



Nature-inclusive design of scour and cable protections



BlueWeek @
28-30 May 2018



Tim Raaijmakers
Programme Manager
Offshore Renewable Energy

Example of ecological monitoring



Monitoring hard substrates Offshore Windfarm
Egmond aan Zee on the order of Nuon and Shell, sept 2011

Courtesy of Bureau Waardenburg & Noordzeewind (Shell + NUON)

- Scour protection ~5 years after installation
- Armour rocks (60-300kg) completely covered with marine life
- This provides evidence that nature in offshore wind farms can actually improveor at least increase biomass



NoordzeeWind



Towards eco-friendly design of wind farms



- With increasing land use of offshore wind farms and reducing LCoE, interest is increasing to enhance ecological value of wind farms and scour + cable protections in particular
- Rock protections (hard substrates) are already rich in ecology and show a great biodiversity (compared to the surrounding sandy seabed)
- In the past years research was done on potential ways to further enhance the ecological quality of scour protections
- Two umbrella species were selected:
 1. Atlantic cod (*Godus morhua*)
 2. European flat oyster (*Ostrella edulis*)
- Focus on nature-inclusive design scour protections targeting the umbrella species



Lengkeek, Wouter; Didderen, K.; Teunis, M.; Driessen, F.; Coolen, J.W.P.; Bos, O.G.; Vergouwen, S.A.; Raaijmakers, T.; Vries, M.B. de; Koningsveld, M. van (2017)



Two selected umbrella species



for ecologists

Atlantic cod
(*Godus morhua*)



for engineers



European flat oyster (*Ostrella edulis*)



Catalogue of potentially eco-friendly measures



- A more complex habitat yields a more diverse biological community
- Use different type of materials and differentiate between pore sizes
- Many shapes and materials can be considered, even 3D-printed structures and artificial materials (e.g. calcareous material to allow settlement of oysters)
- But can you just do anything you want to a scour protection?



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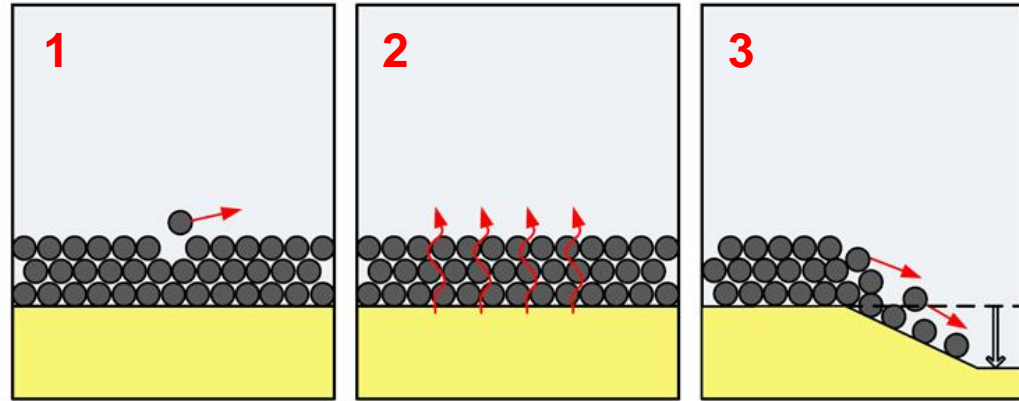
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Requirements for a scour protection



Main design requirements:

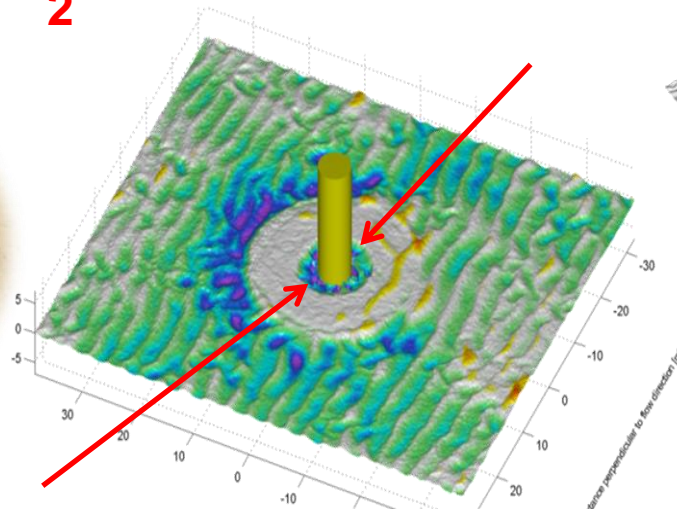
1. External stability
2. Internal stability (filter function)
3. Flexibility (performance around edge scour and in morphodynamic areas)



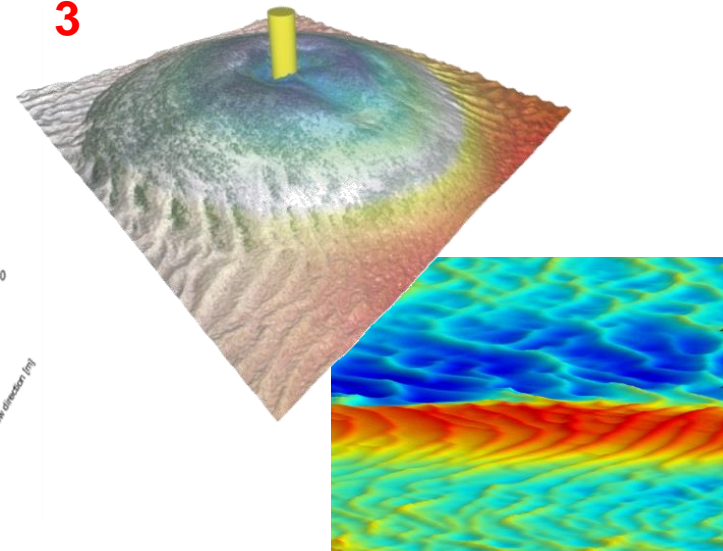
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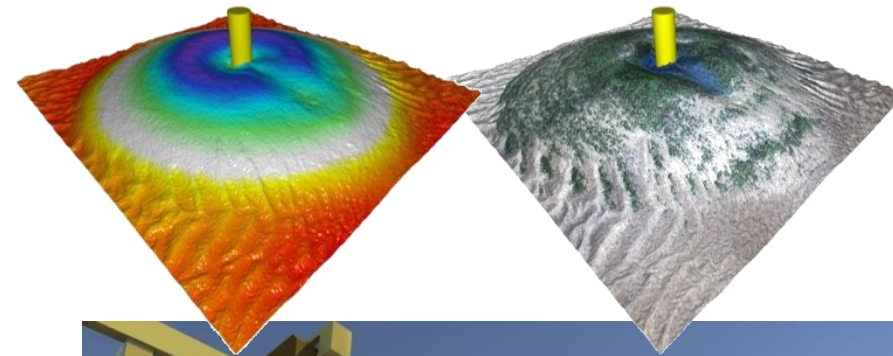
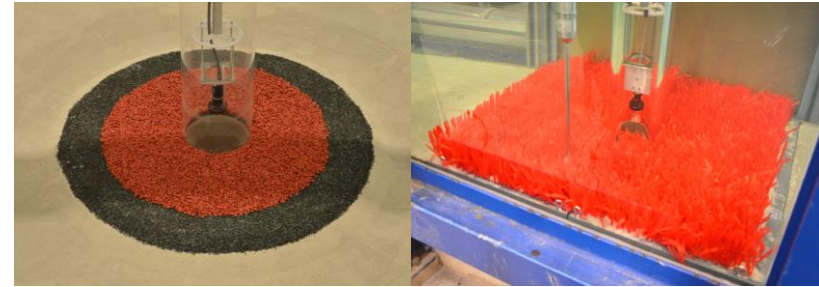
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JIP HaSPRO – Handbook Scour and Cable Protection Methods

- Scour and cable protection methods for offshore wind support structures and cables by model tests on **3 different model scales** (from small scale to world's largest scale)
 - ✓ Optimizing conventional rock protection
 - ✓ Innovative protection systems
 - ✓ Nature-inclusive design
- Deriving design formulae and guidelines
- Developing design software
- Drafting Digital Handbook and Recommended Practice (by DNV GL)
- Project runs between 2016 and 2019



Project structure and sponsors of JIP HaSPro

Cross-over project between TKI Wind op Zee (Energy) and TKI Deltatechnology (Water)



Contractors



Utilities



Suppliers



Engineering **COWI**

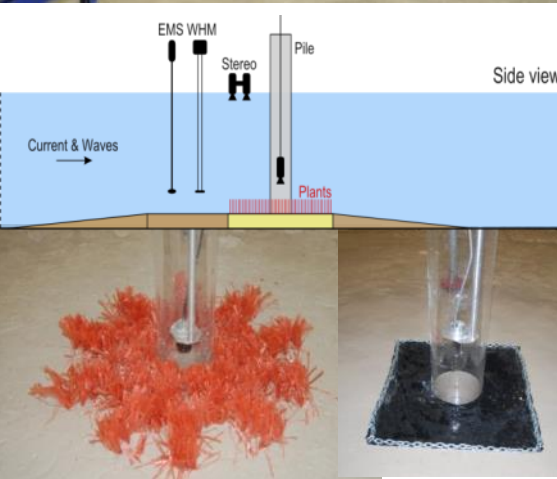
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Overview of scale model test campaigns in JIP HaSPro



Scheldt Flume

- Model scale 1:30 to 1:50
- Tidal currents + waves
- Fast cycle times: many exploratory tests



Atlantic Basin

- Model scale 1:20 to 1:40
- Tidal currents + waves
- Wide test section
- Equipped with mobile bed

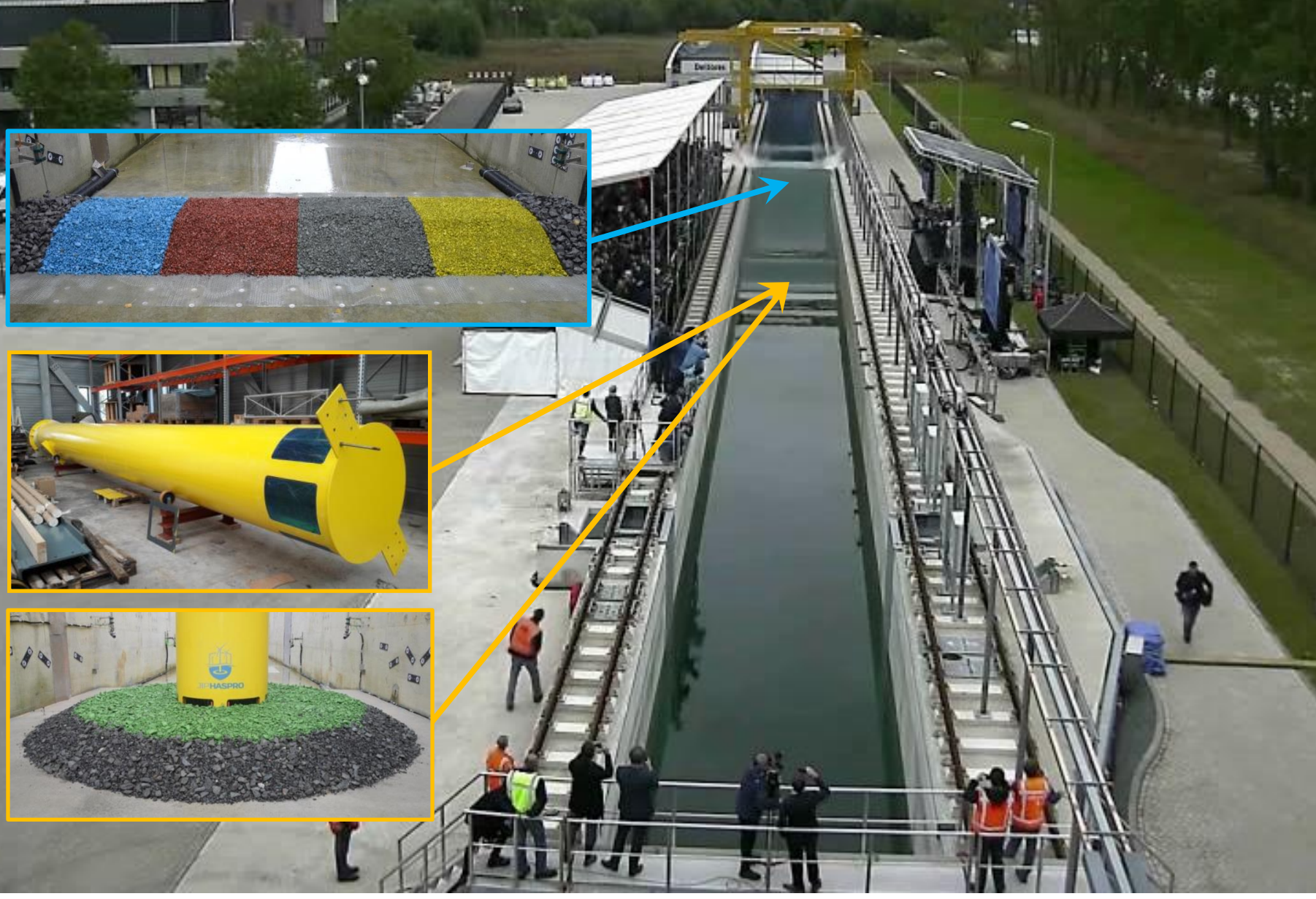


Delta Flume

- Model scale 1:1 to 1:10
- World's largest wave flume
- No scale effect
- State-of-the-art, since Oct. 2015



Test setup in Delta Flume: world's largest wave flume



Ecological elements and natural shell material



Reef balls (by Reef Innovations)



Oyster shells (provided by
Prins & Dingemanse, Yerseke)

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Nature-inclusive designs tested in JIP HaSPro



Monopile scour protection:

Rock scour protection with integrated reef balls and perforated concrete tubes



Cable (crossing) protection:

Rock berms with loose oysters and with integrated reef balls



Gabion mattresses with top layer of rock replaced by oyster shells

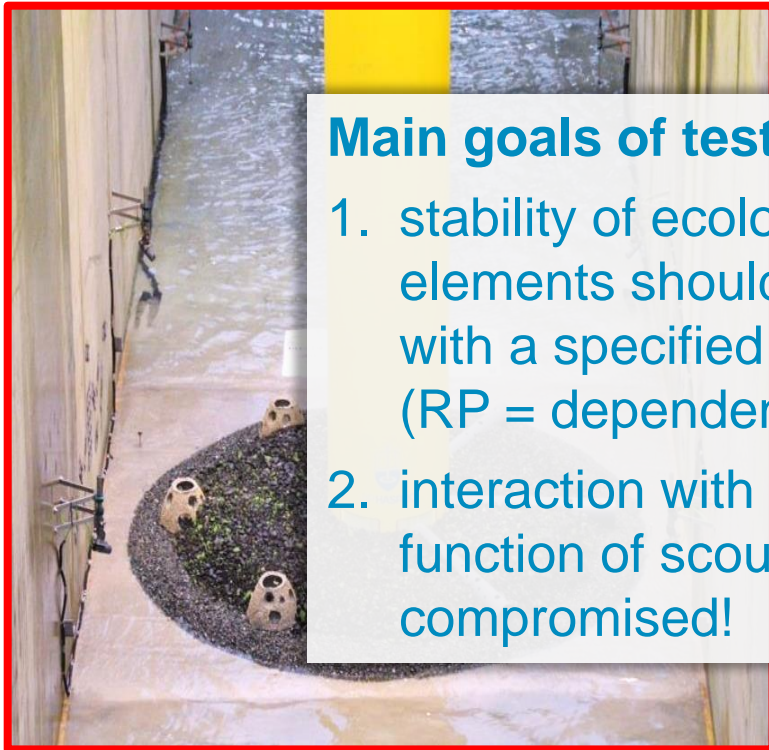


Nature-inclusive designs tested in JIP HaSPro



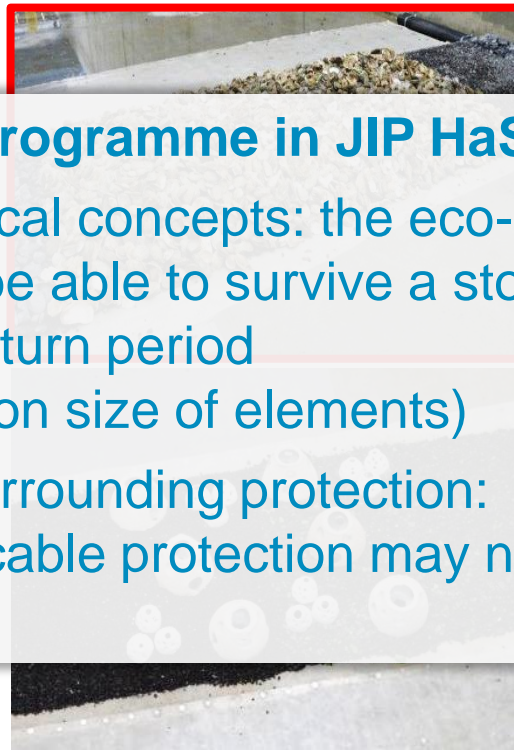
Monopile scour protection:

Rock scour protection with integrated reef balls and perforated concrete tubes



Cable (crossing) protection:

Rock berms with loose oysters and with integrated reef balls

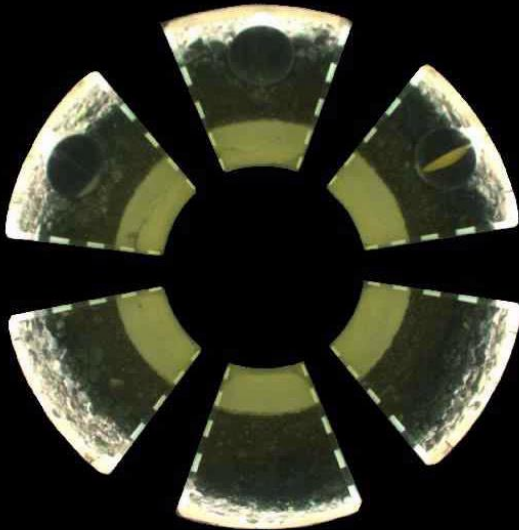


Gabion mattresses with top layer of rock replaced by oyster shells



Main goals of test programme in JIP HaSPro:

1. stability of ecological concepts: the eco-elements should be able to survive a storm with a specified return period (RP = dependent on size of elements)
2. interaction with surrounding protection: function of scour/cable protection may not be compromised!

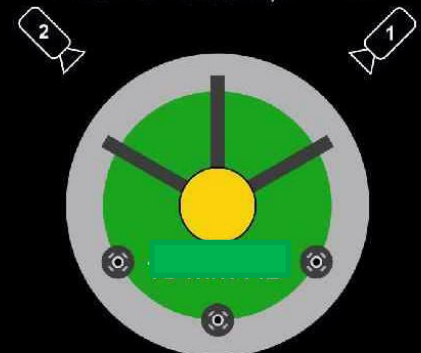


Filling of the flume

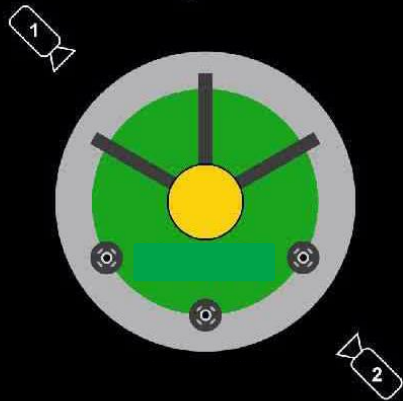
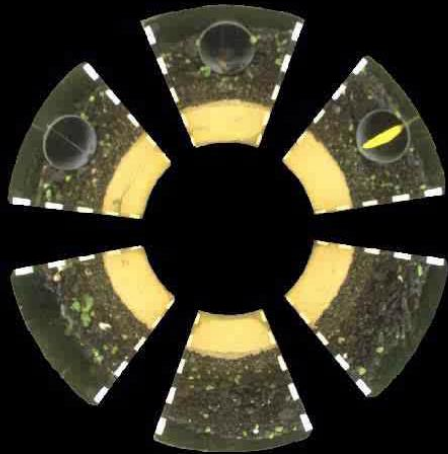
Before G03

*Double-graded rock protection
with ecological elements*

Time = 0.1 min



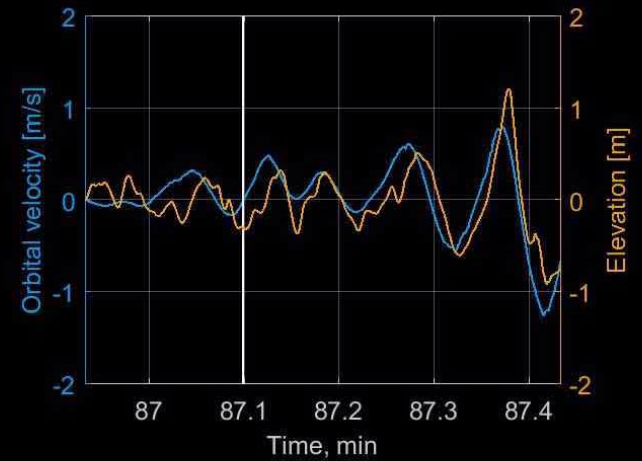
Actual test conditions are blanked



G03

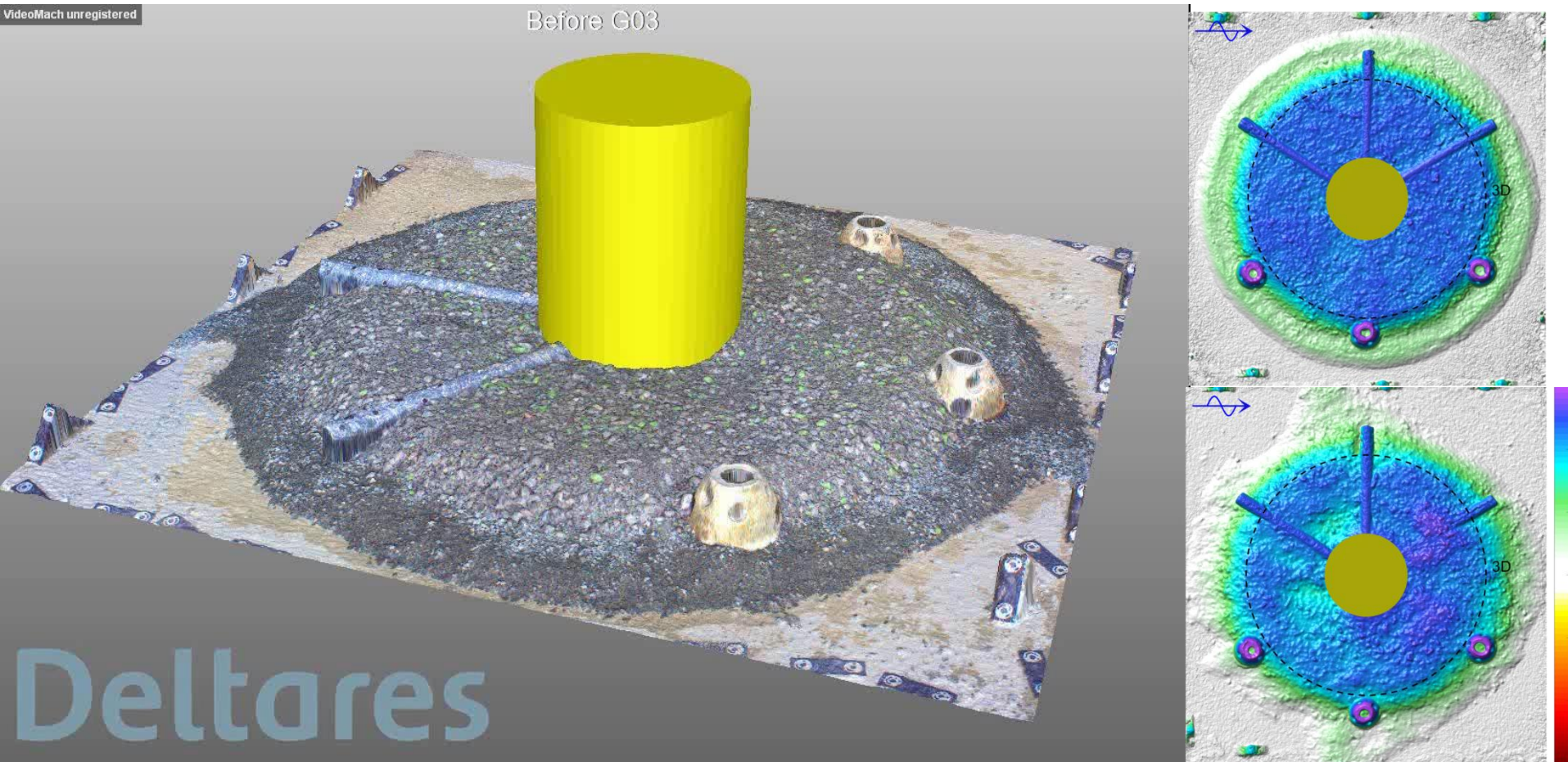
Irregular waves only

Double-graded rock protection



Deformation of scour protection during storm tests

3D-animation switching between height maps and colour images of nature-inclusive scour protection (obtained with 3D-stereophotography)



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Stability of oysters on top of a rock berm



1



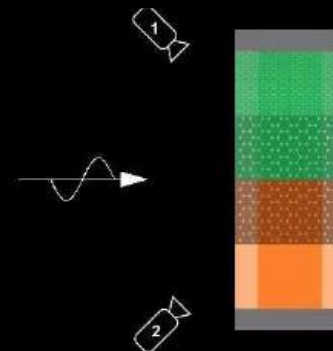
2



F01-IW-3

Irregular waves only

Single-graded rock protection



Actual test conditions are blanked

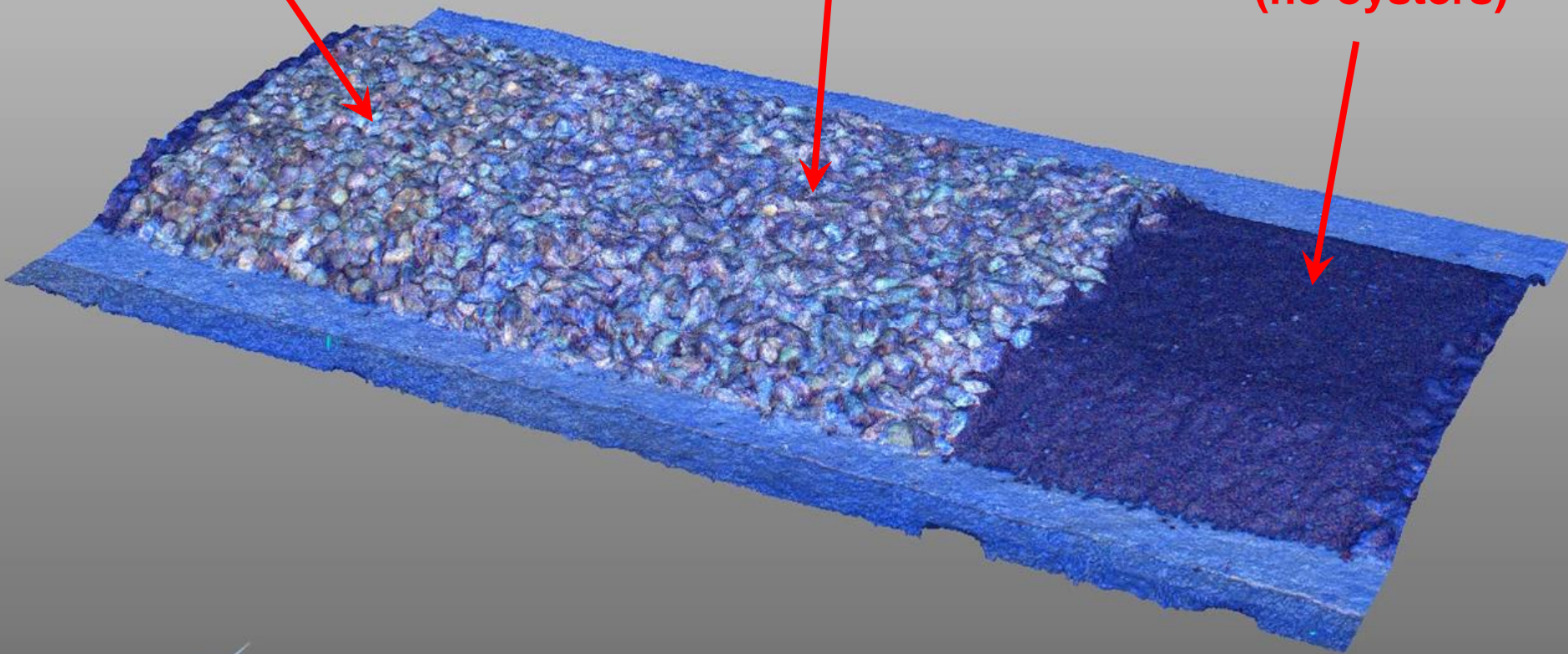
Stability of oysters on top of a rock berm



European flat
oysters

Japanese
oysters

reference
rock berm
(no oysters)



The next-step: eco-pilot projects in the field



- Several nature-inclusive scour protection methods have been investigated: new knowledge on hydraulic stability limits and interaction with surrounding scour protection
- In JIP HaSPro (or any other hydraulic facility) we cannot test whether the designs will work from an ecological point of view
- Offshore pilots are needed, in combination with proper monitoring programs
- Preferably with a monitoring programme that is overarching all individual eco-pilots and collects relevant environmental parameters to be able to draw generic conclusions: how is effectiveness of eco-friendly measures dependent on location?



Joop Coolen



Wouter Lengkeek, Tom van der Have



Tim Raaijmakers, Luca van Duren

SAS Consultancy

Hein Sas



Photos by Udo van Dongen

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Five key take-aways



Future wind farms will put **stronger demands on ecological value**, resulting in increased attention to **nature-inclusive design**



Scour protections are **already rich in ecology** and enhance biomass of the offshore environment, but they can be further improved to target selected **umbrella species**, such as European flat oyster and Atlantic cod



When you ecologically “pimp” your scour protection, do not forget about the functional **requirements related to hydraulics and morphodynamics!**



Several concepts were **successfully tested in large-scale tests** (Delta Flume): design guidelines are currently being developed



The next important step is to start **offshore eco-pilots** to investigate the ecological functioning of these nature-inclusive concepts in the field

Join us in (research) projects to work together on these topics!

more information?



tim.raaijmakers@deltares.nl

