Technische Universität Braunschweig

Leichtweiß-Institut

Roughness effects of oyster reefs and blue mussel beds in the German Wadden Sea – the BIVA-WATT project

Jan Hitzegrad, L. Brohmann, K. Pfennings, T. Hoffmann, A. Wehrmann, M. Paul, N. Goseberg, T. Schlurmann

Agenda

1. Motivation
2. Objectives
3. Preliminary analysis
4. Conclusion & Outlook

Partners:

Technische Universität Braunschweig

Leichtweiß-Institut

ITE

Leibniz Universität Hannover

Ludwig-Franzius-Institut für Wasserbau, Ästuar- und Küsteningenieurwesen

SENCKENBERG world of biodiversity

smile consult

Associated partners:

Niedersächsischer Landesbetrieb für Wasserwirtschaft, Küsten- und Naturschutz NLWKN

BAW Bundesanstalt für Wasserbau

Motivation

Pacific oyster as invasive species

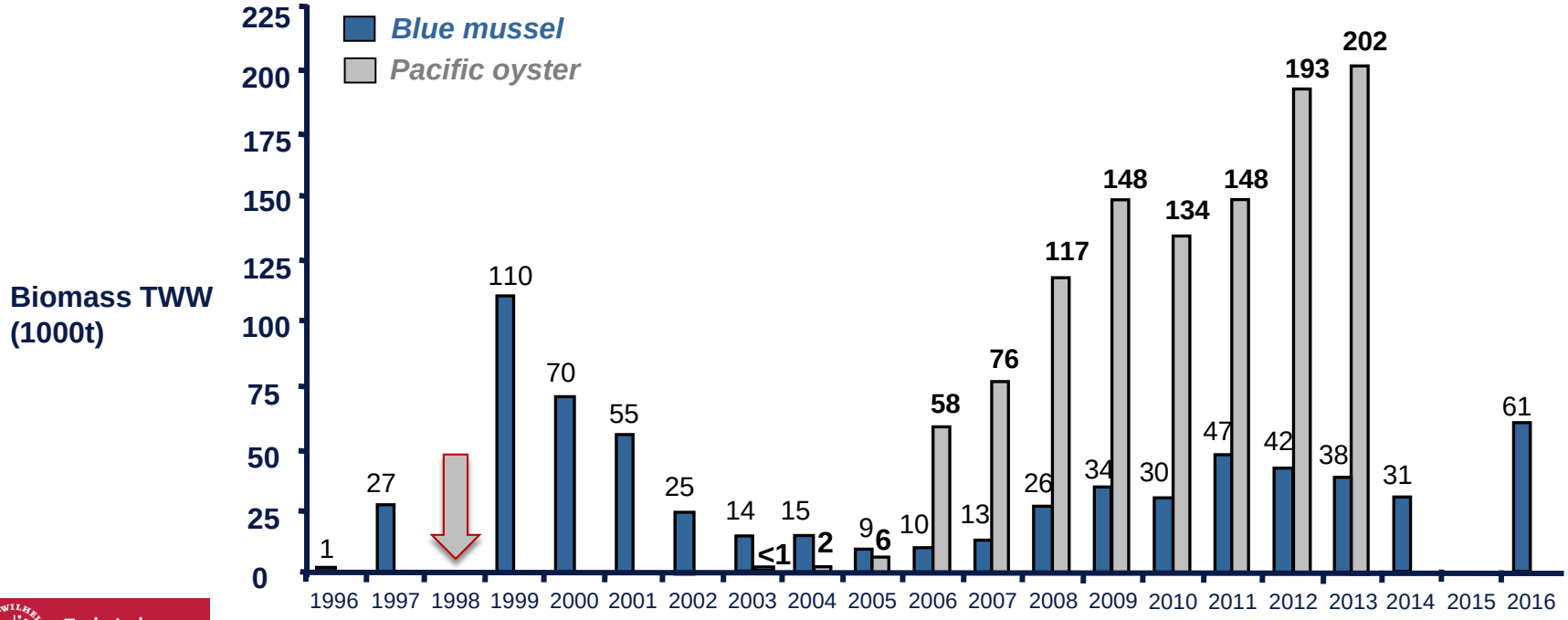
- Formerly native blue mussel beds (*Mytilus edulis*) accounted for 5 – 6 % of the area in the Wadden Sea
- Since 1998 populated by the introduced Pacific oyster (*Crassostrea gigas*)

Oyster reef Nordland, Oct. 2019

Motivation

* Area data and biomass *M. edulis* (1996-2005, 2014-16) Nationalparkverwaltung Nieders. Wattenmeer

Pacific oyster as invasive species in Lower Saxony



Motivation

Pacific oyster as invasive species

- Lower Saxon Wadden Sea
  - 2005: 6 t – 1 000 ha
  - 2013: 202 000 t – 1 800 ha


Merkliste | Login | Registrieren

WESER KURIER

WESER KURIER

TAGESZEITUNG FÜR BREMEN UND NIEDERSACHSEN

START | BREMEN | REGION | WERDER | SPORT | DEUTSCHLAND & WELT | THEMENWELT | V

Politik Wirtschaft Kultur Vermischtes

Startseite » Deutschland & Welt » Vermischtes » Plage in Nordsee: Pazifische Auster gestaltet Wattenmeer um

Aus Muschel-Farmen geflüchtet

Plage in Nordsee: Pazifische Auster gestaltet Wattenmeer um

- 12.11.2017 - 1 Kommentar

Jobs

z.B. Koch

Ort

- Current status:
  - Oyster reefs in Lower Saxony
  - Oyster reefs, mixed beds and mussels beds in Schleswig Holstein

Motivation

Characteristics of Pacific oysters

- Large roughness heights $k > 30$ cm
- Formation of rigid structures inducing scour
- Often located in spatial proximity to morphodynamic active tidal channels
- Resilient to waves and ice drift

Oysters [illegible] 2019

Motivation

State of knowledge

- Few laboratory and numerical studies regarding life **blue mussels** in currents
- One field study investigating wave forcing over an **blue mussel** bed including few storm events by Donkers et al. (2012)

→ Little to no investigations regarding roughness effects of **Pacific oyster** reefs in European waters

Motivation

Knowledge gaps

- Internal **structure** and **morphodynamics** of the mussel beds and oyster reefs
- Interactions of mussel beds and oyster reefs with **waves**
- Interactions of mussel beds and oyster reefs with **tidal currents**
- Interactions of mussel beds and oyster reefs with **combinations of waves and currents**

Agenda

1. Motivation
2. **Objectives**
3. Preliminary analysis
4. Conclusion & Outlook

Objectives

Determine roughness effects of oyster reefs and mussel beds

in the German Wadden Sea

Objectives

Objective 1

Parametrization of natural roughnesses of the biogenic structures

Development of surrogate models of the biogenic structures

Objective 2

Determination of the roughness length z_0 due to currents for both bivalve species

Determination of wave friction factor f_w for both bivalve species

Objective 3

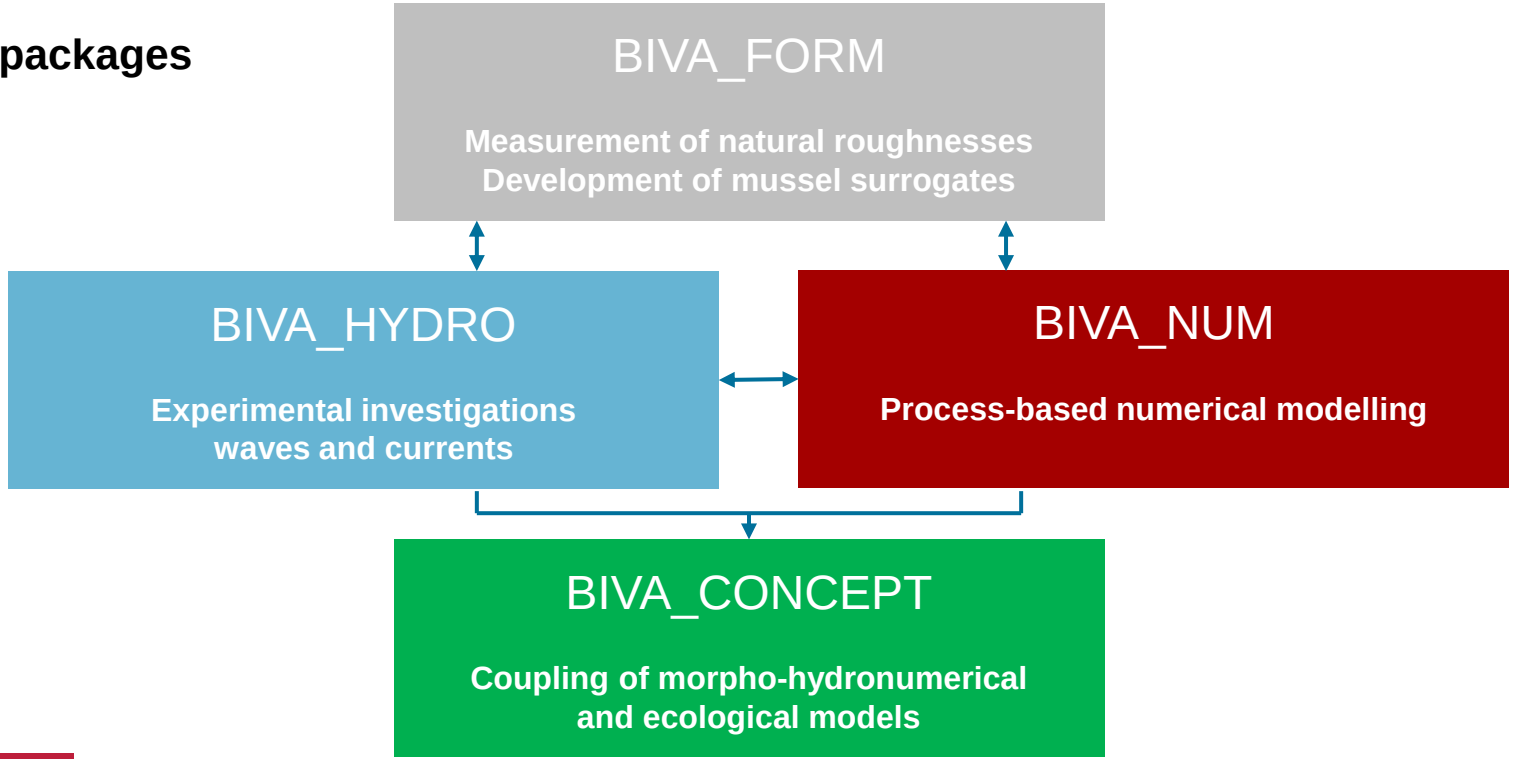
Numerical simulation of the near field of around individual bivalves

Objective 4

Conception and implementation of coupling strategies in morpho-hydronumerical models

Objectives

Work packages



Agenda

1. Motivation

2. Objectives and work flow

3. **Preliminary analysis**

4. Conclusion & Outlook

Preliminary analysis

Field Studies Fall 2019

Preliminary analysis

Field Studies Fall 2019

Oyster reef Kaiserbalje, Nov. 2019

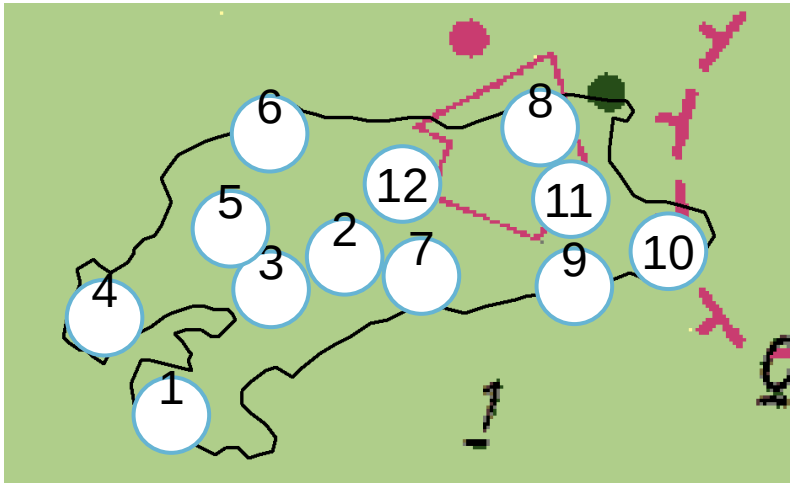
Mussel bed Nordstrand, Nov. 2019

Preliminary analysis

Population dynamics – Nordland, Juist

12 stations

- bed/reef (100 % internal coverage)
- 0.25 m x 0.25 m

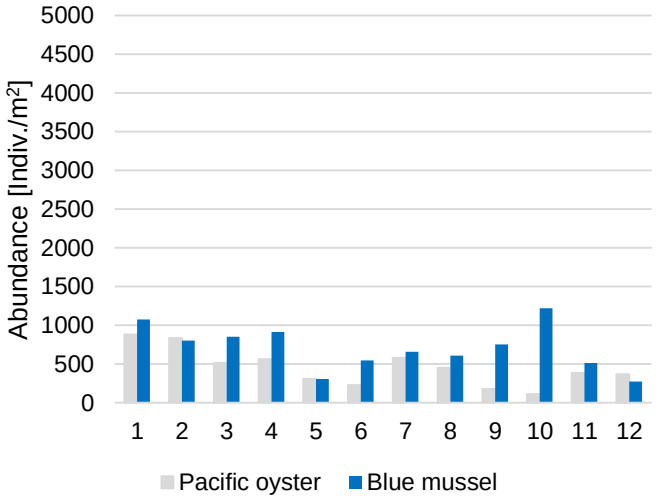


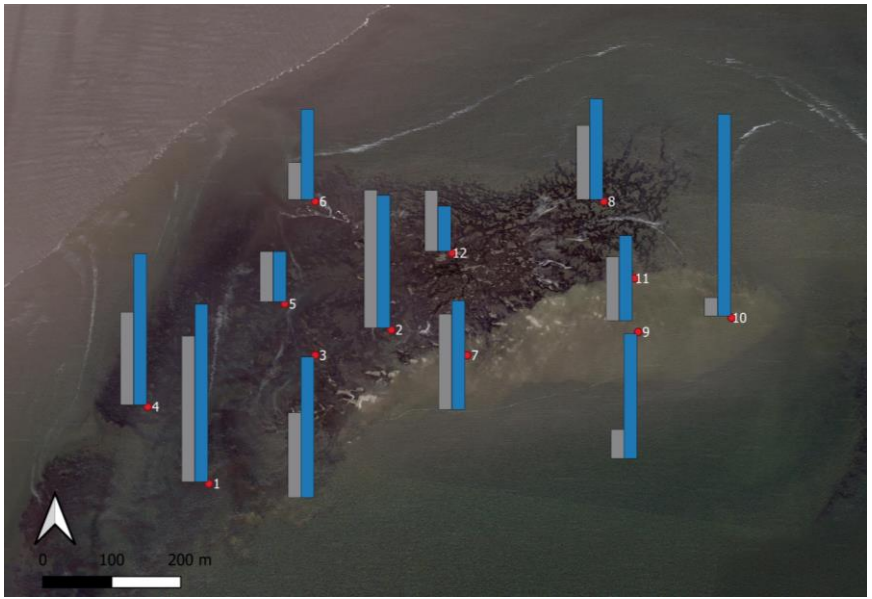
Nordland, Juist

Preliminary analysis

Population dynamics – Nordland, Juist

Abundances - life individuals per m²



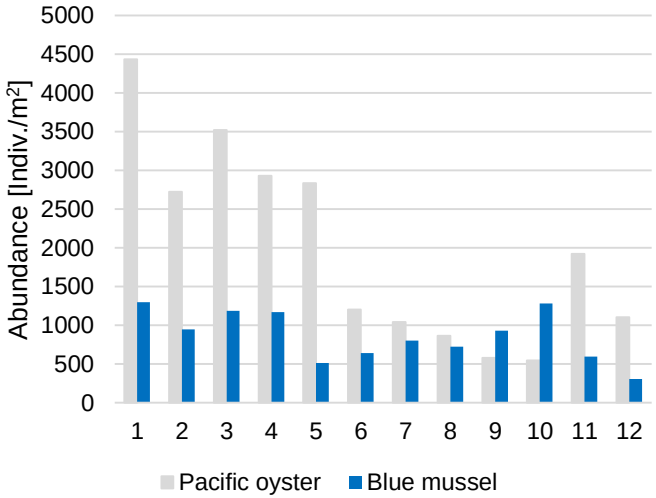


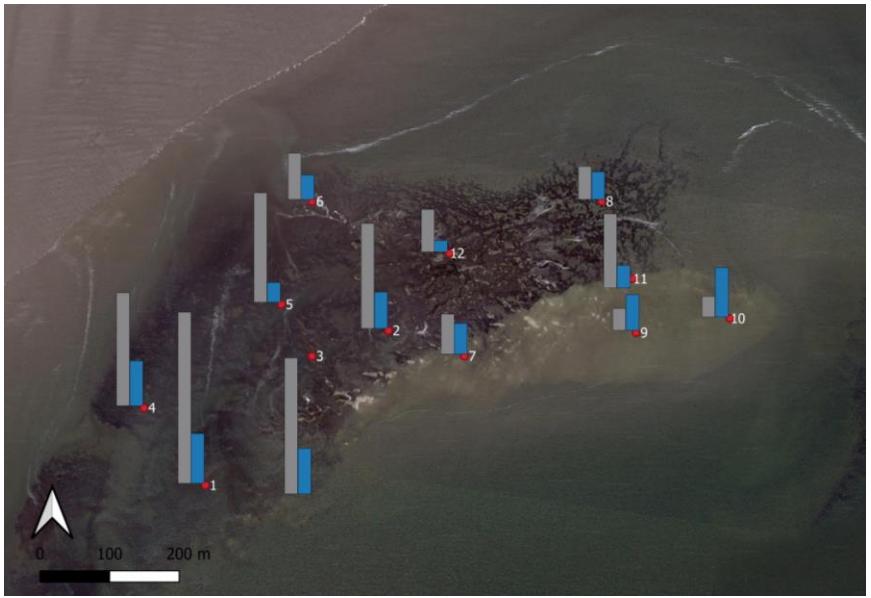
Nordland, Juist

Preliminary analysis

Population dynamics – Nordland, Juist

Abundances - total individuals per m²



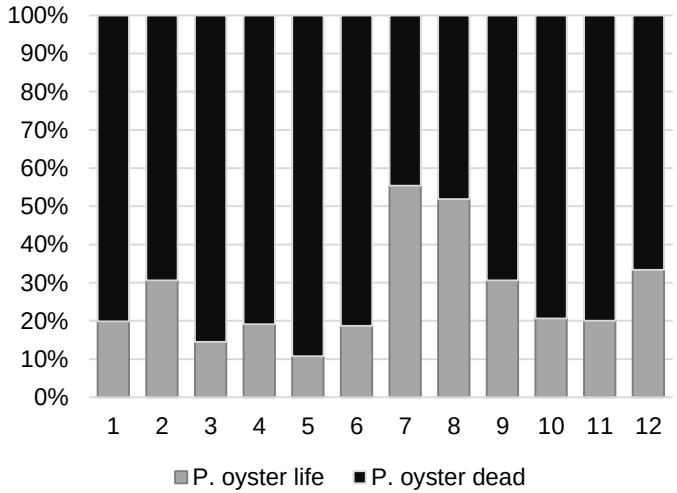


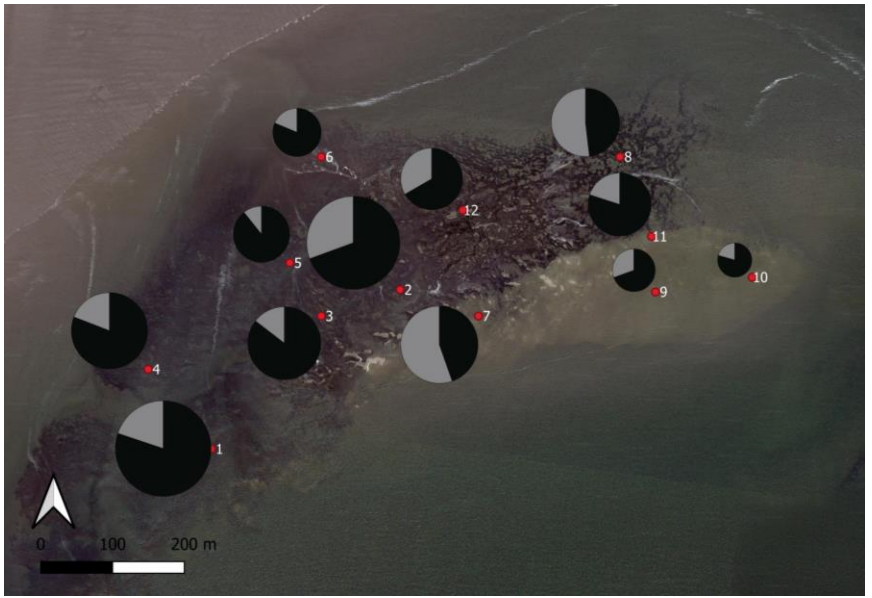
Nordland, Juist

Preliminary analysis

Population dynamics – Nordland, Juist

Relative abundance P. oyster life / dead



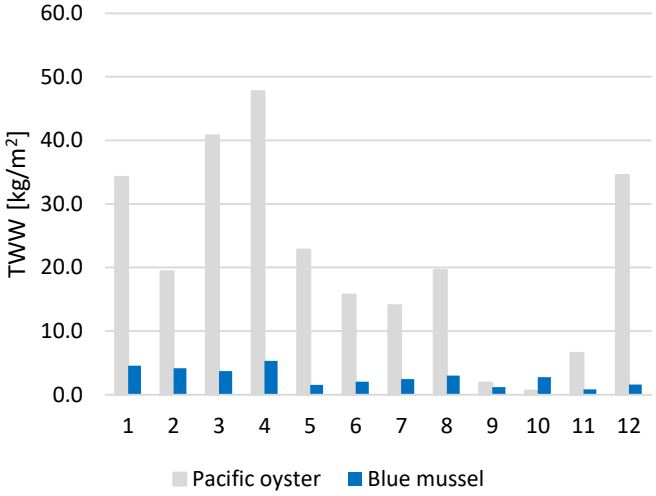


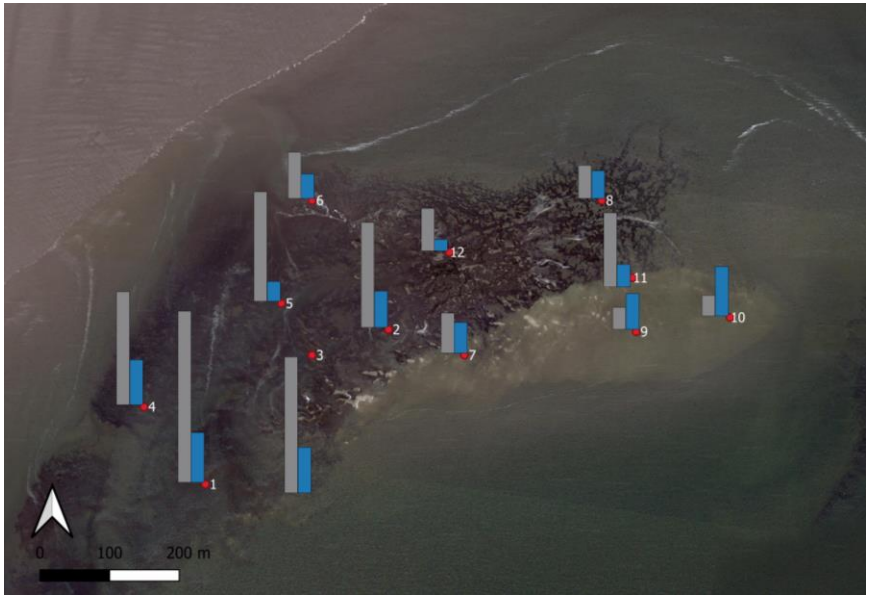
Nordland, Juist

Preliminary analysis

Population dynamics – Nordland, Juist

Biomass per m^2

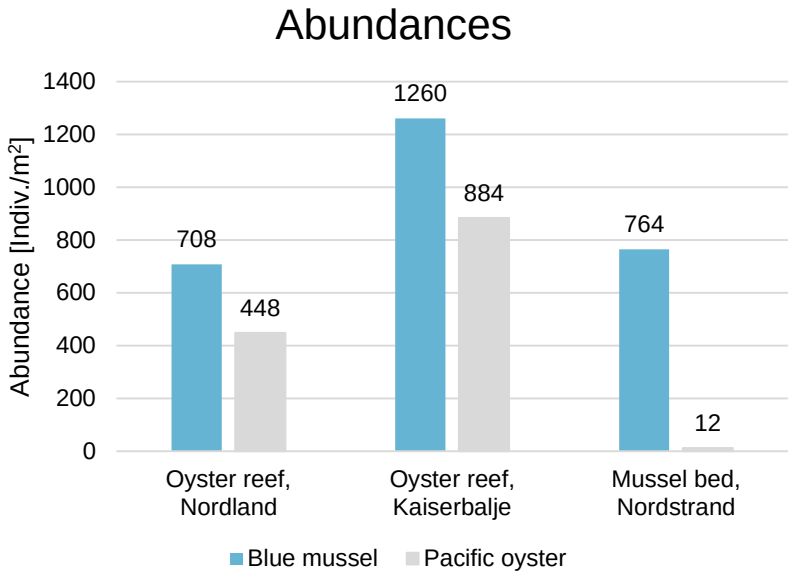


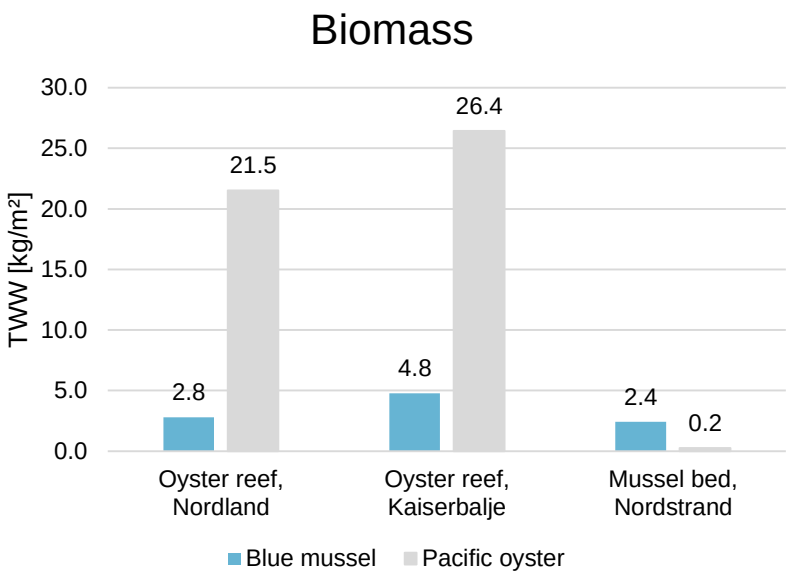


Nordland, Juist

Preliminary analysis

Population dynamics – site comparison

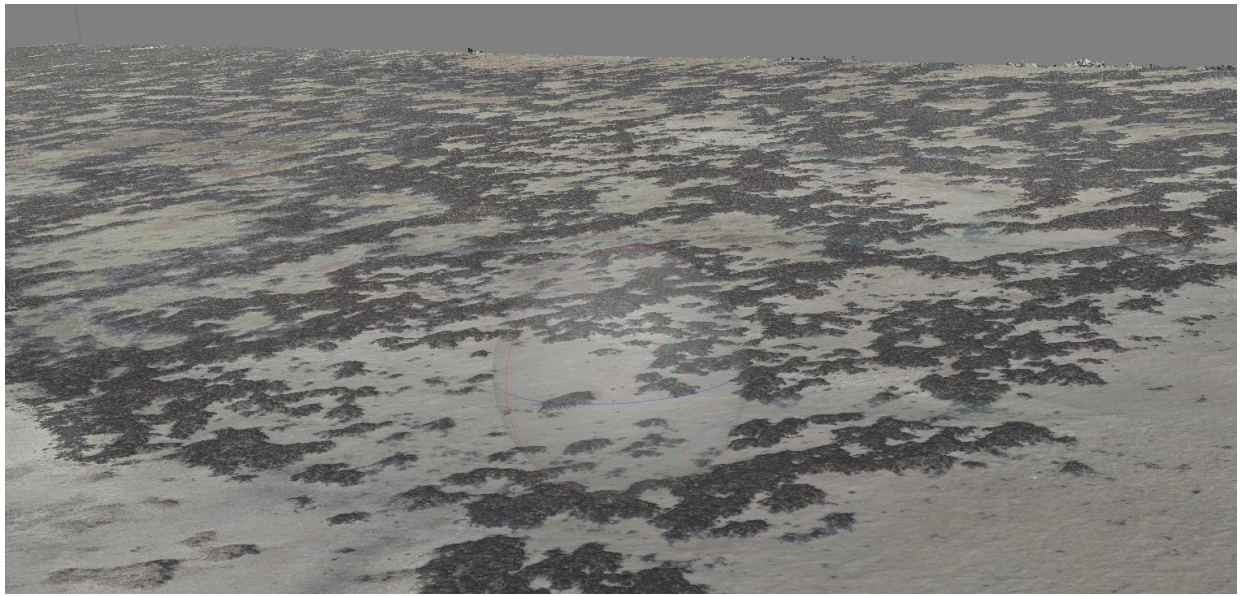




Preliminary analysis

Digital terrain models – Entire reef model

- Entire reef
- ~ 2000 m x 2000 m
- Drone photogrammetry

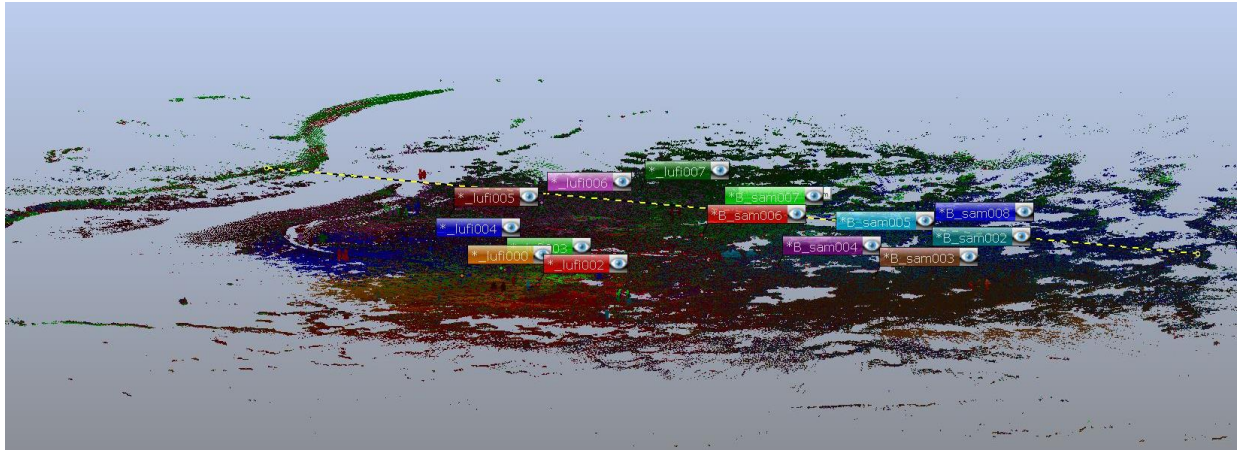


DTM, Oyster reef Nordland

Preliminary analysis

Digital terrain models – Detailed sections

- Detailed model in hydro-morphodynamic interesting section
- ~ 100 m x 100 m
- 3D Laser Scan

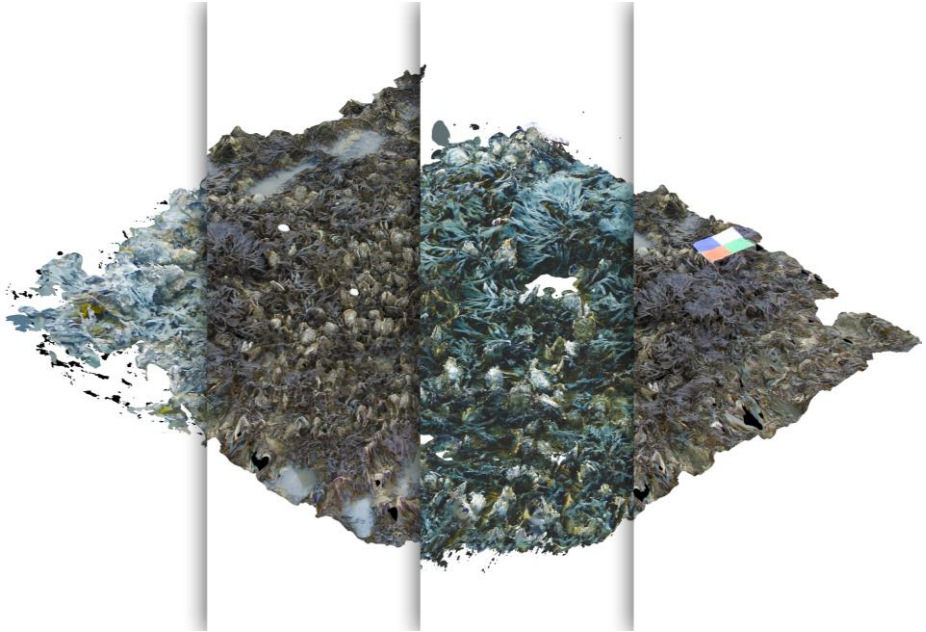


Point cloud, Oyster reef Nordland

Preliminary analysis

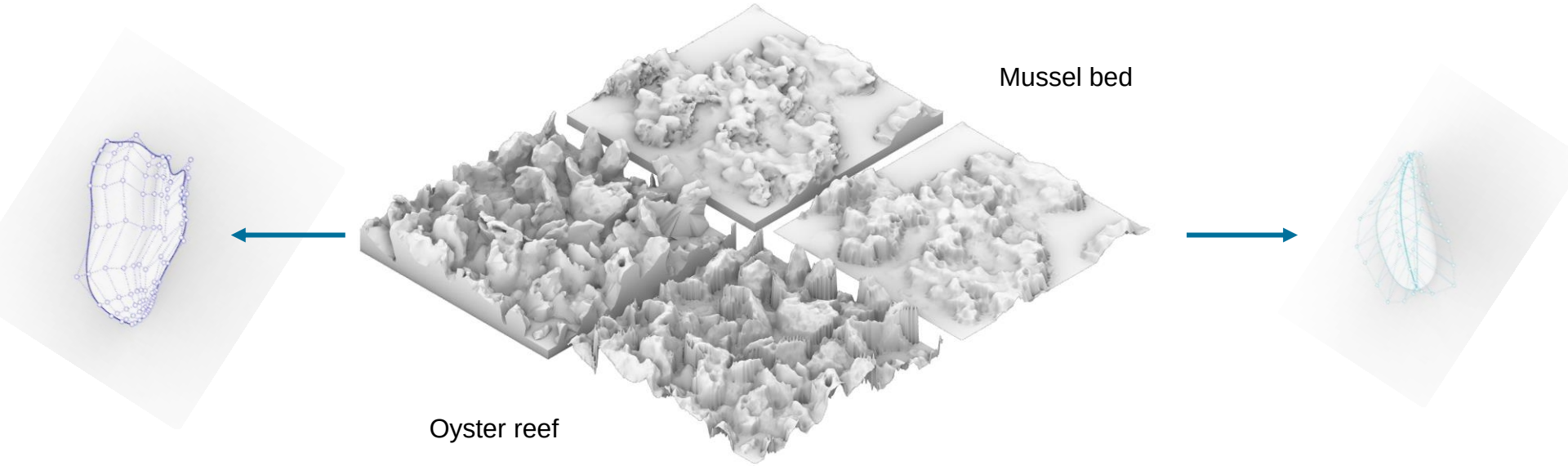
Digital terrain models – Structure types

- ~ 1.0 m x 1.0 m
- Photogrammetry
- 3D Laser Scan



Preliminary analysis

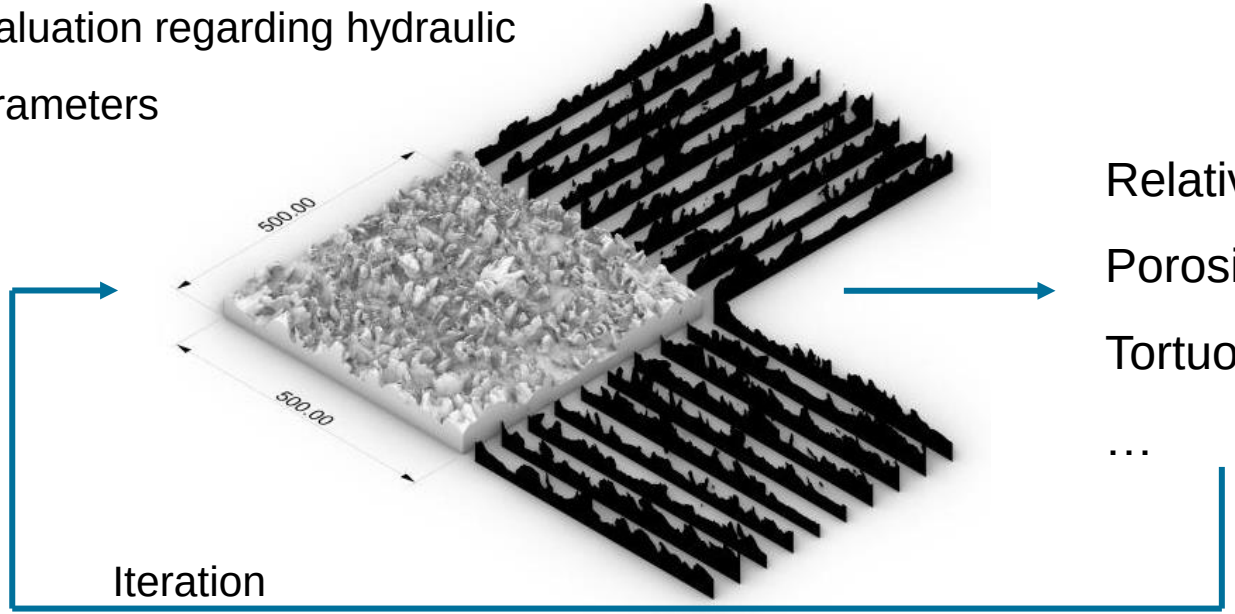
Development of surrogate models



Preliminary analysis

Development of surrogate models

- Evaluation regarding hydraulic parameters



Preliminary analysis

Structure types

1. Reef
2. Patch I
3. Patch II
4. Transitional zone
5. Garland
6. Cluster I
7. Cluster II

Reef

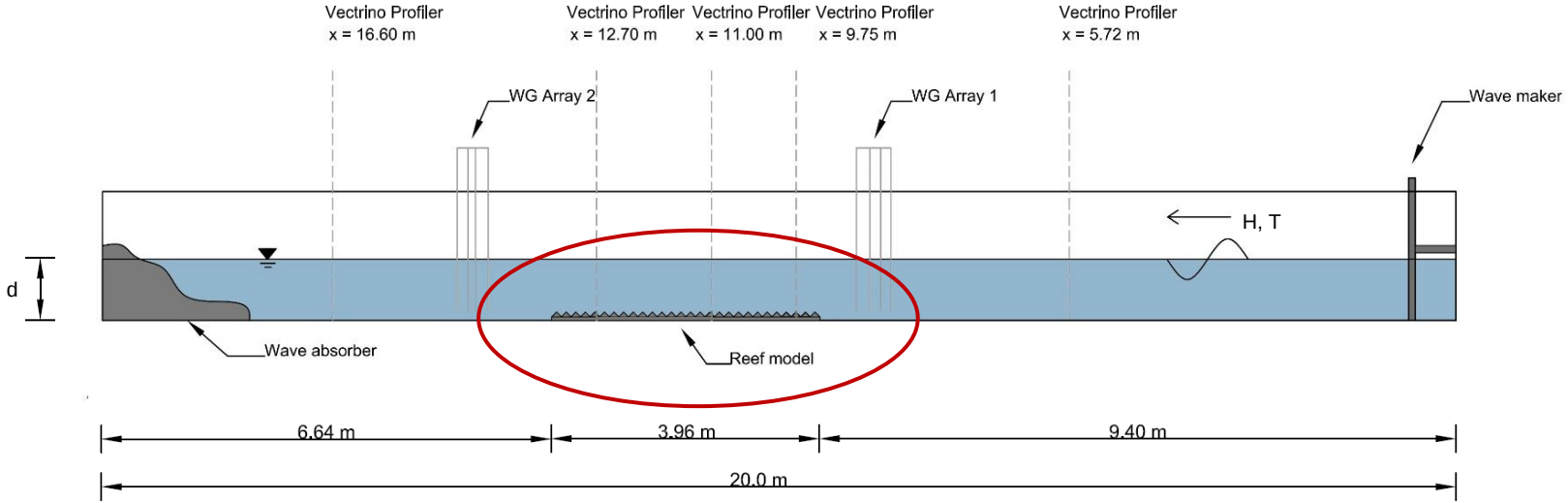
Patch II

Cluster I

Preliminary analysis

Preliminary laboratory 2D experiments

- Berliner Rinne – LWI TU BS

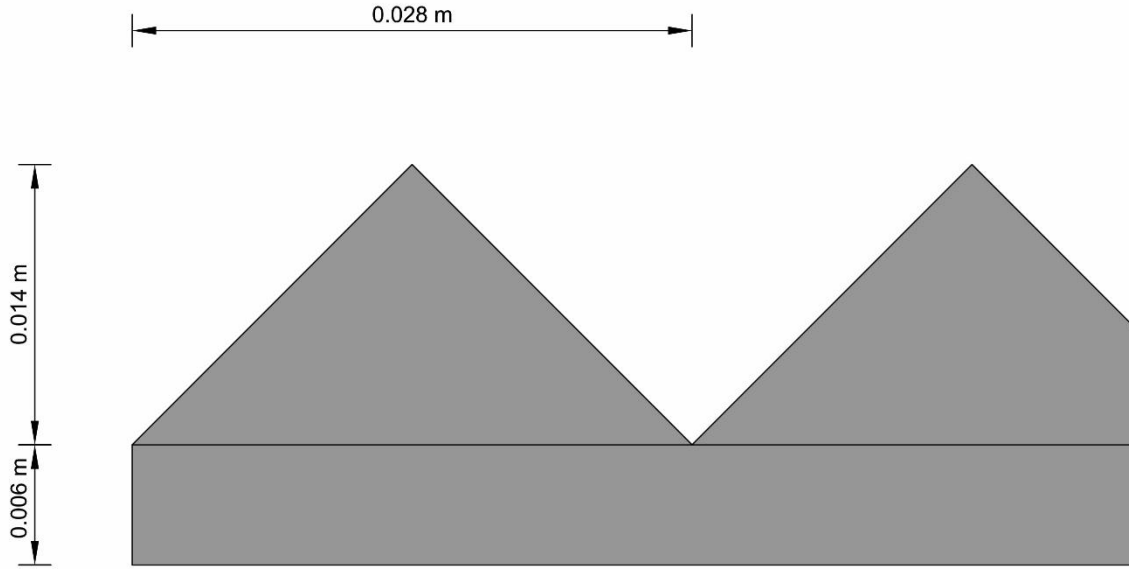


Preliminary analysis

Preliminary laboratory 2D experiments

- Simplified reef model
- Regular pyramid structure
- k = 14 mm

→ Scaling factor 1:10 – 1:20



Preliminary Analysis

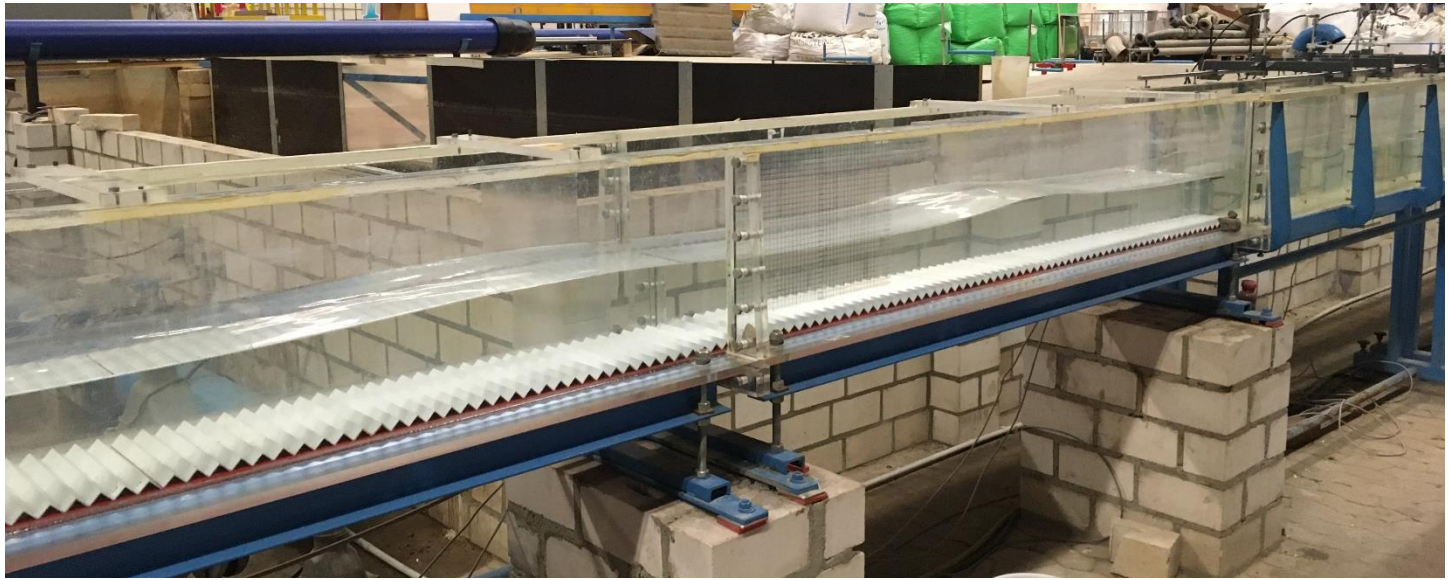
Preliminary laboratory 2D experiments

Test programme

Water Depth d [m]	Period T [s]	Wave Height H [m]	Wave length L [m]	Reef model
0.13	1.01	~ 0.040	1.18	with/ without
0.18	1.01	~ 0.050	1.34	with/ without
0.22	1.01	~ 0.058	1.44	with/ without
0.28	1.01	~ 0.065	1.91	with/ without

Preliminary analysis

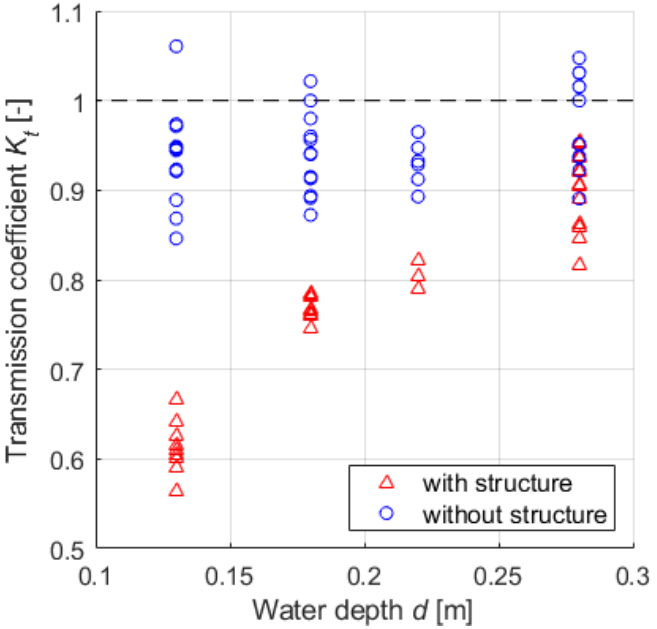
Preliminary laboratory 2D experiments



Preliminary Analysis

Surface level elevations

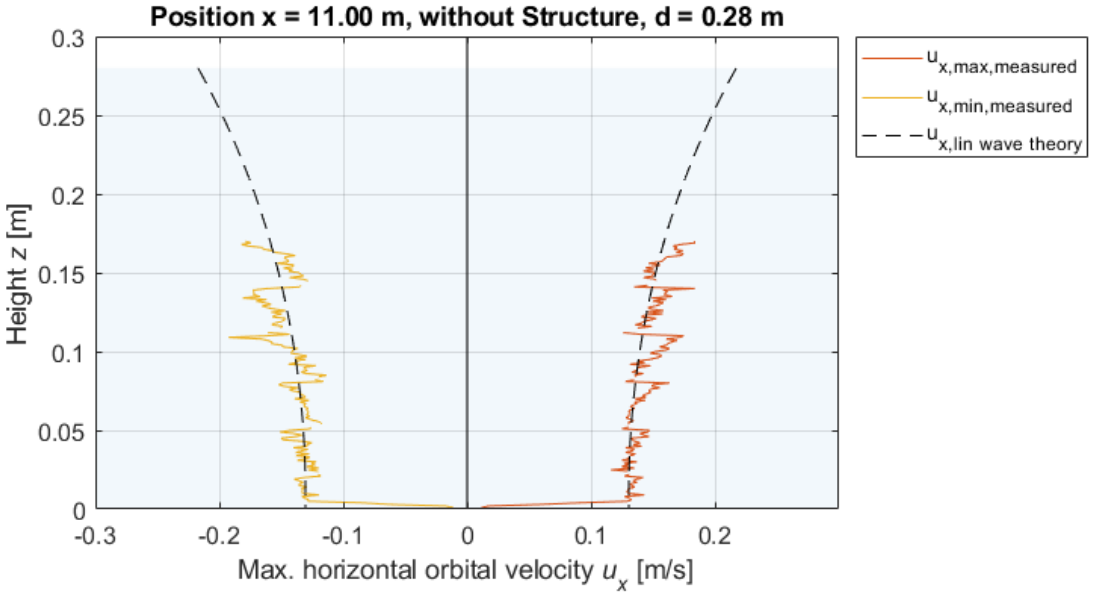
- Transmission coefficient K_t



Preliminary Analysis

Velocity measurements

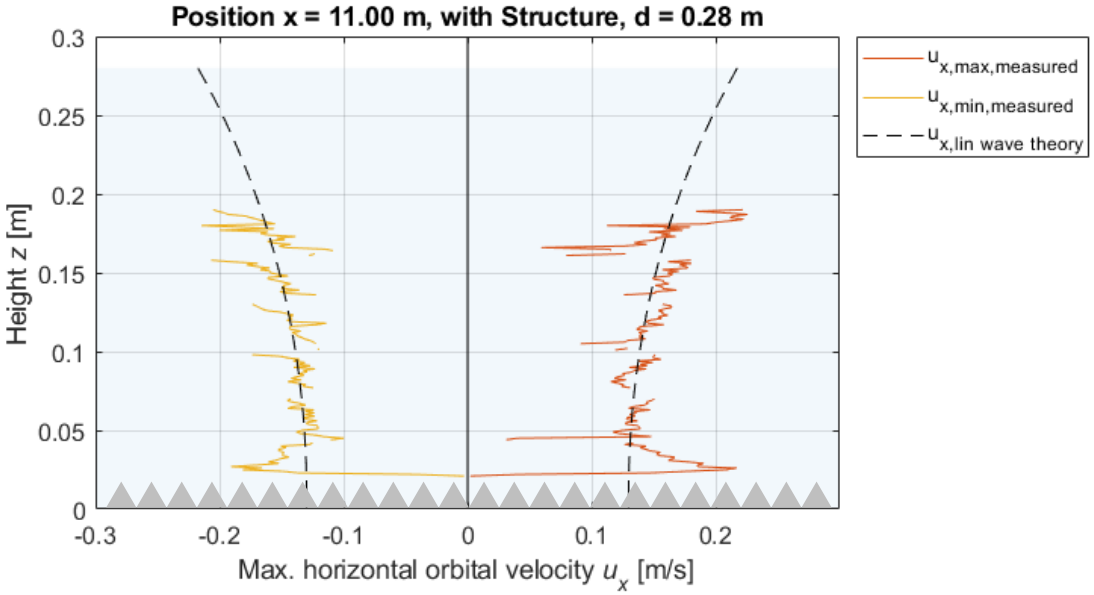
- Velocity profile of the maximal horizontal orbital velocities u_x **without** structure



Preliminary Analysis

Velocity measurements

- Velocity profile of the maximal horizontal orbital velocities u_x **with** structure



Preliminary Analysis

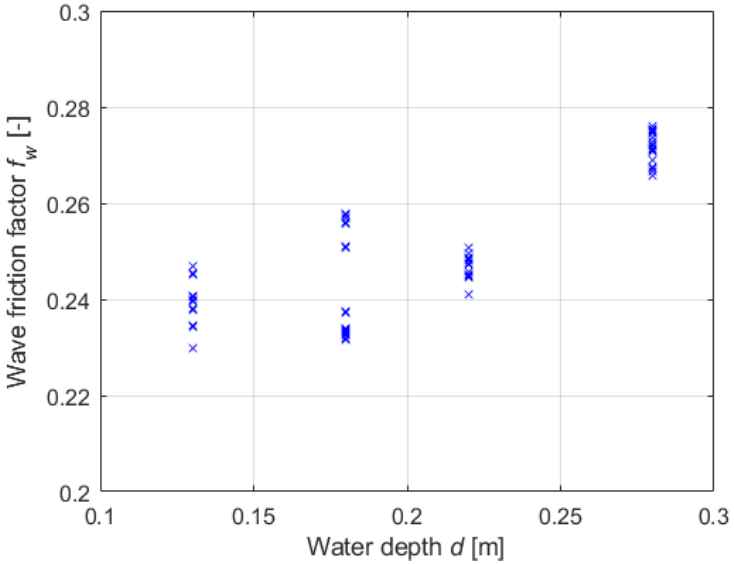
Wave friction factor f_w

- Determination according to Nielsen (1992)

$$f_w = \exp\left(5.5\left(\frac{A_b}{k}\right)^{-0.2} - 6.3\right)$$

where: k = 14 mm

→ Similar results as studies with coral reefs



Agenda

1. Motivation

2. Objectives and work flow

3. Preliminary analysis

4. **Conclusion & Outlook**

Conclusion and Outlook

Objective

- Determine roughness effects of oyster reefs and blue mussel beds

Preliminary investigations

- Population dynamics for the three tested sites for fall 2019
- Development of digital terrain models at full-reef scale, detailed section and structure-type scale
- Preliminary laboratory investigations of a simplifed reef model subjected to waves

Conclusion and Outlook

Next steps:

→ Field studies in half-yearly rhythm to monitor spatio-temporal developments

→ Detailed laboratory studies to investigate interactions of both bivalve species with waves, currents by using parameterized surrogate models

→ Development of a numerical model using laboratory experiments as validation

Technische Universität Braunschweig

Leichtweiß-Institut

SPONSORED BY THE

Federal Ministry of Education and Research

Thank you for your kind attention!

Jan Hitzegrad | The BIVA-WATT project | FZK Kolloquium | 05.03.2020