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MARINEFF
infrastructures maritimes biomimétiques

Edition 2
November 2019

MARINEFF
MARine INFrastructure EFFects

How to get involved

If you are interested in keeping up to date with all current projects, you can subscribe to mailings, follow us on Facebook or Twitter or visit the news section of the website. If you are interested in attending a workshop, please contact Jess Bone, Bournemouth University.

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Mailings sign-up

To sign-up to future Marineff mailings, including this quarterly newsletter, click *here*.

Please note, upon sending an email to this address, you will be automatically signed up to the Marineff mailing list and included in future newsletter communications. Information on how your data is handled can be found at:

www.ciria.org/marineff

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Further information

To find out more about the Marineff project, go to:

http://marineff-project.eu/

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Artificial rockpools – a closer look at the artificial Marineff rockpools

Breakwater modules – a closer look at the enhanced, cubic breakwater modules

Boat mooring modules – a closer look at the subtidal boat mooring modules

ESITC Caen: in focus – a brief profile about the project's lead partner

In a nutshell

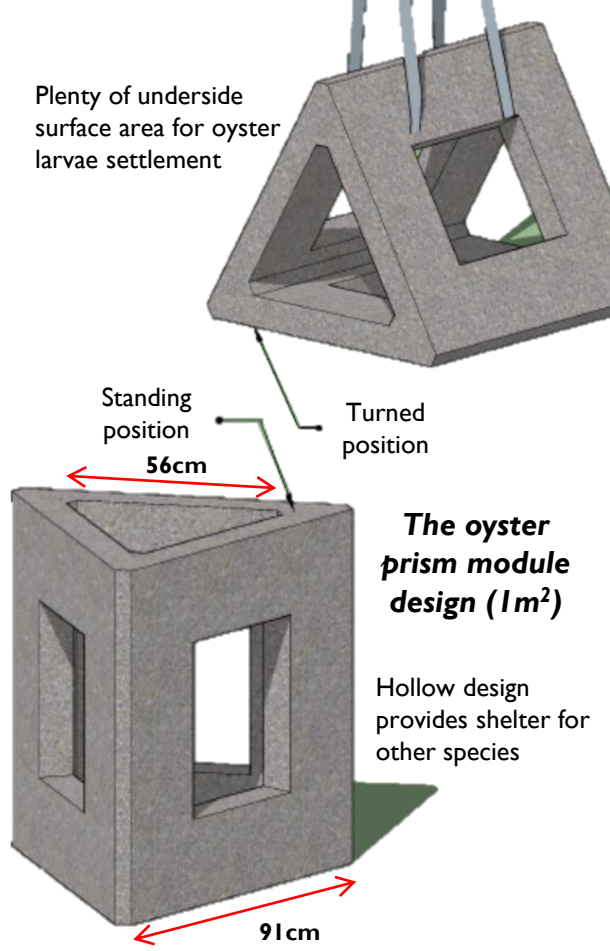
Welcome to the second edition of the Marineff project's dedicated newsletter. Our debut newsletter, published in August, gave an overview of the Marineff project's aims, objectives and current progress. This newsletter will further explore the project's four eco-engineering units: the oyster prism module, artificial rockpools, breakwater modules and boat mooring modules. Readers will get to find out the rationale behind the designs, the concrete formula chosen for their manufacture and where they will be deployed.

Lead partner ESITC Caen also give readers the chance to learn more about their institute, their involvement in the project and their expertise in concrete materials and marine infrastructure.

Oyster prism modules

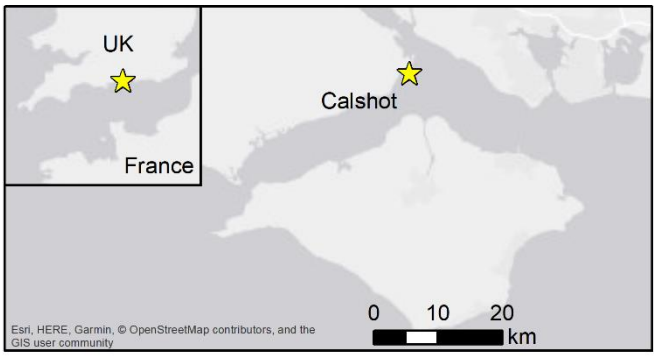
The only eco-engineering unit of WP T1 and for the specific creation of habitat for the native oyster *Ostrea edulis*, is the prism module. Of thirty modules manufactured by French partner TPC, 26 will be deployed in marine subtidal waters off Calshot, Southampton (UK) and 4 in various locations off the coast of Normandy (France). They will be manufactured with the use of custom-made wooden formworks by TPC.

Studies have shown that physiological performance of oysters is enhanced when elevated from the seabed. Oyster larval settlement is favoured on the underside of surfaces where there is less competition from algae and silt settlement. The prism design is stable, elevated, and offers large underside surface area with the advantage of being deployed without a specific orientation. The hollow centre will promote the formation of a reef-like habitat for the use of other commercially-important species.



The oyster prism module design (1m²)

Hollow design provides shelter for other species



Concrete sample tiles and oyster shell control deployed for testing biological colonisation

Following the immersion of concrete samples in the sea for three months, the results are in! Formulas included:

- CEMII and no crushed shell aggregate
- CEMII and 20 percent crushed shell aggregate
- CEMV and no crushed shell aggregate
- CEMV and 20 percent crushed shell aggregate

Compared to reference concrete cured for 90 days, the immersed samples overall performed better in compressive strength tests, which was an unexpected result. CEMII performed better than CEMV in chloride ion diffusion and porosity tests and will be used for the production of the prism modules and the boat mooring modules. Shell aggregate will be added to encourage the formation of biofilms and the colonisation by the native oyster.

Immersed samples testing capacity for species colonisation showed that increasing surface texture (roughness) increased colonisation by biofilms, algae and barnacles.

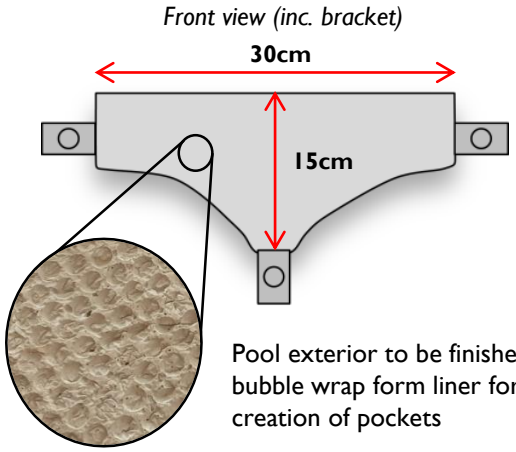
Artificial rockpools

The artificial rockpool has undergone development since the August newsletter. Based on the artificial rockpool designed by project subcontractor, Artecology, the Marineff rockpool will have a higher rim and deeper pool interior. This design by partner, Bournemouth University, will help prevent extreme temperature and salinity values in the pool and provide more habitat.

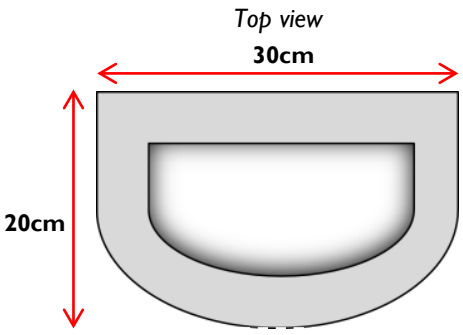
Artecology will be manufacturing 150 Marineff pools over the winter (2019) ready for deployment March 2020. The concrete will be poured into custom-made moulds with a bubble wrap form liner and finished by hand. The bubble wrap will provide an external texture of small, concave pockets which will provide attachment surfaces for sessile species and shelter for grazers. The smooth rim and pool interior will ensure ease of monitoring. Fifty pools each will be deployed at three sites; Poole Harbour, Isle of Wight (UK) and Ouistreham (France).

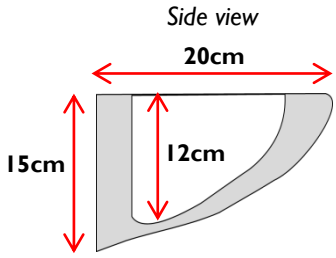
Pre-characterisation surveys have begun with Poole Harbour sea wall hosting a respectable 27 species. In order to achieve the 15 percent increase in biodiversity required by the Marineff project, an additional 4 species must be recorded once the Marineff pools have been installed.

Concrete formulas are about to undergo tests at ESITC's lab facilities. Vicat Prompt, a natural low-carbon lime-based cement, is anticipated to be the final choice.



Pool exterior to be finished with bubble wrap form liner for creation of pockets

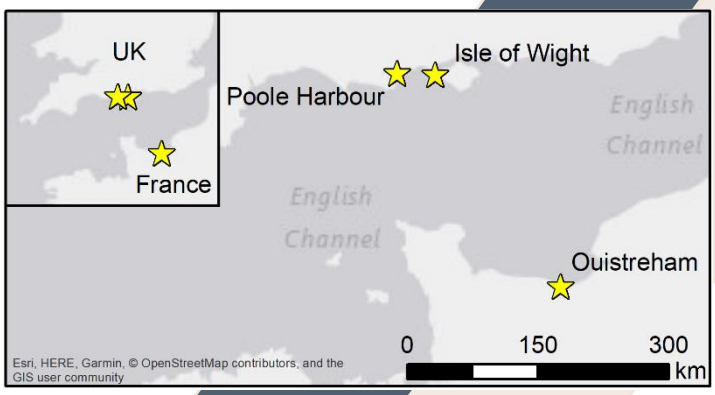




Rockpool design

Pool interior smooth and open for easier surveying

Dr Roger Herbert conducting the pre-characterisation survey at Poole Harbour.



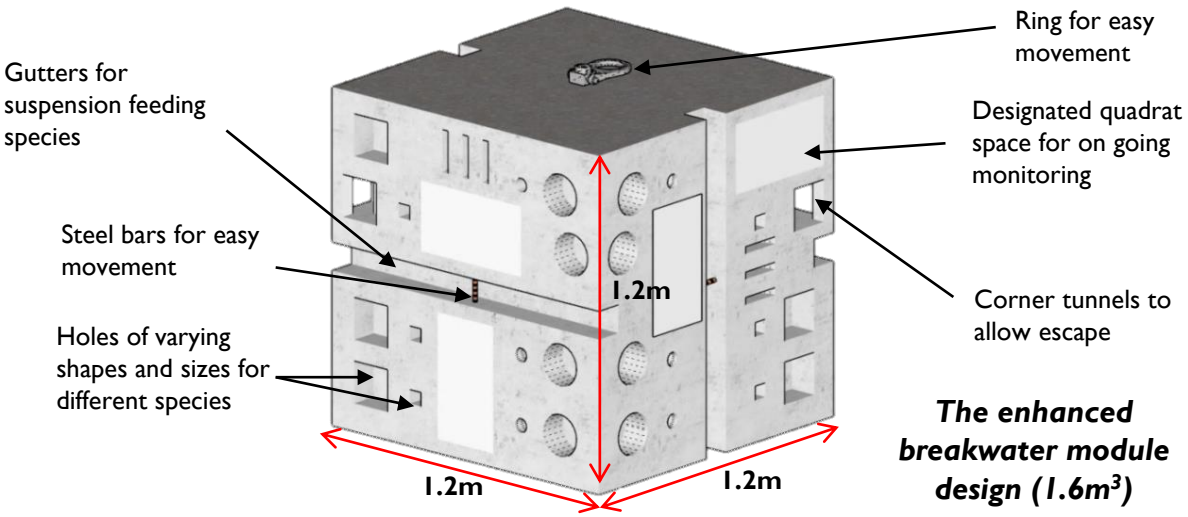
Breakwater modules

The breakwater modules have a dual purpose. By disrupting wave formation they reduce the hydrodynamic force on marine infrastructures such as sea walls or docks. The Marineff project adds ecological value to these breakwater modules by modifying their surface texture and design to enhance the capacity for marine species colonisation, which was inspired by both literature review, the life history and the behaviour of local marine species. Their cubic structure facilitates optimised stability, and easy replication and application within industry.

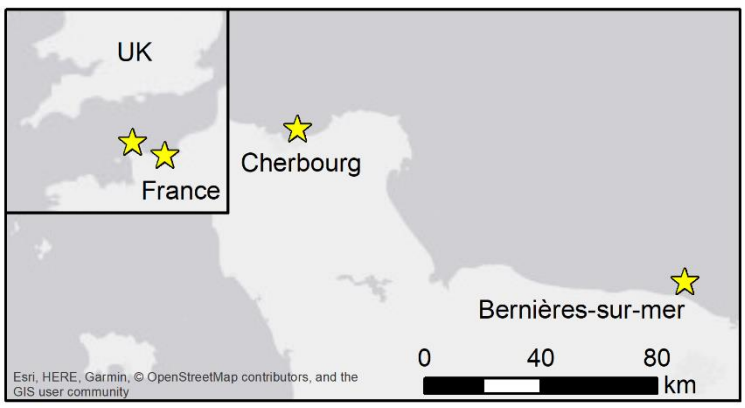
The breakwater modules will be manufactured by TPC over winter (2019) using classic wooden formworks. Following the tests conducted on the four concrete formulas trialled for the oyster prism module, the concrete mix to be used for the breakwater modules is CEMII with no shell aggregate. A total of 36 breakwater modules will be produced; 18 with enhancement and 18 plain to act as controls. They will be deployed in Cherbourg harbour (24 modules) and at Bernières-sur-mer in the bay of Seine (12 modules) in March 2020.

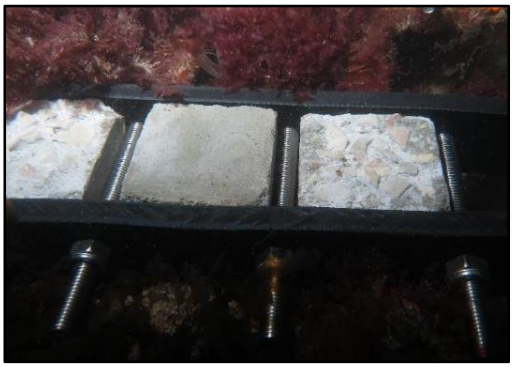
In addition to the breakwater modules, 5 cm x 3 cm concrete tiles have been immersed off the coast of Cherbourg and Bernières-sur-mer in September 2019. They have both a rough and smooth surface that emulates the surface texture of the MARINEFF breakwater modules of the MARINEFF breakwater.

Six tiles will be collected every four months from each site to precisely assess the succession of biological colonisation. These tiles will enable the University of Caen to examine organisms at the microscopic scale and to estimate primary productivity, which would not be possible with the full scale Marineff breakwater modules.



The enhanced breakwater module design (1.6m³)





Smooth and rough concrete tiles

Boat mooring modules

The Marineff project takes boat moorings to a new multifunctional and ecological level with its concrete boat mooring modules. To be deployed subtidally at three sites in the Bay of St Malo, these modules will serve as mooring sites for diving boats while promoting a reef-like habitat. They will be raised on feet to provide shelter for benthic species and ensure a settled and secure placement. Shelves with escape holes will provide intricate microhabitats seen in natural reefs. Horizontal and vertical aspect surfaces will experience light availability and hydrodynamic forces differently and so will cater to the differing niches of marine species. The basin will be finished with holes and grooves for small grazing species.

The boat mooring modules will not be deployed with chains to avoid scour of surrounding seabed. The anchor ring will be replaceable to promote the mooring's longevity. A total of three modules will be deployed in spring 2020, following manufacture ESITC over the winter of 2019.

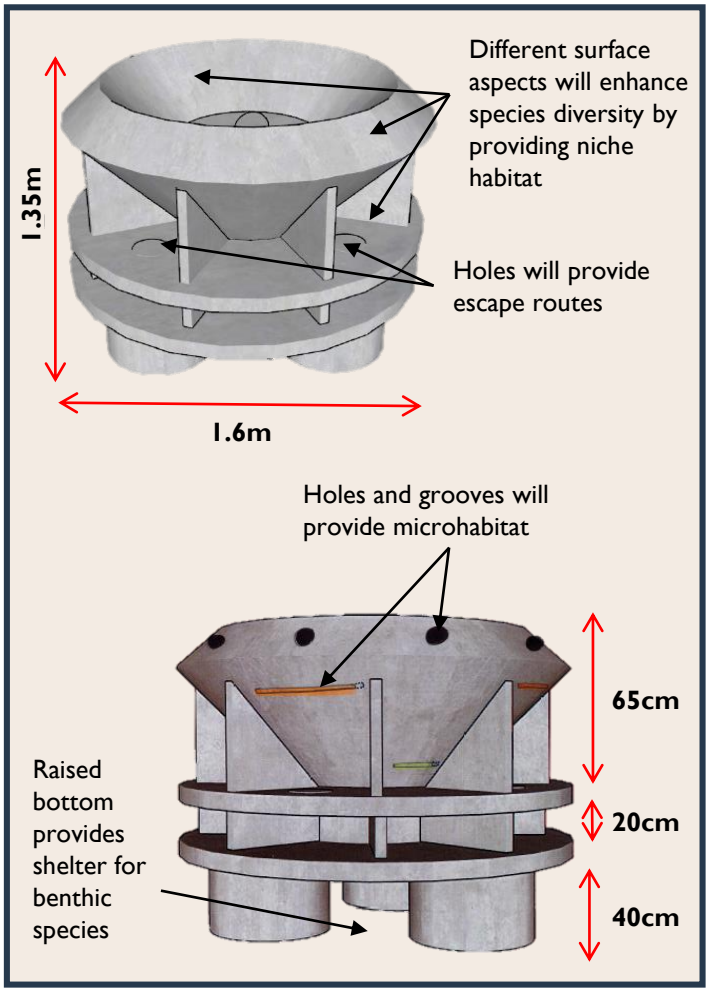
They will be made with two different types of concrete:

CEMII, sand 0/4, gravel 4/16

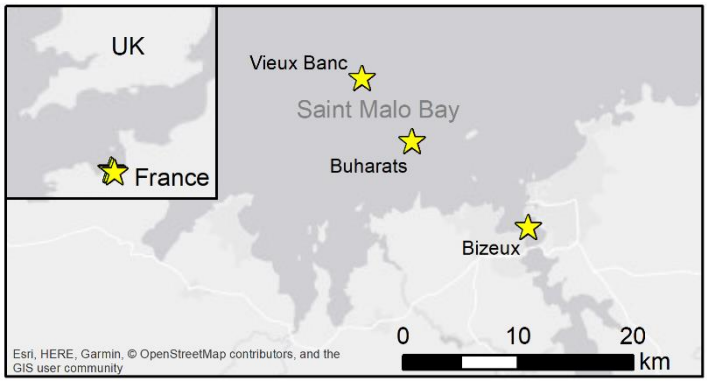
This dense and robust concrete mix will be used to produce the base and central column to ensure the module is heavy enough for anchorage.

CEMII + 20% shell aggregate

The middle tier and basin will be produced with the shell aggregate concrete mix to promote biological colonisation.



The boat mooring module design



The Bay of Saint Malo is rich in marine biodiversity thanks to its abundance of rocky reefs. By introducing the Marineff boat mooring modules to this region, it is anticipated the negative impact of anchor scour on the seabed by local diving boats will be reduced. It will also allow for easy comparison between the communities of the boat mooring module and the natural rocky reefs. Comprehensive pre-characterisation surveys of the sites have already commenced using 3D photogrammetry to characterise the existing habitat.

ESITC Caen: in focus

ESITC (Graduate School of Construction Engineering) Caen are experienced with EU projects, having partnered on several already and led the successful RECIF project. Marine infrastructure has been a key theme for ESITC for many years, with developing specially adapted materials for the marine environment that also satisfies the economic realities of the marine sector.

ESITC's objective is the development and optimisation of concrete formulas for the design of eco-engineering solutions for coastal infrastructure. These solutions will provide new habitats for marine fauna and flora and must therefore be sustainable and environmentally friendly.

To carry out the various experiments, the research team has ample equipment at its disposal. A micro-algae culture system has also been set up in the laboratory to study the bio-colonization of concrete by micro-algae in a controlled environment.

The first step is devoted to concrete optimisation by varying the percentage of shell aggregates and the type of cement. After optimisation, different concrete samples are made for the characterisation of concrete in its hardened state (density, porosity and mechanical strength).

The second stage is dedicated to the study of the materials durability against the marine environment (diffusion of chloride ions and colonisation by marine species). Samples are immersed in situ and in tanks with a circulating seawater system for different lengths of time. Following these periods of immersion, compression tests, porosity measurements and chloride ions profiles are performed.

Following these tests, the optimal concrete formulation is selected for the manufacturing of the eco-engineering solutions.

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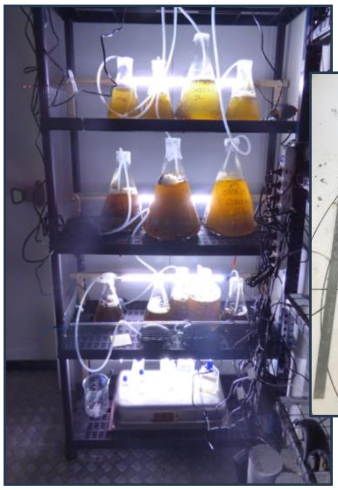

1) Micro-algae culture facility

2) The slump test

3) Ion phase chromatography