EFFECTIVENESS OF ECOMODULES IN INCREASING AQUATIC BIODIVERSITY AND BIOPRODUCTIVITY IN A PORT ENVIRONMENT.

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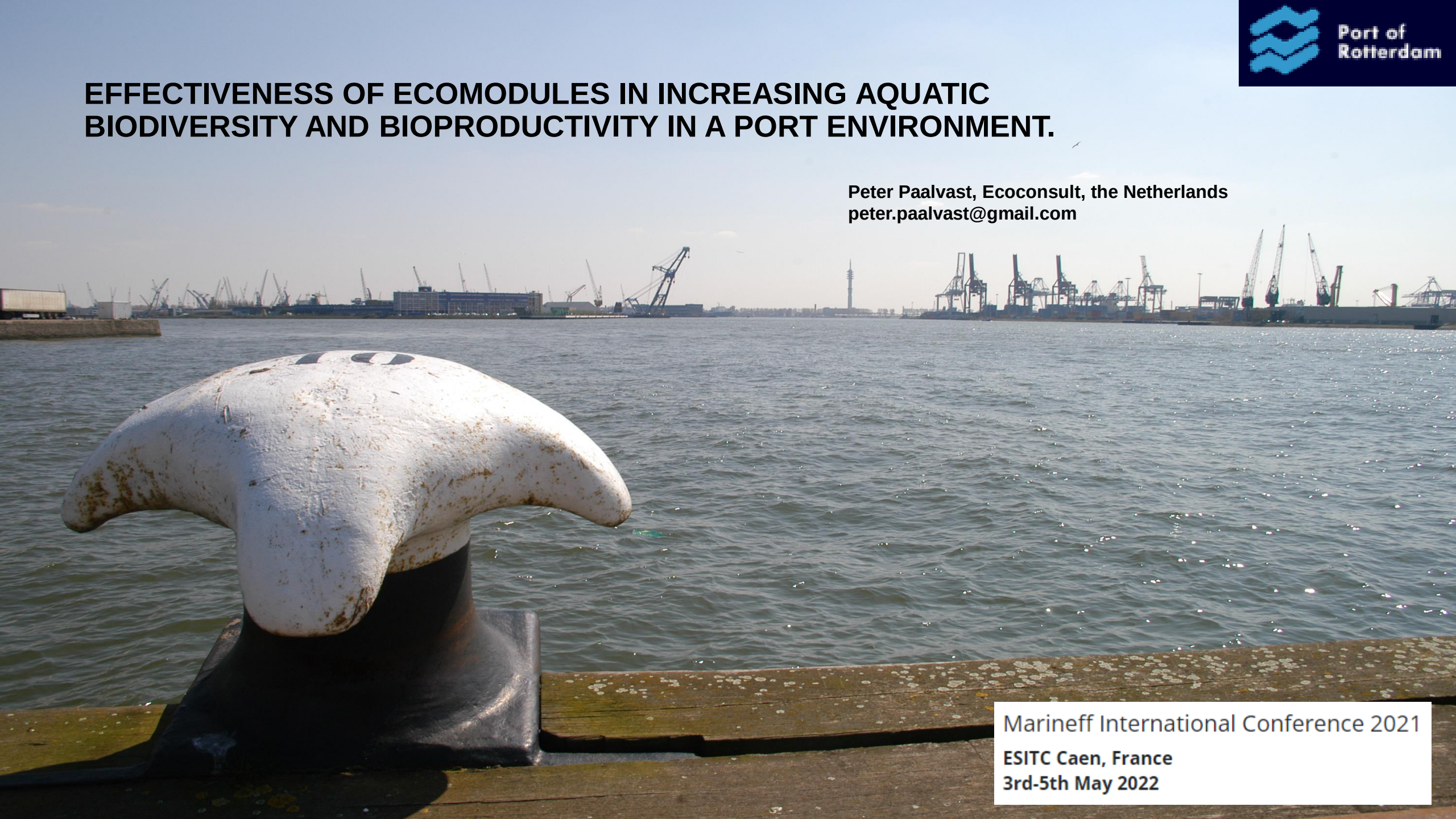
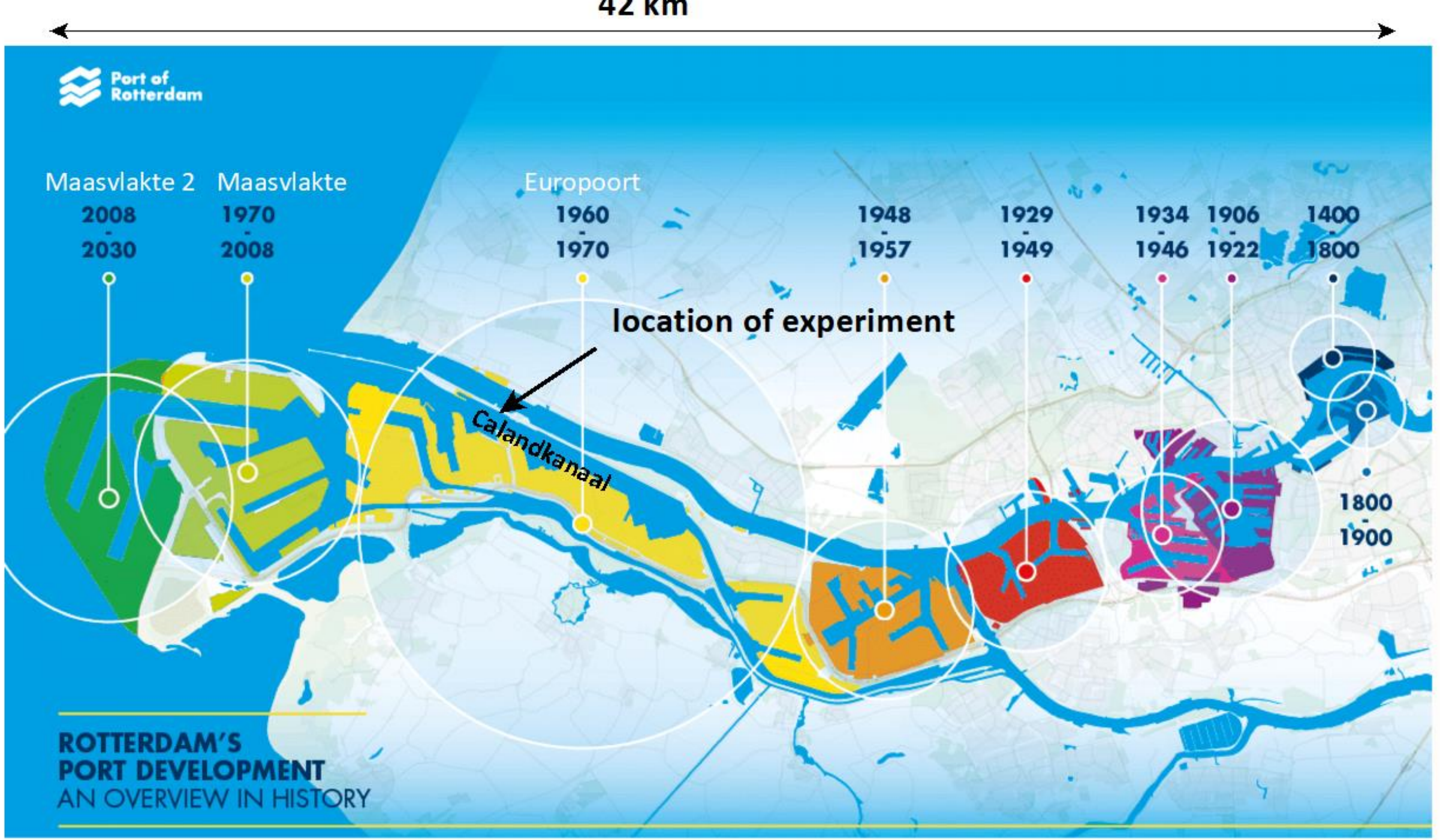
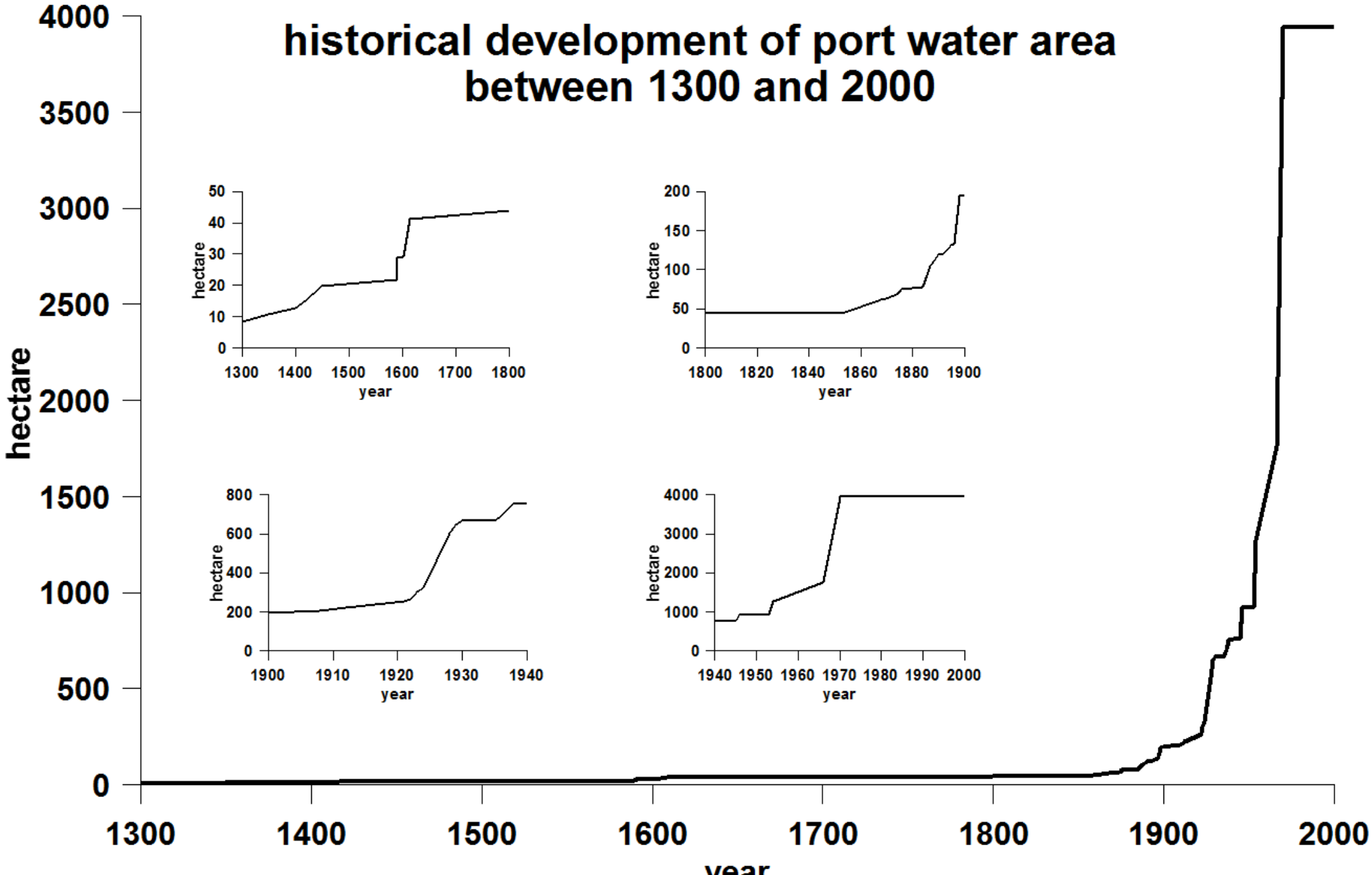


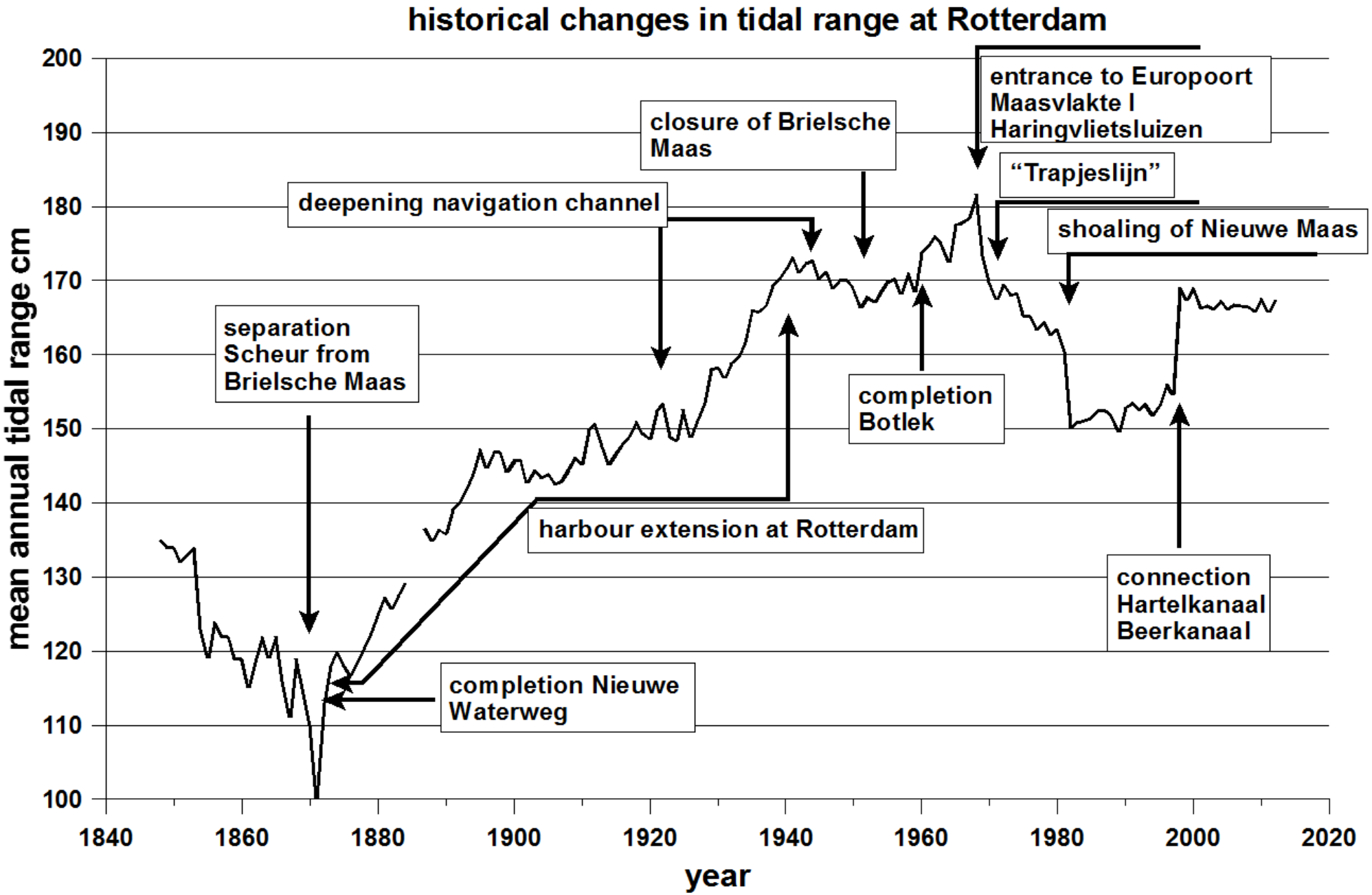
Marineff International Conference 2021
ESITC Caen, France
3rd-5th May 2022

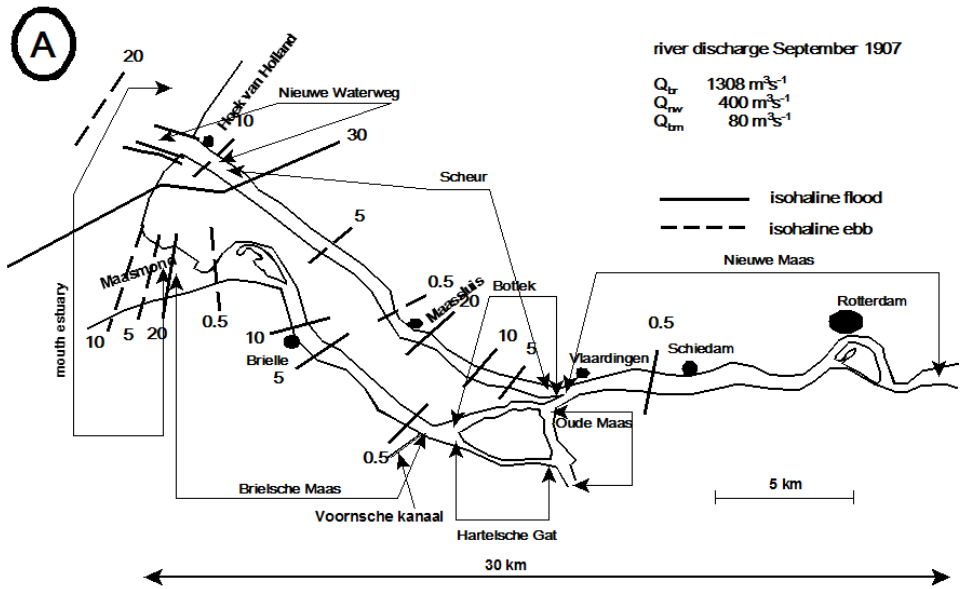
Location of the experiment

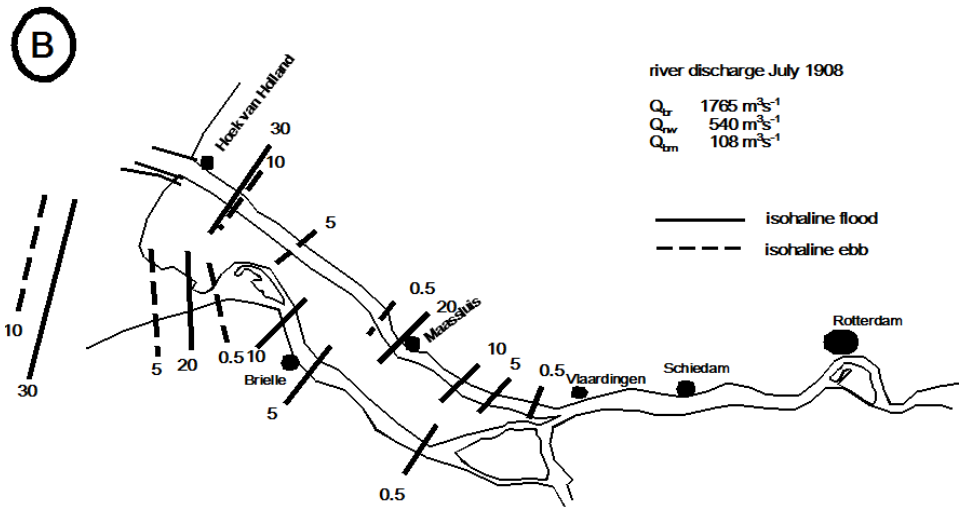
Port of Rotterdam, estuarine environment, sheltered

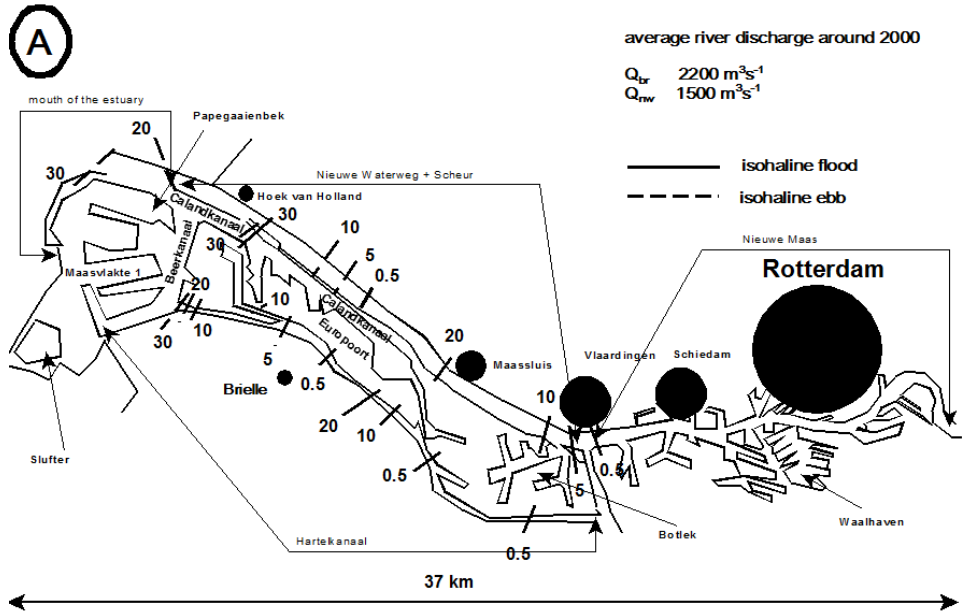

42 km
Port of Rotterdam
Maasvlakte 2
2008
-
2030
Maasvlakte
1970
-
2008
Europoort
1960
-
1970
1948
-
1957
1929
-
1949
1934
-
1946
1906
-
1922
1400
-
1800
1800
-
1900
location of experiment
Calandkanaal
ROTTERDAM'S
PORT DEVELOPMENT
AN OVERVIEW IN HISTORY


historical development of port water area
between 1300 and 2000
hectare
year
4000
3500
3000
2500
2000
1500
1000
500
0
1300
1400
1500
1600
1700
1800
1900
2000
50
40
30
20
10
0
1300
1400
1500
1600
1700
1800
200
150
100
50
0
1800
1820
1840
1860
1880
1900
800
600
400
200
0
1900
1910
1920
1930
1940
4000
3000
2000
1000
0
1940
1950
1960
1970
1980
1990
2000


historical changes in tidal range at Rotterdam
mean annual tidal range cm
year
200
190
180
170
160
150
140
130
120
110
100
1840
1860
1880
1900
1920
1940
1960
1980
2000
2020
entrance to Europoort
Maasvlakte I
Haringvlietsluizen
closure of Brielsche Maas
"Trapjeslijn"
deepening navigation channel
shoaling of Nieuwe Maas
separation Scheur from Brielsche Maas
completion Botlek
harbour extension at Rotterdam
connection Hartelkanaal Beerkanaal
completion Nieuwe Waterweg


A
river discharge September 1907
Q_{tr} 1308 m³s⁻¹
Q_{rw} 400 m³s⁻¹
Q_{brn} 80 m³s⁻¹
isohaline flood
isohaline ebb
mouth estuary
Hoek van Holland
Nieuwe Waterweg
Scheur
Maasmond
Maassluis
Botlek
Nieuwe Maas
Rotterdam
Brielle
Vlaardingen
Schiedam
Oude Maas
Brielsche Maas
Voornsche kanaal
Hartelsche Gat
5 km
30 km


B
river discharge July 1908
Q_{tr} 1765 m³s⁻¹
Q_{rw} 540 m³s⁻¹
Q_{brn} 108 m³s⁻¹
isohaline flood
isohaline ebb
Hoek van Holland
Maassluis
Rotterdam
Brielle
Vlaardingen
Schiedam


A
average river discharge around 2000
Q_{tr} 2200 m³s⁻¹
Q_{rw} 1500 m³s⁻¹
isohaline flood
isohaline ebb
mouth of the estuary
Papegaaienbek
Nieuwe Waterweg + Scheur
Hoek van Holland
Calandkanaal
Beerkanaal
Maasvlakte 1
Nieuwe Maas
Rotterdam
Calandkanaal
Europoort
Maassluis
Vlaardingen
Schiedam
Brielle
Slufter
Botlek
Waalhaven
Hartelkanaal
37 km

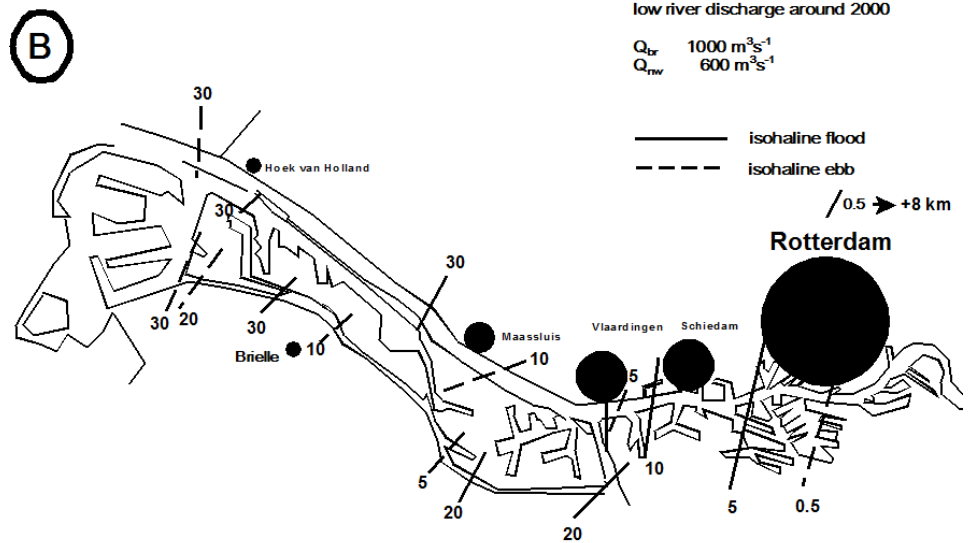
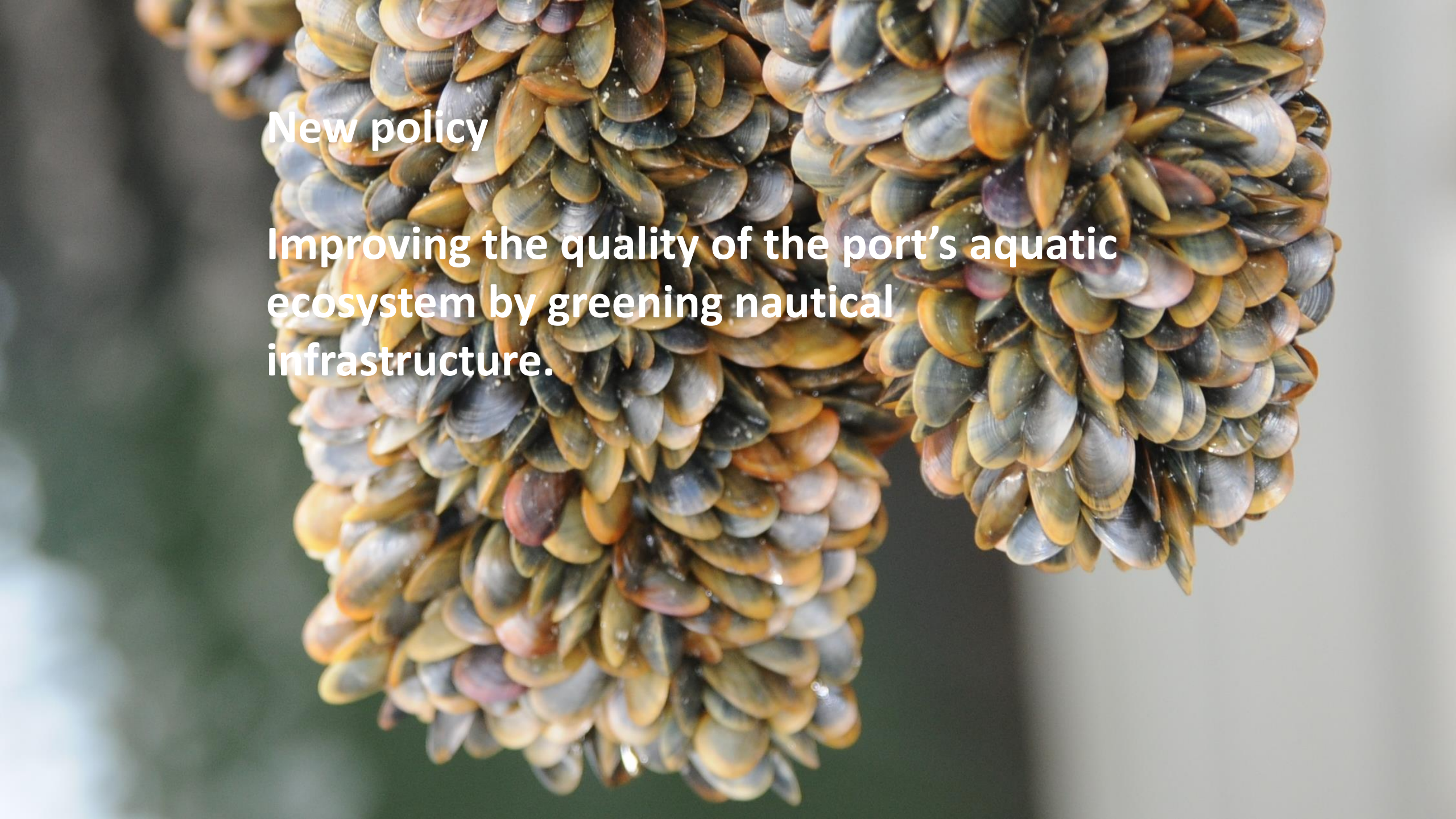

B
low river discharge around 2000
Q_{tr} 1000 m³s⁻¹
Q_{rw} 600 m³s⁻¹
isohaline flood
isohaline ebb
0.5 → +8 km
Hoek van Holland
Rotterdam
Maassluis
Vlaardingen
Schiedam
Brielle

Table 2 Development of river and port area in hectares (ha = 10,000 m^2), river length, shoreline and intertidal ecotopes in the northern part of the Rhine-Meuse estuary between 1834-35 and 2008.

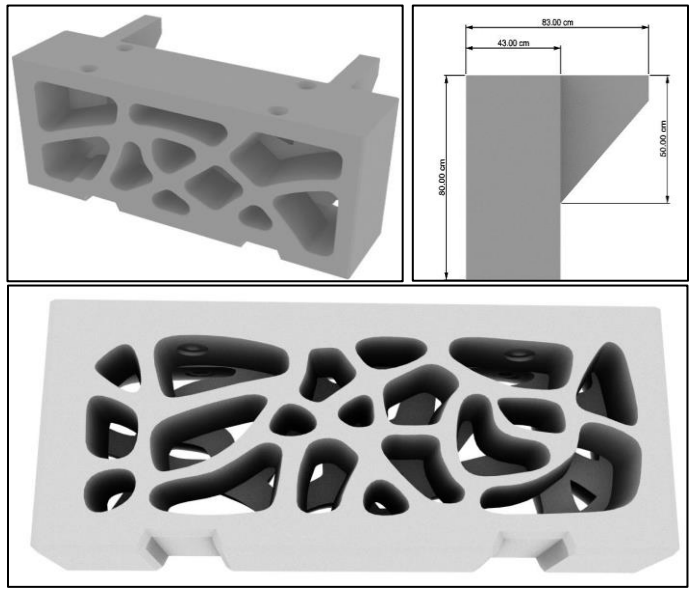
		total area			
item	unit	1834-35	1880-81	1933-35	2008
river surface	ha	3543	4039	3237	2301
port surface	ha	74	90	719	3942
river length	km	59.3	65.6	67.4	42.3
length soft river shoreline	km	839.7	886.9	708.3	1.1
length hard river shoreline	km	12.5	37.4	86.0	90.6
length soft port shoreline	km	4.6	1.7	15.8	0.0
length hard port shoreline	km	29.2	40.3	88.1	253.2
total length soft shoreline	km	844.3	888.6	724.0	1.1
total length hard shoreline	km	41.7	77.7	174.1	343.9
surface soft intertidal ecotopes	ha km^{-1}	79.9	39.9	36.3	0.4
surface hard intertidal ecotopes	ha km^{-1}	0.3	0.5	1.4	8.0


soft
hard
4750 ha
1835
16 ha
beaches and dunes
sand and mud flats
reed and rush beds
river islands
tidal willow coppice
estuarine meadows
piers and jetties
groins
quay walls
retainingwals
rip rap
shore defenses
17 ha
2008
338 ha



New policy

Improving the quality of the port’s aquatic ecosystem by greening nautical infrastructure.

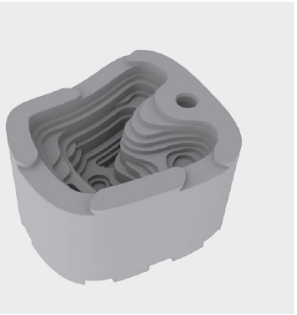


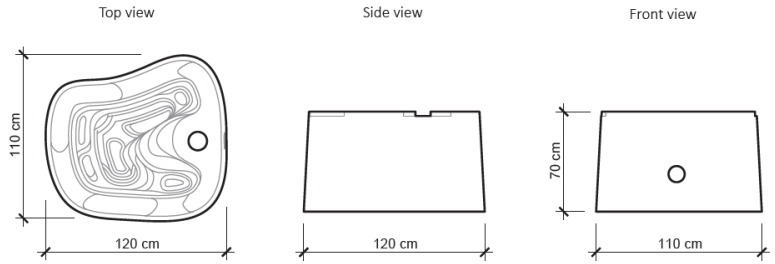
© ECOncrete Unit installed below the concrete cap of the sheet pile quay wall

Unit Length (cm)	Unit Width (cm)	Unit Hight (cm)	Volume (Liters)	Weight (Kg)
120 (4')	110 (3.6')	70 (2.3')	600 (0.8 yd³)	1,400 (3,100 lbs)

ECOncrete® Tide Pool's dimensions can be fitted to specific project requirements.

The specific concrete matrix used for the casting is defined according to the project's distinct constructive and biological requirements.





©ECOncrete artificial tide pools

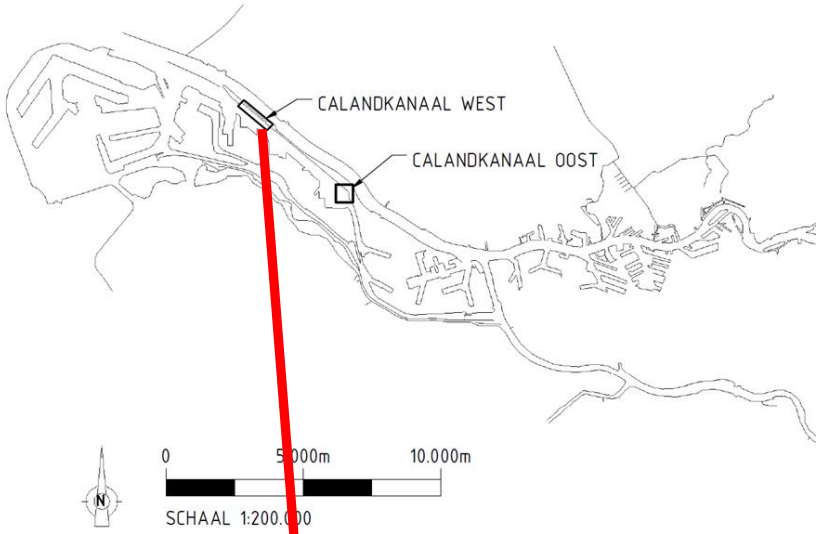
©Ecoconsult hulas

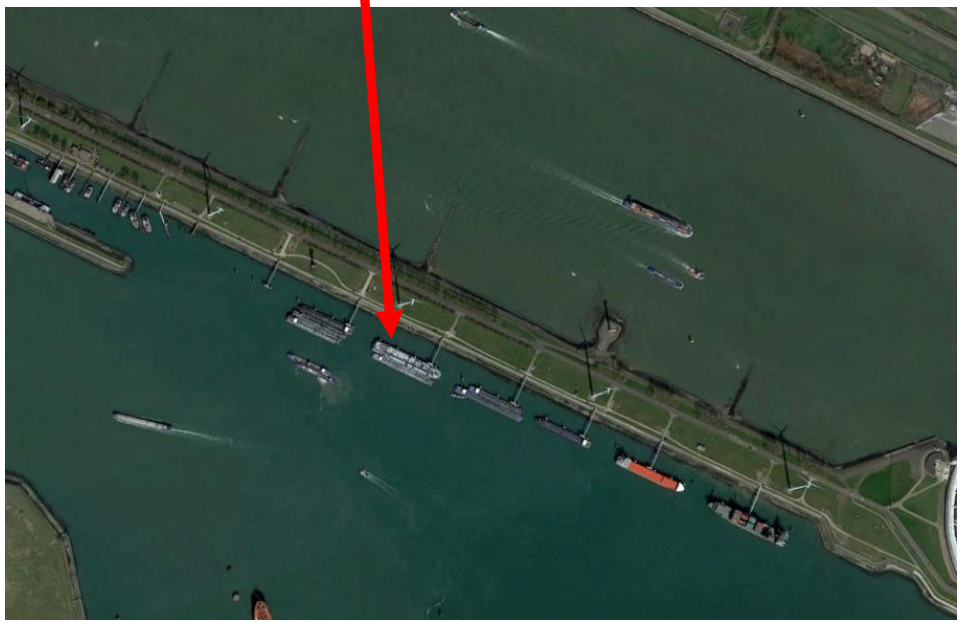
©Ecocean biohut

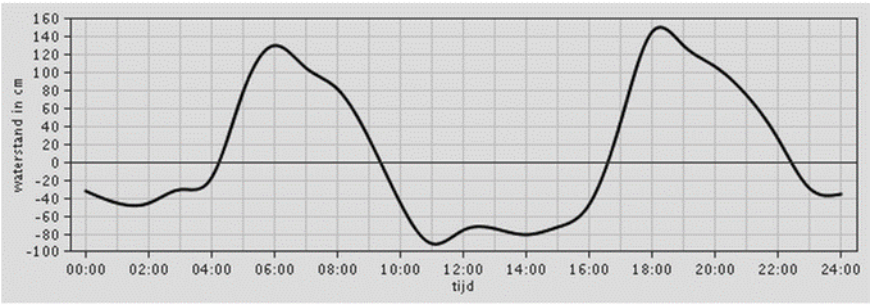
Effectiveness of ecomodules in increasing aquatic biodiversity and bioproductivity in a port environment.

In early spring of 2018 so called ecomodules were attached to new support piles of jetties within the polyhaline part of the port of Rotterdam.

The aim was to test whether ecomodules covered with different structures, such as ropes and pipes, locally increase biodiversity and bioproductivity. Where possible, discarded materials have been used.



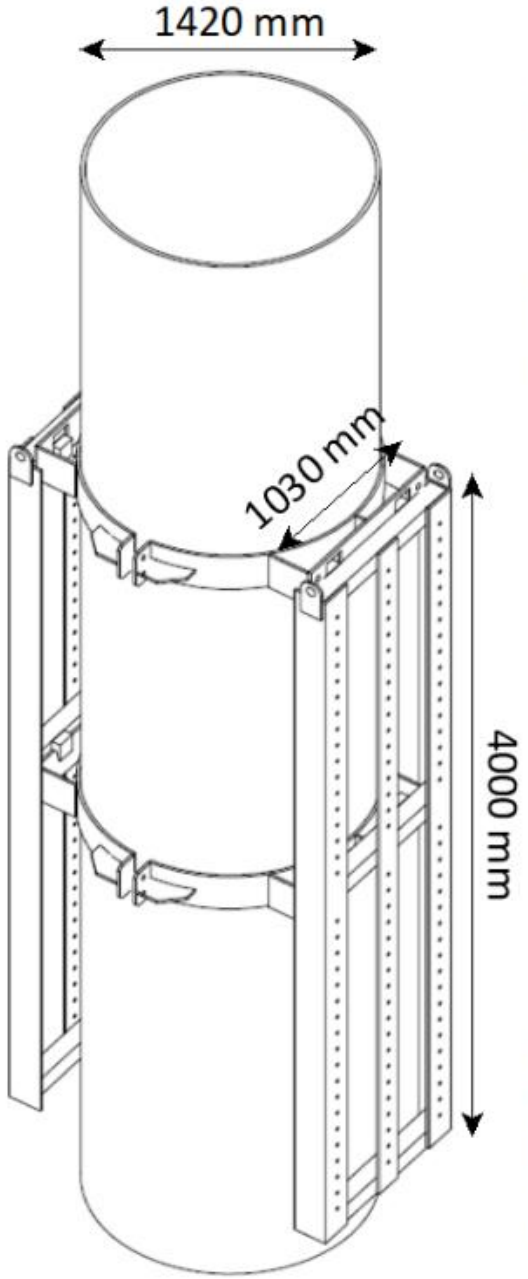


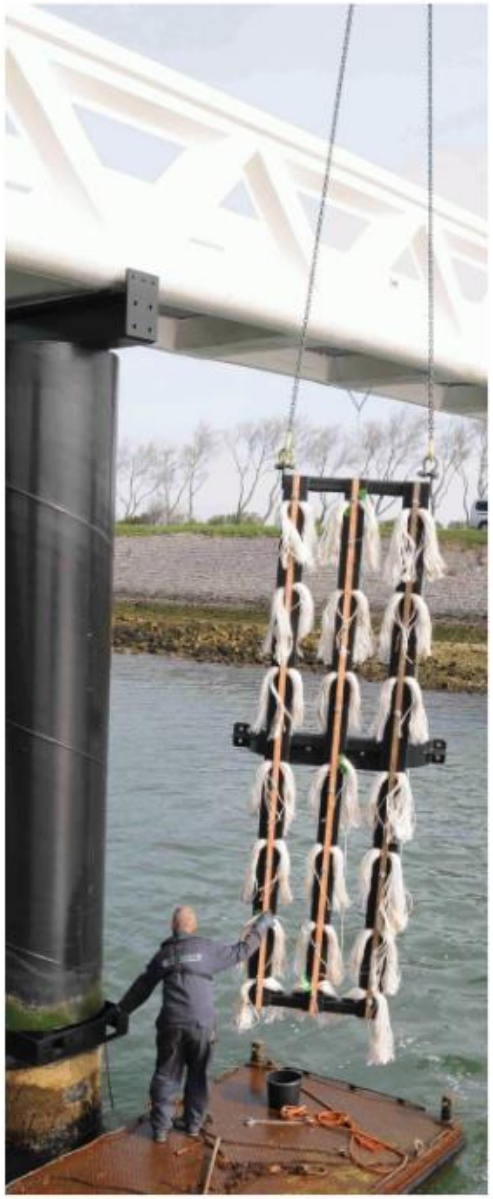


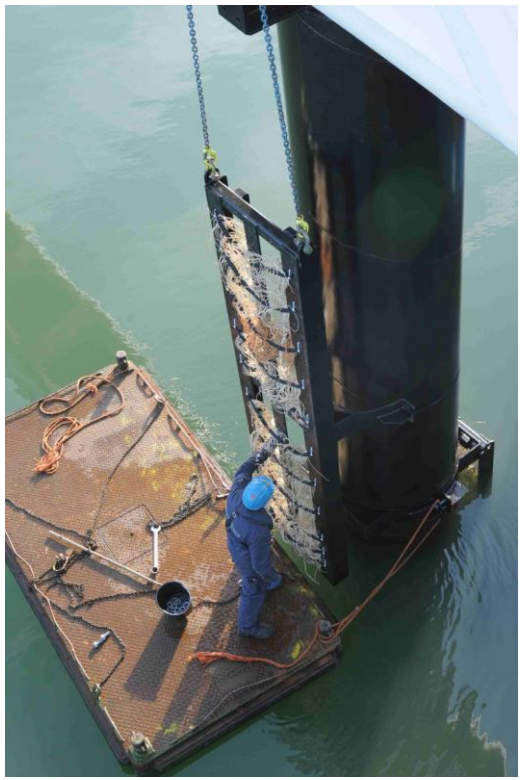
The average tidal range in the Calandkanaal is 1.94m. At springtide the tidal cycle exhibits approximately a 4 h period of flood, a 4 h period of ebb and a 4.5 h low water period. The water is often clear with a Secchi depth up to 3 m.

The water is always polyhaline and depending on the river discharge there is a more or less clear vertical gradient in salinity with high salinity near the sea floor and a lower salinity at the water surface.

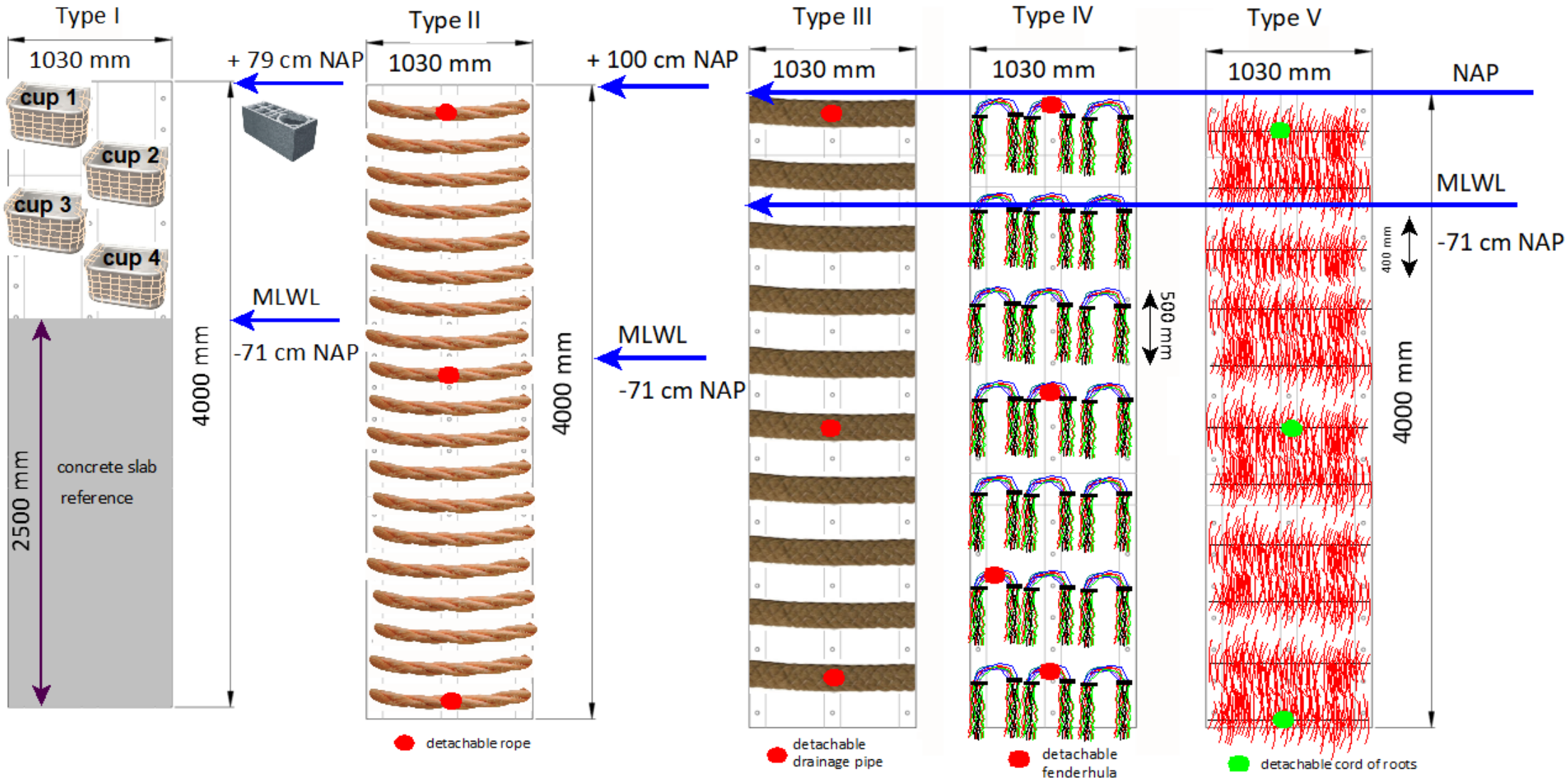
Design drawing of the basis of an ecomodule (left) and the mounting of type IV and V on a support pile of a jetty (right).







Design drawings of the ecomodules and their position in relation to NAP. NAP = Amsterdam Ordnance Datum



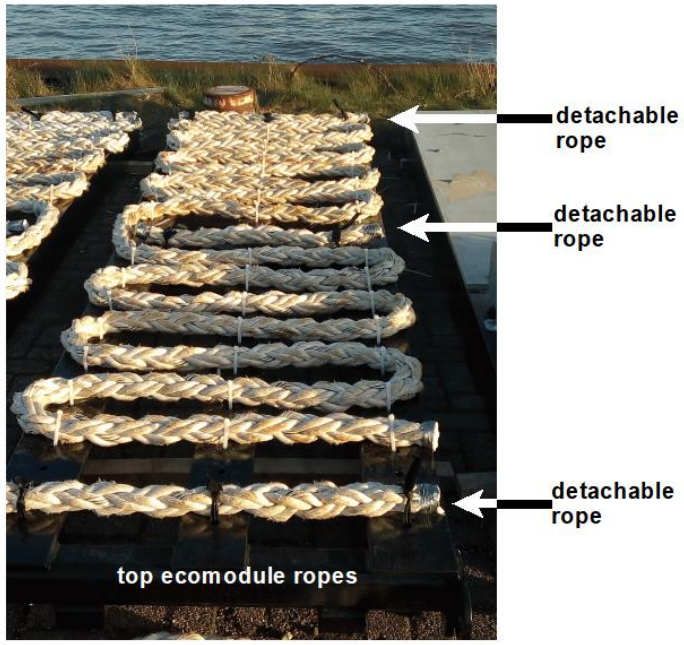
reference tidal cups

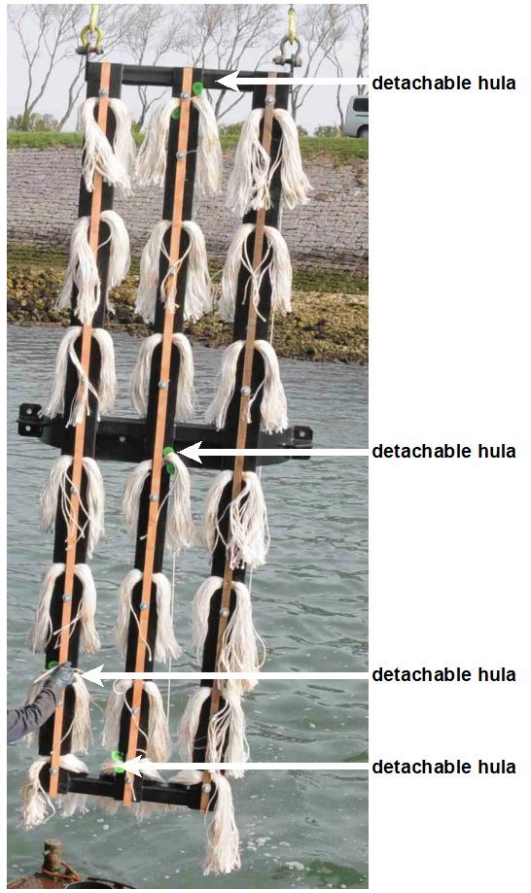
ropes

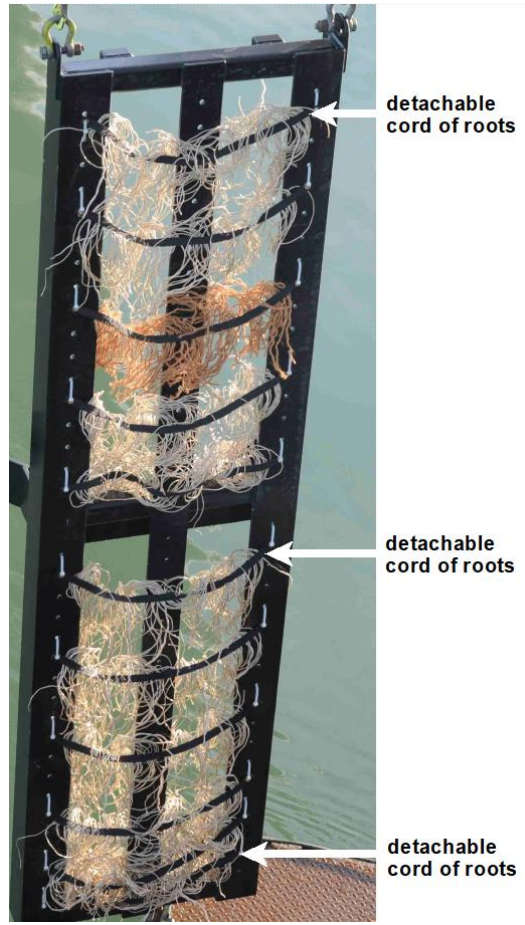
drainage pipes

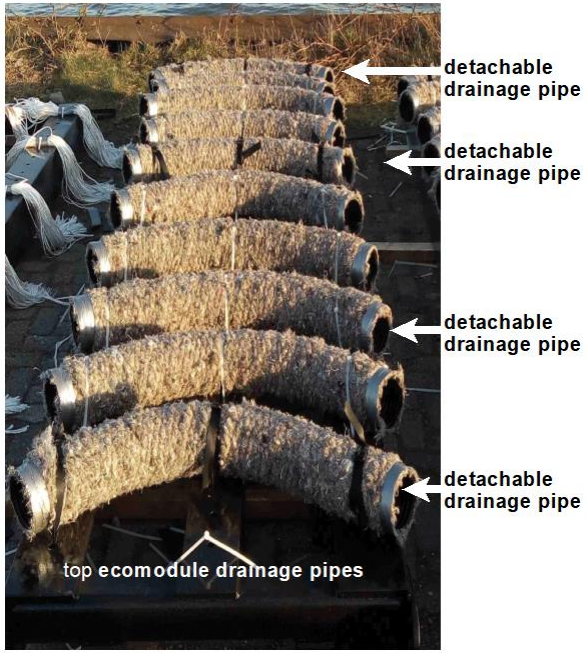
fender hulas

roots


detachable rope
detachable rope
detachable rope
top ecomodule ropes


detachable hula
detachable hula
detachable hula
detachable hula


detachable cord of roots
detachable cord of roots
detachable cord of roots


detachable drainage pipe
detachable drainage pipe
detachable drainage pipe
detachable drainage pipe
top ecomodule drainage pipes

monitoring 27/28 August 2018 (T1) 17/18 June 2019 (T2)

Abiotic parameters

oxygen concentration

salinity

temperature

water transparency

Biotic parameters

the length of zonation of algae and macrofauna

% coverage of algal species

number of algal species

% coverage or estimated number of individuals of sessile macrofauna species

number of sessile macrofauna species

estimated number of individuals of mobile macrofauna species

number of mobile macrofauna species

wet biomass

Abundance scale code for seaweeds and macrofauna.

code	percentage of cover	number of specimen
1	0% - 0.01%	1
2	0.01% - 0.1%	2 – 10
3	0.1% - 1.0%	11 – 100
4	1% - 5%	101 – 500
5	5% - 12.5%	>500
6	12.5% - 25%	
7	25% - 50%	
8	50% - 75%	
9	> 75%	

monitoring results

Abiotic conditions at the monitoring data.

date	**26-8-2018**	**17-6-2019**
time	11:35	11:18
Secchi depth (m)	2.9	3.2
surface		
salinity	25.3	20.5
temperature (ºC.)	19.1	18.6
oxygen saturation (%)	93.1	95.9
oxygen (mg/l)	7.5	7.5
3.5 m below surface		
salinity	25.7	21.6
temperature (ºC.)	19.4	17.6
oxygen saturation (%)	96,9	95.6
oxygen (mg/l)	7.7	7.7

Type I, ecomodule reference tidal cups

T1 27-8-2018

T2 17-6-2019

27-8-2018

17-6-2019

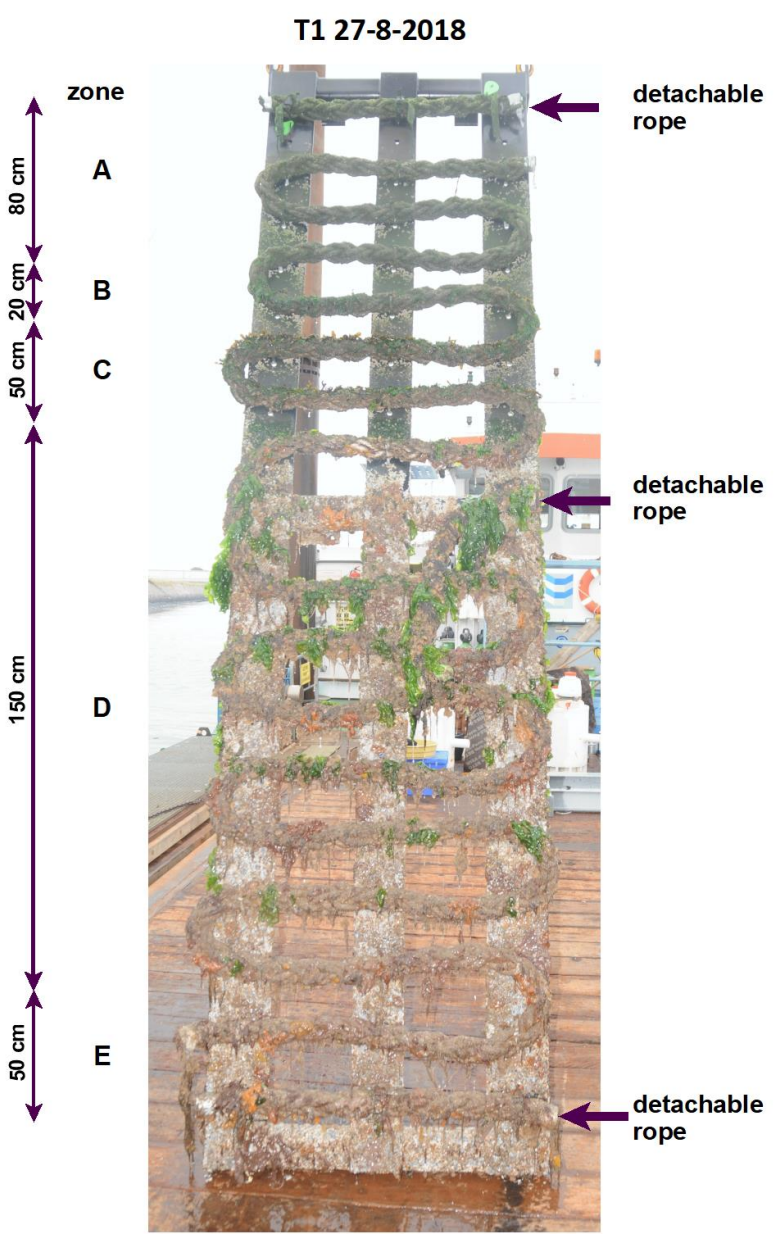
Type II, ecomodule ropes

T1

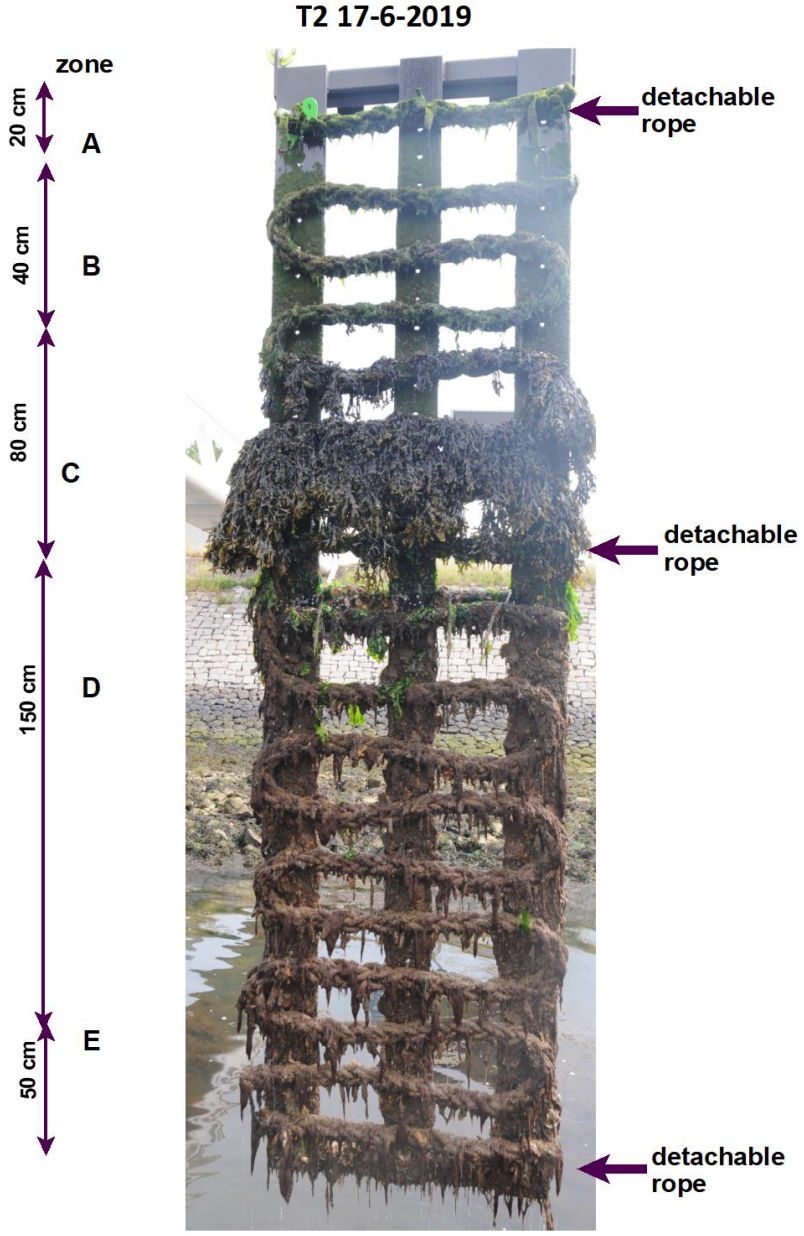
T2

T2

T1 27-8-2018



T2 17-6-2019

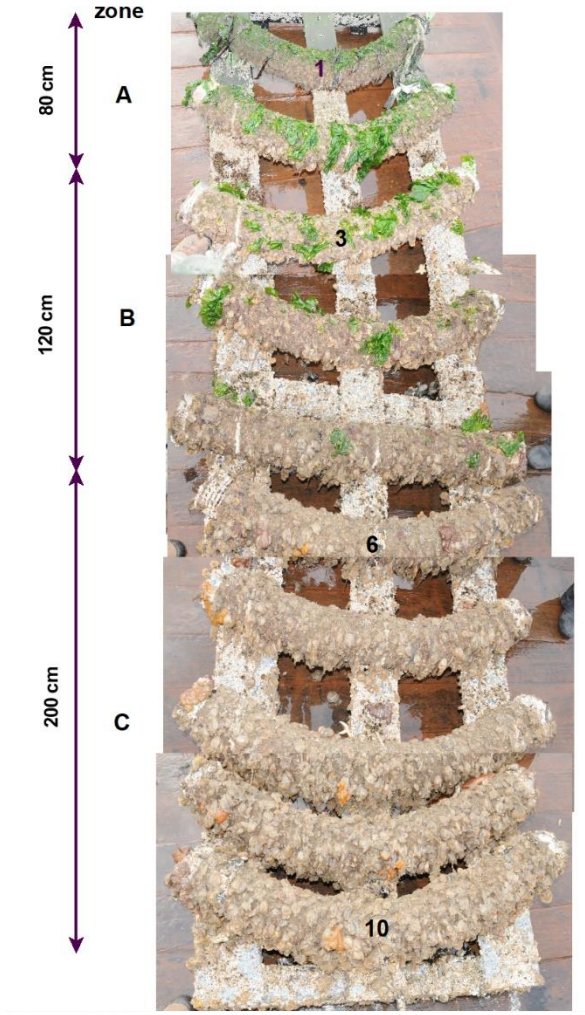


Type III, ecomodule drainage pipes

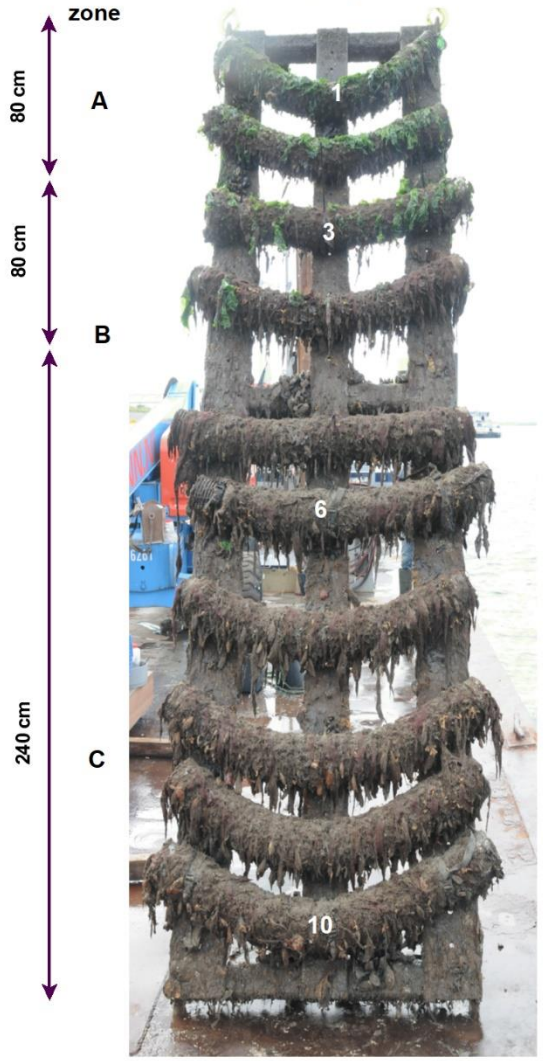
T1

T2

T1 27-8-2018



T2 17-6-2019

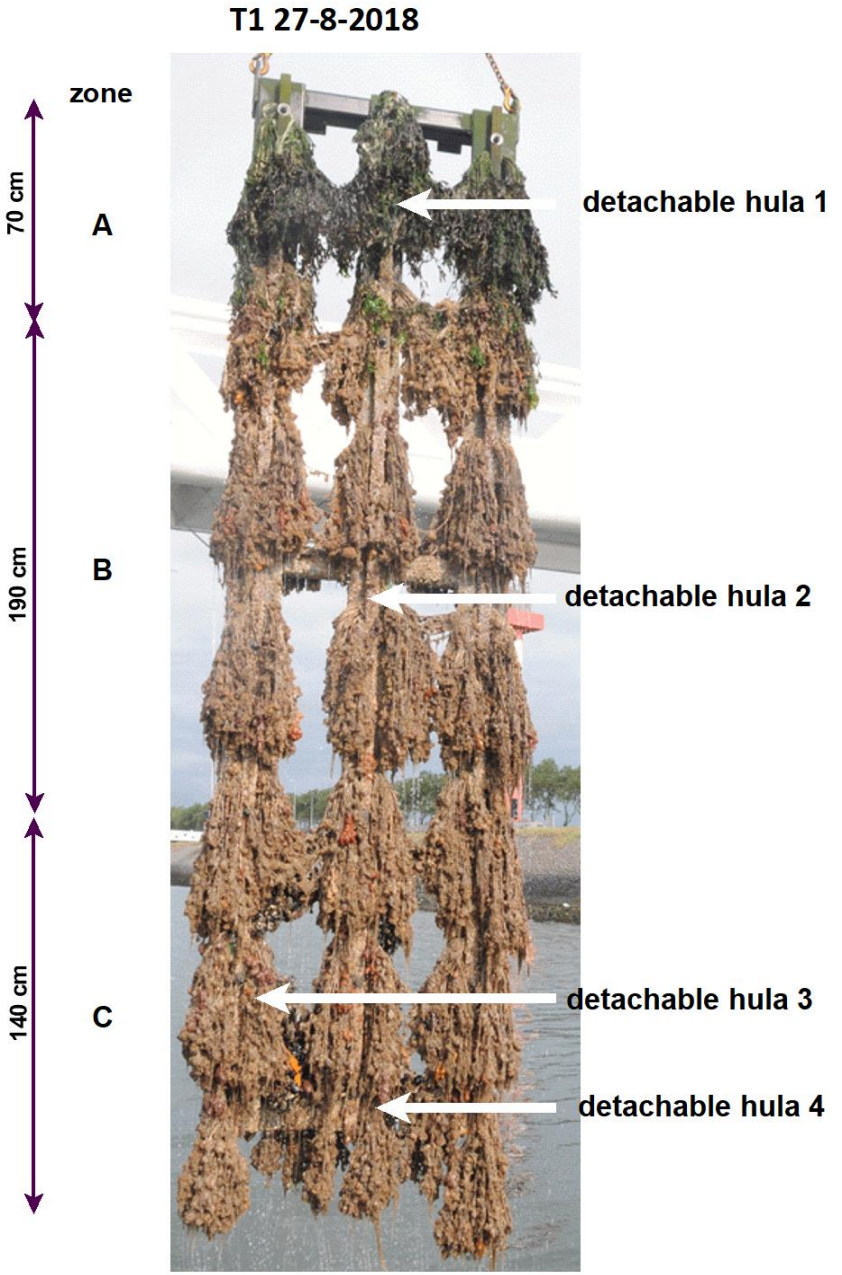


Type IV, ecomodule fender hulas

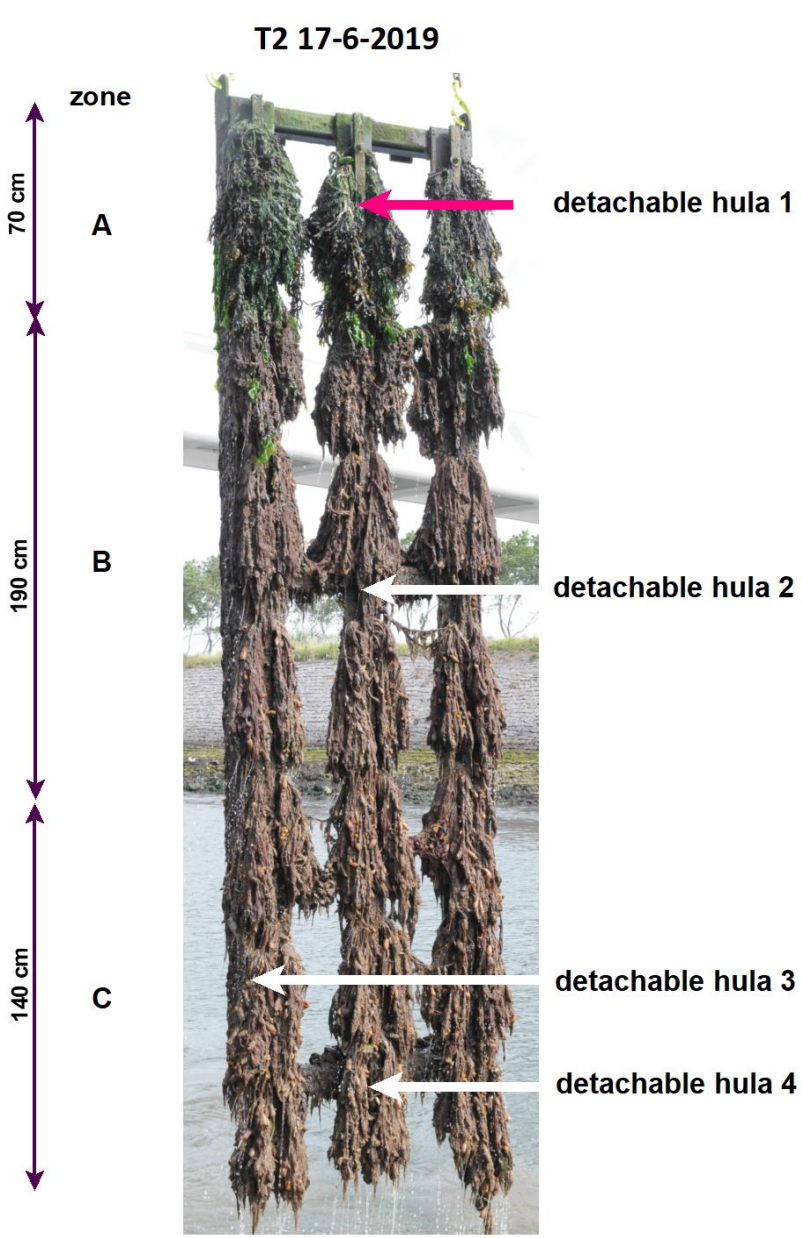
T1

T2

T1 27-8-2018



T2 17-6-2019

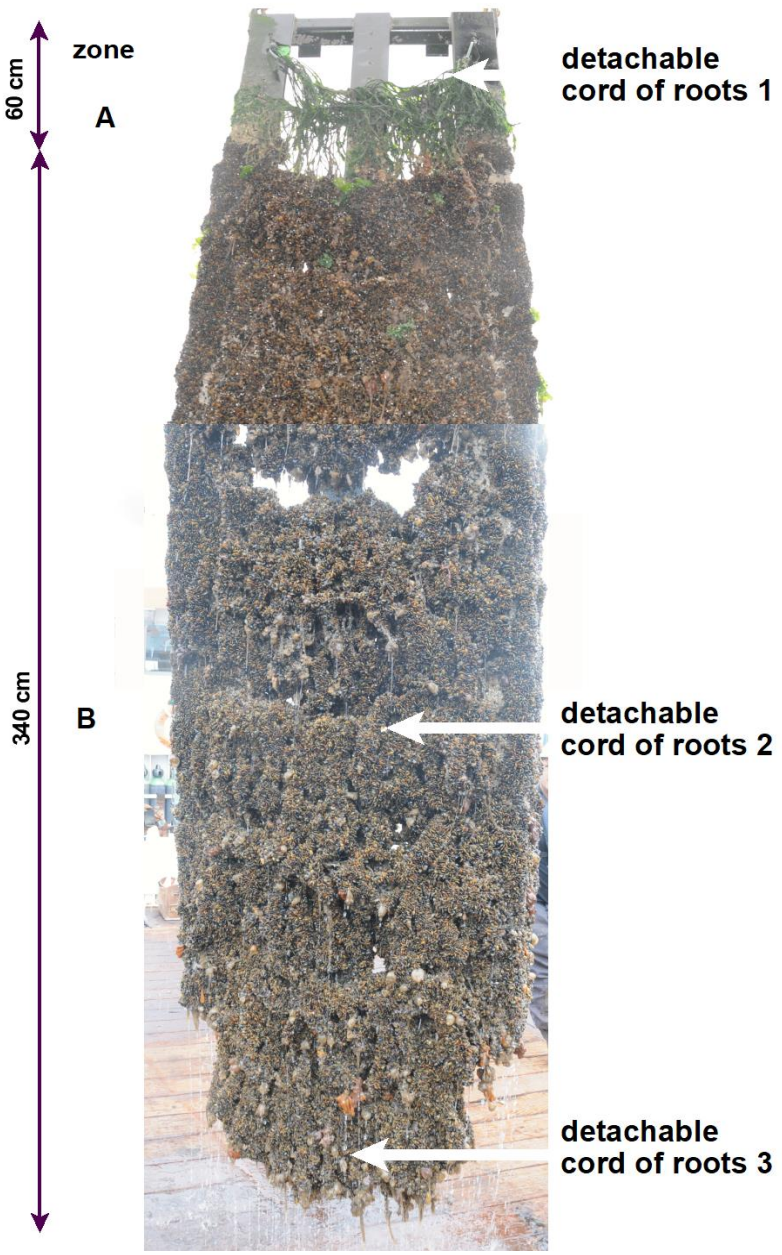


Type V, ecomodule roots

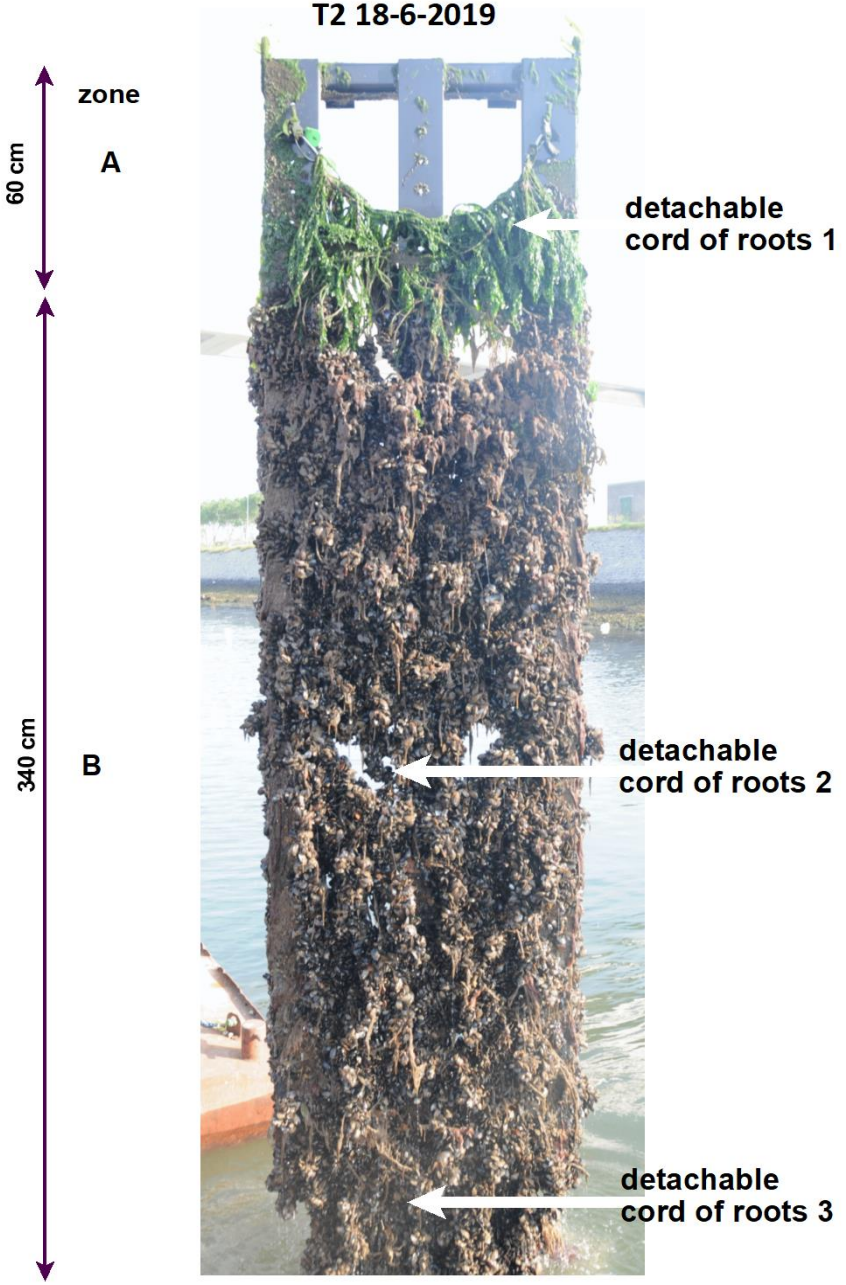
T1

T2

T1 27-8-2018



T2 18-6-2019



Type I
reference plate

Type II
ropes

Type III
drainage pipes

Type IV
fender hulas

Type V
roots

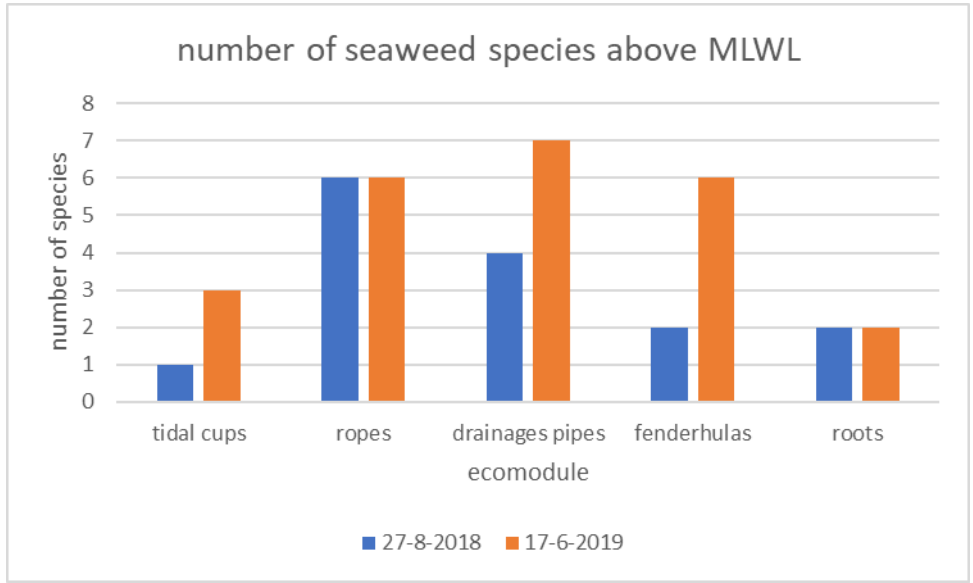
T2 17-6-2019

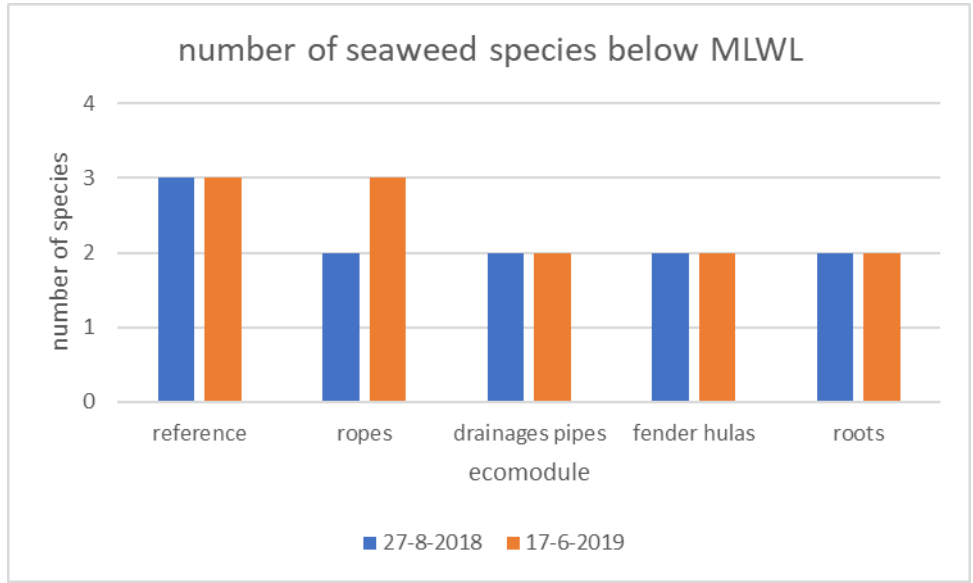
characteristic seaweeds above MLWL for the ecomodules

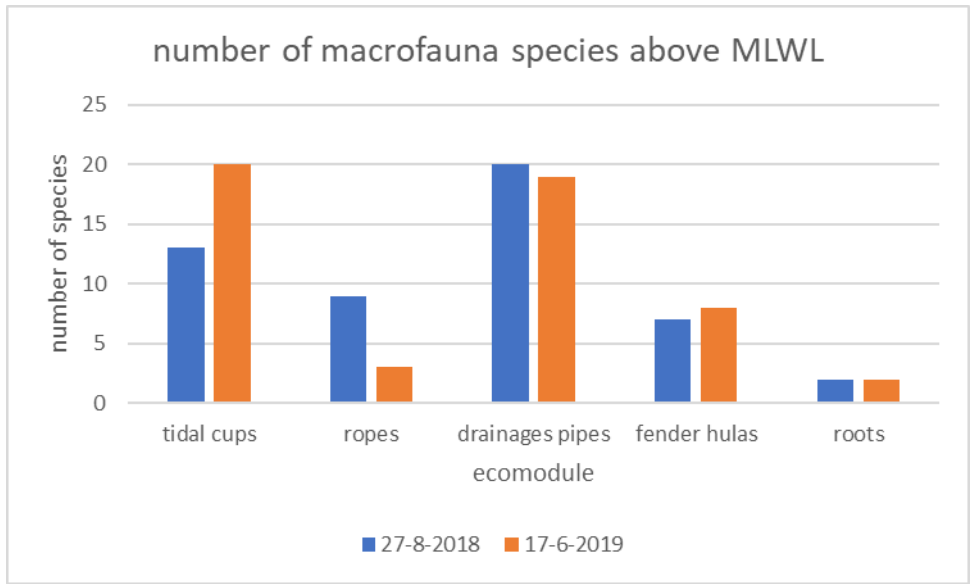
		Type I	Type II	Type III	Type IV	Type V	support pile
(co-)dominating seaweeds		tidel cups	ropes	drainage pipes	fender hulas	roots	reference
green	*Blidingia minima*						
	U. intestinalis/prolifera/B. minima						
	Ulva intestinalis						
	Ulva intestinalis/prolifera						
	Ulva rigida						
red	*Aglaothamnion hookeri*						
	Porphyra purpurea						
brown	*Fucus vesiculosus*						

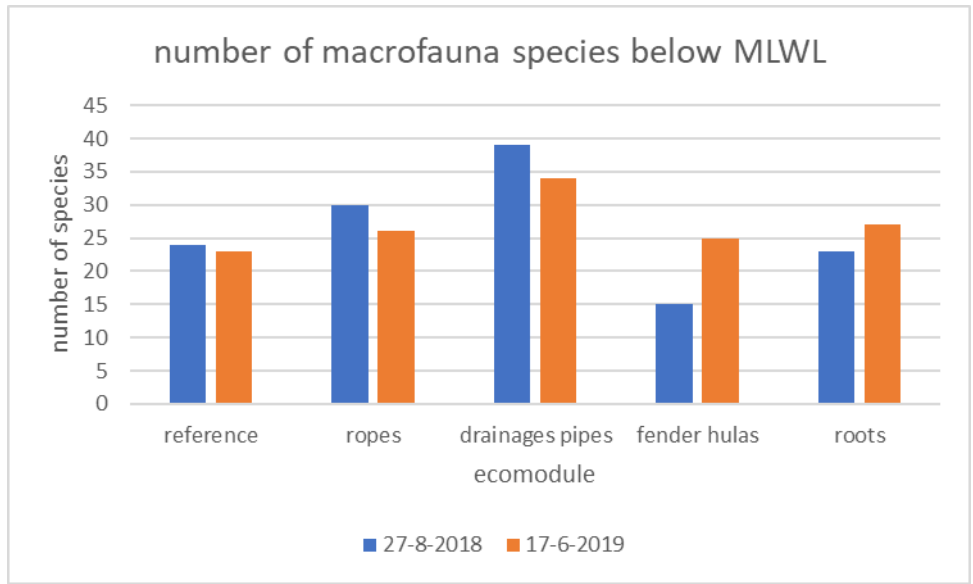
characteristic macrofauna below MLWL for the ecomodules

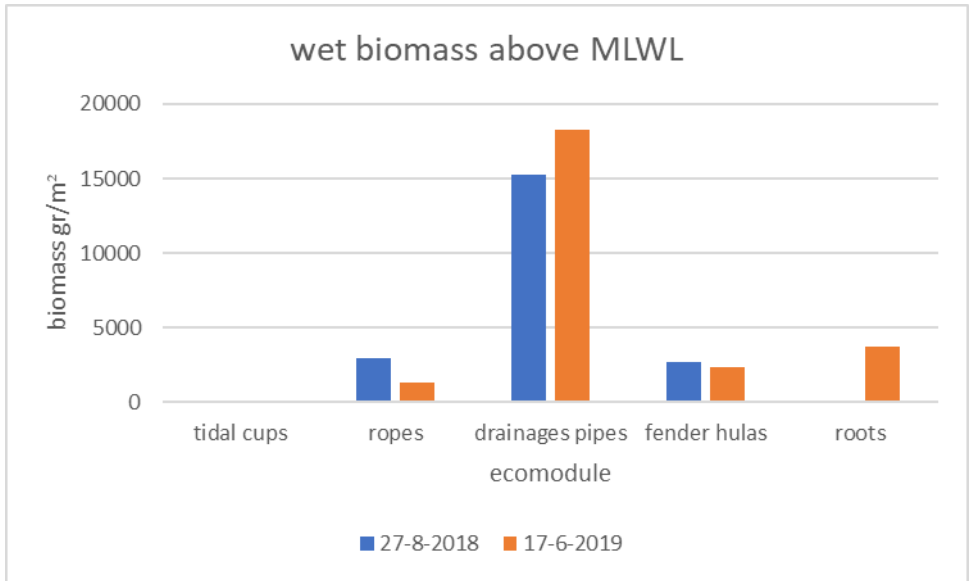
		Type I	Type II	Type III	Type IV	Type V
(co-)dominating groups/species		reference plate	ropes	drainage pipes	fender hulas	roots
sessile	barnacles					
	ascidians colonial					
	ascidians solitary					
	hydrozoans					
	bryozoans					
	mussels					
	Pacific oysters					
mobile	shore crabs					
	starfish					
	butterfish					
	amphipods					

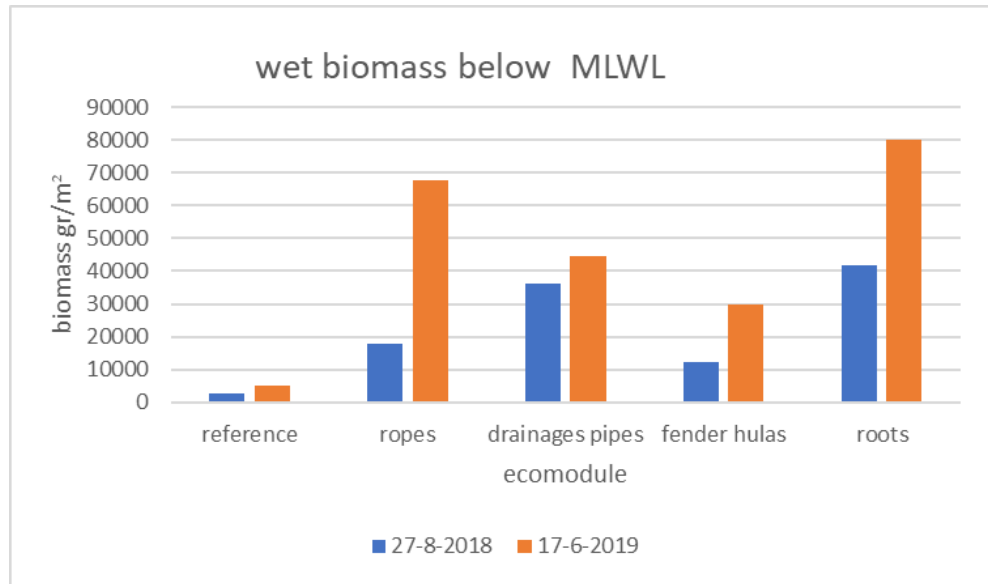

number of seaweed species above MLWL
number of species
0
1
2
3
4
5
6
7
8
tidal cups
ropes
drainages pipes
fenderhulas
roots
ecomodule
27-8-2018
17-6-2019


number of seaweed species below MLWL
number of species
0
1
2
3
4
reference
ropes
drainages pipes
fender hulas
roots
ecomodule
27-8-2018
17-6-2019


number of macrofauna species above MLWL
number of species
0
5
10
15
20
25
tidal cups
ropes
drainages pipes
fender hulas
roots
ecomodule
27-8-2018
17-6-2019


number of macrofauna species below MLWL
number of species
0
5
10
15
20
25
30
35
40
45
reference
ropes
drainages pipes
fender hulas
roots
ecomodule
27-8-2018
17-6-2019

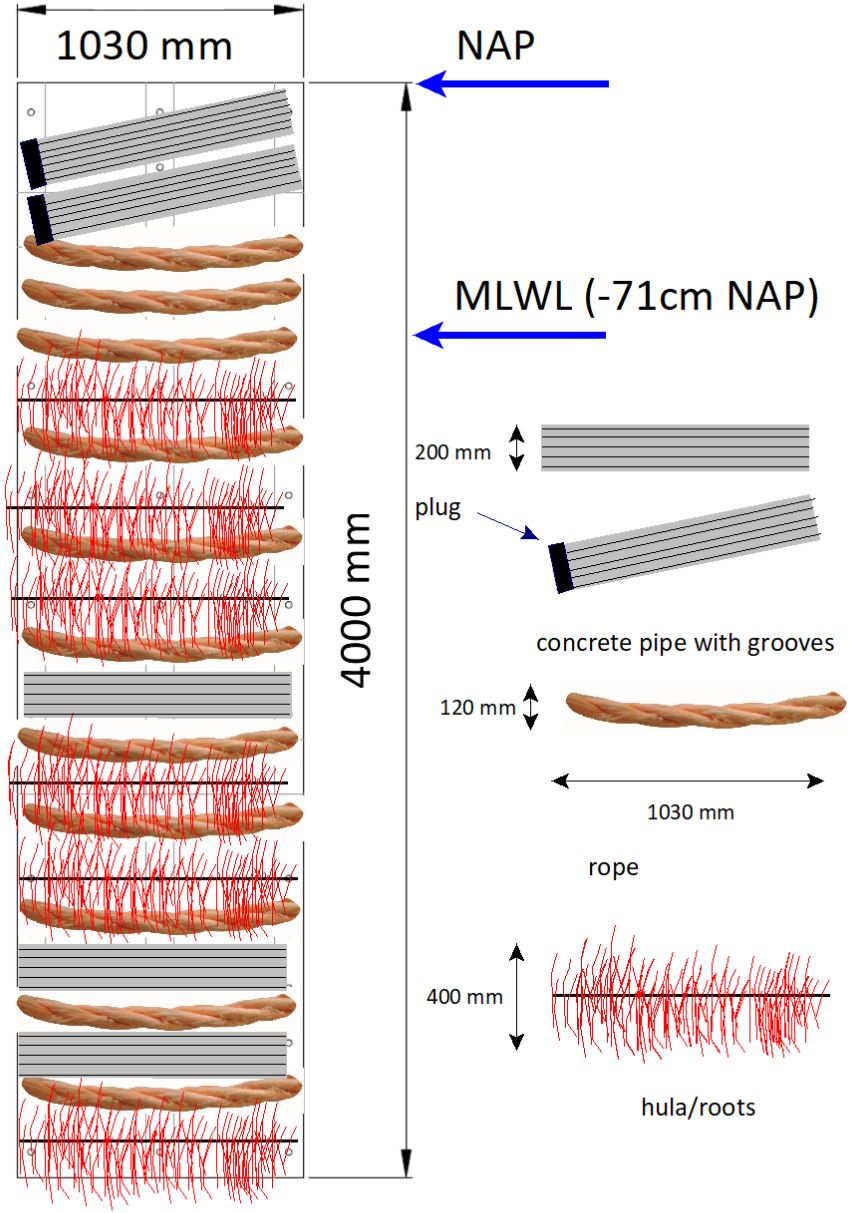

wet biomass above MLWL
20000
15000
10000
5000
0
biomass gr/m²
tidal cups
ropes
drainages pipes
fender hulas
roots
ecomodule
27-8-2018
17-6-2019


wet biomass below MLWL
90000
80000
70000
60000
50000
40000
30000
20000
10000
0
biomass gr/m²
reference
ropes
drainages pipes
fender hulas
roots
ecomodule
27-8-2018
17-6-2019

Findings

- All ecomodules with structural elements scored better on biodiversity than the reference ecomodule
- All ecomodules with structural elements scored better on bioproductivity than the reference ecomodule
- The occurrence of the starfish, *Asterias rubens*, and the common shore crab, *Carcinus maenas*, was probably related to the density of mussels.
- The more complex the structural element either by itself or created by the fouling community, the more butterfish, *Pholis gunnellus*, were found.
- The Pacific oyster, *Crassostrea gigas*, preferred the concrete reference plate to settle
- The polypropylene cords of ecomodule Type V was clearly the substrate on which the mussels settled best
- Doubts have been raised about the durability of the polypropylene sheathing of the drainage pipes of Type III and the bundles of very thin nylon wires on Type IV, i.e. the risk of fibres ending up in the environment. Released fibres could overgrow and be mistaken for food by organisms. This can have disastrous consequences for the organism concerned, for example fish. The advice is not to use them anymore.

ideal ecomodule ropes pipes hulas



intertidal (+MLWL)

- concrete pipes as a shelter for prawns and small fish, grooves to facilitate the settlement of algae.
- ropes as a substrate for large seaweeds

subtidal (-MLWL)

- hulas as substrate for mussels and their associated macrofauna
- ropes for ascidians and hydrozoans
- concrete pipes for barnacles, oysters, et cetera and the inside as a shelter for fish and crabs

This “ideal ecomodule” will be considered for future projects, and applied to mooring posts in a new project elsewhere in the Calandkanaal.

22-3-2018

4-4-2018

16-4-2018

3-5-2018

16-6-2018

12-7-2018

10-8-2018

25-8-2018

18-10-2018

27-11-2018

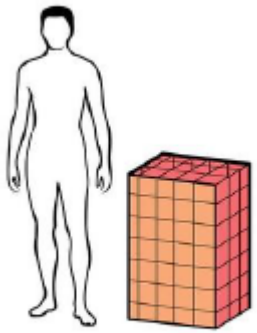
27-12-2018

25-1-2019

25-2-2019

23-3-2018

25-6-2019



Volume (h*w*t):
0,8*0,5*0,36 = 0,14m^3
«Protection» mesh size:
5cm*5cm
"Substrate" mesh size:
2,5cm*2,5cm
Material:
steel + disinfected oyster shells
Weight: 22kg

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