



*Engaged Research for a Sustainable Future*



# Environmental Research Institute

ANNUAL REPORT 2020

Enter

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## VISION

To enable a transition to a zero carbon, resource efficient and sustainable society.

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## MISSION

To generate new research knowledge for the understanding and protection of our natural environment, and develop technologies, tools, services and policy knowledge to facilitate a transformation to a zero carbon, resource efficient, and sustainable society.

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THE ENVIRONMENTAL RESEARCH INSTITUTE IS COMMITTED TO THE FOLLOWING FIVE CORE PRINCIPLES:

**Research excellence**

**Interdisciplinary collaboration**

**Research with impact – Environmental, Societal & Economic**

**High quality postgraduate and postdoctoral education and training**

**Diversity and Equality**

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## Message from ERI Director



The year 2020 was synonymous with COVID-19. The pandemic has impacted us as individuals, families and communities, and has touched every corner of our society. It has been an unprecedented year for our University and Institute. In March 2020, like the rest of the world, we closed our campus and transformed into a remote operation switching very quickly to different delivery modes for our academic programmes. Our research system has been put under immense strain with researchers not being able to access labs, carry out fieldwork, and struggling to meet research deliverables under disappearing budgets.

The ERI has played a leading role in the pandemic response in the University and nationally. Within the ERI Lee Road and Beaufort Buildings, we were fortunate to be able to lead pilot programmes within the University for a limited return of researchers to labs for essential work. In the first few weeks of the COVID-19 restrictions, a number of our research groups responded by manufacturing personal protective equipment for front-line staff using 3-D printing technology. Our research teams were awarded funding

under the COVID-19 Rapid Response Call across a range of areas including tracking COVID-19 clusters, airborne surveillance of COVID-19 virus in work environments, COVID-19 community wide surveillance via wastewater-based epidemiology, and modelling of the dynamics of social and physical distancing. In mid-2020, the Institute hosted a webinar series where our academic staff reflected on the impact of the COVID-19 pandemic on our environment, and the possible lessons we can take forward to create a more sustainable society. Throughout 2020 our staff have been very prominent in the news and media bringing the latest scientific knowledge to bear on different facets of the pandemic as illustrated in this 2020 ERI Annual Report.

Despite the many challenges placed on us by the COVID-19 pandemic, 2020 was very successful year for the Institute. The cross-university ‘Sustainable Futures’ project led Dr Marguerite Nyhan was awarded €3.9M under the Higher Education Authority’s Human Capital Initiative to develop a range of new educational offerings for enterprise to catalyse the transition to zero carbon and resource efficient business in Ireland. The project is a collaboration with NUI Maynooth and Sligo Institute of Technology and will leverage UCC’s Sustainability Strategy and the interdisciplinary strengths of the ERI. Under the project, two new “Sustainable Futures Lab” spaces will be developed; a teaching space in the School of Engineering and Architecture on campus and an academia-industry collaboration space in the ERI Lee Road Building.

The Institute had a number of “firsts” in 2020. We were delighted to welcome Professor Gerry Killeen to UCC as the first ever recipient of an AXA Research Chair in Ireland; the €1M AXA award will focus on eradicating malaria while

also fostering improved management of wildlife areas in Africa. Professor Justin Holmes became the first researcher in Ireland to coordinate two FET-Open proposals; in the RADICAL project he is working with Professor John Wenger and Dr Stig Hellebust to build low cost instruments that will measure the presence of harmful atmospheric radicals in the air, and in the TRANS-LATE project he will develop an advanced heat-to-electrical energy harvesting technology. Professor Maria McNamara was a recipient of a prestigious €2M ERC Consolidator grant to explore how key biomolecules such as melanin, keratin and collagen evolved in animals. This award is particularly significant as it builds on Maria’s first ERC Starting Grant, and double ERC award recipients are very rare.

The impact of ERI research was also evident in 2020. In a significant example of ERI research directly informing government policy, Professor Áine Ryall and Dr James Glynn were invited as expert witnesses to the Oireachtas Joint Committee on Climate Action during pre-legislative scrutiny of the Climate Action and Low Carbon Development Bill. International research by Dr Christie Godsmark highlighted the significant risk to human health from extreme heat due to climate change in African countries. In research to quantitatively characterise several cold water coral habitats in the North East Atlantic Professor Andy Wheeler’s Marine Geology Group made the troubling discovery of micro-plastics at a depth of 2,125m. Research by Professor John Quinn and his colleagues demonstrated that use of breeding information signs for tourists around bird colonies can play a significant role in protection of vulnerable nesting sites.

The Institute, its researchers and centres attract- ed €17.4M in research and educational funding

in 2020. The Institute and centres were awarded 75 new research projects bringing the current total to 274 active research projects worth over €76.8M. Institutes researchers published a record 426 peer reviewed publications and 42 postgraduates graduated under the supervision of ERI affiliated academics in 2020.

We are very pleased to welcome new affiliated principal investigators from across a host of UCC schools and departments in 2020 including Dr Elena Arranz (School of Food and Nutritional Sciences), Dr Kian Mintz-Woo (Department of Philosophy), Professor Cairíona Ní Dhúill (School of Languages, Literature and Cultures), and Dr Marica Cassarino and Dr Annalisa Setti (School of Applied Psychology).

Finally I wish to sincerely thank staff and researchers within the ERI who have shown tremendous agility and resilience in 2020 in adapting to working from home during the pandemic, and continue to produce internationally leading environmental and sustainability research that has scientific and societal impact.

**Professor Sarah Culloty**  
Director, Environmental Research Institute.

## ERI Management



1. Professor Sarah Culloty, ERI Director
2. Professor Jerry Murphy, Director of the SFI MaREI Centre, Vice-Director of the ERI
3. Professor Brian O'Gallachoir, Director of the SFI MaREI Centre, Vice-Director of the ERI
4. Dr Paul Bolger, ERI Manager
5. Dr Gillian Bruton, SFI MaREI Centre Manager
6. Dr Jimmy Murphy, LIR NOTF Manager
7. Jeremy Gault, ERI Beaufort Building Operations Manager



## ERI Academic Advisory Board

### Prof Sarah Culloty

(Chair) Director of ERI  
(Head of SEFS)

### Prof Jerry Murphy

Deputy Director of ERI  
(Engineering)

### Prof Brian Ó Gallachoir

Deputy Director of ERI  
(Engineering)

### Dr Paul Bolger

Manager of ERI

### Prof Ed Byrne

Chemical and Process  
Engineering

### Dr Fiona Cawkwell

Geography

### Prof Eleanor Doyle

Economics

### Dr Niall Dunphy

Engineering

### Jeremy Gault

Beaufort Bldg Operations  
Manager

### Dr Clodagh Harris

Government

### Prof Justin Holmes

School of Chemistry

### Prof Marcel Jansen

BEES

### Dr Maria Kirrane

UCC Green Campus

### Prof Mary McCarthy

Management and Marketing

### Prof Owen McIntyre

Law

### Dr Pat Meere

BEES

### Dr John Morrissey

Microbiology

### Dr Ger Mullally

Sociology

### Dr Stephen Onakuse

Food and Business  
Development

### Dr Eilis O'Reilly

School of Public Health

### Dr Tom Reed

BEES

### Prof Áine Ryall

Law

### Prof Maria de Sousa-Gallagher

Chemical and Process  
Engineering

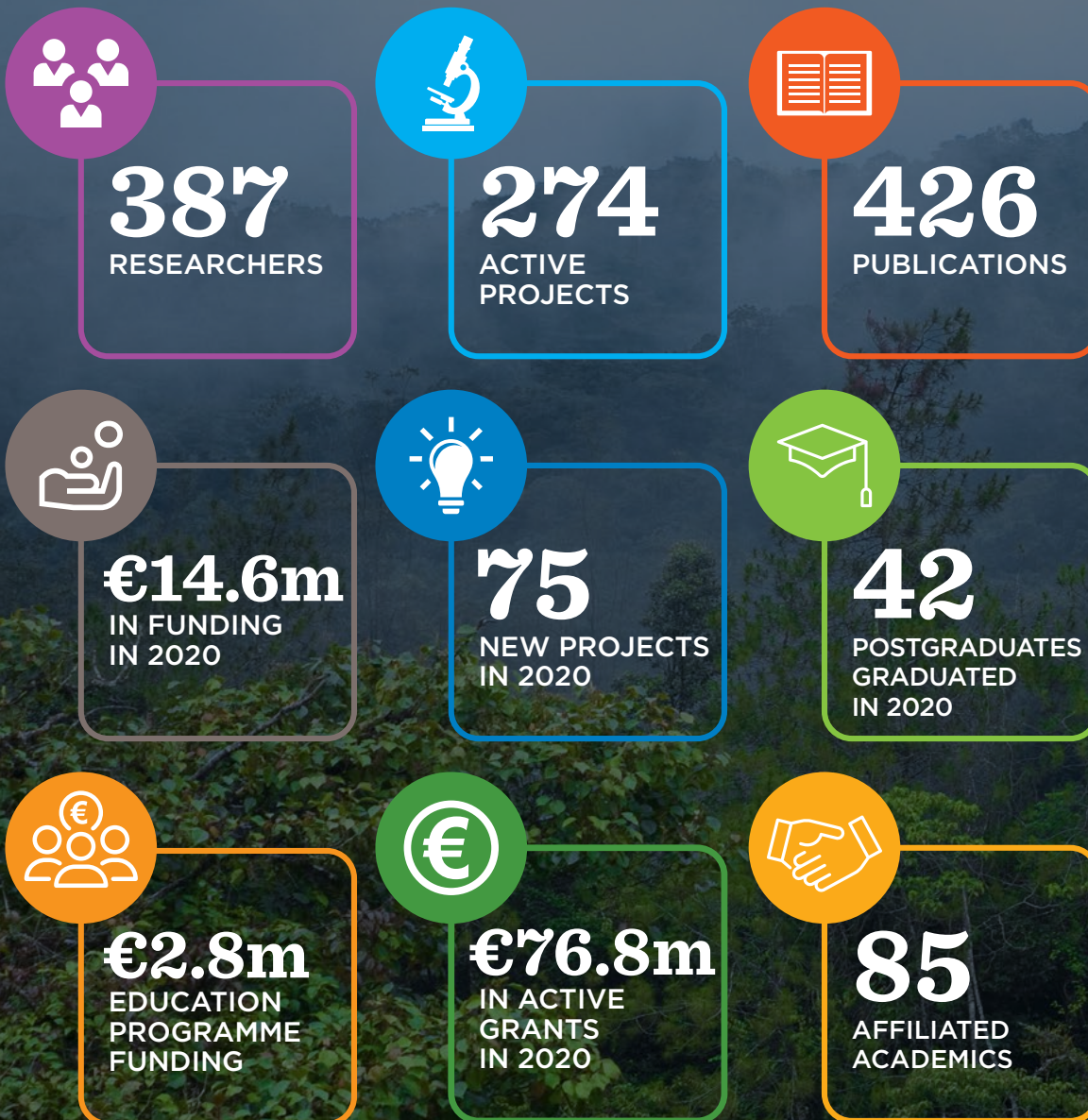
### Prof John Wenger

Chemistry

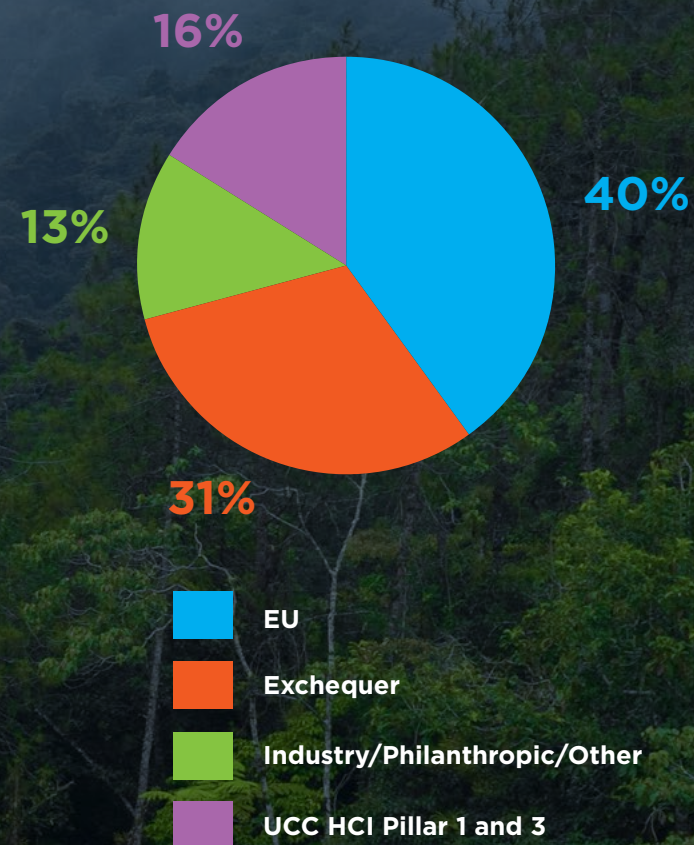
### Prof Astrid Wingler

School of BEES

# Section 1: Snapshot of ERI in numbers for 2020



FUNDING SOURCE



## Section 2: UCC-led 'Sustainable Futures' project will lead the transition to sustainable enterprise and business



UCC were awarded €3.9M in 2020 under the Higher Education Authority's Human Capital Initiative Pillar 1 and Pillar 3 for the "Sustainable Futures" project which aims to develop a range of new educational and training offerings for industry and enterprise to catalyse the transition to zero carbon and resource efficient businesses in Ireland. The project is led by Dr Marguerite Nyhan (School of Engineering & Architecture, ERI, MaREL, and Visiting Scientist at Harvard University) in UCC, in collaboration with NUI Maynooth and Sligo Institute of Technology.



*"We are the university for and of sustainability. This is about translating our knowledge into practice, as set in our Green Mission: student led, research informed, practice focussed."*

**Professor John O'Halloran, Interim President of UCC and member of the Sustainable Futures team**

Diminishing natural resources, growing public awareness of climate change, and concerns over environmental sustainability are pushing enterprises to place circular economy and decarbonisation at the heart of strategy, operations and decision-making. Accordingly, there are a growing number of enterprises, across multiple sectors, which require a skilled workforce who are knowledgeable in sustainability and decarbonisation. The transition towards sustainable and net-zero carbon enterprises is one of the biggest opportunities for companies in the coming years to drive innovation, increase competitiveness and stimulate growth while also managing risk. Successfully achieving systemic change requires not only radical technological innovations and different business models, but also new competences and skills.





*“The newly published Climate Action Bill emphasises the need for industry to shift to a zero carbon and resource efficient business model, and the value of academic-industry engagement has never been more important than when it comes to supporting our colleagues in industry through this transition. This investment in a Sustainable Futures industry-university collaboration will enable us to leverage our transdisciplinary research expertise in support of Irish companies.”*

**Professor Sarah Culloty, ERI Director and Head of the College of Science, Engineering, and Food Science (SEFS)**

Sustainable Futures is a cross-university initiative that will bring together science and enterprise, academia and industry, to drive sustainability and decarbonisation by developing new qualifications and Continuing Professional Development courses that will draw upon UCC’s renowned expertise in the environmental field. The project leverages UCC’s Sustainability Strategy and the interdisciplinary and transdisciplinary strengths and capacity developed within the Environmental Research Institute. The inter-disciplinary, inter-institutional approach of the project is particularly suited to address the complex challenges of the transition to a low carbon economy and the outputs of the project will provide benefits across a range of industries.



*“The Government’s Climate Action Plan proposes major national carbon emissions reduction targets. As such, there has never been a more urgent time to create leaders in environmental sustainability in industry, enterprise, business, and broader society who will drive the transition to a zero-carbon future.”*

**Project lead Dr Marguerite Nyhan, Lecturer in Environmental Engineering in UCC School of Engineering & Architecture, ERI and MaREI researcher and a Visiting Scientist at Harvard University in Boston**

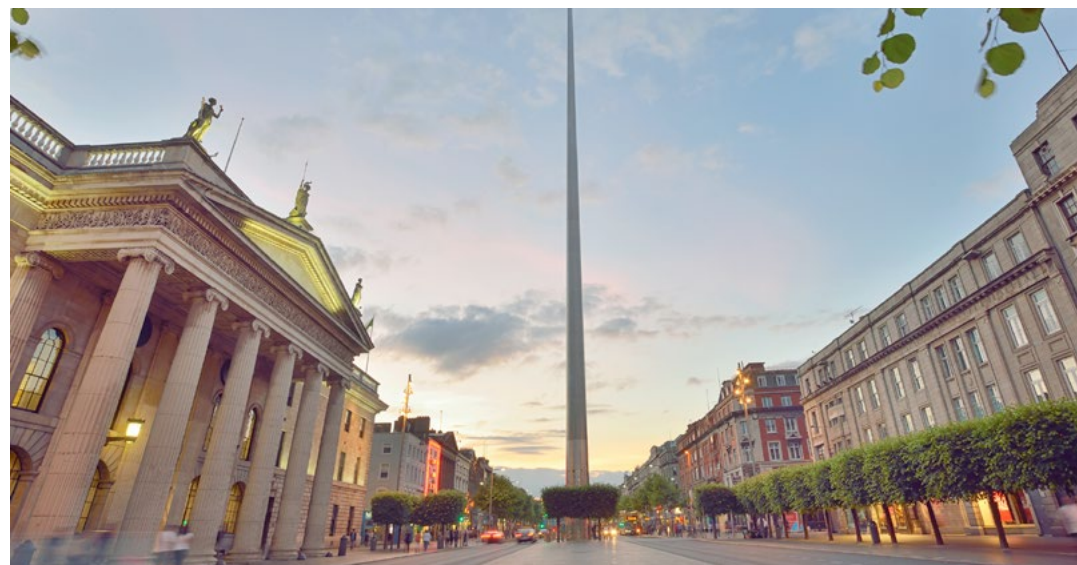
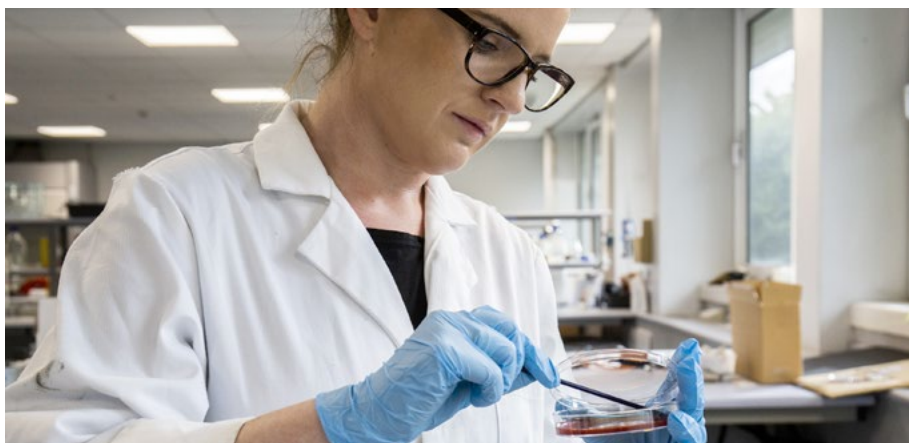
The project aims to engage with industry and business to pursue an enterprise-informed curriculum and will develop new Higher Diploma (Level 8), Postgraduate Certificate (Level 9), Postgraduate Diploma (Level 9), and full Masters (Level 9) qualifications, aimed at a number of demographics including university graduates from all disciplines, operational staff within industry partners, and early to mid-career, current and aspiring leaders who want to develop their capacity to drive the business response to sustainability challenges. New Continuing Professional Development courses will also be developed, aimed at professionals across all sectors wishing to enhance their skills in fields to deliver on all aspects of environmental sustainability within enterprise. The project will also develop and deliver a “Transformative Leadership for a Sustainable Future” immersion programme as a partnership with the Irish Management Institute. Two new “Sustainable Futures Lab” spaces will be developed in UCC under the project; a teaching space in the School of Engineering & Architecture on campus and an academia-industry collaboration space in the ERI Lee Road Building.

## Section 3: ERI research responds to the COVID-19 challenge

### ERI researchers secure funding for COVID-19 research projects

In March 2020, the Irish Government launched a National Action Plan in response to COVID-19. As a key action in this plan a coordinated research, development & innovation funding opportunity was launched to enable research to better understand, mitigate and recover from the impact of COVID-19, and to enhance our readiness and resilience for future resurgences of the virus or other public health emergencies. This call involved SFI, EI, IDA, the HRB and the IRC. This call aims to support research in a number of thematic areas focused on advancing our knowledge of the virus and its impact on our health, and developing solutions that contribute to economic and societal recovery. Five research projects led by ERI researchers have been awarded funding under the COVID-19 Rapid Response Call. Dr Jean O'Dwyer (School of BEES, ERI)

will track COVID-19 clusters based on geo-referenced data to more accurately predict future outbreaks. Professor John Wenger, Dr Stig Hellebust, Dr Mehael Fennelly (all of School of Chemistry, CRAC, ERI) and Professor Mike Prentice (Dept of Pathology) plan to conduct airborne surveillance of SARS-CoV2 in healthcare and airport environments with Professor Mairead Harding and Dr Catherine Gallagher (Cork University Dental School and Hospital), and in a separate project aim to understand and prevent COVID-19 outbreaks in meat processing plants. Dr Niall O'Leary (School of Microbiology, ERI) will conduct COVID-19 community-wide surveillance via wastewater-based epidemiology, and Dr Paul Holloway (Dept of Geography, ERI) will carry out modelling of the entwined dynamics of social and physical distancing.



### The effects of the pandemic on Ireland's energy system

As early as May 2020, energy policy researchers at the MaREI Centre revealed the first full picture of the impact of Covid-19 restrictions on Ireland's energy-related pollution levels. The analysis – *The Pandemic and Ireland's Energy System – what are the impacts for greenhouse gas emissions?* examined Ireland's pollution levels prior to lockdown measures and compared it with those levels during lockdown. Amongst the findings was the observation that pollution from cars dropped by 50%, but air pollution from solid fuel burning did not change. The analysis also showed that for every week in lockdown, Irish people reclaimed five hours that would have otherwise been spent stuck in their car. Nine out of ten flights were cancelled since restrictions commenced and if flight restrictions continued in this vein, it would be the equivalent of switching off Moneypoint coal fired power station for 6 months, the research showed. At

home, our electricity usage pattern replicated a weekend demand profile for seven days a week. Overall, researchers estimated that even at that early stage of May 2020, the energy system CO<sub>2</sub> emissions reductions could be 3MtCO<sub>2</sub> in total (or 2MtCO<sub>2</sub> excluding aviation) which would equate to roughly 5.3% less energy related CO<sub>2</sub> emissions than in 2019. However, they acknowledged that a complete lockdown scenario is only viable for short term, whereas climate change mitigation & adaptation is a marathon event requiring rapid and sustained steady changes in how we consume energy and live our lives. The report was authored by Dr James Glynn, Siddharth Joshi, Maarten Brinkerink, Dr Hannah Daly, Dr Paul Deane, Dr Shane McDonagh, Connor McGookin, Dr Laura Mehigan, Clare Noone, Dr Marguerite Nyhan, Vera O'Riordan, Dr Fionn Rogan, Alparslan Zehir and Professor Brian O Gallachoir.





## Containment strategies for COVID epidemics

As Ireland repeatedly emerged from lockdowns, infectious disease expert Professor Ger Killeen (School of BEES, ERI) used his own recently published research to support appeals for sustained lockdown measures to completely eliminate the virus. Professor Killeen, the AXA Research Chair in Applied Pathogen Ecology in UCC, pointed to countries with ambitious national strategies to completely crush the curve of the epidemic such as China, Korea, Japan, New Zealand and Australia, and compared these to the United States and many hard-hit European countries including Ireland, who strove to merely flatten the curve of their epidemic trajectories so that transmission persisted at rates with which ICUs could cope. Stark evidence provided by models of disease transmission generated by Professor Killeen and colleagues, predicted that sustaining the most restrictive lockdown measures could lead to an exit from lockdown within 3 months. However, the models predicted that repeatedly imposing, lifting and re-imposing restrictions until the epidemic hopefully burns itself out through herd immunity, could see it lingering for many years. Professor Killeen worked to make his simple set of arithmetic modelling analyses easily understandable to non-specialists, as it was essential for policy-makers, health professionals, journalists and the general public that as many people as possible understand the stark consequences of these choices. Ultimately, as the temporary easing of restrictions over Christmas 2020 demonstrated, the slightest relaxation of lockdown, travel restriction or importation controls can cause an enormous rebound effect, leading to Professor Killeen's calls for governments and citizens of every country to embrace intensified containment, elimination and exclusion efforts.

## Producing PPE for frontline healthcare workers and the UCC research community

Dr Ken Bruton (MaREI, ERI, School of Engineering & Architecture) was amongst a team of over 120 Cork-based volunteers using 3D printers to produce batches of visors for PPE face shields to be distributed to healthcare workers. As part of a cooperative maker project supported by the MaREI Centre and coordinated by co-making space Benchspace, Dr Bruton along with CIT colleagues Dr Andrew Cashman and Dr Paddy McGowan, each printed batches of visors in their homes, which were then collected, assembled and distributed to frontline staff. Production was rapidly ramped up to produce over 10,000 face shields in the summer months of 2020. To support the UCC research community in continuing to work safely, Dr Eric Moore's research group (ERI, School of Chemistry) have been printing 3d-printed face shields (pictured) through the rapid prototyping lab of the ERI since the pandemic began. The shields were produced based on available lab resources and materials, designed to be used by anyone who required droplet protection. Dr Moore's team

also supplied the face shields to Cork Garda Síochána, as well as the ERI and School of Chemistry to help the researchers and staff to obtain extra protection.

In addition, ERI-based companies supplied crucial services for COVID-19 diagnostics and sequencing with Helixworks Technologies becoming involved in the Nationwide SARS-CoV-2 Genomics Project, and Glantreo manufacturing selenium nano-particles for Lateral Flow Assays that are used in COVID-19 diagnostics tests.



## UCC-Princeton research paper supports pandemic-recovery carbon pricing

The COVID-19 pandemic created the ideal conditions to introduce a carbon price, according to 2020 policy research from UCC and Princeton University. While endorsed by many economists, carbon pricing has been slower to gain traction because of its potential to shock economies and the difficulty of securing political support for increasing taxes. However, this research by Dr Kian Mintz-Woo (ERI, UCC Dept of Philosophy, and Princeton University) found that a subsequent COVID-19 economic recovery may be an opportune time to introduce carbon pricing to tackle climate change. The study found that at the consumer, producer and government level the coronavirus crisis provides a unique opportunity for mutually reinforcing forward-thinking solutions to improve sustainability and wellbeing as countries recover. The paper identified that increased costs from carbon pricing are better placed to be introduced now when energy prices are at historic lows, that energy producers are now more able to absorb changes as energy production is currently destabilised globally, while governments have an opportune time to introduce carbon pricing by illustrating that the increased additional revenue can be used to meet the needs of its electorate recovering from the COVID-19 pandemic. With markets already reorienting to adjust to supply-and-demand shocks brought on by the pandemic, introducing carbon pricing now would result in marginally less disruption and could actually help drive greener economic activity. Placing a price on carbon could prompt industries to move away from more costly fossil-fuel intensive practices and toward long-term economic and environmental sustainability.



### IN THE NEWS

ERI researchers were prominent in the media during 2020, frequently providing expert opinion and insight on the COVID-19 crisis. See Section 7 (Media) for a snapshot of this coverage.

### COVID-19 WEBINAR SERIES

During the Summer of 2020, the ERI hosted a webinar series 'What can we learn from the COVID-19 pandemic to create a more sustainable world?'. For more details please see Section 8 (Outreach).

## Section 4: ERI Research Highlights 2020



### 4.1 Climate Action

Climate change is one of the greatest threats facing humanity. The transition to a zero carbon and climate resilient society as committed to in the 2015 Paris Agreement is now underway. The ERI Climate Action challenge is focused on understanding, responding, adapting and living with climate change.

#### Ideas that can change our lives

The Deep Institutional Innovation for Sustainability and Human Development (DIIS) project led by Dr Clodagh Harris (Department of Government and Politics, ERI) and Dr Ian Hughes (MaREL, ERI) aims to lay the foundations for a critique and reimagining of the major social institutions in society such as economics, democracy, religion, technology, gender and higher education. In 2020, research from the DIIS project was referenced by President of Ireland, Michael D. Higgins in his address to the OECD's "New Approaches to Economic Challenges" conference on confronting planetary emergencies. President Higgins echoed the central theme of DIIS when he observed that many of the fundamental institutions that societies have relied upon for decades for stability and direction are currently failing, creating a historic moment of deep transformational crisis, that requires not only fundamental innovations in all the major social institutions that make up society, but also new imaginaries to guide the direction of those transformations. The DIIS project also convened a public-facing webinar 'Ideas that can change our lives' which featured keynote speaker President Mary McAleese, along with a panel

of experts drawn from politics, technology, humanities, management and government policy, to explore how the COVID-19 pandemic is fundamentally reconfiguring our societies. The webinar focused on two themes; *Re-Imagining Political Economy* featuring input from Professor William Hynes of the OECD, Dr Clodagh Harris, Professor Kieran Keohane (Department of Sociology & Criminology), Professor Ernst von Kimakowitz (Humanistic Management Network of Switzerland); and *Re-Imagining Sustainability* which saw input from Professor Ed Byrne (UCC Department of Process & Chemical Engineering, ERI), Dr Fionn Rogan (MaREL, ERI) and Dr Niall Dunphy (CPPU, UCC School of Engineering & Architecture, ERI).



#### The emerging threat of heat vulnerability in sub-Saharan Africa



Climate change does not affect all citizens equally, disproportionately affecting poorer people in low-income communities and developing countries around the world. Those in poverty have a higher chance of experiencing the ill-effects of climate change (including financial, health and societal effects) due to the increased exposure and vulnerability. Dr Christie Godsmark (School of Public Health, ERI) uses her research to explore the interconnectivity between climate change, health and vulnerability and to draw attention to the lack of global equity in bearing the collective burden of the climate crisis.

In 2020, Dr Godsmark published extensively on the emerging public health crisis of heat-related morbidity and mortality in Africa, where surface temperatures are projected to increase at a rate

faster than the global average and the propensity of urban informal settlements is rendering residents particularly vulnerable. Dr Godsmark and colleagues assessed the heat exposure, sensitivity and adaptive capacity of informal settlement residents in Dar es Salaam, Tanzania, through a combination of climate analyses, interviews with local government, residents, and health sector respondents, as well as conducting a health impacts literature review, and a stakeholder engagement workshop. The results suggest that increasing temperatures due to climate change will likely be a significant risk to human health in Dar es Salaam, and the heat-health relationship is currently an under-prioritised policy issue. Extrapolating to other African regions, the findings highlight an urgent need for more research on the vulnerability and resilience of residents to heat-health impacts, because many African cities are likely to present similar characteristics to those in Dar es Salaam that increase residents' vulnerabilities. South Africa is another example of a climate-vulnerable nation where extreme weather events are increasing and are impacting health and development in multiple ways. In 2020, Dr Godsmark also published on the impacts of extreme heat; floods and storms; drought; and wildfires on health and development in South Africa. She identified the socio-economic and occupational groups that are most vulnerable, but also described important recent policy and legislative responses that have the potential to create a more climate-resilient nation.

## UCC research guides offshore wind energy development

New ambitious targets in the Programme for Government present a turning point for Ireland’s offshore wind industry. The *EirWind Blueprint for Offshore Wind in Ireland 2020-2050*, published in 2020, outlines strategic recommendations to inform policymaking, at a vital, formative time for the sector. The Blueprint is a synthesis of work arising from the EirWind project over a two-year period from August 2018 to July 2020, involving 18 researchers and seven academic staff from the MaREI Centre, led by Dr Valerie Cummins and Dr Jimmy Murphy, and was supported by ten industry partners. The report described the market opportunities starting with national targets for 70% of renewable electricity by 2030, and analysed three scenarios for production zones in the Irish Sea, the Celtic Sea and the Atlantic. The analysis considered established bottom-fixed technology, as well as Floating Offshore Wind (FLOW) technology, which can

be deployed in deep Irish waters, and is developing rapidly. Opportunities and challenges pertaining to the growth in offshore wind are described in detail as the critical path to offshore wind development is contingent on decisions the government will make now, particularly on investing in more personnel for key government departments and agencies. The EirWind socio-economic study indicates that in 2030, 6.3GW of installed capacity could support 12,000 direct and indirect jobs. Peripheral coastal communities could be transformed by these new employment opportunities. This includes employment in a wide range of industry activities, including planning and development, installation and commissioning, operations and maintenance. This study is the first to undertake a detailed systematic analysis of domestic direct and indirect employment based on Ireland’s ability to supply products and services to the sector.



## SPOTLIGHT ON POLICY IMPACT

### ERI researchers invited to provide evidence to Oireachtas Joint Committee

In a significant example of ERI research directly informing government policy, in 2020 two ERI researchers were invited as expert witnesses to the Oireachtas Joint Committee on Climate Action during pre-legislative scrutiny of the Climate Action and Low Carbon Development Bill. The Bill proposes that Ireland moves to a climate neutral economy with net zero emissions by 2050. This ambition represents a potential game changer for carbon capture and storage (CCS) technology options for Ireland, and Dr James Glynn of the UCC Energy Policy and Modelling Group (MaREI, ERI, School of Engineering & Architecture) provided evidence in relation to the role of carbon capture and offsetting in reaching carbon neutrality. Dr Glynn also acknowledged the role of early dialogue and societal buy in to facilitate behaviour change. The Committee requested further information on these topics which was supplied in the form of a brief entitled *Citizen Engagement and Dialogue* authored by Professor Brian Ó Gallachóir, Dr Clare Watson, Dr Alexandra Revez, Evan Boyle, Connor McGookin, Aoife Deane, Professor Ed Byrne, Dr Clodagh Harris, Dr Ian Hughes, Dr Fionn Rogan, Dr Niall Dunphy and Dr Ger Mullally. This submission summarized insights from research on the societal dimensions of the energy transition, with a particular focus on citizen engagement and dialogue drawing from the Dingle 2030 and the

Deep Institutional Innovation for Sustainability and Human Development projects.

Professor Áine Ryall (School of Law, Centre for Law and the Environment, ERI) was also invited as an expert witness before the Committee. Having served previously as a member of the Expert Advisory Group to the Citizens’ Assembly (2016-2018), Professor Ryall emphasised that the legislation that emerges at the end of process be fit for purpose and enable Ireland to meet its climate obligations. Referring to the recent Supreme Court judgment in *Climate Case Ireland* (July 2020), Professor Ryall identified particular points relevant to the discussion of the Bill such as the principles of public participation and transparency in the formation and publication of climate policy, and that reasonable timeframes are put in place in the legislation to facilitate informed and effective participation in the development of climate policy. Professor Ryall also drew attention to the significant weight that the Court placed on the views expressed by the Climate Change Advisory Council, which confirms the vital role played by the Council, the importance of strengthening its independence and its oversight role and ensuring that it has the necessary range of expertise and resources to support its expanded mandate under the Bill.





## The Science of Wildfires

Wildfires harm biodiversity, damage property and forests and the associated air pollution threatens human health and contributes to global warming. Compared to other sources of air pollution from fossil fuel combustion, agriculture and industry, emissions from wildfires are poorly characterised and understood. The EPA-funded Fires, Land and Atmospheric Remote Sensing of EmissionS (FLARES) project aims to develop systematic approaches to the acquisition and collation of a range of data on agricultural and uncontrolled wildland burning events from satellite datasets. These will be validated by *in situ* observations, and measurement of relevant emission factors for Irish wildfires, with the objective of improving the accuracy and reducing uncertainty in

the quantification of annual greenhouse gas and particulate emissions. The work builds on previous EPA-funded work to characterise upland habitats from satellite imagery, thus enabling the type of vegetation burned to be identified, and biomass lost to be calculated. The reliability of existing satellite and ground datasets will be evaluated, and proposals made for future air quality monitoring drawing on the inter-disciplinary expertise of the Earth Observation and Atmospheric Chemistry teams within the consortium which consists of academics (Dr Dean Venables, Dr Stig Hellebust and Clara Felberbauer of the ERI and CRAC, and Dr Fiona Cawkwell and Emma Chalencon of the ERI and Dept of Geography) and industry partners (Randbee consultants and EO Analytics).

## UN praises exemplary Dingle Peninsula 2030 project

Ireland has witnessed a significant increase in interest in the role of citizens and communities in the energy transition to a low-carbon future. Working with and for a community encourages active citizen participation, which contributes to citizen empowerment, the development of societal capital and social cohesion. The role of communities is seen as essential in climate action and yet it is poorly understood. A 2020 EPA report from Dr Clare Watson, Evan Boyle, Professor Brian Ó Gallachóir (MaREI, ERI, School of Engineering and Architecture), and Dr Gerard Mullally (ERI, CPPU, Dept of Sociology and Criminology) explores how to shift focus away from the individuals acting to address climate change towards the role of collective action and looking at the existing social, institutional and infrastructural barriers to action. The Dingle Peninsula 2030 project, a collaboration between Dingle Creativity and Innovation Hub, ESB Networks, North

East and West Kerry Development and the MaREI Centre, aims to work with the local community, transport and farming sectors to help the Peninsula become more sustainable and meet the UN Sustainable Development Goals. The partnership's sterling efforts so far have been recognised by the United Nations, who praised the initiative in 2020, holding it up as an example which will inform similar initiatives elsewhere within Ireland and abroad. Dr Clare Watson also contributed to the book *'Ireland and the Climate Crisis'* (edited by Dave Robbins, Diarmuid Torney, and Pat Brereton) which was launched by Minister Eamon Ryan in 2020, emphasising the crucial role that the societal dimension is playing to achieve climate mitigation and adaptation. Clare's chapter, *Community Engagement and Community Energy*, reflects on the experience and capacity of the communities involved in the co-creation of the Dingle Peninsula 2030 project.



## European Green Deal and its implications for Ireland

The Green Deal is framed as a new growth strategy and roadmap for making the EU's economy sustainable and enabling it to achieve its commitment under the Paris Agreement. In 2020, the Oireachtas Library & Research Service in collaboration with Dr Paul Deane, Senior Research Fellow at the MaREI Centre and the ERI, published an overview of the European Green Deal and its implications for Ireland in 2020. In the compiling of this report, Dr Deane and colleagues examined the key elements of the European Green Deal; the parts of the Green Deal which have the strongest implications for Ireland; the current policy position on a 2050 greenhouse gas emissions target for Ireland and what the EU Climate Law means for existing policies and the EU's greenhouse gas emission reduction target for 2030. Amongst the key implications for Ireland found by the researchers were a revision of the EU's current binding target for 2030 to cut greenhouse gas emissions by at least 40% below 1990 levels. The researchers emphasised that meeting our 2050 target will have implications for several sectors such as agriculture, the built environment, energy, and transport, and advised that in some cases, these sectors will be required to fully decarbonise and deliver negative emissions. The researchers welcomed the establishment of the EU Just Transition Fund to support the green transition, which will see funding of €30

million being made available to Ireland for structured support targeted at specific carbon-intensive regions. At a national level, Dr Deane was also invited by the Irish Fiscal Advisory Council to present MaREI research findings regarding the potential impact of climate change on the economy and public finances, at the Fiscal Advisory Council's annual conference. The Council is a statutory body tasked with providing an independent assessment of official budgetary forecasts and endorsing the macroeconomic forecasts produced by the Department of Finance on which budgets and stability programmes are based.



## Supporting climate adaptation through capacity building and policy co-production

Co-production of policy and practice supports in the area of climate adaptation is being consistently driven by the Climate Ireland project, led by Dr Barry O'Dwyer (MaREI, ERI) and funded through the Department of Communication, Climate Action and Environment (DCCAE) and the EPA. With a remit to support national adaptation to the impacts of climate change, Climate Ireland is directly supporting the development and implementation of local and sectoral adaptation strategies through its online platform, as well as through the provision of policy guidance and training. To meet the requirements of Action No. 150 (*support the development of local authority climate action leadership and capacities*) of the Climate Action Plan 2019, the Climate

Ireland team has been working closely with the Climate Action Regional Offices (CAROs) to support the development of bespoke climate action training programmes for Local Authority Staff to be delivered through 2021. As part of these activities, Climate Ireland has co-ordinated the development of a three day Building Capacity Training programme to be delivered to all Local Authority Climate Action Teams and an online Raising Awareness Training Programme to be delivered through Climate Ireland's online learning platform. The training will also feature contributions from SEAI, Met Éireann, OPW, DCCAE, IPA and the Local Authority Energy Agencies. This online programme aims to reach 22,000 learners through 2021.



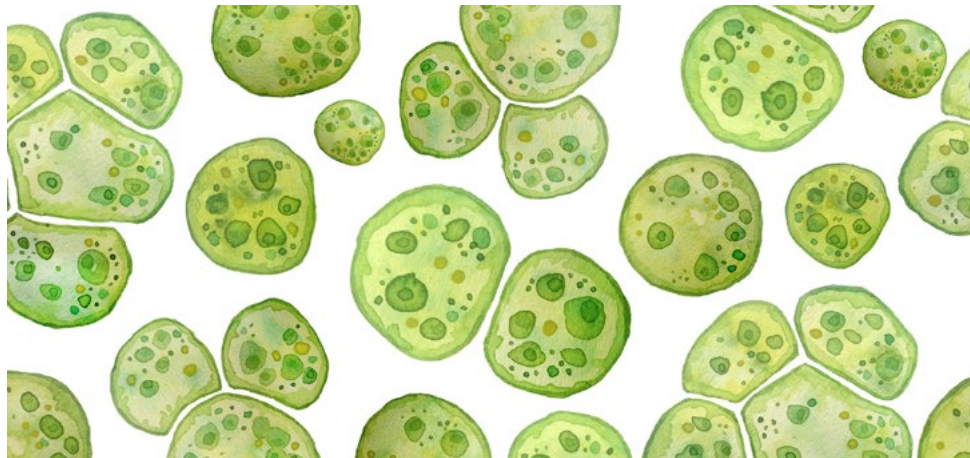
## 4.2 Circular Economy

A shift from a “take-make-consume” to a closed-loop economy where resources are kept in use for as long as possible is now an imperative for society and economy. The ERI Circular Economy challenge is focused on producing food and goods in a closed-loop approach with minimal or no waste.

### Solving Food and Climate Challenges using Microalgae

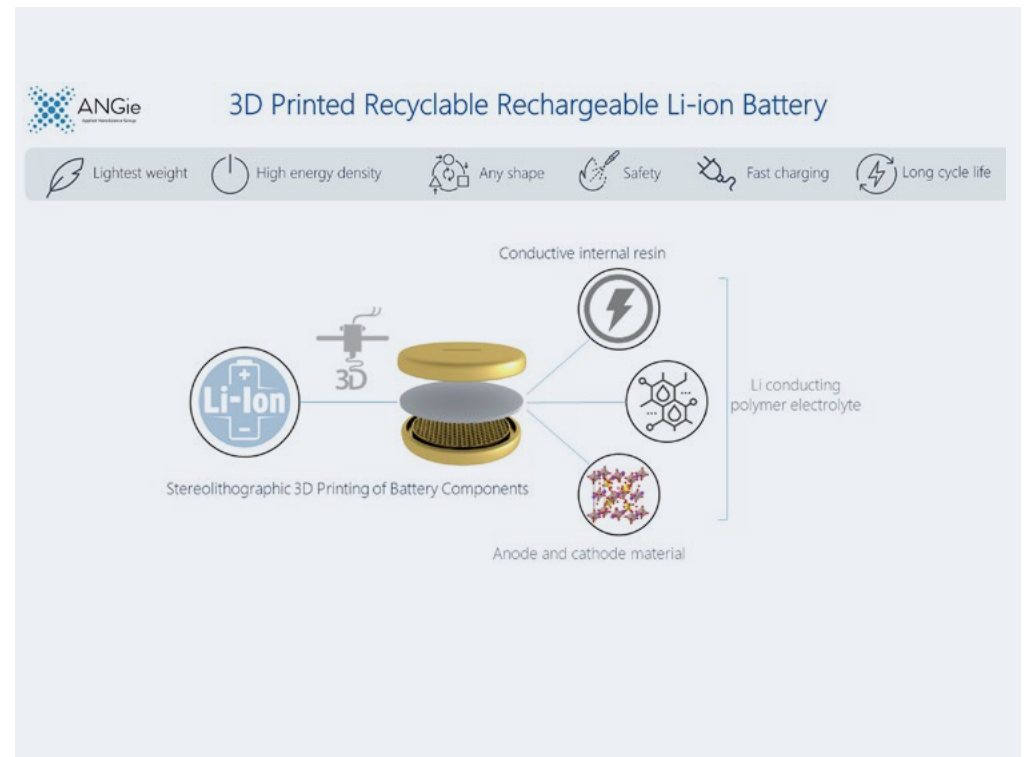
Microalgae represent a rich, but largely untapped, source of lipids in particular, essential long chain Omega-3 PUFAs. Displaying unique structural characteristics, long chain Omega-3s help maintain membrane fluidity in humans - playing a key role in correct brain and eye development in infants, ensuring healthy cardiovascular function in adults and aiding in the management of chronic inflammatory diseases in old age. Around ninety percent of global Omega-3 supply originates from wild stocks of forage fish, most notably the Peruvian anchovy. Due to historic over-fishing, warming oceans and increasing demand from an expanding global aquaculture sector, however, the UN Food & Agriculture Organisation forecasts an annual global shortfall of 2.3 million metric tons of fish oil by 2025. Dr. Linda O’Higgins (ERI) was awarded a Commercialisation Fund

from Enterprise Ireland in 2019 for a two-year project, entitled *Systems Engineering for Microalgae Omega-3s* (SyMO3), which will develop an innovative new platform for more cost-competitive cultivation of lipid-rich microalgae. The SyMO3 project has designed a novel Photodynamic Bio-film Reactor (PdBR) for attached - rather than suspended - cultivation of lipid-rich microalgae. Overcoming a key production bottle-neck of high-water volume, the SyMO3 PdBR incorporates a state-of-the-art LED lighting system, and light recipes aimed at enhancing Omega-3 synthesis in biofilm-forming microalgae are now in development. Cultivating photosynthetic microalgae species, the SyMO3 PdBR will also provide a tool for sequestration of industrial CO<sub>2</sub> emissions and support the development of Ireland’s circular bio-based economy.



### 3D printed rechargeable batteries with water-based electrolytes that are fully recyclable

Being able to print a battery and in any shape so that it matches the form factor of the device, rather than the other way round, provides us with opportunities for miniature structural batteries built into the material that makes up a product, device or wearable. Making these batteries fully sustainable and recyclable is a major challenge. The research group led by Professor Colm O’Dwyer (School of Chemistry and the ERI), are developing a range of 3D printed rechargeable Li-ion batteries that water-based electrolytes and more sustainable iron phosphate and manganese oxide electrode materials. These printable batteries can be fully recycled by combustion, back to their starting materials in a single step.





### Dairy waste not a problem but an opportunity

Currently, there are an estimated 1.4 million dairy cows in Ireland, and these cows excrete up to 40-60kg of waste per cow per day. The waste includes a mixture of organic solids, nitrogen, potassium and phosphate. Storage and further management of this waste involves substantial costs for farmers, as well as representing a significant source of pollution for aquatic ecosystems.

In January 2020, the EPA-funded Newtrients project, held a workshop on resource recovery from dairy processing wastewater which has a high concentration of carbohydrates, protein, fat, nitrogen and phosphorus. National and international experts from industry and academia presented the latest insights in the use of dairy processing wastewater as source of bioenergy, and as a feedstock for the production of valuable biopolymers. Newtrients PI Dr Niall O’Leary (School of Microbiology, ERI) drew on extensive research expertise in biopolymer production to propose a reframing of dairy processing waste as a particularly promising

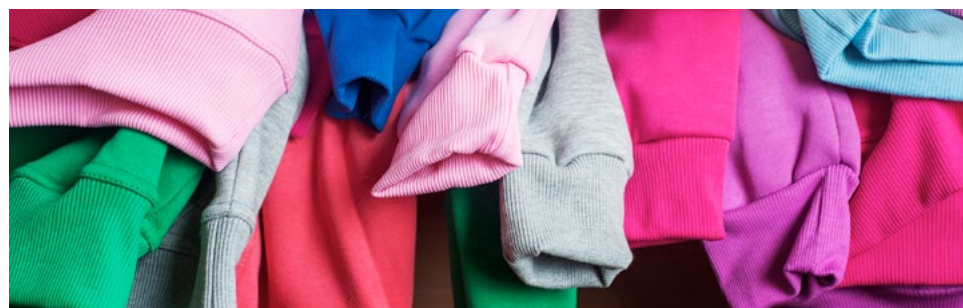
feedstock for the sustainable production of biodegradable plastics. Newtrients PI Professor Marcel Jansen (School of BEES, ERI), an expert on the use of aquatic duckweed plants to recover nitrogen and phosphorus from effluent, emphasised the exciting possibility of producing a high protein plant-based feed from waste water, having a direct impact on the sustainability of the dairy sector and decreasing the reliance on imported feed.

Further addressing this challenge, a new project called BRAINWAVES also led by Professor Jansen and funded by the European Regional Development Fund through the Ireland Wales Cooperation Programme, will develop innovative, economically viable technologies to grow common duckweed on farm waste and integrate these with local conditions for Irish and Welsh farmers. The project will develop indoor and outdoor duckweed cultivation systems to maximise duckweed growth and demonstrate phytoremediation capacity.

### Recycling of sportswear offers solution to textile waste

The clothing industry accounts for about 10% of global carbon emissions, and nearly 20% of wastewater production. In addition, global clothing manufacturing processes use more energy than both aviation and maritime shipping combined. In March 2020, the European Commission adopted a new circular economy action plan, which includes an EU strategy for textiles, in an effort to stimulate innovation and boost reuse within the sector. In UCC, Dr Karzan Zangana, a Senior Postdoc in the Materials Chemistry & Analysis Group (led by Professor Justin Holmes of the School of Chemistry and the ERI) has developed an energy efficient and environmentally friendly process for chemically

recycling waste plastic. In collaboration with Dr Antonio Fernandez-Mato’s group at Loughborough University in the UK, Dr Zangana has successfully recycled polyester off-cuts from GAA sports shirts supplied by O’Neills, the Irish International Sports Company. These off-cuts have been converted back into chemicals that can be used to either regenerate virgin polyethylene terephthalate (PET) or upcycled into biodegradable plastics, such as polybutylene adipate terephthalate (PBAT) which is used for compostable plastic bags for gardening and agriculture. This research has been funded by Science Foundation Ireland’s Advanced Materials and BioEngineering Research (AMBER) Centre.



## The Emerging Role of Online Food Retail Systems for Sustainability

Lockdown restrictions in 2020 prompted people to explore the options for online grocery shopping, which appears to present environmental advantages in terms of reduced emissions from individual trips to the shops and less usage of plastic bags as deliveries arrive in reusable crates. The PLATEFORMS project (CUBS, ERI) aims to produce in-depth and practical-oriented knowledge on how sustainable household food consumption can be enabled through socio-technical innovations in food provisioning platforms. In October 2020, the PLATEFORMS team, led by Professor Mary McCarthy and Dr Claire O'Neill hosted a webinar exploring the emerging role of online food retail systems for sustainability in the Irish market, with contributions from online retailers Neighbourfood and Musgrave Group who shared their experience with

providing an online service to consumers, as well as research findings on consumer perspectives from the PLATEFORMS research team. The audience heard from Dr Shadi Hashem, of the PLATEFORMS research team, about the results of an audit of the digital food provisioning landscape in Ireland before and after March 2020 which showed a 41% increase in online food provisioning systems in March - coinciding with the first lockdown. Input from Dr Claire O'Neill highlighted the key themes which are emerging from the PLATEFORMS consumer interviews such as appreciation of increased accessibility to seasonal and local produce, increased food planning and meal preparation, and increased frustration with food waste from an environmental and economic perspective.



## The impact of biofuels research on the decarbonisation of industry

All major Irish food and drinks companies will in future have to commit to reducing carbon emissions if they are to be part of Origin Green – Bord Bia's national sustainability programme. Almost 300 food and drink companies across Ireland are verified members of Origin Green, representing more than 90% of food and drink exports. In one of the most significant decarbonisation measures undertaken in the sector, new procedures and guidelines published in 2020 put carbon emission targets on a mandatory footing for food and drink manufacturers. The move seeks to enable the sector to accelerate its contribution to the programme for Government's aim of carbon neutrality by 2050.

The decarbonisation of large facilities in the food and beverage sector can be challenging, and researchers in the Circular Economy and Environmental Systems (CEES) group led by MaREI Co-Director Professor Jerry Murphy (ERI, MaREI, School of Engineering & Architecture) have been working closely with industry partners to support them in making this transition. A key project being led by Dr

Richard O'Shea has assessed the potential for biogas to reduce Scope 1 greenhouse gas (GHG) emissions (those associated with fuel combustion) at a large distillery, as well as calculating the potential GHG savings from substituting synthetic fertiliser with digestate in the cultivation of barley. It is anticipated that this could also reduce the Scope 3 (delivery and supply chain) emissions of the distillery. Dr O'Shea evaluated the potential drawbacks associated with anaerobic digestion such as truck movements, digester size, and the potential reduction in animal feed production. Scenario analysis on using distillery by-products to produce biogas was also carried out. The analysis took into account the impact on emissions from fuel use at the distillery, from the supply chain and from imported animal feed, as well as the reduced protein production from animal feeds made by the distillery, and the electricity savings. Further work is ongoing with the distillery to determine the optimal strategy for using the digestate, remaining after the anaerobic digestion process, as a fertiliser on agricultural land.





## 4.3 Healthy Environment

Our economic prosperity and well-being is underpinned by the quality of our environment and natural capital. The ERI Healthy Environment challenge is focused on protecting our natural ecosystems and providing a healthy environment for humans to live in.

### Ireland's First AXA Research Chair



In May 2020, applied pathogen ecologist Professor Ger Killeen became the first ever AXA Research Chair in Ire-

land, when he received a €1m AXA research funding award. The award will bring the fight against malaria one step closer to eradication while at the same time fostering improved management of wildlife areas in Africa.

Malaria, transmitted through the bites of mosquitoes, still infects hundreds of millions of people each year. Currently, the most effective way to prevent the spread of the disease is with insecticide-treated nets (ITNs) placed over all beds and other sleeping spaces to protect the human users and also kill mosquitoes attempting to attack them. While increasingly widespread use of ITNs has achieved great reductions of malaria burden since the turn of the century, a recent report by the World Health Organization (WHO) found the fight against this mosquito-borne disease stalled from 2014 onwards. Based in the School of BEES and the ERI, Professor Killeen is leading a research program to characterise the opportunities and obstacles that arise notably from biodiversity conservation efforts in Africa. Through pioneering

research, he aims to prove that malaria elimination will require interventions that target all the different blood-feeding behaviours mosquitoes can exhibit, including feeding upon wild animals. An opportunity may exist to preserve and restore insecticide susceptibility in vector populations if mosquitos can be found to persist in conservation areas where pesticides are absent. Professor Killeen is particularly interested in Wildlife Management Areas (WMAs) in Tanzania, where he has been based at the Ifakara Health Institute (IHI) for the last 17 years. Professor Killeen and UCC have committed to sharing two-thirds of the funding with organisations in Tanzania, and to supplementing postgraduate degree scholarships for local scientists. In making this commitment, UCC is investing in strengthening resilience of the country at institutional level.



### UCC contributes to major global report on plant biodiversity

Plants and fungi have the potential to solve urgent problems that threaten human life, but these vital resources are being compromised by biodiversity loss. In 2020, BEES/ERI plant scientist Dr Eoin Lettice, contributed to a new report that takes a deep dive into the state of the world's plant and fungal kingdoms globally. The new data, the result of a huge and unprecedented international collaboration bringing together 210 scientists from 42 countries, show how we are currently using plants and fungi, what useful properties we are missing, and what we risk losing. Dr Eoin Lettice is one of the co-authors of *State of the World's Plants and Fungi*, published by the Royal Botanic Gardens, Kew which comes at a critical time for global biodiversity. It sheds

light on the extinction risk of plants and fungi globally, with two in five plants now at risk of being wiped out. The report highlights the pressing need to explore the solutions that plants and fungi could provide to address some of the pressures facing people and the planet. These pressures include the triple threats of climate change, biodiversity loss, and food security. The challenges in sustainably using plants and fungi to supply food to an increasing human population is also highlighted in the report, as just 15 plants provide 90% of humanity's food energy intake, but the report shows that there are at least 7,039 edible plant species known to science. These novel crops could hold the key to feeding a growing global population.

## UCC Ornithology Group guiding the conservation of Irish bird species



“The study showed that many tourists, especially those looking for that perfect photograph of birds on their nests, got too close to the gannets - often to within less than one metre. This led to a 60% reduction in breeding success compared with birds at undisturbed parts of the colony.”



An assessment of bird populations on the island of Ireland (*Birds of Conservation Concern in Ireland Review*) recently revealed that 63% of Ireland’s 211 regularly occurring wild bird species are now of serious conservation concern. Birds are key indicators of environmental health and changes to their distributions and populations reflect changes in habitats, food chains and wider biodiversity. Research ongoing in the UCC Ornithology Group led by Professor John Quinn (School of BEES, ERI) is contributing to real world impacts for some of Ireland’s most threatened bird species.

### Gannets

A study by Debs Allbrook, an MSc student in the group, examined the level of disturbance caused by tourists to the nests of gannets on the Great Saltee Island in County Wexford - one of the most important seabird colonies in Ireland.

As part of her research, Ms Allbrook then conducted a simple experiment to see if tourists would pay attention to an information sign warning them that their actions could be damaging, and remarkably, the vast majority of people observed the warning. People stayed away from the birds and fewer disturbance events were observed. For such a basic management tool, studies that show the effectiveness of signage like this are surprisingly rare worldwide, and have never been conducted in Ireland previously. Additional studies performed by the group on the impact of rats preying on seabird chicks on the Island has led to the National Parks and Wildlife Service (NPWS) initiating an eradication campaign which may also be expanding nationally to other vulnerable nesting sites.

### Hen-Harriers and Short-eared Owls

Within the UCC Ornithology group, a 2020 study led by Dr Darío Fernández-Bellón tapped into expert knowledge from across Europe to identify the threats and the most effective conservation strategies for two emblematic Irish birds of prey: Hen Harriers and Short-eared Owls. The research published in *Bird Conservation International*, highlighted worrying declines in both species’ numbers in the face of similar threats, and stressed that designation of protected areas is not sufficient in reversing the declines but needs to be combined with proactive habitat and species management to be truly effective.



### The Woodcock

The Irish Woodcock breeding population has undergone a severe decline in its range over the last 40 years, resulting in it being added to the Red List of breeding birds in Ireland. The reasons for the decline are unknown but are likely to include changes in habitat linked to more intensive farming, climate change and predation pressure. The Irish Woodcock Project led by the UCC Ornithology Group aims to undertake the first Irish breeding Woodcock Survey to provide a baseline against which to assess future population change. A joint collaboration between UCC, the National Association for Regional Game Councils in Ireland, and the Game & Wildlife Conservation Trust from the UK, the project has received much media attention over the past 12 months, with PhD student James O’Neill even featuring on BBC2’s Winterwatch programme.

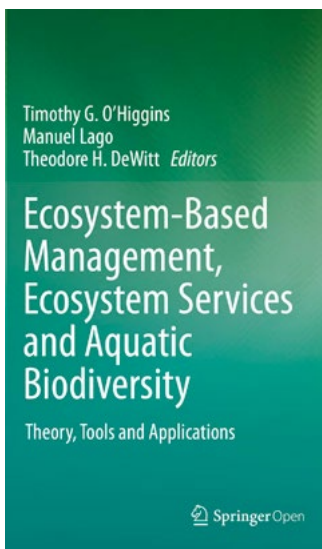
## The surprising impact of river litter on freshwater biodiversity

We are unfortunately accustomed to the sight of pieces of litter of various shapes, sizes and materials lying in our rivers and streams. While anthropogenic litter has been shown to reduce organism fitness and cause mortality in marine ecosystems through entanglement and ingestion, the effects of anthropogenic litter on urban river ecosystems has yet to be fully explored. A 2020 study published by Dr Markus Eichhorn (School of BEES, ERI) and PhD student Hazel Wilson was the first study to examine the role of human litter in rivers as a provider of a novel habitat for invertebrates.



“The authors demonstrated that litter increased habitat heterogeneity and therefore biodiversity in rivers. This implies that projects to remove litter from urban rivers should consider the broader effects on species in streams and find other ways to create habitat structures for those organisms which would otherwise be lost.”

## Ecosystem-based management as a strategy for preservation of biodiversity



Aquatic ecosystems are rich in biodiversity and home to a diverse array of species and habitats, providing a wide variety of benefits to human beings. Many of these valuable ecosystems are at risk of being irreversibly damaged by human activities and pressures, including pollution, contamination, invasive species, overfishing and climate change. Such pressures threaten the sustainability of these ecosystems, their provision of ecosystem services and ultimately human well-being. Ecosystem-based management (EBM) is now widely considered the most promising paradigm for balancing sustainable development and biodiversity protection, and various international strategies and conventions have championed the EBM cause and the inclusion of ecosystem services in decision-making. Yet, what

it entails and how it can be implemented presents many challenges. A 2020 open access book, *Ecosystem-Based Management, Ecosystem Services and Aquatic Biodiversity* edited by Dr Tim O'Higgins (ERI, MaREI) and colleagues Manuel Lago and Theodore H. DeWitt introduces the essential concepts and principles required to implement ecosystem-based management, detailing tools and techniques, and describing the application of these to a broad range of aquatic ecosystems. The book also features a chapter authored by Dr Anne-Marie O'Hagan (ERI, MaREI, School of Law) on the topic of *Ecosystem-Based Management and Ecosystem Services in EU Law, Policy and Governance*. The book has been welcomed by the USA Environmental Protection Agency as a unique policy resource.

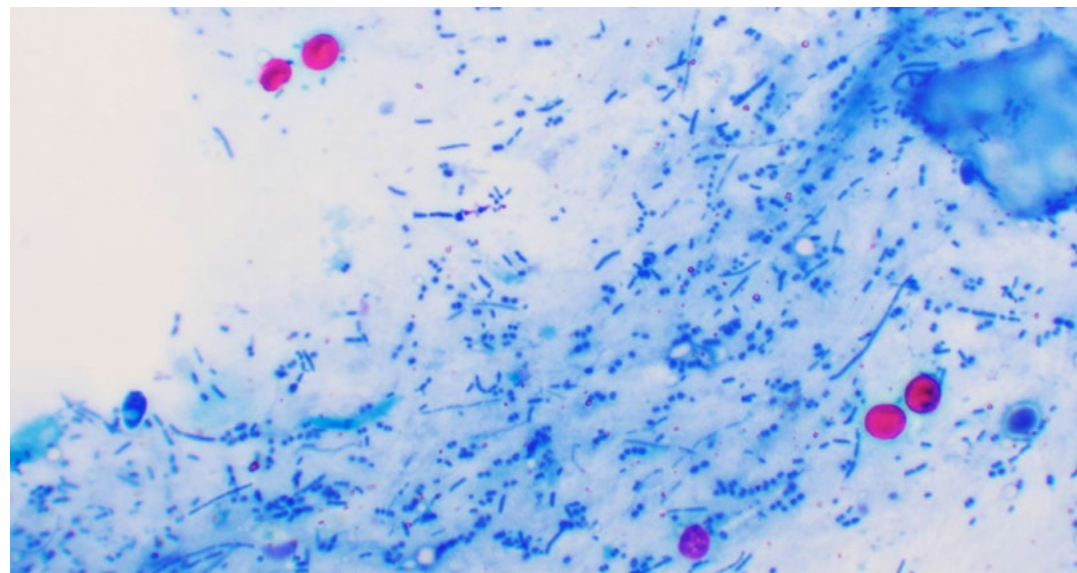
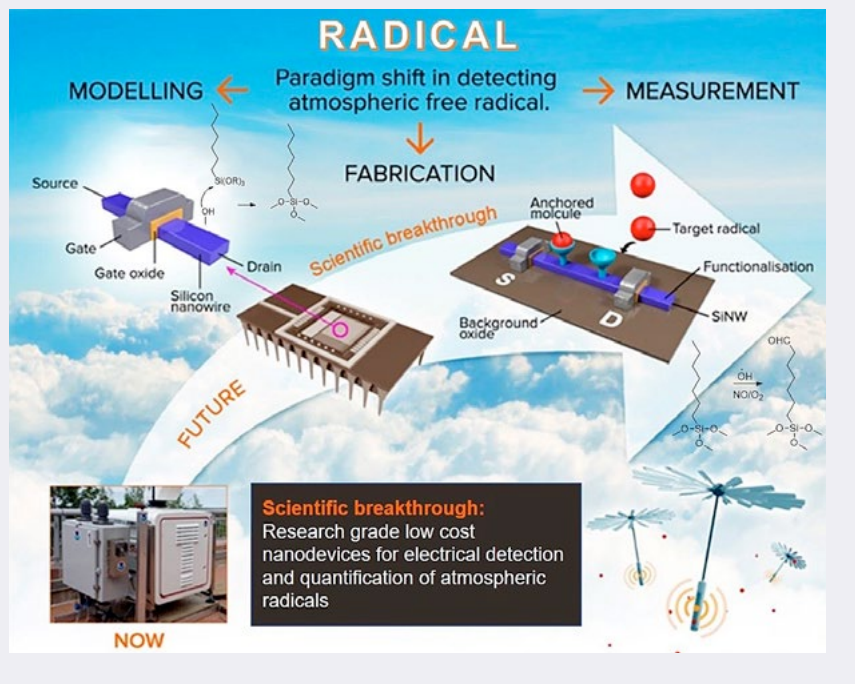
## Particle radioactivity and human health

Air pollution is a well-established risk factor for cardiovascular morbidity and mortality. Numerous epidemiological, biomedical and clinical studies indicate that ambient particulate matter (PM) air pollution is strongly associated with increased cardiovascular diseases including myocardial infarction, cardiac arrhythmias, ischemic stroke, vascular dysfunction, hypertension and atherosclerosis. However, the mechanisms by which exposure to PM might increase risk of cardiovascular morbidity and mortality are not fully known. Few studies have investigated the potential role of particle radioactivity which refers to the radiometric components of PM air pollution, in exacerbating these health cardiac health outcomes. It is hypothesized that these naturally occurring radionuclides may attach to PM air pollution and continue to release ionizing radiation after inhalation and deposition in the lungs. A 2020 collaborative study from Dr Marguerite Nyhan and colleagues in the ERI, MaREI, Harvard School of Public Health and Harvard Medical School found that regional particle radioactivity is positively associated with inflammatory biomarkers in an elderly cohort, indicating a potential pathway for radiation-induced cardiovascular effects.



## ERI Professor becomes the first academic in Ireland to coordinate two FET-Open proposals

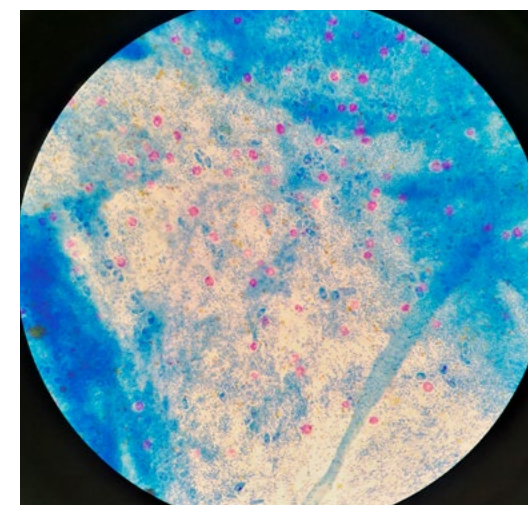
A UCC-led research project, RADICAL, has received €3.2m in European funding to develop a more cost effective way to measure air pollution. It is hoped that the research team, drawn from industry and academia and led by Professor Justin Holmes, Professor John Wenger and Dr Stig Hellebust (all of the School of Chemistry, ERI) will bring about the creation of low cost electrical sensors for detecting harmful particles in the atmosphere, and that these devices can be subsequently deployed on airplanes, ships and other platforms to monitor air quality. The team has plans to design and build high-tech low-cost instruments that will measure the presence of harmful atmospheric radicals in the air. Professor Holmes was also the recipient of a second FET-funding award this year, for the €3.5m TRANS-LATE project, which will develop an advanced heat-to-electrical energy harvesting technology. In partnership with Dr Kafil M. Razeeb, who leads the Advanced Energy Materials Group at Tyndall National Institute, Professor Holmes will develop a complete prototype device that can efficiently convert any wasted heat below 100 °C into usable electricity. There are now just four proposals co-ordinated by Irish researchers that have been funded under the EU H2020 FET-Open programme and Professor Holmes is co-ordinating two of these.



## Study finds *Cryptosporidium* present in ‘safe’ drinking water

Globally, groundwater accounts for approximately 95% of available freshwater and represents a key source of domestic drinking water, with approximately 31.5% of the world's population relying on groundwater for daily consumption. In 2020, Dr Jean O'Dwyer and Dr John Weatherill launched the UCC Water and Environment Research Group (hosted by ERI and the School of BEES) which has received €1.5 million in funding to date with projects ranging from disinfection by-product formation in drinking water to assessing pathogens in groundwater. In contrast to surface water, which is susceptible to the influence of both point and diffuse contamination, groundwater is generally considered to be of higher quality, owing to the contaminant attenuation capacity provided by overlying soil cover. However, both field studies and outbreak investigations indicate groundwater systems can be significant sources of enteric pathogens including *Cryptosporidium* species. Research published by Dr Jean O'Dwyer and Luisa Andrade (BEES, ERI, iCRAG) in 2020 provides the first global baseline detection rates for *Cryptosporidium* in domestic groundwater supplies, and finds that

*Cryptosporidium* frequently occurs in groundwater sources and is a latent health concern. The study identifies a critical lack of understanding of *Cryptosporidium* transport into groundwater sources and calls for integration of groundwater and public health research for improved prevalence insights.





### Concerning discoveries about microplastics in our environment

Until now, breakdown of microplastics (plastic pieces smaller than 5 mm) had been thought to occur mainly through very slow processes in the marine environment such as sunlight or wave action, which can take years or decades. However, in 2020, the EPA-funded Impacts of MicroPlastics (IMP) project discovered that a very common invertebrate animal found in Irish freshwater streams is able to rapidly breakdown these microplastics in just hours. Study leader Dr Alicia Mateos-Cárdenas, supervised by Professor Marcel Jansen (both of BEES, ERI), Dr Frank van Pelt (Department of Pharmacology and Therapeutics, ERI) and Professor John O’Halloran (BEES, ERI), found that microplastics in our freshwaters are being broken down into even smaller nanoplastics (smaller than 1 µm, at least five thousand times smaller in size) by a type of small freshwater crustacean called *Gammarus duebeni* as part of their digestive process. These findings could have implications for how microplastics make their way into the food chain worldwide as, though this spe-

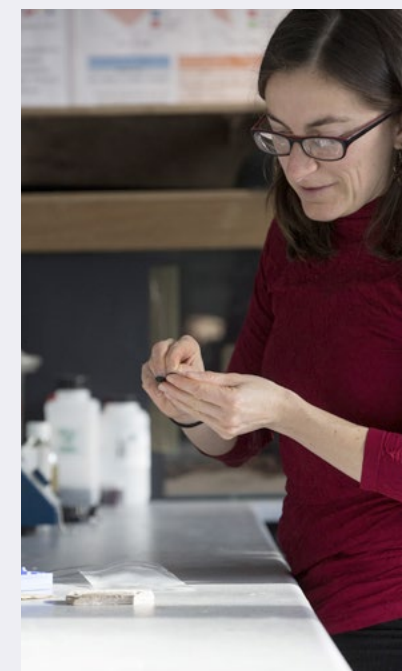
cies lives in Irish streams, they belong to a bigger animal group of invertebrates commonly found around the world in freshwaters and oceans.

Separately, research published by Professor Andy Wheeler’s Marine Geology Group (ERI, BEES, iCRAG) which aimed to quantitatively characterise several cold water coral habitats in the upper Porcupine Bank Canyon in the North East Atlantic, made the troubling discovery of microplastics at a depth of 2,125m. The canyon, some 320 km due west of Dingle, was investigated on a research expedition led by Dr Aaron Lim on board the Marine Institute’s RV Celtic Explorer, and while it was shocking to discover plastic at this depth, the study also individually mapped coral mounds and monitored the currents to which they are exposed. This is important because globally, our oceans are showing signs of acceleration due to climate change and understanding how our cold water corals will respond will allow for effective management of Ireland’s marine resources.

### School of BEES academic amongst Irish recipients of prestigious ERC Award

School of BEES, ERI and iCRAG researcher Professor Maria McNamara was the recipient of over €2m in the 2020 European Research Council (ERC) Consolidator Grants allocation. One of just eight Irish awardees, and amongst an even smaller cohort to have received two ERC awards during her career, Professor McNamara’s funded research project *‘Palaeochem: Biomolecular innovation and the evolution of animals: insights from taphonomy and the fossil record’* aims to understand how key biomolecules such as melanin, keratin and collagen evolved in animals, and to understand how well these important biomolecules can be preserved in fossils. This research will build on the pioneering discoveries regarding fossil melanosomes made by Professor McNamara’s group over the last number of years. Most studies of fossil melanin had previously focussed on melanin in fossil feathers and skin (which is where birds and mammals store melanin), but Professor McNamara’s research shows that amphibians and reptiles also concentrate melanin in their internal organs, where it supports the immune system and stores metals but is also potentially a toxic source of free radicals. During the evolution of hair and feathers, mammals and birds evolved more sophisticated immune systems than amphibians and reptiles. This meant that large amounts of melanin were no longer necessary in in-

ternal organs. Melanin storage then shifted to hair and feathers, which are dead tissues, thereby removing harmful metals and free radicals from living body parts and setting the scene for the evolution of the incredible diversity of plumage and fur patterning which we see today. Professor McNamara’s latest project will establish UCC as a global centre for cutting-edge research on fossils and evolution, and allow her team to use the research results as the basis for exciting STEM-based community engagement activities with the public.



## Section 5: Research Centres' Reports

### 5.1: MaREI, the SFI Research Centre for Energy, Climate and the Marine

MaREI is coordinated by the ERI and is Ireland's SFI Centre for energy, climate and marine research, development and innovation working across 12 Irish academic institutions and collaborating with over 50 industry partners. The Centre is led by Co-Directors Professor Brian Ó Gallachóir and Professor Jerry Murphy.

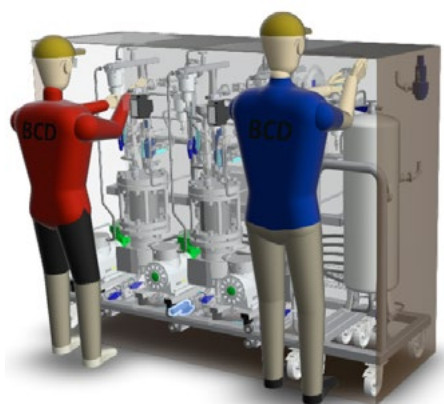


#### Circular Economy and Environmental Systems



##### Strategic Laboratory Upgrade and Capacity Building

Over the course of 2020, Dr Richard O'Shea, Davis Rusmanis and Professor Jerry Murphy of the Circular Economy and Environmental Systems (CEES) research group designed and coordinated major upgrade works to the LG30 laboratory in the Environmental Research Institute Lee Road Building. The laboratory upgrade consisted of the installation of; a new ATEX rated fume hood, flammable gas detectors, intrinsically safe gas supply systems, refurbishment of existing ventilation equipment, and the addition of additional power sockets. In parallel, the researchers also oversaw the design, fabrication, and installation of a bespoke experimental apparatus for use in batch and continuous biological hydrogen methanation experiments. Initial experimental work to commission this apparatus is currently ongoing. The laboratory upgrade builds upon prior expertise in the field of bio-methanation and power to gas systems and in particular builds upon laboratory work based in a previously published paper from the group<sup>1</sup>. The new facilities and experimental apparatus have increased the capability of the research group to pursue research centred on the conversion of renewable electrical energy into gaseous renewable fuels by combining hydrogen and carbon dioxide in a biological system. Bio-methanation systems can replace traditional biomethane upgrading systems used by anaerobic digesters and facilitate an increase in the production of renewable gaseous fuels. This technology can also aid in the interconnection of the gas, electricity, and water networks and can allow for the decarbonisation of sectors such as heavy goods transportation and heavy industry which are difficult to address via electrification alone. The researchers would like to commend the efforts of all those involved in the delivery of this strategically important upgrade including Gillian Bruton, Manager of the SFI MaREI Centre, and Aidan O'Dwyer in Building and Estates.



<sup>1</sup>Voelklein, M., Rusmanis, D, Murphy, J.D. (2019) *Biological methanation: Strategies for in-situ and ex-situ upgrading in anaerobic digestion* Applied Energy 235, 1061-1071, with a Field Weighted Citation index of 4.48, and more than 30 citations.

##### MaREI Biofuels Symposium

The CEES group also hosted the web-based *MaREI Biofuels Symposium* on 29th April 2020. Researchers based in UCC and NUI Galway presented on Circular bioenergy and biorefinery system; Hydrogen economy; Biogas production; and Biogas upgrading and digestate valorisation. This symposium attracted more than 120 attendees overall.

##### Decarbonisation of industry

Projects relating to the decarbonisation of industry using biogas have been progressed by CEES over the last year. As outlined in Section 4.2 (Circular Economy), collaborative work with a large Irish distillery has assessed the potential to reduce Scope 1 GHG emissions using biogas derived from anaerobic digestion of distillery by-products. A second industry decarbonisation project was also initiated which assessed the biomethane potential of distillery by-products from eight different distilleries in seven different countries across the globe. Samples from each distillery were received along with high level process data for each distillery. The biomethane potential of by-products was quantified using laboratory trials. The potential Scope 1 GHG emission reductions possible when using the biogas to replace fossil fuels consumed by each distillery has been calculated, as well as an initial estimate of the required anaerobic digestion plant size. Monthly progress review meetings were held with the industrial partner's group technical manager and a total of eight reports have been developed detailing the potential GHG mitigation associated with biogas derived from by-products at each distillery. Dr O'Shea and Professor Murphy also presented overviews of the research to the group director of sustainable performance and the global sustainability manager of the industrial partner.

## Promoting wellbeing in 2020

There was a number of wellbeing activities rolled out by MaREI since March 2020 to combat the sense of isolation accompanying COVID-19 lockdown conditions. These included a weekly PhD Newsletter, weekly coffee mornings, the Christmas Party & Quiz, Marchaton and wellbeing training on Mindfulness and avoiding burnout. MaREI have also supported a range of upskilling training during this period on topics such as Mobile Video Production, Project Management, Job Search Strategies, using LinkedIn and '10 things to do during your PhD to be job ready'.



## Entrepreneurship and innovation

The vision of Entrepreneurship @ MaREI is to facilitate and support the entrepreneurship and innovation activities of everyone associated with MaREI and our areas of interest. This includes industry partners, research community, students and start-ups. *Entrepreneurship Opportunities for PhD's and Post Docs* was the first event of 2020 and focused on the local, national and International supports available to third level post graduate students and researchers. The event was attended by over 100 people and addressed by colleagues from UCC Research HR, UCC Innovation, Enterprise Ireland and MaREI. As lockdown progressed, MaREI's Entrepreneurship activities moved online with an April webinar in collaboration with the then Chair of AUTM Marc Sedam, to celebrate World Intellectual Property Day 2020; and in June the "Commercialise your research, your way" webinar in partnership with Enterprise Ireland. Over 500 registered from third level institutions all over Ireland and beyond.

## EU projects update

The SELKIE (Development of a streamlined commercialisation pathway for the Marine Renewable Energy Industry) project is coordinated by MaREI and funded under the Ireland-Wales INTERREG Programme (2014-2020). Through the SELKIE project, MaREI and partners are providing technical expertise and developing a suite of bespoke multi-use technology tools, templates, standards, and models to assist in the commercial development activities of over 150 SMEs across the wave and tidal sectors. The JONAS (Joint framework for Ocean Noise in the Atlantic Seas) project is coordinated by MaREI and brings together partners from across the European Atlantic to address threats to biodiversity from underwater noise pollution on sensitive species. JONAS will develop and pilot a noise-monitoring platform, harmonize technical approaches to Marine

Strategy Framework Directive and Maritime Spatial Planning requirements, and promote the adoption of quieter operational practices among users of the North-East Atlantic marine space. JONAS is funded through the Atlantic Area INTERREG Programme (2014-2020). SATURN (Solutions @ Underwater Radiated Noise) is a €9M H2020 project coordinated by MaREI; the project brings together leading experts in all related fields (e.g. bioacoustics; marine ecology; maritime architecture and engineering; maritime policy) to develop standards and methodologies to address the complex global issue of underwater radiated noise. SATURN adopts a transdisciplinary approach and will collaborate with researchers, practitioners, competent authorities, maritime operators, shipping/offshore/naval industries, and NGOs.



## Outreach & EPE

The MaREI Centre demonstrated an adept management of the challenges of engaging online, delivering their educational programme, including Climate Hacks and providing support to institutional programmes by making MaREI educational resources available online via ScoilNet and RTÉ Home School Hub. In addition, the MaREI researchers participated in Clean Coasts, FameLab, and the Climate Ambassadors programme, as well as having a significant role in the organisation of online festivals such as Science Week, Cork Science Festival, Cork Discovers, and Engineers Week 2020. For more information on these activities, see our Outreach Section 8.

## Lir NOTF

Lir National Ocean Test Facility (NOTF) is a custom designed test facility for laboratory testing of offshore wind, wave and tidal energy devices. In 2020, despite the pandemic conditions, the team tested 16 devices and had 89% occupancy across four tanks and the electrical laboratory. The opportunity was also taken for performing upgrades and maintenance, including the installation of viewing cameras which will allow close observation of device performance.



## Translating research analysis into policy insights

### Policy guidance

A key priority of the SFI MaREI Centre for Energy, Climate and the Marine (MaREI) is to inform policy and practice through knowledge exchange for societal impact. In 2020 MaREI facilitated informed decision-making by providing research, analysis, results, data, insights and tools to civil servants, politicians, public bodies, state agencies, advocacy groups, civil society organisations and citizens. Centre researchers drafted Ireland's planning guidelines for climate adaptation and their climate mitigation analysis informed the increased Government ambition that is being embedded in new climate legislation. MaREI's climate mitigation analysis informed the increased Government ambition that is being embedded in new climate legislation. A 2019 Climate Policy paper from Dr James Glynn *et al.*, was a particularly significant source of guidance for the Irish Government's policy formation to meet the new EU emission targets. Internationally, collaborative research with the International Renewable Energy Agency underpinned the EU decision to increase its 2030

renewable energy target by 14%. MaREI was represented at a range of policy stakeholder events throughout the year, including the Marine Renewables Industry Association annual meeting, with local authorities through Climate Ireland, with government departments through projects like CREDENCE, CHIMERA and the secondment of Dr Ian Hughes (who holds a joint position as Senior Policy Advisor in science, technology and innovation (STI) policy for the Department of Jobs, Enterprise and Innovation and as a Senior Research Fellow with MaREI), as well as with Oireachtas committees (See Section 4.1 Climate Action), and with industry/agency partners events with ESNB, GNI, and SEAI. MaREI hosted climate research and energy policy stakeholder workshops including ESRI-UCC-MaREI energy research and climate action conference with over 300 registrations, and Marine Law expert, Dr Anne-Marie O'Hagan (MaREI, ERI, School of Law) also chaired the Law and Governance sub-group of the Expert Advisory Group on Expanding Ireland's Marine Protected Area Network.

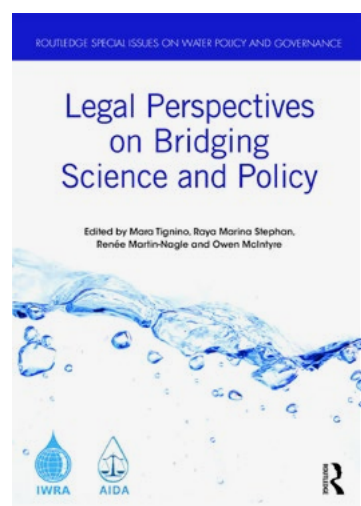
### Policy co-production

An example of how the MaREI co-production approach to policy formation is being successfully implemented is in the area of climate mitigation modelling, specifically the CAPACITY (Climate Action Pathways & Absorptive Capacity) project. The 2015 Paris Agreement contains a commitment to "Holding the increase in the global average temperature to well below 2°C above pre-industrial levels and pursuing efforts to limit the temperature increase to 1.5°C above pre-industrial levels". Despite a high-level commitment from Ireland, a clear and detailed pathway that would align Ireland with the Paris Agreement goals has yet to be developed and agreed. The CAPACITY project will further develop and update tools that the MaREI Energy Policy and Modelling Group have developed to facilitate insights and robust decision making about the appropriate long-term decarbonisation pathway for Ireland.



## 5.2: Centre for Law and the Environment

The Centre for Law and the Environment is a centre of excellence for research, teaching and advocacy work relating to law and the environment. Based in the School of Law, and affiliated to the Environmental Research Institute, the Centre supports and promotes a wide range of research activity in Environmental, Marine, Climate, Energy and Natural Resources Law. Although the Centre is rooted firmly in the discipline of Law, it is engaged in significant interdisciplinary research collaborations and extensive outreach and advocacy activity. The Centre is led by its Co-Directors Professor Owen McIntyre and Professor Áine Ryall.



### High-impact, frontier research activity

Applied research, with a ‘real world’ focus is the hallmark of the Centre’s work to date. During 2020, key publications included two significant collections edited by Professor Owen McIntyre: O. McIntyre, and S. Nanwani (eds.), *The Practice of Independent Accountability Mechanisms (IAMs): Towards Good Governance in Development Financing*, (Brill, Leiden, 2020) and M. Tignino, R.M. Stephan, R. Martin-Nagle and O. McIntyre (eds.) *Legal Perspectives on Bridging Science and Policy*, (Routledge, London, 2020). Centre PIs continued to publish their work in important edited collections and in a wide range of national and international peer reviewed journals including: *Review of European, Comparative and International Environmental Law (RECIEL)*; *Environmental Liability: Law, Policy and Practice*; *International Environmental Agreements: Politics, Law and Economics*; *Irish Supreme Court Review* and *Irish Planning and Environmental Law Journal*. In 2020, Amy O’Halloran was awarded an Irish Research Council / Environmental Protection Agency Postgraduate Scholarship (2020-2023) for a project entitled *Private Transnational Environmental Regulation and Systemic Interactions in Global Environmental Governance*.



### Researchers provide expertise nationally and globally

Centre PIs are called on regularly to give expert input to law and policy developments at the highest level. During 2020, for example, Professor Owen McIntyre was invited by UN ECE / UNESCO to act as External Reviewer of the *Second Progress Report on Sustainable Development Goal (SDG) Indicator 6.5.2*, measuring transboundary water cooperation. Professor Áine Ryall was invited to give expert evidence to the Joint Oireachtas Committee on Climate Action in October 2020 on the draft Climate Action and Low Carbon Development (Amendment) Bill 2020. Dr Ruby Moynihan was appointed as an international expert to China’s new Wuhan University Institute of Boundary and Ocean Studies, International Water Law Academy, of which Professor McIntyre is a member of the

founding faculty. In addition, Dr Moynihan was an invited Senior Visiting Research Fellow to the New Zealand Centre for Public Law at the Victoria University of Wellington, where she conducted research on freshwater and ocean ecosystems, climate adaptation in coastal environments and marine protected areas. Professor Áine Ryall convened an expert session at the PILnet Global Forum on 20 October 2020. The Forum was a truly ‘global’ event, reaching over 800 participants from 70 countries across different time zones. The Forum theme in 2020 was Protecting Our Future. The expert session led by the Centre for Law & the Environment focused on Climate Change, Human Rights and Public Interest Law.

### Integration of Research and Teaching

Research-based teaching, at both undergraduate and postgraduate levels, is an important element of the Centre’s activity. The Centre offers the LLM (Environmental and Natural Resources Law), in addition to a range of undergraduate modules in environmental law. The Centre’s Co-Directors also contribute annually to the University Wide Module on Sustainability. During 2020, guest lectures, seminars and workshops were delivered at the Centre by the Chief Justice of Ireland, the

Hon Mr Justice Frank Clarke (Adjunct Professor, School of Law, UCC) and by leading practitioners and experts including: Dr Fred Logue (FP Logue Solicitors), Dr Andrew Jackson (UDC Sutherland School of Law) and Darragh Page (Programme Manager, Environmental Protection Agency). These engagements enable our students to gain important insights into how environmental law operates in practice and underpin our commitment to experiential learning.

## UCC advises on Scottish Wildlife Crime Legislation



Professor Mark Poustie, Dean of the School of Law, chaired the Scottish Government's Wildlife Crime Penalties Review Group from 2014 to November 2015 and authored the group's report: *Wildlife Crime Penalties Review Group Report* (Scottish Government, November 2015). The Review Group was established because there was a perception that penalties available and those actually imposed by the courts were not acting as a deterrent to further wildlife crime and were tarnishing Scotland's image. This report made a number of recommendations including uprating and harmonising available penalties for key wildlife offences so they were comparable with those available in the case of pollution offences which have been significantly uprated and harmonised over the last 30 years. The Scottish Government accepted the majority of the recommendations and the changes to penalties that were recommended were implemented by the Animals and Wildlife (Penalties, Protections and Powers) (Scotland) Act 2020 which was brought into force at the end of November 2020.

## Enforcing European Union Environmental Law

In 2020, the Centre was again successful in securing funding from the Department of Foreign Affairs *Communicating Europe Initiative*. This prestigious funding supported a webinar on *Enforcing European Union Environmental Law* held on 8 December 2020. Convened by Professor Áine Ryall, this event attracted over 160 participants. It explored a range of themes including: the role of the EU Commission; the impact of Brexit; developments in appropriate assessment; and the influence of EU law on the right to participate in environmental decision-making. The Hon Ms Justice Marie Baker of the Supreme Court chaired the event. As part of the *Communicating Europe Initiative* project, the Centre produced a series of podcasts exploring different dimensions of EU environmental law enforcement. The podcasts, which are available on the Centre's website, feature Judge Anthony M Collins, Judge of the General Court of the European Union; Leo Flynn, Legal Advisor in the Legal Service of the European Commission; and Attracta Uí Bhroin, Environmental Law Officer, Irish Environmental Network and Vice-President, European Environmental Bureau.

The Centre's Co-Directors also contributed to a virtual conference organised by the Environmental Protection Agency (EPA) and the Irish Centre for European Law (ICEL) on the theme *Environmental Law Enforcement: Emerging Challenges 2020* held on 11 November 2020. The conference was convened by Professor Áine Ryall and Dr Tom Ryan (EPA) and the Opening Address was delivered by the Chief Justice, the Hon Mr Justice Frank Clarke. The purpose of the conference, which attracted over 700 delegates, was to explore the role of law and its enforcement in shaping our approach to environmental protection. Professor Owen McIntyre delivered an invited paper on the theme *The Environmental Liability Directive: Disjointed and Discredited?* Professor Áine Ryall examined *New Directions in Environmental Law Enforcement*.



## Digital Badge in Climate Law & Governance for Engaged Citizenship



In November 2020, the Centre for Law & the Environment launched a new short course leading to the Digital Badge in *Climate Law & Governance for Engaged Citizenship*. This initiative, which was aimed at first year undergraduate students at UCC, is part of a research project funded by the National Forum for the Enhancement of Teaching and Learning in Higher Education and the Higher Education Authority (HEA). The *Teaching Environmental Law for Policy Innovation & Impact* project aims to design, develop and test a series of new models of experiential learning in the field of environmental law and policy. The short course, which was delivered online, created a dedicated forum for students to reflect on key elements of climate law and governance. The idea behind this short course is to harness the enthusiasm generated by student-led initiatives to date, and to equip students with the skills needed to participate effectively in climate policy debates. The course attracted an enormous level of interest, with over three times as many expressions of interest received as the number of places available.



### 5.3: Aquaculture and Fisheries Development Centre (AFDC)

The AFDC is a centre of excellence for aquaculture and fisheries research focusing on fisheries and fish population genetics, health of aquaculture species, and marine mammal research based in the School of Biological, Earth and Environmental Sciences and affiliated to the ERI. The Centre is led by its Director, Professor Sarah Culloty.



#### Europe's rivers are broken, but there is a fix

Research stemming from AMBER, a large collaborative Horizon 2020 project including a UCC-based team of researchers led by Professor Phil McGinnity (ERI, BEES, and AFDC), has found that Europe's rivers have at least 1.2 million instream barriers. The results, published in the journal *Nature* in 2020, show that Europe has probably some of the most fragmented rivers in the world. The study detected thousands of large dams, but also a myriad of low-head structures such as weirs, culverts, fords, sluices and ramps which had been overlooked and are the main culprits of fragmentation. The impact of the river barriers identified will be exacerbated by global warming. The data generated within the project will help to manage future risk, prioritise action and co-ordinate responses to the fragmentation of Europe's river system. These results feed directly into the new *EU Biodiversity Strategy* and will help to reconnect at least 25,000 km of Europe's rivers by 2030.



#### Captive-bred salmon perform poorly in the wild

The deliberate introduction of captive-bred salmon into the wild is a common management response to natural or human-driven declines in salmon numbers. It is also sometimes done to increase the numbers of fish available for angling. On the face of it, introductions appear to be a good idea: wild salmon have very low survival rates as juveniles in the river (as low as 0.3%) due to natural limits of the ecosystem such as competition, predators, and food scarcity, whereas salmon bred in a protected hatchery environment can be expected to survive there at much higher rates, allowing large numbers to be moved to the wild at a suitable stage. However, new research led by Ronan O'Sullivan, Dr Tom Reed, Professor Phil McGinnity and colleagues in the FishEYE research group (School of BEES, ERI) has now demonstrated, using genetic fingerprinting techniques, that captive-born salmon had as little as one third of the lifetime reproductive success as wild salmon spawning in the same river. Moreover, the overall productivity of the mixed population was much lower in years where captive-bred fish

comprised a greater fraction of potential spawners. Further research is needed to work out exactly what is happening when the wild and captive salmon mix, but the research team suspects that hybrid offspring produced by mating between captive and wild parents are genetically less well-equipped to deal with life in the river. If true, this means that the widespread release of captive animals into the wild might actually do more harm than good in many cases.



#### Researchers look to the past to protect the future of cockles

Cockles are an emblematic shellfish species across Europe, valued for meat, cultural symbolism and ecological value. Records of cockles can be found throughout history, from a wide range of sources including museums, scientific works and fisheries records. A 2020 study published in *PLOS ONE*, from the InterReg-funded COCKLES project examined a large volume of historical information about cockles. This data included locations of where they were found, and how many were there. Lead author, Dr Kate Mahony (School of BEES, AFDC, MaREI and

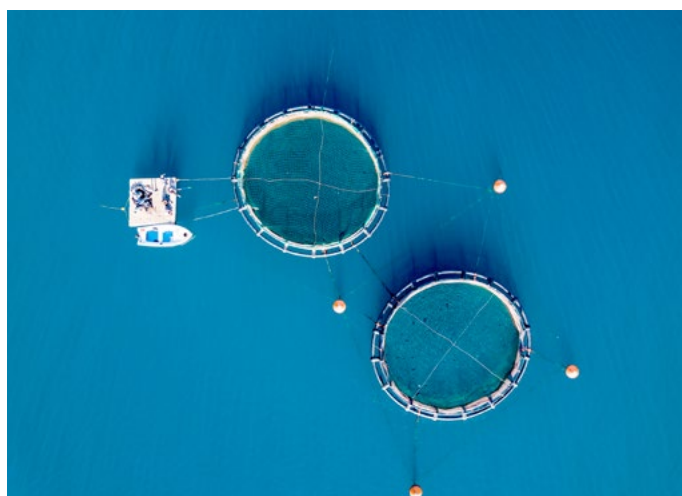
ERI) and colleagues Dr Sian Egerton, Dr Sharon Lynch and Professor Sarah Culloty, then compared cockle density with changing climate in the Atlantic. It was evident that cockles were influenced by a wide range of parasites, temperature fluctuations, and varying methods of fishing and legislation. This study also found many inconsistencies with regard to the collection and reporting of such data, with much of it never progressing beyond academia to those in the fishing industry who could translate the findings into tangible impacts. The team

has since led calls for standardising the monitoring and reporting processes and for the creation of an online portal to increase knowledge transfer both locally and internationally.



## Plant-based fishmeal for more sustainable aquaculture

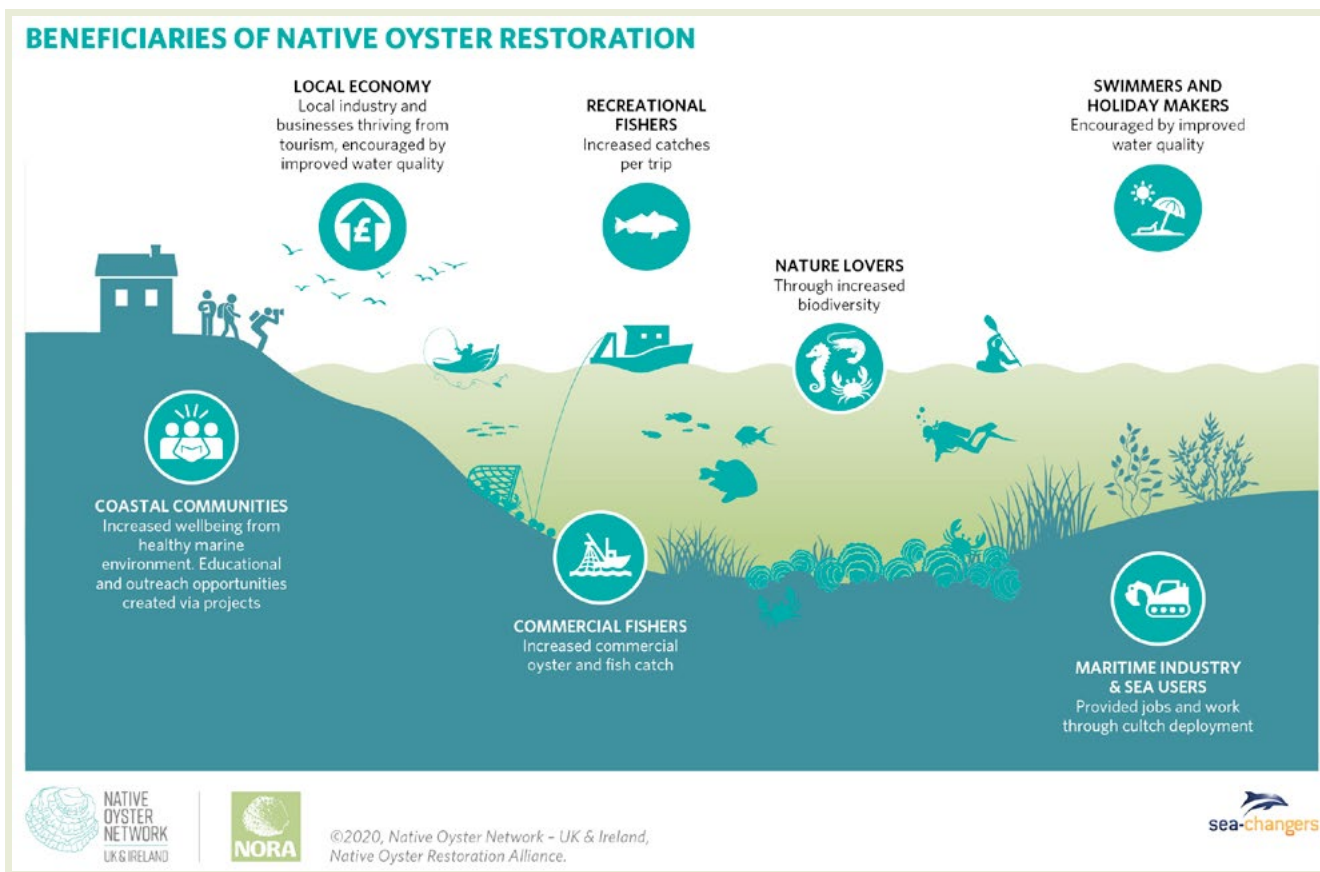
Fishmeal is generally considered the gold standard dietary protein source for many fish species, but it is also now considered both environmentally and ecologically unsustainable and there are societal and economic pressures on the aquaculture industry to find alternative proteins. Plant proteins are the most common replacements for fishmeal in aquafeeds, but it has been found that increasing the proportion of plant protein beyond 50% results in poor growth and negatively impacts the gut microbiota of fish. Creating sustainable feeds that promote fish welfare and maximise growth potential, while remaining cost-efficient, is a prominent challenge for the aquaculture industry. Research led by Dr Sian Egerton, Professor Phil McGinnity and Professor Sarah Culloty, investigated the effects of supplementing an 80% plant protein aquafeed for farmed Atlantic salmon with a partly-hydrolysed fish protein hydrolysate (FPH) to complement the plant proteins and promote good gut health. Published in *Scientific Reports*, the study successfully reduced fishmeal to 6% of dietary protein contribution without negative effects on growth, suggesting that FPH supplementation could go some way towards sustainable food production and help to reduce the volume of wild fish species used in aquafeeds. The results indicate that improved essential amino acid bioavailability, in particular branched chain amino acids, facilitated the high growth rates recorded. Furthermore, a cost comparison of the different feeds highlighted that this formulation is an economically viable alternative.



## UCC team part of European effort to restore vulnerable Oyster populations

With an estimated decline of 95% since the 19th century, native oyster reefs are now one of the most threatened marine habitats in Europe. In some regions, native oysters are now considered extinct. The key driver behind this huge decline is historic overfishing; however, habitat loss, disease, pollution and invasive non-native species are all contributors. The Native Oyster Restoration Alliance (NORA) aims to support the protection and ecological restoration of the native European oyster, *Ostrea edulis*, and its habitat in areas of its current or historical distribution. Irish members of NORA, Professor Sarah Culloty and Dr Sharon Lynch of the Shellfish Health Research Group (ERI, MaREI, School of BEES, AFDC) made significant

contributions to this effort in 2020, with Dr Lynch (as an *O. edulis* and pathogen/parasite expert) contributing to the “*European native oyster monitoring recommendations handbook*” and “*European guidelines on biosecurity in native oyster restoration manual*”. These handbooks contain appropriate methods relating to oyster habitat monitoring, how to measure the interactions of biodiversity associated with restored oyster reefs, to monitor socio-economic benefits of restoration projects, and how to measure the carbon storage of oyster reefs. These two documents will provide an invaluable resource guiding researchers, policy makers and industry in the recovery process.



Infographic ©2020, Native Oyster Network – UK & Ireland, Native Oyster Restoration Alliance.

## 5.4: UN Environment Programme GEMS/Water Capacity Development Centre

The UN Environment Programme GEMS/Water Capacity Development Centre (CDC) provides global capacity development in water quality monitoring and assessment working on a programme of activities to support the Water Sustainable Development Goals. The Centre is based at the School of Biological, Earth, and Environmental Sciences and ERI.



### Launch of UNEP GEMS Water /CDC Phase 2

As the global population grows, so too do the demands for water – for drinking, sanitation, farming and energy production, among many other uses. At the same time, human activity, pollution and climate change are disrupting natural water cycles, putting freshwater ecosystems under pressure. The UNEP GEMS/Water Capacity Development Centre (CDC) aims to improve the capacity of all countries, especially developing countries, to monitor and assess their freshwater quality in order to improve sustainable use of freshwaters globally. It was established in 2015 following a renewed mandate for GEMS/Water (the Global Environment Monitoring System for Freshwater) from the first United Nations Environment Assembly (UNEA). The first phase of the programme was co-funded by the Irish Government from 2015 to 2020 and enabled UNEP to support the establishment and activities of the Centre in UCC.

Phase I saw completion of the global assessment of water quality monitoring activities and capacity development needs. In the first phase the tasks were to raise awareness of the importance of water quality, to deliver education and training workshops and to bring people together to support efforts towards the Sustainable Development Goal (SDG) indicator 6.3.2 for ambient water quality. In the Centre's short existence, past participants in the education and training programmes have already begun using their knowledge to improve freshwater quality monitoring and assessment in their countries and local areas.

In 2020, the GEMS/Water CDC received €750,000 funding for Phase II of the Global Water Quality Monitoring Capacity Development (2021-2023) programme. The second phase of this important initiative will facilitate the development and implementation of a capacity development consortium of global providers for a wide range of water quality topics under the umbrella of the World Water Quality Alliance.



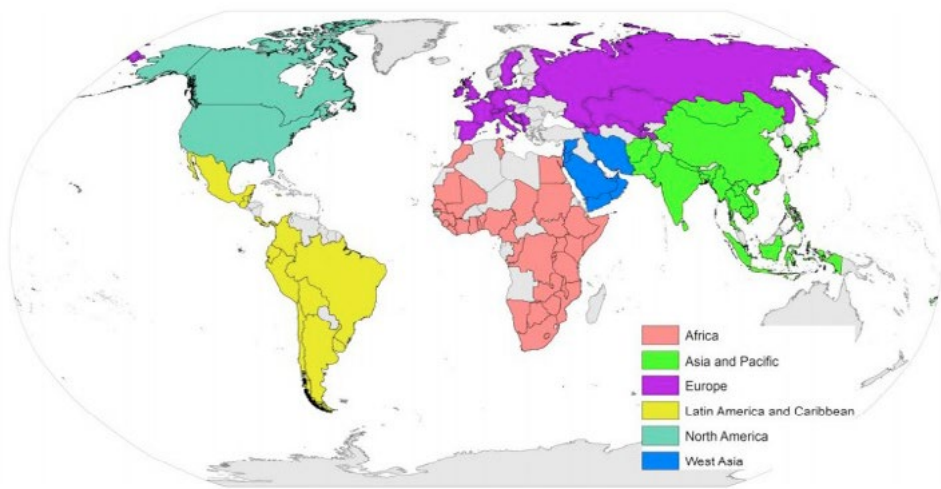
## Initiation of the World Water Quality Alliance (WWQA) Capacity Development Consortium

The scoping of capacity development needs in education and training for water quality monitoring, that was completed in 2019 as part of UNEP GEMS Water/CDC Phase I, highlighted some topics and global regions that would benefit from focussed activity. The courses created and being run on-line by the Centre are addressing some of these needs. The iden-

tified priority needs for capacity development topics have been highlighted to partners of the World Water Quality Alliance that are interested in joining a capacity development Consortium. Collaboration with partners who join the Consortium in order to support these needs, will be one of the activities in Phase II. The World Water Quality Alliance (WWQA)

was launched in 2019, bringing together a wide range of expertise in water quality, water technology, governance, and diplomacy to provide stakeholders with evidence-based assessment, services, and solutions on water quality problems. UNEP GEMS Water/CDC Director, Deborah Chapman, is the co-chair for the WWQA Technical Advisory Commit-

tee and the CDC is taking the lead, together with the GEMS/Water team in Nairobi, in developing a WWQA Capacity Development Consortium to enhance the range and global coverage of capacity development activities for water quality.



Map displaying the 107 countries the CDC has engaged with since 2014.

### International impact

Since the Centre's inception, the team have engaged with 107 countries through training workshops, short on-line courses, and blended learning programmes. As a result of the GEMS/Water on-line training activities, 96 staff from government water authorities and similar agencies from 29 countries have been trained and educated in the full spectrum of activities necessary for water quality monitoring and assessment since the agreement commenced in 2015. These staff are now able to train personnel in their own organisations, and to recommend improvements in monitoring and data generation practices in their own countries. This will lead to an improved and more efficient use of resources for water quality monitoring and assessment, and to the generation of more reliable water quality data, as monitoring networks in these countries are gradually updated.

### SDG indicator 6.3.2



Improving ambient water quality globally is one of the 169 ambitious targets set out in the 2030 Agenda for Sustainable Development. UNEP, through the GEMS/Water Programme, is responsible for supporting countries globally in gathering the relevant data for Sustainable Development Goal Indicator 6.3.2 on ambient water quality. The indicator

is defined as the proportion of water bodies in a country having good ambient (i.e. natural, untreated water in rivers, lakes, groundwater) water quality representing a combination of natural influences and the impacts of anthropogenic activities. Consequently, it enables the impact of human development on ambient water quality to be evaluated over

time and it provides an indication of whether the services that can be obtained from the aquatic ecosystems can be met, such as clean water for drinking, preserved biodiversity, sustainable fisheries, water for irrigation, etc. Significant progress was made in 2020 towards key support activities, including the completion of a research project on validating Citizen Science methods for SDG Indicator 6.3.2, a country pilot study completed, as well as a contribution to a paper about citizen science monitoring for the SDG Indicator 6.3.2 in England and Zambia, which explores how citizen science and regulatory monitoring can work together to provide data for SDG6. Support and technical advice was given to >30 countries for the SDG Indicator 6.3.2.



### Training, education, communication and networking

Key activities progressed by the Centre each year include design and provision of training activities, workshops and courses (which were all delivered online in 2020 due to COVID-19), the design and drafting of five handbooks for publication in 2021 to accompany training and on-line courses covering topics such as freshwater monitoring programme design, water quality monitoring and assessment in rivers, lakes, reservoirs, and groundwater, and water quality monitoring with biota and particulate matter. Six students were awarded the MSc in Freshwater Quality Monitoring and Assessment in 2020 and another six will complete in 2021 due to delays caused by COVID-19. Many of the research projects being carried out by the MSc students will benefit the environment agencies in their home countries and assist them in understanding and managing their freshwater quality.

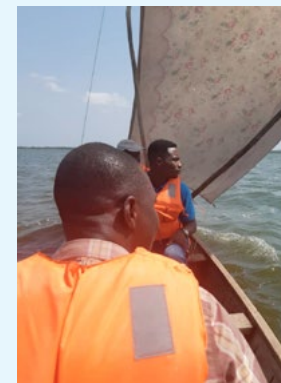
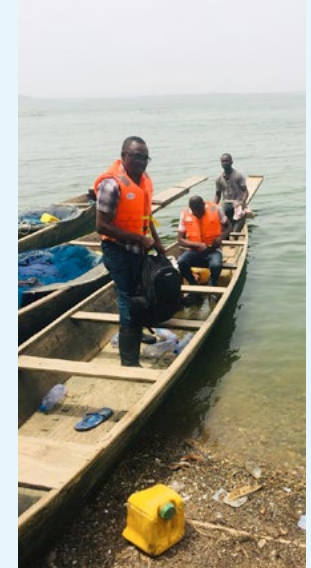
### Taking a closer look at the ongoing research of MSc student, Jeremiah Asumbere, in Ghana

Evaluating water quality risks to human health at the Weija Reservoir, Accra, Ghana

Jeremiah's project focuses on both environmental and public health protection in Accra, Ghana. His research aims to shed light on the pollution present in the Densu river basin and especially in the Weija reservoir. The Densu river system is one of the largest contributors to surface water reserves in Ghana but it is considered to be polluted. The Densu river supplies the Weija reservoir. Similar to many river systems across the globe, the Densu catchment is exposed to pollution from a variety of different land uses including agriculture and industries like mining. The Weija reservoir is used for drinking water supply by the Ghana Water Company among other uses. There have not been any recent studies at the Weija reservoir despite its importance for supplying drinking water and the escalating threat of pollution.

Jeremiah's project involved assessment of the potential threats to the water quality by carrying out a number of field campaigns and laboratory analysis to provide further information on the impacts on water quality. His analyses included methods to detect and measure pesticides and heavy metals of concern along with commonly monitored physical and chemical parameters. The results of these sampling campaigns helped to determine the water quality and the potential human health and environmental risks. The information obtained on the water quality and potential pollution threats is beneficial for all who value and use the water body, including the Ghana Water Company and the Ghana Environmental Protection Agency.

**Right:** *Sampling for water quality parameters in the Weija Reservoir and at the banks of the River Densu, Accra, Ghana.*



## 5.5: Cleaner Production Promotion Unit (CPPU)

The CPPU conducts engaged research focused on the theme of society, sustainability and energy, with a particular emphasis on people's relationship with energy and the energy system. The unit is led by Dr Niall Dunphy (School of Engineering & Architecture, and ERI).



### CPPU researchers lead new EU project tackling energy poverty



Between 50 and 125 million people are at risk of energy poverty in the EU. Efforts to address this issue will require a suite of measures informed by participatory and inclusive approaches. A new CPPU coordinated Horizon 2020 project addressing energy poverty commenced in September 2020. This. €2m three-year project entitled *'EnergyMeasures: Tailored measures supporting energy vulnerable households'* involves twelve partners from across Europe, working to develop engagement initiatives in seven European countries: Belgium, Bulgaria, Ireland, Netherlands, North Macedonia, Poland, and the UK. EnergyMeasures involves identifying energy poor households, selecting and

deploying appropriate low-cost energy conservation measures, and leveraging this deployment for a more wide-ranging engagement to support residents to understand and change their energy-related behaviours. EnergyMeasures will produce a wealth of materials that will enable concrete hands-on work with local communities on the topic of energy poverty. The project's success will be measured against the following outputs; number of households recruited/retained in the project, measures installed, energy reductions and potential financial savings. The impact will be more money saved in households, warmer homes, greater energy efficiency and reduction in emissions.

### Launch of new carbon capture and storage project

Oil refineries play a major role in our modern lifestyles, making it possible to provide an almost infinite range of everyday products – from electronics, fuels and medical supplies to construction materials and sports equipment. These industries emit carbon dioxide (CO<sup>2</sup>) as part of their inherent processes. Carbon capture, utilisation and storage (CCUS) technology offers a way to reduce these emissions substantially as part of Europe's wider efforts to meet climate targets by 2030 and the EU's commitment to net-zero emissions by 2050. The REALISE (Demonstrating a Refinery-Adapted Cluster-Integrated Strategy to Enable Full-Chain CCUS Implementation) CCUS project, sees CPPU collaborating with industry experts and scientists from around Europe in a concerted drive to support the refinery sector's decarbonisation ambitions. Within this Horizon 2020-funded project, CPPU leads a package of work focused on the societal readiness of the technology, and the social acceptability of its potential deployment. This project focuses on the full CCUS chain – from CO<sub>2</sub> capture, transport and geological storage to CO<sub>2</sub> reuse. Results will support CCUS delivery by demonstrating the technology, enabling sizeable cost-reductions, undertaking public engagement and assessing financial, political and regulatory barriers.



### Addressing non-technological barriers within the marine renewable energy sector

Ocean energy can provide clean, predictable, indigenous and reliable energy and contribute to the EU's objective of reaching a share of renewables of at least 32% of the EU's gross final consumption by 2030. October 2020 saw the launch of another exciting new ocean wave energy project SafeWAVE: Streamlining the Assessment of Environmental Effects of Wave energy. The project, co-funded by the European Maritime and Fisheries Fund (EMFF) is led by AZTI from Spain and involves partners from France, Portugal, Ireland and Spain. The nascent status of the Ma-

rine Renewable Energy sector, particularly ocean wave energy, yields many unknowns about its potential environmental pressures and impacts. As such, it can be perceived as risky by regulators and other stakeholders, sometimes also leading to opposition within intended communities and creating a critical obstacle in the consenting of ocean wave energy projects.

The aim of the SafeWAVE project consists of overcoming these non-technological barriers that could hinder the future development of one of the main pillars of the

EU Blue Growth strategy. The UCC principal investigators are Professor Gregorio Iglesias and Dr Anne Marie O'Hagan (MaREI, ERI) and Dr Niall Dunphy (CPPU, ERI). Within this project, CPPU leads a work package exploring education and public engagement around marine developments.





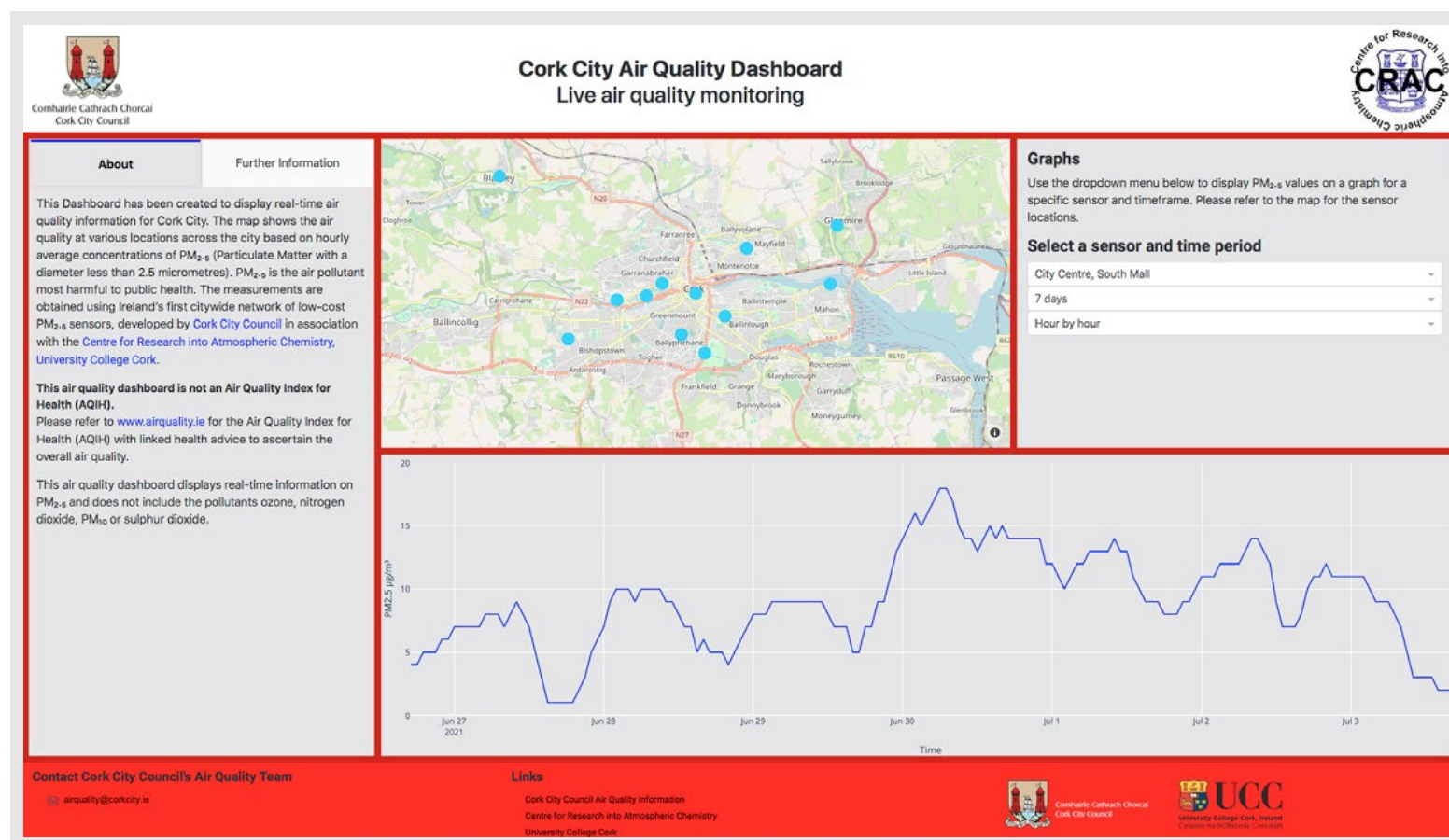
## 5.6: Centre for Research into Atmospheric Chemistry (CRAC)

CRAC is a leading national centre for atmospheric chemistry research carrying out laboratory, field and modelling studies to support clean air quality. The Centre is based in the School of Chemistry and Environmental Research Institute. The CRAC Centre Director is Professor John Wenger.



### Cork City Council & CRAC collaborate to launch air quality dashboard

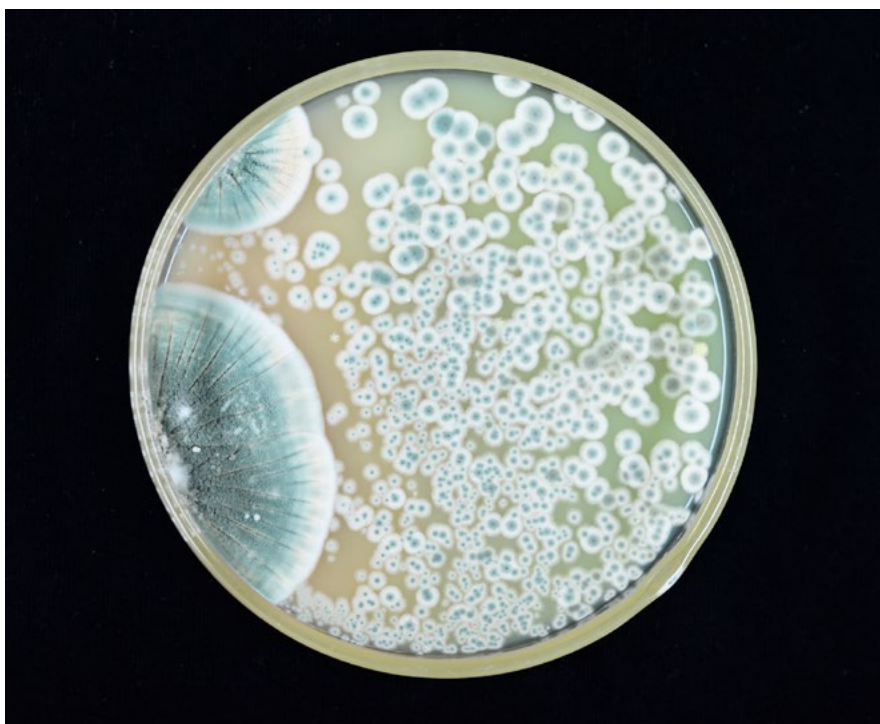
CRAC researchers have tirelessly highlighted the concerning levels of air pollution derived from the burning of solid fuels in Ireland, prompting Minister for the Environment Eamon Ryan to announce measures for the further regulation of solid fuel use for domestic home heating. Locally, after many months of collaborative effort to install Ireland's first citywide network of low-cost PM<sub>2.5</sub> (particulate matter of 2.5microns) sensors - the PurpleAir network - Cork City Council and CRAC have now launched an air quality dashboard, which displays real-time air quality data at various locations across the city based on hourly average concentrations of PM<sub>2.5</sub>, allowing vulnerable residents to avoid certain areas of high pollution or to take precautions such as wearing of masks which filter such particulates. The dashboard shows the corrected particulate matter levels after extensive calibration against reference monitors in the PurpleAir network and a correction factor has been applied to the data displayed, thus the readings are significantly more accurate when compared to the original sensor readings. The launch of the dashboard comes shortly after Cork Council launched its draft Air Quality Strategy for public consultation, making it the first local authority in the Republic of Ireland to draft such a strategy.



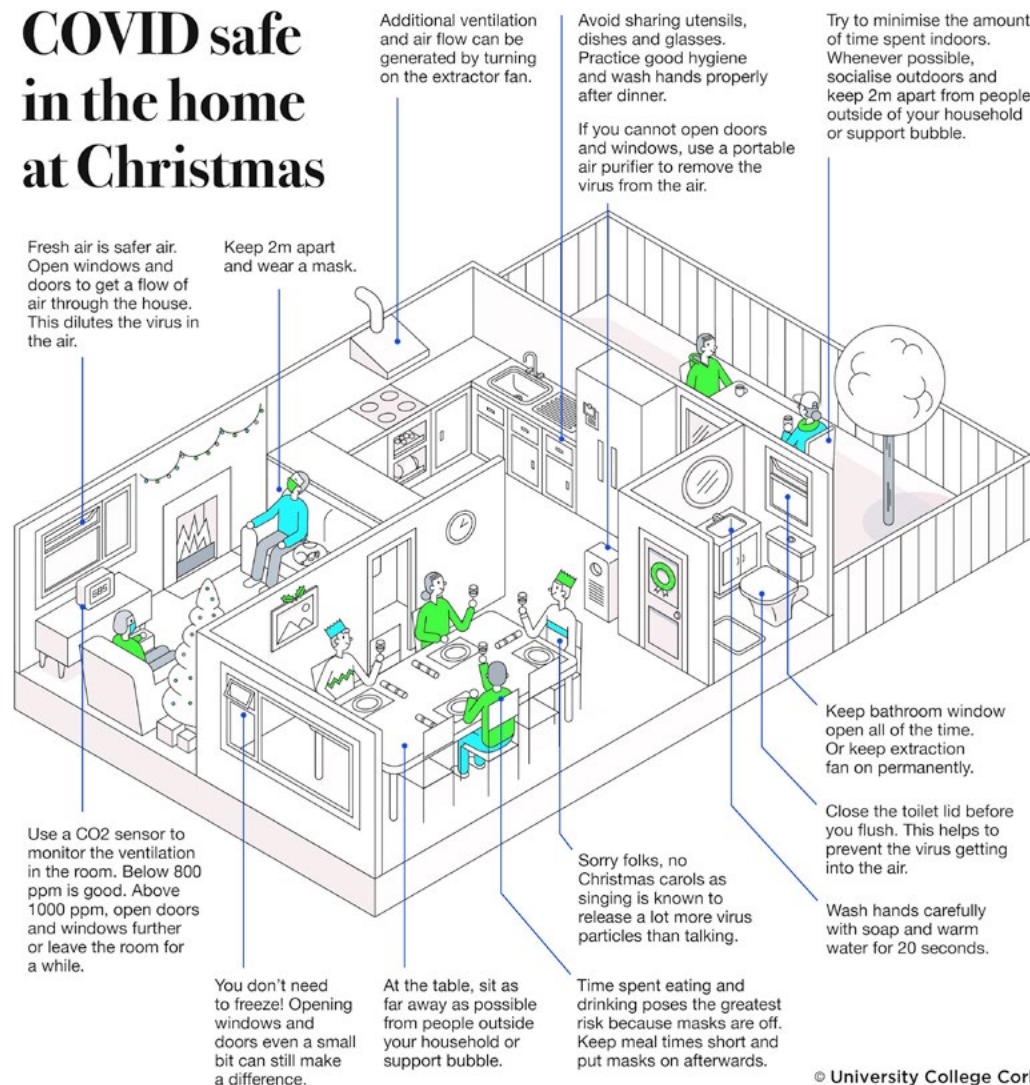
## Fungal spore forecast

Fungal spores are microscopic particles responsible for the reproduction of fungi. We inhale huge numbers of these particles in each breath and for most people, this doesn't cause any problems. However, some people with compromised respiratory systems are more susceptible to allergic reactions and infections from mould spores. It can therefore be useful to know when mould spores are at their highest concentrations and reduce our exposure to them, particularly during peak spore seasons. The EPA-funded FONTANA project (Fungal mOnitoring NeTwork ANd Algorithm) will provide the EPA, the agricultural sector, Met Éireann, policymakers (including the insurance industry), and the scientific community with relevant, traditional,

real-time data regarding fungal spores. Led by Dr David O'Connor (TUD) and Dr Stig Hellebust (CRAC, School of Chemistry, ERI), the overall aim of the work is to provide increased monitoring capabilities to the Irish pollen network - effectively creating an Irish bioaerosol network for the concurrent measurement of both pollen and fungal spores. Such a network will be established through the integration of traditional, spectroscopic and chemical methodologies into the currently functional sampling infrastructure (Cork, Dublin and Carlow). Allied to this, a new site in the west of Ireland will be established and the collected fungal spore data from all sites will be utilized to create the first ever Irish fungal spore model.



## COVID safe in the home at Christmas



## Keeping our homes COVID-safe

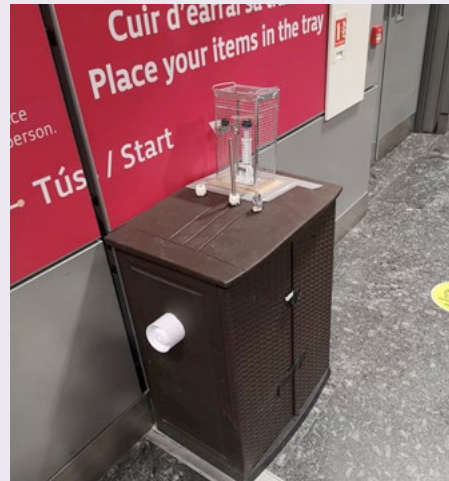
Research clearly shows that ventilation plays a very important role in preventing the spread of COVID-19, with fresh air being the safest option (rather than recirculated air). While Christmas may be a distant memory now, this handy guide developed by Professor John Wenger and colleagues in CRAC helped many to stay safe while enjoying a socially distant celebration in the home. The guide uses common settings in the home to illustrate useful advice, particularly in relation to the importance of ventilation - guidance which will continue to be invaluable all year round for the foreseeable future.

## CRAC researchers part of national initiative to understand how COVID-19 is spread in the community

### Airborne surveillance of SARS-CoV2 in healthcare and airport environments

Funded by the SFI's COVID-19 Rapid Response Research and Innovation Programme, Dr Mehael Fennelly, Dr Stig Hellebust and Professor John Wenger are working in collaboration with Professor Mike Prentice (UCC Dept of Pathology), Professor Mairead Harding and Dr Catherine Gallagher (Cork University Dental School and Hospital) on the surveillance of SARS-CoV-2 in healthcare and airport environments. Several diverse environments were selected for monitoring biologically-derived aerosols with potential human origin in indoor air, including two clinical (Cork University Dental School and Hospital and CUMH) and one public (Cork Airport). Aerosol and environmental data was collected

by the wideband integrated bioaerosol sensor (WIBS-4a), optical particle sizer (OPS-3330) and AirVisual Pro (IQAir) real-time air monitoring instruments. Furthermore, environmental data was also collected from several low-cost aerosol monitors at all locations. The results to date demonstrate that continuous air monitoring and collection devices can provide effective monitoring for air management in diverse clinical and public locations. So far, this project has helped inform current safe clinical practice where the analysis of aerosol mitigation during simulated dentistry procedures has contributed to the safe reopening of Cork University Dental Hospital and School.

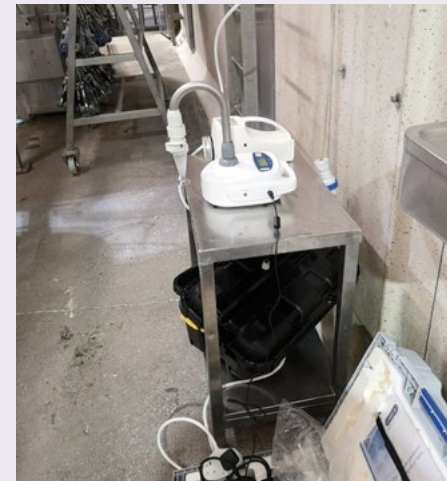


**Above:** (Left) Data collection inside a simple enclosure at Cork University Dental School and Hospital. (Right) Data collection set-up at Cork Airport.

### Understanding and Preventing COVID-19 Outbreaks in Meat Processing Plants - Prepared for the Future (UPCOM)

A pilot study coordinated by Department of Agriculture, Food, and the Marine (DAFM) was carried out in the Summer of 2020 to investigate spread of COVID-19 in Meat Processing Plants (MPPs). The CRAC research team contributed to investigating potential airborne transmission of the virus in the plant by focusing on environmental factors in affected MPPs. Following this, an interdisciplinary, multi-institution and multi-partner project was funded by SFI to further investigate meat processing facilities. The project is led by Professor Grace Mulcahy at the UCD School of Veterinary Medicine. The UCC team, led by Professor John Wenger, Dr Stig Hellebust and Dr Mehael Fennelly of CRAC,

and Professor Mike Prentice (UCC Dept of Pathology) is assessing environmental factors associated with the potential transmission, which will include heating, ventilation, and air conditioning infrastructure at a MPP. Air changes per hour will be measured using fluorescent tracer molecules, with several environmental and aerosol samplers analysing air temperature, CO<sub>2</sub>, and airborne particles. The efficacy of aerosol interventions such as filtration (with and without UV germicidal irradiation) will also be measured. This data could, once proven, be used to develop effective monitoring and air management protocols in other industrial and workplace settings as part of infection reduction strategies.



**Above:** (Left) Conventional data sampling at an MPP. (Right) Protective instrument housing for aerosol collection at an MPP.

## Section 6: Meet our new PIs



### Dr Elena Arranz (UCC School of Food and Nutritional Sciences & the ERI)

Dr Elena Arranz joined UCC in 2020 as a Lecturer in Sustainable Food Systems in the School of Food and Nutritional Sciences and an ERI PI. Prior to joining UCC, Elena was a member of Dr Linda Giblin's group in Teagasc Moorepark, first as Research Officer and then as Marie Skłodowska-Curie Career-FIT fellow, developing plant and dairy-based protein beverages and studying how processing can affect their

functionality. In 2020, Elena was selected as member of the Management Committee of CIRCUL-A-BILITY COST Action and Academic Collaborator with VistaMilk (SFI Research Centre). Elena's main area of research is sustainable food systems. She is focused on plant-based products, waste valorisation in the food industry and the relationship between nutrition and health.



### Dr Kian Mintz-Woo (UCC Department of Philosophy & the ERI)

Dr Kian Mintz-Woo joined UCC as a Lecturer in the Department of Philosophy and an ERI academic in 2020. Prior to joining UCC, Kian was a postdoctoral research associate at the University Center for Human Values and the Princeton School of Public and International Affairs at Princeton University in the USA. Kian works on moral and normative issues, both fundamental (in moral ontology and metaethics) and applied (in climate ethics and climate economics). Kian has broad in-

terests in climate, some of which cluster around the morally relevant assumptions that go into pricing carbon (i.e. the social cost of carbon), such as discount rates and scope of climate harms; loss & damage (i.e. the impacts of climate beyond our ability to mitigate or adapt); and carbon taxes (i.e. policies internalising the externalities of climate change). Kian was recently named as 2020 Finalist for the Andrew Light Award for Public Philosophy.



### Professor Caitríona Ní Dhúill (UCC School of Languages, Literature and Cultures & the ERI)

UCC's newest Professor in German at the UCC School of Languages, Literatures and Cultures, is also one of our newest ERI Academics - Professor Caitríona Ní Dhúill. Prior to joining UCC, Professor Ní Dhúill taught German language and literature at the universities of St Andrews, Vienna, and Durham, UK, and is now an international affiliate of the Centre for Culture and Ecology, Durham, which she founded in 2017, and a member of the Arbeitskreis Kulturanalyse Wien (Vienna School of Cultural Analysis). Caitríona's research areas are German,

Austrian and comparative literature from the late nineteenth century to the present day; utopian fiction and theory; gender theory; life writing and biography; ecocriticism, environmental humanities and literature in the Anthropocene. Caitríona aims to find ways of drawing on the resources of her discipline to help achieve a just transition to a post-fossil fuel economy, covering everything from education for sustainability to critical perspectives on consumer capitalism, cultural dimensions of energy transition, and food sovereignty.



### **Dr Marica Cassarino (UCC School of Applied Psychology & the ERI)**

A psychologist in UCC's School of Applied Psychology investigating how the lived environment can support health and well-being over the lifespan, with a special interest in ageing processes, Dr Marica Cassarino became an ERI-affiliated researcher in 2020. Marica has a particular interest in how people interact with built and natural environments with regards to their attitudes, feelings, and behaviour. Marica is passionate about investigating the impact of increasingly urban environments on health and wellbeing, particularly for vulnerable groups. She also works in the area of attitudes towards the environment and sustainable de-

velopment. Her work focuses on how people shape and are shaped by their environment, particularly in relation to psychological attitudes and behaviour. Marica's research falls within the remit of three main Sustainable Development Goals, namely, Health and Wellbeing (Goal 3), Sustainable Cities and Communities (Goal 11) and tackling inequalities (Goal 10). She is particularly focused on the development of Healthy Environments, as well as understanding determinants of climate action across different demographic groups.



### **Dr Annalisa Setti (UCC School of Applied Psychology & the ERI)**

Dr Annalisa Setti is a lecturer and researcher in the UCC School of Applied Psychology and an affiliated researcher with the Institute for Social Sciences in the 21st Century (ISS21) Ageing Cluster and the Cork Neuroscience Institute. Annalisa's background is in experimental Cognitive Psychology across the lifespan, particularly Embodied and Grounded Cognition, whereby cognitive and functional abilities are determined in interaction with the environment. Our cognitive abilities and wellbeing depend both on our lifestyle and on the environment we live in. Annal-

isa studies these interactions with experimental, epidemiological and neuroscience methods and is particularly interested in understanding how different people (e.g. people with different sensitivities to the environmental stimulation) and different age groups experience the benefits of nature and the challenges of complex environments, like urban environments, to foster efficient cognitive performance and better quality of life. Annalisa's recent work also looks at our connection with nature as entry point for climate action.



### **Professor Ger Killeen (UCC School of BEES & the ERI)**

Professor Ger Killeen is the new AXA Research Chair in Applied Pathogen Ecology at the School of BEES and the ERI. Prior to joining UCC, Professor Killeen was based at the Ifakara Health Institute (IHI) in Tanzania for over 16 years, during which time he established what is now known as its Environmental Health and Ecological Sciences Department. He has supported several national malaria control programmes and established the locally managed Dar es Salaam City Council Urban Malaria Control Programme, which is now being used as a model system for government scale-up of active larval source management of malaria vector mosquitoes to all major urban centers in Tanzania. Pro-

fessor Killeen works on a variety of basic and applied aspects of malaria transmission control, especially vector control, with a strong emphasis upon quantitative ecology and mathematical modeling, as well as capacity strengthening at individual, systems and institutional levels. More recently, he has also started working on applying some of these new methodologies and control tools to combat Zika, Dengue and Chikungunya viruses, as well as developing new mathematical models of transmission and containment dynamics for the 2019 novel coronavirus. He is also a founding member of the Independent Scientific Advocacy Group for the elimination of COVID from the island of Ireland.

## Section 7: ERI in the Media 2020



### JANUARY

**Imagining 2050: The Ireland of the future**, Professor Brian O’Gallachoir & Dr Alex Revez, *The Irish Times*, January 2020

**UCC’s interdisciplinary mode of problem solving**, Dr Paul Bolger, *The Irish Examiner*, January 2020

### FEBRUARY

**Why we need more marine protected areas**, Sarah Ryan Enright, *RTÉ Brainstorm*, February 2020

**Election 2020 climate policies: From the ambitious to the vague**, Dr Paul Deane, *The Irish Times*, February 2020

### MARCH

**Paying tribute to our trees**, Dr Eoin Lettice, *The Irish Examiner*, March 2020

**Creative ideas for wind turbines**, Dr Paul Leahy, *The Echo*, March 2020

### APRIL

**Greens’ 7% carbon cut requires ‘far-reaching changes’ and €40bn, experts say**, Dr Hannah Daly, Dr James Glynn, Professor Brian Ó Gallachóir, *The Irish Times*, April 2020

**Sea trout population under threat, UCC research finds**, Louise Archer *The Irish Examiner*, April 2020

### MAY

**Researchers at UCC found pollution from cars down by 50pc during lockdown**, Energy Policy & Modelling Group/MaREL, *RTÉ Radio One*, May 2020

**UCC Professor Gerry Killeen comments on the current approach to flatten the curve**, *Today FM*, Ian Dempsey’s Breakfast Show, May 2020

### JUNE

**Record Arctic temperatures will have ‘devastating effects’; UCC scientist warns**, Dr Kieran Hickey, *The Irish Examiner*, June 2020

**Researcher contracts under strain as economic recession looms**, Dr Mark Jessop, *The Irish Times*, June 2020

### JULY

**Small crustacean can fragment microplastics in four days, study finds**, Dr Alicia Mateos-Cárdenas, *The Guardian*, July 2020

**Opinion: We need serious help to ‘stop burning stuff’ to heat our homes**, Professor John Wenger, *The Journal*, July 2020

### AUGUST

**Op-Ed - Supreme Court ruling a turning point for climate governance**, Professor Áine Ryall, *The Irish Times*, August 2020

**The MaREI EirWind Blueprint-Vital ideas for policy making**, Dr Paul Leahy, *Irish Tech News*, August 2020

### SEPTEMBER

**UCC’s Andrew Wheeler spends his life exploring the seabed of deep Atlantic**, *RTÉ One*, Ireland’s Deep Atlantic, September 2020

**UCC Professor Jerry Murphy speaks about the biogas resource in Ireland**, *RTÉ One*, Eco Eye, September 2020

### OCTOBER

**Warning issued as dozens of venomous jellyfish spotted on Cork beaches**, Dr Tom Doyle, *The Irish Examiner*, October 2020

**Why we need a technological dialogue around climate change**, Dr Fionn Rogan & Dr Alex Revez, *RTÉ Brainstorm*, October 2020

### NOVEMBER

**10 Things to Know About**, The PhenoClimate project, Dr Fiona Cawkwell, Dr Paul Holloway and Professor Astrid Wingler, *RTÉ One*, November 2020

**Mooney Goes Wild**, The Cockles project, Dr Kate Mahony, November 2020

### DECEMBER

**Is Eolaí Mé - Dinosaurs Episode**, Professor Maria McNamara, *TG4*

**Ear to the Ground**, Professor John Quinn, *RTÉ One*, December 2020

## COVID-19 in the Media



**“What the Coronavirus can tell us about Climate Change”**

*University Times*  
Dr James Glynn  
June 2020



**“1,000 cases of COVID-19 a day if schools reopen”**

*Irish Examiner*  
Prof Gerry Killeen  
August 2020



**“The COVID-19 pandemic has exposed why we urgently need to re-imagine democracy”**

*Democratic Audit*  
Dr Clodagh Harris & Dr Ian Hughes  
June 2020



**“How we have rediscovered the natural world during lockdown”**

*RTÉ Brainstorm*  
Dr Eoin Lettice



**“Will working from home help save the environment?”**

*RTÉ Brainstorm*  
Dr Hannah Daly



**“Why have petrol prices fallen at the pumps?”**

*RTÉ Brainstorm*  
Dr Paul Deane



**“How coronavirus measures have changed electricity demand”**

*RTÉ Brainstorm*  
Sid Joshi



**“Economic recovery post COVID-19 and climate action can align”**

*The Irish Times*  
Prof Brian O’Gallachoir  
May 2020



**“Coronavirus and Spanish flu: economic lessons to learn from the last truly global pandemic”**

*The Conversation*  
Dr Eoin McLaughlin  
March 2020



**“Politics of a Pandemic – how COVID-19 changes could open doors to a better Ireland”**

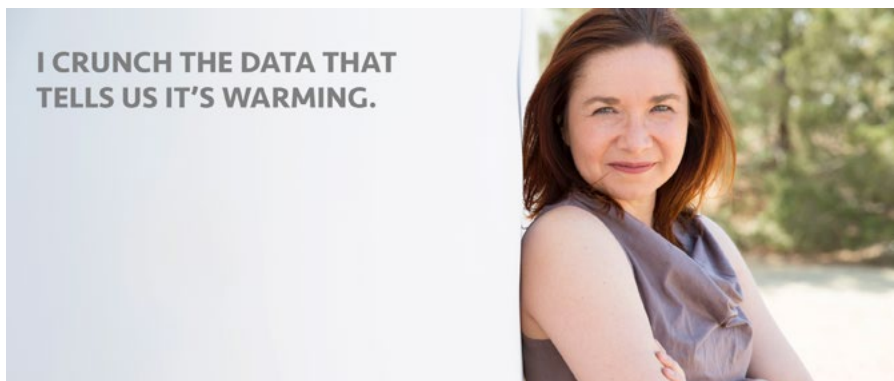
*Journal.ie*  
Dr Stephen Onakuse  
April 2020

## Section 8: Outreach and Public Engagement

### Leading international climate scientist speaks at UCC on need to adapt to climate change

Professor Katharine Hayhoe is an atmospheric scientist and professor of political science at Texas Tech University, where she is also Director of the Climate Science Center. In addition, Professor Hayhoe is also a renowned communicator who has served as an expert reviewer for the Intergovernmental Panel on Climate Change's Fourth Assessment Report and been named amongst Time Magazine's 100 Most Influential People. In March 2020, UCC were fortunate to play host to the first of a series of seminars during Professor Hayhoe's week-long tour of Ireland. During her visit to UCC, Professor Hayhoe spoke to an audience of over 200 at UCC's Devere Hall about the actions which can be taken at an international, national and local level to make a difference to climate change. She brought the message home

by highlighting the necessity to both adapt and mitigate and used Cork City Council's Climate Adaptation Strategy, which the ERI played a role in developing, as an example of how adaptation can look different in different countries. For example rainfall is a key impact of climate change that is being felt by Ireland in particular and it is being adapted to. However, Professor Hayhoe also noted that as a country Ireland is receiving mostly 'C's from the Engineers Ireland 2019 Report Card on the State of Ireland. This annual independent assessment of Ireland's infrastructure is generated by a panel of engineering experts grading sectors of infrastructure and developing recommendations. A 'C' grade is 'mediocre' implying that infrastructure is inadequately maintained, and/or unable to meet peak demand, requiring significant investment.



### Virtual Science Week 2020

2020 marked the 25th year of the SFI Science Week which took place in November against the societal backdrop of COVID-19 lockdown. As a result the core theme for Science Week 2020 was 'Choosing our Future', focusing on how science can improve our lives in the future and in the present, and exploring how science can help us to make positive choices that will impact the environment, our health, and our quality of life. As both seasoned organisers of and participants in the SFI Science Week, the MaREI Centre rolled out a dynamic online campaign of awareness and engagement resources and activities for Science Week 2020 which saw over 7,700 people watching the videos that were created and attending their online events. The programme in UCC included a live panel discussion with researchers addressing questions and misconceptions about the energy and climate challenges that face our country and our planet as we transition to a low-carbon society, and a Climate Action youth event in collaboration

with UCC Student Societies. UCC's Science Society also hosted an information evening on the ERI as part of the festival, with invited speakers ERI Director Professor Sarah Culloty and ERI Manager Dr Paul Bolger. Meanwhile, ERI academics along with colleagues in the UCD Earth Institute asked primary school children from The Children's House in Stillorgan and Rathfarnham Educate Together School to send in their questions about nature. Having received questions about everything from mushrooms, flowers, birds and insects to blue skies and green leaves, ecologists, zoologists, plant scientists, environmental scientists, geographers, botanists and geneticists (including Dr Eoin Lettice, Professor Astrid Wingler – both ERI, BEES, and Dr Paul Holloway of the Dept of Geography and the ERI) explained the most commonly asked questions about the world around us, through a series of YouTube videos over the course of Science Week.



## Science on the screen

The COVID-19 pandemic presented challenges to conventional public engagement and outreach activities. Embracing the webinar format, the ERI launched its COVID-19 webinar series early in the first lockdown of 2020.

### What can we learn from the COVID-19 pandemic to create a more sustainable world?

In this summer webinar series, the ERI invited four of its affiliated academic staff to reflect on the impact of the COVID-19 pandemic on our environment, and the possible lessons we can take forward to create a more sustainable society.

- **A global perspective on tackling COVID-19 now and preventing further pandemics in the future**

*Professor Ger Killeen, AXA Research Chair in Applied Pathogen Ecology at the Environmental Research Institute and School of Biological, Earth & Environmental Sciences, UCC.*

- **COVID-19 and our energy system – lessons for Ireland’s sustainable energy transition**

*Dr Hannah Daly, Energy Policy and Modelling Group, The SFI MaREI Centre for Energy, Climate and the Marine, School of Engineering & Architecture, and the ERI.*

- **COVID-19 and the environment: rediscovering nature in a global pandemic**

*Dr Eoin Lettice, Plant Science Lecturer and PI, Environmental Research Institute and School of Biological, Earth and Environmental Sciences, UCC.*

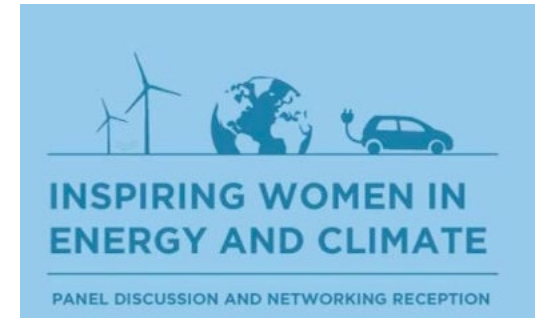
- **The links between air pollution and COVID-19**

*Professor John Wenger, Director of the Centre for Research into Atmospheric Chemistry, Environmental Research Institute and School of Chemistry, UCC.*

The UCC Marine Geology Research Group (iCRAG, BEES, ERI) also launched a series of ‘Wednesday Webinars’ exploring topics like ice ages, deep sea corals and fossil plankton with both national and international speakers. The MaREI Centre also reconfigured their stakeholder and public engagement activities to deliver a series of webinars which engaged approximately 3,000 people. These included the ESRI-UCC-MaREI energy research climate action webinar, Retrofitting Homes symposium, the Biofuels symposium, the EirWind webinar on *Blueprint for Offshore Wind*, a series of entrepreneurship and innovation webinars, a webinar with SEAI & Engineers Ireland “*Developing Wind Turbine Blades for the Future Challenges in the Onshore and Offshore Wind Energy Sectors*”, as well as online workshops with community representatives from the Dingle Peninsula 2030 project.

## Inspiring the next generation of female researchers

To celebrate International Women’s Day 2020, Dr Hannah Daly (MaREI, ERI, School of Engineering & Architecture) hosted “*Inspiring Women in Energy and Climate*” in UCC with participation of Women in STEM and Engineers Without Borders societies. This event featured a panel of inspiring women from across industry, academia and public service, who are dedicating their careers to creating a sustainable energy system and tackling the challenge of climate change. The audience heard from ERI Director Professor Sarah Culloty (ERI, MaREI, BEES), then-Vice President of Research and Innovation Professor Anita Maguire, Dr Marguerite Nyhan (School of Engineering & Architecture, ERI, MaREI, Visiting Scientist at Harvard University) and Dr Hannah Daly as well as speakers from the EPA, European Commission and Arup. Separately, Professor Maria McNamara (School of BEES, ERI) was also invited to speak on the topic of ‘*Life as a palaeontologist – pros/cons, goals and choices*’ at the Irish Association for Women Geoscientists Pathfinders event in the School of Geological Sciences, UCD in October 2020.



## The Green Scene

In 2020, Professor Brian O’Gallachoir of the Energy Policy and Modelling Group (MaREI Co-Director and ERI Vice-Director) was invited to co-host the popular weekly *Green Scene* slot with Pat Kenny on Newstalk radio. This series comprises a weekly update on energy and environmental matters, and covers areas such as air quality, emissions, renewable energy as well as topical environmental talking points from the news each week. For example, in October Professor O’Gallachoir spoke about the long-awaited Climate Legislation detailing what Ireland will need to do to achieve the level of emissions reduction now needed. Professor O’Gallachoir

also discussed the 2020 report from the Climate Change Advisory Council, and a new report from The Irish Wildlife Trust on the deterioration of Ireland’s marine habitats.



## In a climate emergency, is civil disobedience a necessity?

In February, ERI manager Dr Paul Bolger participated in the advance screening and Q&A for Professor Jan Haaken's new film *Necessity: Oil, Water & Climate Resistance*, which was held in St. Johns College, Cork. *Necessity* traces the fight in Minnesota against the expansion of pipelines carrying toxic tar sands oil through North America. The film follows indigenous activists and non-indigenous allies in their resistance to the pipelines traversing native lands and essential waterways. This event was collaboration between Women Producing Media, the UCC Department of

Sociology & Criminology, the ERI and St. Johns, and was the first of two film screenings which the ERI was invited to participate in during 2020, with Dr Niall O'Leary (School of Microbiology, ERI) featuring in the online *Sick of Plastic* Screening and panel discussion in May 2020 hosted by The Action Network. *Sick of Plastic* follows the life cycle of plastic while also examining the worldwide effect it has on both the health of our planet and the people who inhabit it. Niall was amongst a panel of experts who discussed the issues involved in the film and provided an Irish perspective.



## Stand-up for climate

Bright Club Ireland is a comedy night featuring academics from science, humanities, and social science talking about their work alongside professional comedians and musicians. In 2020, Dr Aoife Long (MaREI, ERI), who had formerly *Danced My PhD*, showcased the further diversity of her science communication talents by taking part in the Bright Club and performing her online comedy set which touched on the ups and downs of life as researcher. Aoife also took part in the ESAI Citizen Engagement Webinars which ran during the summer

of 2020, speaking about *Developing a dance-based workshop in Science Communication*. The webinar series also featured an appearance from Dr Jean O'Dwyer (iCRAG, BEES, ERI) on *Safeguarding private water supplies from contamination through public engagement*.



## Science for everyone – just some of ways in which our researchers have brought science to new audiences in 2020

**The Cork Literary and Scientific Society** recently celebrated their 200-year anniversary having begun in 1820 to host public lectures on a wide range of topics. As part of the anniversary celebrations, Professor Maria MacNamara (School of BEES, ERI), spent the evening speak-

ing to the society audience on the topic of *'Fossils in technicolor: detection and applications of fossil colour in ancient frogs, snakes and dinosaurs'*. Additionally, in March the Society heard from Dr Markus Eichhorn (School of BEES, ERI) on the topic *'Lasers in the Jungle'*.

**Cork Skeptics** is a group dedicated to promoting skepticism, science, and rational thinking in Cork City, Ireland and beyond. In January, the group invited Dr Paul Deane (MaREI, ERI, School

of Engineering & Architecture) to give an interactive public lecture in Blackrock Castle Observatory on the topic of *'Gone Fission – Is it time for Ireland to give nuclear power a chance?'*

**Dr Alicia Mateos Cárdenas** (BEES, ERI) was a guest on the Sustainable Ocean Alliance webinar series *Unmasking the Plastic*, which seeks to go beyond recycling to understand why plastics exist, who is producing them, and the wide-ranging ef-

fects on our social, cultural, political, and environmental landscapes. Alicia was amongst a diverse group of global experts with wide-ranging experiences and expertise as she provided insights from her research project *The Impact of Microplastics*.

**Cork Geological Association** brings together members of the general public who have an interest in earth sciences with a strong emphasis on geology. It presents an annual programme of lectures on geological and related topics and organ-

ises field trips to areas of geological interest in Ireland and abroad. In January, the Association heard from Dr Jean O'Dwyer (School of BEES, ERI) on the topic of *'Hydrogeology – Microbial contaminants in groundwater, a public health risk?'*

**PhD student Luke O'Reilly** of the Marine Geology Research group (iCRAG, BEES, ERI) was well-received for his online talk to the Kilkenny

Subaqua Club on the topic *'Cold Water Corals: Out of Sight, Not out of Mind.'*

**Professor John Wenger** (CRAC, School of Chemistry, ERI) appeared on the Pint of Science online event in May to talk about air pollution measurements taken in Cork, some of his research

on sources of air pollution, and about the impact of COVID-19 on air quality. John also mentioned his use of citizen science to track and to tackle air pollution.

## Section 9: Awards

### Professor Áine Ryall recognised in UCC Awards

Congratulations to Professor Áine Ryall, who was the recipient of the UCC College of Business and Law Advanced Researcher of the Year Award 2020. This award recognises and celebrates those UCC researchers who are making exceptional and influential research contributions, pushing boundaries, enhancing knowledge, and raising the national and international research profile of the University.

### SFI Science Awards recognise Professor Brian O’Gallachoir as key leader in the Irish Research Community

Professor Brian O’Gallachoir (ERI, School of Engineering & Architecture, and Director of MaREI) was presented with the SFI Best International Engagement Award 2020 by Minister for Further and Higher Education, Research, Innovation and Science, Simon Harris TD, at the annual SFI Science Summit in 2020.

### UCC Palaeobiology laboratory named finalist at the Irish Lab Awards

The UCC Palaeobiology group led by Professor Maria McNamara (BEES, ERI) was named as a *Research Laboratory of the Year* finalist at the Irish Lab Awards 2020. This is the second year in a row that Professor McNamara’s group has been recognised at the Irish Lab Awards, having won ‘Best Start-up Laboratory of the Year’ in 2019.

### MaREI researcher Connor McGookin receives winning vote in SFI outreach competition

Congratulations to Connor McGookin (ERI, MaREI) for winning first prize in the SFI’s *‘I’m an Engineer Get Me Out of Here’* - an online, student-led STEM enrichment activity which allows school students to connect with engineers through energetic, real-time text-based chats and then vote for their favourite engineer.

### Dr Marguerite Nyhan recognised as Emerging Leader by USA Alumni Association

Dr Marguerite Nyhan (School of Engineering & Architecture, ERI, MaREI and Visiting Scientist at Harvard University) has received an Irish USA Alumni Association Emerging Leader award, which recognises young alumni of U.S. exchange programs, who have made a significant contribution to their community and demonstrated the potential for leadership and continuing service.

### Dr Eoin McLaughlin wins prestigious international sustainable development research society award

An article written by Dr Eoin McLaughlin (ERI, CUBS) and colleagues in University of St Andrews in the UK, entitled ‘The Circular Economy: Swings and Roundabouts?’, which examines the conceptual relationship between the circular economy and sustainable development has been awarded the best Sustainable Development Article 2019 from the International Sustainable Development Research Society (ISDR).

### Professor Astrid Wingler selected for Fulbright-EPA Award

Professor Astrid Wingler (Head of Plant Science, BEES, ERI) was the recipient of a Fulbright Award in 2020. Professor Wingler will visit the Department of Plant Sciences at the University of California, Davis from June to Sept 2021. In collaboration with colleagues at UC Davis, she will explore how annual exotic grass species differ from native perennial species in the processes involved in allocating carbon below ground, and how this affects the ability of Californian grasslands to sequester carbon. The research will combine plant physiological methods with plant and soil ecology, with the aim of transferring the expertise to back to Ireland to improve the sustainability of Irish grasslands.

### Dr Clodagh Harris awarded prestigious University of Canberra Award

Congratulations to Dr Clodagh Harris (ERI, Dept of Government and Politics) who has been awarded the University of Canberra’s Distinguished International Visitor Prize for 2020. The Prize is awarded to academics that facilitate strategic research collaborations between University of Canberra-based researchers and international partners

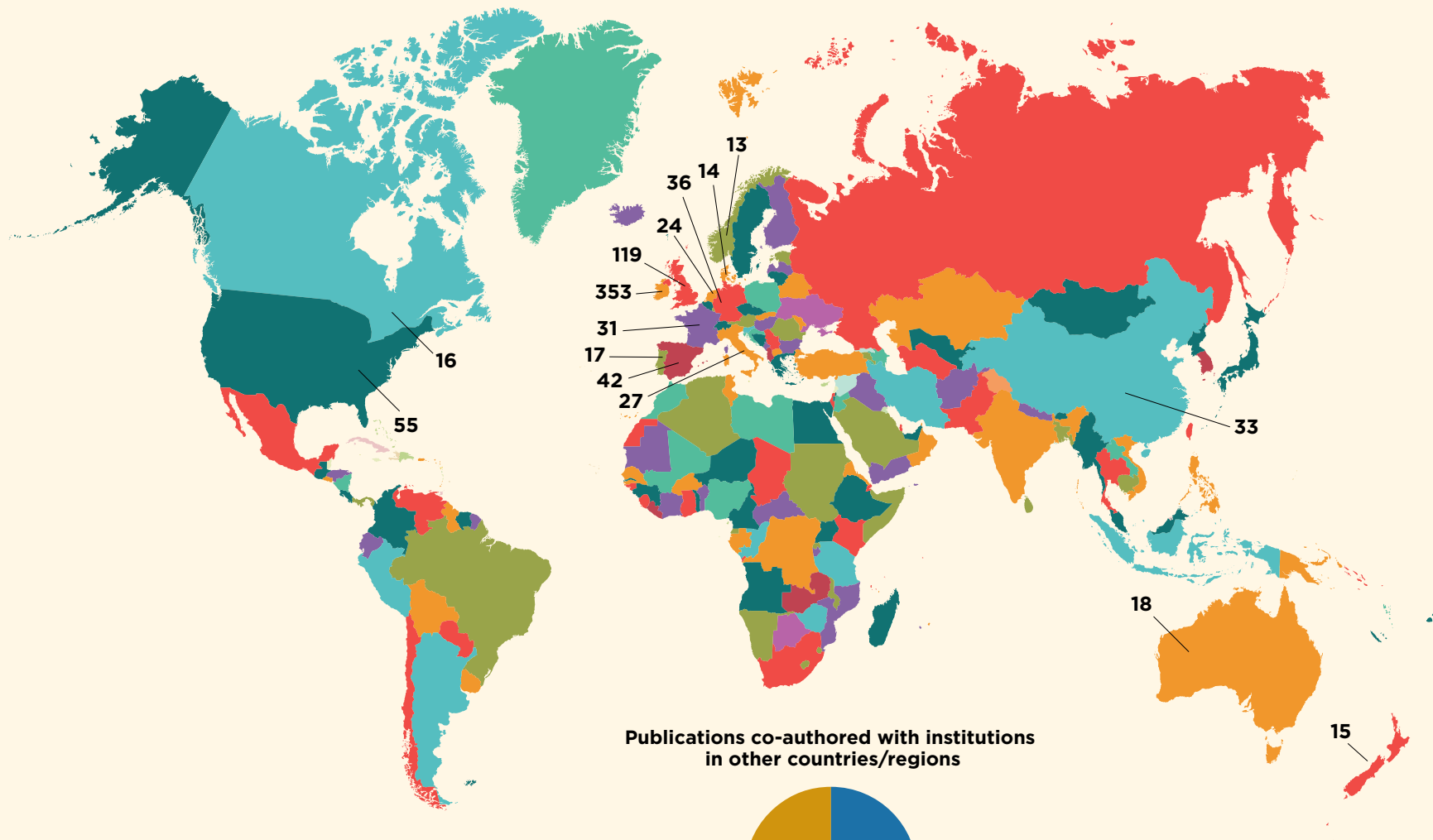


## Section 10: ERI around the world in 2020

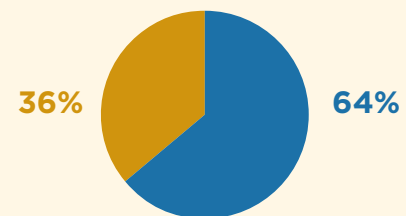
The ERI has collaborative partnerships with over 500 national and international universities and companies, which result in hundreds of publications annually. The top 15 countries with which we produced the most publications in 2020 are highlighted here.

### Top 15 countries

Ireland	353
United Kingdom	119
United States	55
Spain	42
Germany	36
China	33
France	31
Italy	27
Netherlands	24
Australia	18
Portugal	17
Canada	16
New Zealand	15
Denmark	14
Norway	13



Publications co-authored with institutions in other countries/regions



■ Published with national co-authors  
■ Published with international co-authors

## Section 11: ERI 2020 PhD and Research Masters Awards

POSTGRADUATE		QUALIFICATION	SUPERVISOR(S)
Archer	Louise Claire	PhD (Science)	Dr Thomas Reed Professor Philip McGinnity
Balaji	Preethi	PhD (Science)	Dr Fiona Cawkwell
Banta	Russell Alan	PhD (Science)	Dr Eoin Flynn Professor Justin Holmes Dr Paul Young
Barrett	Dylan Edward	Master of Research	Dr Barbara Doyle-Prestwich Dr Eoin Lettice Dr Fidelma Butler
Brosnan	Stephen	PhD (Commerce)	Dr Declan Jordan Dr Jane Bourke Dr Patrick Morrissey Dr Eleanor Doyle
Buckley	Darragh	PhD (Science)	Professor Colm O'Dwyer Professor Martyn Pemble
Buckley	Paul Christopher	PhD (Science)	Professor John Wenger Professor John Sodeau
Collins	Evan Vincent	MSc (Commerce)	Dr Lawrence Dooley Professor Mary McCarthy Dr Seamus O'Reilly
Drummond	Conor Michael	PhD (Commerce)	Dr Helen McGrath Professor Mary McCarthy
Duffy	Annie	Master of Research	Dr Dominic O'Sullivan
Felemban	Shifa	PhD (Science)	Dr Eric Moore Dr Patricia Vazquez
Fennelly	Mehael	PhD (Science)	Professor Michael Prentice Professor John Sodeau Professor Justin Holmes
Finlay	Ross	PhD (Science)	Dr Thomas Reed
Galluccio	Emmanuele	PhD (Engineering)	Dr Ray Duffy Professor Justin Holmes
Giraud	Elsa	PhD (Science)	Professor Justin Holmes Professor Michael A Morris
Gray	Stefan Robert John	PhD (Arts)	Dr Robert J Devoy Dr Kieran Hickey Dr Barry M Brunt
Hanley	Martina Mary	Master of Research	Dr Barbara Doyle-Prestwich Professor Astrid Wingler
Ihua	Wada Maureen	PhD (Science)	Professor Alan Dobson Dr David Clarke
Kennedy	Michael Noel	PhD (Science)	Dr Brenda Long Professor Justin Holmes Dr Ray Duffy

POSTGRADUATE		QUALIFICATION	SUPERVISOR(S)
Lalor	Fergal Martin	PhD (Engineering)	Professor Ed Byrne Dr Colin Sage Dr John J Fitzpatrick
Lambert	Luke	Master of Research	Dr Fiona Cawkwell Dr Paul Holloway
Lyons-Coakley	Maria Bernadette	DBA (Business Economics)	Dr Eleanor Doyle Dr Connell M Fanning
Mackey	Pamela	PhD (Science)	Dr Gerard P McGlacken Professor Martyn Pemble
Mackey	Katrina	PhD (Science)	Dr Gerard P McGlacken
Mateos Cárdenas	Alicia	PhD (Science)	Professor Marcel Jansen Professor John O'Halloran Dr Frank N A M Van Pelt
Meehan	Dara Eoin	Master of Research	Dr Barbara Doyle-Prestwich Dr Rossana Henriques
Murphy	Nora Teresa	DBA (Business Economics)	Dr Eleanor Doyle
O'Halloran	Edmond James	PhD (Science)	Dr Eoin O'Reilly Professor Justin Holmes
O'Keeffe	Paul	PhD (Science)	Professor Sebastian Wiczorek
Pasik	Adam Jozef	Master of Research	Dr Paul Leahy Dr Kieran Hickey
Pfalgraf	Hadley Colette Benbow	Master of Research	Dr Suzanne Timmons Dr Claire O'Neill
Quinlivan	Lauren Clare	MSc	Dr Deborah Chapman Dr Tim O'Sullivan
Rossi	Valentina	PhD (Science)	Professor Maria McNamara Dr David Jarvis
Ryan	Louise Patricia	PhD (Science)	Professor Martyn Pemble
Tang	Zhengguang	PhD (Commerce)	Dr Catherine Kavanagh Dr Eleanor Doyle
Thompson	Rosalyn	PhD (Science)	Dr Pdraig Whelan Professor Mark Charles Emmerson Dr Eoin Lettice
Van Druenen	Maart Kate	PhD (Science)	Professor Justin Holmes
Walsh	Thomas	PhD (Law)	Professor Owen McIntyre
Whelan	Joseph Kevin	PhD (Arts)	Dr Fiona Dukelow
Xie	Chun	PhD (Science)	Professor Sebastian Wiczorek
Yue	Xiufeng	PhD (Engineering)	Professor Brian Ó Gallachóir Dr Fionn Rogan

## Section 12: ERI 2020 Peer-reviewed Publications

1. Adrita, M., Brem, A., O'Neill, P., Gorman, E., O'Sullivan, D. and Bruton, K. (2020) *Development of a decision support system to enable adaptive manufacturing*, Smart and Sustainable Manufacturing Systems, 4, 146-162.
2. Ahmed, M.R., Doyle, N., Connolly, C., McSweeney, S., Krüse, J., Morrissey, J., Prentice, M.B. and Fitzpatrick, D. (2020) *Tracking Yeast Metabolism and the Crabtree Effect in Real Time via CO2 Production using Broadband Acoustic Resonance Dissolution Spectroscopy (BARDS)*, Journal of Biotechnology, 308, 63-73.
3. Ainscough, K.M., O'Brien, E.C., Lindsay, K.L., Kennelly, M.A., O'Sullivan, E.J., O'Brien, O.A., McCarthy, M., de Vito, G. and McAuliffe, F.M. (2020) *Nutrition, Behavior Change and Physical Activity Outcomes From the PEARS RCT—An mHealth-Supported, Lifestyle Intervention Among Pregnant Women With Overweight and Obesity*, Frontiers in Endocrinology, 10, 938.
4. Al Kez, D., Foley, A.M., McIlwaine, N., Morrow, D.J., Hayes, B.P., Zehir, M.A., Mehigan, L., Papari, B., Edrington, C.S. and Baran, M. (2020) *A critical evaluation of grid stability and codes, energy storage and smart loads in power systems with wind generation*, Energy, 205, 117671.
5. Albuixech-Martí, S., Lynch, S.A. and Culloty, S.C. (2020) *Biotic and abiotic factors influencing haplosporidian species distribution in the cockle Cerastoderma edule in Ireland*, Journal of Invertebrate Pathology, 174, 107425.
6. Alexander, J.K., Caro, L., Dernaika, M., Duggan, S.P., Yang, H., Chandran, S., Martin, E.P., Ruth, A.A., Anandarajah, P.M. and Peters, F.H. (2020) *Integrated dual optical frequency comb source*, Optics Express, 28, 16900-16906.
7. Alkhayou, H. and Ashwin, P. (2020) *Weak tracking in nonautonomous chaotic systems*, Physical Review E, 102, 52210.
8. Allbrook, D.L. and Quinn, J.L. (2020) *The effectiveness of regulatory signs in controlling human behaviour and Northern gannet (Morus bassanus) disturbance during breeding: an experimental test*, Journal for Nature Conservation, 58, 125915.
9. Álvarez, M., Ramos, V., Carballo, R., Arean, N., Torres, M. and Iglesias, G. (2020) *The influence of dredging for locating a tidal stream energy farm*, Renewable Energy, 146, 242-253.
10. Andrade, L., Kelly, M., Hynds, P., Weatherill, J., Majury, A. and O'Dwyer, J. (2020) *Groundwater resources as a global reservoir for antimicrobial-resistant bacteria*, Water Research, 170, 115360.
11. Antonelli, A., Fry, C., Smith, R.J., Simmonds, M.S.J., Kersey, P.J., Pritchard, H.W., et al. (2020) *State of the World's Plants and Fungi 2020*, Royal Botanic Gardens, Kew.
12. Appah, J.K.M., Lim, A., Harris, K., O'Riordan, R., O'Reilly, L. and Wheeler, A.J. (2020) *Are Non-reef Habitats as Important to Benthic Diversity and Composition as Coral Reef and Rubble Habitats in Submarine Canyons? Analysis of Controls on Benthic Megafauna Distribution in the Porcupine Bank Canyon, NE Atlantic*, Frontiers in Marine Science, 7, 571820.
13. Archer, L.C., Hutton, S.A., Harman, L., McCormick, S.D., O'Grady, M.N., Kerry, J.P., Poole, W.R., Gargan, P., McGinnity, P. and Reed, T.E. (2020) *Food and temperature stressors have opposing effects in determining flexible migration decisions in brown trout (Salmo trutta)*, Global Change Biology, 26, 2878-2896.
14. Archer, L.C., Hutton, S.A., Harman, L., Russell, Poole, W., Gargan, P., McGinnity, P. and Reed, T.E. (2020) *Metabolic traits in brown trout (Salmo trutta) vary in response to food restriction and intrinsic factors*, Conservation Physiology, 8, coaa096.
15. Ariste, A.F., Batista-García, R.A., Vaidyanathan, V.K., Raman, N., Vaithyanathan, V.K., Folch-Mallol, J.L., Jackson, S.A., Dobson, A.D.W. and Cabana, H. (2020) *Mycoremediation of phenols and polycyclic aromatic hydrocarbons from a biorefinery wastewater and concomitant production of lignin modifying enzymes*, Journal of Cleaner Production, 253, 119810.
16. Arneill, G.E., Critchley, E.J., Wischnewski, S., Jessopp, M.J. and Quinn, J.L. (2020) *Acoustic activity across a seabird colony reflects patterns of within-colony flight rather than nest density*, Ibis, 162, 416-428.
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18. Balbaied, T. and Moore, E. (2020) *Electrochemical detection and capillary electrophoresis: Comparative studies for alkaline phosphatase (ALP) release from living cells*, Biosensors, 10, 95.
19. Balbaied, T., Hogan, A. and Moore, E. (2020) *Resazurin-based assay for quantifying living cells during alkaline phosphatase (ALP) release*, Applied Sciences (Switzerland), 10, 3840.
20. Ballinger, R.C. and Gault, J. (2020) *Editorial: Reflections on coastal climate change adaptation in North West Europe*, Marine Policy, 111, 103409.
21. Banta, R.A., Collins, T.W., Curley, R., O'Connell, J., Young, P.W., Holmes, J.D. and Flynn, E.J. (2020) *Regulated phase separation in nanopatterned protein-polysaccharide thin films by spin coating*, Colloids and Surfaces B: Biointerfaces, 190, 110967.
22. Bao, X., Sun, H., Iglesias, G., Wang, T. and Shi, C. (2020) *Signal denoising method for modal analysis of an offshore platform*, Journal of Loss Prevention in the Process Industries, 63, 104000.
23. Barrett, N.J., Hogan, R.I., Allcock, A.L., Molodtsova, T., Hopkins, K., Wheeler, A.J. and Yesson, C. (2020) *Phylogenetics and Mitogenome Organisation in Black Corals (Anthozoa: Hexacorallia: Antipatharia): An Order-Wide Survey Inferred From Complete Mitochondrial Genomes*, Frontiers in Marine Science, 7, 440.
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27. Belletti, B., Garcia de Leaniz, C., Jones, J., Bizzi, S., Börger, L., et al. (2020) *More than one million barriers fragment Europe's rivers*, Nature, 588, 436-441.
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30. Bergillos, R.J., Rodriguez-Delgado, C., Medina, L. and Iglesias, G. (2020) *Coastal cliff exposure and management*, Ocean and Coastal Management, 198, 105387.
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32. Blomberg, A.J., Nyhan, M.M., Bind, M.-A., Vokonas, P., Coull, B.A., Schwartz, J. and Koutrakis, P. (2020) *The Role of Ambient Particle Radioactivity in Inflammation and Endothelial Function in an Elderly Cohort*, Epidemiology, 31, 499-508.
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34. Bookelaar, B., Lynch, S.A. and Culloty, S.C. (2020) *Host plasticity supports spread of an aquaculture introduced virus to an ecosystem engineer*, Parasites and Vectors, 13, 498.

35. Bose, A., O'Shea, R., Lin, R. and Murphy, J.D. (2020) *A perspective on novel cascading algal biomethane biorefinery systems*, *Bioresource Technology*, 304, 123027.
36. Bot, F., Crowley, S.V. and O'Mahony, J.A. (2020) *Solubility enhancement of milk protein isolate by sodium caseinate addition: Comparison between wet- and dry-blending approaches*, *International Dairy Journal*, 105, 104661.
37. Bot, F., Crowley, S.V., O'Sullivan, J.J., O'Sullivan, M.G. and O'Mahony, J.A. (2020) *Colloidal, tribological and sensory properties of oral nutritional supplements*, *Italian Journal of Food Science*, 32, 956-969.
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39. Bradfield, T., Butler, R., Dillon, E.J. and Hennessy, T. (2020) *The factors influencing the profitability of leased land on dairy farms in Ireland*, *Land Use Policy*, 95, 104649.
40. Breen, P., Pirota, E., Allcock, L., Bennison, A., Boisseau, O., Bouch, P., Hearty, A., Jessopp, M., Kavanagh, A., Taite, M. and Rogan, E. (2020) *Insights into the habitat of deep diving odontocetes around a canyon system in the northeast Atlantic ocean from a short multidisciplinary survey*, *Deep-Sea Research Part I: Oceanographic Research Papers*, 159, 103236.
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42. Brem, A., Cusack, D.Ó., Adrita, M.M., O'Sullivan, D.T.J. and Bruton, K. (2020) *How do companies certified to ISO 50001 and ISO 14001 perform in LEED and BREEAM assessments?*, *Energy Efficiency*, 13, 751–766.
43. Brydegaard, M., Jansson, S., Malmqvist, E., Mlacha, Y.P., Gebru, A., Okumu, F., Killeen, G.F. and Kirkeby, C. (2020) *Lidar reveals activity anomaly of malaria vectors during pan-African eclipse*, *Science Advances*, 6, eaay5487.
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45. Bsaibes, S., Piel, F., Gros, V., Truong, F., Lafouge, F., Ciuraru, R., Buysse, P., Kammer, J., Loubet, B. and Staudt, M. (2020) *Monoterpene chemical speciation with high time resolution using a fastGC/PTR-MS: Results from the COV3ER experiment on Quercus ilex*, *Atmosphere*, 11, 690.
46. Buchwitz, M., Marchetti, L., Jansen, M., Falk, D., Trostheide, F. and Schneider, J.W. (2020) *Ichnotaxonomy and trackmaker assignment of tetrapod tracks and swimming traces from the middle Permian Hornburg formation of Saxony-Anhalt (Germany)*, *Annales Societatis Geologorum Poloniae*, 90, 291-320.
47. Buckley, D., Inguva, S., McNulty, D., Zubialevich, V.Z., Parbrook, P., Gity, F., Hurley, P.K. and O'Dwyer, C. (2020) *Photoconductive Solution Processed ZnO Quasi-superlattice Films*, *ECS Transactions*, 98, 151-158.
48. Buckley, D.N., Quill, N., O'Dwyer, C., Melly, T., Harvey, E. and Lynch, R.P. (2020) *(Invited) development of nanoporous structures and oscillatory behavior during anodization of n-InP in alkaline electrolytes*, *ECS Transactions*, 98, 89-106.
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50. Canwat, V., Oelofse, M., Onakuse, S. and de Neergaard, A. (2020) *Effects of certified-organic production on supplier failures and potential income effects of supplier failures on producers: Evidence from vegetable and macadamia producers in Kenya*, *Agribusiness*, 36, 751-769.
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52. Carr, C.M., Clarke, D.J. and Dobson, A.D.W. (2020) *Microbial Polyethylene Terephthalate Hydrolases: Current and Future Perspectives*, *Frontiers in Microbiology*, 11, 571265.
53. Carral, L., Tarrío-Saavedra, J., Iglesias, G. and San-Cristobal, J.R. (2020) *Evaluation of the structural complexity of organisations and products in naval-shipbuilding projects*, *Ships and Offshore Structures*, online.
54. Carroll, E., Buckley, D., McNulty, D. and O'Dwyer, C. (2020) *Communication - Conductive Paintable 2D Layered MoS2Inks*, *ECS Journal of Solid State Science and Technology*, 9, 93015.
55. Carss, D.N., Brito, A.C., Chainho, P., Ciutat, A., de Montaudouin, X., Fernández Otero, R.M., Filgueira, M.L., Garbutt, A., Goedknecht, M.A., Lynch, S.A., Mahony, K.E., Maire, O., Malham, S.K., Orvain, F., van der Schatte, Olivier, A. and Jones, L. (2020) *Ecosystem services provided by a non-cultured shellfish species: The common cockle Cerastoderma edule*, *Marine Environmental Research*, 158, 104931.
56. Cassarino, M., Bantry-White, E. and Setti, A. (2020) *Neighbourhood environment and cognitive vulnerability—a survey investigation of variations across the lifespan and urbanity levels*, *Sustainability (Switzerland)*, 12, 7951.
57. Cassarino, M., Quinn, R., Boland, F., Ward, M.E., McNamara, R., O'Connor, M., McCarthy, G., Ryan, D., Galvin, R. and Robinson, K. (2020) *Stakeholders' perspectives on models of care in the emergency department and the introduction of health and social care professional teams: A qualitative analysis using World Cafés and interviews*, *Health Expectations*, 23, 1065-1073.
58. Chen, M., Li, C., Morrison, A.P., Deng, S., Teng, C., Liu, H., Deng, H., Xiong, X. and Yuan, L. (2020) *Design and implementation of a compact single-photon counting module*, *Electronics (Switzerland)*, 9, 1131.
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## DISCUSSING GLOBAL WARMING IN THE SAUNA

A poem by Dr Fionn Rogan

The moment of recognition is delayed  
(we're wearing only swimming togs after all),  
Identities confirmed, greetings done:  
Two academics meet in the sauna at lunchtime.

How's it going?  
Not too bad  
How's the semester?  
Grand.

We're sitting comfortably on the top bench  
Where it's a balmy 90 degrees,  
Tentatively exchanging conversation  
In the hot dry heat.

How's the research going?  
Not too bad  
What are you working on?  
Usual stuff, climate change.

We work in the same department  
But don't always see eye-to-eye,  
My colleague has no problems  
Telling others what's on his mind.

This obsession with reducing carbon  
He says, throwing up his hands  
Global warming's going to happen anyway  
Just adapt like we always have.

He's probably expecting a reaction  
But I decide to bite my tongue,  
It's too hot to get animated  
And I want to see where this goes.

Sure it's easy to go on strike  
When you're only still in school  
Let's see what happens in the real world  
Will they protest when it's on them!?

I continue to listen quietly  
Sitting on the bench staying stum  
I think I'll learn more about contrarians  
By calm observation up close.

He wipes the sweat from his brow  
And steps down to the middle bench  
In the marginally cooler temperature  
He launches off again.

Just build those flood defences higher  
Or move further inland  
Much easier to do that  
Than decarbonise the energy system.

All the clichés are displayed,  
Tiresome talking points ad nauseum;  
He's sweating heavily now  
What's a few more degrees you know.

There's not much science on display  
Just a spectacular lack of self-awareness,  
He moves to the lowest bench  
We'll all be grand, he predicts.

And I suppose we will  
After all there is an exit door  
My colleague's edging towards it  
He looks at me once more.

Well I'm cooked anyway  
See you later!  
I wish him well  
As he rushes to go.

He cools down with a cold shower  
Not everyone will be so lucky.

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