# Realized

| CONVENTIONAL | | INNOVATIVE |
|---|---|---|
|  Bird counting | 1. Bird Numbers | Drone  |
|  Sediment Core | 2. Benthos as bird food | DQ-Method  |
| X | 3. Benthos as bioturbator | Camera-redox core  |
|  RTK-DGPS | 4. Medium scale morphology | Drone  |
|  LIDAR | 5. Large-scale morphology | Drone  X 1 Echosounder |
| X | 6. Short-term (daily) changes in sediment height | Acoustic SED/sensor  |
|  Sediment sample | 7. Soil density | Acoustic SED/sensor |
|  Aquadopps and wave gauge | 8. Hydrodynamics: flow / waves | Bio-Phys sensor  |
| X | 9. Sediment concentrations in water | Stand-alone sensor  |
| X | X2. Benthos feeding behavior | Valve gaping mode – BioPhys  |
| | X3. long-term continuous observation | Water-proof interval camera  |
| | X4. Sub tidal biodiversity monitoring | Underwater vacuum cleaner  Photogrammetry  |

# Bird Number: Drones

| CONVENTIONAL | | INNOVATIVE |
|---|---|---|
|  Bird counting | 1. Bird Numbers | DRONE  |

- Birds are key species in Natura 2000 áreas;
- Can we use drones for Bird monitoring on tidal flats?
  - Species identification and quantification;

# Results

| CONVENTIONAL | | INNOVATIVE |
|---|---|---|
|  Bird counting | 1. Bird Numbers | DRONE  |

- Bird counting was possible 100m away and 40m high;
- Bird identification:
  - 40m away and 15m high
  - 20m away and 25m high

# Results

- Results with camera resolution 17MP and 8.8mm focal lenght

# Results

| CONVENTIONAL | | INNOVATIVE |
|---|---|---|
|  Bird counting | 1. Bird Numbers | DRONE  |

- Specs for Bird identification (drone flying at 50 m):
  - Same camera: camera resolution of 975MP
  - Best camera for an inspire 2 (45mm focal lenght): camera resolution of 80MP (max. resolution available 20MP)

# Results

| CONVENTIONAL | | INNOVATIVE |
|---|---|---|
|  Bird counting | 1. Bird Numbers | DRONE  |

- Birds seem to get used to the drone
- Season may influence the number and behavior of birds;
- Paper in preparation;





# Realized

| CONVENTIONAL | | INNOVATIVE |
|---|---|---|
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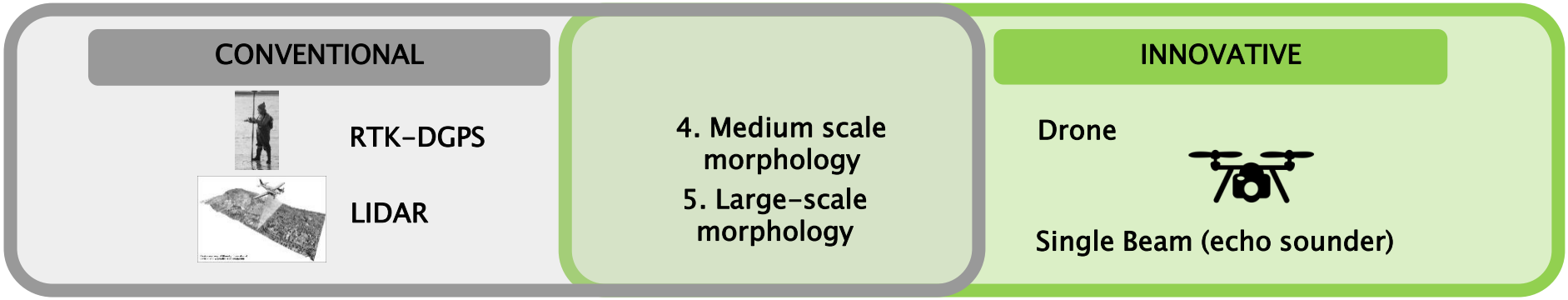
| | X4. Sub tidal biodiversity monitoring | Underwater vacuum cleaner   Photogrammetry |

# Medium and Large scale Morphology

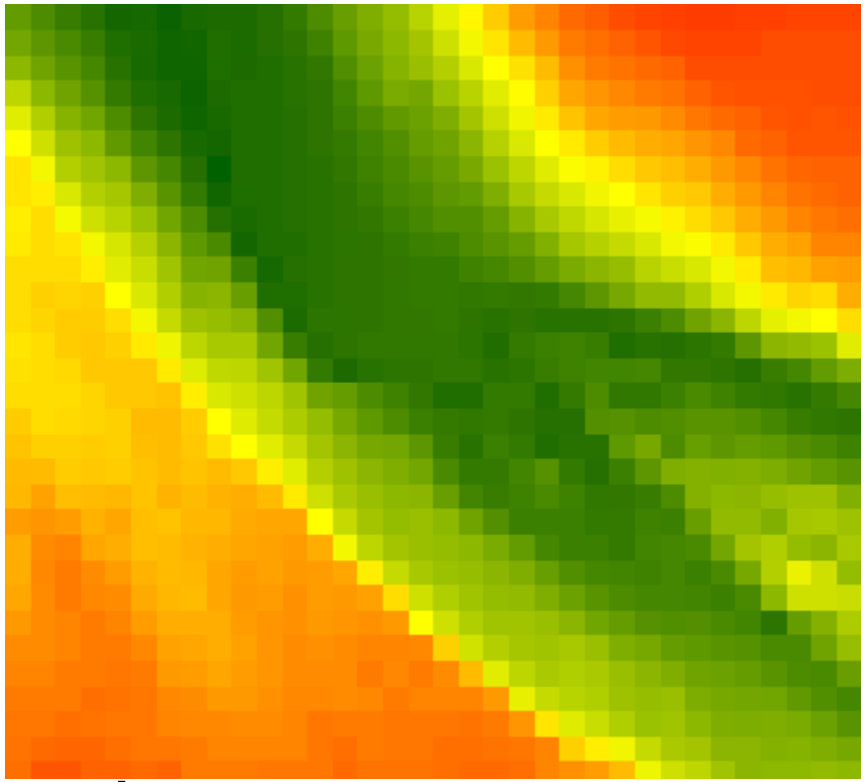



- It is important to understand the morphological changes:
  - insight to the functioning of tidal ecosystems;
  - Assessment of restoration measures;

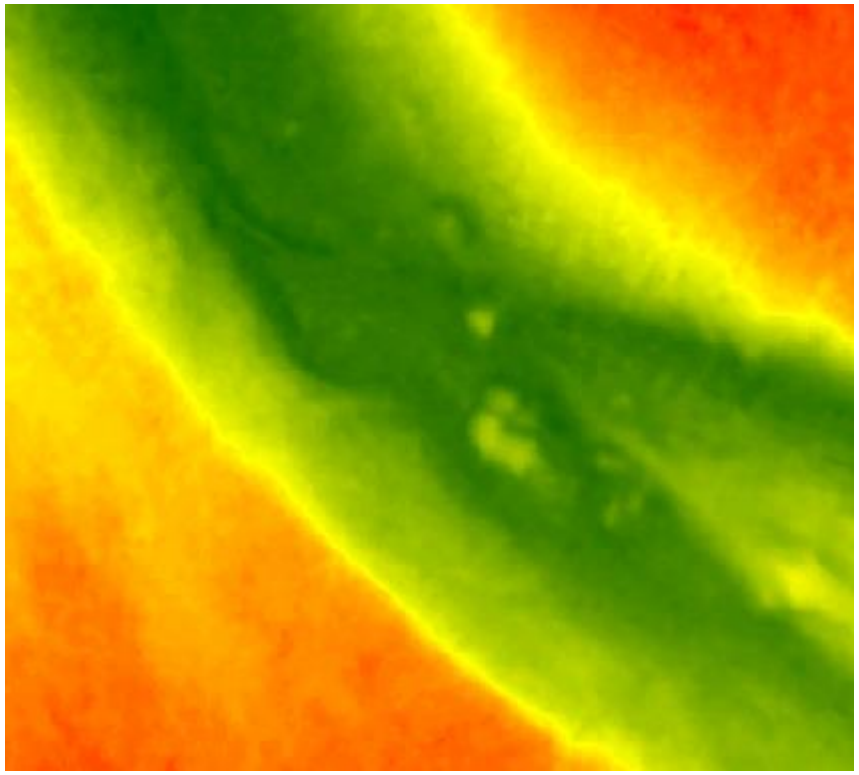
# Results Drone

Comparison Lidar Vs. Drone

- High Resolution:



Lidar DEM: 2X2 m

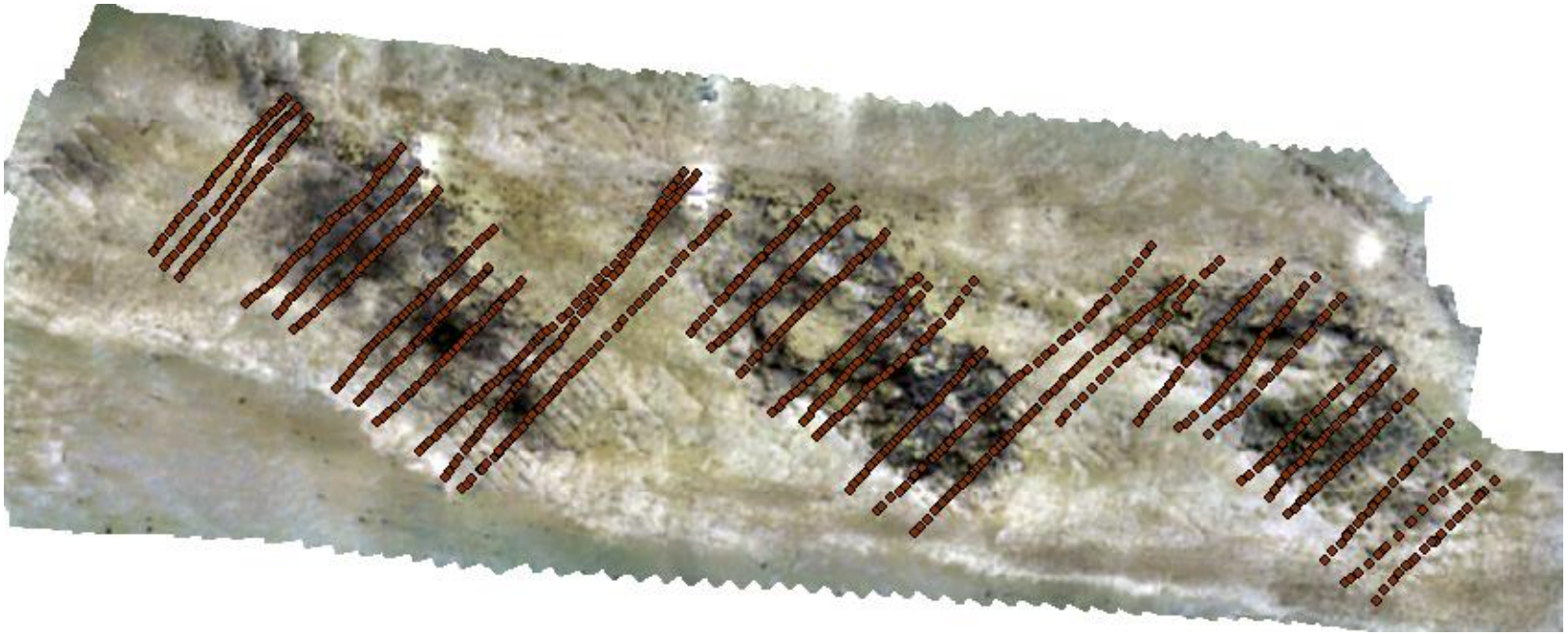


Drone DEM: 0.14X0.14 m

# Results

## Viane (Oosterschelde) – MMM project

- Method:
  - Drone images processed with Agisoft Metashape
  - dGPS measurements over the tidal flat
    - (average 750 points per measurement)

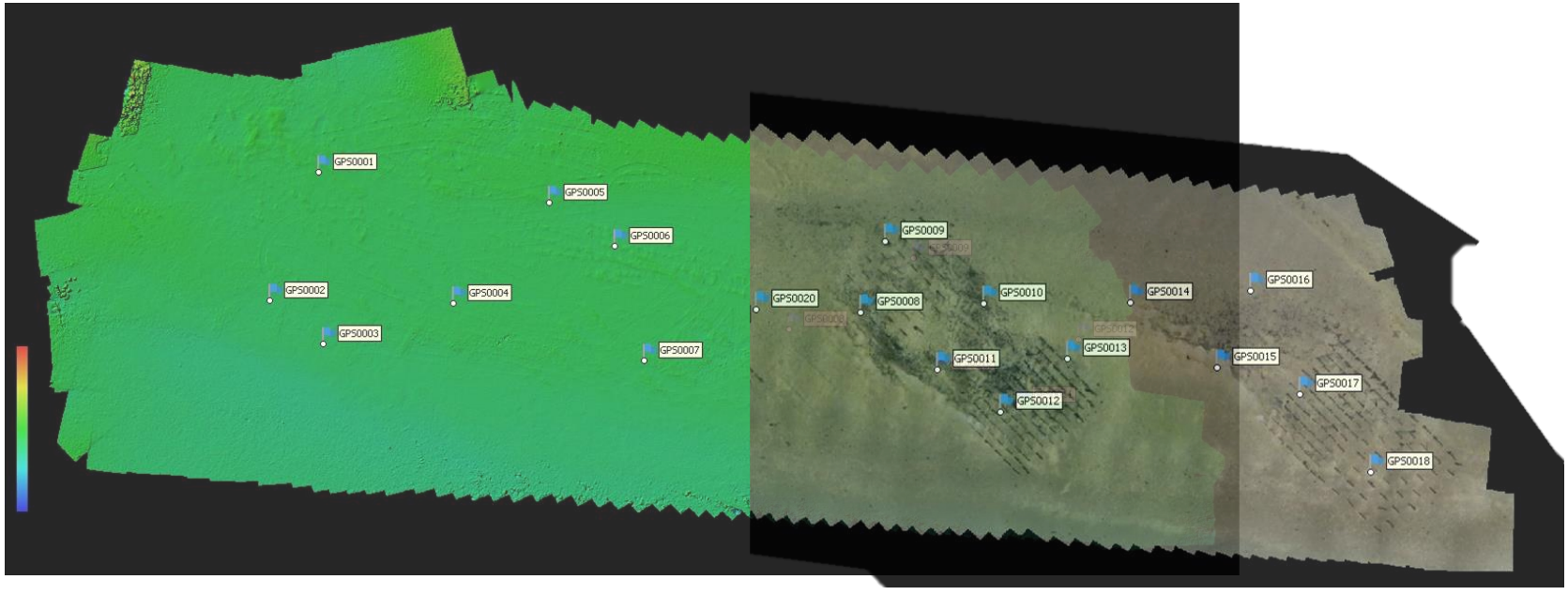


# Results Drone

- Comparison of results obtained by drone and dGPS:
  - Average height difference of 0.010m
  - Other Features:
    - Mussel movement
    - Heterogenity in the morphology of the terrain

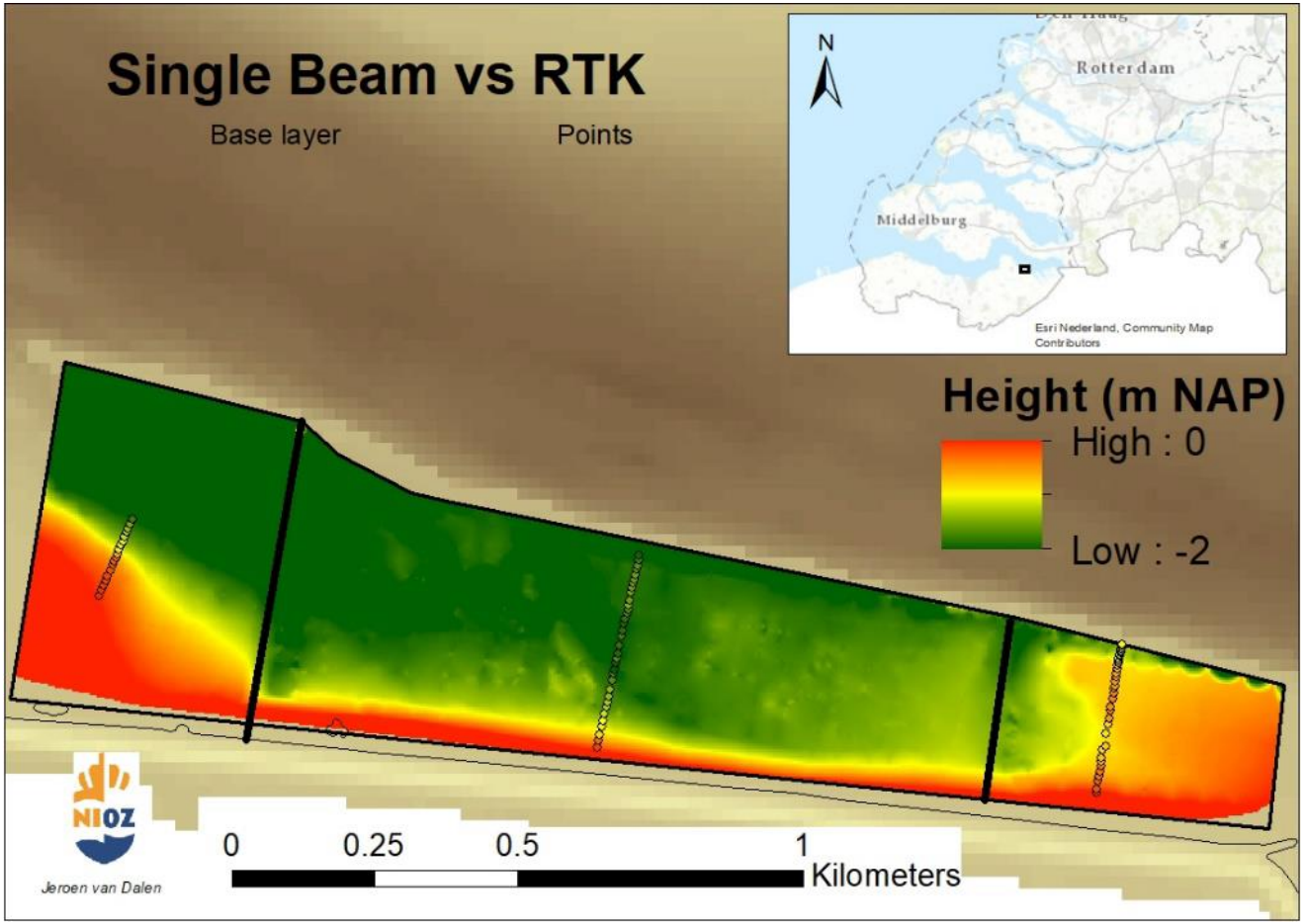
# Results Drone

- Implemented already in several other projects (NIOZ):
  - Zuidgors
  - Natuurimpuls



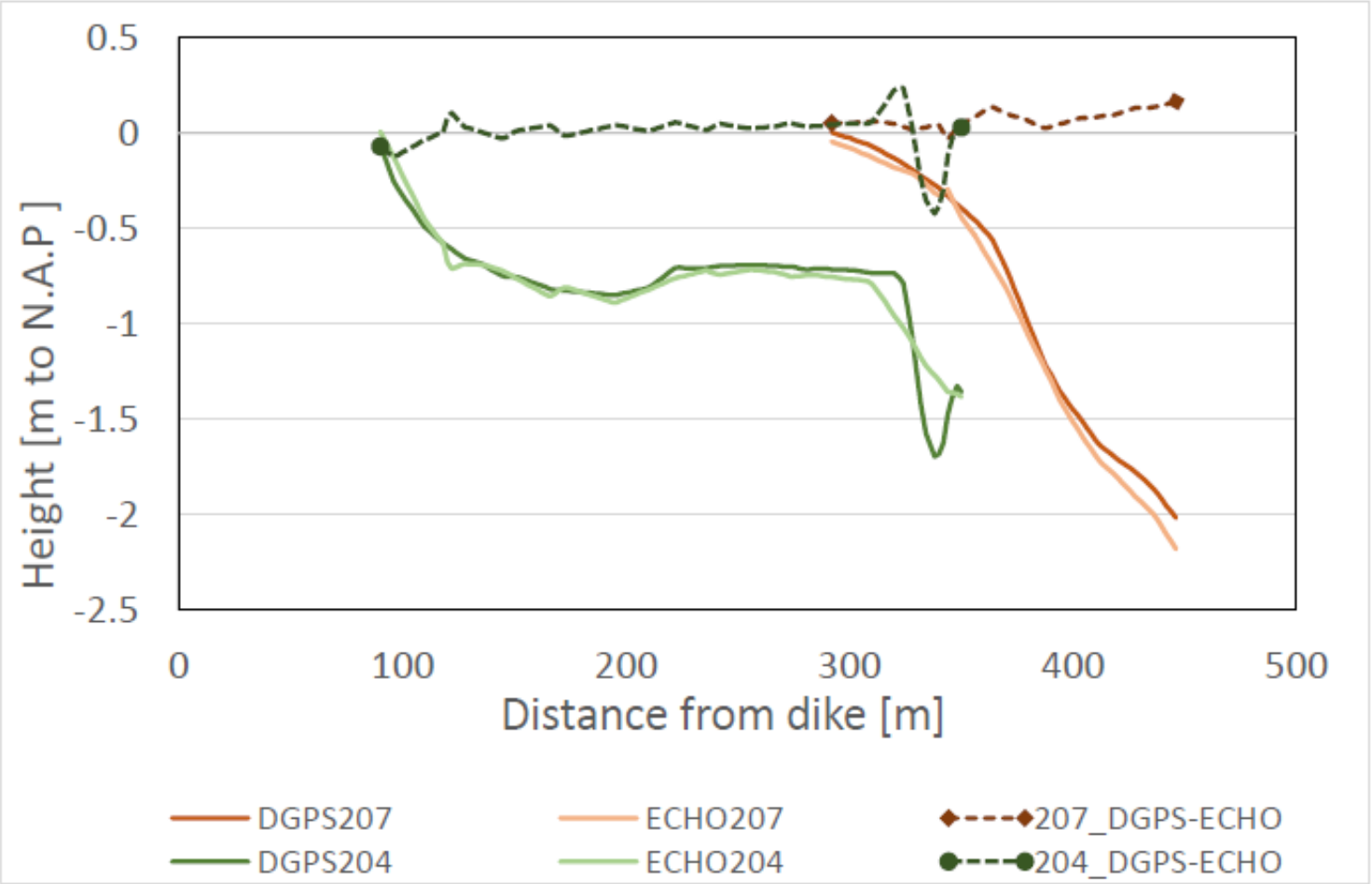
# Results Single Beam (Echosounder)

- Measured during High Tide



# Results Single Beam (Echosounder)

## Single Beam (Echosounder):



# Results Single Beam (Echosounder)

- Single Beam (Echosounder):
  - 1m grid resolution
  - Particular interesting in very soft environments and low emersion time;
  - Average height difference(to dgps) 5cm

# Realized

| CONVENTIONAL | | INNOVATIVE |
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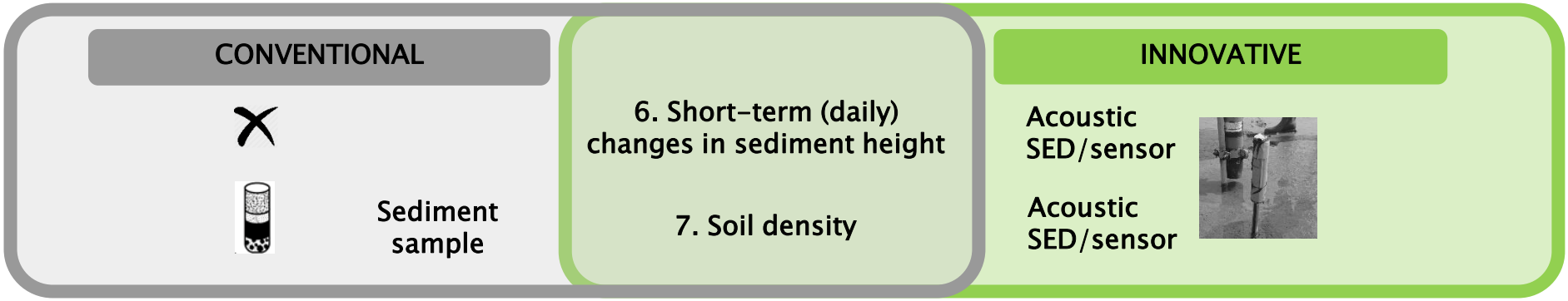
| X | 6. Short-term (daily) changes in sediment height | Acoustic SED/sensor  |
|  Sediment sample | 7. Soil density | Acoustic SED/sensor |
|  Aquadopps and wave gauge | 8. Hydrodynamics: flow / waves | Bio-Phys sensor  |
| X | 9. Sediment concentrations in water | Stand-alone sensor  |
| X | X2. Benthos feeding behavior | Valve gaping mode – BioPhys  |
| | X3. long-term continuous observation | Water-proof interval camera  |
| | X4. Sub tidal biodiversity monitoring | Underwater vacuum cleaner  Photogrammetry  |

# Results Accoustic Sed sensor

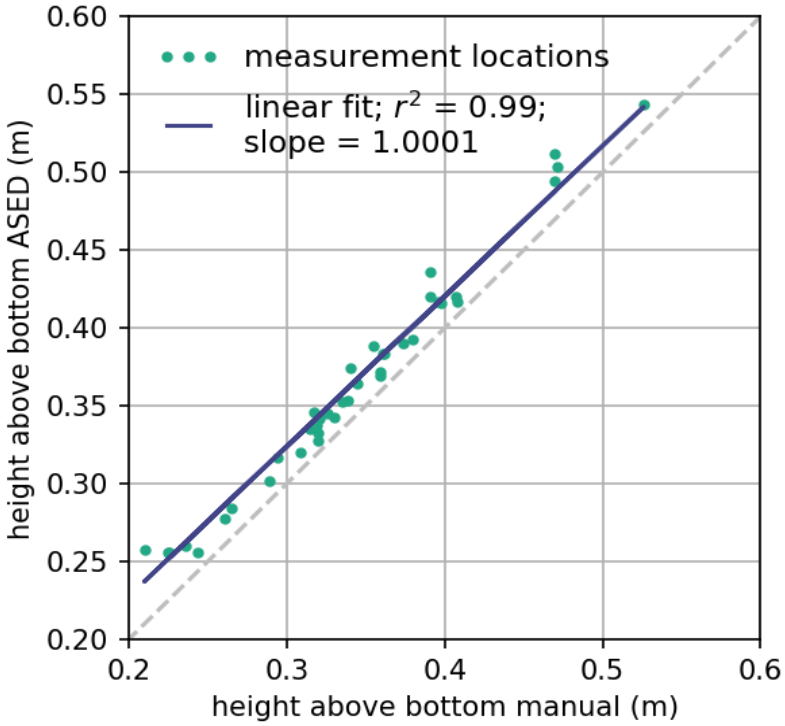



- Comparison between versions:
  - Version1: Light sensor
  - Version2: Acoustic sensor

# Results Accoustic Sed sensor

- Able to measure the bed-level with a 2 mm-resolution
- Comparison between versions:
  - Version1: Measures on dry periods
  - Version2:Measures under water
- Scouring issue was solved

# Results Accoustic Sed sensor




- Draft Manuscript finished:
  - Willemsen, P.W.J.M.[1,2*], Horstman, E.M.[1], Bouma, T.J.[3], Baptist, M.J.[4], van Puijenbroek, M.E.B.[4], Borsje, B.W.[1]

# Realized

## CONVENTIONAL

Bird counting

Sediment Core

X

RTK-DGPS

LIDAR

X

Sediment sample

Aquadopps and wave gauge

X

X

## 1. Bird Numbers

## 2. Benthos as bird food

## 3. Benthos as bioturbator

## 4. Medium scale morphology

## 5. Large-scale morphology

## 6. Short-term (daily) changes in sediment height

## 7. Soil density

## 8. Hydrodynamics: flow / waves

## 9. Sediment concentrations in water

## X2. Benthos feeding behavior

## X3. long-term continuous observation

## X4. Sub tidal biodiversity monitoring

## INNOVATIVE

Drone

DQ-Method

Camera-redox core

Drone

Drone

Acoustic SED/sensor

Acoustic SED/sensor

X 1 Echosounder

Bio-Phys sensor

Stand-alone sensor

Valve gaping mode - BioPhys

Water-proof interval camera

Underwater vacuum cleaner

Photogrammetry

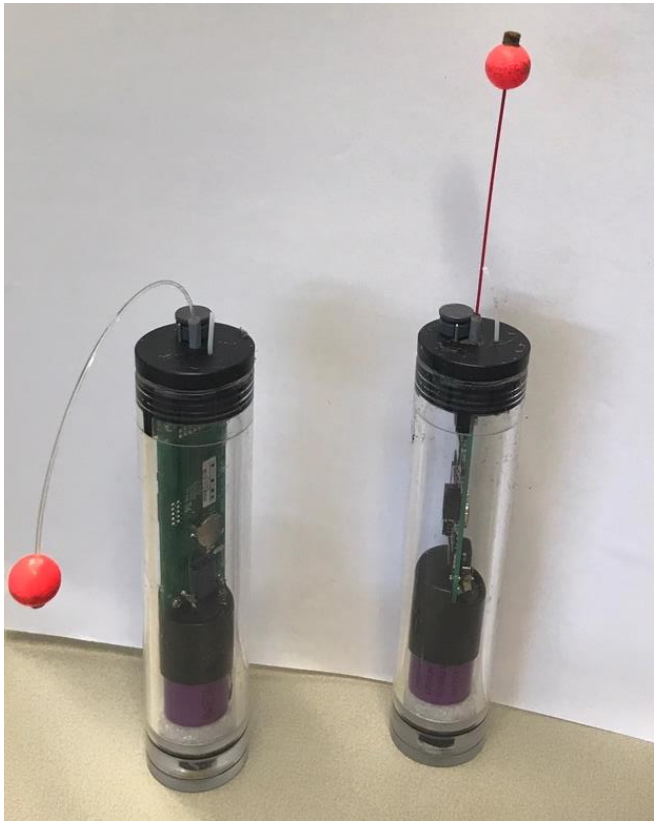
# Results Bio-Phys Sensor

| CONVENTIONAL | | INNOVATIVE |
|---|---|---|
|  Aquadopps and wave gauge | 8. Hydrodynamics: flow / waves | Bio-Phys sensor  |

- What is it?
  - Long-term standalone data logger for measuring a range of ecological, physical relevant parameters like:
    - Shell opening/closing (to monitor feeding behavior);
    - Plant movement under waves;
    - Temperature;
    - Flow direction and waves;
    - Valve gaping

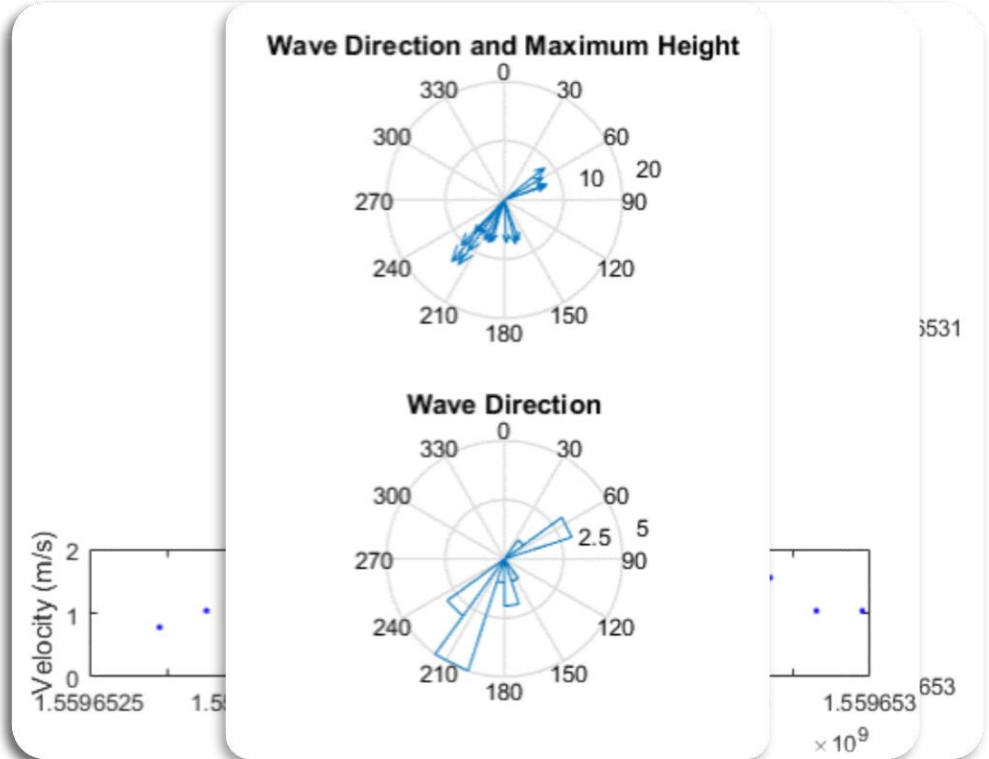
# Results Bio-Phys Sensor

- We knew the potentials but we lacked the how to:



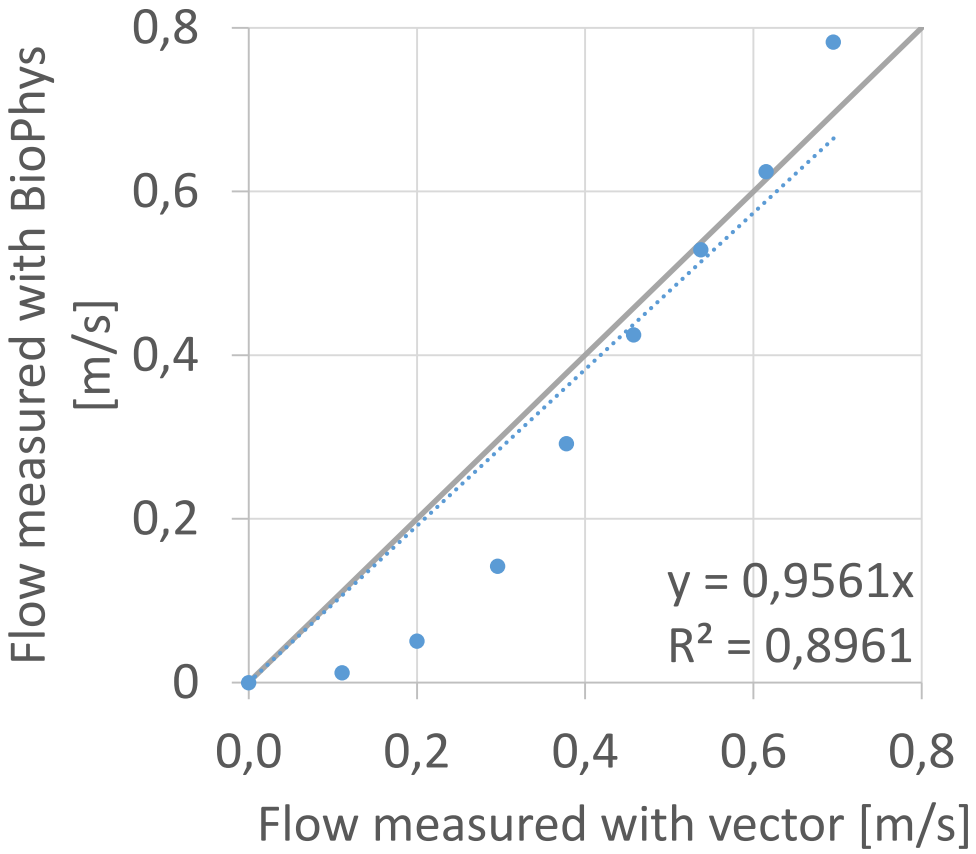
# Results Bio-Phys Sensor

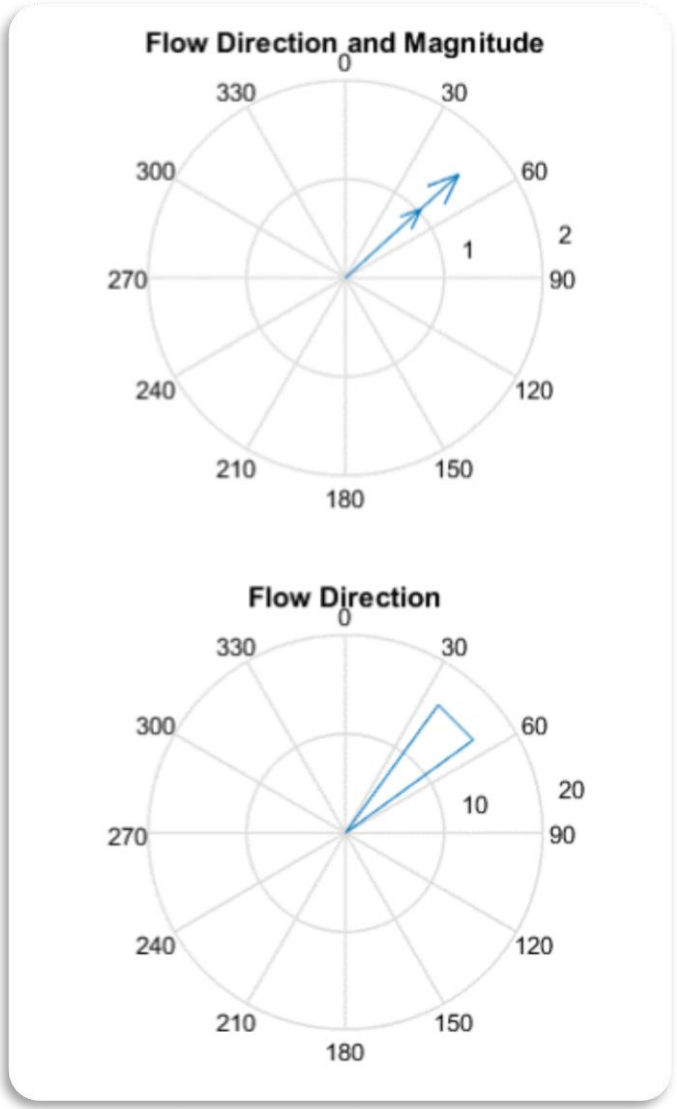
- BioPhys first steps:
  - Understand how the sensor works:
  - Preparation of scripts for validation and also for users



# Results Bio-Phys Sensor

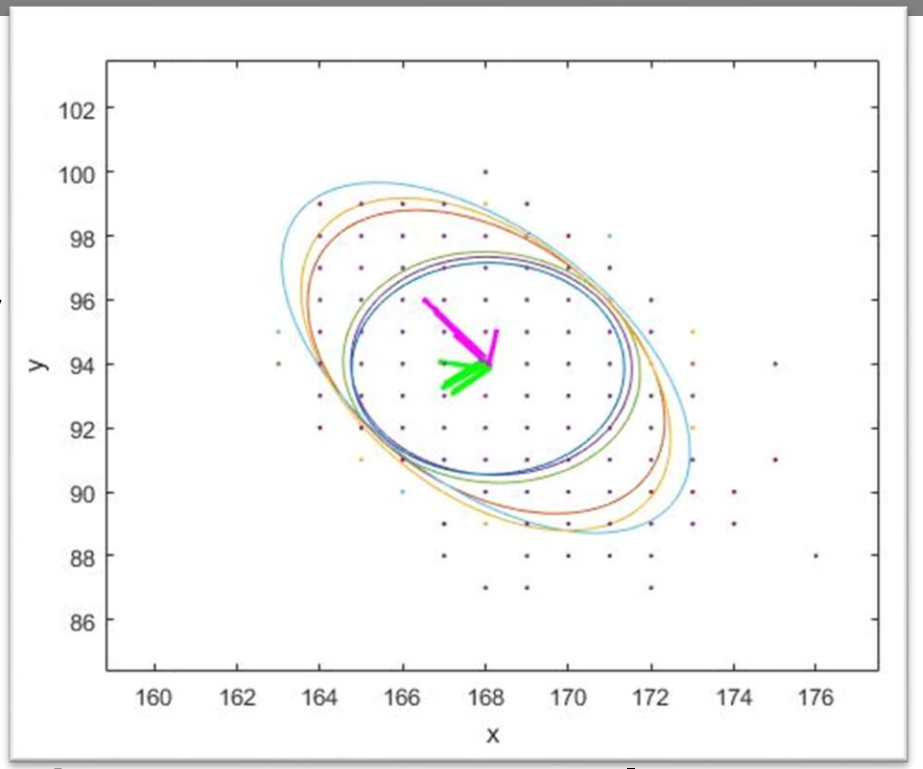
- Flume Tests results (10Hz)



# Results Bio-Phys Sensor

- Conclusions from the flume tests:
  - Sensor can accurately identify:
    - Flow Magnitude
    - Flow Direction
    - Wave Direction
  - Lower stiffness tip: higher accuracy at low flow velocities and lower wave height;
  - Technical report in preparation;



# Realized

## CONVENTIONAL

Bird counting

Sediment Core

X

RTK-DGPS

LIDAR

X

Sediment sample

Aquadopps and wave gauge

X

X

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8. Hydrodynamics: flow / waves

9. Sediment concentrations in water

X2. Benthos feeding behavior

X3. long-term continuous observation

X4. Sub tidal biodiversity monitoring

## INNOVATIVE

Drone

DQ-Method

Camera-redox core

Drone

Drone

X 1 Echosounder

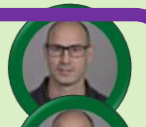
Acoustic SED/sensor

Acoustic SED/sensor

Bio-Phys sensor

Stand-alone sensor

Valve gaping mode - BioPhys

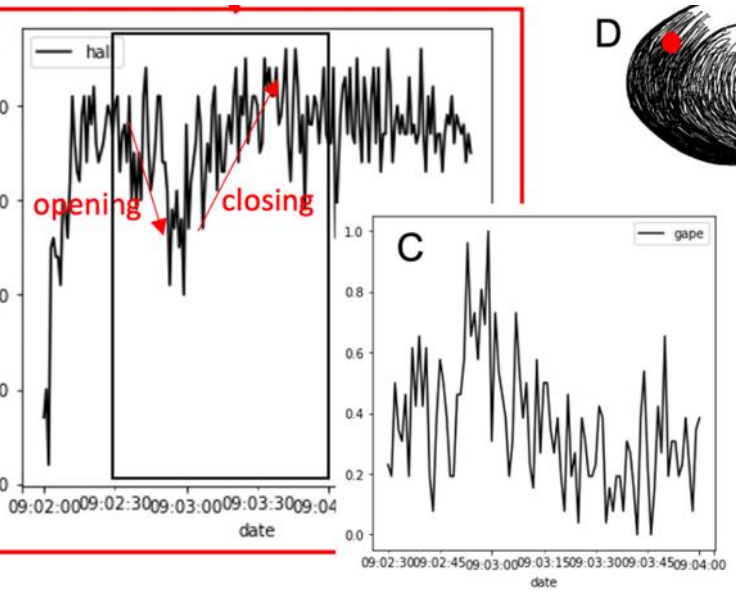


Water-proof interval camera

Underwater vacuum cleaner

Photogrammetry

# X2 – BioPhys → valve-gaping mode



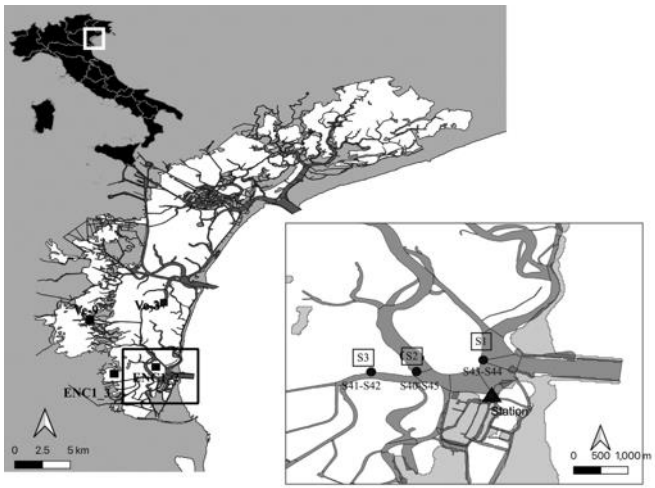


mussel with magnet


Measured = distance between
- Mussel-magnet
- Sensor-head

*distance changes when mussel feeds*

6-month test in Lagoon of Venice
(also 1-month test Waddensea)

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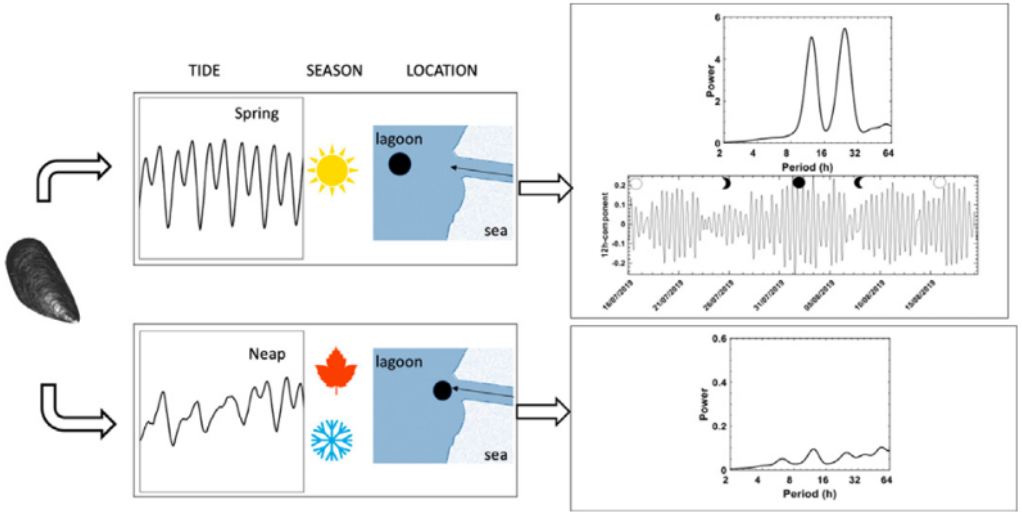
# X2 – BioPhys → valve-gaping mode

## How to cope in heterogeneous coastal environments: Spatio-temporally endogenous circadian rhythm of valve gaping by mussels

### HIGHLIGHTS

- It is necessary to understand how organisms respond to environmental changes.
- Transitional coastal areas are great model systems.
- Mussels behaviour was monitored long-term and in continuous in three sites.
- It followed the tidal rhythm particularly in more internal site and in summer.
- Responses to small scale changes are important for management and for predictions.

### GRAPHICAL ABSTRACT

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# X2 – BioPhys → valve-gaping mode

- Mass production stage

- Useful for understanding carrying capacity
  - Waddensea
  - Eastern Scheldt
  - Western Scheldt
  - North Sea

# X3 – Waterproof time-laps camera's

- Meerwaarde met Mosselen
  - camera on stick to stay dry

- GoPro
  - waterproof
  - *BUT* short operation time-lapse mode

- NIOZ time-laps camera's
  - resolution: 2592x1944
  - field of view: 170 degrees
  - 20 min interval + flash = 120 d
  - 20 min interval (no flash) = 200 d
  - Reached mass-production stage

# Realized

## CONVENTIONAL

Bird counting

Sediment Core

X

RTK-DGPS

LIDAR

X

Sediment sample

Aquadopps and wave gauge

X

X

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7. Soil density

8. Hydrodynamics: flow / waves

9. Sediment concentrations in water

X2. Benthos feeding behavior

X3. long-term continuous observation

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## INNOVATIVE

Drone

DQ-Method

Camera-redox core

Drone

Drone

X 1 Echosounder

Acoustic SED/sensor

Acoustic SED/sensor

Bio-Phys sensor

Stand-alone sensor

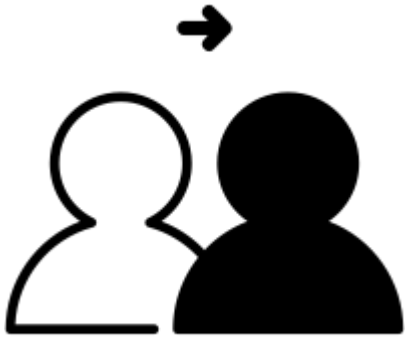
Valve gaping mode - BioPhys

Water-proof interval camera

Underwater vacuum cleaner

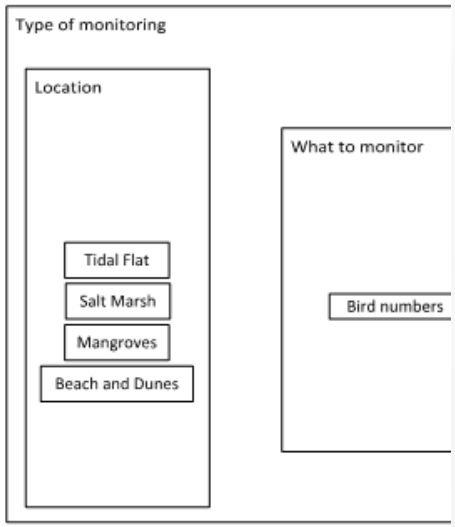
Photogrammetry

# Results: Knowledge transfer to professionals



- Framework tool for monitoring options:
  - Based on results of WP 2 and 3;
  - A tool for managers;
  - Insight into costs and benefits of various monitoring options;

# Framewor




## TELESCOPE

| | |
|---|---|
| **Goal** | Bird counting and identification |
| **Typical area** | Tidal Flats, salt marshes, beaches, dunes, mangroves |
| **Typical time resolution** | Weeks–decades |
| **Investment costs** | 1000-5000 euros |
| **Operation Costs** | 0.31 €/km + 0.21€/km (traveling costs) |
| **Labor** | High |
| **Spatial Coverage** | Spot |
| **Time Frequency** | Interval |
| **Detail level** | High |

**Method**

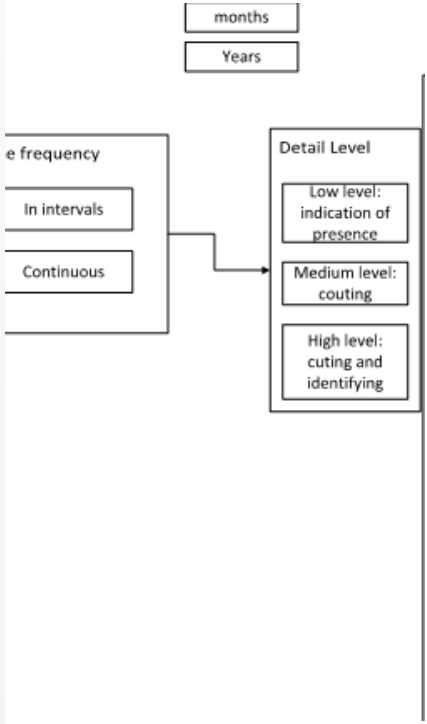
The bird observer goes to the field with a telescope (and a clicker if desired). This is preferably done during high tide in an area where the birds rest at that moment or in low tide while birds are feeding. The observer will count the number of birds per species or the amount of birds in total, depending on what the aim of the research is. With this method you can count the total number of birds as well as identify birds species.

**Materials**

- Telescope
- Tripod
- Clicker

**Additional information**

For this method specialists are necessary if bird identification is a goal of the research.



# Results: Knowledge transfer to education

- **Active participation of students in the project:**
  - 20 did the minor(5 in 2018, 10 in 2019, 5 in 2020);
  - 3 students from Waterloo Canada did internship;
  - 3 students from Ferrara university did the master;

# Results: Knowledge transfer to education

- **Integration in educational modules at HZ university of applied Sciences:**
  - 61 students followed Ecological Engineering module in 2018 and 2019
  - 36 students participated in the Coastal challenge course and attended the guest lecturers in 2020
  - Engineering department may be interested in the sensors part;

# Other results

- Human Capital:
  - participation in several conferences:
    - Scheldt symposium
    - Martec 2020 (maritime technology conference)
- Papers:
  - How to cope in heterogeneous coastal environments: Spatio-temporally endogenous circadian rhythm of valve gaping by mussels (Published)
  - Constructed oyster reefs can protect sand nourishments from erosion: contrasting impacts of wave versus current influenced reefs (Revision submitted)

# Other results

- Other Papers on the writing process:
  - Advantages of using Drones for assessing Morphological changes in the intertida area: morphological changes in a intertidal mussel área
  - Use of drones for bird monitoring in intertidal areas;
  - Channel development of the perkpolder basin;
  - Tecnhical report: Bio_Phys

# Thesis outline

- **Implementation and Effectiveness of Building with Nature Methodologies**
  - Understanding the conditionality of ecosystem services: The effect of tidal flat morphology and oyster reef characteristics on sediment stabilization by oyster reefs
  - Constructed oyster reefs can protect sand nourishments from erosion: contrasting impacts of wave versus current influenced reefs

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Nationaal Regieorgaan Praktijkgericht Onderzoek

# Thesis outline

- **Implementation and Effectiveness of Building with Nature Methodologies**
  - Perkpolder paper: Morphological response to a dike breach on a management realignment project
  - Drone and effects of mussels?
  - Bio-phys sensor
  - Framework paper
  - Project paper