SHELLFISH FARMING IN OPEN SEA WITH ADVANCED CONCRETE RAFTS

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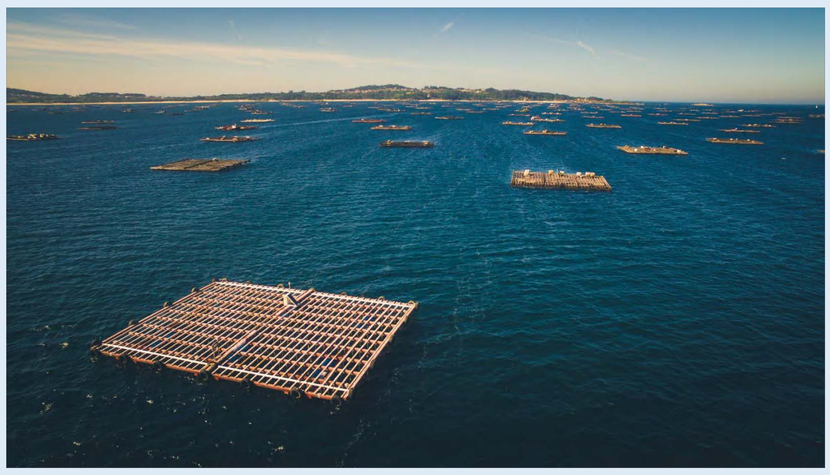
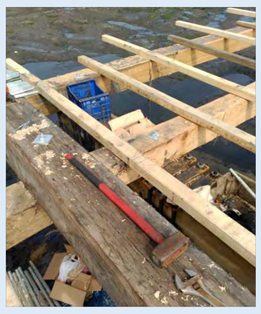


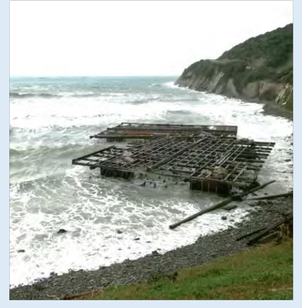
ABSTRACT

Nearly 85% of mussel aquaculture around the world is suspended and off-bottom (McKindsey et al. (2011)), including the technique of the floating raft system used in Spain to produce 40% of the EU mussel. Since its origins in Galicia to our days, the rafts have been built with eucalyptus wood. This imply a short lifetime and a high carbon footprint associated to the protection coatings. In 2015 the company RDC developed a 540 m² precast raft made of Ultra-High-Performance Fiber-Reinforced-Concrete (UHC), an extremely compact and durable composite (this project received funding from the EU's H2020 programme under GA Nº738777). Four years after the idea, there are more than 5.000 m² under operation and proving high resiliency and very low maintenance costs. Considering the UHC raft performance, a new design is under development to enable it to cover other needs (project OpenMode-863562, co-funded by the European Maritime & Fisheries Fund (EMFF)). This new generation is adapted for open waters, connectable and sensor-equipped, allowing intensive harvesting in new areas, adapting the modules to the farm needs and facilitating their transport and assembling. The project will test these capacities with eight pilots floated in five countries across three EU sea basins.

THE TRADITIONAL RAFT (WOOD)

Wooden rafts are used in Spain since 1900 due to their reduced purchase cost, lightness and flexibility. The intensive system is feasible for the upwelling-downwelling dynamics on the continental shelf (Figueiras et al. (2002)). The structure can carry up to 500 ropes and produces nearly 60 tones/year. However, its use has three main disadvantages: ❶ Economic: It has low durability (≈12 years) and needs periodic investment in maintenance which undermines the sector's profitability. ❷ Industrial: each raft is built manually through a high-risk job in the inter-tidal zone using hammers. Replacing the damaged elements is a slow work. ❸ Environmental: it implies intense deforestation. The degradation of the wood and the products used to protect it cause water pollution.



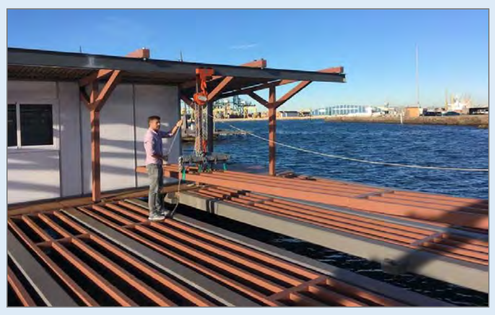


THE 540 m² UHC RAFT (2016)

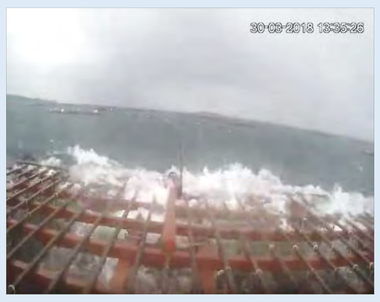
In 2015 RDC designed a precast raft made of UHC, an innovative material that provides higher durability (>30 years) under aggressive exposure environments. The structure has the same area and elements than the traditional raft (20x27 m). The first prototype was precast in 2016 for the Technology Center AZTI. An intensive work was carried in laboratory and testing prototypes with the support of the H2020 project **SELMUS-738777** (SME Instrument Phase 2). After 2 years there are already more than 4500 m² harvesting in two Spanish basins. There are two designs for mussels (one of wood+UHC and other flat with UHC) and one for oysters with a system to raise the harvest. The product is aligned with the EU Blue Growth strategy, as: ❶ It boosts the shellfish aquaculture competitiveness. ❷ It improves maritime spatial planning and integrated maritime surveillance concentrating the farms on controlled and visible modules. To reach a similar production some regions use a tangle of kilometers of submerged ropes (long-line method) and plastic elements.

The continuous monitoring systems (Integrated Sensor Network) and cameras are proving the resiliency of the rafts, which are already demanded by the Galician farmers because they have proven to minimize the operating expenses.

	wood (traditional raft)	UHC (Formex®)	steel S355	Ordinary concrete
weight	1	1.1	≈1.2	≈3
maintenance costs	1	0.1	2 to 3	2 to 3
lifetime	1	3 to 5	≈0.5	≈0.5
slenderness of beams	1	1.8	1 to 1.5	1
price	1	1.2 to 1.5	1.5 to 3	1.5 to 2
surface finishes	★★	★★★★	★★★	★★
sustanability	★★	★★★	★★	★★

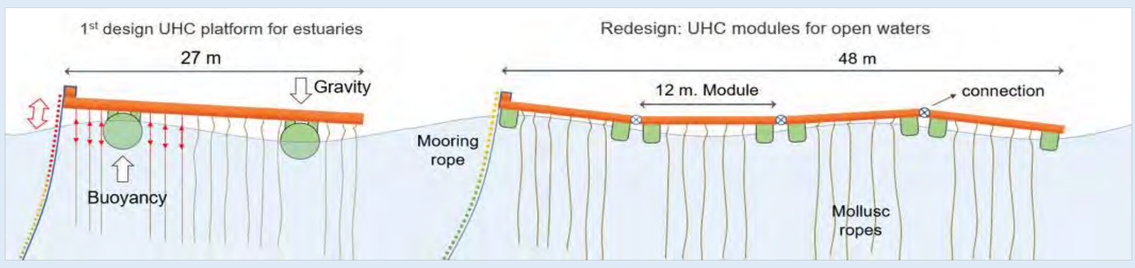


Since 2018 and under the H2020 project **ReSHEALience-760824** (www.uhdc.eu) an intense work is being developed to estimate the real durability of structures in XS and XA aggressive environments. A TRL7 540 m² UHC raft will be floated in Valencia with continuous monitoring including a continuous measurement of the strain in the beams. Some of them are designed to suffer micro-cracking under service to evaluate the level of self-healing reached with different concrete mixtures.



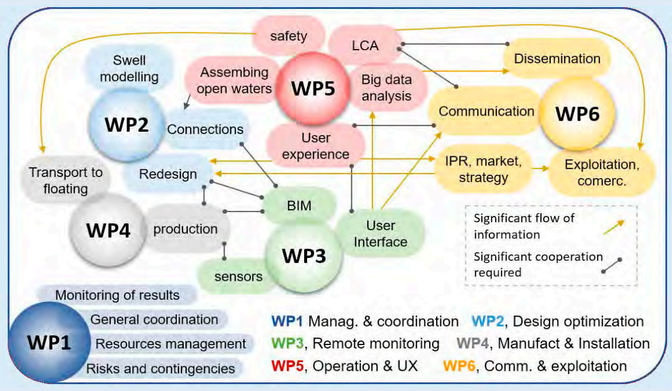
THE MODULAR RAFT (2019): SCALING UP A SUSTAINABLE SOLUTION

The 540m² UHC raft is for very productive semi-opened waters, and the transport required for the precast elements is complex and expensive. The project **OpenMode-863562** uses the progress achieved up to now to adapt the rafts for open waters. For this, they need to be: ❶ Modular: The length of its beams will be 12 m to be exportable in 40' containers, so that an EU-produced hi-tech solution can easily exported. The smaller size will also reduce the stresses under intense swell. The simple packing and assembling facilitates its reuse. ❷ Connectable: Elements can be connected onshore or offshore to form larger structures (12x24, 12x36 m…), with a type of connection that depends on the swell and BG application. ❸ Sensor-equipped: A remote system will send weather, marine, water and structural parameters to support the decision taking and minimize costs, risks and environmental impacts of visiting the platforms.



The project will float eight 140 m² pilots before 2021. Four to test the connection systems in the Bay of Biscay (Atlantic basin), one in the Baltic Sea with the support of the Technical University of Denmark to test nutrient mitigation and two in the Dalmatian coast to increase the productivity and face up predatory problems.

The last is in Malta to explore the possibilities to combine the structure with solar energy. There are specific tasks dedicated to BIM, maritime safety, Life Cycle Assessment, User Experience, trainings and optimization of harvesting through Big Data analytics.



As a conclusion, since 2016 the use of UHC for the production of resilient shellfish farms is proving a reduction of the maintenance costs and increase of their lifetime. The system is being redesigned to be easy-to-transport, connectable and modular to be used for other aquaculture practices and in other sectors, as floating photovoltaics.

Type of raft →	Traditional	Polyethylene	UHC	UHC, modular
	1900	2009	2016	2019
Sea conditions	Calmed and semi-opened			all
Surface area	540 m²			140 m² and connectable
Lifetime expected	10 to 15 years	3 to 15 years	25 to 50 years	
Maintenance (1 to 5)	5	4	1	1
Sectors	Shellfish			Shellfish, energy

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REFERENCES

McKindsey, C., Archambault, P., Callier, M., Olivier F., 2011. Influence of suspended and off-bottom mussel culture on the sea bottom and benthic habitats. Canadian Journal of Zoology, 89, 7, 622-646.

Figueiras, FG, Labarta, U., Fernández M.J. Coastal upwelling, primary production and mussel growth in the Rías Baixas of Galicia. Hydrobiologia, 9-2002, Volume 484, Issue 1–3, pp 121–131.