Wadden Sea ecosystem

From sediment composition to shorebird numbers

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Photo: Benjamin Gnepp

Wadden Sea



Ebb en flow tide



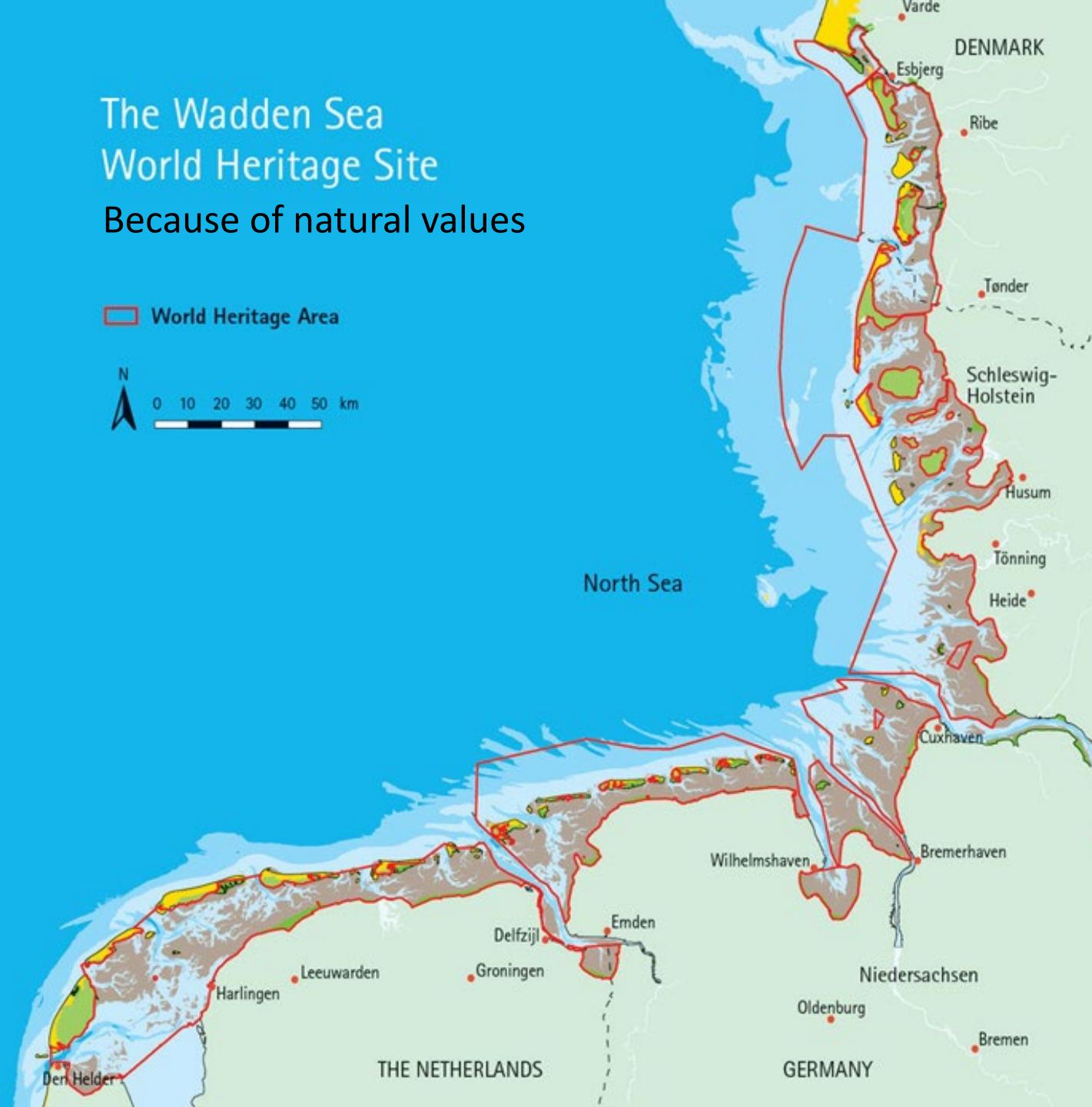
The Wadden Sea World Heritage Site

Because of natural values

■ World Heritage Area



0 10 20 30 40 50 km



Natural values of Wadden Sea - heavily affected by humans



How do these changes affect the ecosystem with cascading effects in the food web?

Millions of (shore)birds



Shorebirds

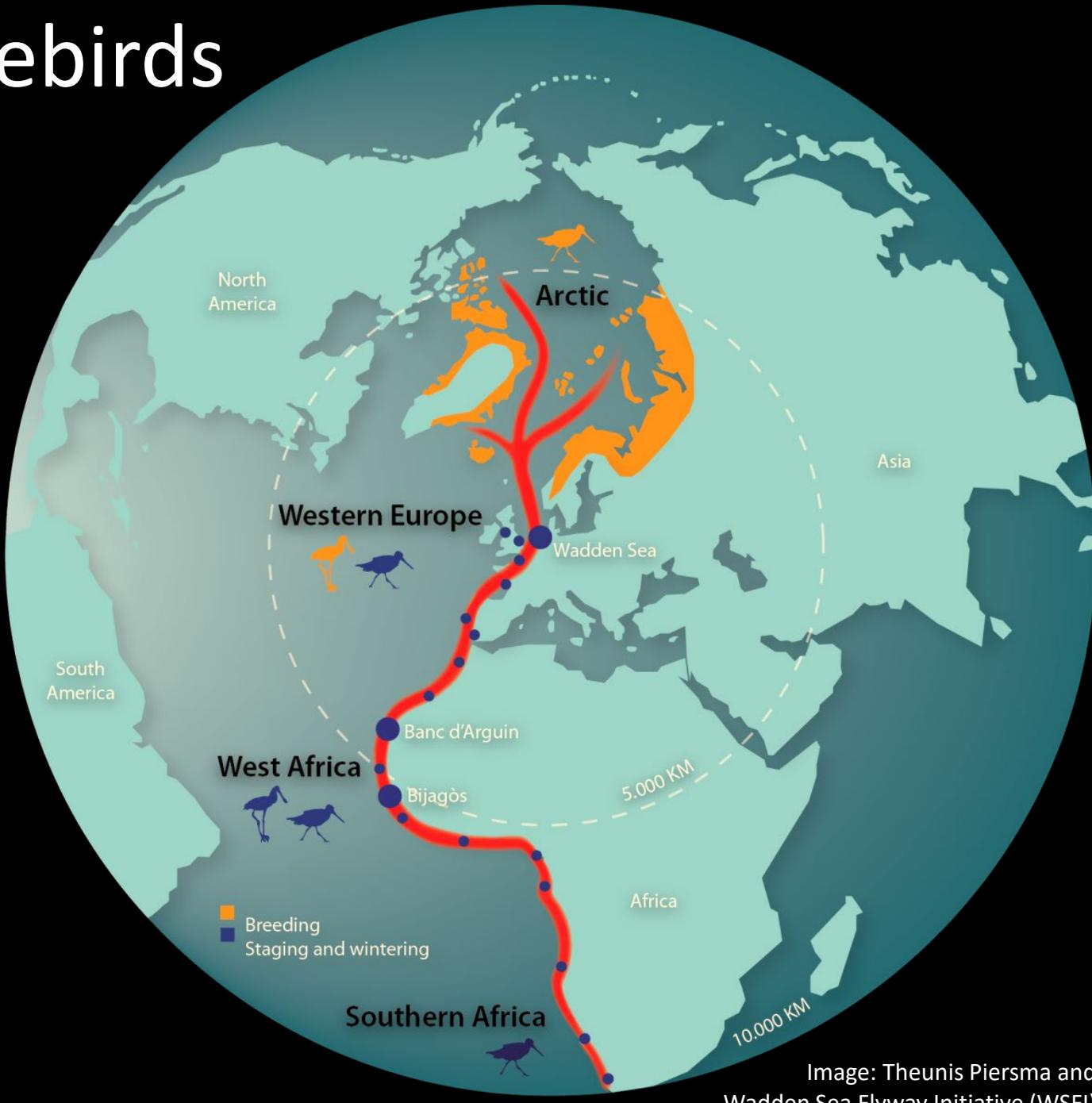
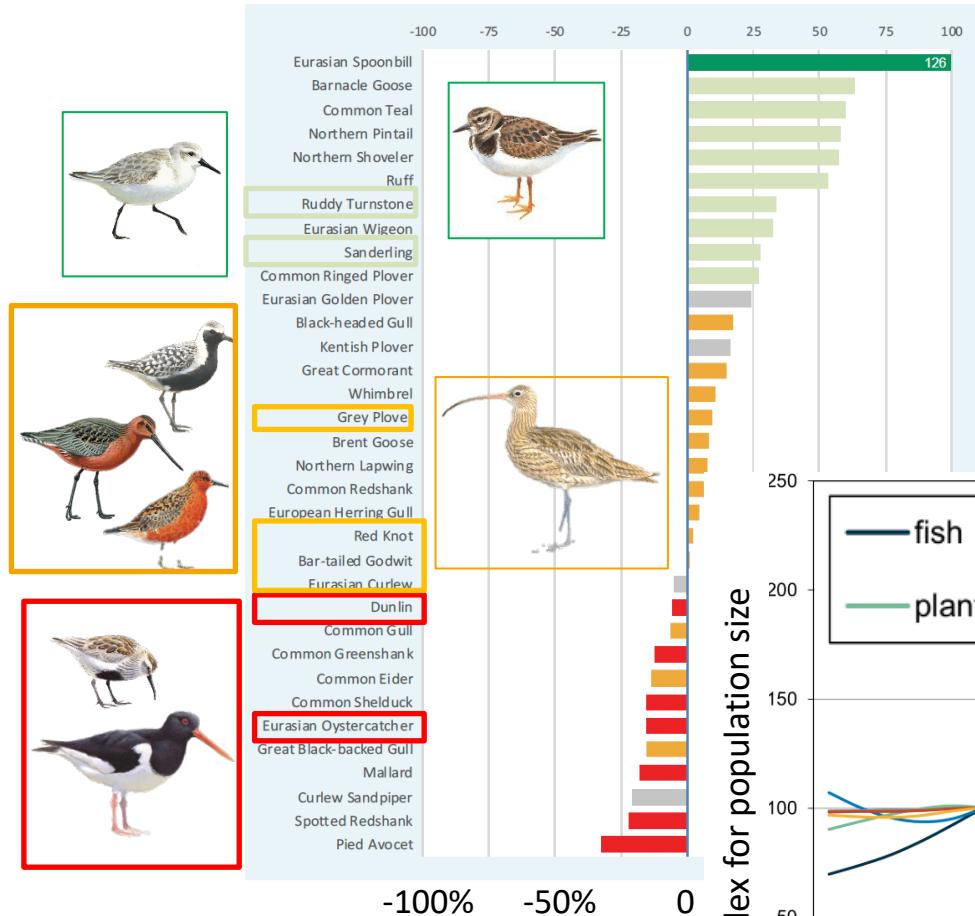


Image: Theunis Piersma and
Wadden Sea Flyway Initiative (WSFI)

Safety and food



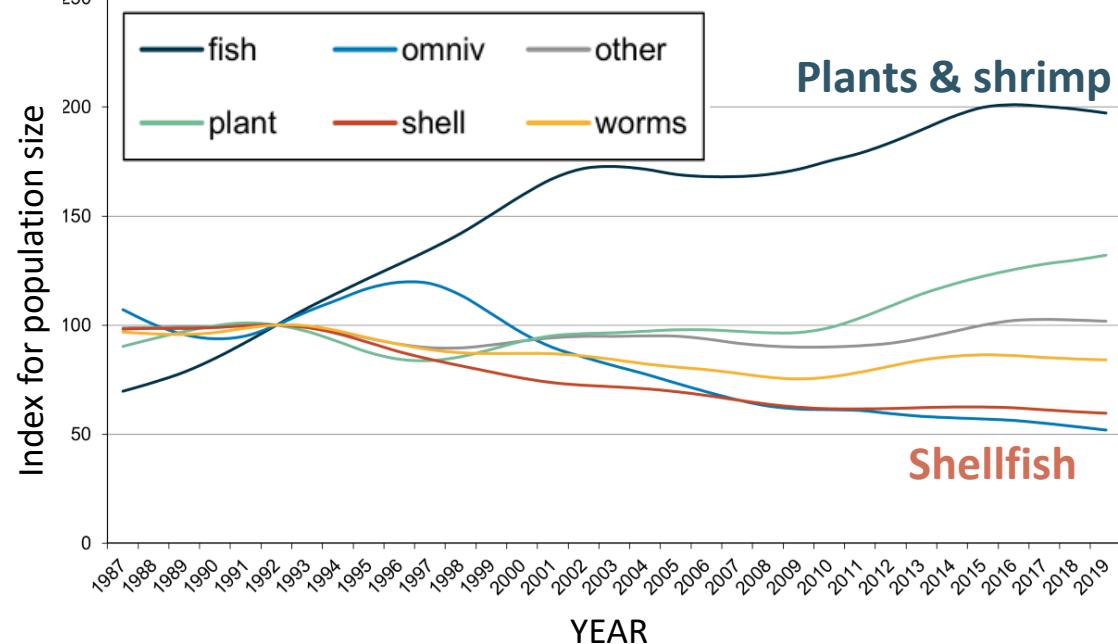
Population changes in the past 10 years (%)



Kleefstra et al 2022

(for predicting) it's important to understand the key processes underlying these patterns

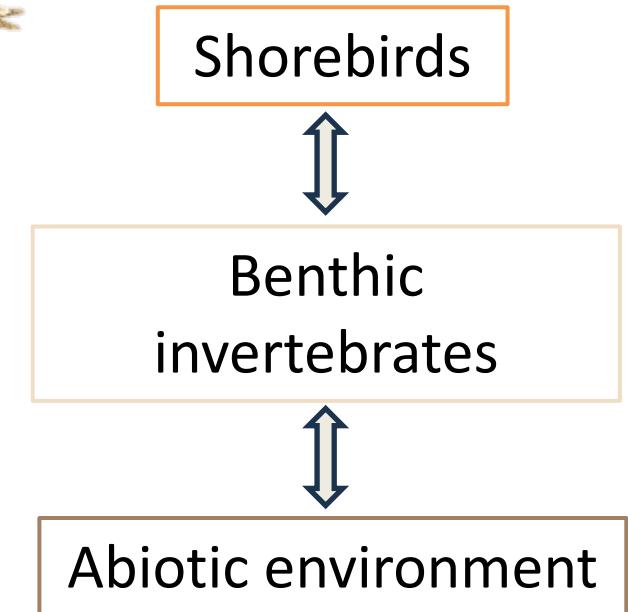
Changes seem related to diet



Simplified ecosystem/food web



Illustration J-C. Goubert
and Vogelbescherming

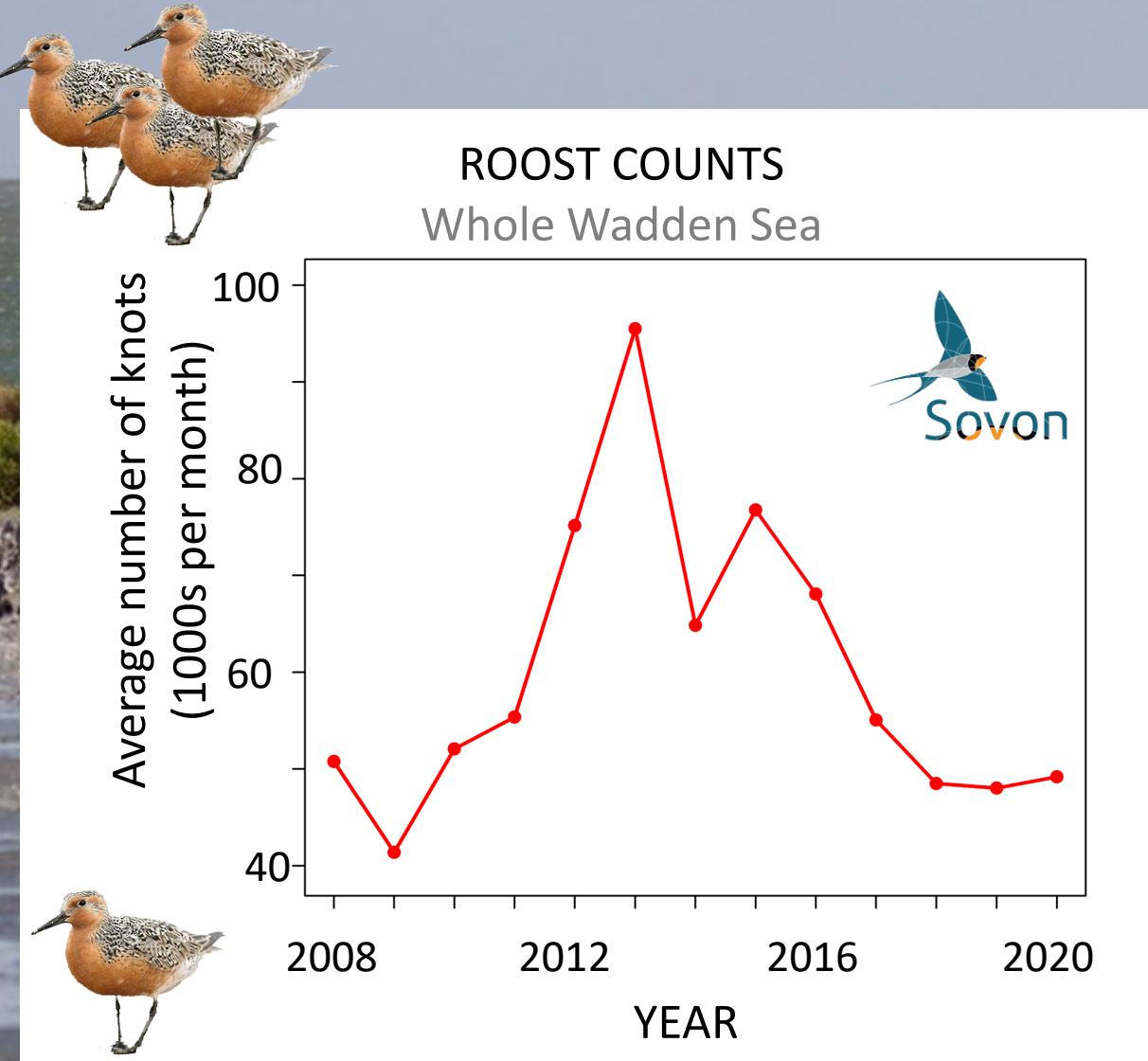


How do species interact with and are affected by their changing (food) environment?

Red Knot - *Calidris canutus*



Why does Red Knot population size vary?



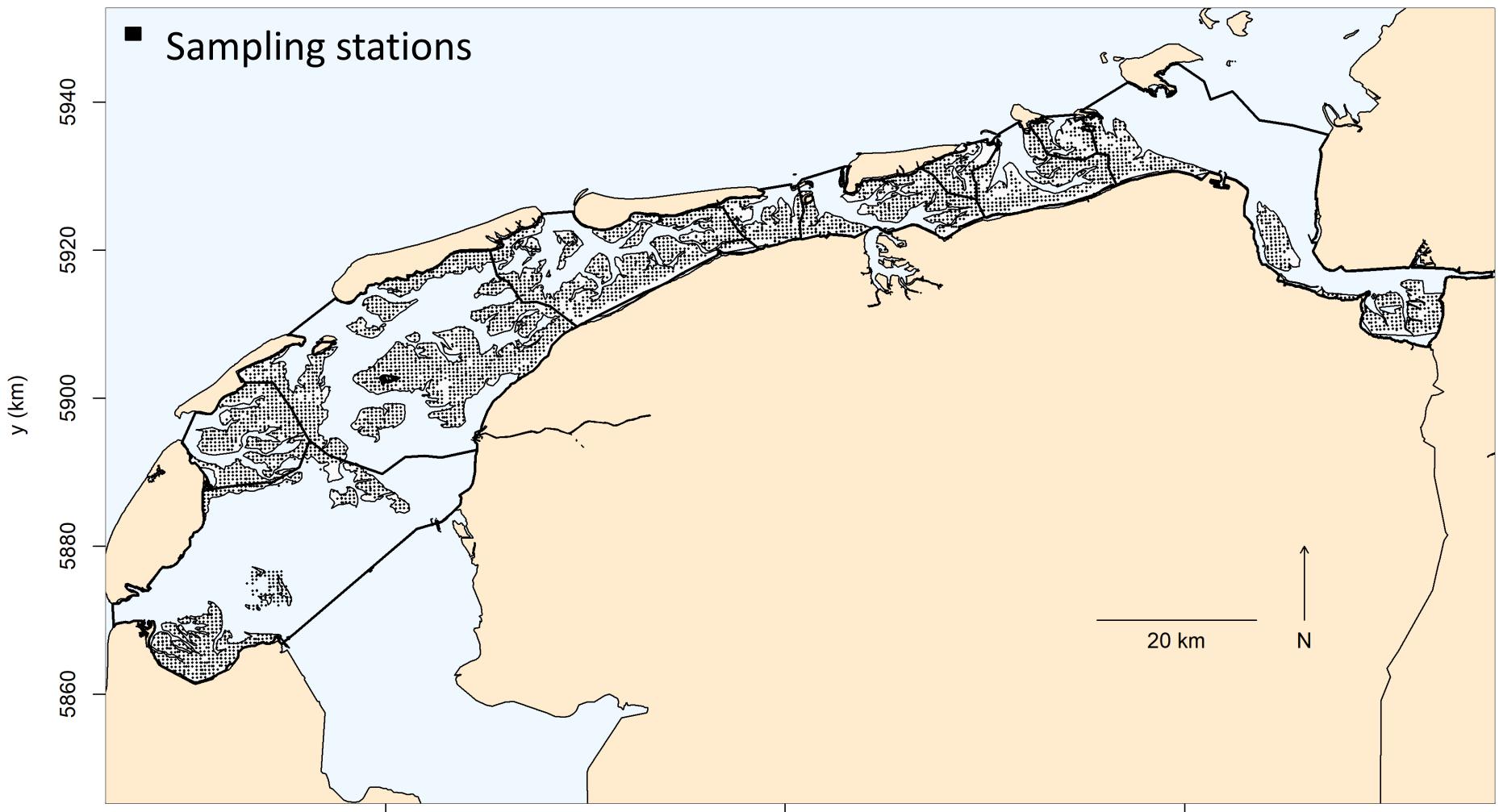
SIBES

Synoptic Intertidal BEnthic Survey

Summer sampling
2008-onwards



~4,500 Sampling stations yearly



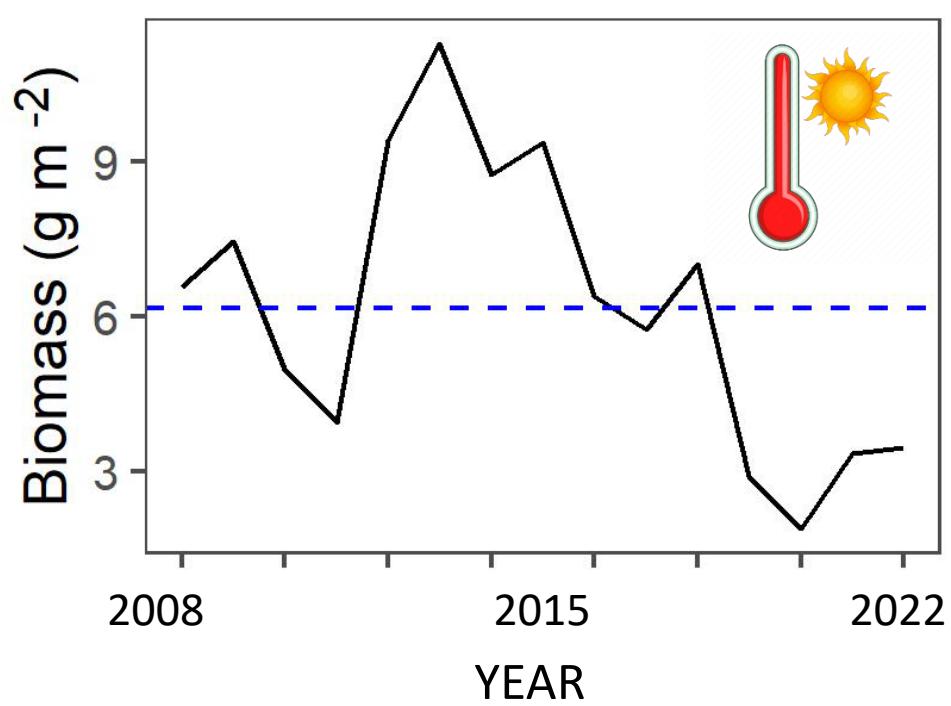


Photos: Fred Wiering

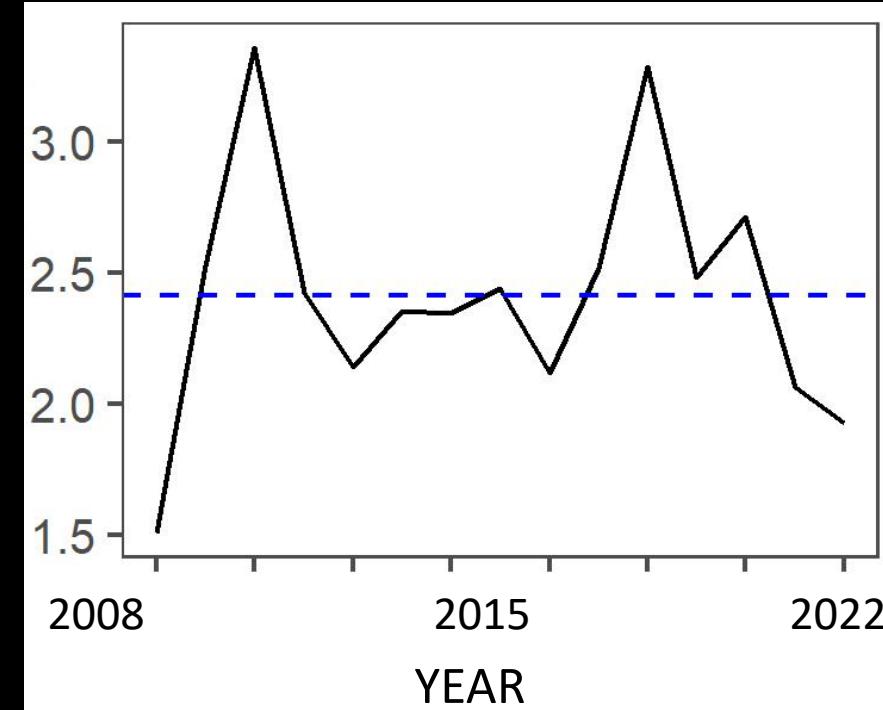
Count individuals of all species and measure their biomass, and estimate sediment grain size



The two most abundant species

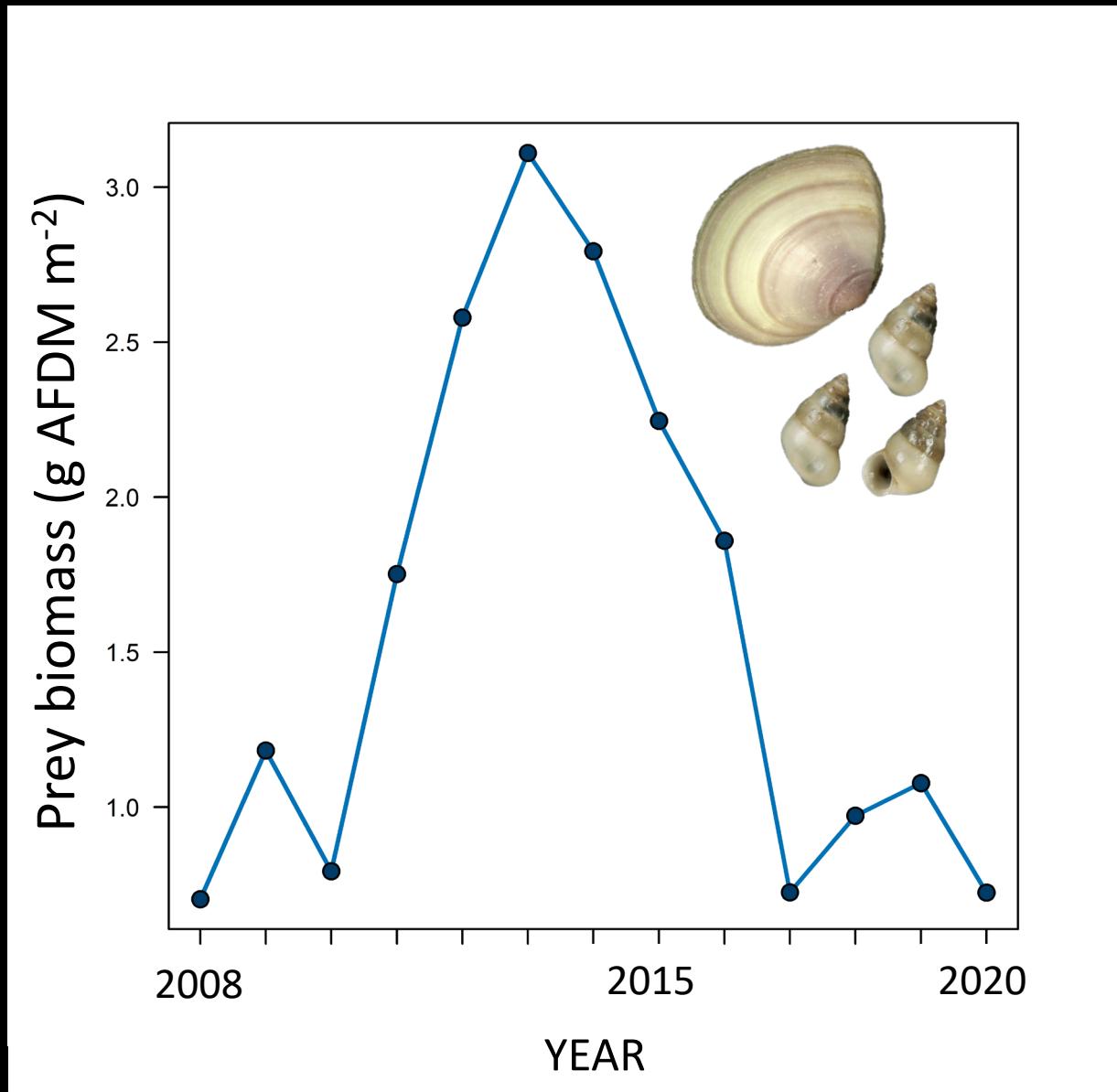


Cerastoderma edule
(Common Cockle)

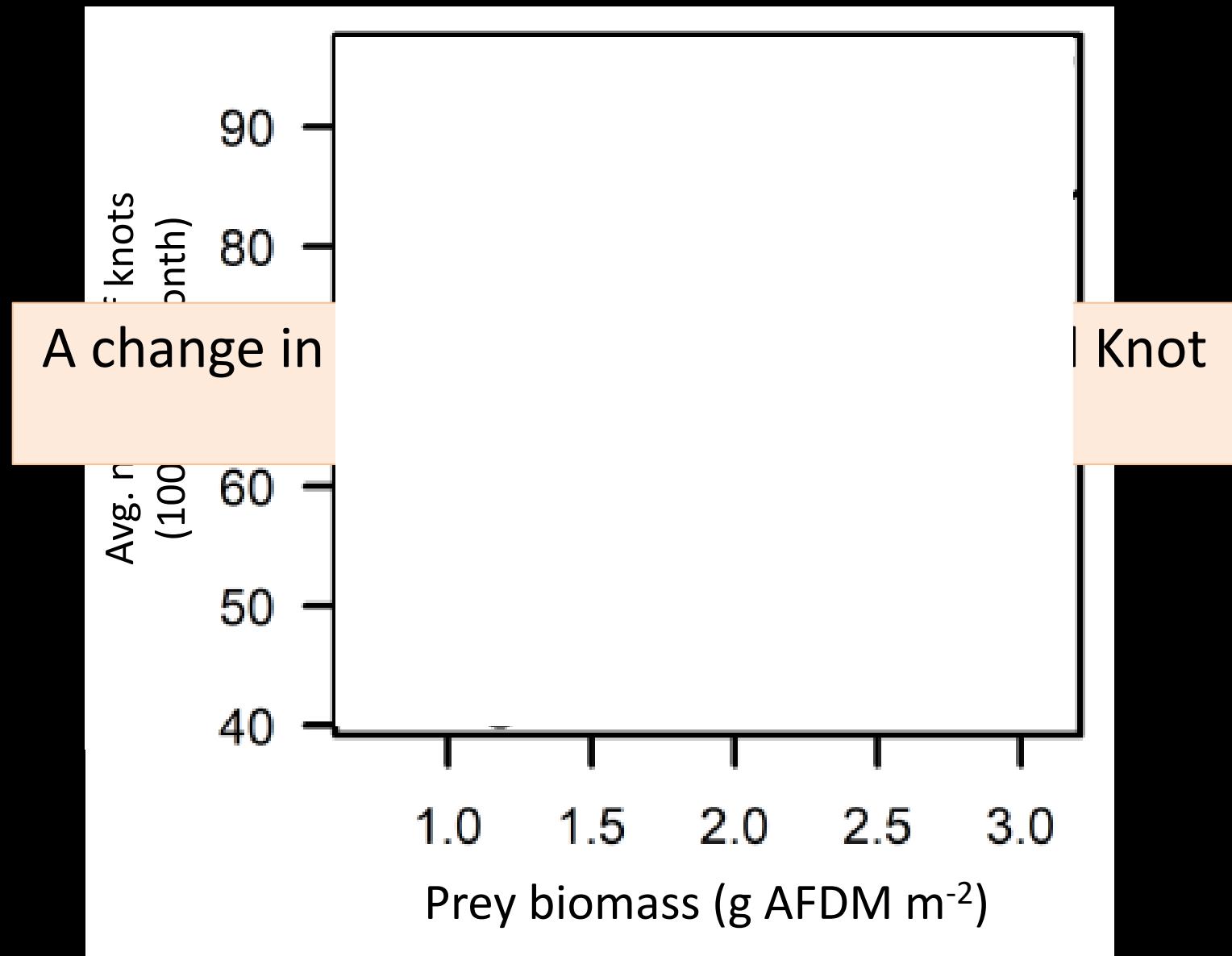


Arenicola marina
(Lugworm)

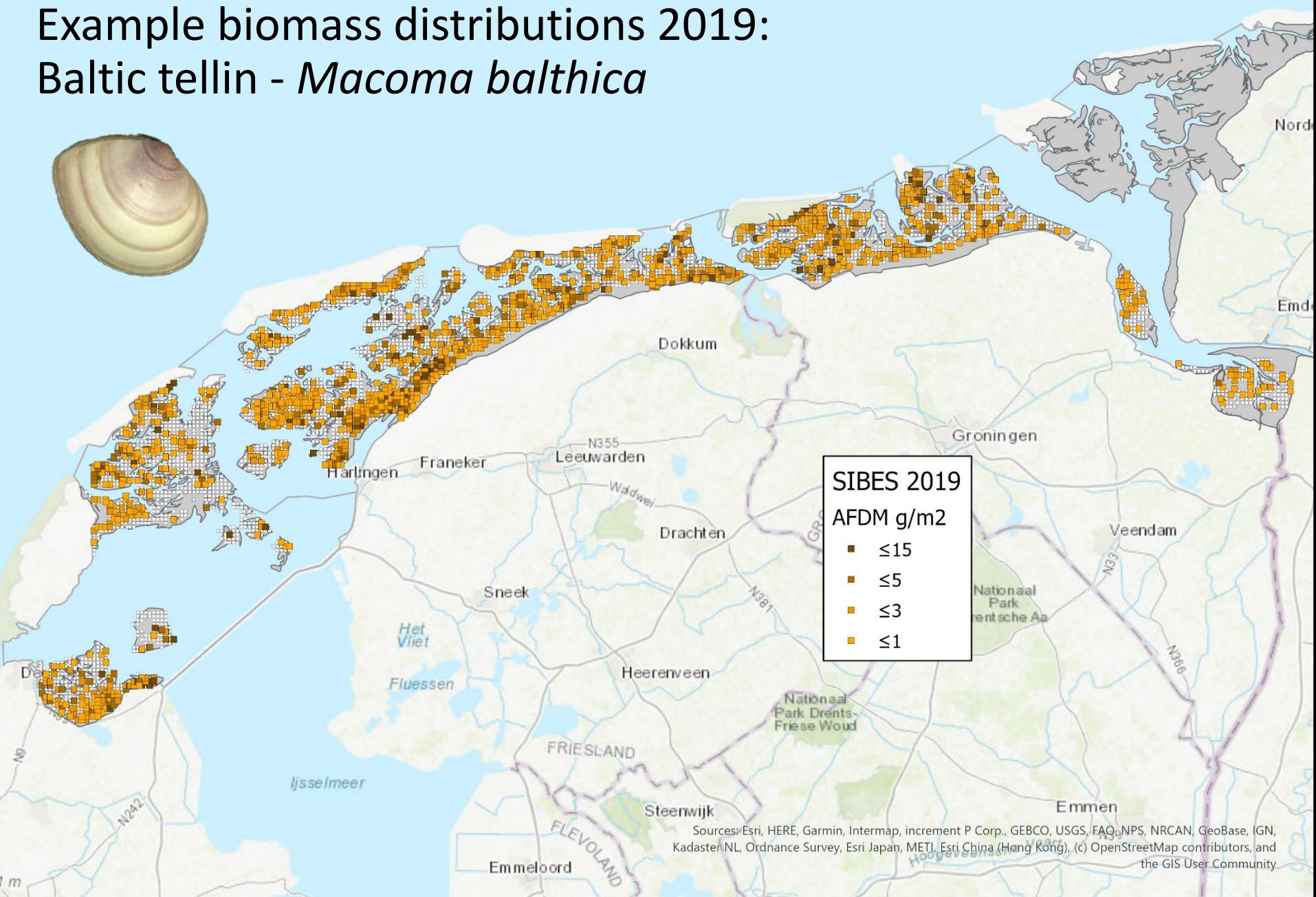
What about the food for knots?



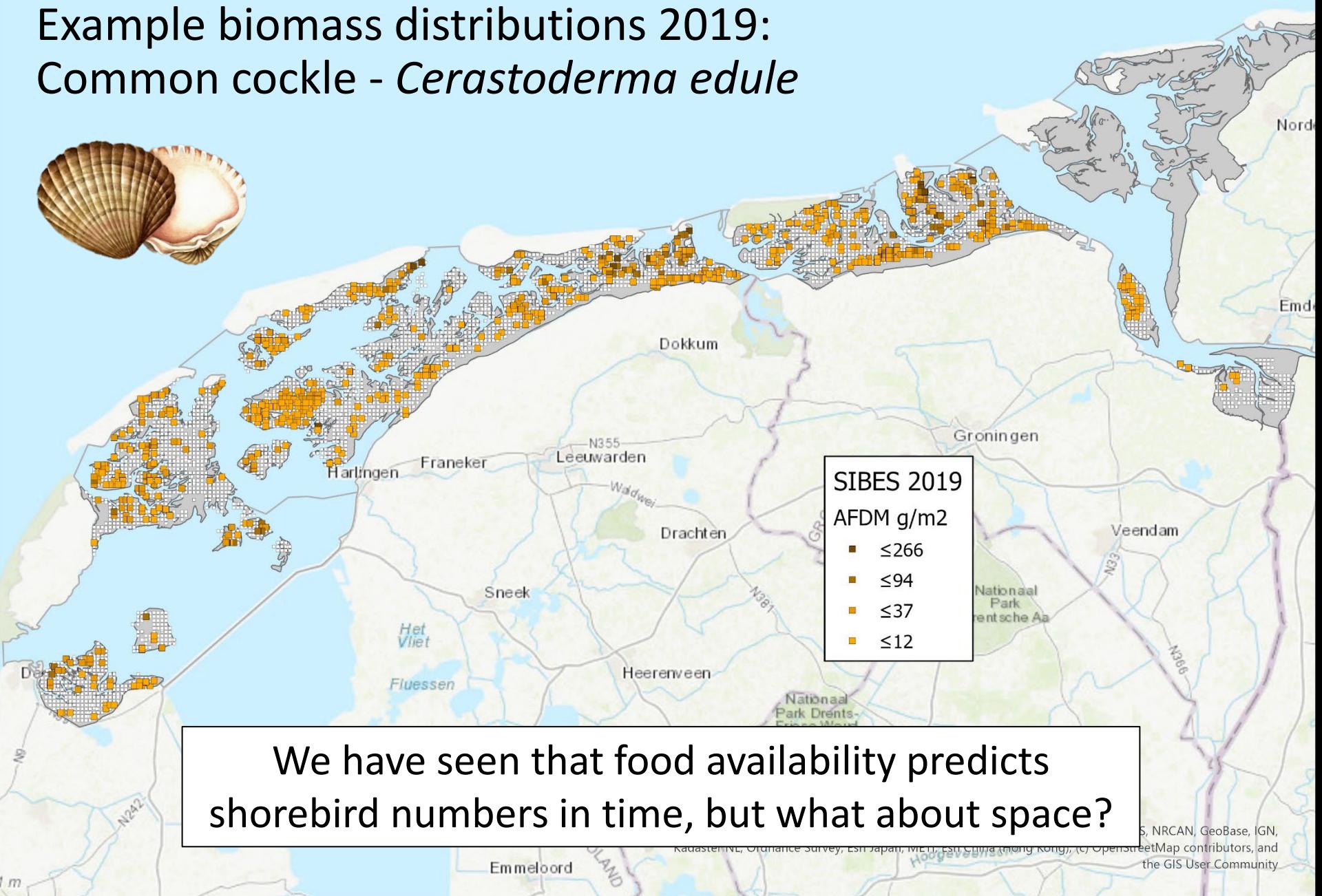
Does food availability predict Knot numbers?



Example biomass distributions 2019: Baltic tellin - *Macoma balthica*



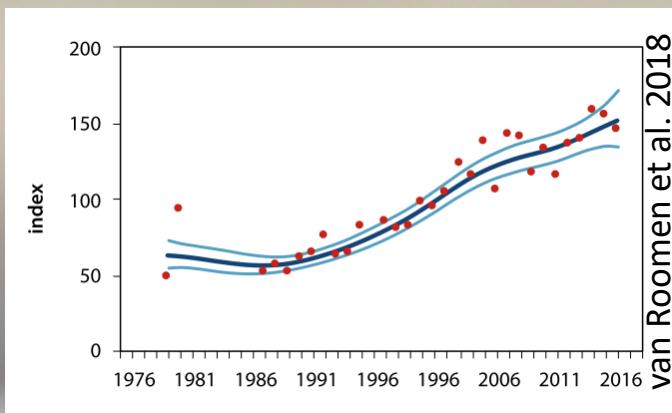
Example biomass distributions 2019: Common cockle - *Cerastoderma edule*



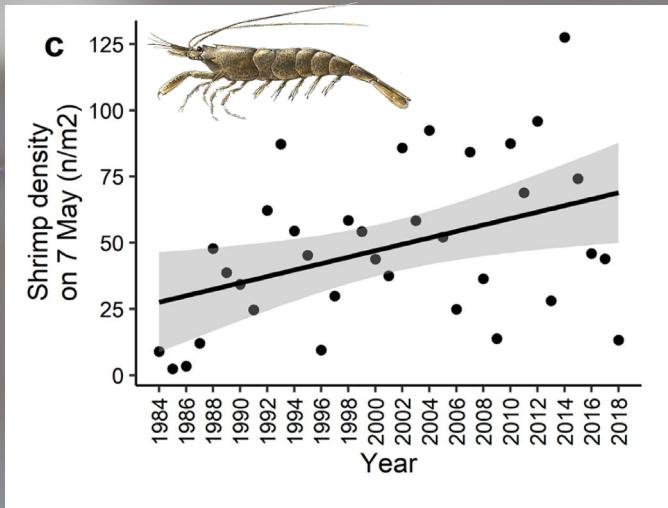
We have seen that food availability predicts shorebird numbers in time, but what about space?

Sanderling – *Calidris alba*

Do sanderling select mudflats with the most shrimp?



van Roomen et al. 2018

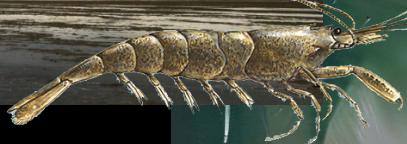


Shrimp sampling

Emma Penning



Shrimp densities ($n\ m^{-2}$) resource landscape



Where do sanderling go?

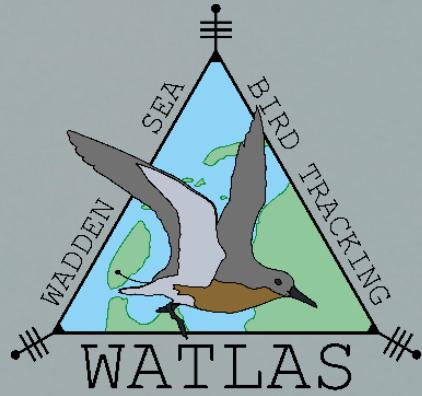


Photo: Emma Penning

- Difficult to follow with binoculars
- Need transmitters for remote tracking
- But sanderling are small (50 g)

WATLAS

Wadden Sea Advanced Tracking and Localization of Animals in real-life Systems





2018: tagged 94 Sanderling (50 g)

2.4 g tag

3 s interval



Photo: Selin Ersøy

◆ receiver stations

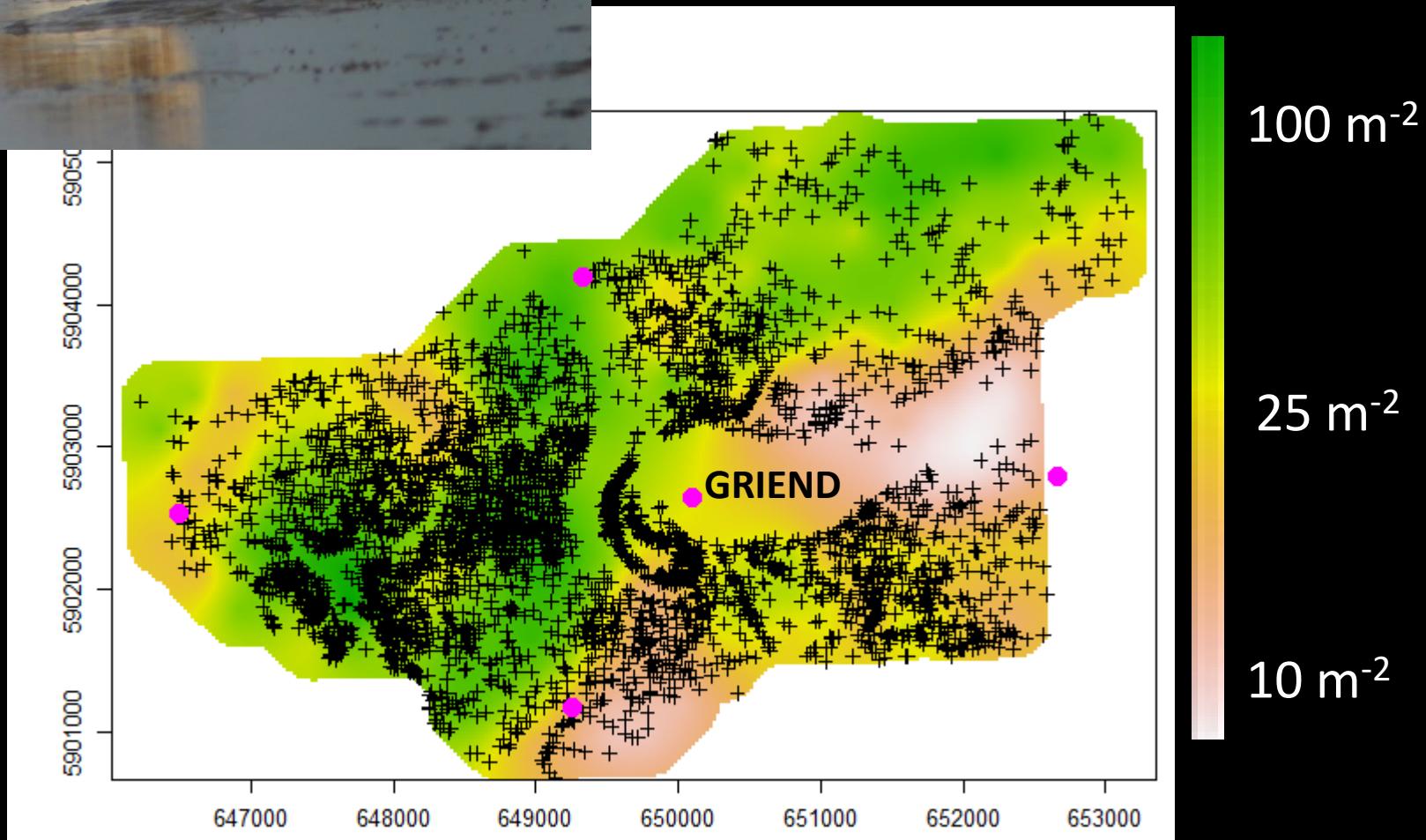


5 km

2018-07-26 08:36:00 s

Resource selection: used-availability design

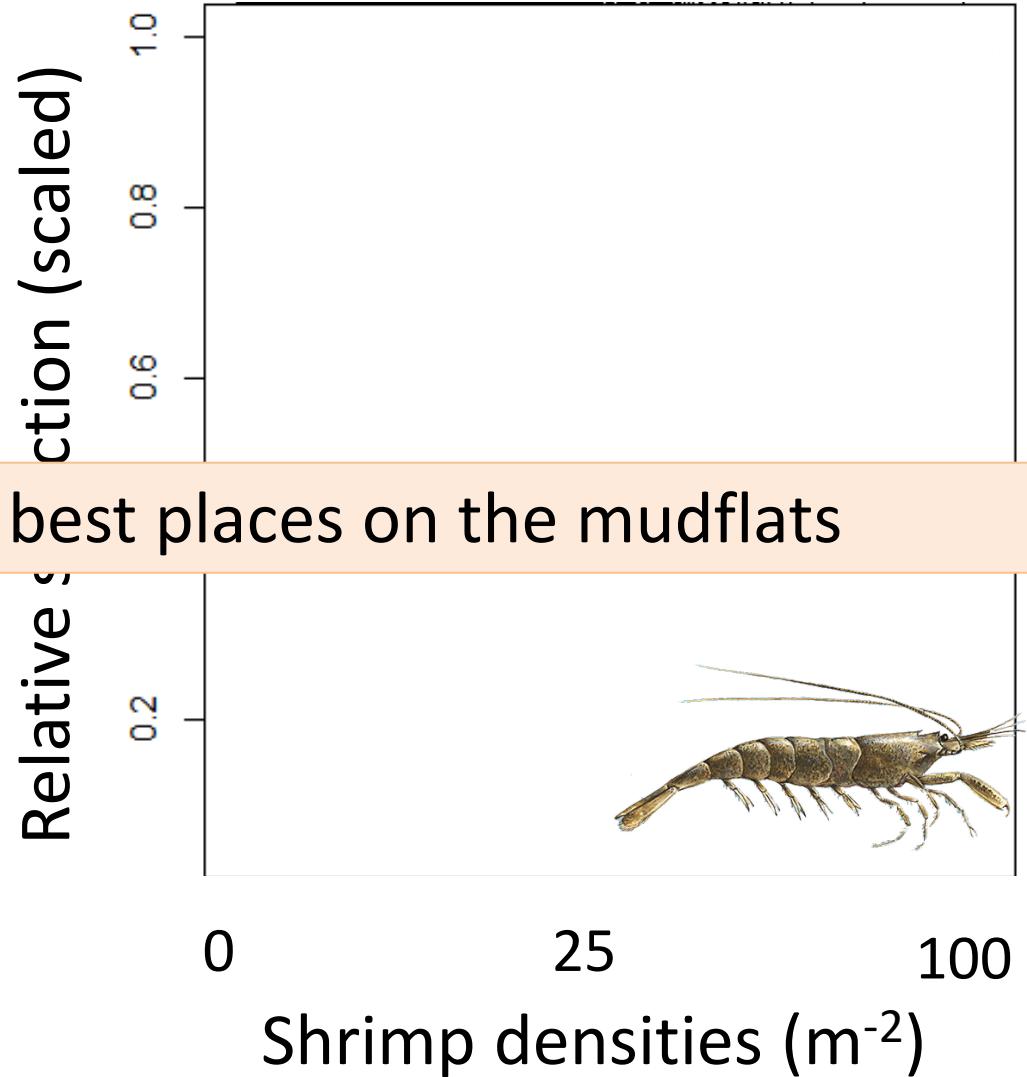
- Selected foraging period (mudflats available)
- 4,187 residence patches of 72 birds
- Mean duration 23 minutes (SD 32)
- 15 times available points ($n = 62,726$)



Do sanderling select highest prey densities?

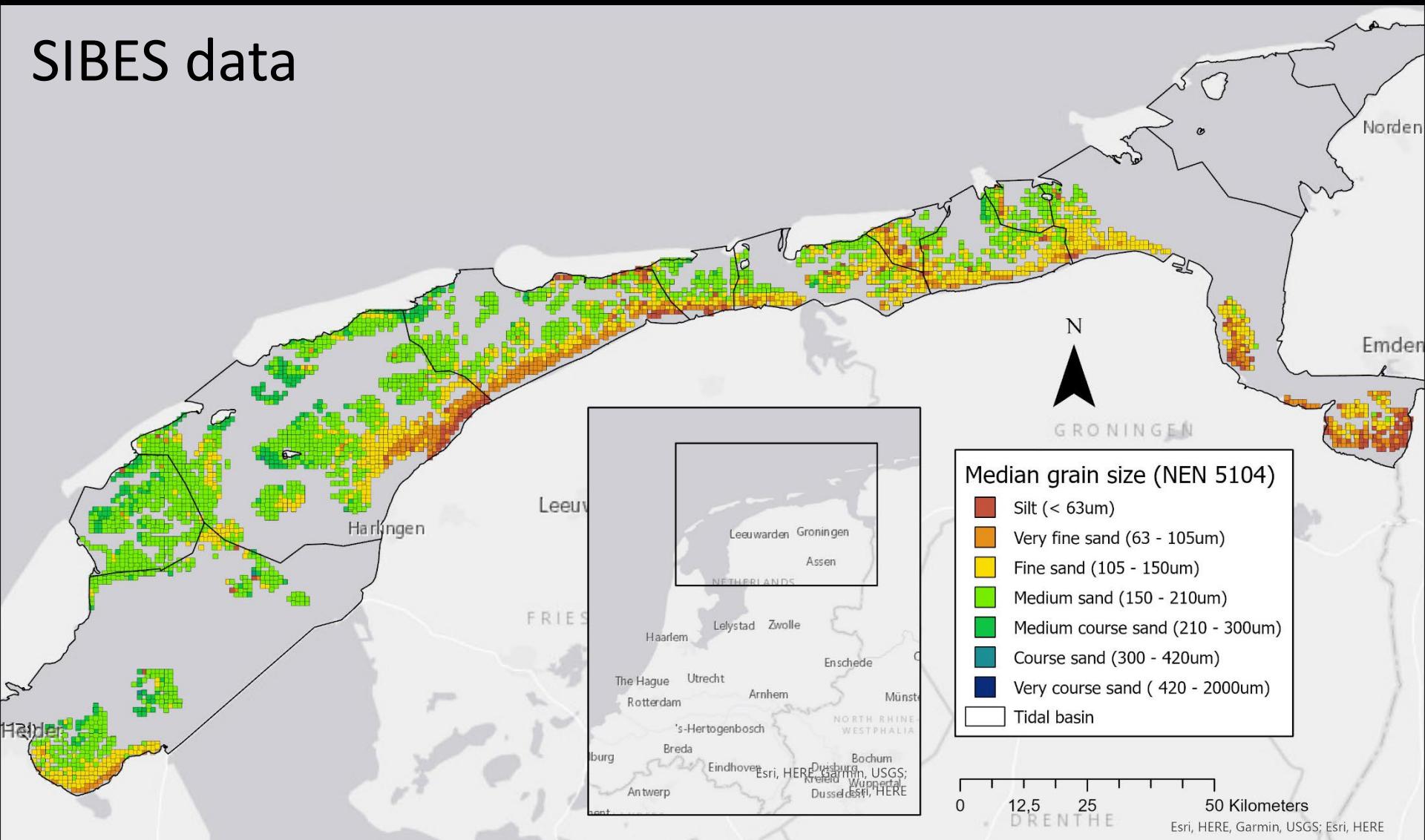


Birds select best places on the mudflats

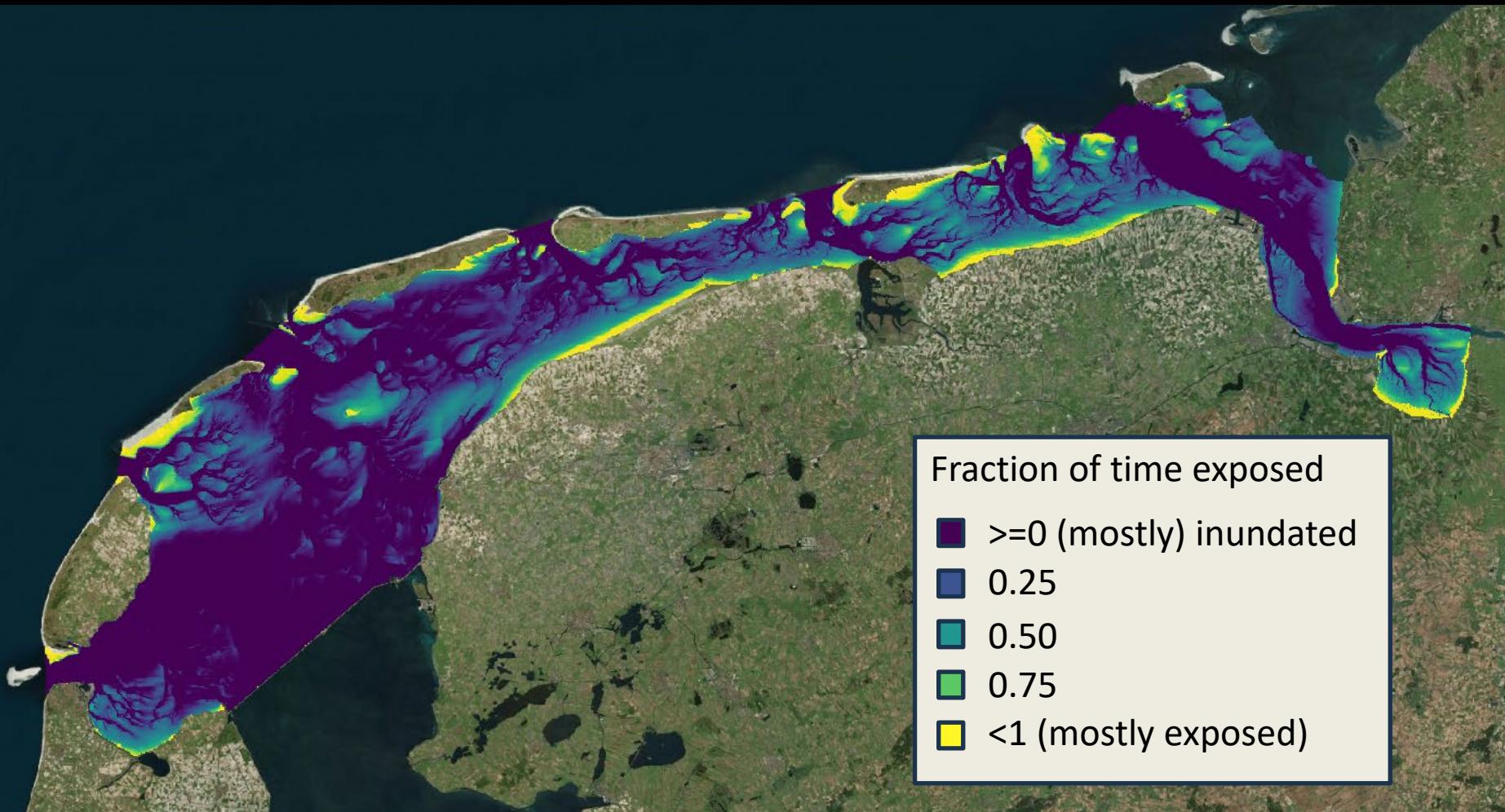


Like birds, do invertebrates select habitat? median grain size

SIBES data



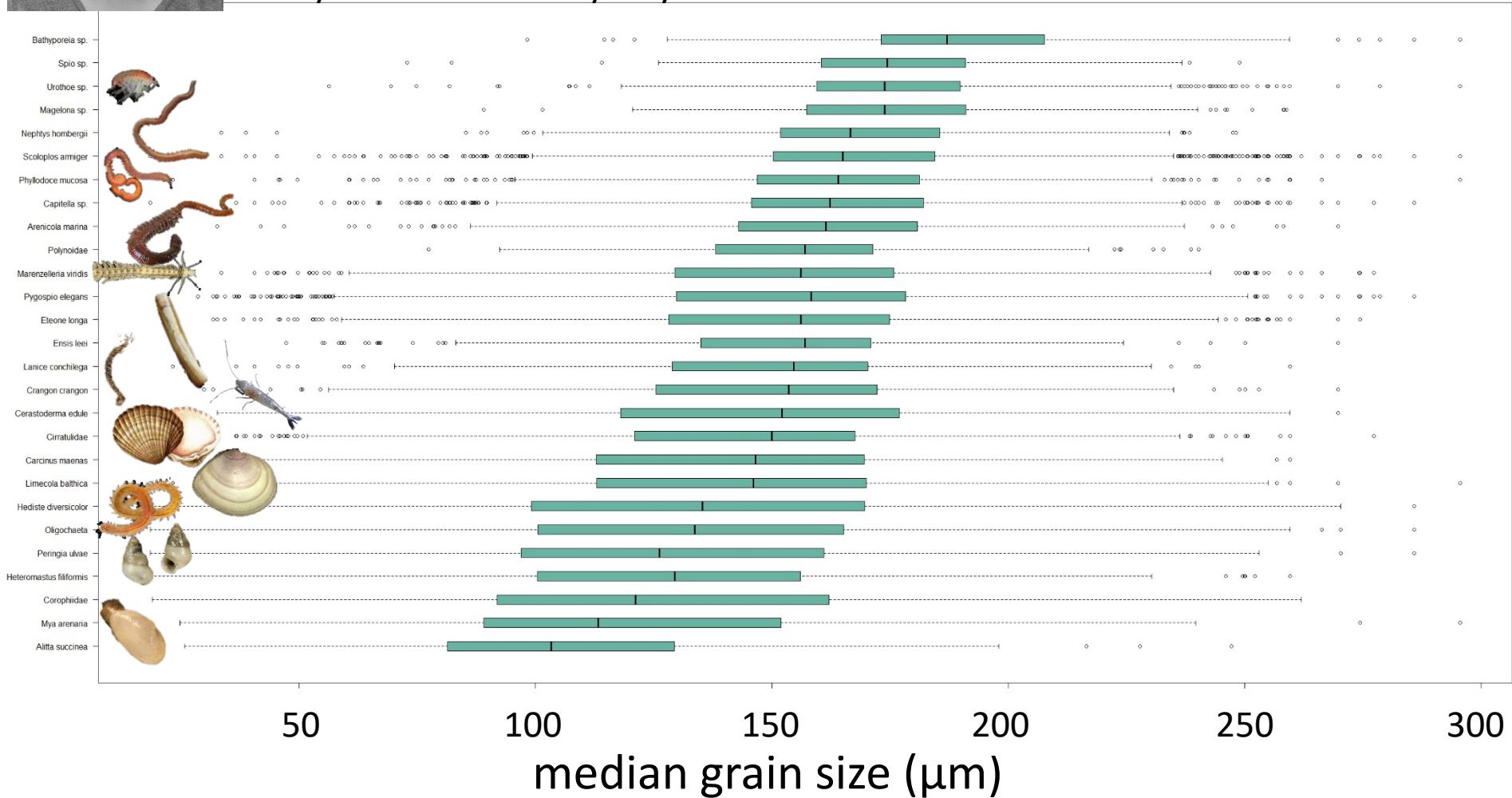
Like birds, do invertebrates select habitat? exposure time





Median Grain Size

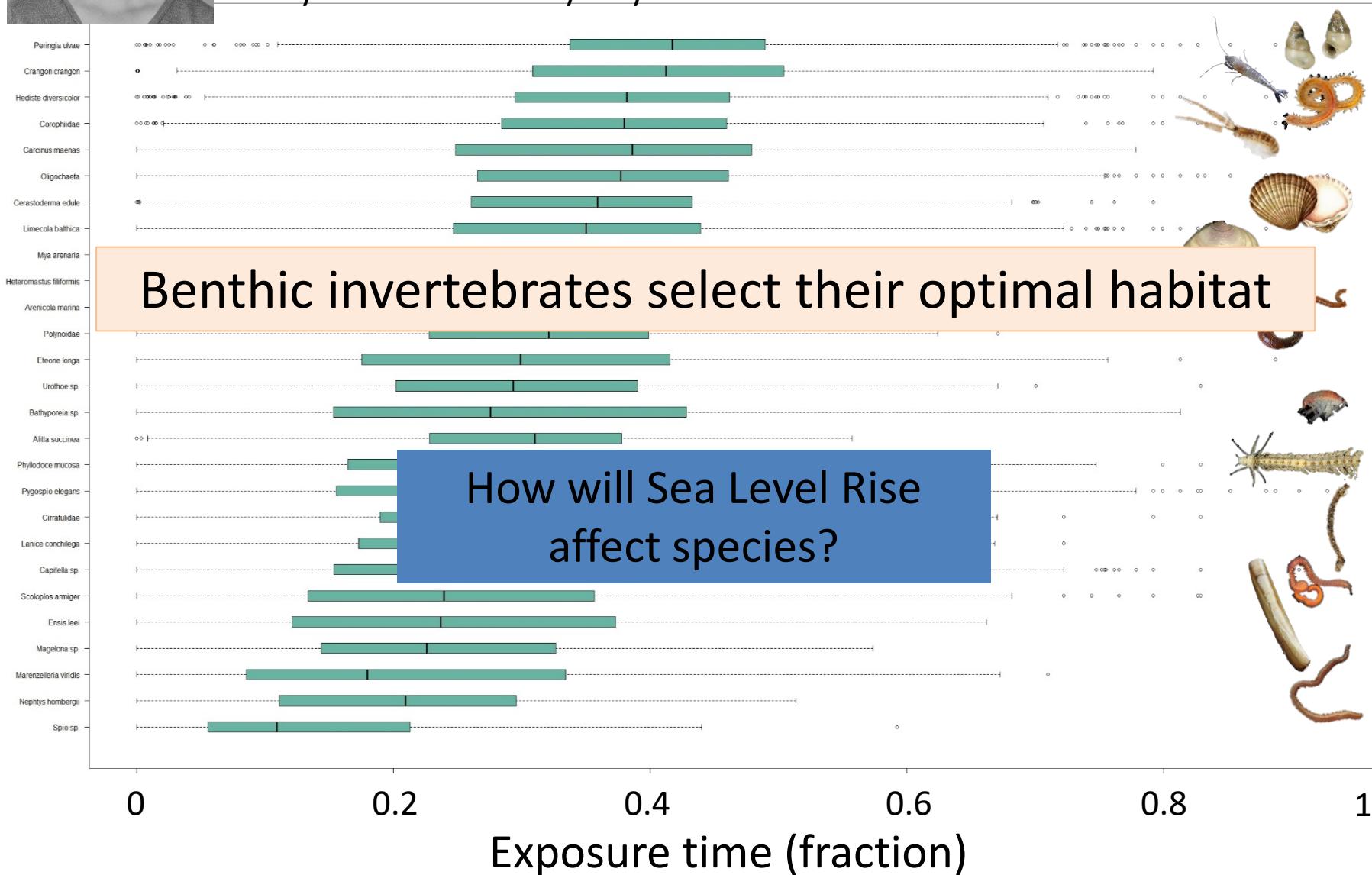
Hailley Danielson-Owczynsky



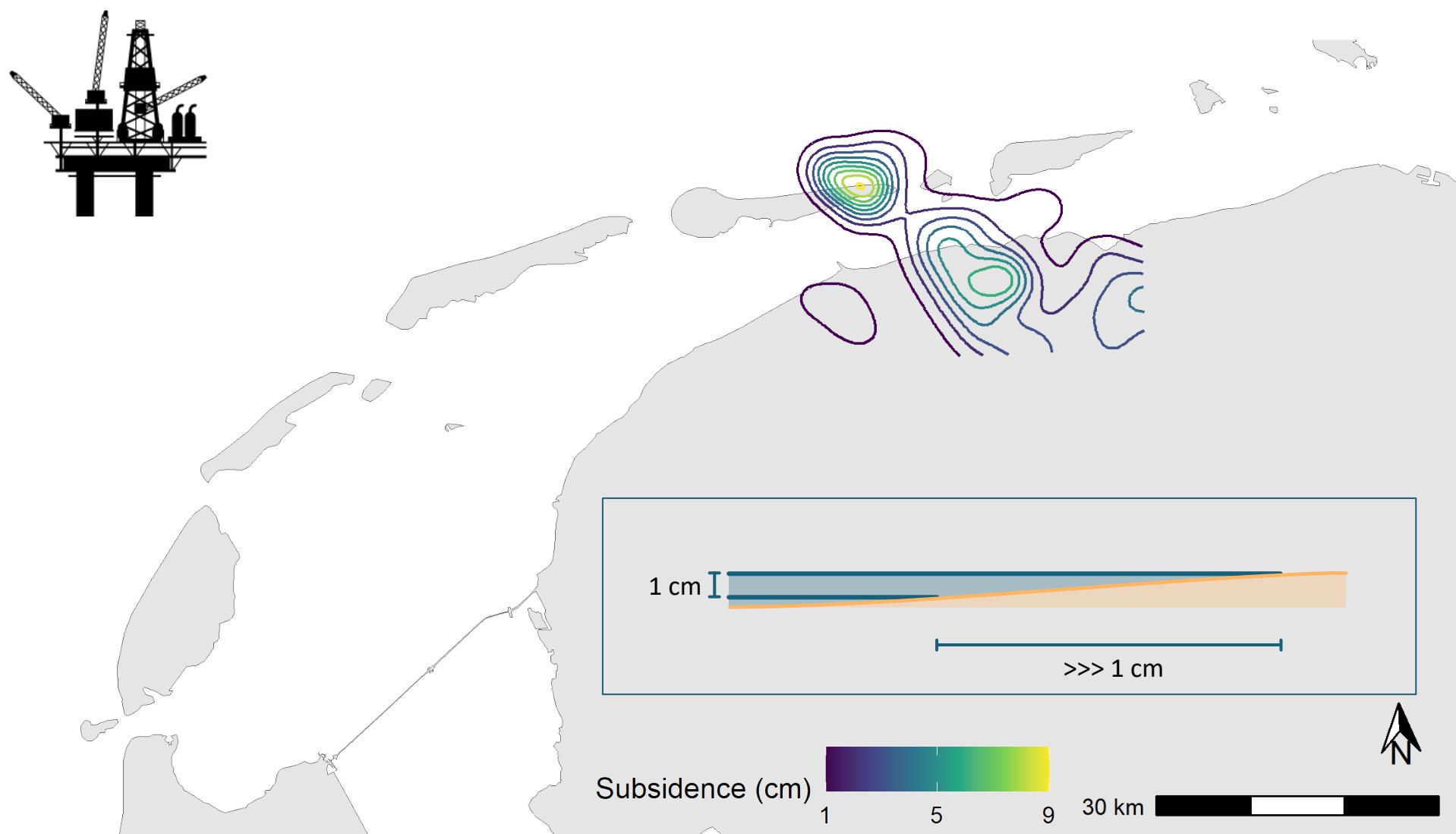


Exposure time

Hailley Danielson-Owczynsky



Does land subsidence affect habitat & invertebrates?



Does land subsidence affect habitat & invertebrates?



Subsidence

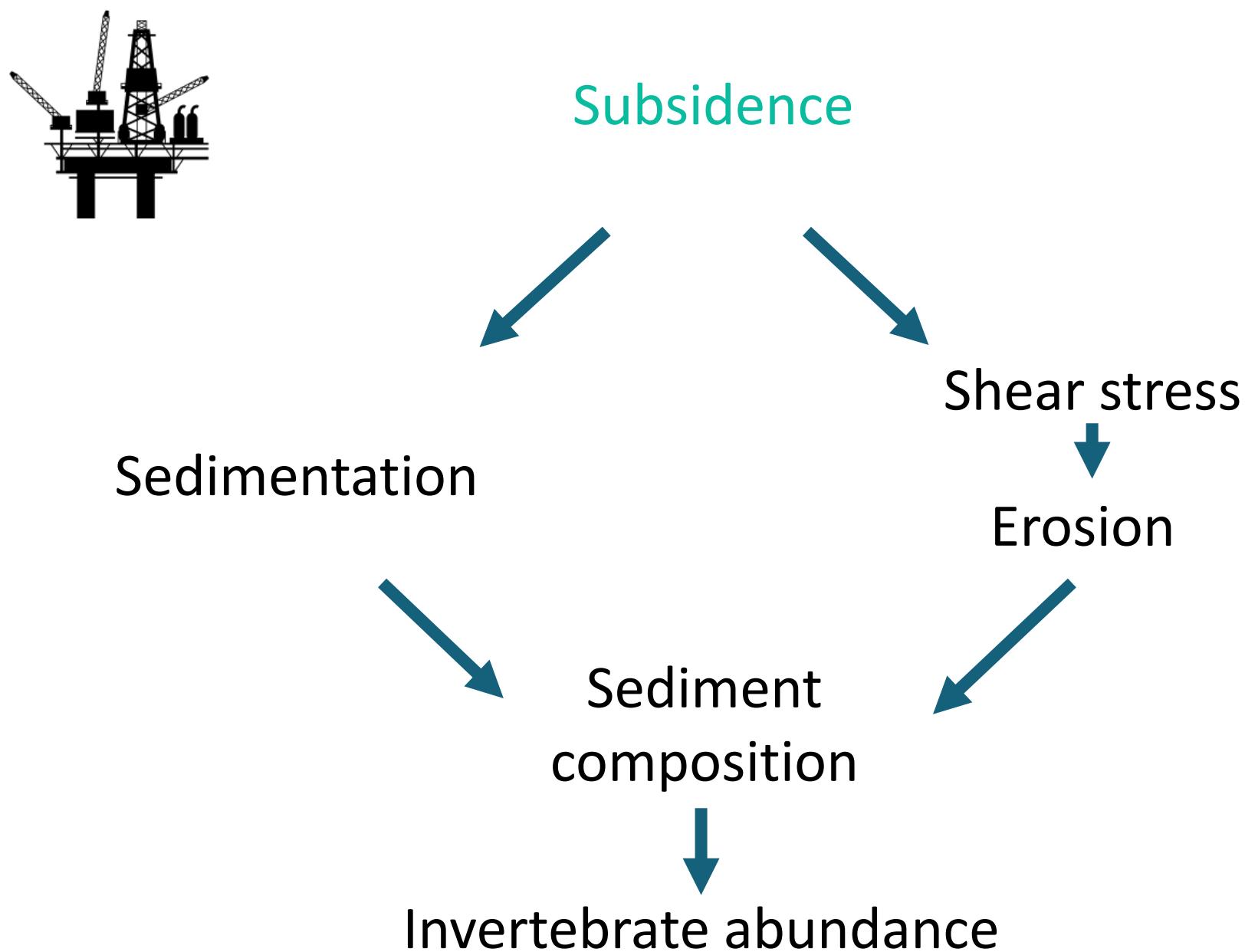


Sediment
composition



Invertebrate abundance

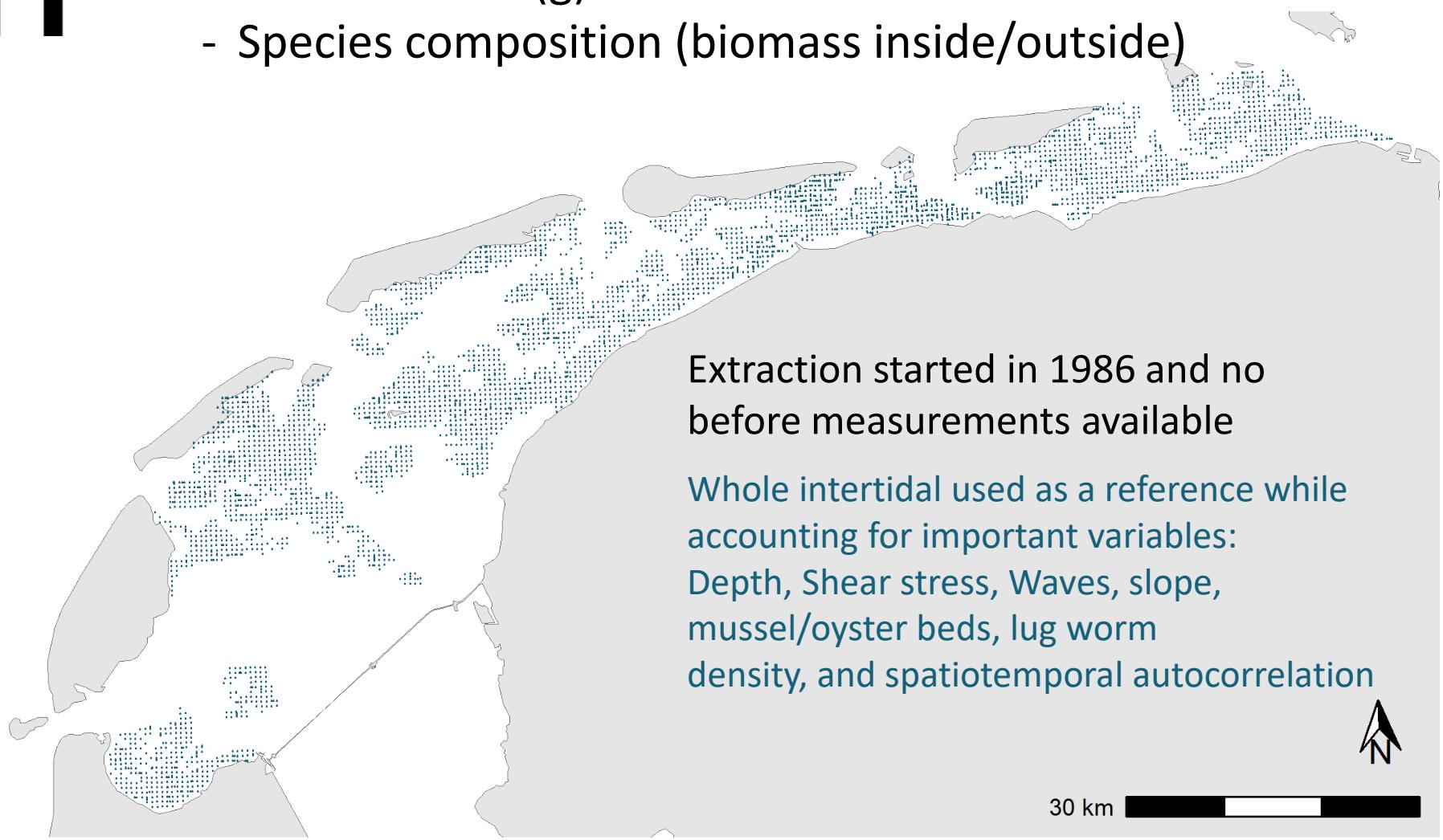
Does land subsidence affect habitat & invertebrates?



Does land subsidence affect habitat & invertebrates?



- Median grain size (μm)
- Mud content (%)
- Total biomass (g)
- Species composition (biomass inside/outside)



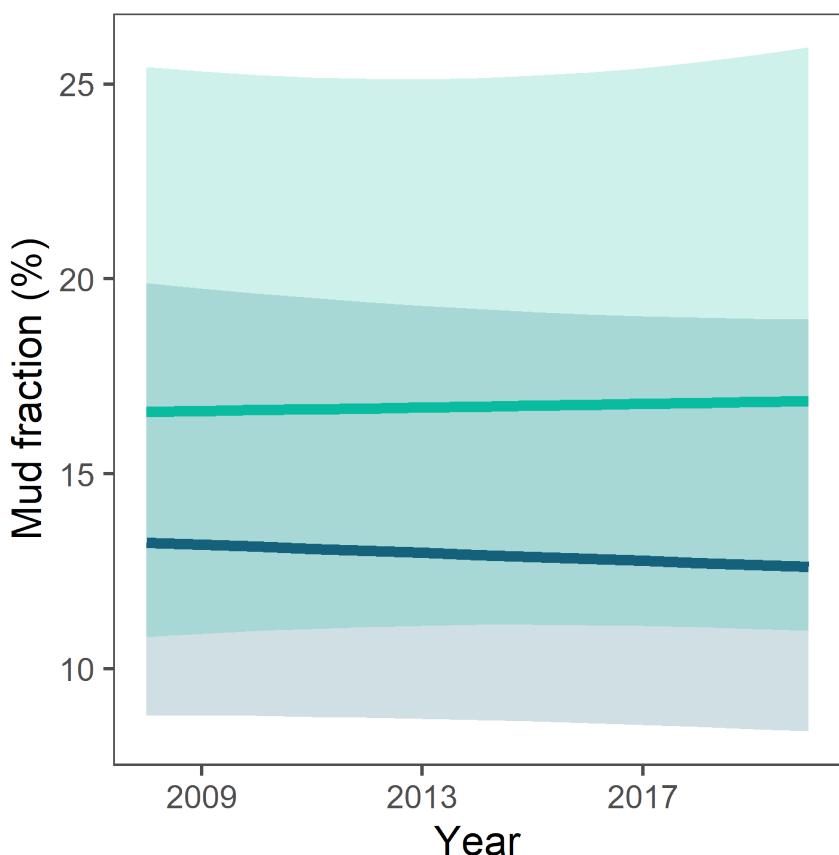
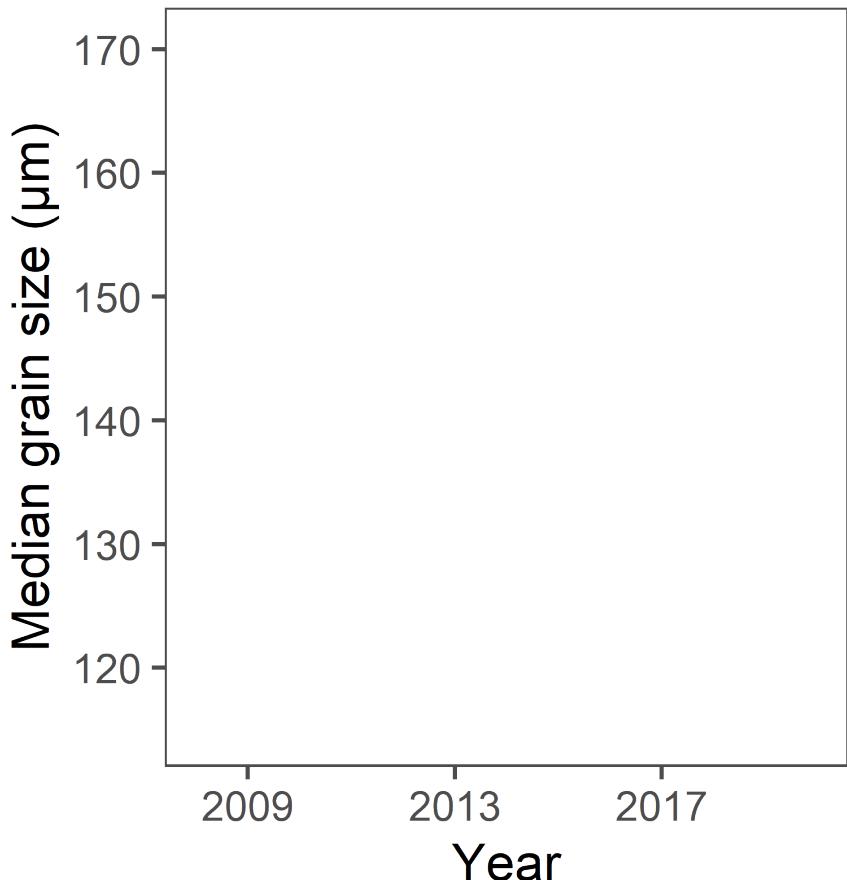
Extraction started in 1986 and no before measurements available

Whole intertidal used as a reference while accounting for important variables:
Depth, Shear stress, Waves, slope,
mussel/oyster beds, lug worm density, and spatiotemporal autocorrelation

Does land subsidence affect habitat & invertebrates?



- Median grain size is decreasing
- and the subsidence area is more muddy

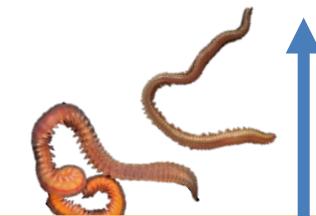
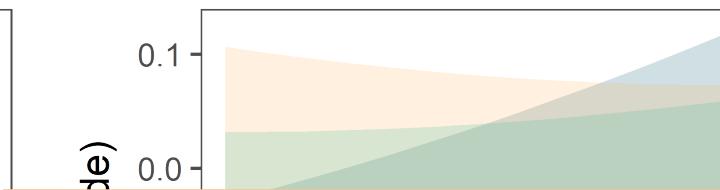
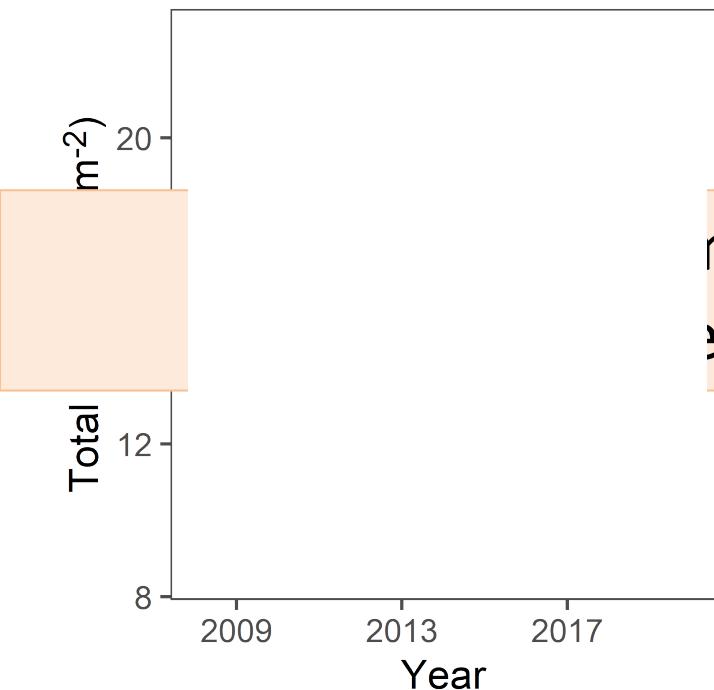


No subsidence Subsidence

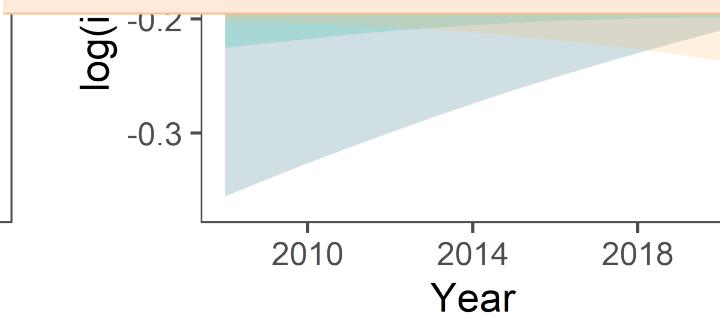
Does land subsidence affect habitat & invertebrates?



- Total biomass not statistically different
- But species composition is changing



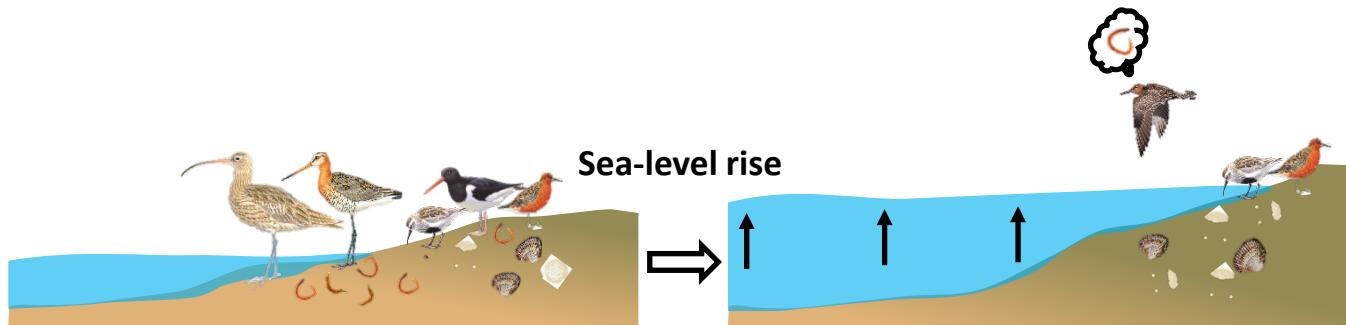
Inposition and the invertebrate
are different in gas extraction area



No subsidence Subsidence

Sea Level Rise

- Roughly 15 to 100 cm sea level rise for 2100, and a predicted area loss of 15-90% depending on IPCC scenario (Vermeersen et al 2018 and Wang et al 2018)
- Probably also sediment composition change
- With cascading effects from sediment to invertebrates to birds



Being such an important natural area, this will be disastrous

Summary



Birds



Benthic
invertebrates



Abiotic environment

- Mudflats might look the same, but are very different
- Sediment composition and inundation determine invertebrate community
- Invertebrates abundance determine where birds go and bird population size
- Wadden Sea is known for charismatic fauna, but invertebrates are the foundation of the food web (and sediment)
- Humans affect ecosystem with cascading effects from sediment to invertebrates and birds
- To increase climate-change resilience, remove pressures

Team work!

Anne Dekkinga, Frank van Maarseveen, Bas Denissen, Sivan Toledo, Job ten Horn, Luc de Monte, Roeland Bom, Emma Penning, Benjamin Gnepp, Selin Ersoy, Haley Shepherd, Christine Beardsworth, Paula de la Barra, Evy Gobbens, Elif Duran, Jena Edwards, Hailley Danielson-Owczynsky, Mark Rademaker, Margot Moen, Thomas Lameris, Martin Bulla, Eva Kok, Theunis Piersma, Rosemarie Kentie, Sander Holthuijsen, Loran Kleine Schaars, Job ten Horn, Jeroen Kooijman, Anita Koolhaas, Simone Miguel, Dennis Mosk, Bianka Rasch, Charlotte Saull, Eveline van Weerlee, Lotte Niemeijer, Patrick Snoeken, Henk van der Veer, Bram Fey, Klaas-Jan Daalder, Hein de Vries, Hendrik Jan Lokhorst, Ewout Adriaans, Wim-Jan Boon, Dave Huijsman, Johan van Heerwaarden, Martin Laan, Jeras de Jonge, Jesper van Bennekom, Aris van der Vis, Yetzo de Hoo, Ingrid de Raad, Marten Tacoma, NMF, COS, NIOZ and all volunteers and students!



www.nioz.nl/watlas

Photo: Benjamin Gnepp

Thank you for listening, questions?

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**Any questions later?
Contact me!**

