The current buzzword in the UK academic hothouse is ‘Global Challenges’ – and for good reason. The United Nations’ Sustainable Development Goals – global targets around environment and development which the world has signed up to delivering on by 2030 - are looking ever more tricky to deliver. The Research Councils UK’s (RCUK) substantive Global Challenges Research Fund, therefore, is a welcome effort to direct scientific excellence at real-world problems through close collaborations with in-country partners and the application of transformative interdisciplinary actions.

In a way, that is precisely what the Sustainable Earth Institute at Plymouth University was set up to do. We are a platform for translating cutting-edge research into meaningful action, which we achieve by bringing together researchers and practitioners from multiple disciplines to work on some of the most pressing societal issues. You can get a flavour of the breadth of that work in the pages that follow, which showcase a suite of current research projects confronting a variety of global challenge themes.

Many of those themes feature prominently in ‘Sustainable Earth 2017’ (29 and 30 June) - our annual shop window for promoting what we do. As ever, the conference offers an eclectic mix of environment-related interests, though this year’s headline sessions merge global health and climate change. Infusing the event, however, is arguably our greatest academic challenge: communicating effectively with those communities that are most at risk. Which is exactly why these ‘research stories from the Sustainable Earth Institute’ are so telling.

“We are a platform for translating cutting-edge research into meaningful action, which we achieve by bringing together researchers and practitioners from multiple disciplines to work on some of the most pressing societal issues.”

Professor Iain Stewart,
Director of the Sustainable Earth Institute
Studies of the impact ocean acidification on zooplankton are usually carried out in the laboratory and very few species have been investigated. The current research used two volcanic CO2 seeps off Papua New Guinea as natural laboratories, thus giving us a clearer picture of the future impact of acidification on zooplankton communities.

A major reduction in zooplankton biomass was found on three separate expeditions in sites with high CO2. Joy’s PhD supervisor in Plymouth, Professor Jason Hall-Spencer, said “This research shows that if CO2 emissions were to continue along the IPCC’s ‘business-as-usual’ predictions there would much further damage to coral reef ecosystems worldwide. Demersal zooplankton are hardly ever studied as they hide within coral reefs by day, but at night they move up into the water providing vital food for corals and fish”.

Joy Smith has been studying coral reef zooplankton with colleagues in Australia, and has shown that rising CO2 levels cause a significant reduction to demersal zooplankton that live in coral reefs. This research has been the basis of her joint PhD at the Universities of Plymouth and Bremen.

Ocean acidification has diverse effects on zooplankton, damaging coral reefs.

Words: Professor Jason Hall-Spencer

With adequate protection from overfishing and habitat destruction I am confident that we can slow the decline in coral reefs.

Professor Jason Hall-Spencer
Research has shown that almost 100,000 tiny ‘microbeads’ of plastic could be released in every single application of cosmetic products. This could result in up to an estimated 80 tonnes of unnecessary microplastic waste entering the sea every year from the UK alone.

Microplastics can be mistaken for food by fish, leading to harmful effects on the growth, movement and breeding success of marine life.

Consumers have an important role in influencing the demand for products such as toothpaste soap and facial scrubs. A study led by Professor Alison Anderson explored the public perception and awareness of microbeads with help from marine biologists, psychologists and health experts.

Results showed that whilst environmentalists were originally aware of the issue, it lacked visibility and immediacy for beauticians and students. Regardless of any perceived level of harm in the environment, all three groups agreed that the use of microbeads was unnatural and unnecessary, and were surprised and concerned at the quantities and potential impact on the environment of the microbeads.

This research could inform future communications with the public and industry, as well as giving a positive indication that a ban on microbeads would be accepted.
Now, antibiotic resistant infections are a major threat to human health, killing over 25,000 people a year in Europe. A recent governmental review on antimicrobial resistance predicted that drug resistant infections could kill 10 million people a year globally and take $100 trillion off the global GDP.

The antibiotics crisis could be considered another ‘sustainability crisis’ alongside climate change, biodiversity loss and ocean acidification for example. They are all a consequence of our lack of attention to the long-term or the systemic, and dealing with it is likely to require difficult choices about who wins and loses. It is also a crises of the commons – a commons that is perhaps even more intangible than the air or sea.

Therefore, how we deal with the antibiotic crises may help us understand how to deal with other sustainability issues, and how we are dealing with things like international climate change negotiations may help with the antibiotic crises. However, there are signs antibiotics may be fixable through science in the way other sustainability issues can’t be.

Concerted efforts are urgently needed in the development of new antibiotics and diagnostic tools to guide prescriptions if we are to avert the crisis we face and sustain modern medical practice. In Plymouth, we are developing a new class of antibiotics for use in prevention and treatment of infections caused by ‘superbugs’ like MRSA. These new antibiotics work in completely different ways to current antibiotics and have excellent potential for use against drug resistant infections. In recent trials, a single dose of one of these new antibiotics was as effective as six doses of the current therapy, which justifies progressing towards clinical trials in humans.
Risky Communications

Words: Professor Iain Stewart

Faced with the soaring social and economic toll of natural calamities, in 2015 the world has adopted ‘a broader and a more people-centred preventive approach to disaster risk’.

The United Nation’s Sendai Framework recognised that a significant gap in our ability to deal with these events was in reaching the “last mile” - the most vulnerable and exposed populations - with timely, understandable and actionable warning information.

Plymouth University geoscientists are working to deliver on one of the key ambitions of the Sendai Framework, namely to ‘strengthen the utilization of media, including social media, traditional media, big data and mobile phone networks, to support successful disaster risk communication’.

Working on the volcanic Caribbean island of St Vincent, Dr Paul Cole (former Director of the Montserrat Volcano Observatory) and PhD student Lara Mani have pioneered the development of a video game that uses virtual reality simulations of known historical events to convey future hazard threats. Field testing confirms the potential effectiveness of such ‘serious games’ in communicating disaster risk to at-risk communities.

Dr Paul Cole and PhD student Lara Mani have pioneered the development of a video game that uses virtual reality simulations of known historical events to convey future hazard threats.

Simply raising awareness of hazards, however, isn’t enough. Social science studies document how people with a high awareness of hazard threats often show little inclination to prepare for them. One of the gravest hazard threats confronts Istanbul, where 13 million people live alongside the North Anatolian fault line and face a high probability of a major earthquake in the coming decade or so. PhD student Johanna Ickert is studying how Istanbul’s transformation of its most at-risk neighbourhoods has met strong opposition from local communities.

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With little signs of community preparedness, Johanna, a visual anthropologist, is exploring how film can be used in a participatory way to more effectively build local seismic resilience.

That resilience is especially critical in the days and weeks after a seismic shock, when damaging aftershocks hinder disaster relief efforts. To address this, a research project led by Edinburgh University is exploring the use of mobile phone technologies to get vital safety information to emergency managers and humanitarian agencies. Drawing on experience from Istanbul and elsewhere, Professor Iain Stewart is part of the team trying to understand how such information can be most effectively conveyed to those operating in crisis situations.

The findings from the current research underline the need for a holistic approach to risk communication that encompasses not just knowledge about the natural hazard but also understanding of the socio-economics, infrastructure, governance and culture of a community that is affected. Looking forward, it will require fresh inter-disciplinary linkages and the recognition of the importance of engaging with local people to understand what information is actually needed by those who are living with disaster.
The deep biosphere describes any habitat located below the surface of the continents and the bottom of the ocean, and comprises much of Earth’s total living biomass.

"Due to the importance the deep biosphere may play on Earth and also in the search for extra-terrestrial life, this realm has received considerable attention in research endeavours over the past three decades. Despite this, it is the most poorly understood ecosystem on Earth."

Dr Hayley Manners

Diverse and mostly uncharacterised microorganisms live in the deep biosphere, potentially playing a role in mediating global biogeochemical processes.

The research conducted by Hayley Manners and colleagues at Plymouth University and the University of Southampton is investigating whether evidence of microorganisms colonising volcanic deposits in the deep biosphere can be detected using their organic remains. As part of this work Hayley participated in an International Ocean Discovery Programme (IODP) Expedition (Exp370 – T-Limit of the Deep Biosphere; www.jamstec.go.jp/chikyu/e/exp370) last September, which aimed to investigate the temperature limit to life in the deep biosphere off Cape Muroto, Japan.

Understanding the origin, evolution and significance of this realm is important if we want to determine the role of the deep biosphere in the Earth system and how microorganisms thrive in such extreme environments, which in turn may provide insight into life elsewhere in the solar system.
There is growing concern about the impacts of ocean sprawl (the proliferation of artificial structures in our seas) on the structure and functioning of marine ecosystems, such as changes in ecological connectivity, facilitation of invasive species and global biotic homogenization.

Research led by Louise Firth explored how eco-engineering techniques can be used to mimic natural rock pools, pits and crevices on artificial structures. One such structure is the BIOBLOCK, which is a precast habitat enhancement unit that has multiple habitat types for supporting native biodiversity in intertidal habitats.

Results from the study showed that small-scale engineering interventions can have a significant positive effect on the biodiversity associated with artificial structures, promoting more diverse and resilient communities on local scales.

This knowledge can be applied to the design of multifunctional structures that provide a range of ecosystem services, whilst simultaneously delivering their primary engineering function.

Eco-engineering creates more sustainable ecosystems for the mutual benefit of society and nature

Almost 40% of the human population lives within 100km of the coast.

Coastal defences are proliferating globally to protect infrastructure and property from rising and stormier seas. Many counties are now boasting >50% artificial coastlines.

These featureless artificial structures often replace natural habitats and represent poor habitat for marine life, often being dominated by invasive and opportunistic species.

Small-scale engineering interventions can have a significant positive effect on the biodiversity associated with artificial structures
While tobacco is important, other factors such as smoke from cooking fires, outdoor air pollution and exposures at work are rising causes of chronic lung disease. Lung disease is putting a major strain on patients, families and health services.

Working with communities in Uganda, Vietnam and Kyrgyzstan, Dr Rupert Jones is running programmes to reduce the exposure to those at risk, and diagnose and treat lung disease. The team is designing and implementing new education and treatment programmes including pulmonary rehabilitation. This programme is highly effective and teaches people, whose lives are blighted by disabling breathlessness, about their disease and the steps they can take to get back work again.

Lung disease is putting a major strain on patients, families and health services.

In Jinja District of Uganda, we are working with the midwives to develop a ‘train the trainer’ programme to raise awareness of the dangers of cooking smoke for pregnant mothers and small children. Exposure in pregnancy can lead to adverse pregnancy outcomes and early infant death, poor lung growth and adult lung disease.

Chronic Obstructive Pulmonary Disease is almost unknown in many parts of the world but the World Health Organisation (WHO) estimates it is now the third leading cause of death worldwide. In a large survey in Masindi District we found 16% of adults over 30 years were affected, especially non-smoking women.

Addressing the problem of chronic lung disease in resource-poor settings

Words: Dr Rupert Jones

Lung damage from the air we breathe is a growing global problem and one of the leading causes of death worldwide.
Aquaculture is an exceptionally efficient food production system; as poikilothermic animals, fish easily outperform terrestrially farmed animals in terms of feed conversion rates. Finfish also have a lower environmental footprint than most terrestrially farmed animals, with carbon and methane outputs lower than those associated with beef, lamb and pork production. Bivalves and algae are extractive species, requiring no man-made feed sources, and as such they can have a positive impact on the environment, removing sources of phosphorous and nitrogen from the water column.

Our research at Plymouth University helps to underpin the sustainability of this expanding industry through fundamental and applied research to improve aquatic animal nutrition and health, and through our MSc in Sustainable Aquaculture Systems programme, we are training future aquaculture practitioners and policy makers. Our current research programme includes BBSRC, NERC, Innovate UK and industrial funding across a range of projects aimed at protection against sea lice parasitism, microbiome characterisation, gut health and use of algae and other raw materials to fish meal and fish oil in aquafeeds.

The human population is estimated to increase to 9 billion by 2050, requiring a 60% increase in food production by 2050, and 50% more protein by 2030. With only modest increases of agriculture production and more than 80% of the world’s fisheries fully exploited, aquaculture is an increasingly important contributor to food security.

Global aquaculture production has been expanding at a compound rate of more than 8% per annum over the past three decades. Total aquaculture production volume (approx. 100 million MT; farm gate value of US$160 billion) now exceeds beef production and accounts for 50% of the seafood consumed by humans. Finfish production accounts for the largest share of this activity with annual production standing at 50 million MT, which is worth US$ 100 billion.

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Uncertainty and Environmental Regulation

Climate Change is no longer a priority, or even an afterthought, for the hollowed-out US Environmental Protection Agency. There are thinly veiled threats to water-down UK ambitions in respect of the conservation of the natural environment following the decision to leave the European Union. It appears that hard fought environmental gains, underpinned by effective and ambitious regulation are in the cross-hairs.

Words: Jason Lowther

Inertia over the UK Government’s air quality plans means tens of thousands will suffer the effects of poor air quality for considerably longer than permitted in EU law – it’s certainly not contested, or imagined. To those slashing red-tape or making bonfires of regulators, framing environmental protection as an obstacle to growth permits the characterisation of environmental harm as nebulous, contested or imaginary.

The impacts of Brexit on environmental regulation, alongside ocean resource management and on cultural-heritage management comprise current sustainability-focused research projects underway in law. The centrality of the regulatory regimes to positive change is often understated and rarely appreciated. Whether it be creating a discourse around concepts like the creation of a crime of Ecocide, or forcing the hand of government to enforce the laws it is bound by, accountability is key and the mechanisms to effectively enforce are critically important.
Tom’s career has taken him around the world. Based in Sweden and the UK at the Brixham Laboratory, a state-of-the-art research laboratory that years later would effectively be given to the University by AstraZeneca, Tom led the company’s global environmental research program and worked extensively across Europe, Japan and North America. During his career in industry he investigated the use of agrochemicals, biocides and metals on marine and freshwater organisms, leading the adoption of methods to reduce animal testing and seek alternative environmental test methods. Tom’s work on animal alternatives has had a global impact, with the methods he developed being adopted in the environmental test guidelines program of the Organisation for Economic Co-operation and Development (OECD).

Tom’s role then shifted into the pharmaceutical healthcare sector, and he began to consider the environmental impact of medicines and the manufacturing facilities required to make them. It took him off to AstraZeneca’s R&D Headquarters near Stockholm for two years, before he moved back to the UK to become Head of Science for Environment and Health at Plymouth Marine Laboratory. Two years later, he joined the Centre for Environment, Fisheries and Aquaculture Science (Cefas), one of Defra’s science agencies, where he advised on the environmental safety assessment of chemicals in marine and freshwater ecosystems and fisheries.

Tom first arrived at the University of Plymouth in 1991 where he completed his industry-sponsored PhD on the effects of marine pollutants on the immune system of marine animals. Building on his international career, Tom returned to the University in 2013 and today teaches across a range of undergraduate and postgraduate courses in aquaculture, biology and environmental toxicology. Tom also serves as a member of the UK government’s advisory Expert Committee on Pesticides, is active as a science advisor to the UK Government Office for Science and the OECD. Tom is also an Elected Fellow of the Royal Society of Biology and a Fellow of the Linnean Society, and in his spare time enjoys sea kayaking and volunteering as a British Canoeing coach.
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If you have an article that you would like to contribute to a future edition of Sphere, please contact sei@plymouth.ac.uk