# Research group: Building with nature

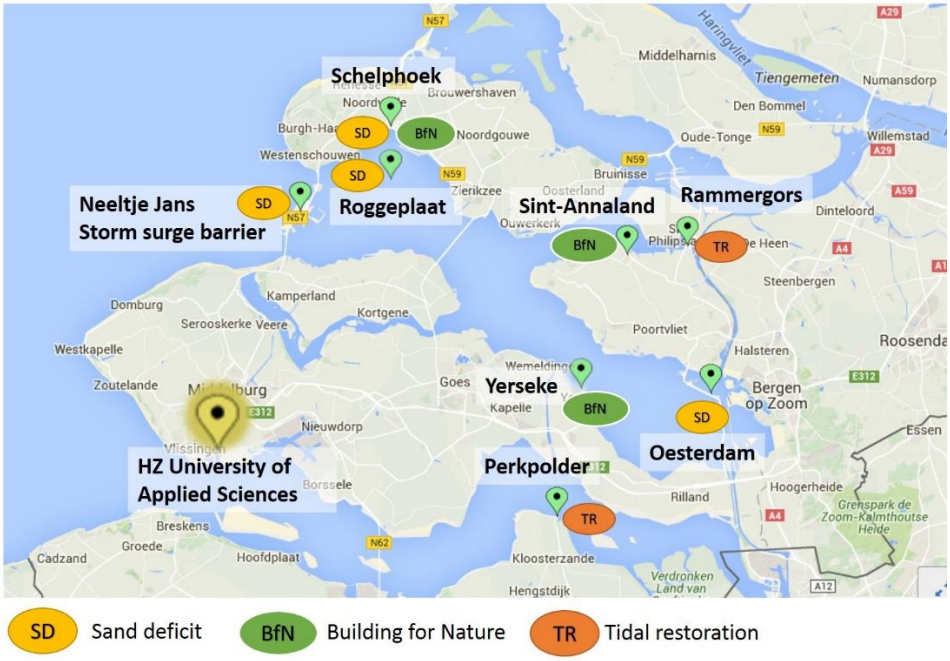
Delta Academy Applied Research Centre

WHAT DO WE DO?

DELTA ACADEMY

# BUILDING WITH NATURE

In the research group *Building with Nature* we focus on combining civil engineering and ecological functions to create nature-based solutions in the coastal area. We work in close collaboration with research institutes, commercial companies and construction firms to advise the government and develop strategies. We conduct our applied research projects with large student involvement, resulting in a new generation of young professionals with an understanding of the benefits of *Building with Nature* approach. Our research focuses on three main themes: Sand nourishments and shellfish reefs, Improving the ecology and usage of hard substrate (Building for Nature), and Tidal restoration. For an overview of our project sites please see the map below.




## Sand nourishments and shellfish reefs

The delta area of the Netherlands is an ideal 'living laboratory' in which to develop and test 'soft engineering approaches' to coastal defense structures. The Eastern Scheldt currently faces a deficit of sand, due to the construction of the Eastern Scheldt storm surge barrier in 1986. This deficit results in erosion of the tidal flats which can have serious consequences not only for coastal protection, but also for the economy, ecology and recreation associated with the area. By investigating a 'soft engineering approach' we investigate methods of using living organisms like oysters and mussels to help stabilize sediment. Secondly we investigate the usage of sand nourishments, which act as a sediment source for the eroding tidal flats and lower the wave load on the dike and thereby extend the lifespan. These methods are also intended to increase the biodiversity of the intertidal area and provide more plentiful marine bird feeding grounds.

## Building for nature

Dikes and coastal banks are hard and inhospitable. They do their job of protecting the coast line, but not much else. Our research group investigates how we can turn these often barren constructions, designed purely for structural purposes, into multi-use, multi-purpose and biologically friendly habitats. We are developing methods to increase the biodiversity and natural values of the revetment materials used to reinforce the dikes. By making alterations to these otherwise biologically hostile surfaces, we are looking for ways to increase the biological growth on the dikes and banks while not compromising the integrity of the structure. In combination with the Aquaculture research group we are also looking at whether

shellfish can be cultivated on the dikes and banks and thereby also provide an economical function for these structures. Furthermore, we are investigating what alterations we can make to the banks of the Nieuwe Waterweg, an artificial water body connecting the Port of Rotterdam to the sea that will increase the natural values of the area.

### Tidal restoration

Developments in the delta have led to the decision to restore coastal ecosystems in certain areas by reverting them back into saltwater tidal zones. Restoring tidal areas will have major impacts on the sediment morphology, hydrodynamics and ecology of the area. As a research group we are involved in documenting, modelling and predicting these changes as they occur.

# TEAM


*For questions about our research and collaboration opportunities please contact:*
*Matthijs Boersema (matthijs.boersema@hz.nl)*
*Cell phone: +31 620133209*

# EASTERN SCHELDT – NATURE VALUES

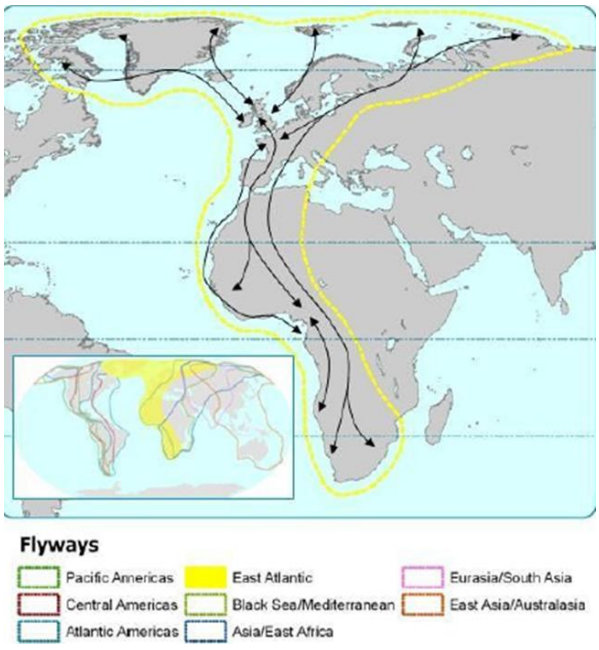
## Background information

Zeeland is the most authentic coastal province of the Netherlands, where the deltas of the Rhine, Meuse and Scheldt meet. This area offers a great diversity of ecosystems; river arms and estuaries, mudflats and salt marshes, beaches and dunes, dikes.

After the flood disaster in 1953, the Delta Plan dams were built, including a storm surge barrier that, when closed, could completely separate the Eastern Scheldt from the North Sea which united the islands of Zeeland. This was the finishing touch of the fight against the sea, actually Building *against* Nature, which has not been more intense anywhere else on earth.

The Eastern Scheldt (35,000 ha) has partially kept its tidal character after the construction of the flood barrier. Although natural values decreased after the construction of the storm surge barrier, these values are still considerable.

The Eastern Scheldt is also a protected area and part of the Natura 2000 network that is created within the framework of the Birds and Habitats Directive. This means that the nature conservation goals for the Eastern Scheldt relate to the importance of the area for migratory birds.





## Current research projects

The storm surge barrier created an imbalance between sedimentation and erosion. As a result, the sand flats are eroding, leading to a smaller areas for the birds to feed, and even more importantly, to a shorter available feeding time.

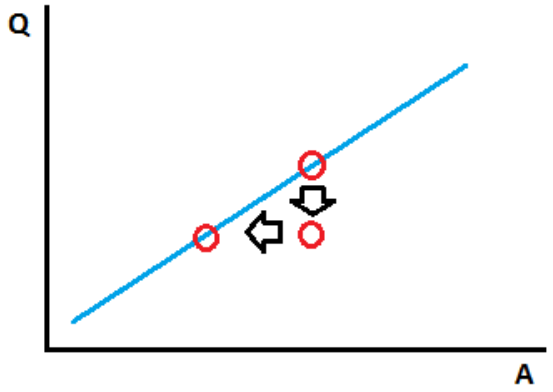
An important part of nature conservation in the Eastern Scheldt is aimed at preserving the sand flats which supply a larger living space for benthos, the food source for migratory birds.

Apart from the sand flats, benthos and birds, an important nature conservation goal is the extension of the area of salt marsh. One method of achieving this is through salt marsh restoration projects like Rammegors.

# STORM SURGE BARRIER/OESTERDAM
## SAND DEFICIT, SAND NOURISHMENT PROJECTS

### Background information
Intertidal areas in the Eastern Scheldt are important for recreation, safety and natural values. But since the construction of the storm surge barrier in 1986 (see picture on the right), the Eastern Scheldt has a sand deficit problem. The channel cross-sections (A) are too large for the new tidal prism (Q), see the figure below, where the blue line is a representation of the morphological equilibrium.

Rijkswaterstaat is trying to mitigate the erosion of the tidal flats with local sand nourishments, for example at the Oesterdam. How effective these nourishments are in relation to safety and natural values will be studied in a three year research program (2014-2017). This research will help Rijkswaterstaat to realize future nourishments like at the Roggeplaat.




### Partners in this project
Rijkswaterstaat Zee en Delta, NIOZ, Wageningen Marine Research,Deltares and HZUniversity of Applied Sciences *[contact: Matthijs Boersema]*

### Current research themes at Oesterdam
- Morphological changes

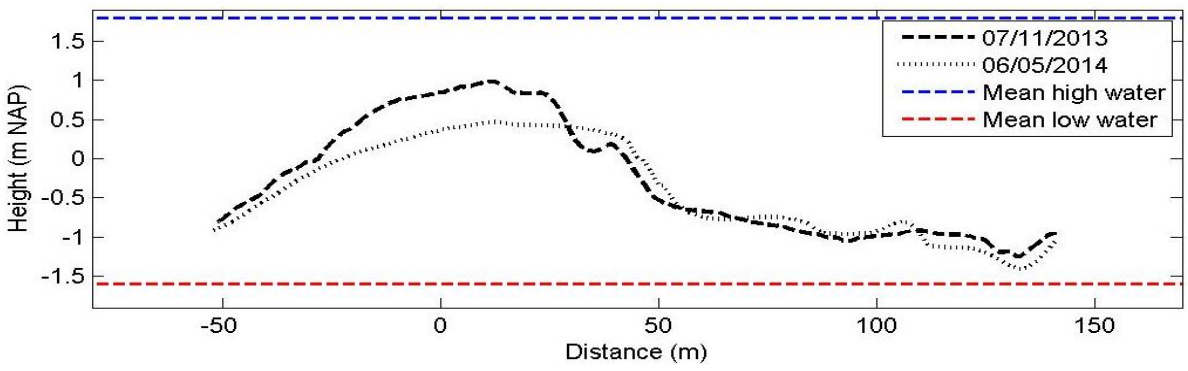
The large scale morphological development of the Oesterdam sand nourishment is monitored in relation to waves and tides. First conclusions: the nourishment is slowly eroding and the morphology is dominated by wave action.

- Channel development

The nourishment resulted in the development of a tidal channel, this channel is growing in length and width, but will reach an equilibrium stage in the coming year.

- Sediment transport

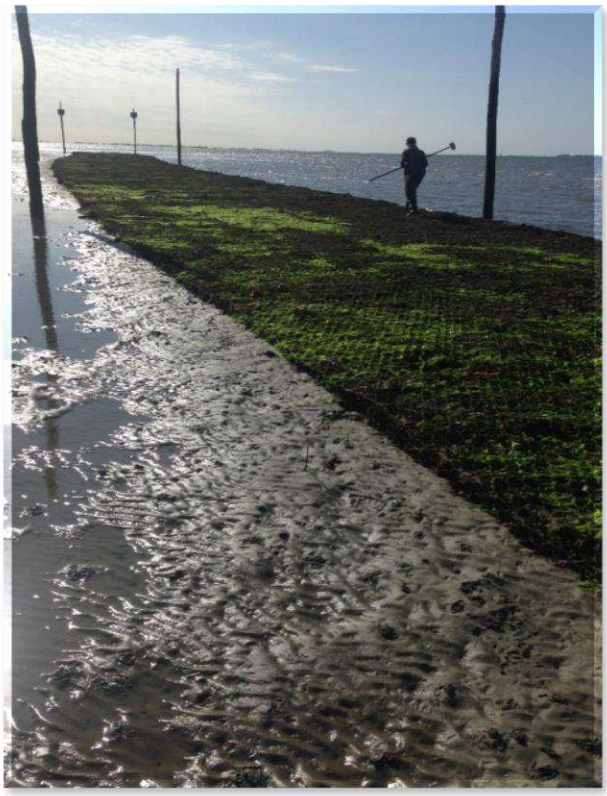
The direction of sediment transport is related to the direction of the wind, the most exposed areas show more sediment transport, while sheltered areas show less sediment transport, and here biological factors can play a role in sediment stability.



# OESTERDAM
## MORPHOLOGY ARTIFICIAL OYSTER REEFS

### Background information
In nature, oysters form complex 3D structures named reefs. They are considered ecosystem engineers as they are able to change waves, currents and sedimentation patterns in their surroundings. In that way oysters reshape the landscape, and their effect can occur up to several hundred meters away of the reef.

Nowadays we want to use these abilities, in our advantage, by building artificial oyster reefs. It is also expected that these artificial reef will become living structures after being colonized by other oysters. This innovative solution can be used not only to protect dikes against wave action but also to stabilize sand on sand banks. For these purposes four oyster reefs were constructed at the “Oesterdam safety-buffer project”.

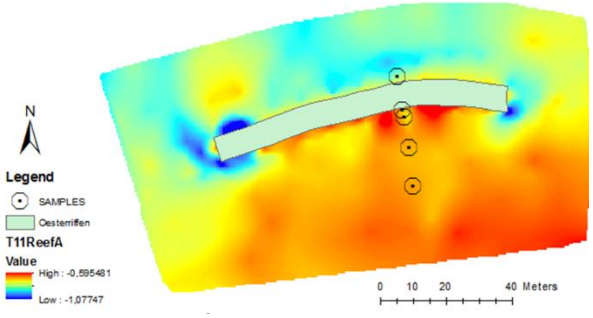


### Partners in this project
Rijkswaterstaat, NIOZ, Wageningen Marine Research, Deltares and HZUniversity of Applied Sciences
*[contact: João Salvador de Paiva]*

### Current research projects
- Morphology On the oyster reefs

Since 2014 students at the HZ have been monitoring the morphology on the artificial oyster reefs. The main goal is to evaluate the efficiency of the artificial oyster reefs regarding sediment stabilization. Parallel to this other parameters are being monitored for example to see if the reef is developing into a living reef.

As the oyster reef Technology is still in the beginning the results/work can be very important for improving the design of artificial oyster reefs.



# OESTERDAM
## BIODIVERSITY ON THE OYSTER REEFS

### Background information

After the sand nourishment was laid it was important to stabilize the new sediment to prevent erosion. Artificial oyster reefs were placed at strategic locations on the sand flat. These were intended not only as a soft engineering approach to stabilizing the sediment, but also as a habitat for organisms that are a food source for coastal and migrating birds, thereby increasing the natural values of the area. The reefs are expected to develop into living natural reefs that can adapt to changing environments.

*H. takanoi*

*C. maenas*

### Current research projects

- Biodiversity on the reefs

Since 2014 students at the HZ have been monitoring the biodiversity on the artificial oyster reefs. Do the reefs increase local biodiversity? How does it change over time? What sort of organisms are living there? Are the exotic or native? All of this is important to know before informed decisions about placing similar reefs in other locations can be made

- Battle for the Reef

To investigate the competition between exotic and native species on the reef, the populations of two crabs on the reefs have been specifically monitored. *Carcinusmaenas* is a native species while *Hemigrapsistakanoi* is an exotic species. Is there competition for habitat between these two species? How does the crab community change over time? Are the reefs a haven for the establishment of exotic species in the Eastern Scheldt?

- Does density matter?

Artificial reefs are expensive and labour intensive to place. A huge amount of oyster shells are necessary to fill the cages. Is it necessary for the cages to be densely filled with shells?, Is there a difference in the biodiversity that develops between densely and loosely packed reefs? The HZ is conducting an experiment using small replicate 'reefs' to investigate these questions

### Partners in this project

Rijkswaterstaat,NIOZ, Wageningen Marine Research, Deltares and HZUniversity of Applied Sciences
*[contact: Anneke van den Brink]*

# ROGGENPLAAT

## DESIGNING A SAND NOURISHMENT TO MITIGATE INTERTIDAL HABITAT LOSS

### Background information

Since the mid-1980s intertidal flats of the Eastern Scheldt are constantly eroding as a side effect of the storm surge barrier that was constructed in the mouth of the estuary. Less intertidal habitat means less feeding possibility for wading birds and less wave dissipation in front of the dykes.

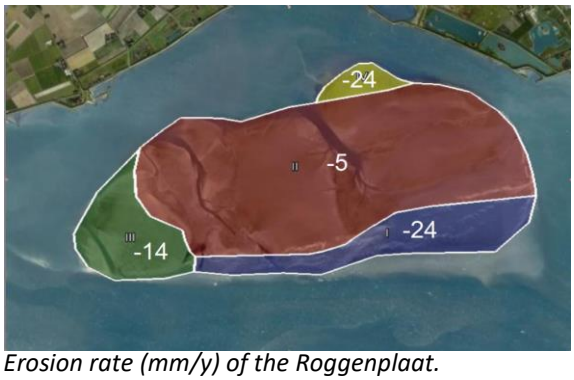
Sand nourishment is a *Building with Nature* type of solution to mitigate the sand deficiency. A large sand nourishment of 1.6 million cubic meter of sand is planned at Roggenplaat in 2017 and requires a smart design.

*Sand nourishment under construction*

*Start of a field monitoring campaign.*

### Partners in this project

Rijkswaterstaat,NIOZ, Wageningen Marine Research, Deltares and HZUniversity of Applied Sciences
*[contact: Joost Stronkhorst]*




*Erosion rate (mm/y) of the Roggenplaat.*

### Research activities

**Design of the sand nourishment**

Knowledge of morphological processes, the presence of natural features including mussel beds and practical experience with sand nourishment will all be taking into account to select the right shape, time and place for the sand nourishment. Three options will be studied:

- Area and height: sand is applied directly at the appropriate height on 2-3 intertidal areas;
- Relief: sand is deposited in long ridges to create local shelter to speed up recolonization of benthos
- Wave and tide: natural forces of waves, wind and tide are used to transport sand from foreshores on top of the sand flat.

In addition, field experiments will be conducted in 2015/16 to improve the design for the most ecological-effective execution of the sand nourishment.

The designs will be used by Rijkswaterstaat and NGO Natuurmonumenten during stakeholder meetings.

**Field monitoring**

A monitoring program will the effects of the sand nourishment on benthos, birds, mussel beds, morphology etc. This concerns both the reference period prior to the nourishment in 2015/16, during (2017) and after the completion of the nourishment (2018/24).

# ADDITIONAL VALUE IN MUSSELS (MEERWAARDE MET MOSSELEN)

## Background information

How can we use Mussels for generating Multi-ecosystem services?

Within a collaboration with commercial mussel growers, nature conservation groups, the government and scientists of NIOZ, IMARES and Deltares, the HZ University of Applied Sciences explores the opportunity to create and maintain intertidal mussel beds by active management. The research aims to develop methods to combine a number of seemingly contradictory goals:

- create new, commercially relevant production locations for mussel growers;
- develop new, environmentally friendly methods to diminish erosion of tidal flats;
- enhance the environmental quality to fulfil Natura-2000 goals.

## Partners in this project

Rijkswaterstaat,NIOZ, Wageningen Marine Research, Deltares and HZUniversity of Applied Sciences, Roem van Yerseke
*[contact: Tjeerd Bouma]*

## Current research

By means of experimental and comparative experiments, we will test a number of factors that could be used to improve the chances of establishing intertidal mussel beds, and potentially lead to their enhanced ecological and economical value as well as a positive effect on sediment stability.

Understanding the role of active long-term management in achieving these goals is essential. The project aims to yield applicable knowledge, based on in-depth understanding.

# SINT ANNALAND – BUILDING FOR NATURE

## Research outline

The dike was divided into sections of 10m in length, each with a certain type of block. There are two standard block types: Hillblocks and Hydroblocks, which have a flat surface. There are also two types of Hydroblocks with an ecotop: one type has a lava stone ecotop (reddish) and the other a basalt ecotop (dark grey). The lava stone ecotop has a high water retaining capacity. The same goes for a new type of Hillblockwhich is produced from a more porous type of concrete. Finally, there are blocks with diamond-shaped pits of various sizes. These blocks were designed by the Building for Nature project to study the effects of pit size on species abundance. These blocks have also been placed at two other field locations: Krabbenkreekdam and at NIOZ, Yerseke.

In the coming years the ecological development on the dikes will be monitored by the Building for Nature project. More insight will be gained concerning the relationship between the surface characteristics and zonation patterns in seaweed species and the presence of animal species. This will ultimately lead to design criteria for revetments intended to have an added value to nature.

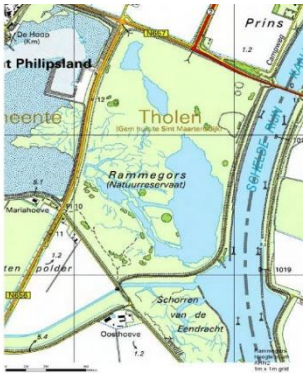
## Background information

In May 2015 a mosaic of different types of blocks was placed on the dike at Sint-Annaland. This new revetment has been designed as a research area for studying the ecological development on dike blocks. This research is part of the RAAK-PRO Building for Nature project.

## Partners in this project

The research group Building with Nature of the HZ Delta Academy is the coordinator of the RAAK-PRO project Building for Nature. Partners involved are: Rijkswaterstaat, Projectbureau Zeeweringen, Deltares, Wageningen Marine Research, NIOZ, Haringman Betonwaren, and HZ University of Applied Sciences. The project is grant-supported by SiA. *[contact: Matthijs Boersema]*

# RAMMEGORS TIDAL RESTORATION
## MONITORING AND RESEARCH

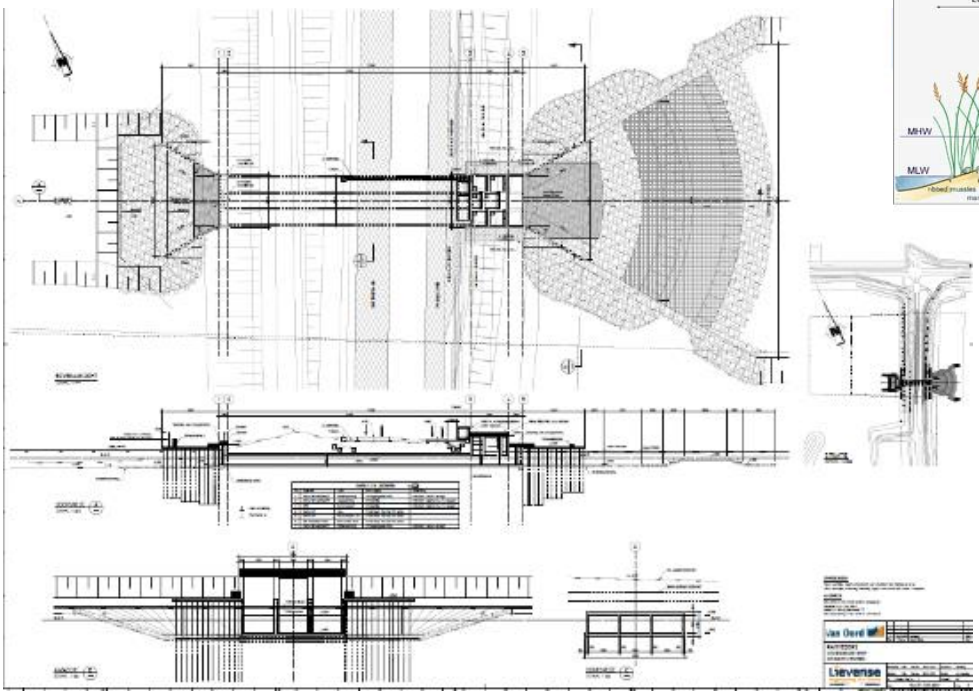


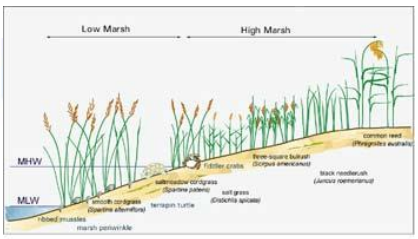

### Background information

In the seventies of the previous century, the Rammegors area (75 ha) was created by connecting the islands of Tholen and St. Philipsland (picture on the left). The area was created by dikes and was originally meant to serve as a deposit for dredged material from the Scheldt-Rhine channel. The tide disappeared until 2014, in that year the connection with the Eastern Scheldt was restored. See the inlet construction at the bottom.

### Research projects

In the Rammegors monitoring project the development of the area will be followed over the period 2015 t/m 2017. The knowledge generated in the project will be used in future tidal restoration projects. The monitoring concentrates on the development of vegetation, morphology, benthos and the impact of saline water on the surrounding polder areas



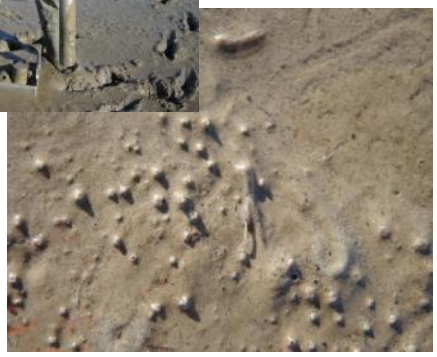



### Partners in this project

Rijkswaterstaat, Staatsbosbeheer, Wageningen Marine Research, Deltares, NIOZ, Arcadis, HZ University of Applied Sciences*[contact: Matthijs Boersema]*

# PERKPOLDER TIDAL RESTORATION
## MONITORING AND RESEARCH

### Background information
Starting from 2003 the ferry between Kruiningen (Zuid-Beveland) and Perkpolder (Zeeuws-Vlaanderen) became out of service, which was caused by the opening of the Western Scheldt tunnel. This fact was a starting point for the development of *Plan Perkpolder* to prompt the social-economic development of the area. This plan combines the development of real estate, recreational facilities and nature restoration.



*Sampling sediment cores*


### Current research projects
This three-year project (from 2016 to 2019) is executed by the Centre of Expertise Delta. The research focuses on the morphological and ecological developments, and the groundwater changes in the Perkpolder tidal basin. In addition to developments inside the tidal basin, the effects of saline groundwater on the surrounding agricultural areas are investigated. To reduce the impact of saline water a unique seepage discharge system is constructed around the Perkpolder tidal basin, at the landward side of the dyke.

The goal of current research is to determine whether the tidal environment is contributing to the Natura 2000 conservation goals for the Western Scheldt and Saeftinghe. Added to that the newly created natural area serves as a compensation measure for the second extension of the waterway to the Port of Antwerp.

The development of knowledge and the education of new deltaprofessionals are two important goals. This project offers the opportunity to study the real development of a managed realignment site, in which an agricultural area is transformed in a salt-water natural area.

### Partners in this project
Rijkswaterstaat, NIOZ, Wageningen Marine Research, Deltares and HZ University of Applied Sciences
*[contact: Matthijs Boersema]*

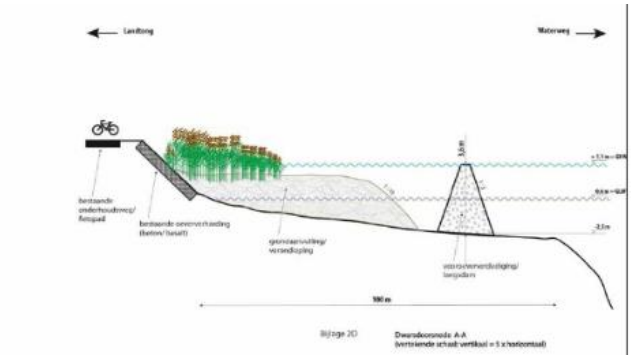
# ROTTERDAM DELTA – GROENE POORT

## Background information

In the project *Groene Poort*, five kilometers of banks of the Nieuwe Waterweg will be developed into nature development areas, by diminishing the effects of wave energy. For this, dams will be built between groynes and parallel to the banks. Materials used for the dams are local construction residues. Moreover, sediment, originating from the Nieuwe Waterweg itself, will be added to create less depths.

## Current research

HZ University of Applied Science and Hogeschool Rotterdam University of Applied Sciences will write a monitoring plan and also cooperate in the actual monitoring of the ecological (physico-chemical, biological and hydromorphological) developments of the area. Moreover civil-engineering aspects of the dams themselves will be monitored.



## Partnersin this project

Community of Rotterdam, Rijkswaterstaat, Ark Natuurontwikkeling, WWF, Deltatalent, Hogeschool Rotterdam, and HZ University of Applied Sciences *[contact: Anneke van den Brink]*