ECOSTRUCTURE

Climate Change Adaptation through Ecologically-Sensitive Coastal Infrastructure

Newsletter No. 5 | December 2021

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In This Issue

Another Year Over...

It's hard to believe that 2021 is nearly over and that we're entering our final year as a project. This year has been a blur from start to finish, with a number of exciting highlights outlined in the following pages. We're especially thrilled to be releasing some of the final tools and outputs of the project – the result of several years of research and collaboration across our consortium (pages 2 to 6). If you haven't heard about them yet, read on to learn about the digital tools, resources, publications, and maps that we've been releasing this autumn and winter, with more coming early next year.

Our team has been busy publishing as well, with seven papers published in academic journals in 2021 (page 7). All of these publications, tools, and outputs can be accessed from our (award-winning!) website at www.ecostructureproject.eu.

As always, thank you for following our research and engaging with us this year.

Wishing you good health and a happy new year,

The Ecostructure Team

EU Funds: Ireland Wales Programme 2014-2020

Tionól Réigiúnach an Deiscirt Southern Regional Assembly

Cláir Chistí Eorpacha Struchtúrtha agus Infheistíochta na hÉireann 2014–2020

Cómhaoinithe ag Rialtas na hÉireann agus ag an Aontas Eorpach

UNDEB EWROPEAIDD EUROPEAN UNION

Llywodraeth Cymru Welsh Government

Cronfa Datblygu Rhanbarthol Ewrop

European Regional Development Fund

New Tools and Outputs

As we near the end of the project, many of our final stakeholder-focussed tools and outputs are being released. Browse through them in the following pages to learn more.

OUTPUT 1

Characterising and Quantifying Marine Artificial Structures along the Irish Sea Coastline

Paul Brooks *University College Dublin*

Understanding where, what and how many artificial structures occur along our coastlines is crucial to understand their effects and whether they can be retrofitted with ecoengineering adaptations to mitigate effects of climatic change. In addition, understanding where and what type of structures are along our coasts can help coastal managers, planners and other stakeholders to make decisions on areas that may be at risk from coastal erosion, damage to infrastructure from increased storminess, and/or rising sea levels associated with climatic change. With this in mind, Ecostructure researchers at UCD created a database documenting all of the artificial structures along the Irish sea coastline of both Ireland and Wales. Subsequently, researcher Bryan Thompson used Google Earth to characterise and quantify these structures and the extent of coastal hardening along the Irish Sea coast. In total, 6,886 artificial structures were recorded, with the highest densities (26- 68 per km) of structures recorded on urbanised coastlines in both Ireland and Wales. The results also indicated that 586 km – approximately 10% of the shoreline – has already been hardened, the majority by seawalls and rip-rap structures. Furthermore, the work highlights that the combined perimeter length of artificial structures represents a 7% net gain in coastal length in the study area.

Data gathered and processed during this research (raw data and GIS maps) has now been stored in an online repository available upon request at https://zenodo.org/record/4290359#.YYVfQxrP3IV. It is envisaged that this valuable baseline data will facilitate the management of existing structures as well as aiding the planning and design of future structures. We're also finalising a manuscript to be published in the journal *Ocean and Coastal Management* soon, so keep an eye on our website and social media!

See page 7 to view our 2021 publications.

OUTPUT 2

Tool for predicting biological communities on coastal structures

Tasman Crowe *University College Dublin*
Peter Lawrence *Bangor University*

Over the last two years the Ecostructure team has developed a new tool called **BioPredict** to provide an online platform to predict biological communities on artificial structures in the Irish Sea to help bring biodiversity considerations into planning and management of coastal infrastructure. The tool is based on an extensive biological dataset collected by the team at 69 sites on the Irish and Welsh coasts and on physical and chemical data collated from a number of sources. It enables a user to interactively map biodiversity at the sites and use models to understand which factors influence patterns of distribution of selected species, groups of species and functional or species richness. Factors may include the type, building material and environmental context of the artificial structure or concentrations of nutrients in the surrounding water. Modelled outputs include indications of uncertainty.

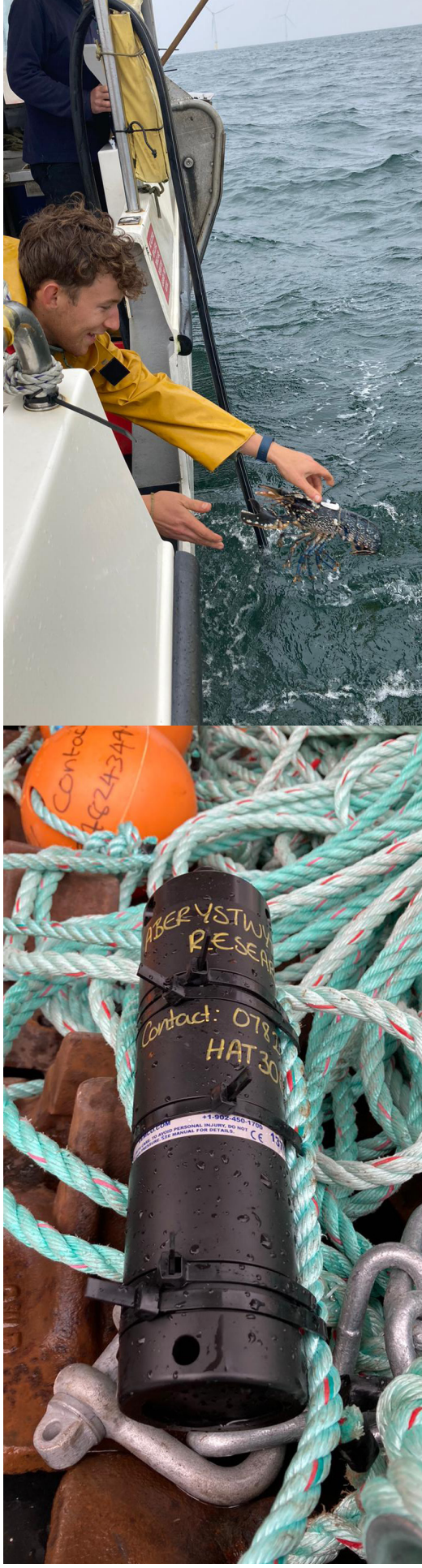
BioPredict is designed to help environmental decision makers determine which species are likely to colonise a planned structure in a new location or, where possible, to alter design parameters or choose particular localities to favour selected biodiversity outcomes. It can also guide management strategies to enhance biodiversity on existing structures, for example by indicating potential benefits of reduced nutrient input or simply highlight particularly well performing structures biologically worthy of visits and reconnaissance. The tool has already been demonstrated for stakeholders at Natural Resources Wales. It will be made publicly available in the coming months for all to use and the team welcomes feedback to further improve it in the future.

OUTPUT 4

Tool for predicting ecosystem services delivered by coastal structures

Tom Fairchild *Swansea University*

Ecosystem functions and services are becoming important areas of discussion when thinking about environmental policy and decision making. Indeed, functions and services are explicitly considered as aspects of environmental management policy in the Wellbeing of Future Generations Act, and the Environmental Act 2016 in Wales. This explicit inclusion provides pathways to manage the environment to enhance or maintain ecosystem functions – critical processes that maintain the health and resilience of ecosystems – and the services that humans get from them, rather than the previous singular



Above: *Harry Thatcher releases a tagged European lobster to track its movements around a windfarm in the Irish Sea.*

Photo: A concrete "crustacean cabana" awaits deployment in Swansea Bay

Tool for predicting ecosystem services delivered by coastal structures

continued from page 3

focus of enhancing the number of species present.

Coastal habitats provide a particular challenge, as how the seaweed and animal communities provide functionality and services is relatively poorly understood, and very little information exists for most species that live there. To address that problem, we have developed a tool, using trait-based models, to predict key ecosystem functioning rates and service indicators for shallow coastal and intertidal communities. This EFPREDICT tool allows users to understand how effective different communities are likely to be at performing a range of functions, and to simulate how changes in the community - or in their environment - might affect this. The tool has been created as an easy to use and open source R-package with user-friendly excel data templates, as well as a quick reference guide that outlines how a range of common community types typically provide ecosystem functions.

The tool and accompanying guides will be available on December 17 at https://doi.org/10.6084/m9.figshare.c.5505186.

View the Tool and Guides

OUTPUT 3

Tool for predicting effects of coastal structures on dispersal and gene flow of native and non-native species

Peter Robins *Bangor University*

The introduction of marine non-native species through commercial shipping, aquaculture, and recreational boating is recognised as a significant environmental threat, with potentially far-reaching economic and ecological consequences. Once introduced and established into a region, natural dispersal plays an important role in their potential spread. Understanding patterns of natural dispersal from points of initial introduction can direct management efforts to appropriate areas, such as natural zones of likely accumulation, and give early warning of arrival to new areas.

Online Larval Dispersal Tool

Our understanding of the mechanisms of dispersal of marine invertebrates through their larval stages and our ability to predict dispersal through understanding of shelf sea and coastal hydrodynamics has made important advances over the last 20 years. However, such predictive capacity is rarely available to coastal managers in an accessible and timely manner. Ecostructure researchers at the School of Ocean Sciences, Bangor University have produced a freely-available online tool for coastal managers to facilitate rapid prediction of

Tool for predicting effects of coastal structures on dispersal and gene flow of native and non-native species

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dispersal of marine invertebrate larvae from over 100 coastal locations around the Irish Sea. The tool allows selection of release location, season of release, and length of larval lifetime and larval behaviour – all factors which are known to have significant impact on dispersal patterns. While the motivation for this work comes directly from our interests in marine non-native species management, we anticipate this tool being of interest to a range of users, including educators and those interested in dispersion of contaminants such as plastics and oil.

Use the Online Dispersal Tool

View the animated explainer video in English or Welsh.

English

Cymraeg

OUTPUT 6

Decision support tool for building ecologically sensitive design into coastal structures

Pippa Moore & Ally Evans *Aberystwyth University*

Work Package 3 recently launched a decision support tool that allows practitioners to make informed, evidence-based decisions on eco-engineering solutions for their particular context. Led by Dr Ally Evans, we used the Conservation Evidence framework to undertake a review of the marine eco-engineering literature, synthesising this into an online resource and downloadable pdf entitled 'Enhancing the biodiversity of marine artificial structures'. The synopsis includes summaries of 43 potential eco-engineering actions and the associated outcomes for biodiversity, based on evidence from 176 studies undertaken around the world. We also commissioned an animated video introduction to the synopsis, outlining some of the biodiversity issues associated with traditional marine artificial structures and how eco-engineering can lead to biodiversity benefits.

On Thursday the 4th of November we held a launch event for this resource with over 150 registrants from as far away as Australia, the United States and Malaysia, as well as key national and regional stakeholders and practitioners. The event was hosted by our Stakeholder Committee Chair Dr Louise Firth of Plymouth University. Presentations on the Conservation Evidence Project, the Ecostructure Project and how to use the decision support tool were given by Professor Bill Sutherland of Conservation Evidence and Cambridge University, Professor Pippa Moore of Newcastle University (until recently Aberystwyth University and WP3 lead) and Dr Ally Evans, respectfully.

Download the synopsis as a pdf from the Conservation Evidence webpage, or search the online resource for the evidence that is most relevant to you at the links below.

Download the PDF Synopsis

View & Search the Synopsis Online

OUTPUT 8

Tools for early warning and rapid response to invasive species

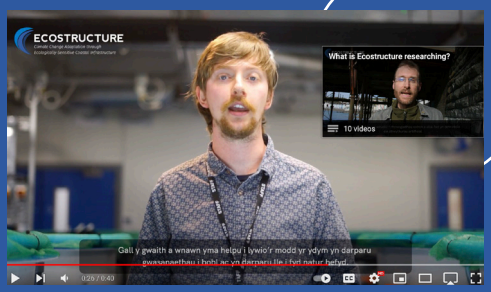
Jens Carlsson *University College Dublin*

Invasive non-native species (INNS) are of significant concern as they can act as vectors for diseases, cause changes in habitats, and increase pressures on our native organisms through competition or predation. Over the last 10 years, biologists have been developing non-invasive genetic methods to detect the presence of INNS that do not rely on collection or visual observation. Because all organisms shed DNA into the environment (through sources such as blood, skin, mucous, sperm, eggs and faeces), this environmental DNA (or 'eDNA') and can be extracted from, soil, air and water samples. The DNA can then be interrogated using quantitative (q)PCR for the presence of individual target species.

Quantitative PCR using species specific genetic assays are very effective at finding low concentrations of DNA - a needle in the haystack tool. Alternatively, the overall diversity of organisms contributing DNA to an environmental sample can be interrogated by using universal markers such as the barcode of life gene COI, an approach known as 'metabarcoding'. While qPCR allows us to search for the needle in a haystack, metabarcoding allows us to describe the haystack. The Ecostructure team assessed how both qPCR and metabarcoding performed when deployed to detect the invasive tunicate, *Didemnum vexillum*. Our findings demonstrate a superior detection capability when using qPCR over metabarcoding and we recommend that biologists searching for individual species should employ species-specific qPCR approaches. However, while metabarcoding does not have the same capability to detect Didemnum vexillum, metabarcoding provides a much broader overview of biodiversity, and because it is not species-specific, metabarcoding can allow early detection of DNA from non-native organisms even in areas where their presence is unexpected. Both of these approaches can be of value to coastal and marine environmental managers.

Our work and methods for the targeted qPCR assay are detailed in the paper The use of environmental DNA metabarcoding and quantitative PCR for molecular detection of marine invasive non-native species associated with artificial structures, published in the journal *Biological Invasions*.

View the Paper



New Videos!

Meet our researchers and get to know what they've been working on in the Ecostructure project in our latest video series.

These videos and more can be viewed on our YouTube account. Follow the link to watch and learn about the eco-engineering enhancements we've been testing, biophysical modelling, and our latest fieldwork in the Irish Sea.

Visit our YouTube Channel

2021 Publications

Link

Influence of concrete properties on the initial biological colonisation of marine artificial structures

Ecological Engineering

Natanzi, A.S., Thompson, B.J., Brooks, B.R., Crowe, T.P., McNally, C.

Link

Replicating natural topography on marine artificial structures – A novel approach to eco-engineering

Ecological Engineering

Evans, A.J., Lawrence, P.J., Natanzi, A.S., Moore, P.J., Davies, A.J., Crowe, T.P., McNally, C., Thompson, B., Dozier, A.E., Brooks, P.R.

Link

Fucus vesiculosus populations on artificial structures have potentially reduced fecundity and are dislodged at a greater rate than on natural shores

Marine Environmental Research

Farrugia Drakard, V., Brooks, P., Crowe, T. P., Earp, H. S., Thompson, B., Bourke, N., George, R. Piper, C., & Moore, P. J.

Link

Artificial shorelines lack natural structural complexity across scales

Proceedings of The Royal Society B

Lawrence, P.J., Evans, A.J., Jackson-Bué, T., Brooks, P.R., Crowe, T.P., Dozier, A.E., Jenkins, S.R., Moore, P.J., Williams, G.J., Davies, A.J.

Link

Eco-engineering of seawalls — An opportunity for enhanced climate resilience from increased topographic complexity

Frontiers in Marine Science

Md, S., O'Sullivan, J.J., Abolfathi, S., and Pearson, J.M.

Link

Genetic diversity and relatedness in aquaculture and marina populations of the invasive tunicate Didemnum vexillum in the British Isles

Biological Invasions

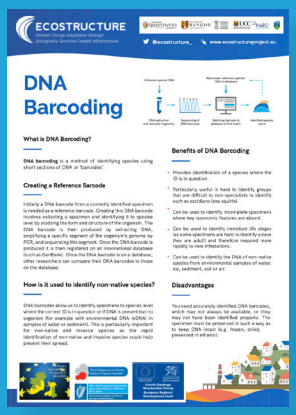
Prentice, M.B.,. Vye, S.R., Jenkins, S.R., Shaw, P. W., Ironside, J.E.

Link

The use of environmental DNA metabarcoding and quantitative PCR for molecular detection of marine invasive non-native species associated with artificial structures

Biological Invasions

Gargan, L.M., Brooks, P.R., Vye, S.R., Ironside, J.E., Jenkins, S.R., Crowe, T.P., Carlsson, J.



New Fact Sheets Explain eDNA & DNA Barcoding

Morag Taite (WP8) and Amy Dozier (WP6) collaborated to create two new fact sheets on eDNA and DNA barcoding. All fact sheets are available in both English and Welsh on our website, and can be used as material for schools, workshops, and more.

View Fact Sheets

These and all previous publications can be found on the Ecostructure website.

Our Publications

Welcome New Staff!

Tomas Buitendijk

We'd like to extend a warm welcome to Tomas Buitendijk, who joins Ecostructure as a Post-doctoral Researcher in cultural ecosystem services for Work Package 7, based at University College Dublin.

Tomas Buitendijk recently completed his Ph.D. at Dublin City University's School of English. In this project, he developed a 'poetics' of the sea in the twenty-first century, by examining changing representations of seascapes across a range of contemporary cultural expressions. In combination with leading ecocritical theory, this resulted in a conceptual framework for the multispecies marine society, which describes the possibility of productive cross-species cohabitation in coastal and marine environments during the current period of climatic upheaval. Tomas was one of the lead organisers of the September 2019 'Planet Ocean' interdisciplinary workshop, and helped found the UK-Ireland 'Blue Islands' research network. In his work with Ecostructure, he hopes to draw on cultural and historical artefacts, ecocritical theory, and conversations with industry partners and community groups to characterise the cultural meaning and potential value of existing and new natural and artificial coastal infrastructure.

RESEARCH UPDATES

Designing Habitat Units for European Lobsters

Tom Fairchild *Swansea University*

In Work Package 9 we have been looking at how European Lobster (*Hommarus gammarus*) use different hole sizes and shapes as habitat, and whether habitat preferences could be used to enhance the designs of subtidal infrastructure to provide more, and better, homes for lobsters. Preliminary lab work suggests that lobsters do select the size and shape of their burrows, with preference toward tightly fitting holes with slightly wider front apertures where they can spread out their claws. From this we have designed a field experiment using large concrete habitat units dubbed "crustacean cabanas," which provide an array of hole shapes and sizes. These habitat units have been deployed in Swansea Bay, close to existing subtidal infrastructure. Monitoring to establish the use of these spaces over time by lobsters, as well as other animal species, is ongoing using our remotely operated underwater vehicle (ROV).

Habitat Preferences of Early Benthic Phase Lobsters

Harry Thatcher *Aberystwyth University*

During spring of 2021 we were able to complete our behavioral trials focused on the habitat preferences and predator response of early benthic phase (EBP) lobsters. The results of these trials are currently being used to inform the design of habitat units that will be aimed at increasing suitable settlement habitat for EBP lobsters, and providing a means of safely releasing EBP's raised in hatcheries. Over 2022 we will be trialing these habitat units at sea to assess the survival of pre-seeded EBP lobsters within the units.

Following our behavioural trials, we were able to deploy our acoustic telemetry array within the Gwynt y Môr windfarm to investigate the movements of adult lobsters in association with windfarm features, e.g scour defenses. To do so, we deployed moorings that held acoustic receivers around three turbine locations and caught, tagged and released a number

Preparing to deploy an acoustic receiver to track tagged lobsters at a windfarm in the Irish Sea.

Habitat Preferences of EBP Lobsters

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of lobsters from each turbine. The lobsters were then left to move around the site as they wished, with our receivers collecting data relating to their geographic location. During October we retrieved the receivers and downloaded the data. Over the four month deployment we collected over 300,000 detections from the tagged lobsters and we are very excited to share the results in more detail in the near future.

Marine Invasive Non-Native Species

Morag Taite *Aberystwyth University*

Many marine organisms release larvae into the water, allowing them to disperse by drifting and/or actively swimming before settling on a hard natural or artificial surface where they spend the rest of their lives. These sessile organisms include many non-native seaweeds, barnacles, sea-squirts, molluscs, and worms. Ecostructure researchers from Aberystwyth University deployed settlement plates on onshore and offshore sites associated with human activities in Wales and Ireland to sample these sessile organisms. The onshore sites included Porthdinllaen lifeboat station and marinas at Conwy, Holyhead, Aberystwyth, Milford Haven, Porthcawl, Carlingford, Malahide, and Dun Laoghaire. Offshore sites included the proposed windfarm site at Awel y Môr, the existing wind farm site at Gwynt y Môr, and a Trinity Lights cardinal marker just south of Gwynt y Môr. We successfully retrieved samples from all locations except the Awel y Môr site, as the mooring had been washed away in storms. Specimens of organisms settling on the plates have been preserved, and tissue samples have been taken for DNA barcoding. We will compare the settlement plate results with those obtained through analysis of environmental DNA in water samples from the same sites and through computer modelling of larval dispersal. This should give us an indication of the extent to which the predictions of the models and the detection of species DNA in the water corresponds to the presence of living larvae that are capable of settling on artificial structures.

We also organised an invasive and non-native species (INNS) training workshop with Natural Resources Wales (NRW), the National Museum of Wales (NMW), and the North Wales Wildlife Trust. This workshop was specifically aimed at Seasearch and Shoresearch volunteers, along with other members of coastal communities who regularly spent time on the shore and were interested in learning how to identify INNS. The workshop involved a series of talks mixed with a practical ID session, in which participants were able to see INNS up close and get a better understanding of what they should be looking out for. The participants were very engaged in the workshop and all said it has made them much more aware of INNS, and they will be more likely to look for and report them in the future.

Top: *Morag Taite deploys settlement plates at an offshore site with the help of Harry Thatcher.*

Above: *Morag Tatite teaches INNS identification in a recent workshop.*

Biosecurity and recreational boating

Liz Morris-Webb *Bangor University*

The early stages of Ecostructure worked with marina operators in Ireland and Wales to explore ways to reduce the risk of spreading invasive non-native plants and animals by recreational boating through the implementation of biosecurity in the day-to-day operations of marinas. Marina operators are aware of the need to change the culture of biosecurity amongst boaters, but have called for evidence that the materials they promote to their customers are effective at improving biosecurity behaviours. Although there are now many educational campaigns aiming to improve biosecurity practice amongst boaters including the Check Clean Dry campaign in the UK, few have robustly researched the effect of these materials on the intention to practice biosecurity amongst the recreational boaters themselves.

Responding to the call from marina operators and other stakeholders, we are now working with the Great British Non-Native Secretariat (GBNNS) and The Green Blue to develop a survey to test the efficacy biosecurity education materials that target recreational boaters and paddlers. This includes developing interactive virtual workshops to showcase and discuss biosecurity materials at a virtual marina on the online meeting and conference platform Gather. In December, Ecostructure along with recreational boating organisations and marinas around Wales and Ireland will launch one of its final online surveys: 'Biosecurity and marine recreational boating and paddling'. We will explore biosecurity practice amongst the marine boating community and test the effect of different educational materials on the boaters' intention to undertake better biosecurity practices. This survey will help the GBNNS, marinas and boating organisations to select the most effective materials in future.

Take the Survey

Upscaling eco-engineering solutions

Ruth Callaway *Swansea University*

Completing key ecological research in the first few years of the project left us with several questions. How can we apply our findings to larger, commercial projects? Which organisations, decision makers and enterprises need to be consulted for upscaling our academic findings? Although there is considerable interest to develop coastal eco-engineering, it remains a challenge for many

Upscaling eco-engineering solutions

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eco-engineering projects to overcome project planning hurdles, cost implications, manufacturing constraints, health and safety concerns, and aesthetic perceptions.

Partners at MaREI, UCC have been working on a report reviewing the policies, legal requirements, and management practices relevant for eco-engineering in Ireland and Wales. This analysis includes insight from interviews with governmental and commercial organisations regarding the role of legislation in the decision-making process for coastal infrastructure projects. Meanwhile, engineers from UCD have collaborated with a concrete manufacturer to produce larger versions of the most successful formliners developed during the past years, which will be deployed next year in Dublin Port. In Wales, the Mumbles Sea-Hive project has served as a case study to explore how eco-engineering interventions can be integrated. Collaboration with the local council, engineering design companies, formliner and precast concrete manufacturers, and the construction industry has enabled specific challenges to be worked through collectively. This project has taken the first steps towards upscaling academic designs, using commercial formliners, UHPC pre-cast units, and industry standard construction. Importantly, the Mumbles Sea-Hive project produced value for the wider community. Primary schools visited the project, and for many children it was the first outdoor event since the Covid-lockdown. Coastal eco-engineering projects present a fantastic opportunity for teachers to talk about climate change, sea-level rise and biodiversity loss by translating global phenomena to the local scale. Projects such as these can also highlight measures to mitigate biodiversity loss and encourage children and adults to engage with their local shore. The local community council encourages engagement with the project and people are invited to share their views (www.bit.ly/SeaHiveConsultation). The path to ubiquitous eco-engineering application for coastal infrastructure projects remains rocky, but the enthusiasm of all stakeholders to create solutions is palpable.

Thank you to everyone who engaged with us both in person and online this year. Wishing you a very happy 2022!

Above: The Mumbles Sea-Hive Project

We Won!

In case you missed it, Ecostructure's website won the "Better World" award at the 2020 .eu Web Awards! The phenomenal awards gala featured beautiful performances that were streamed live from the Teatro Verdi in Pisa, Italy. The award was presented to Ecostructure Communications Officer Amy Dozier on behalf of MaREI, University College Cork, by none other than Grammy-winning musician Sting. Our prize was a beautiful glass trophy along with a billboard at Brussels Airport over the summer of 2021. We still haven't recovered from hearing 'Ecostructure' and 'eco-engineering' from the mouth of Sting, and we hope our win and billboard has helped to spread awareness of eco-engineering solutions to climate change.

Visit our award-winning website with resources, publications, videos and more at

www.ecostructureproject.eu