SAMS
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ISSUE 37

ABOUT US

SAMS (Scottish Association for Marine Science) is Scotland's largest and oldest independent marine science organisation. It delivers marine science for a healthy and productive marine environment through research, education, enterprise and engagement with society.

Based near Oban, SAMS employs 150 staff and as a partner in the University of the Highlands and Islands trains 160 students.

SAMS is a charitable body (009206) whose 300 members elect its governing Council.

It is also a Company Limited by Guarantee registered in Scotland (SC 009292) and delivers its enterprise porfolio *via* a commercial subsidiary, SAMS Research Services Ltd.

President: Prof GS Boulton
Director: Prof NJP Owens

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FROM THE EDITOR

Climate change covers a range of topics and the word clearly describes what we are witnessing on our planet. To plan how best to manage such a changing world and give ourselves the best chance of finding answers to our numerous global challenges we need our finest minds at the forefront of global research.

But given the ongoing gender disparity, do we really have the best people for the job? According to a 2012 report, women are involved in only 12% of scientific decision-making.

In this issue we speak to three scientists from SAMS about their views of the gender issue in science.

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Front cover
Dr Raeanne Miller presents a talk at the Accenture Girls in STEM event in Edinburgh.

Photo by Mike Wilkinson

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By SAMS Director
Professor Nicholas Owens

MARINE SCIENCE IN A POST-BREXIT BRITAIN

The sea and science have no borders. Actually, that statement is not strictly accurate. The sea does have borders, of course; the coastline is a border, of sorts, and there are some pretty impressive physical 'borders' in the open sea.

I well remember the first time I crossed the Antarctic Convergence in the Southern Ocean; I might well have just gone through the wardrobe door into Narnia, so abrupt was the transition. Of course there are also political borders and boundaries in the sea, or at least lines on charts.

But marine scientists mean something different when we say there are no boundaries. We are saying that the physical, chemical and biological worlds do not respect any social or politically imposed borders.

The issue of borders has been sharply brought into focus with the decision of the majority of UK voters to leave the EU. It certainly feels there are some very strong borders being erected against us, potentially restricting our scientific endeavours. We are beginning to hear of examples UK scientists prevented or discouraged from joining EU consortia, and non-UK scientists turning down job offers in the UK. The EU scientific community is important to us. About 15 % of our research income at SAMS was from the EU last year and a priceless component of our science comes from our EU staff and students and our collaborators. Whilst we are all nervous about the future at the moment, we must do everything we can to ensure we maintain our EU partnerships and relationships through lobbying, debate, contribution and discussion.

However, it is worth stepping out of the immediate feeling of crisis and taking the longer view about science. It may seem fanciful and philosophical, but scientific endeavour, like the sea, has always transcended social and political boundaries. Yes, we are in a storm at the moment but science is an activity of like-minded people, who by and large, are not constrained by boundaries.

I do not know how this current hiatus will turn out but I am confident a satisfactory solution will be found and we have to be among the architects of the solution. I firmly believe we should be expending our energies on looking for solutions rather than bemoaning what has happened. We need to swap the telephoto lens for one with a wide-angle view.

I am a great fan of Melvyn Bragg's Radio 4 series – 'In Our Time' – a history of ideas. This programme always highlights to me the bigger picture in which we find ourselves because of what has happened in the past. We are now at such a time and we have the responsibility and opportunity to move our science on in different ways.

I was also impressed with the editorial written by Lord David Willetts, the former Science Minister, in the Foundation for Science and Technology Journal for July 2016 (http://www.foundation.org.uk/journal/pdf/fst_21_09.pdf). Like many of us Prof Willetts recognised the challenge now facing UK science but eloquently made the case for taking advantages of new opportunities, rather than focussing on the decision.

GRAHAM SHIMMIELD

Trinidad, 1 Dec 1958 – Liverpool, 24 Dec 2016

On Christmas Eve the devastating news reached us that our highly respected former Director, Graham Barry Shimmield, had died from cancer.

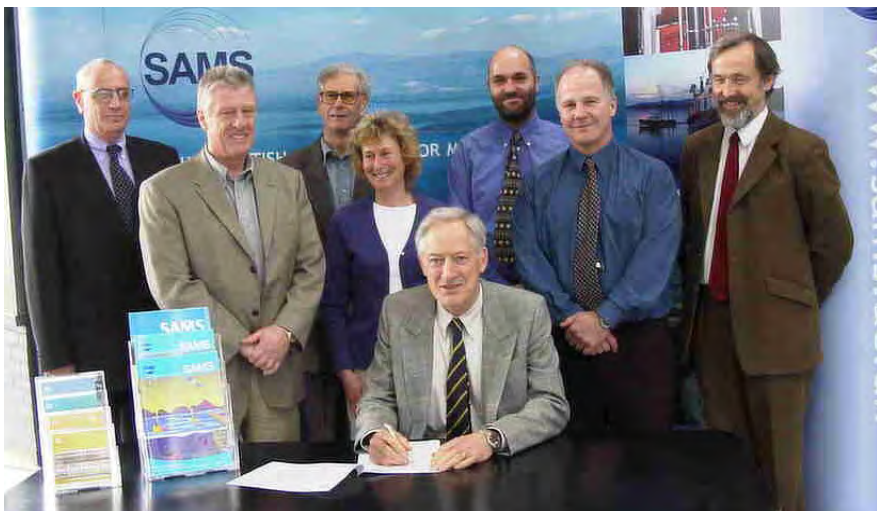
EDINBURGH DAYS

A geologist by training, Graham received his PhD in 1985 from the University of Edinburgh. He remained there until 1996, first as Lecturer and then Reader in Chemical Oceanography in the Department of Geology and Geophysics, developing a diverse research portfolio focused on indicators of climate change and human impacts on the marine environment. During this time he got married to Tracy and had two daughters.

SAMS LEGACY

As SAMS Director from 1996 to 2008 Graham transformed the organisation: doubling the number of staff; developing the Marine Science BSc and PhD programmes; negotiating a new relationship with NERC; building an £8M laboratory; developing the European Centre for Marine Biotechnology as a business incubator; broadening SAMS research to include Arctic science, biotechnology and social science; and setting up SAMS' first commercial subsidiary, SRSL. Arguably he was also the architect of a new sense of colleagiality and joint purpose among the staff, the ethos of SAMS as a family.

Graham was appointed joint Director of SAMS and the NERC's Dunstaffnage Marine Laboratory at the tender age of 37. In the early days he embedded SAMS in the UHI Project to help develop a new university and conjured up his masterplan for SAMS' future - including nascent ideas around a technopole with incubator hub and full-blown science park on our doorstep. He had to grow rapidly into his role as he arrived at times of fundamental change: in 1999 the political landscape changed with Scottish devolution and the opening of the Scottish Parliament. Then in 2001 NERC disbanded the Centre for Coastal and Marine Sciences (CCMS) of which DML had been part alongside Plymouth Marine Lab and the then Proudman Oceanographic Lab - casting SAMS into a funding and identity crisis. In response Graham diversified and grew SAMS.



In 2002 a new NERC-SAMS agreement placed the management of the entire laboratory at Dunstaffnage back to SAMS - handing greater responsibility and authority to SAMS Council and the Director. The agreement was signed by SAMS President Dr Ian Graham-Bryce (seated) in the presence of Council members (standing from left) Prof Mike Cowling, Dr Alistair Goodlad, William Balfour, Jane Twelves, Dr (now Prof) Paul Thompson, SAMS Director Prof Graham Shimmield and Prof Geoffrey Boulton (current SAMS President).

BIGELOW LEGACY

When Graham moved to the Bigelow Laboratory for Ocean Sciences in Maine, USA, in 2008 as their new Executive Director he created a similar legacy on the other side of

the Atlantic: nearly doubling the size of this institution, developing a philanthropy programme that allowed the building of a $32M marine research and education campus and the delivery of his final project, a $6M residence facility that was opened posthumously on 12th May 2017 as the Graham Shimmield Residence Hall.

MARINE SCIENCE LEGACY

Graham published more than 70 peer-reviewed papers, was a Fellow of the Royal Society of Edinburgh since 1998 and of the Royal Society of Biology since 1999. He was president of the European Federation of Marine Sciences & Technology Societies; chairman of the European Census of Marine Life; trustee and executive committee member for the Consortium for Ocean Leadership; and chairman of the International Science Advisory Board for the Decommissioning of Man-Made Structures in the North Sea, Oil & Gas.

CHARISMA

Graham had a sheer inexhaustible capacity for work, an encyclopedic knowledge of the marine science landscape, was a visionary strategist and innovator, a demanding but protective boss, a tough, tenaceous and competitive leader, and with his humble, generous and compassionate personality, very charismatic. His sense of responsibility was absolute and he packed 100 years of achievements into his tragically short 58 years of life. Extreme mountaineering and cycling served perhaps as an antidote to boardroom pressures.

HRH The Princess Royal opened the new SAMS research laboratory on 6th April 2004 - one of Graham's most tangible legacies to marine science in Scotland.

Graham is survived by his daughers Anna and Helen, his parents and his long-term partner and new wife, Jane.

We shall celebrate Graham's contribution to marine science and SAMS with an event on 21-22 September.

Anuschka Miller

Graham Shimmield loved working in the Arctic and initiated a major Arctic research focus at SAMS that has continued to flourish. This picture shows him in August 2007 in northern Svalbard during his last cruise with SAMS when he chose to be the 'gofer' on an expedition to recover our moorings onboard RV *Jan Mayen*.

PERSONAL RECOLLECTIONS OF GRAHAM

by Nicholas JP Owens

I can't remember the first time I met Graham. It would have been on some NERC committee. But I properly got to know him in 1992 when we went to sea together on the Sterna Expedition to the Southern Ocean aboard the RV *James Clark Ross*. It was an amazing cruise: a two ship expedition working in the Bellingshausen Sea Marginal Ice Zone (MIZ). I was Chief Scientist and Graham and Jim Smith from Edinburgh were looking at the isotope signatures of sinking particles. Our objective was to learn everything we could about the MIZ, its biogeochemistry, biology and physics. It was an incredible experience when we deliberately got the ship fast in the sea ice in ice stations. Meanwhile the RRS *Discovery* worked the open waters to the north as they became ice-free following the spring melt. We also had to do Antarctic base reliefs which gave us time ashore after shifting cargo. On one such jolly Graham impressed us all with his skiing abilities. Overall it was a most memorable cruise involving two medical evacuations back to Port Stanley and the sad deaths of the mothers of two of the scientists. All these events brought us close together and I left the cruise knowing Graham well.

Following this our paths kept crossing. We next worked together when Graham, now Director of the Dunstaffnage lab, invited me to become external examiner for the new UHI marine science degree. I was at Newcastle University

From left: Nick Owens with Ed Hill and Graham in 2013 in Hobart during the annual meeting of the Partnership for Observation of the Global Oceans (POGO).

and it allowed me to visit SAMS and socialise with Graham and many who are still here.

Then the Centre for Coastal and Marine Sciences (CCMS) arrived and, as one of the programme reviewers, I had the chance to take a view on SAMS' science and spent yet more time with Graham. Soon after this, in 2000, I applied to become the Director of PML and Graham was on my interview panel. I recall him falling asleep during my talk... This was a trait of Graham's, down to his crazy travel schedules. Graham became my line manager during those last days of CCMS and I had the opportunity to comment during a 360° review on his bonkers travel behaviour: he didn't listen but we remained good friends. For a few months Graham, Ed Hill and I jointly ran CCMS in the absence of a CCMS Director. Eventually we made a pitch to NERC Council about the future of CCMS, only to be told we each had a year to extract our organisations from CCMS and to become independent. That evening Graham and I left together on the train to London. We bought four cans of Stella each and by the time we got to London we were in fighting mood – ready to take on the world. Graham of course went on to do what he did at SAMS – a difficult act to follow.

After I had left PML for BAS Graham invited me to join SAMS Council. It was during my short stint on Council that he left for Bigelow. I kept up meeting Graham during POGO meetings and laterly in his role as Chair of the Insite Programme. Finally he became an advisor on a fundraising development group I set up at SAHFOS.

Graham was a kindhearted colleague and friend. He had boundless energy, a charismatic and persuasive personality and a great sense of humour: in short, someone with whom it was a pleasure to spend time with, at work or play. It was an honour to have known Graham and the world is genuinely the poorer for him not being in it.

MARINE PROTECTED AREAS HELP LIMIT CLIMATE CHANGE

Scotland's Marine Protected Areas (MPA) are helping to combat climate change, according to new research findings by SAMS scientists.

Evidence gathered for a report published by Scottish Natural Heritage (SNH) found that the amount of carbon stored within Scotland's inshore MPA network is equivalent to four years of Scotland's total greenhouse gas emissions.

The world's oceans and coastal ecosystems play a vital role in trapping and storing carbon dioxide from the atmosphere that would otherwise contribute to climate change. So-called 'blue' carbon is captured and stored across a range of marine habitats and seabed types. Some blue carbon is stored in living habitats, such as seagrass beds, kelp forests, cold-water coral reefs, and mussel beds. The majority is stored in seabed sediment, accumulated over many years.

As with peatlands on land, healthy marine habitats can provide multiple benefits, including by storing carbon. However, when they are damaged or destroyed, the greenhouse gas is released back into the atmosphere.

Scientists estimate that about 90% of the blue carbon within Scotland's MPA network is stored in seabed sediments and is relatively stable.

The living habitats, however, such as maerl and flame shell beds, are more sensitive to physical disturbance and many of these are protected features in the MPA network.

Professor Mike Burrows from SAMS, the principal author of the report, said: "Coastal vegetation and sediments are sources and stores for 'blue' carbon. While it has been a challenge to map coastal habitats and sediment deposits, our understanding of the processes involved have allowed us to calculate how much blue carbon is produced and stored in each of the MPAs.

We now have a good baseline for directing efforts to protect blue carbon in Scotland's coastal seas." website.

AMBIO COMES TO SAMS

The UK's marine biogeochemistry community will gather at SAMS this autumn for the annual AMBIO (Advances in Marine Biogeochemistry) conference.

The event, which welcomes around 60 participants, connects disciplines and establishes networks for the integration of early career scientists.

AMBIO VIII will take place from 5-8 September and will involve talks, poster sessions and workshops. There will also be a conference dinner and ceilidh on the Thursday night.

SAMS marine geologist Dr Kirsty Crocket, who is helping to organise AMBIO VIII, said: "We are excited to be hosting an event like this at SAMS.

"As well as showcasing one of the most beautiful parts of the country, we will have the opportunity to share our research with early career researchers from across the UK.

"Delegates at AMBIO events are always enthusiastic and energetic, which is crucial to forming collaborations."

AMBIO is a special interest groups of the Challenger Society.

ARCTIC SCIENCE AT SAMS
NEW COLLEAGUES AND PROJECTS

The impact of reducing Arctic sea ice cover on polar oceanography and ecosystems remains a major research focus at SAMS in 2017, a year when the institute will host the **UK Arctic Science Conference** in Oban from September 19–21.

SAMS is reaffirming its commitment to Arctic research by leading two projects in the Natural Environment Research Council's Changing Arctic Ocean research programme: Arctic PRIZE and DIAPOD will rely on international collaborations to help understand rapid changes in the Arctic, focussing on climate, ocean properties, marine life and food stocks. **Arctic PRIZE** aims to examine how reducing sea ice cover is affecting the productivity of the Arctic, while **DIAPOD** assesses the role of the copepod zooplankton *Calanus* as a crucial element of the marine food web. The SAMS contribution to these projects includes autonomous robotic systems from its NERC-funded Scottish Marine Robotics Facility.

Dr Kirsty Crocket, SAMS Palaeoceanographer, has recently been appointed as scientific coordinator for the entire Changing Arctic Ocean programme. Visit the new website for an overview: **www.changing-arctic-ocean.ac.uk**

SAMS is also part of the international **Blue Action** project, which aims to improve descriptions, models and predictions of the weather and climate on seasonal to decadal time scales in the Arctic and over the northern hemisphere.

Dr Tom Brown recently joined SAMS and is currently investigating how organic carbon derived from sea ice is used in polar environments. He has developed chemical biomarkers, including fatty acids, sterols and highly branched isoprenoids (HBIs) to understand how species may respond to decreasing sea ice cover, and potentially carbon supply.

The Arctic region has seen dramatic changes in climate over the past decades, with ice melting at a faster rate each year because of rapid warming. The average Arctic sea ice cover for November 2016 set a record low, leading to suggestions that sea ice cover could be at a tipping point, from which the region may not recover.

A NEW CLIMATE CHANGE DIET FOR BELUGA WHALES...

A researcher at SAMS has found evidence that marine species in the Arctic may have already been forced to alter their diets because of reducing levels of sea ice in the region.

Dr Thomas Brown has devised a new method to measure how much of a species' diet is derived from sea ice. Using the formula to monitor the eating habits of the beluga whale, he found a substantial change in how the community based off Baffin Island was getting energy from food. His findings have been published in the journal *Limnology and Oceanography*.

The Arctic population of beluga whales is already listed as 'near threatened' by the International Union for Conservation of Nature (IUCN). Because of overfishing and hunting up to the 1980s, the Cumberland Sound community studied by Dr Brown is also described as 'threatened' by the Committee on the Status of Endangered Wildlife in Canada.

Dr Brown's findings show that since 2000 these beluga whales and their prey, which are thought to be mainly Greenland halibut and Arctic cod, are adjusting to changes in the supply of food. Compared to before 2000, these fish and whales now demonstrate an increasing reliance on energy sourced from open water algae, rather than the Arctic's energy-rich sea ice algae that grow within the Arctic ice during spring.

Dr Brown said: "Some scientists are predicting that Arctic sea ice will disappear completely in the next 20 years or so, meaning this change is likely to be forced upon all Arctic animals."

"We know that carbon from sea ice algae is important for Arctic animals, but we need to quantify how much of that carbon is consumed in order to understand the full impact of sea ice loss."

The beluga whales in Cumberland Sound are in a sub-polar region, putting them on the front line of change in the Arctic. While their continued presence indicates they seem to be coping with these initial changes, there is a clear shift in the food web and ecosystem in the Arctic Ocean.

"Have the beluga whales altered their diet, or has their prey changed the way they feed to cope with the changing climate? It is important that we take steps to better understand how other Arctic and sub-Arctic animals will cope with the coming change."

CLOSE PARTNERSHIP BETWEEN SAMS AND NORWAY 'CRUCIAL' FOR ARCTIC RESEARCH

The sea ice melt in the Arctic offers us one of the most visual examples of how the Earth's climate is changing. The rapid melt has consequences for the entire planet, yet there is more research to be done to fully understand the extent of the impact.

Last year the House of Lords Arctic Committee warned that the UK could fall behind other nations in terms of Arctic research and urged the government to increase funding for Arctic science.

NERC has since issued a £16m UK research programme: Changing Arctic Ocean, which aims to understand how change in the physical environment will affect the large-scale ecosystem structure and biogeochemical functioning of the Arctic Ocean.

As an Arctic nation Norway is at the forefront of such research and, according to Professor Jørgen Berge of UiT, The Arctic University of Norway, Tromsø, the country considers its work in the Arctic as 'vital'.

One of the foremost Arctic researchers, Prof Berge has identified skills at SAMS that have become integral to his research on polar night ecology and how creatures are adapting to a rapidly changing Arctic climate.

"Our main discovery has been the fact that organisms and ecosystems are not in a state of rest or inactivity during the polar night," said Prof Berge. "It is in fact a critical time period for reproduction with activity levels on a par with those found during the light part of the year."

"During the last year, three major publications have come out, all of which deal with important breakthrough discoveries concerning the polar night, and all of which are based upon a close collaboration between researchers from Norway and SAMS. The partnership with SAMS has been absolutely crucial. I have worked closely with SAMS for 10 years, and the competence and capability of my partners there continues to be a backbone on the work we have done together.

"The physicists with their insight into local and large scale processes, the biologists with expertise on biological clocks and circadian rhythms, and not the least the eagerness to work in multidisciplinary teams are among their main strengths."

This willingness to cross borders to collaborate and share resources is an attribute required by small institutes to succeed, says Prof Berge.

"Norway places great emphasis on creating strong partnerships, both nationally and not least internationally. The strong collaboration and partnership between SAMS and Norwegian institutions like UiT and UNIS is a prime example of such a strategy - a partnership that benefits all parts. SAMS has a very strong standing and reputation internationally."

THOUSANDS OF UK CITIZEN SCIENTISTS STUDY COASTLINE

A major survey of the UK coastline is currently underway, thanks to an army of 'citizen scientists' who have been recruited with help from SAMS.

The Capturing our Coast (CoCoast) project aims to train more than 3,000 volunteers in monitoring and sampling coastal areas around the UK, in what is the world's largest ever coastal citizen marine science project.

The volunteers will help collect data around key species such as mussels, wading birds and hermit crabs. Results of the data collected will help inform future policy in conservation and marine protection and potentially give a better overall picture into how our climate is changing. SAMS is the only Scottish-based partner in the £1.7m project, which is funded by the Heritage Lottery Fund and led by Newcastle University.Volunteers are being trained in data collection at various centres across the country, including SAMS, where CoCoast's Scottish officer, Dr Hannah Grist, is based.

SAMS ecologist Professor Michael Burrows said: "Over the past few winters we have seen increasingly severe and frequent storms that are likely to be associated with rapid climate change.

"Alongside warming temperatures and ocean acidification, documenting how these changes are affecting our coastal habitats will be key evidence for influencing policy in the near future.

"Vulnerable rocky shoreline species can't escape the weather, and the storms we have seen the last two winters are likely to become more frequent, with greater damaging effects.

"As scientists, we can't be everywhere but people can tell us what's going on in their own back yard and we can collectively gather the evidence to fit into the wider picture."

Those interested in becoming a CoCoast citizen scientist can register online to attend training courses around the country.

Other partners in CoCoast include the universities of Hull, Portsmouth and Bangor, the Marine Biological Association of the UK and the Marine Conservation Society.

www.capturingourcoast.co.uk

Dr Hannah Grist is the CoCoast co-ordinator for Scotland and is based at SAMS.

ROBOTICS – THE FUTURE OF DATA COLLECTION

By Fraser MacDonald

Somewhere, in the middle of the North Atlantic, the new workhorses of oceanography are enduring 14ft swells and gale force winds. They don't get seasick, they don't need breaks.

'Diving deeper, travelling further, collecting more data'. That's the ambition of the marine robotics community - and it's a community that has grown exponentially within the past decade.

In 2012, UK Government announced what it believed to be the country's eight great technologies. Among the list was robotics and autonomous systems. The net result of government support is a significant investment across research institutes and the commercial sector.

SAMS has been at the forefront of this growth and, in 2015, announced the opening of the Scottish Marine Robotics Facility (Scot-MRF). Scot-MRF brings together a broad range of robotics and marine technologies to support SAMS research programmes.

The facility aims to push the boundaries of how scientists develop, deploy and operate

robotic systems, drawing on SAMS' exceptional scientific and technological expertise to answer some of the most complex oceanographic and atmospheric questions. From the perspective of a marine scientist, robotic systems offer a range of exciting capabilities. Systems can now spending up to seven months at sea, observe the seabed at 6,000 metres below the surface or produce high resolution maps of seabed topography.

From the North Atlantic Glider Base (NAGB), based at Scot-MRF, SAMS operates autonomous Seagliders that monitor the north Atlantic and track the ocean currents that drive our national and international climate.

Diving to depths of 1,000 metres and travelling at a snail's pace of 25 centimetres per second, autonomous Seagliders are the long-endurance brother of the autonomous system family. They are capable of measuring fundamental parameters; i.e. temperature, conductivity, density, dissolved oxygen and fluoresce, and can be 'piloted' from anywhere with an internet connect (including a smart phone). By using Seagliders, research programmes such as OSNAP and the Extended Ellet Line are able to vastly increase data collection between annual ship-based cruises.

Collecting data throughout the year, including the harsh winter months, is vastly improving the resolution in which we can view physical changes in the ocean and, subsequently, the global climate.

As well as Seagliders, Scot-MRF specialises in the deployment and operation of: short endurance, autonomous underwater vehicles (AUVs), airborne remote piloted aircraft systems (RPAS) and more commonly used remotely operated vehicles (ROV), which are tethered to a ship and controlled directly by a pilot.

Each system has strengths that are best utilised depending on the task at hand. Balancing the power requirements with endurance and manoeuvrability continues to be a challenge for the robotics community.

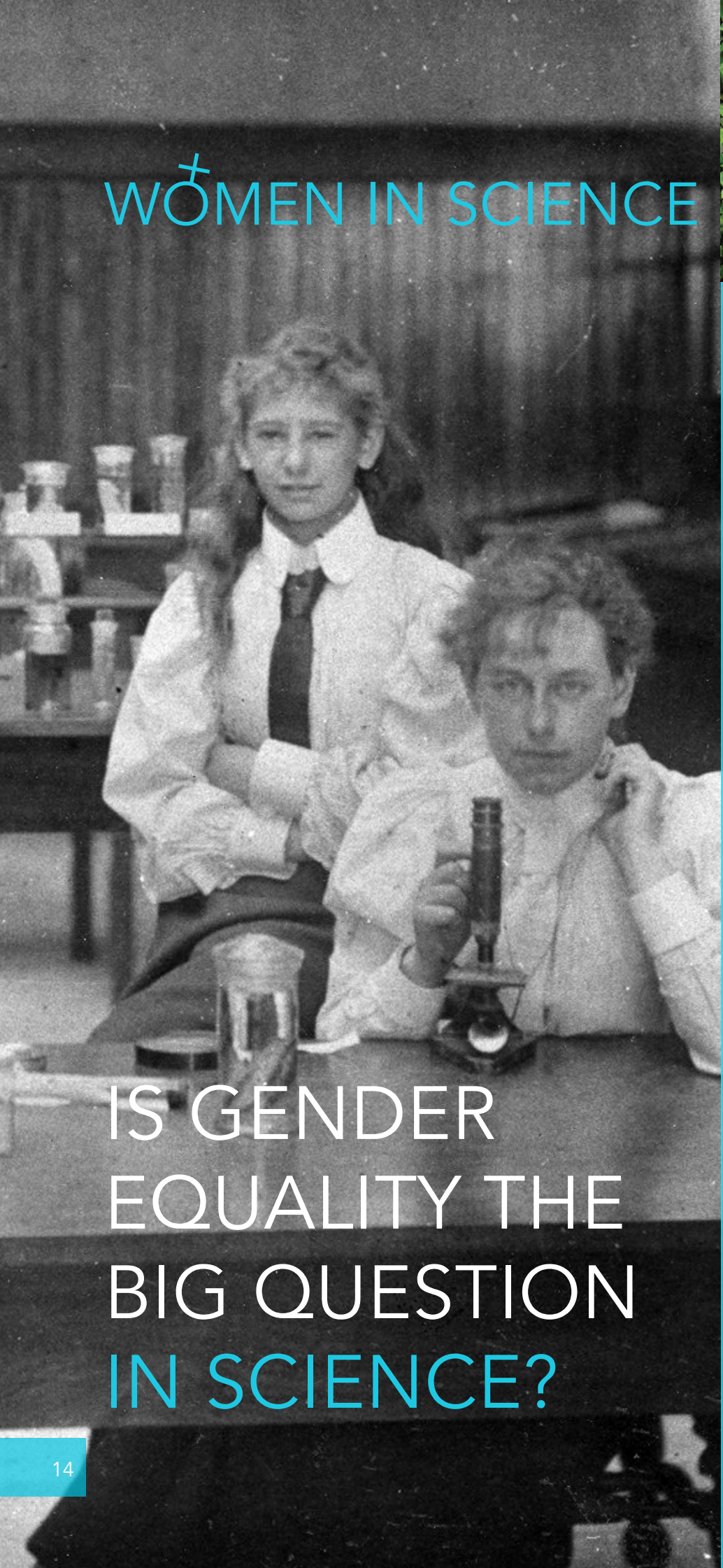
Fundamentally, the growing diversity of robotic platform capabilities is confined by the development in battery and sensor technology. In response, the community has begun exploring combined platform missions, bringing together multiple devices to perform carefully orchestrated missions. In 2015, Scot-MRF performed one of the first AUV/RPAS missions, allowing a remote aircraft to 'follow' an AUV on deployment.

This was no simple task but the outcome will allow subsurface and atmospheric measurements to be collected simultaneously, opening exciting opportunities to better understand complex ocean-atmospheric relationships. Applications could include monitoring and quantifying oil spills and identifying harmful algal blooms.

To ensure that robotics continues to support and enhance our science, SAMS and Scot-MRF have partnered with some of the UK's top marine institutes to provide a new Centre For Doctoral Training. The centre, known as NEXUSS (Next Generation Unmanned Systems Science), is joint funded by NERC and EPSRC and aims to develop a generation of future environmental science leaders.

These exciting studentships tackle major challenges in the environmental sciences by applying cutting-edge concepts, maintaining the UK's leading role in robotic development.

WOMEN IN SCIENCE



IS GENDER EQUALITY THE BIG QUESTION IN SCIENCE?

by Meagan Currie

I am an American undergraduate planning to major in microbiology and, taking a temporary pause from academia, I found myself on a science communication internship in the amazing community of SAMS.

There, I had the privilege of speaking with three of the many female scientists who generously offered their own experiences and insights into the evolution and direction of women in science.

Like so many students, I am drawn to research, innovation and technology, and although society is experiencing improvements in reducing all forms of bias in the scientific disciplines, there is no denying that gender disparities continue to exist in science, technology, engineering and mathematics (STEM).

In a study published in 2012, which evaluated the roles of women with STEM careers in the world's leading knowledge-based economies (the EU, United States, Brazil, South Africa, India, Korea and Indonesia), women participate in only about 12% of scientific decision-making in the academic and corporate sectors. Women comprise 26.4% of Britain's science and engineering technicians, 17% all UK STEM professorial positions and 13% of all STEM careers in the UK.

DR. TRACY SHIMMIELD

Tracy is a scientific pioneer. Her research career flourished in the most gender-divided fields in STEM, and through her work in SAMS' commercial operations she represented the vital link between research and enterprise at SAMS.

At 16, Tracy entered into an all-male workplace in the pharmaceutical industry – an experience she describes as, "quite an education". As Tracy said: "The fact I was female never really entered my head, to be honest. If you've got ambition and drive, then you tend to find your path."

Early in her education Tracy ignored blatant, gender-based disregard (her high school and physics professor assured her that, as a woman, her career in science would stop when she started a family).

She also was unperturbed by the striking gender-ratio during her early years of research as one of only two women in a staff of over 50.

In 1997, after securing EU funding to examine the Baltic Sea, Tracy relocated to SAMS with then husband Graham Shimmield and played a pivotal role in the evolution of the institute.

"It had an absolutely great atmosphere," she recalled. "I had always been in a single-discipline environment before, so coming into an area where all the marine fields were there was exciting; it was fun."

Despite the positive research environment at SAMS, she spoke of the particular challenge of moving into the managerial side of science. She said: "I used to be the only woman in an executive group, and that was hard at times. When I came in it was a group of people that communicated in the same way – women communicate differently. **Do you change in order to communicate more like a man, or do you communicate like a woman and slowly affect the environment?** It's wrong to think it will change suddenly just because you come in. **I think women, even confident women, actually take knocks to their self-confidence more than men**. We question our use and how well we're doing. Women can be their own worst enemies for that."

In March of 2014 Tracy became a finalist in the prestigious Director of the Year Awards, organised by the Institute of Directors (IOD). She was also recently inducted into the Scottish Innovation CAN DO forum, an elite position given to just six female and 12 male executives across the country.

UPDATE

In late 2016 Tracy was appointed Co-Director of the new Lyell Centre in Edinburgh, which supports the terrestrial and marine geology and geoscience work at the British Geological Survey and Heriot-Watt University.

WOMEN IN SCIENCE

DR RAEANNE MILLER

Raeanne is the epitome of an energetic, young female researcher intent on making professional waves.

As the only Scottish-based scientist awarded a place on the inaugural all-women Homeward Bound expedition to Antarctica last winter, she has become increasingly conscious of gender differences in science.

On December 2 last year Raeanne, a marine ecologist, joined 76 other STEM professionals for the maiden voyage of this remarkable initiative. The 10-year Homeward Bound project aims to unite women in STEM by creating a supportive network of fellow female professionals, constructively improving their leadership skills, and educating them on cutting-edge polar and environmental research techniques. Over the coming years, the initiative will form a network of 1,000 influential female scientists.

Raeanne is particularly interested in the programme's efforts to target participants' personal unconscious biases, a phenomenon in which she has developed a growing interest.

"Mental bias doesn't just come from men," she says. "Women are prone to limiting themselves and one another as well. I think being aware of that bias is really important in analysing your initial gut feeling towards decisions and taking a moment to think, "Why do I feel that way?"

Confronting these biases early in life is critical, as the UK faces a severe shortage of STEM professionals in decades to come. Increasing the number of women in the STEM labour market could increase British income by £2 billion (Science and Technology Committee, 2014). Raeanne has become increasingly involved in outreach efforts, serving as a keynote speaker at a Girls in STEM conference at the National Museum of Scotland in Edinburgh. The UK-wide event aimed to encourage girls aged 11 – 15 into STEM subjects.

Raeanne's personal connections to science were present from a very young age, a factor that she discovered nearly all of her fellow Girls in STEM keynote speakers shared. "My dad was an engineer, so I've never questioned wanting to do science," she explained.

"It could be a male or female role model, but a lot of us had dads who were scientists or engineers."

Since 2011, the percentage of women completing engineering and technological degrees has increased by 5% in the UK. In 2014, women completed 59% of degrees in the biological sciences and 41% of those in physical sciences (WISE annual report, 2015). However, the gender ratio divide becomes increasingly significant in the professional arena past the post-doctoral level. Women hold, on average, only 17% of all STEM professorial positions (Science and Technology Committee, 2014).

Raeanne observed: "Women tend to have kids at the same time that you're expected to move all over the world for your job. The fact is that in science you are judged on your publication output and your grant input. If you choose to have kids, it can mean a gap in your publications and grant success."

The intrinsic psychological differences between men and women and their impacts in the workplace are of interest to Raeanne. "Women often seek a different level of professional validation than most men," she said. "We frequently have less confidence in the quality of our work."

"But if you know what motivates you and those around you, you're better able to understand other people's perspectives and what helps them to work most effectively. I think that's something that women in leadership positions can be really good at."

For women, who have struggled to gain the same levels of recognition as their male colleagues historically, the changing face of communication is a remarkable tool for self-promotion and networking. Raeanne has embraced the rapid changes in scientific communication, and makes a large effort to maintain a professional social media profile.

"It will never replace your career-related achievements, but social media is fantastic because it's a complete leveller," she explained. "You can connect and exchange information with people at all professional levels, not just on a peer-to-peer basis."

WOMEN IN SCIENCE

DR BHAVANI NARAYANASWAMY

As a senior lecturer, a leading principal investigator, a wife and a mother of two young children, Bhavani is the illustration of a woman who refuses to accept that you should choose between family life and a career.

She currently juggles an impressive array of tasks as convenor of the MASTS Deep Sea Forum, the head of the SAMS graduate programme, the lead deep-sea ecologist at SAMS, and is currently completing the papers for a series of Seamounts research projects, as well as drafting two grant proposals.
Of course, Bhavani is also chairwoman of Taynuilt Primary School Parent Council...

Bhavani is one of many scientists at SAMS who are also parents. Her children, now five and seven, are enrolled locally at nursery and primary school. Both Bhavani and her husband, Prof Keith Davidson, are senior researchers at SAMS.

Explaining how the couple manage full-time research and raising a family, Bhavani said: "It was never a matter of sacrifice. We just needed to work out how to find balance." Admitting she lost 'career momentum' while on maternity leave, she added: "You must be realistic and not punish yourself. I tried to keep in touch with colleagues professionally while on maternity leave so I didn't slip off the radar, but the second time through I decided, "No, it's too much pressure".

In order to smooth the transition back into work, the Research Excellence Framework acknowledges circumstances such as maternity leave, and accordingly mitigates the number of publications an institution can expect from employees.

For STEM research couples who split childcare equally, the system can make the first few years of parenting quite inflexible for fathers.

Bhavani said:
"We need to support women in science, but we also need to support parents in science."

For most STEM careers, conference trips and research expeditions are necessary but Bhavani has become extremely selective about what she chooses to attend since becoming a mother.

"When I am working, I appreciate time is precious, so I don't stop for coffee, I don't stop for lunch, because I don't have time to do that. But it means that between the time I pick up my children and the time they go to bed I don't do any work. It wouldn't be fair on them if I did. Only after they go to bed do I start again.

"Inside, every parent is struggling and we feel that everyone else is doing better than we are. No one wants to ask for help, but by talking to friends and colleagues, things become a little more manageable. People are typically receptive to the demands of parenting."

SEAWEED INDUSTRY DOUBLES UP DOWN UNDER

A former SAMS researcher who heads up an Australian seaweed company that supplies seaweed products says demand is high for the 'superfood' that has been shown to have remarkable health benefits.

Entrepreneur and researcher Dr Craig Sanderson, who completed his PhD at SAMS, is joint owner of Kai Ho Ocean Treasure and is overseeing a doubling of sales year on year. His company, based in Tasmania, began in 2014 selling ingredients to local restaurants and distributors in the larger cities of Australia. Since then, interest from organic health food stores has grown and sales are picking up across the country for the company's dry packaged products.

Dr Sanderson reckons the popularity of seaweed as a food is down to its versatility and nutritional benefits. "It is high in protein, dietary fibre, long-chain omega-3 fatty acids and has a suite of vitamins, minerals and antioxidants," he said. "Regular consumption can reduce obesity and associated illnesses."

There are many uses for seaweed products, including keeping the flavouring and colour distributed evenly through flavoured milk products, giving smoother texture for ice cream, and maintaining the head on beer.

"A local company is doing very well extracting fucoidans from seaweed. This is a nutraceutical with anti-viral and anti-cancer properties."

"In Tasmania, we are marketing a seaweed that looks like little green glass beads and tastes like cucumbers which is commanding good prices."

A challenge for producers is getting the required volume of seaweed all year round. Dr Sanderson's company has looked to overcome this by growing its own seaweed and, at present, the company stockpiles seasonal produce by freezing it so it can be used out of season.

Scotland has a long tradition of seaweed use: eg as a fertiliser and in the manufacture of glass and soap. Seaweed has also been part of the diet of Irish and Scottish coastal dwellers for at least 4,000 years.

But Dr Sanderson has his sights set on a future food product that should capture the imagination: Scottish bacon flavoured dulse. Stranger things have happened...

WORKING WITH PERU AND SEYCHELLES IN BLUE ECONOMY RESEARCH

SAMS' international reputation in aquaculture development has led to partnerships with two international universities, both looking to develop the blue economy in their respective countries.

The institute has recently signed two memoranda of understanding, one with Peru's top-ranked research university, Universidad Peruana Cayetano Heredia (UPCH) in Lima, and the other with the University of the Seychelles (UniSey).

Situated on the Pacific coast, and incorporating parts of the River Amazon, Peru has traditionally relied on minerals and oil extraction for economic growth. Its fishing sector is promising, but unsustainable and vulnerable to climate change and volatile export markets.

This has prompted the government to further develop alternative industries. One of these is aquaculture, a sector that can provide sustainability, but has yet to fully develop its potential. Through UPCH, Peru is looking to realise this potential in aquaculture and took the first steps towards collaborating with SAMS when Dr Maria Rivera Chira, representing university rector Dr. Fabiola León Velarde, signed a memorandum of understanding at the Scottish institute with SAMS deputy director Prof Axel Miller.

Dr Rivera was accompanied by Dr Luis Huicho from the Peruvian university during the visit to SAMS. Their trip followed on from a British Council-funded visit by SAMS researchers to Lima last November.

"Peru is rich in biodiversity, but we need to conserve that," said Dr Rivera. "Our university is only 54 years old and we have only been doing marine science for 10 years. This is our first steps into aquaculture – it is a very exciting time for us."

Meanwhile, Senior Lecturer in Sustainable Aquaculture at SAMS, Dr Adam Hughes has recently returned from a three-month sabbatical in the Seychelles, where he signed a memorandum of understanding with UniSey (see page 22 for Adam's story).

The memorandum was signed by the vice-chancellor of UniSey, Professor Dennis Hardy, in a ceremony at the British High Commission in Victoria. Also present at the ceremony was the British High Commissioner to Seychelles Caron Röhsler.

Ms Röhsler said SAMS' expertise in mariculture, aquaculture, renewable energy and a range of other ocean potentials had impressed conference organisers.

And Prof Hardy said his university was privileged to be associated with one of the world's leading centres for marine sciences.

SEAWEED FARMING – A NEW SCOTTISH INDUSTRY?

By Meagan Currie

Plans to expand what is currently the only commercial-scale seaweed farm off the coast of mainland Britain could allow entrepreneurs to exploit the potential of the UK seaweed industry.

SAMS first initiated offshore cultivation in 2013, and has since provided the test-bed for a series of projects intent on establishing where, when and how seaweed growth is most effective.

Over the last five years SAMS has been involved in multiple initiatives to develop sustainable seaweed farming techniques, including the EU funded AT~SEA project, which designed revolutionary, multi-layer textile substrates to improve seaweed growth and yield. Since the project's completion in 2015 the spinoff company AT~SEA Technologies has been designed to continue technical developments.

The Port a Bhuiltin farm currently consists of 100 metre long-lines, spaced 4 metres apart and arranged in a grid. Rather than conventional rope, Drs Adam Hughes and Phil Kerrison are employing uniquely designed textile ribbons, which provide an ideal substrate onto which seaweed juveniles can anchor during seeding. During the five-month growth cycle, this farm alone can produce a spectacular 20 tonnes of product. Plans are now underway to install an additional hectare grid at the Port a Bhuiltin site, thereby doubling the farm size and resulting harvest.

SAMS can effectively perform all of its independent research on 800 metres of line, leaving four kilometres available for harvesting and other industrial purposes. The farm is an ideal platform for businesses wanting to learn the seaweed growth techniques, as SAMS provides both a pre-established setting ideal for many local species, and the knowledge and experience of seaweed experts. Two such projects are already underway: the £2.78 million initiative SeaGas - funded by the Centre for Process Innovation - and the Horizons 2020 project Macrofuels. SAMS is also leading the ensiling storage research for the SeaGas project.

In the future, Dr Kerrison also hopes to cater to the caterers. He said: "It's a great opportunity for chefs and restaurants to learn more about the product and to grow their own samples."

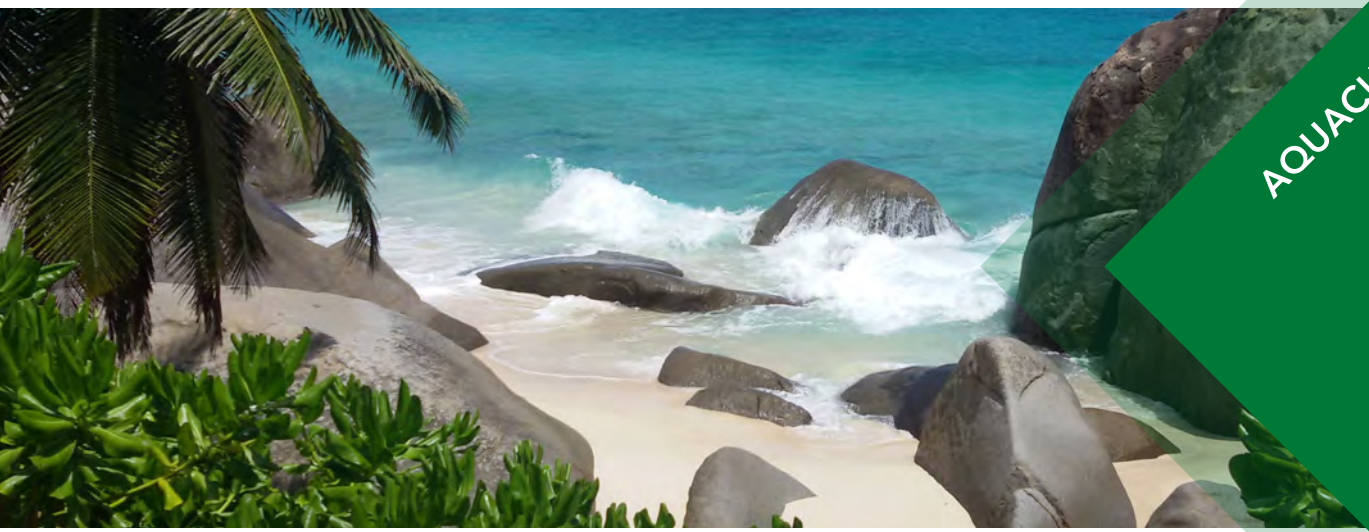
Seaweed farms have great potential value to the fish farm industry; seaweed absorbs excess nutrients such as those produced by fisheries, and could act as a productive nursery environment for commercially valuable fish. Through research and innovation, SAMS hopes to give the budding UK industry an environmentally sustainable foundation on which to grow.

SAMS is a leading institute in the GloablSeaweed network, which aims to bring together algal scientists and industry representatives in order to pool expertise.

A SABBATICAL IN THE SEYCHELLES

By Dr Adam Hughes

AQUACULTURE



Dr Hughes, SAMS prinicipal investigator into sustainable aquaculture, has recently returned from the Seychelles, where he helped the University of the Seychelles to develop the country's 'blue economy'. The following article was written by Dr Hughes during his stay there:

Here I sit in the cool of the dawn overlooking Anse Royale Bay, as the sun begins to colour the eastern sky, silhouetting the massive thunder heads that sit on the horizon with a pale pink glow. It is a favourite time for me; I won't say a quiet time, the surf thunders in the background, the geckos, chickens and dogs make for a unique, if not particularly melodious, dawn chorus.

But it is a time when the house is cool and quiet and a good time to sit on our veranda with the laptop, look out onto the Indian Ocean and do some work. It is also a good time to take stock of where we are: The Seychelles. When I told colleagues where I was planning to take my sabbatical, there was a pause followed by a wry smile on their faces. The inevitable jokes follow, mainly based around cocktails, beaches and palm trees.

So what I am doing in this earthly paradise and why did we make the decision to uproot our family life and take a three-and-a-half-month mini-sabbatical with the University of Seychelles (UniSey)? The Seychelles offered an unparalleled opportunity to have real impact, and open up another area of research. It is the smallest country in Africa when you look at the land mass, but has the second largest area of marine space on the continent.

The government of the Seychelles has pledged to base the economic and social development of the country on its marine resources, to look to the oceans to provide sustainable prosperity for its people, to embrace the Blue Economy. One of the areas that the Seychelles want to develop is aquaculture. Currently the economy here is based on tourism and fisheries, but the government is keen to diversify.

My host, the Blue Economy Research Institute (BERI) at UniSey, was recently created in response to the realisation that the Blue Economy is knowledge-based and that there was a real lack of capacity within the Seychelles in this field. It has been a great experience to be part of the BERI, a very small group with huge potential.

The Seychelles faces some of the toughest challenges of our modern world, such

as climate change adaption and mitigation, resource depletion, social and economic development.

But with its abundant marine resources, opportunities are as plentiful as the challenges, and for a marine scientist that is an exciting environment in which to work. My academic endeavor has concentrated on understanding how the Seychelles can develop a Blue Economy for aquaculture that allows social and economic development without depleting the very ecological resources that the country depends on.

When you come into an on-going political process such as this it can be difficult to find the line between being 'an external expert who knows everything and has all the answers' (despite having spent just a couple of months in the country) and academic detachment where you stand back and observe and wait to be invited into discussions.

To try and find this balance I set up a meeting with the Seychelles Fishing Authority (SFA), which is responsible for the development of aquaculture within the Seychelles Government. After some discussion, the concept of aquaculture within marine protected areas came up. I wrote a briefing document describing how aquaculture fitted into the International Union for Conservation of Nature's (IUCN) marine protected area classification and gave examples of good practise from around the world. This work and the subsequent discussion grew into an on-going relationship between SFA and the Ministry for Finance on how to co-develop aquaculture and the Blue Economy.

On a more personal note, the idea of a sabbatical was born four years ago after my wife Susannah and I were driving back from a concert we had been to for my 40th birthday. We started to discuss what we wanted to do in the future. Although both of us love living in Argyll, we had both travelled extensively before we had children and we thought we would like to do so again, but this time sharing the experiences with our two boys. The only question was 'when?' The surprising solution came through SRSL.

We were successful in bidding for a contract to provide technical expertise to the Seychelles Government through the Commonwealth Secretariat for development of the Blue Economy, and during a field trip in 2014 I made contacts within UniSey to allow the sabbatical to take place.

And so here we are. It has been exactly what we wanted: the university is about a five-minute walk from Anse Royale beach, so when I finish work, and some of the heat begins to go out of the sun, I leave the office, and walk down to meet the family for some snorkelling or messing around in the breakers, then tea and maybe a cold beer on the beach.

Susannah is home-schooling the children but is also involved in a few conservation organisations, so the boys are now regularly on 'turtle patrol' in the mornings, touring local beaches to check on turtle nests.

The weekends are spent exploring the marine life. The boys have become expert snorkelers and marine life aficionados (much better at identifying fish than me) and have an understanding of life beyond Argyll.

This sabbatical has been an opportunity to balance the professional and personal, to open up new intellectual fields and to share with my family some of the wonders of the world.

I have been extremely lucky to be able to do this, and even more so to be able to do it in the Seychelles. For that, I am very thankful.

HOW TO HUNT FOR A SEAWEED TREAT

Seaweed: one of our natural larder's greatest ingredients is right on your doorstep.

Seaweed's uses in food have been widely overlooked in modern times but whether it's the crimson-purple of *Palmaria* (dulse) against a dark slate shore, the flowing locks of *Himanthalia* (sea spaghetti) in a current, or the bright green of *Ulva* (sea lettuce) against the earthy brown inter-tidal wracks, there's a world of seaweed out there to be collected, tasted and used for a variety of cooking.

Ocean Explorer Magazine met up with SAMS support scientist and seaweed forager Lars Brunner to get his top tips on collecting seaweed for cooking:

1. It always pays to do a little RESEARCH. With the rise in popularity of seaweeds for food, there are a variety of well-illustrated field guides/ cookbooks on the market. Know where to go. Different species of seaweed live in different seashore habitats. Avoid areas that may be prone to pollution sources.

2. PLAN your visit. The best time for collecting seaweed is on a low tide.

3. Most importantly: BE SAFE. It's easy to slip and injure yourself on the shore or to be caught out by the rising tide.

4. For the first time collector the three best species to keep an eye out for would be: *Palmaria palmata* (common name dulse) – a beautiful red seaweed that occurs on exposed rocky shores in the low tide zone; *Osmundea pinnatifida* (common name pepper dulse) – a small red seaweed, never growing much bigger than 3cm, that has a rich smoky tang; and *Ulva lactuca* (sea lettuce) - a very common bright-green seaweed that is easy to find, especially in the summer.

5. Once you have collected your seaweed, give it a RINSE under some fresh water. Most seaweeds can be stored for short periods in the fridge, but use them as soon as possible – FRESH IS BEST. To dry seaweeds leave them in a low oven (40-50°C) for a few hours, or blot dry with paper and leave to dry naturally.

6. Only take what you need, and never clear an area of a type of seaweed!

19 NATIONALITIES IN ONE AQUACULTURE MSc COURSE

An international group of students on a prestigious MSc programme is catching the eye of the global aquaculture industry.

The 25 students, who come from all corners of the globe, are the second cohort to join the Erasmus Mundus Joint Masters Degree in Aquaculture, Environment and Society (ACES), awarded jointly by the University of the Highlands and Islands and the University of Crete.

The students originate from 19 different countries, including New Zealand, Jamaica, Peru, Brazil, Pakistan, China, Colombia and the USA.

They spent the first six months of the 2-year-programme at SAMS in Oban, and in February moved on to Crete in Greece, where they will stay until relocating to Nantes in France for the final taught semester. For their research project the students will then split up and work at the most appropriate organisation to support their chosen topic of investigation.

The academic course covers industry-relevant aspects of aquaculture, such as environmental issues, governance, technology, life cycles and feed production.

Course leader Dr Elizabeth Cottier-Cook, a senior researcher at SAMS, said: "The ACES programme provides fully-funded scholarships for EU and non-EU students in a bid to attract the very best aquaculture students from around the world."

"ACES encourages the students to share their experiences of the aquaculture industry from nation to nation. This encourages a curiosity about links between academia and industry."

Guest lecturers and scholars from the United Nations and from research institutes in Tasmania, Israel and the USA, also contribute to the teaching of the course.

Marine Harvest sponsors a scholarship for one EU-based student, who will complete their studies with the company. The company's Business Support Manager, Steve Bracken, said: "Courses like EMJMD ACES are an important vector to bridge the gap between education, research and development, and applied industry techniques and knowledge.

"Aquaculture-based academia within the UK is growing and the research undertaken at SAMS, Crete and Nantes is industry-relevant. Students educated there learn and understand theories, techniques and skills that can bring a significant and sustainable growth to Europe's salmon farming industry."

To find out more about this exciting course, please visit our website:

www.emm-aces.org

GLOBETROTTING GRADUATE DIVES INTO DREAM SCHOLARSHIP

A marine science graduate has been given a 'dream ticket' to spend the year diving in the most stunning underwater locations around the world, thanks to a prestigious European scholarship.

Felix Butschek, who graduated from SAMS UHI with a first class honours degree in Marine Science with Arctic Studies in September 2016, is the European representative on the Rolex Scholarship Programme, run by Our World-Underwater Scholarship Society.

The year-long scholarship, which attracts applications from across Europe, allows Felix to train in underwater research, photography, marine conservation and equipment design and testing in global locations of his choosing.

The 24 year old, who is originally from Innsbruck, Austria, is 'working' his way down his wish-list of SCUBA diving experiences, including cave diving in Mexico, cold-water dives in Antarctica, wreck diving in Alaska and exploring the marine life around the Galapagos Islands.

"Winning this scholarship is definitely a dream come true for me," said Felix. "Recreational divers might get to do these things in a lifetime and I get the chance to do them in a year. It is a huge privilege."

Felix said his time at SAMS, which hosts the UK's National Facility for Scientific Diving, had prepared him well for 'a year on the road.' As part of his scholarship he even returned to Oban for a commercial SCUBA diving course run by SAMS.

Applicants for the Rolex Scholarship Programme are, among other criteria, required to have high academic standing and have Certification as a Rescue Diver or equivalent with a minimum of 25 dives logged in the past two years.

As a student Felix was instrumental in setting up a student branch of the British Sub Aqua Club at SAMS UHI and helped in the discovery and identification of several WWII flying boats near Oban.

SAMS UHI STUDENTS MAKE WAVES WITH MAIDEN SAILING VICTORY

A new sailing team formed by students at the Scottish Association for Marine Science (SAMS UHI) has navigated its way to a national title just months after starting up.

The University of the Highlands and Islands Wind and Wave Club, which is so far made up entirely of SAMS UHI students, won the silver class at the recent Ladies Team Racing Championship at Forfar Loch, organised by Scottish Student Sailing and hosted by Dundee Sailing Club.

It was the ladies team's first competition, having only started training in October 2016, and three of the six women had only set foot in the Racing Firefly boat used in competition two weeks prior to the event. The inexperienced team was led by captain Ashlie McIvor, who has only been sailing since May that year.

The multi-national SAMS UHI team, taken from undergraduate and Masters levels, comprises: Ashlie McIvor (Scotland), Regina Huttunen (Finland), Fatima Gianella (Peru), Iona Helyer (Scotland), Francesca Molinari (Italy) and Lea Riehn (Germany). When racing, the team identified themselves by wearing shower caps in their university colour of purple.

Club coach Joe Penhaul-Smith, a PhD student at SAMS UHI and former Staunton Harold sailor, said: "I only set up the club a couple of months previous to the competition because there seemed to be a fair bit of interest in watersports at SAMS UHI.

"We have around 10 to 15 sailors at training at the moment, some of whom are complete beginners, so to have won a competition so early on is fantastic.

"We are currently borrowing boats and equipment from Oban Sailing Club but I hope that with some more support the club can continue to grow."

The Wind and Wave Club is open to all University of the Highlands and Islands students and trains every weekend at Oban Sailing Club.

The club is affiliated to Oban Sailing Club, where Professor Finlo Cottier from SAMS is commodore.

SAMS' SAM IS UNIVERSITY'S FINEST

A graduate from SAMS won the title of University of the Highlands and Islands Student of the Year 2016.

Samuel Black (22) from Dunbar in East Lothian graduated from the Scottish Association for Marine Science UHI (SAMS UHI) in 2016 with a 1st class honours degree in Marine Science with Arctic Studies. He was selected for the award in light of his exceptional academic work, his enthusiasm and his contributions to SAMS UHI, the surrounding area and his local community.

As well as achieving top grades throughout his four years at the Argyll-based institution, Sam also found time to set up a diving club, help children learn about the Arctic and take part in an extreme challenge to raise money for the charity, Breast Cancer Now.
Sam was nominated for the Student of the Year award by Polly Crooks, a registry officer and student support worker at SAMS UHI. Her nomination was supported by several other members of staff, including Sam's lecturers.

Polly explained: "Sam was a fantastic, hardworking student who achieved excellent grades. His enthusiasm for marine science, SAMS UHI and the surrounding area was hugely apparent. He chose to study in Svalbard in his third year and excelled in this environment; his passion for outdoor recreation coupled with his interest in Arctic science helped him to achieve impressive results."

"Sam was always willing to assist with outreach work and promotion of our programmes. While studying in the Arctic, he set up a link to a school in his hometown so pupils could learn about the Arctic."

"During his last and most demanding year of studies, Sam embarked on a mission which involved a swim on Loch Shieldaig, a bike ride and a marathon which included the ascent of two Munros. He was one of the youngest competitors in Celtman and raised thousands of pounds for charity."

Speaking about becoming the University of the Highlands and Islands Student of the Year, Sam said: "I'm extremely honoured by the award and I'd like to thank all the staff and my fellow students at the Scottish Association for Marine Science UHI for their unrivalled help and support throughout my final year. SAMS UHI will always be my home university in my head and in my heart. You can take Sam out of SAMS, but you can't take SAMS out of Sam."

Sam also won this 2016's Tripartite Undergraduate Dissertation Prize, an annual UK award from the Challenger Society for Marine Science, the Institute of Marine Engineering, Science and Technology and the Society for Underwater Technology for the best project by a BSc student in marine science, engineering or technology.

Sam is currently studying towards an MSc in climate change at the University of Copenhagen.

CHIEF SCIENTIST PUTS SAMS SCIENCE UNDER THE MICROSCOPE

Scotland's Chief Scientific Adviser has praised SAMS research and its relevance to the environment, industry and communities during her first visit to the institute.

Professor Sheila Rowan MBE was appointed to the part-time Scottish Government role in June 2016 and remains Director of the Institute for Gravitational Research at the University of Glasgow.

Her visit in February was organised by SAMS Physical Oceanographer Prof Mark Inall, who is also Director of the Scottish Alliance for Geoscience, Environment and Society (SAGES).

Picture: On her visit to SAMS, Prof Sheila Rowan, right, met senior members of staff including, from left: Prof Mark Inall, Director Prof Nicholas Owens, Prof Keith Davidson and Prof Sheila Heymans.

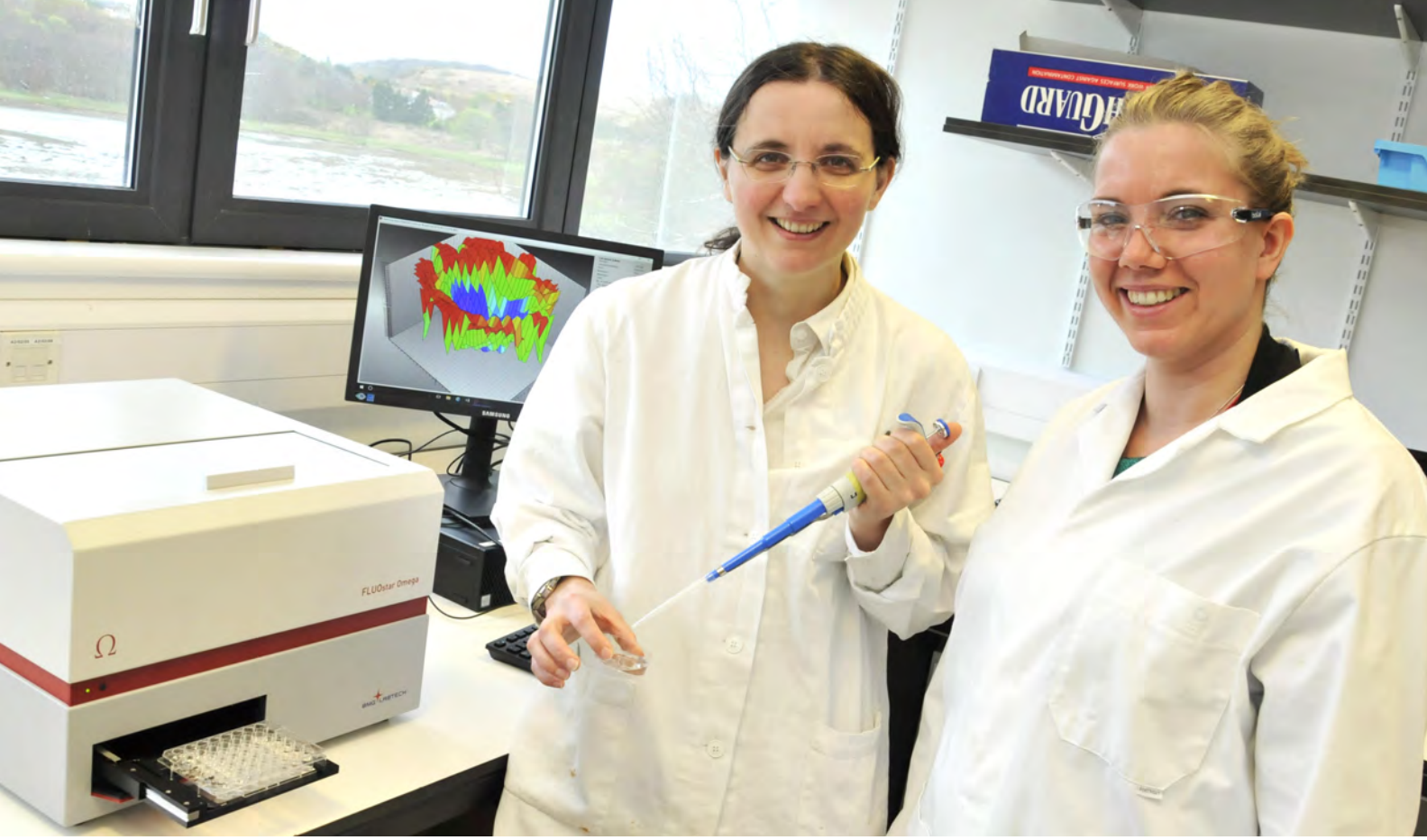
Prof Rowan said: "One of the reasons for visits like this is to make sure I have the fullest picture of the research environment and expertise across Scotland. At SAMS there is a real mix of fundamental research in marine areas but also recognition of how that connects with industry, the environment and our communities. I was very interested to find that recognition here."

The Chief Scientific Adviser for Scotland is responsible for advising the Scottish Government about science-related issues; championing the use of science to inform policy development; and supporting Scotland's world-leading science base and its potential to benefit Scotland's economy, people and environment.

A JOLLY GOOD FELLOW

A member of SAMS Council, Prof Sandy Tudhope, has been elected as a Fellow of the Royal Society of Edinburgh. Prof Tudhope, Head of the School of GeoSciences at the University of Edinburgh, joins a prestigious Fellowship whose varied expertise supports the advancement of learning and knowledge in Scottish public life. New Fellows are elected each year through a rigorous five-stage nomination process. The breadth of the Fellowship extends to more than 1,600 individuals from the UK and abroad.

President of the Royal Society of Edinburgh, Professor Dame Jocelyn Bell Burnell said: "Each newly elected Fellow has been nominated on their exceptional and extensive achievements."



TOWARDS DISEASE-RESISTANT ALGAE FOR SEAWEED FARMING

SAMS is the first organisation to use a hi-tech piece of lab equipment to help breed disease resistant algae for the seaweed-growing industry.

Representatives from BMG LABTECH have recently delivered a NEPHELOstar to Dr Claire Gachon, senior lecturer in molecular phycology.

In a novel application for this type of instrument, Dr Gachon will use the NEPHELOstar to measure biomass and determine which algal cultures are resistant to different diseases. This, in turn, will help SAMS breed seaweed strains most resistant to diseases.

Dr Gachon said: "We will use this state-of-the-art equipment to identify algae that are resistant to disease. We will then correlate the data with genotype information to find out which strains are the most suitable for breeding seaweed.

"This is important research for the seaweed industry globally; just like in land-based agriculture, disease can be devastating to the production line."

This pioneering work is part of the GENIALG project, which aims to improve the genetic resources available to breeders for sustainable, large-scale kelp farming throughout the EU.

Catherine Wark, applications and business development manager at BMG Labtech, said: "This device is typically used by drug companies, so the work at SAMS is certainly a novel use of the technology."

Dr Gachon believes that, beyond algae, the technology could become a mainstream tool for non-invasive measurement of biomass of many different types of aquatic organisms.

BACTERIA: DETECTING LEAKS AT CARBON CAPTURE SITES

Bacteria and archaea could be used to monitor stored carbon dioxide (CO_2) and convert it into useful products, such as ethanol and acetate, say researchers at the Oban-based Scottish Association for Marine Science (SAMS) and the University of Oslo.

In an Opinion published in *Trends in Biotechnology*, they discuss how new bioinformatics tools would enable researchers to read shifts in microbial community genetics - making it possible to detect potential CO_2 leaks - and how such analyses could contribute to making large-scale capture and storage of CO_2 feasible.

Rising CO_2 levels contribute to both global warming and ocean acidification. Capturing this CO_2 from large point sources and storing it in underground geological formations, a process called carbon capture and storage (CCS), is considered one promising way to keep it out of the atmosphere and reduce its effects. The CO_2 is buried in porous and permeable rock that is blanketed with at least one layer of impermeable rock. But this potential solution comes with risks, says Dr Natalie Hicks, a biogeochemist at SAMS. "One of the biggest concerns with carbon capture storage is the environmental impacts if there is a leak," she said.

"How would we know about it? How would we detect it? And what would the environmental implications be?"

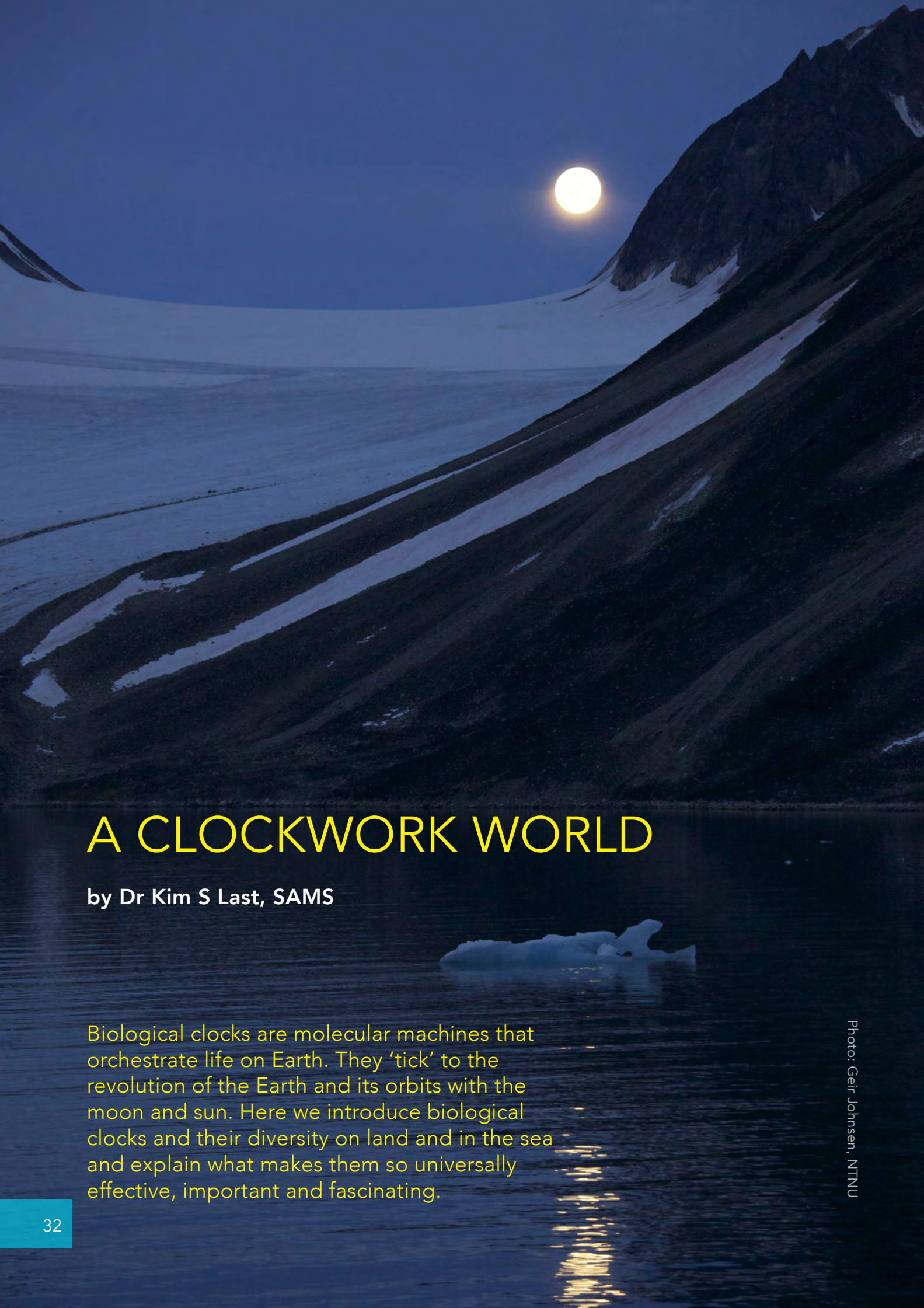
Dr Hicks and her co-authors, who include a multidisciplinary team of geneticists and engineers, say that in addition to physical methods of monitoring CCS sites, such as measuring CO_2 levels, it should be possible to monitor the bacteria and archaea living in sediment overlying these sites to detect potential leaks.

They point to a simulated CO_2 leak experiment previously conducted in a sub-seabed reservoir near to SAMS that detected changes in the microbial communities around the reservoir, before other organisms were visibly affected.

Dr Hicks and her colleagues further argue that in addition to monitoring for leaks, bacteria and archaea could help convert stored CO_2 into useful products, including ethanol, acetate, acetone, lactate, and methane.

Metabolic pathways in bacteria that assimilate CO_2 are well known, but others have been discovered in recent years that convert CO_2 into these chemicals.

Photo courtesy of NFSD



A CLOCKWORK WORLD

by Dr Kim S Last, SAMS

Biological clocks are molecular machines that orchestrate life on Earth. They 'tick' to the revolution of the Earth and its orbits with the moon and sun. Here we introduce biological clocks and their diversity on land and in the sea and explain what makes them so universally effective, important and fascinating.

Photo: Geir Johnsen, NTNU

THE CLOCK INSIDE

Biological clocks are almost universal to all living organisms on Earth. Indeed, even you have one, a highly accurate machine, continuously subtly adjusting your behaviour, metabolism, even the activity of your genes.

Have you ever guessed what time it might be and guessed almost exactly right? Have you ever woken up in the morning just before the alarm has gone off? This is not coincidence but the work of our inner clock which is 'ticking' from the moment we are born to the day we die.

If we mess with it, we really notice: Take a long haul flight to Los Angeles from the UK and you will spend the first few days asleep when you should be awake; you will feel hungry when everyone else isn't; basically you will be all muddled and this is because the clock, which measures 24 hours, is out-of-sync with the new time zone. We have not yet evolved a clock to deal with a rapid time shift as a result of high-speed transportation half way around the planet. After a few days, however, your clock will shift slowly to the new time-zone, so little harm is done and you can enjoy the rest of your break.

So how does this clock function and why have one anyway?

CIRCADIAN CLOCKS

The most commonly studied clock, the one inside us, is called the circadian clock. It gets its name from the Latin *circa* meaning 'about' and *diem* which means 'day' and it measures the time of day much like any watch. Although pretty accurate, it is usually just a bit fast or (in humans at least) slow, hence the *circa* bit.

Our master clock is located in the suprachiasmatic nucleus or SCN (a grand name for something the size of a small garden pea). The SCN sits in the brain just by where the optic nerves cross and it synchronises a multitude of other clocks in our cells, tissues and organs.

We also have a clock hormone, melatonin, secreted into the blood at night via the pineal gland, which informs the body that it is time to go to sleep.

The clock itself is a molecular machine which constitutes positive and negative feedback between circadian clock genes and what the clock proteins they produce - as shown in figure 1: In mammals clock genes (*Per* and *Cry*), located in the nucleus of the cell, are switched on via clock proteins (BMAL/CLOCK) using promoter regions (E-boxes). *Per* and *Cry* then generate clock proteins (conveniently called PER and CRY). These move out of the cell into the cell cytoplasm where they group together in a certain way so that they can re-enter the nucleus. Once inside the nucleus they interact with the activator clock proteins (BMAL/CLOCK), essentially switching them off. This then also switches off *Per* and *Cry* genes. Eventually, after about 24 hours, the inhibitory proteins PER/CRY run out and this is when the whole cycle starts again and so on and so forth.

Quite simply the clock is an unseen evolutionary marvel, ticking away within our body, with peaks and troughs of clock gene proteins, cycling through the day.

CLOCK EVOLUTION AND FUNCTION

It is believed that the circadian clock evolved as life first appeared on Earth, billions of years ago.

The primary function of the clock was probably to allow simple organisms to avoid the harsh ultra-violet radiation of the day since the Earth's atmosphere was almost non-existent at this time. Imagine a filamentous cyanobacteria gliding out from under rock at the edge of the shore for a few hours a day to photosynthesis – get the timing wrong and it would have been fried like a metaphorical egg!

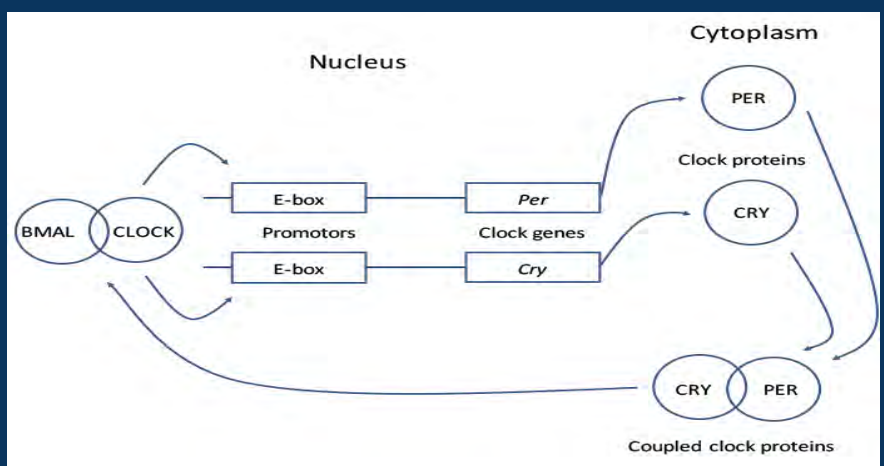


Figure 1: The mammalian circadian clock where BMAL/CLOCK activates the *Per* and *Cry* clock genes to produce PER / CRY proteins that will eventually repress their own activity, a process that takes 24 hours.

Life back then was harsh but it takes little imagination to see how timing affects most of life's tasks: avoiding predators, finding a home, food, a mate etc. The clock allows organisms to anticipate rather than simply to react to future events.

Many physiological processes take time, such as the secretion of enzymes in our stomach. Every day our bodies produce gastric enzymes well before mealtimes, improving the overall digestive efficiency. For this, correct timing is essential.

The circadian clock has several important characteristics. It is primarily set by the day/night cycle through entrainment. Without entrainment the clock would eventually stop working. This is why people near the Arctic often use daylight simulation lamps to entrain their clock and prevent seasonally affective disorder (SAD). The clock is also immune to temperature change which is especially important in organisms that cannot control their internal temperature. It would be of limited use to have a clock that ran fast in the summer and slow in the winter!

Amazingly, the clock free-runs, which means that even without a day/night cycle we can still observe the workings of a clock through rhythmic behaviour. For example, if you were in a dark cave you would still get up and go to bed each "day" following a rhythm of around 24 hours for several months. This has been done by an inquisitive scientist...

COMPLEX CYCLES

We have seen how the circadian clock is of great value to terrestrial organisms living in a 24-hour world, but can organisms synchronise to environments with cycles of different durations?

The Earth and moon spin about a common centre of gravity and it takes approximately one month (or 29.5 days) for the moon to circumnavigate Earth, also the interval between successive full or new moons. Since the Earth is spinning beneath the moon we also experience ca two high tides per day (every 12.4 hours, at least in the UK) with only one high and one low tide occurring during the day or night. So if you were a nocturnal crab, as many crabs tend to be, and preferred to scuttle about on the shore when the tide is high to look for food, home or a mate, then you would only be able to do this every 24.8 hours... Unfortunately for them - and the scientist trying to make sense of it all - it gets more complicated: Twice per month the Earth, moon and sun all align and we experience spring tides constituting the highest tides with a period between spring (or neap) tides of approximately 14.7 days. So if our hypothetical crab lived very high or low on the shore its home would only be (un-) covered by seawater around every two weeks, important information when considering the time available to roam about at night doing "crab stuff"...

TIDAL CLOCKS

Scientists have known for a long time that marine organisms can anticipate the rise and fall of the tides. The first published study that observed a tidal clock in action occurred in the marine lab in Roscoff, France, at the turn of the century. Here a very small flatworm (so small that it lives in the water between sand grains) was brought into the laboratory to study its algal symbionts. To their surprise the scientists found the animals migrating up and down in the sand at the same time as the tide flooded and ebbed on the shore. The scientists were puzzled and explained it, comically to us now, as being due to some unknown "cosmic force".

It wasn't until much later from studies on crabs that it became accepted that such rhythmic behaviour is due to a circa-tidal clock which free-runs with a period near 12.4 hours. Data emerged from studies on many other species showing that marine animals - and many algae - follow not only circatidal but also circasmilunar (~14.7 days) rhythms. These may be modified by a circadian rhythm, suggesting that there might be more than one clock operating in marine animals and that these must somehow communicate with each other.

The two main hypotheses attempting to explain circatidal clock behaviour are: two completely separate clocks, one at 12.4 hours, the other at 24 hours; or one clock at 24.8 hours but coupled in antiphase (essentially two clocks overlapping) with the ability to produce two 12.4 hour clocks.

Recent molecular evidence including gene cycling in a marine worm (Fig 2), is revealing that the former maybe more likely but, we need more data to be sure. Irrespective of the underlying process, it is clear that crabs at least know the time day and the time of tide simultaneously which is, quite simply, an astonishing achievement (not bad for a little critter who has never been to school)!

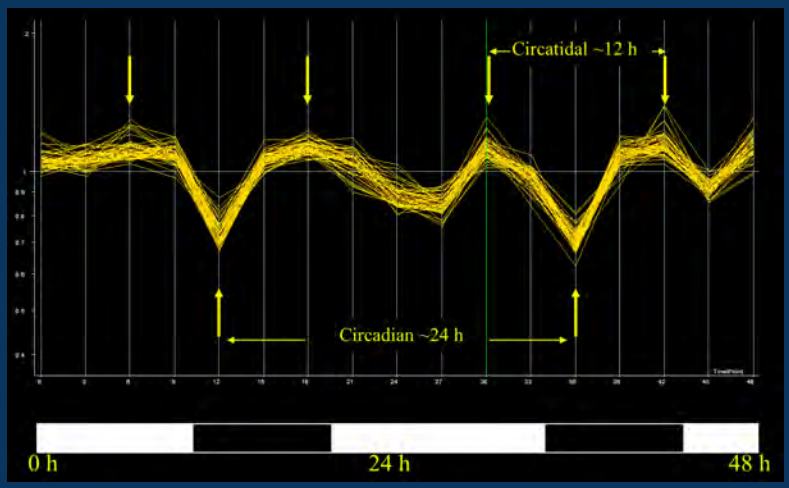


Figure 2: Gene cycling (left) in a marine worm over two days. The king ragworm *Nereis virens* (right) is a seashore inhabitant that "knows" the time of day and tide. Peaks and troughs in its gene expression suggest that many genes cycle with periods matching the day and night and tidal cycles. Rectangles show times of day (white) and night (black). Image credits: Cas Kramer (University of Leicester) and Kim Last.

LUNAR CLOCKS

Moonlight has been shown as an important signal to synchronise reproductive events, especially in marine organisms from worms to turtles. Circalunar clocks entrain to moonlight and are most prevalent in regions that lack clear seasonal signals (such as near the equator), where the days are similar in length, and the sky is often clear with little temperature variation between summer and winter. Perhaps one of the most impressive mass synchronous spawning events is that of corals on the Great Barrier Reef in Eastern Australia. Here approximately 30 coral species all spawn on only one or two nights of the year, a truly remarkable natural phenomenon. In other season-less environments, such as the high Arctic during the winter, moonlight may be equally important, not in reproduction but in predator avoidance. A recent discovery has revealed mass migration of zooplankton, such as the copepods shown in figure 3, migrate down to deeper water during the full moon periods when the sun is permanently below the horizon. The suggestion is that there maybe marine "werewolves" hunting zooplankton by moonlight, a truly scary suggestion if you are only a few millimetres long.

ANNUAL CLOCKS

One biological clock trumps all others, the circannual clock. What this clock lacks

Figure 3: Copepods such as *Calanus finmarchicus* undergo vertical migrations in response to both sun- and –moonlight as part of one of the biggest migrations on the planet. Image credit: Kim Last

in precision, it makes up for in length! Circannual rhythms of reproduction have most notably been demonstrated in a beetles and trout, whilst the annual moult cycle of sheep is also clock regulated. These clocks span years when free-running, are entrained by the seasonally changing day-lengths and are obviously most common in long-lived species. However, they are notoriously hard to study requiring dedication and funding, something few of us have in equal measure.

THE FINAL HOUR

To date scientists do not know how non-circadian clocks work, either at the physiological or molecular levels. However, numerous circadian clock genes have been isolated in marine organisms and so it is likely that the circadian machinery, at least in part, also exists in such organisms. Recent research has revealed that in the sea louse and a marine worm disruption of the circadian clock does not result in disruption of tidal or lunar rhythms. It appears therefore that there are separate clocks but how they are potentially coupled to each other and how they maintain rhythms that are hours, days, months and years long, remains unknown. What is known with great clarity is that "timing is everything", an expression that holds a lot of truth, at least to life on Earth.

"GoMA Display"
The Clyde Reflections display at the Gallery of Modern Art.
Photo by Alan Dimmick

SAMS BURSARY

Clydesiders' relationship with the sea

What does the Clyde mean to you? That was the question posed by a unique project that combines art, science and film to challenge people's perceptions of the west coast waterway.

Clyde Reflections is a 33-minute film and audio-visual installation based around interviews with seven people that explore their perceptions of the marine environment in the Firth of Clyde.

It was selected to run at Glasgow's Gallery of Modern Art (GoMA) last summer as part of the gallery's Moving Image Season.

The project, partly funded by a SAMS bursary, was devised by Glasgow-based artist Stephen Hurrel and social ecologist Dr Ruth Brennan, a SAMS Honorary Research Fellow.

Encouraging viewers to reflect on the shifting nature of relationships between people and place, the film features underwater and microscopic footage, combined with voice recordings of people who have a close relationship with, or specialist understanding of, the Firth of Clyde.

These include a retired fisherman, a marine biologist, a diver, a marine conservationist, a spiritual leader and a physical oceanographer. Interviewees represent three different islands: Cumbrae, Arran and Holy Isle.

Ruth said: "The aim of the film is not to deliver a specific message, but rather to provoke thought and reflection. How are people's perceptions of the Clyde formed and how can the same body of water be perceived so differently by so many people?
"We also want people to consider and contemplate the bigger picture: How can we live sustainably? How do we deal with climate change? What is our relationship to the sea?

"Having shown the film to different audiences it is incredible to see how people can have such contrasting emotions after watching it."

Clyde Reflections was commissioned by Imagining Natural Scotland with funding from Creative Scotland's Year of Natural Scotland 2013 and SAMS, with support from the Marine Alliance for Science and Technology for Scotland (MASTS).

Stephen Hurrel and Dr Ruth Brennan

MARINE ALGAE - THE HEIGHT OF FASHION

Jessica Giannotti believes marine science is beautiful – and she has the proof.

The SAMS UHI marine science graduate has established a textiles business, Crùbag (Gaelic for crab) and uses microscopic images of marine algae to inspire her evocative designs, which can be seen in a growing number of outlets throughout the UK. The concept has been well received in the fashion industry, with Jessica displaying her work in London and Paris during her first year in business.

Her first set of designs, The **Gachon Collection**, were inspired by photographs of green and brown algae taken by SAMS' Dr Claire Gachon. Microscopy images taken under UV light revealed colours and patterns of healthy algal cells, and the spores of infections attacking the tiny plant life. The results produced luxury scarves, cushion covers, and pocket squares, inspired by the beauty of the oceans.

"Each piece tells a story about the oceans, cutting-edge research, and current environmental issues," said Jessica, who is originally from Venezuela. "At Crùbag it is our mission to show the tiny windows of wonder that scientists are opening, and share the passion and love we have for the sea."

This passion for the marine environment could have been the key to a career in research, but it was Jessica's desire to share this love for the environment with a broader audience that led to her business plan. Crùbag and SAMS are both based at the Scottish Marine Institute in Dunstaffnage, and a portion of Crùbag's sales goes towards scientific research. The Gachon collection was presented in London at the Phycological Society Congress and at a meeting on marine protected areas organised by ScotLink at the Edinburgh Botanical Garden. Crùbag was also invited to two National Economic Forum meetings with ministers, including First Minister Nicola Sturgeon.

Through Emergents, a Highland-based community interest company, Jessica attended Paris Fashion Week followed by a trip to the London Design Festival and then London Craft Central, where discerning customers were curious to learn about Dr Gachon's research.

Crùbag's new **Flora Collection** was inspired by SAMS PhD student Ruth Flora Paterson's research on harmful algal blooms and was launched at the 17th International Conference on Harmful Algae in Florianópolis, Brazil.

You can purchase Crùbag products at SAMS' Ocean Explorer Centre and online:

www.crubag.co.uk

MY RESEARCH

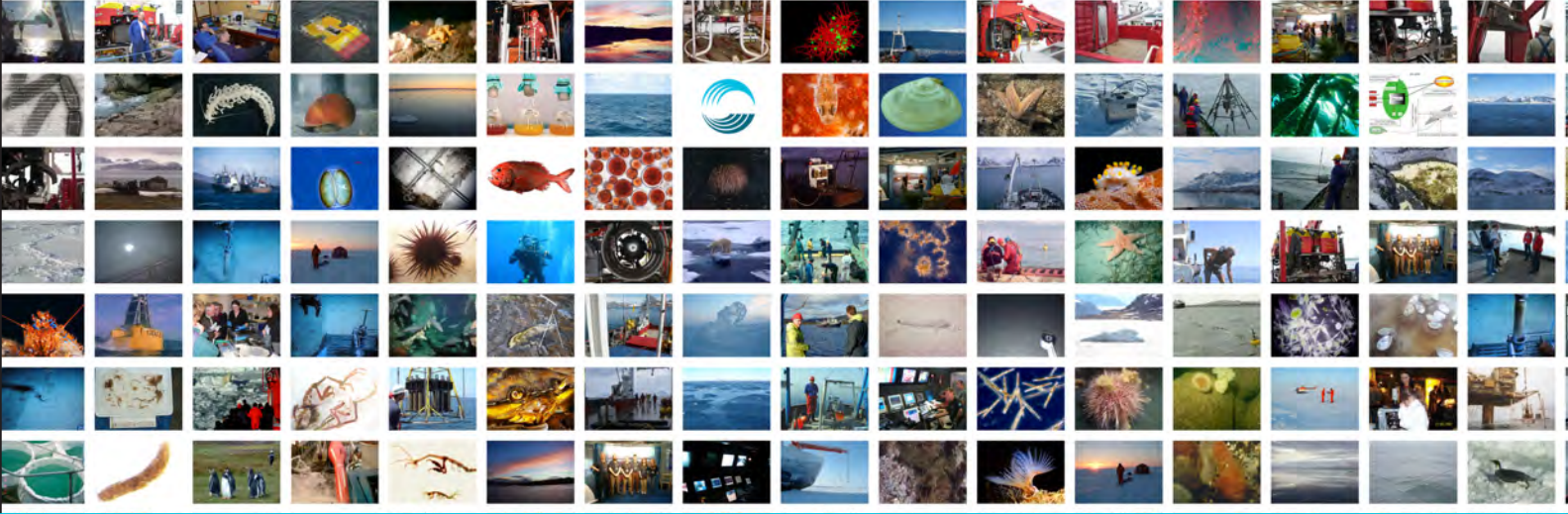
SAMS' Professor Kenny Black, who has just retired, talks about his career

What drew you to a career in marine science research?
I am a graduate of Lochgilphead and Oban high schools and went to Stirling to do chemistry. After my honours project I realised that research was not for me. After finding out that school teaching was also not for me, I started a PhD at St Andrews on (synthetic) lipid chemistry with Professor Frank Gunstone. After my PhD I again resolved that research was not for me. I had various jobs as a fisheries manager, deerstalker and forest ranger, all in Argyll. They were fun, but I had a growing family and it was difficult to pay the bills. I applied for what I thought was a chemistry technician's post at Dunstaffnage Marine Laboratory in 1991 and was surprised to be offered it after being unable to answer many questions well at interview. I was even more surprised to find myself in charge of a marine ecology research group studying aquaculture environment interactions. After a few years, I discovered that research was, after all, for me.

What was your main area of research?
I am interested in interactions between human activities and the environment. This has allowed me to have fun in the Arctic (looking at pollutants) and in Papua New Guinea (PNG) looking at the effects of mine–tailings on the deep ocean. I have also had the pleasure of working at sea on several research cruises in the Atlantic and the Arctic as well as in PNG. But my bread and butter was aquaculture environment-interactions, which is very much a live topic given the expansion targets for aquaculture in the EU and Scotland. I worked mainly on modelling the fate and impact of particulate organic matter and medicines lost from marine cage farms and I co-developed the world's most advanced tool for this purpose, DEPOMOD, which is mandated in Scotland and widely used across the globe.

How did this research help industry and the public?
Aquaculture is a growing industry globally and already provides more food for human consumption than capture fisheries, which have likely peaked in production globally. It has great potential both to create employment in rural areas and to provide food security, improved human health and export income for Scotland. Globally, aquaculture development is vital to feeding the growing population. Fish are the most efficient convertors of feed into meat with the lowest carbon footprint. Aquaculture does have detractors and it is important researchers continue to work to mitigate any negative impacts from aquaculture.

During the course of your career, what has been the biggest changes in research?
The challenge is not thinking of good ideas but persuading someone to pay for them. I have been fortunate to have been involved in many successful proposals and to have worked with some excellent people. But you are only as good as your last grant and it appears that nowadays researchers have to run ever faster to stand still.



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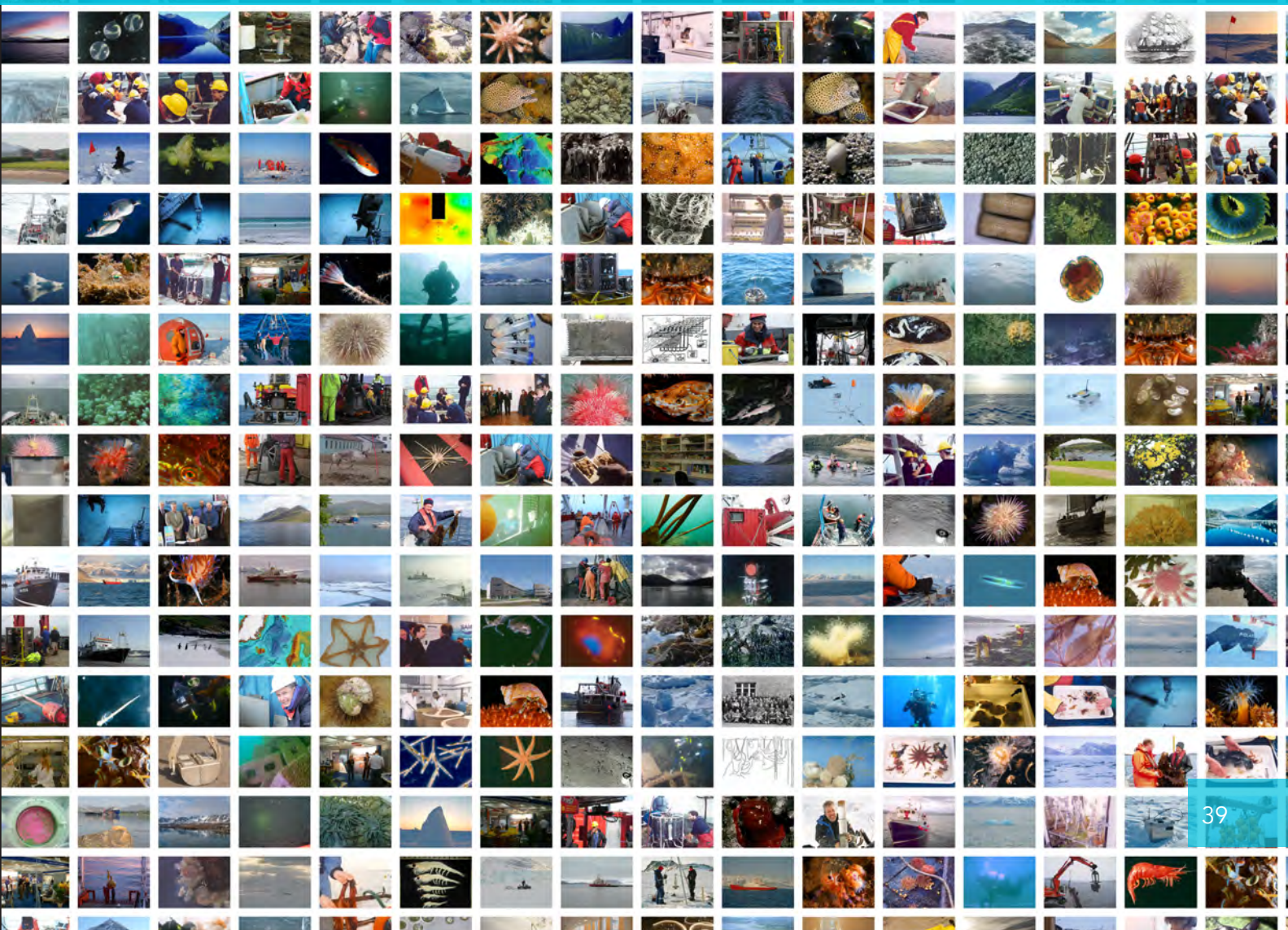

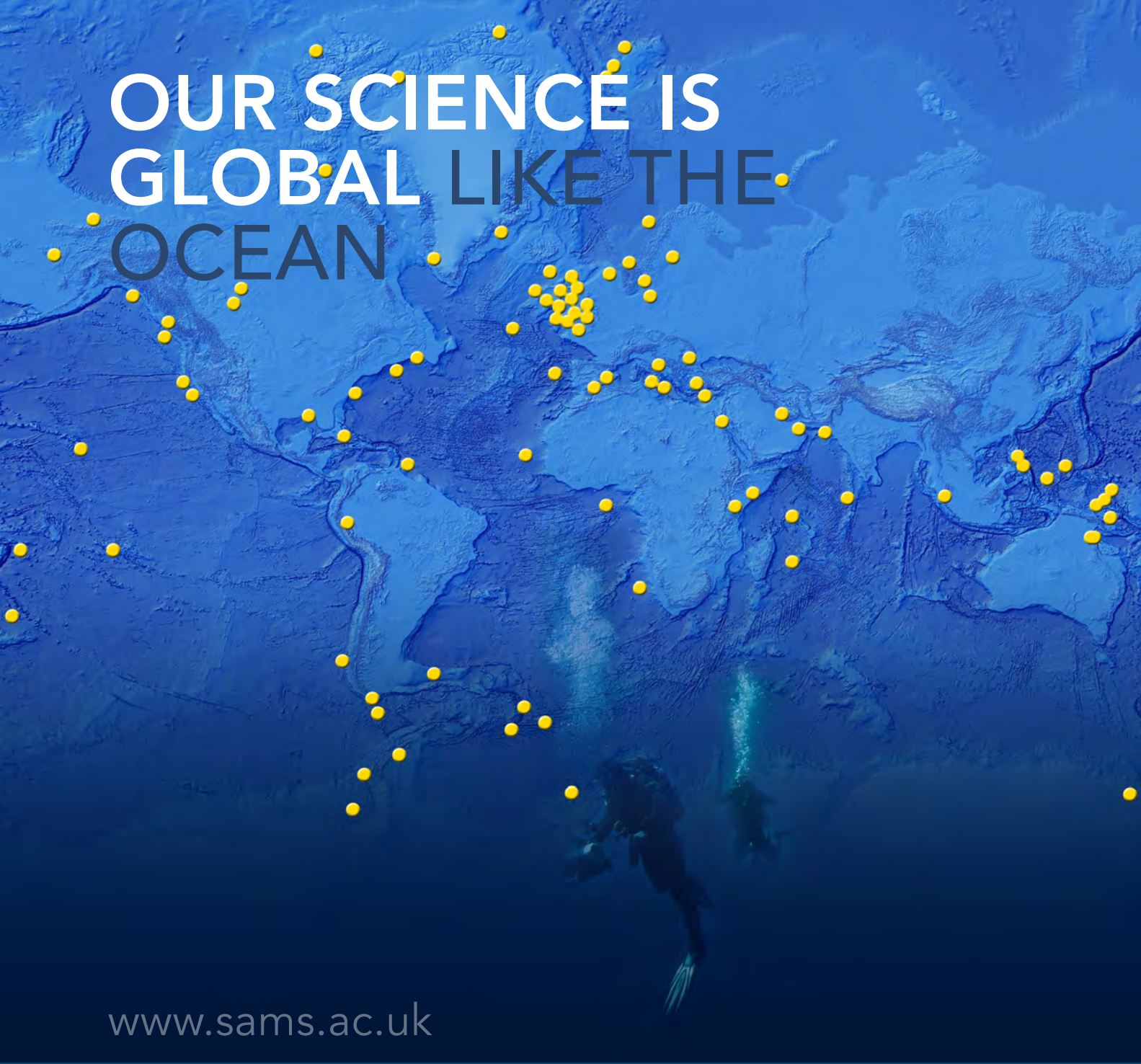

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