MAY 2020

COASTBUSTERS, ECOSYSTEM BASED COASTAL DEFENSE

A JOURNEY UP TO NATURE
INSPIRED SOLUTIONS.

Coastbusters

CONTENT

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INTRO

COASTBUSTERS: ECOSYSTEM BASED COASTAL MANAGEMENT

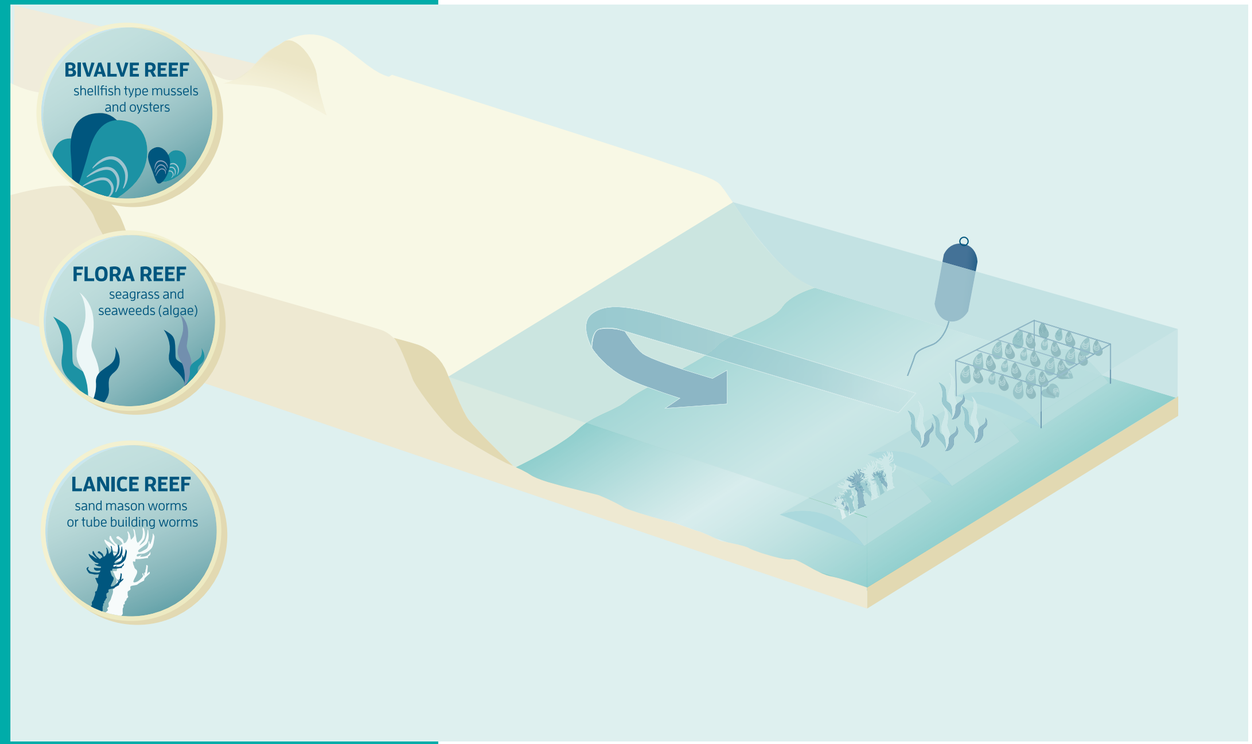
Our coastal zones are increasingly affected by climate change, inducing sea level rise and more frequent weather extremes such as storms and floods. In addition, intensified human activity are heavily reducing the resilience of our coastal ecosystems. Traditional solutions that combat these problems will become unsustainable in the future.

Within the Coastbusters project we looked into a new innovative approach: a more ecologically sound solution by combining nature-inspired designs in coastal protection systems.

In the preface you will find some of our sources of inspiration and critical supporters, namely people that have guided us on our path towards nature inclusive innovations in coastal management.

Furthermore the Coastbusters looked into key biobuilder species to enhance coastal stabilisation. Biobuilders are species of marine plants and animals that have a positive effect on the natural processes and dynamics of coastal ecosystems. They help reduce the power of storms and keep the sediments in place on the beach by building up biogenic reefs, countering erosion. Initially, our Coastbusters team has selected seagrasses and seaweeds, bivalves and tube building worms as promosing biobuilder species for the Belgian North Sea zone.

Our initial experiments - both under dedicated laboratory conditions and in real life field pilots at the dedicated testzone of the Belgian Marine Spatial Plan near De Panne,- confirm the integrated feasibility of some biobuilders as nature inspired coastal protection element. Next to technical, economic and social values, a dedicated assessment on the environmental benefits shows the ecosystem services provided by our Coastbusters type solutions. Improved water quality, enhanced sea habitats or stimulated biodiversity enforce our belief in biobuilders as the future, resilient (hence, more sustainable) coastal management practice - integrating critical functions of the coastal zone of tomorrow.



Coastbusters, a consortium between ILVO, DEME, eCoast, Jan De Nul and Sioen funded by the Agency for Innovation and Entrepreneurship (VLAIO), was the first up and running research project explored within the framework of the Flemish Spearhead Blue Cluster. The project started in April 2017 and ran for three years. Presented approaches and shared ideas received an ever growing support from several players and stakeholders in society (civilians, universities, governmental organisations, etc.) - creating inspiring awareness on our future coastal management.

PARTNERS

DEME

eCOAST MARINE RESEARCH

ILVO Instituut voor Landbouw- en Visserijonderzoek

Jan De Nul GROUP

SIOEN

PREFACE
A LINK TO APPLICATIONS IN THE FIELD

2

Philippe De Backer
Minister of the Belgian North Sea

About 2000 years ago, the first dykes were built in our region. They were the first type of coastal protection in our country. The purpose of these dykes was the same as today: Protecting the land behind the dunes against storms, floods and flash floods. These first and rather primitive constructions began to decay after some time which meant that the sea would gain territory again. This phenomenon would repeat itself over and over again: Man fighting against water, sometimes winning, sometimes losing although the used techniques became more sophisticated.

Despite the growing knowledge and innovation, that cyclus has shown us throughout the ages, how weak we are against the forces of nature, and water in particular. To protect our coasts and hinterland, we construct dykes, spray quantities of sand on beaches and build large infrastructure. All of these projects are tough challenges. It requires quite some financial resources for construction, maintenance and preservation. But it is also an ecological challenge, because of unpredicted consequences on the environment, the bottom of the sea and the landscape.

We are realizing more and more that we need other, more durable, more sustainable and more innovative solutions to protect our coast. Solutions that are financially affordable and future-oriented. That's exactly what Coastbusters is all about. It's an unique approach and a textbook example of the working-with-nature principle. For the first time in our history we are not fighting against Mother Earth but instead we are investigating how she can help us to protect our coast.

By making use of bio-organism such as seagrasses, seaweeds, clams and tubeworms we are building natural reefs that are self-sustaining. It's innovative, unique and above all: It's Belgian technology.

Our country was the first one to implement marine spatial planning in 2014. We revised it in 2020. We are at the top when it comes to offshore energy. It is with projects like Coastbusters, we show the world again and again that a small country can do great things.

The EU has the ambition to create 7 million jobs in the Blue Economy by 2020. Our companies are world class and are already contributing to that ambition. I'm proud that they are doing the needed investments and research. That way they stay at the top when it comes to Blue Economy and Blue Growth. As minister responsible for the North Sea, I challenge future policy makers to keep supporting our companies by creating the right framework, by offering clarity and legal certainty. But above all things: being ambitious and looking beyond the end of the legislature.

We have to do everything we can to remain a pioneer. That's why we have the ambition to make our North Sea the largest outdoor laboratory and blue economy incubator of the whole world. By continuing our dedication to cooperation and innovation, there will be even more useful experiments in the future. Experiments that will lead to concrete applications that will give mankind and nature the possibility to grow together, without threatening each other.

Let us ensure that, next to chocolate, beer and diamonds, we can add these innovative applications to the list of our most well-known export products.

② WORLD-LEADING SOCIAL BIODIVERSITY ENTREPRENEUR

Ignace Schops

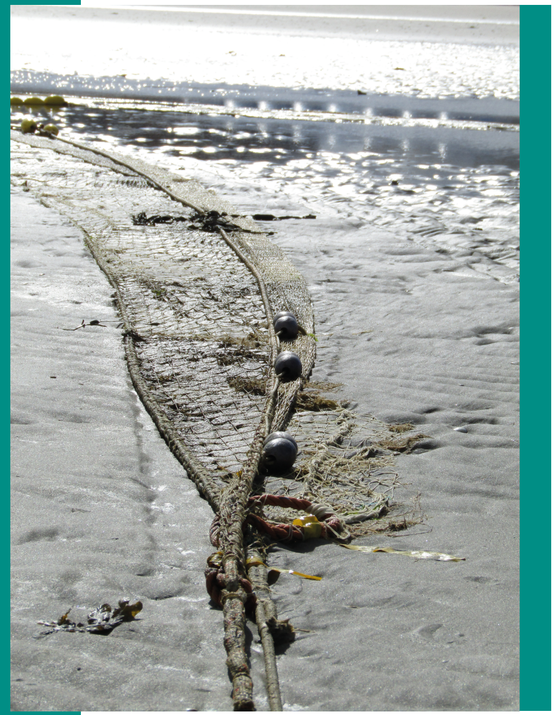
A few months ago, the Global Assessment Report on Biodiversity and Ecosystem Services was published by the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES). As you might expect, the news wasn't encouraging Our natural ecosystems are degrading at a spectacular fast rate. A million species are projected to be threatened with extinction, many within decades. Linking this IPBES report with the UN Special Report on Global Warming of 1.5°C the message is clear. If we want to thrive on a planet that looks similar to the one we're on now, we must quickly disrupt business as usual and embrace transformative global change, securing abundant clean air, clean water, natural lands, healthy oceans, and glorious species biodiversity for future generations. We now have entered the Anthropocene, the geological era where the planet and the atmosphere change due to the influence of the human behavior.

We are losing our comfort zone; but we have to...
If we want to embrace the transformative change and prevent disasters due to climate change, many reports underline the important role that Nature Based Solutions and Natural Climate Solutions can play.

Coastal zones hold a great importance for society, economy and environment. Coastal ecosystems have always been natural defense systems that protect inhabitants and infrastructure from coastal change.
Today, these natural defense systems are hindered from change over time, and may no longer have the ability to offer protection. Challenges such as erosion, flooding, and storm surges are primary concerns for coastal communities around the world. It is vital that we face these challenges with sustainable and functional solutions.

Coastbusters develop solutions that offer long term coastal resilience, embracing the naturally changing coastal ecosystem Coastbusters work with natural "bio-builders", species of marine plants and animals that have an additional positive effect on the natural processes and dynamics of coastal ecosystems. Coastbusters control the impact of storms, counter erosion processes and help to keep sand and sediments in place. This is the way forward. Let's follow nature's design.

> **Think globally, act locally and change personally!**



In the Netherlands the large-scale delta works were instigated by the severe flooding of 1953 and the intention to protect the country against a repetition of such a disaster. In Flanders the Sigma Plan came about after the Scheldt floods of 1976. Since then, the need to protect against flooding has only increased. Climate change is causing increased sea level rise. The frequency and intensity of storms is also increasing. While at the same time, more and more people worldwide live in areas that are vulnerable to flooding.

The special report on the oceans by the UN climate panel in the autumn of 2019 left no doubt that the situation is alarming.
New coastal defence projects are needed. Not only in the countries of the North Sea, but worldwide. There is a growing scientific and social consensus to avoid construction of hard structures as much as possible and to look for alternatives that take into account the ecosystems of the sea. Coastbusters is an innovative research project that seeks sustainable solutions for coastal defence that are both effective and respectful to and even enhance harmony with nature. This progressive research project brings together the unique knowledge of the Flemish companies DEME, Jan De Nul, Sioen Industries and eCoast and the research institute ILVO.

As the Blue Cluster, we are proud to support this project and to help promote its results. This is a promising new and sustainable Flemish export product in the making.

Caroline Ven
CEO at The Blue Cluster

BLAUWE CLUSTER

③

FLORA REEF SEAWEED

One of the Coastbusters concepts was a biogenic reef based on seaweed. The seaweed was impregnated onto special innovative textile bags. Two experimental setups were performed during the project

Cultivation of seaweed on innovative textile substrates at a nearshore location (De Panne)

The advanced textiles for seaweed cultivation (AlgaeTex) were impregnated with seaweed seeds and lowered into the sea as big bags (geobags-3D textile bags) or fixed onto frames. The bags and frames were placed at the test site at three different depths. Unfortunately the seaweed tests turned out to be unsuccessful due to the aggressive local hydro- and morphodynamics.

Cultivation of seaweed on biodegradable textile structures in the 'Spuikom'

Following the lessons learnt during the previous experiment at De Panne a subsequent experiment was set up to test geobags (50x50x50cm) seeded with seaweed (*laminaria* - sugar kelp) at another location: the Spuikom in Ostend. Part of the bags were made of biodegradable material. The bags were placed in December 2018 at a depth of 1 - 1,5m. By spring 2019 no laminaria had grown on the bags. Possible reasons for this result are (1) sedimentation, (2) bad seed quality and (3) competition with other species.

④

FLORA REEF SEAGRASS

Seagrass was another type of flora reef/aquatic vegetation that was examined and tested for its coastal protecting potential.

Tests were executed at the CCMAR research centre in Faro, Portugal. Seagrass meadows are known to reduce wave and current energy. The reduction of energy influences sediment motion and renders an impact on coastal sediment transport. Seagrasses additionally stabilize bottom sediments with their dense roots and rhizomes that form a secure mat. This sediment stabilization and consequential erosion prevention is especially important during storms that threaten coastlines.

We investigated how a seagrass meadow can be planted efficiently over a large area in such a way that it would be able to act as a coastal protection feature.

Seagrass planting techniques have proven to be an effective means for creating new seagrass habitats and rehabilitating ecosystem functioning.

The majority of seagrass restoration efforts are focused on adult plants, e.g. sod-transplantation. Seed-based techniques are also promising for seagrass restauration. So far, they have been studied in controlled lab conditions and on a small scale by the academic sector, focusing on several species such as on *Cymodocea nodosa, Ruppia sp. and Zostera Marina.* However, as of yet these methods haven't been economically feasible on a large scale.

The overall objective of the experimental Assemble+ Campaign of Coastbusters at CCMAR – UAlgarve (CB-PT19) was as follows: (1) find a way to efficiently (trans)plant seagrass meadows, (2) select the most appropriate engineered substrate, (3) successfully apply a coating technique with live seagrass seeds without jeopardizing the germination process and (4) develop a protocol to measure the survivability and germination of the seeds and juvenile plants in controlled and natural conditions.

The seeds were broadcasted on units of three different type of geo-engineered textiles, embedded in Algae Binder glue. The textile differentiated by being single layered fine or wide mazed textile and multi-layered textile.

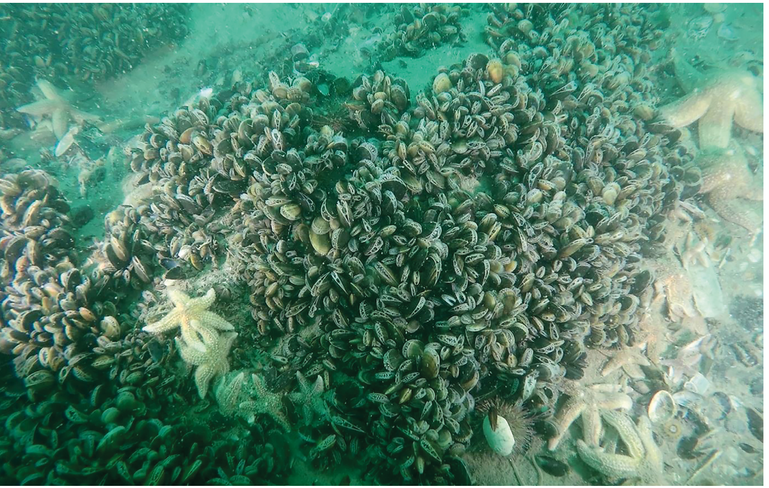
Seed germination and seedling establishment was monitored over time in order to identify the most suitable textile(s). A preliminary study in the aquaria facility of Ramalhete station – CCMAR identified brackish water condition as the optimal parameter for inducing seed germination.

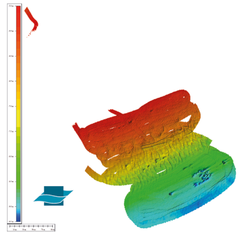
The highest seedling establishment rate was observed in textile 3 – the multilayered textile, which was also the textile with the best performance in retaining the Algae Binder glue. A similar, positive, performance of this textile was observed in the mesocosm experiment, where glue and seeds were kept throughout the 3-weeks experiment period. The other two types of textile did not give similar promising results.

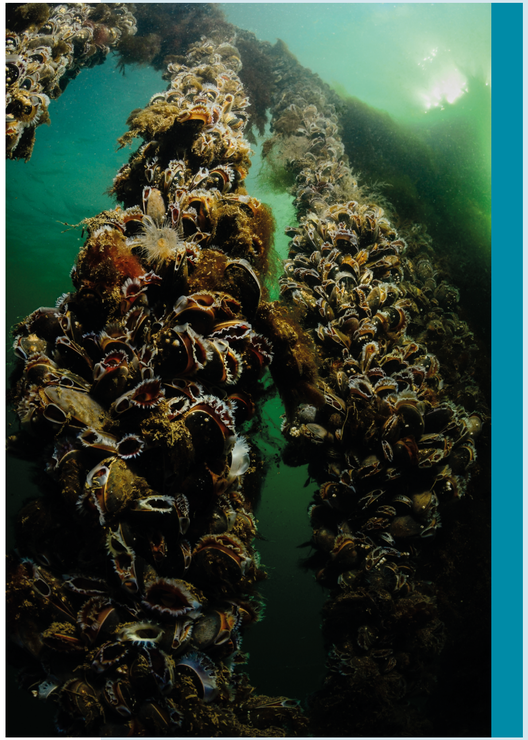
The successful results obtained in the short-time campaign pointed out the strong potential of the concept. An investment in extending the knowledge, the feasibility and the technique around the concept would presumably bring excellent results. Ideally, the story will continue with extended laboratory experiments to find the ultimate plantlet development techniques, optimalize the growth of the seedlings and perform natural lab experiments, as well as perform tests with biodegradable textiles.

Cultivation of seagrass on innovative textile under lab conditions

The Coastbusters developed a successful seeding procedure under lab conditions to attach and grow seagrass-seeds (Z. Marina) on three textile substrates.







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BIVALVE REEF

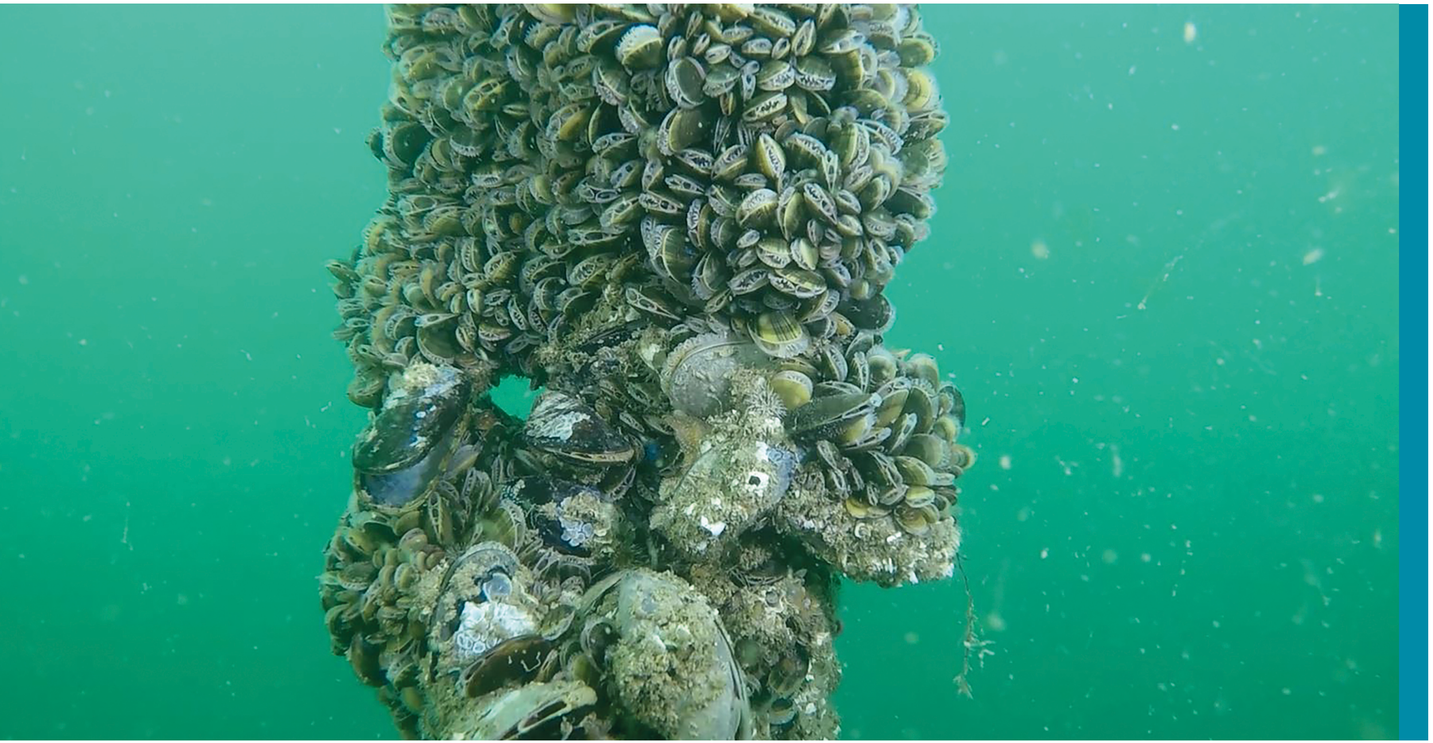
BIVALVE REEF
shellfish type mussels and oysters

Mussel beds are biogenic reefs that can serve for bio-stabilization of the sediment in a high energy environment (e.g. high turbidity, high current velocity, strong wave action, etc.). Coastbusters investigated the use of a mussel bed, among others, as a nature-inspired design for coastal protection and biodiversity enhancement. In order to initiate such a mussel bed, Coastbusters relied on aquaculture techniques to capture (*Mytilus edulis*) mussel spat and to grow these mussels in a fast manner with the use of a modified conventional mussel longline system. This setup enables a strong concentration of mussels above a site suitable for a mussel bed. When the mussels are big and dense enough, they detach in clumps and fall to the bottom. These mussel clumps will finally form a mussel bed, if they persist long enough to establish a dense population. Coastbusters also investigated different hard substrates as reef-initiating structures installed underneath the dropper lines (i.e. bags with shell material or stones) and as barrier to prevent the mussels to be washed away.

The project provided a first solid knowledge base on the technical requirements of a longline system in a high energy coastal environment, e.g. choice of anchors, mooring lines, type of backbone. This gave an initial insight in the efficiency of different (non-)biodegradable materials (e.g. dropper lines). The project also generated knowledge on the safe deployment and decommissioning of such an installation.

A mussel bed has a significant im-pact on the soft sediment through the production of (pseudo-)feaces, making the sediment more cohesive and less erodible. But also through its 3D-stucture, a mussel bed causes alterations in the hydrodynamics and enhances sediment stabilization. The project, therefore, also explored and identified the basic general ecosystem services of a mussel bed, such as enhancement of the local biodiversity, i.e. 38 adds in comparison with the soft sediment in the vicinity of the test location.

In conclusion, Coastbusters was able to build a dense mussel bed under the mussel longline system for two consecutive seasons, but during each winter period the mussel bed disappeared. The reason is still not clear, e.g. loss of mussel bed integrity due to starfish predation, not enough protection/attachment for the mussels during storm events, or a combination of both. Preliminary results on the use of dropper line materials revealed further room for improvement on the selection of materials. This NID concept finds its follow-up in the Blue Cluster/VLAIO project Coastbusters 2.0.



A selection of the dropper lines of the bivalve setup was removed and representative mussel patches - growing on these droppers - were collected and analyzed. (see figures to the right). During the processing and analyses of the samples, mussels directly attached to the dropperlines were logged as “primary mussels”, others were recorded as ‘secondary mussels’.

The dropper lines can support very high numbers of mussels over an extended period of time - forming a complex community of mussels that can survive and regrow even after 2 years in the rough conditions of the North Sea. Next to the large mix of mussel sizes, a fascinating (bio-fouling) community of organisms reflected high potentials on biodiversity enhancement of both mussels and benthic infaunal community on the biogenic mussel reef.

Based on the videos made during the project, an estimate could be established of the different epifaunal species associated with the bivalve reef. Several crab species, like the shore, velvet and flying crab were most abundant. Different echinoderms such as the common starfish, brittle stars and sea urchins were also abundant on and around the mussel patches.

DROPPER LINES - INSTALLATION STRUCTURES

SECONDARY AND PRIMARY COUNTS — FIGURE 1

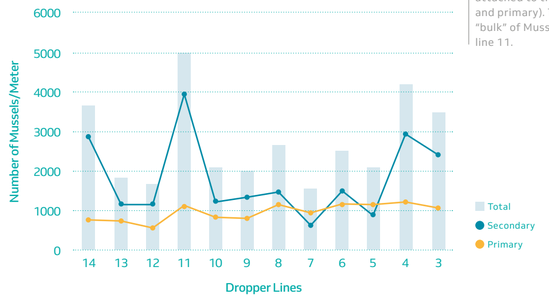


Figure 1 shows the number of mussels attached to the dropper lines (secondary and primary). The peaks indicate a large “bulk” of Mussels, for example at dropper line 11.

AVERAGE SIZE CLASS DISTRIBUTION — FIGURE 2

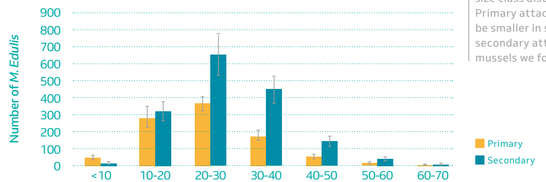
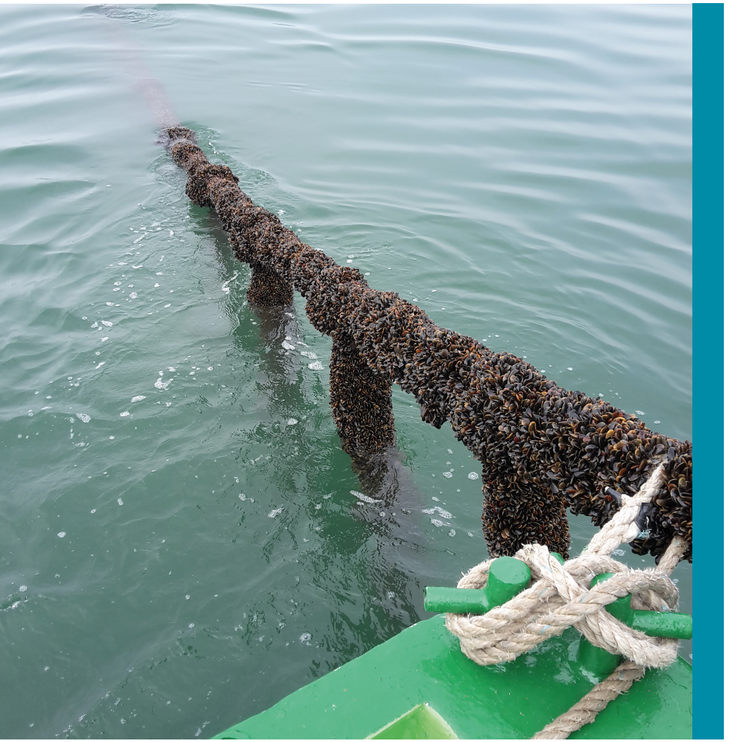


Figure 2 gives an overview of the average size class distribution of the mussels. Primary attached mussels tend to be smaller in size in comparison with secondary attached mussels. Most of the mussels we found were 20-30mm.



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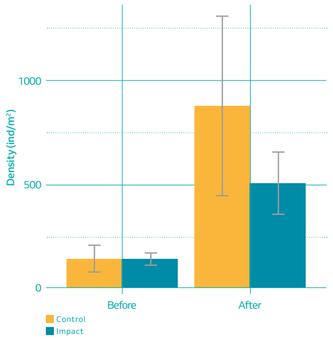
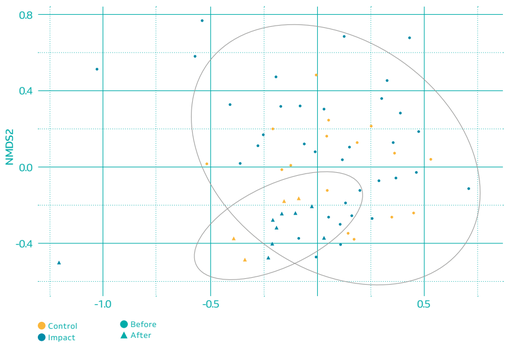
DEVELOPMENT OF THE REEF

MUSSEL SPAT IN SEDIMENT DURING SUMMER



This figure shows the mussel spat density (individuals/m²) in sediment before and after the installation of the test infrastructure (dropper lines). 'Impact' refers to the test site. 'Control' refers to a specific area surrounding the test site that was determined in the monitoring plan.

INFAUNA



This nMDS plot (nonmetric multidimensional scaling) displays the species found in the sediment (infaunal community) at the testsite. Points that are close together represent samples that are similar in community composition. A small difference in the infaunal community composition before and after the implementation of the bivalve reef was observed. This may be the result of small changes in the densities of less abundant species rather than big community changes. Species like *Abra alba, Fabulina fabula, Ensis leei* and oligochaetes stayed abundant over time.

INFAUNA

FIGURE 1

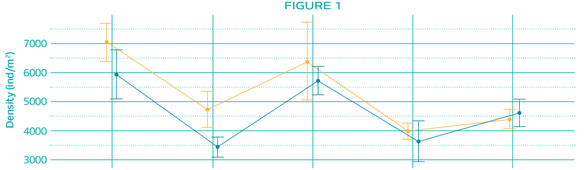
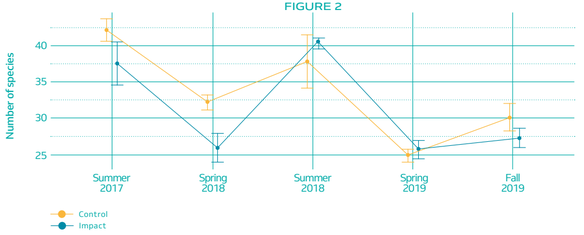


FIGURE 2



These graphics render the density (indivuals/m2) and number of species found over time (infaunal species). Errors bars are standards error. A clear seasonal trend (winter period <> summer period) was observed for the species located in the sediment of the reef site and control site.

BIVALVE REEF
shellfish type mussels and oysters

6

LANICE REEF

Aggregations of *Lanice conchilega* (sand mason worm or tube building worm) can stabilize the sediment bed of sandy shorelines. Therefore, this polychaete is considered an interesting target species in the search for nature-inspired designs in coastal zone management. In contrast with marsh plants and mangroves, *L. conchilega* aggregations cannot be planted. Tube worms undergo a pelagic larval phase prior to their settling in the bottom. This settlement process is facilitated by the presence of epibenthic structures, shells or tubes of adult conspecifics. To induce and enhance adult aggregation developments, larval settling need to be enhanced. This can be done by using a substrate mat designed in such a way that larval settlement and survival is optimized. Therefore, we investigated during this project the cultivation of the larvae and enhanced the larval settling process by using artificial substrates through laboratory trials and small scale field studies.

Laboratory experiments on inducing spawning were carried out in order to develop a standard protocol to produce larvae of *L. Conchilega.*

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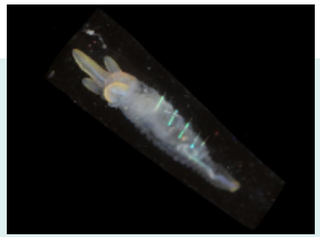
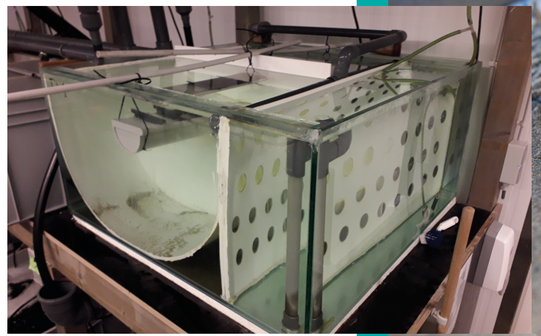


Several trials were conducted and a spawning and fertilization event was recorded.

Furthermore, as young sand mason worms prefer tubes of adult conspecifics, shell fragments or other hard epi-benthic structures to settle, these settlement conditions were examined by providing artificial settlement substrate for the larvae. Different designs of geo-textiles and their biological and mechanical properties were investigated and tested in controlled laboratory conditions. The in-vitro substrate settlement experiments with larvae revealed the potential of artificial substrates to trap larvae.

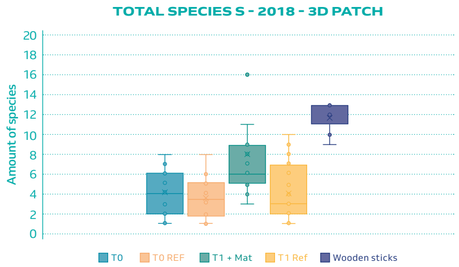
Wyns et al. 2020

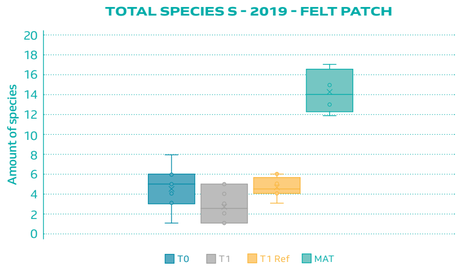


LANICE REEF
sand mason worms
or tube building worms

In parallel, small scale field studies were conducted to optimize the design and installation to attract larvae of the sand mason worms and enhance settlement with the purpose of inducing a natural reef. Visual check, together with sediment samples revealed a positive effect of certain geo-textiles on the settlement of *L. conchilega*, while at the start of the in-situ tests, no sand mason worms were found in large numbers on site. Additionally, a higher number of species was observed with bothgeo-textiles and the wooden sticks (epibenthic structures).

Therefore we are optimistic that *L. conchilega* can be an interesting biobuilder species coastal defense purposes in the future.





These figures show the amount of species that were found after one month of field trials. In 2018 we tested wooden sticks and 3D geotextiles to attract Lanice. In 2019 we investigated felt geotextile. We found a higher amount of species underneath and on the surface of the 3D geotextile (T1+MAT) in 2018 and at the surface of the felt geotextile (MAT) in 2019. Also, the use of wooden sticks in 2018 gave interesting results towards further development of innovative geotextiles.

Reference samples: T0 REF & T1 REF.
Core samples: T0 & T1 taken under the geo-textiles and geo-textile samples (MAT).

ECOLOGICAL MONITORING

Next to a traditional "technical" monitoring on bathymetry, hydrodynamics and morphological characterization of the test site, a dedicated ecological monitoring program was deployed. Three main goals were initially defined:

- the ecological development of infaunal life (species living in the local seabed) in and around the pilot test setup in front of the coast of De Panne
- the survival of the biobuilder species
- the development of the biogenic reef itself

Specific quantification of the benthic life in the sublittoral areas adjacent to and in the pilot test fields was done based on Van Veen samples of the local sea bed sediments. Collected samples were washed over a 1 mm-sieve, before getting fixated in formaldehyde and labelled for further processing. A series of Van Veen samples were collected during the whole period of the pilot test: next to the reference TO-campaign, four more sampling periods were identified over a period of two years:

Littoral sampling was done with a sampling tube that was pushed 15 cm into the beach sand. Collected sediment samples were emptied and washed out in the 1 mm-sieve, before preservation for further laboratory processing.

No real changes were observed in the infaunal community compositions before and after the implementation of the bivalve reef setup. No clear impact of the dropper lines and mussel reef on the infaunal communities was recorded yet. However, a significant difference in mussel spat densities in the sediment was observed before and after the installation of the dropper lines.

Survival status, together with built-up and growth of the biogenic bivalve reef, was observed in a dedicated diving campaign. To have an insight on the survival and built-up of the biogenic reef, regular diving campaigns were performed using high quality underwater video equipment. From there, spatial and temporal distribution of species (biodiversity) and bivalves density over the reef footage was identified. Selected samples quantified the visual observations. From there, a general ecological assessment on biodiversity abundance and biogenic reef resilience was made.

Collected sediment samples (both from sublittoral and littoral sites) were colored to distinguish organisms from sediment through decantation in the laboratory. The decantated material was then examined under a binocular microscope were organisms were determined and classified. The residue fraction was also checked for the presence of heavier organisms. All found organisms were weighed and counted. Observed benthic life composition in all samples were grouped in accordance to their abundance:

- Bivalves: *Kurtiella bidentata, Ensis leei, Fabulina fabula, Abra abra, Tellimya ferruginosa, Mytilus edulis, Tellinidae, Spisula solida, Lutraria lutraria*
- Gastropoda: *Crepidula fornicata, Tritia reticulata*
- Polychaeta: *Spirobranchus lamarckii, Owenia fusiformis, Capitella, tharyx, Lanice conchilega*
- Decapoda: *Liocarcinus vernalis and L. navigator, Crangon crangon*
- Echinodermata: *Ophiura ophiura, Echinocardium cordatum, Psammechinus miliaris, Asterias rubens*

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T0	INSTALLATION BOTTOM BIVALVE REEF	INSTALLATION LONGLINE BIVALVE REEF	T1	T2	T3	T4
22 June 2017	24 November 2017	**14 March 2018**	17 April 2018	13 July 2018	24 Apr 2019	25 Oct 2019

TABLE: VAN VEEN SAMPLING

INSTALLATION	1	2	3	4	5	6	7	8	9
14 March 2018	9 April 2018	5 July 2018	30 august 2018	21 Sept 2018	15 Oct 2018	3 Apr 2019	12 Jun 2019	12 Aug 2019	4 Dec 2019

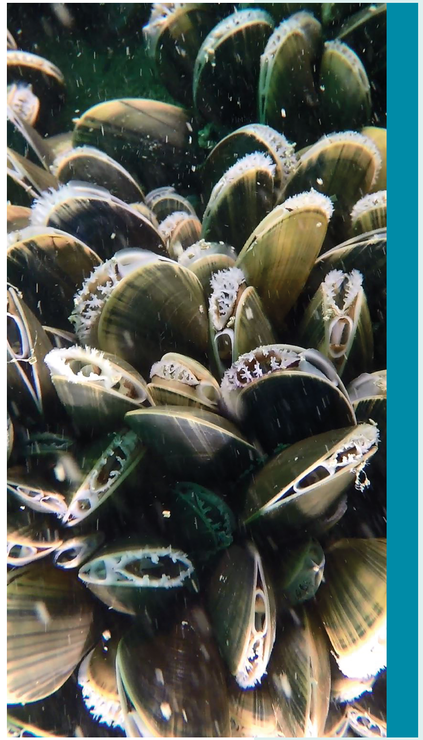
TABLE: DIVING CAMPAIGNS.

8

HOW CAN A BIVALVE REEF DELIVER ECOSYSTEM SERVICES?

In a first attempt to quantify and value ecosystem services of the bivalve reefs in the western Belgian Part of the North Sea (BPNS), more specifically at the Coastbusters study site, ecosystem services were identified using the qualitative evaluation tool developed in the project "Ecosystem vision for the Flemish coastal zone" (Van der Biest et al. 2017b). For these identified ecosystem services (shrimp production, carbon retention, water quality regulation, coastal protection and recreational diving), a meta-analysis of literature on bivalve reefs in environmental conditions similar to the BPNS was performed (e.g. similar landscape-setting, climatic conditions, socio-economic pressures).

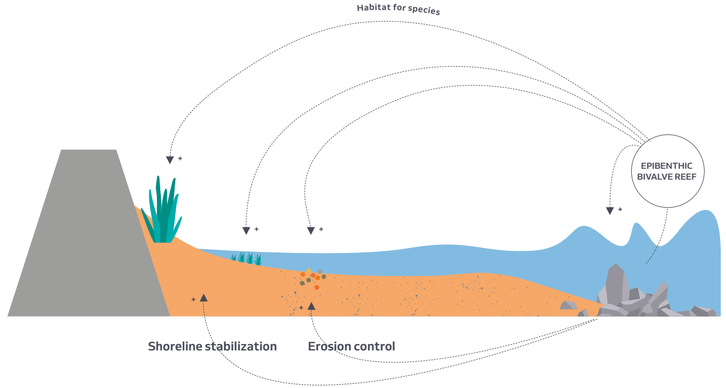
The analysis resulted in a quantification of the most important ecosystem processes and/or parameters that are indicators of final ecosystem services. These biophysical estimates were then translated into an economic value based on commonly used monetary valuation techniques for ecosystem services (incl. avoided costs, market price). This resulted in an initial estimate of the potential yearly economic benefits of the Coastbusters reef (per 1 ha) in terms of ecosystem services.

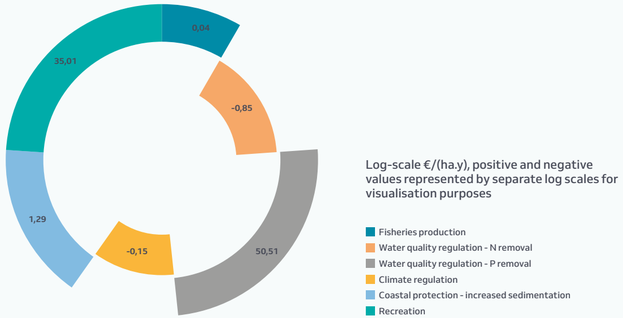


As the bivalve reef is located in shallow water in the wave breaking zone, a well-oxygenated scenario was chosen: sediments in the matrix between the mussel patches on the sea bed are continuously being stirred up and well-oxygenated. Next to the general positive impacts on coastal protection (sediment accumulation in the foreshore), shrimp production and recreational diving, dedicated nutrient-related ecosystem services (nitrogen, phosphorus and carbon retention/regeneration) were identified.

The bivalve reef is both a net sink of phosphorus due to binding of phosphorus to iron oxide in the sediment and a source of carbon due to biocalcification (bivalve shells).

The yearly added benefits (sum of five ecosystem services) of one hectare of a bivalve reef in comparison with one hectare of unstructured, sandy foreshore at the Coastbusters site are estimated at € 85.000 - indicating an important potential added value in terms of ecosystem services. However, important uncertainties associated with the simulated results underpin the need for site-specific monitoring and research.





Coastbusters, ecosystem based coastal defense

9

CONCLUSION

UP TO A NEXT LEVEL OF NATURE INCLUSIVE COASTAL ZONE MANAGEMENT

Flood disaster risks are increasing year by year for many coastal societies. Conventional coastal engineering solutions such as concrete sea walls or rock breakwaters run up to their limits: they become unsustainable due to their limited resilience, higher costs and societal impacts. Coastbusters offers an alternative: future coastal flood protection by ecosystem creation and nature inclusive technical design provide a more sustainable and cost-effective management approach to conventional coastal engineering in certain cases.

Within the initial Coastbusters project our integrated team has developed pioneering steps towards biogenic reefs as an additional tools for ecosystem based flood defense. Three biobuilders species were tested as basic tools.

MARINE FLORA REEF

Dedicated pilot field tests with basic seaweed (*laminaria* - sugar kelp) - seeded on different geotextile setups - demonstrated that ambient (dynamic) circumstances in the Belgian North Sea are too aggressive for the smooth development of a seaweed biogenic reef. Additional laboratory experiments with seagrass (*Zostera Marina*) indicate high potential substrates for seagrass growth. First modest steps towards biodegradables textiles under marine conditions are taken.

LANICE REEF

The Coastbusters research team succeeded in pioneering the cultivation of the sand mason worm and enhancement of larval settling process by using specific substrates under controlled laboratory conditions. Small scale field tests along the Belgian coast confirm the potentials of *Lanice Conchilega* as a resilient coastal builder. However, more fundamental research on both initiation and intensified reef development of the sand mason worm is needed before dedicated “ecological engineering” can be induced

BIVALVE REEF

The pilot field tests with *Mytilus edulis* (blue mussel) using aquaculture-like techniques proved very promising. The engineered set up (integrating technical and ecological features) attracts the bivalve larvae, facilitates efficient settlement, induces a steady growth of the mussels and finally generates a proper bivalve biogenic reef at the local seabed environment. Doing so, the experimental configuration not only introduces an alternative coastal protection system, but also creates abundant biodiversity.

A preliminary assessment on the biogenic mussel reef has shown that the bivalve reef delivers a series of ecosystem services - indicating a clear added value of the alternative coastal management approach.

The feasibility of the basic concept is clearly demonstrated, but several questions and operational challenges still remain. The acquired insights have led to a competitive valorization of sustainable nature inspired design business opportunities for all industrial partners and will generate exceptional knowledge acquisition for the research institutes, putting the Flemish marine knowledge community at the forefront in this innovation field. Dynamic resilience, storm survivability, ecosystem household or biodiversity preservation are just a few topics to be managed and engineered in a further development towards nature inclusive coastal management. A new Coastbusters project is currently started: the promising bivalve reef concept will be further explored and monitored in detail.

> Let’s explore the full potentials of this new era of nature guided coastal protection.

Coastbusters, ecosystem based coastal defense

SPECIAL THANKS TO

- VLAIO and the Blue Cluster.
- Sioen, DEME, ILVO, eCoast, Jan De Nul and VLIZ (joined later on), partners in the project.
- MDK, KBIN OD Natuur, MRCC and the municipalities De Panne, Bredene and Heist to facilitate the field tests on their beaches.
- CREST as an open forum to reflect our research ideas with the top scientist of our Flemish coastal protection landscape.
- NGO's WWF and Natuurpunt for their critical but most of all inspiring discussions.
- Brevisco for their competent operational support during operations in front of the Belgian Coast.
- Local coastal communities and a bunch of enthusiastic students looking for a challenging topic for their internship or thesis work and coming up with refreshing ideas.
- Universities and high schools for their open mind and confidence in Coastbusters as an inspiring research topic.

CAN COASTBUSTERS INDUCE A LONG-TERM 'BOOST' FOR MARINE NATURE?

As a human being, you experience a boundary between sea and land. Both seem to function independently: the tide covers the beach with salty water, while the beach, dunes and polders gradually announce the hinterland. Only seagulls and seals seemingly dare to explore both worlds. However, nature does not draw any strict boundaries between sea and land. Natural processes such as wave action and the life cycles of marine organisms take place at the interface between sea and land.

If we want to protect our 'concrete' Belgian coast against the rising sea level, we must look at possible solutions on land (like dunes and the dune-for-dyke concept) and at sea. The latter is what the Coastbusters project does by using mussel beds as living coastal buffers against storms. In the long term, working with nature is the best and cheapest way to protect us against the consequences of climate change. By creating natural reefs, we strengthen the sandbanks off the coast against the force of the waves. These sandbanks are our first line of defense during storms.

Projects such as Coastbusters also provide 'new' nature, if successful. The shellfish can form a self-organising system that will expand in time. A real win-win for man and nature.

However, these projects are only in their infancy. We are very hopeful that these natural reefs will attract other organisms and develop into fish spawning areas. But... it's still unsure if and when this will happen, and what the long-term effects will be. In comparison, it takes several decades for a plantation to evolve into a natural and biodiverse forest.

Although often forgotten, it is ever so vital to protect existing marine nature. After all, projects like Coastbusters are adding marine nature. Therefore, they are an addition, a bonus and not a replacement.

4Sea – Joining forces to achieve nature and climate goals in the Belgian part of the North Sea. Natuurpunt, WWF Belgium, Greenpeace Belgium and Bond Beter Leefmilieu

BLUE WATERS

MEGAN PHILIPS

Blue waters peaceful as ice,
Standing frozen as the rays of light break through the waves.
The ocean plays and tumbles
Like a child after school,
But what may seem peaceful to the eye
Tells another story underneath:
Mother Nature's untamed beast
Fighting to be released.

YOUNG SEA

CARL SANDBURG
Uit: Chicago Poems, New York
(Holt and company), 1916.

The sea is never still.
It pounds on the shore
Restless as a young heart,
Hunting.

The sea speaks
And only the stormy hearts
Know what it says:
It is the face
Of a rough mother speaking.

The sea is young.
One storm cleans all the hoar
And loosens the age of it.
I hear it laughing, reckless.

They love the sea,
Men who ride on it
And know they will die
Under the salt of it

Let only the young come,
Says the sea.

Let them kiss my face
And hear me.
I am the last word
And I tell
Where storms and stars come from.

Coastbusters