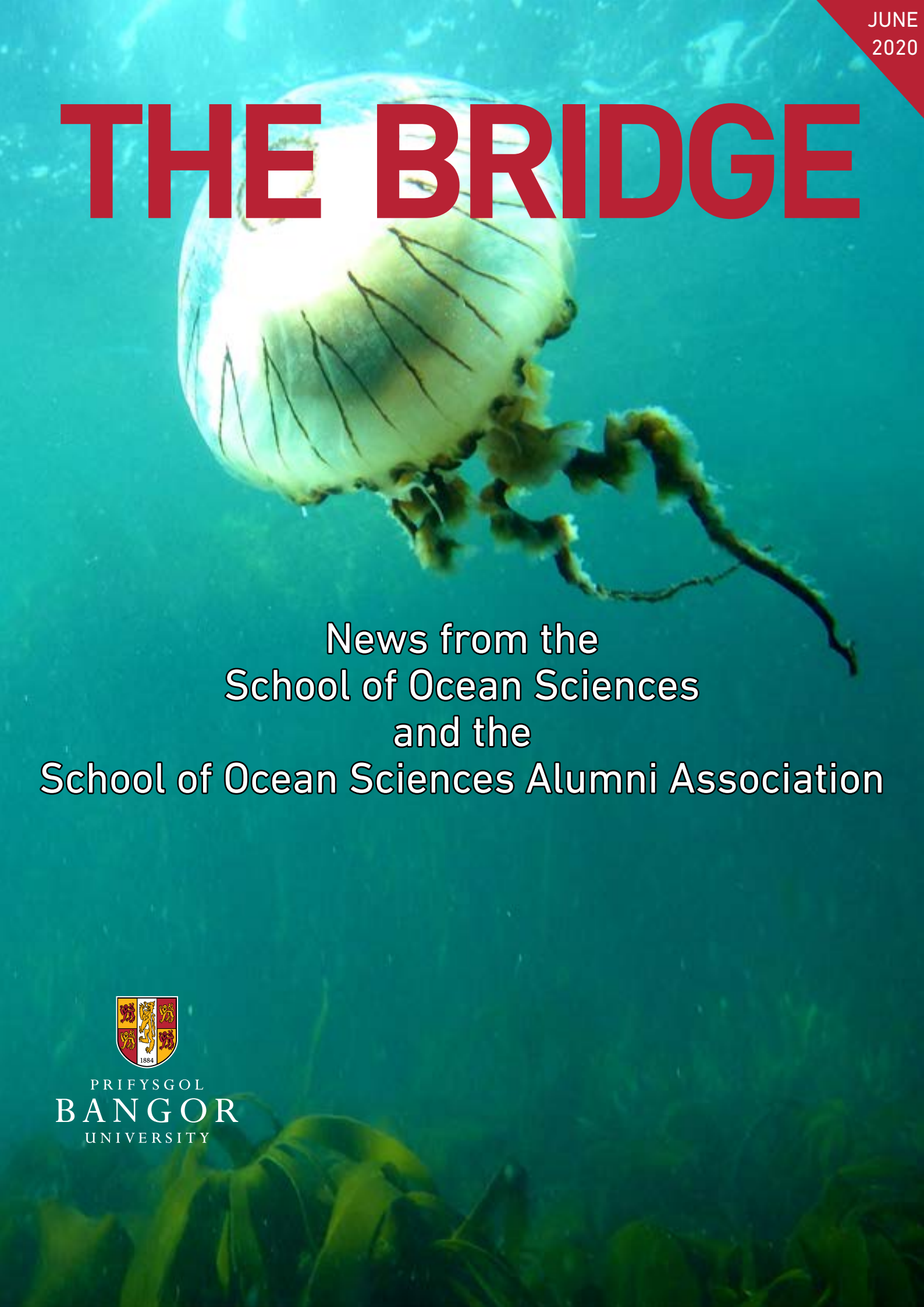
JUNE
2020

THE BRIDGE



News from the
School of Ocean Sciences
and the
School of Ocean Sciences Alumni Association

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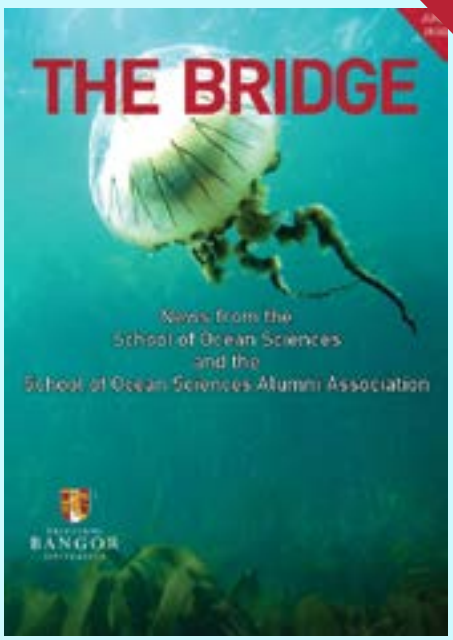
TEF Gold
Teaching Excellence

THE BRIDGE June 2020



Please send your School of Ocean Sciences news to:
sos-newsletter@bangor.ac.uk

Please send your School of Ocean Sciences Alumni Association (SOSA) news to:
alumni@bangor.ac.uk

Follow the School on social media:
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Welcome to our School of Ocean Sciences (SOS) newsletter which incorporates the alumni newsletter "The Bridge". In these exceptional days of lockdown we are happy to be able to bring you the latest news and successes from the school, and also from some of our graduates. We are excited to share a range of our research highlights, including important research on tracking the COVID-19 virus. We apologise that, due to the lockdown, we are not able to bring you as much alumni news as usual, but this will leave more for the next edition!

A clear message from the current situation is that we can't fight nature, and so we must focus our minds on the need to develop a more sustainable future. Before lockdown we had the great pleasure of welcoming back SOS alumna Professor Jacqueline McGlade to give a public lecture on the oceans and sustainability.

We are also pleased to be able to celebrate 52 years of world leading science from our research vessels, The *Prince Madogs*. Finally as a reminder of how beautiful our surroundings area, we've included some of the stunning pictures entered in our recent student photo competition.

We hope that you are all safe and healthy and enjoy sharing our achievements.

Tom Rippeth, Editor

2020 OPEN DAYS

Virtual Open Days:
3rd June, 27th June and 8th July

MAKING A DIFFERENCE IN THE CURRENT CRISIS

Ocean Science research to improve prediction of Covid-19 hotspots

Researchers from the Schools of Ocean Sciences and Natural Sciences at Bangor University are analysing samples from sewage taken from water treatment plants across Wales.

In doing this they hope to be able to map the numbers of people infected in different areas. The team are using method which they have originally developed for monitoring norovirus in waste water.

School of Ocean Science's Dr Shelagh Malham explains: "Because infected individuals start to shed the virus in faeces anything from 5 days to two weeks before the onset of the COVID-19 symptoms, the amount of the virus found in sewage at water treatment plants gives advanced warning of the levels of virus developing in the communities served by the treatment plant."

Talking to the BBC about this monitoring programme, Prof Davey Jones of the School of Natural Sciences said: "It maybe gives us a two weeks window in which we can actually monitor whether Covid-19 is going up or down in the population before it actually hits the hospitals."
https://www.bbc.co.uk/news/uk-wales-52544247

He also commented that it is an effective virus tracing method which is relatively cheap and simple, because the sewage system captured data on a large majority of the population. Here in Wales, 75% of the population are connected to 21 individual treatment plants operated by Welsh Water.

The data produced by this analysis also reveals the proportion of virus carriers there are who haven't showing symptoms, or have only experienced very mild symptoms, but could be an important source of infection.

Commenting further, Davey Jones explained: "Looking at the genetic code of the virus, we can see whether different parts of Wales have different areas being infected by different strains of the virus," he said. "We could also drill into individual regions within a city such as Cardiff, and evaluate whether different parts of the city are more infected than others."

This research is funded by NERC and involves Welsh Water. The results are being fed through to the UK government's Department for Environment, Food and Rural Affairs (Defra) and the Technical Advisory Board of the Welsh Government.

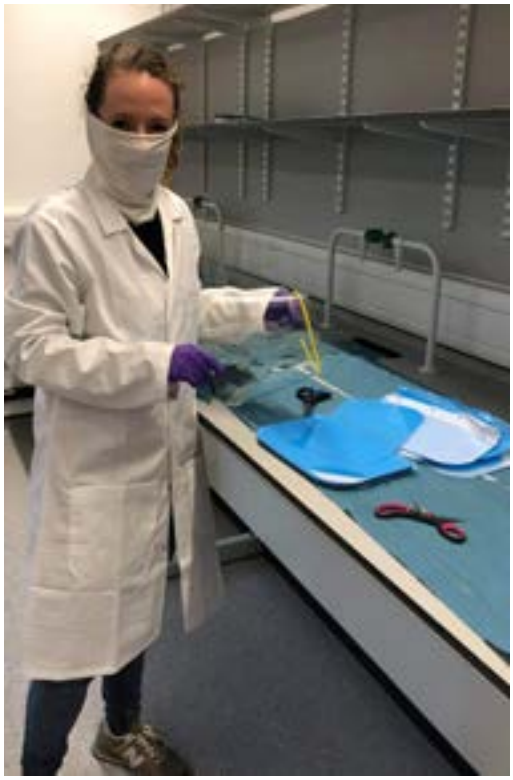
Ocean Sciences staff and students help effort to provide personal protect equipment for frontline workers

Following an early call by Ester Howie, prompted by a plea from local GP practices, many SOS staff have been involved in making protective equipment for frontline workers through a major University effort co-ordinated by M-Sparc (the Science Park in Gaerwen support by Bangor University).

Peter Lawrence of the School of Ocean Sciences alone has produced over 300 recyclable headbands for units for use by the NHS, and a further 50 or so for local shops.

This tremendous voluntary effort has so far produced over 6,000 face masks, which is more than required by the local health care services, and so masks have been made available to other key workers in the Anglesey area.

M-Sparc Science Park



Susan Allender of the School of Ocean Sciences constructing protective face masks.

University Sports Hall becomes a field hospital

In a further effort to help fight the virus, the University Sports Hall, on Ffriddoedd Road has been turned into a field hospital, Ysbyty Enfys Bangor.

A project of this sort would normally take 16 months to complete, but was completed in just 16 days. Ysbyty Enfys provides around 250 additional beds for North West Wales. The University has also made Halls accommodation available for health care workers.

At the time of writing the Covid-19 infection rate is reaching its peak in North Wales and this new field hospital will be particularly important in supporting our existing ICUs.

LOOKING TO THE FUTURE

We were delighted to host our annual careers fair at the School of Ocean Sciences just before the lockdown.

We were pleased to welcome back so many of our alumni who were here representing their employers. The careers fair is the main annual event which the school runs, and provides a direct link between past and present students as well as helping our current students decide on their future career direction.

With a large growth in the marine sector expected in coming years, many companies are particularly keen to meet their next generation of employees. Bangor University has been producing top quality marine science graduates for over 50 years and so it's not surprising that UKs off-shore industry is dominated by our graduates at all levels.

The fair was run by 27 student volunteers under the leadership of Dr Katrien van Landeghem, with over 150 students attending. Exhibitors included Shipping company Bark EUROPA, MOWI, Ecoscope, Intertek Energy & Water, Love the Oceans, X-Ray Mineral Services, STEMnet, Ocean Matters Ltd, Fugro, Morlais (Menter Môn), Living Seas, Wildlife Trust, Menai Science Park (M-Sparc), IMarEst and Anglesey Sea Zoo. Displays included virtual reality and strange-looking amphibians. There was also the opportunity to find out about a career in teaching.

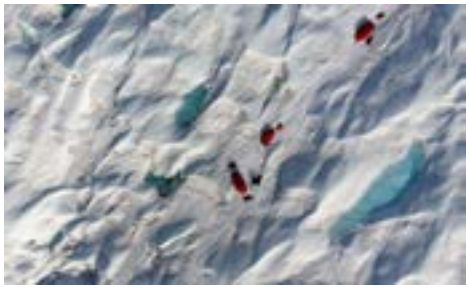
This year also saw an early morning session on the day, at which students heard about opportunities at an additional information session by employers.

FOLLOWING IN THE FOOTSTEPS OF NANSEN

– the Greenland Crossing Expedition

Last May SOS Geophysics PhD student Katie Retallick set off on an adventure of a lifetime, following in the footsteps, or should we say ski tracks, of the great polar explorer and oceanographer Fredtjof Nansen, in skiing across the central Greenland Icecap.

But before she could set off there were a couple of barriers to her plan. Although she could ski, downhill, to a reasonable standard she had never skied cross country or toured anywhere. She also had limited experience of camping in snow. To overcome this she joined a 5 day polar training course where she learned how to cross-country ski and then to ski pulling a pulk (sled).



After the polar training she travelled to Svalbard, at 78°N, where she took a skidoo from the main settlement of Longyearbyen to the East coast. From there she jumped on her skis and crossed the island of Spitsbergen from East to West over a 10 day period. After 2 years, with experience of skiing and living in all conditions, Katie decided she was ready for the expedition to cross Greenland!

Ahead of the expedition Katie undertook a rigorous training programme of running and hillwalking, and kept that going, but the main addition to training was tyre pulling (much to the amusement of her neighbours in the small Sonwdonia village of Penmachno!).
In May 2019, Katie joined a group of 5 to fly to the West coast of Greenland, via Copenhagen, arriving in Kangerlussuaq where she was stunned to find the temperature was 20°C! With everything packed, and a final meal at the surprisingly exquisite local restaurant, the team set off to the glacier in a huge 4x4 bus. When they reached the end of the road there was a bit of work in store, as they had to carry everything over a kilometre across moraine and streams in order to reach the edge of the ice.
Initially the going was severe, with lots of steep ice that had been pushed up into 2-10m high mini mountains. This required both strength and careful balancing to manoeuvre the equipment over, and agility and speed to avoid being run over by a descending pulk!

The team pressed on, on foot, and after 5 days eventually managed to switch to skis as the terrain flattened out. With skins attached, the team then had another 2 weeks of skiing uphill towards the top of the ice cap. Although a very gentle slope, it was definitely noticeable as the pulks were still heavy. Snow conditions changed daily but the wind generally remained the same, a headwind generated by the katabatic flow of air from the top of the ice cap down to lower altitudes.

After 10 days with nothing to see but the snow and sky, the team came across DYE II, an abandoned US early warning station from the Cold War. Exploring inside was a great contrast to their trip so far, and they were amazed to see that everything had been left as it was when the station was last used in the 1990s. The large radar, televisions, VHS players, furniture and even food remained in place (although the beer bottles were empty!). It provided a nice break from skiing and an opportunity to see what it must have been like to operate in such a remote environment.

The team continued East reaching the summit of the icecap at 2,500m on the 18th day of skiing. Any thoughts of it being all downhill from here were dispelled, as for the next week the scenery did not change at all. The snow was flat and featureless which made navigating extremely challenging. They used a compass mounted on their harness in front of them to ski on a bearing, as without distinct features on the ground it was easy to ski with bias to the left or right.

It wasn't until a few days of the trip that the snow conditions eased, and the team were finally able see the mountains of the East coast in the distance. By this stage they were now achieving 40km a day, with lighter pulks and were heading down the final slopes towards the glacier at the base of the ice cap. They had crossed Greenland under their own power, 583km in 27 days, with 2000m ascent, carrying 30kg food (and raised £1,600 for Dementia UK).

Asked "Would you do it again?", Katie responded "Absolutely, without a doubt! I hope to have many more adventures travelling on skis in polar regions". Maybe she can pick up where Nansen left off and ski to the North Pole?!

JACQUI MCGLADE WELCOMED BACK TO BANGOR

We were pleased to welcome Ocean Sciences alumna Jacqueline McGlade back to Bangor to give a public lecture entitled 'The Future of our Oceans' in March.

In her lecture, McGlade drew on her own research on plastics in our seas. She demonstrated that banning single-use plastics is not enough to safeguard the health of our oceans, and that what is needed is a complete redesign of global production systems. She then outlined ways that we can work to "conserve and sustainably use the oceans, seas and marine resources for sustainable development" (one of the UN's Sustainable Development Goals) in the face of unsustainable consumption and production and the rapidly changing climate.

Jacqueline McGlade is the Frank Jackson Foundation Professor of the Environment at Gresham College. She is also Professor of Resilience and Sustainable Development at University College London and Professor and Director of the Sekenani Research Centre of the Maasai Mara University in Kenya.

She served as Executive Director of the European Environment Agency from 2003-2013, and from 2014-2017 was Chief Scientist and Director of the Science Division of the United Nations Environment Programme based in Nairobi. She studied at the Universities of Bangor, Guelph (Canada) and Cambridge, and is an Honorary Fellow of Bangor University.

Marine Biology group at Sherkin Island, July 1975, Jacqui is front row, 3rd from right. (photo courtesy of Chris Wallas chris.wallas@mdba-systems.com)

TOP 70 GLOBALLY FOR SUSTAINABILITY

Bangor University has recently been ranked among the top 70 global universities, for their work toward the United Nations Sustainable Development Goals.

This is a major achievement and recognition for our University, and clearly acknowledges the excellent progress we are making towards becoming 'a Sustainable University'.

Bangor University is the only Welsh institution listed and is among 15 other UK Universities in the ranking's own definition of the top 70 in the Impact Rankings.

Research within the School of Ocean Sciences continues to contribute towards the United Nations Sustainable Development Goals. This includes blue carbon research, the development of more sustainable fisheries including capture techniques, hatcheries and aquaculture, and the development and resource assessment of offshore renewable energy.
www.timeshighereducation.com/rankings/impact/2020

Mangroves and blue carbon

Dr Martin Skov and other SOS scientists, with colleagues in Kenya and the UK, have been promoting mangrove restoration and conservation in East Africa since the early 2000s.

Research on mangrove ecology and carbon-sequestration eventually formed the scientific basis for setting up the world's first community-led project to finance conservation activities through 'blue carbon' trading.

The 'Mikoko Pamoja' project in Gazi Bay, 50km south of Mombasa in Kenya has been selling carbon certificates on the voluntary carbon market since its initiation in 2013. These certificates trade the exact amount of carbon emission that has been avoided through protecting the forest against illegal cutting.

The money arising from carbon trading are used to fund community activities associated with protecting the mangrove, including local environmental jobs and the costs of planting and patrolling protected areas. The rest of the funds are spent on activities that benefit the livelihoods of the villages surrounding the mangrove, such as a new wing in a local school, new clean water supplies and the purchase of teaching materials.

Bangor student Ada Barbanera with the local team identifying mangrove macrofauna in strongly degraded areas of mangrove forests in Kenya.

Since the initiation of Mikoko Pamoja the state of mangroves across Gazi Bay have greatly improved, including in areas well outside the zones designated for protection. Thus, local mangrove protection can generate wide benefits to the broader environment and to the people whose livelihoods depend on that environment.

This year, a new, similar project was launched in another Bay in Kenya: the Vanga Blue Forests projects is the second such community project in the world. You can find more information about Mikoko Pamoja here www.mangrovealliance.org/mikoko-pamoja, or by visiting the website of the 'ACES' charity that we set up to promote similar projects across East Africa. www.aces-org.co.uk/mikoko-pamoja-project

Development of tools to assist the development of sustainable fisheries

To assess the impact of trawl fishing on the sea and the rate at which it recovers Drs Lowri Evans, Jenny Shepperson and Professor Jan Hiddink have recently developed a web-based application, the Benthic Impacts Tool, which performs a quantitative assessment of the impact of bottom-towed fishing gear on the seabed.

Based on recent research, the Benthic Impacts Tool focuses on the ratio between depletion and recovery of animals living on the seabed. One version of the tool has been created to aid in assessments for the Marine Stewardship Council and another version for adaptive management of Marine Protected Areas in the UK. They are now working to ensure a future of evidence-based decision making in fisheries management and research.

The School of Ocean Sciences is also home to the only marine ornamental fish research hatchery in the UK. It has been developed as part of the SustaiNable Aquariums Project (SNAP); a collaborative research and development project between The Deep, Merlin Entertainments Ltd (SEA LIFE), the Zoological Society of London (ZSL) and the Centre for Applied Marine Sciences. This unique facility is run by Dr Tom Galley and Dr Nick Jones..

INTRODUCTIONS, PROMOTIONS AND AWARDS

Laura Richardson

We welcome back Laura as a Marie Skłodowska-Curie Sêr Cymru II COFUND Fellow.

Laura graduated with BSc Joint Hons in Social Anthropology with Development Studies at the University of Sussex before coming to Bangor to undertake the MSc in Marine Environmental Protection. She then worked for the School of Ocean Sciences at Bangor University as Project Support Officer on DEFRA funded Darwin Initiative projects in the Cayman Islands for 3.5 years before undertaking a PhD in the Centre of Excellence for Coral Reef Studies at James Cook University in Australia.

Her PhD examined how coral reef fish assemblage structure, function, and resilience are influenced by the taxonomic composition of habitat-building corals. She then returned to the UK as a Post Doc researcher at Exeter and Bristol Universities.

Laura is joining the rapidly growing Coral Reef research group and her research will focus on how ecological communities are organised by anthropogenic and biophysical processes interacting across space and time. She will focus mainly on tropic coral reefs.

Dr Martyn Kurr

Lecturer in Marine Biology/Ecology

We welcome back Martyn who has been appointed a lecturer in Marine Biology. Martyn undertook an MSci in marine biology at Bangor University between 2006-2010.

He then undertook a PhD on the sexual dimorphism and invasive ecology of marine macroalgae supervised by Dr Andrew Davies and Prof Jan Hiddink. Martyn then taught at Newcastle University where he was also marine lead for internationalisation. During this time he also supervised two doctoral-level projects, and was made a fellow of the Higher Education Academy. Martyn's research interests include non-native species, macroalgal ecology, intertidal ecology and animal behaviour.

Martyn says: "It is a great pleasure to return to the School of Ocean Sciences. I am enjoying working with this fantastic team of scientists and support staff once again."

James Waggitt

Lecturer in Marine Biology/Ecology

James was recently appointed as a permanent lecturer at the School of Ocean Sciences, following approximately 2 years on a fixed-term contract in the same role.
He completed a BSc and MRes in Marine Biology at Plymouth University between 2006 and 2010 where he first became fascinated by seabirds – in particular, their at-sea distribution and behaviour. Following a summer of volunteering at seabird colonies across the UK in 2011, James subsequently completed a PhD on seabird ecology under the supervision of Beth Scott at the University of Aberdeen. He then joined the School of Ocean Sciences as a Research Officer.
His current research aims to understand responses of seabirds to physical processes in coastal environments, including tidal cycles and weather events and has already developed strong collaborative links with oceanographers in the school. Using this knowledge, we can predict impacts of hard infrastructure and environmental change on these communities. He is also involved in the development of statistical models that estimate and predict at-sea distributions of cetacean and seabird species at regional and continental scales.

Laura Haggett

Marketing and Recruitment Clerical Officer

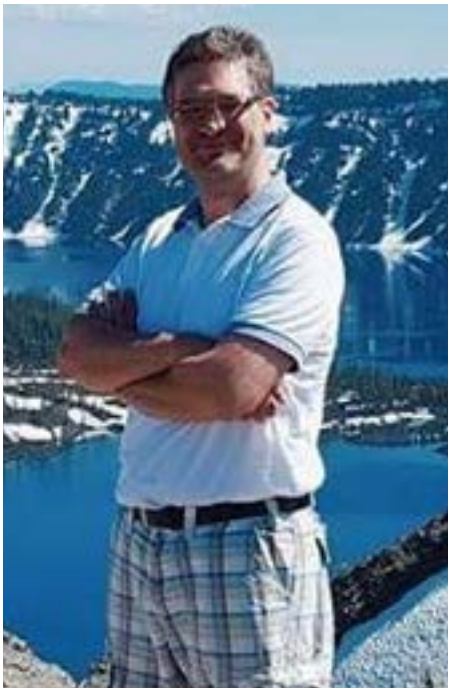
Laura is the new Marketing and Recruitment Clerical Officer in Ocean Sciences. Laura graduated from Bangor University in 2012, having studied BSc Psychology and MSc Psychological Research. Since then she has been working with the University in various departments such as the Dyslexia Centre, and Commercial Services. She also currently lives and work in Halls of Residence as a Senior Warden. In her spare time she crafts and sells natural soaps, solid shampoos and other bath & body products; all in plastic-free packaging. (Facebook/Instagram @coedennoeth)

Yueng-Djern Lenn (promoted to Reader)

Yueng is a physical oceanographer with interests in understanding the physical processes which support the ocean overturning circulation and how they impact climate in the polar oceans. Her current focus is on the impact of Arctic sea ice retreat on midlatitude weather and the impact of declining sea ice on primary production in the Arctic. Originally from Singapore, Yueng is a Cambridge graduate who studied for her PhD at the SCRIPPs Oceanographic Institution in the US. During this time she published the first ever observations of an Ekman Spiral in the Ocean. She moved to Bangor as a Post Doc researcher in 2007, joining Tom Rippeth and John Simpson's research group, and was subsequently awarded a NERC independent research fellowship.

Yueng also co-ordinates educational outreach and STEM activity across the School of Ocean Sciences. This work was recognised when she reached the national finals of the 2018 Womenspire Awards.

In the photo, Yueng is demonstrating how water can become supercooled below its usual freezing point due to the high pressure at the base of glaciers.



Mattias Green (promoted to Personal Chair)

Mattias is a physical oceanographer who specialises in using models and observations to explore how the tides interact with other components of the Earth system and how these interactions change over long timescales. His major discoveries include a 'super tidal cycle' linked to continental drift, which helps explain the age of the moon. He is also collaborating with scientists from Oxford and Upsala in looking at the role of tides in a key stage of the evolution of life on Earth, the development of quadrupeds.

More recently he has teamed up with collaborators from NASA to investigate how tides lead to the demise of life on in the planet Venus (a paper downloaded over 6,000 times since it was published last year).

Mattias is originally from Sweden having undertaken his PhD Physical Oceanography at Gothenburg University. He moved to Bangor as a Post Doc researcher in 2004, joining Tom Rippeth and John Simpson's group, and was awarded a NERC Advanced fellowship in 2008.

Simon Neill (promotion to Personal Chair)

Simon is a physical oceanography who specialising in ocean renewable energy, and in particular the characterizing the wave and tidal energy resource, understanding wave-tide interaction, optimizing grid integration of arrays of marine renewable energy devices, and quantifying the environmental impacts of extracting energy from the oceans.

Simon originally studied Civil Engineering at Dundee University before undertaking a PhD in estuarine physics at Strathclyde University. He then moved to Bangor to work at the Centre for Applied Marine research. He has recently published a text book on marine energy: "Fundamentals of Ocean Renewable Energy: Generating Electricity from the Sea" and leads the Smart Efficiency Energy Centre (SEEC)

Ocean Sciences Successes in this year's Student Led Teaching Awards

We are thrilled that Ocean Sciences Dr Sarah Zylinski was the outright winner of the "Student Engagement Award".

In their citation the Students Union described Sarah as "a key figure in the relationship between Course Reps and the School of Ocean Sciences, helping students to drive change in the School".

As well as the school being nominated for the "School of the Year" award, Ocean Sciences staff also featured strongly in the final of other categories. Ian McCarthy and Adel Heenan were both nominated for Post Graduate Teacher of the Year award. Dei Huws and Ian MacCarthy were both nominated for the Teacher of the Year award. Craig Robinson was nominated for the New Teacher of the Year award. Stefanie Kraft for the Academic Support Staff Member of the Year and senior tutor Dr Laura Grange was nominated for "Outstanding Pastoral Support".

Commenting on the results head of school Professor John Turner said:

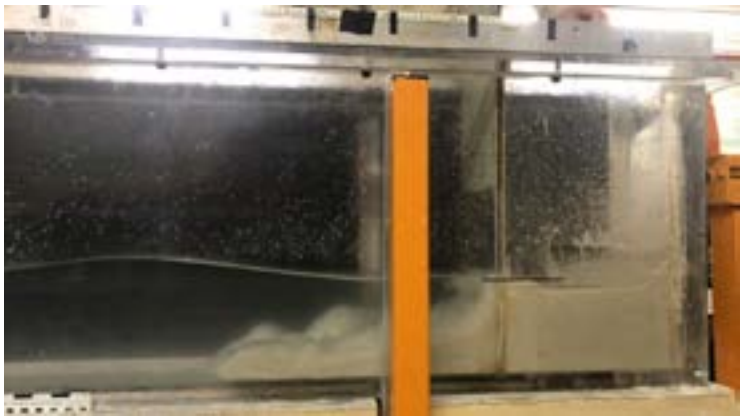
"Great to see that our students nominated so many staff in various categories for the Student Led Teaching Awards this year, including Dei Huws, Ian McCarthy (twice), Adel Heenan, Craig Robertson, Stefanie Kraft and Laura Grange, as well as Ocean Sciences for best School. Particular congratulations go to Sarah Zylinski for winning the Best Student Engagement Award for being a key figure in the relationship between Course Reps and the School, providing impartial advice and assisting students to drive change. We are grateful to our students for their nominations."

Tsunami video wins Silver Publishers' Award of the Geographical Association

An educational video on tsunamis, made by Time for Geography in collaboration with Bangor University and the University of Dundee, has received the 2020 Silver Publishers' Award by the Geographical Association.

The Silver Award is the highest accolade given annually for materials associated with geography in schools and colleges that make a significant contribution to geographical education and professional development.

The video explores how tsunamis are formed at sea and how their effect can be recognised in the coastal landscape through a combination of animations, fieldwork in Scotland, and demonstrations in the Hydrodynamics Laboratory at Bangor University.



Aimed to boost knowledge at GCSE, A-level and equivalent, Dr Jaco H. Baas (School of Ocean Sciences) and Prof. Sue Dawson (Dundee) help students to understand tsunamis using physical geography and oceanography, and to assess tsunami hazards in the UK.

At the awards ceremony, the Geographical Association highlighted the focus of the video on subject matter that is not typically found in textbooks. They added that, combined with the voices of academic geographers, a clear outline is provided to students of how disciplinary knowledge is developed through tectonic hazards research.

Dr Baas explains: "Reaching out to schools and colleges by sharing knowledge and demonstrating how to do research is an important and gratifying task. The tsunami video provides physical as well as geological information. This underlines the value of using a multidisciplinary approach at all levels of education."

The two-part tsunami video is available from the Time for Geography website:
timeforgeography.co.uk/videos_list/plate-tectonics/tsunamis-causes
timeforgeography.co.uk/videos_list/plate-tectonics/tsunamis-uk-evidence

SOS RESEARCH HIGHLIGHTS

Scientists complete largest global assessment of ocean warming impacts

A group of international marine scientists, including SOS's Prof Jan Hiddink, have compiled the most comprehensive assessment of how ocean warming is affecting the mix of species in our oceans – and explained how some marine species manage to keep their cool.

Researchers from the UK, Japan, Australia, USA, Germany, Canada, South Africa and New Zealand analysed three million records of thousands of species from 200 ecological communities across the globe.

Reviewing data from 1985 – 2014, the team showed how subtle changes in the movement of species that prefer cold-water or warm-water, in response to rising temperatures, made a big impact on the global picture.

The findings, published in the journal Nature Climate Change, show how warm-water species increase and cold-water marine species become less successful as the global temperature rises. However, the study also suggests that some cold-water species will continue to thrive by seeking refuge in cooler, deeper water.

Commenting, Prof Hiddink said:

"This research shows that shifts in the fished species in response to climate change are predictable, giving the fisheries industry and ecosystems managers a opportunity to anticipate and prepare for these changes"
The truly global study looked at data from the North Atlantic, Western Europe, Newfoundland and the Labrador Sea, east coast USA, the Gulf of Mexico, and the North Pacific from California to Alaska.
While the global warming trend was widely seen, the North Atlantic showed the largest rise in average temperature during the time period. However, for fish communities in the Labrador Sea, where the temperature at 100 metres deep can be as much as five degrees Celsius cooler than the surface, moving deeper in the water column allowed the cold-water species to remain successful. This new result have important implications has to how the marine food chain will respond to a warming world.

Burrows, M. T., Bates, A. E., Costello, M. J., Edwards, M., Edgar, G. J., Fox, C. J., Halpern, B. S., Hiddink, J. G., Pinsky, M. L., Batt, R. D., Molinos, J. G., Payne, B., Schoeman, D., Stuart-Smith, R. D. & Poloczanska, E. S. (2019). Ocean community warming responses explained by thermal affinities and temperature gradients. Nature Climate Change, 9, 959-963
https://www.bangor.ac.uk/news/research/scientists-complete-largest-global-assessment-of-ocean-warming-impacts-42384

Irrawaddy Dolphin Research

Irrawaddy Dolphins are rare freshwater dolphins and are classed critically endangered species, vulnerable to human activities in South-East Asia.

Since graduating with a MSci in Marine Biology and Oceanography in 2017, School of Ocean Sciences alumna Emma Keen has been assisting cetacean research across Europe and Asia and, in particular, Irrawaddy Dolphin conservation in Cambodia.

Her research on Irrawaddy Dolphins with the Cambodian Marine Mammal Conservation Project has just been published in Raffles Bulletin of Zoology. In this paper, Emma and co-authors used a combination of shore and vessel-based surveys. The team found that dolphins were present in the region across the annual cycle, but were particularly prevalent in the monsoon and post-monsoon season. They also found that dolphin favoured certain areas in the Kep archipelago and were usually seen feeding. The Irrawaddy Dolphin is an endangered species endemic to south-east Asia. The ongoing research by Emma and the Cambodian Marine Mammal Conservation Project will be invaluable for marine management and conservation schemes in the region.

Sarah E. Tubbs, Emma Keen, Amy L. Jones & Rachana Thap (2020). On the Distribution, Behaviour and Seasonal Variation of Irrawaddy Dolphins (Orcaella brevirostris) in the Kep Archipelago, Cambodia. Raffles Bulletin of Zoology 68: 137–14.

Underwater Gliders help improve weather forecasts

An underwater turbulance glider. Copyright: Rockland Scientific

Wind rows illustrated in this seascape looking towards Penmaenmawr

New measurements of how waters mix just below the surface of the Atlantic Ocean are to be used to improve weather forecasts.

The water turbulence was measured by an underwater 'glider' and the results of the research, led by Bangor University researcher Natasha Lucas with Tom Rippeth, are published in a new Journal paper.

Our weather is largely driven by heat supplied to the atmosphere by the ocean. In order to be able to make reliable seasonal predictions of the weather, it is vital that the transfer of heat from the ocean to atmosphere is correctly predicted.

A key process in determining this transfer of heat is 'Langmuir circulation', or wind rows, which we often see in lakes and the ocean in windy conditions. Commenting on the work, lead author Natasha Lucas, of Bangor University's School of Ocean Sciences says:

"We have known for a while that it is likely that Langmuir processes are important in determining the exchange of heat between the ocean and the atmosphere. However, to accurately represent these processes we needed to be able to make measurements of turbulence close to the ocean surface.

The recent development of underwater gliders from which we can measure turbulence over recent years has enabled us to be able to make the measurements near the sea surface. In this new paper, we report a series of measurements made using an underwater glider in the mid-Atlantic Ocean during an autumn storm. These new measurements are being used by the Met Office to improve weather forecasts."

Professor Stephen Belcher, Chief Scientist at the Met Office and a co-author on the paper said:

"Getting the interaction between the atmosphere and oceans right is important to all that the Met Office does, from weather forecasts to climate projections. This work is already being implemented into Met Office forecasts systems, and we should be seeing the benefit soon."

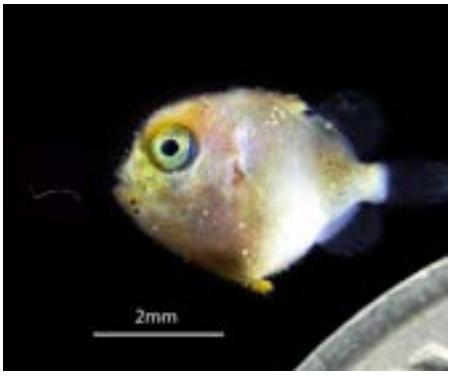
Lucas, N., Grant, A. L. M., Rippeth, T.P., Polton, J., Palmer, M., Brannigan, L. & Belcher, S. E. (2019). Evolution of Oceanic Near Surface Stratification in Response to an Autumn Storm. Journal of Physical Oceanography. 49(11), 2961-2978.
https://www.bangor.ac.uk/news/research/underwater-gliders-help-improve-weather-forecasts-42324

Prey-size Plastics are Invading Larval Fish Nurseries

A scribbled filefish, about 50 days old and two inches long, surrounded by plastics. Sample taken in a surface slick off West Hawaii. Credit: Photograph courtesy of David Liittschwager

New research has shown for the first time, that larval fish across a range of fish species from different ocean habitats are surrounded by and ingesting plastics in their preferred nursery habitat.

Many of the world's marine fish spend their first days or weeks feeding and developing at the ocean surface, but little is known about the ocean processes that affect the survival of larval fish. Larval fish are the next generation of adult fish that will supply protein and essential nutrients to people across the world. NOAA's Pacific Islands Fisheries Science Center and an international team of scientists, including Bangor University in the UK, conducted one of the most ambitious studies to date, to shed light on this critically important knowledge gap.



Larval triggerfish with a ~1mm long blue plastic fiber found in its stomach. Credit: Jonathan Whitney, NOAA Fisheries.

"The new study combined field-based plankton tow surveys and advanced remote sensing techniques to identify larval food resource for larval fish", said Dr. Jamison Gove, a research oceanographer for NOAA and co-lead of the study. "We found that surface slicks contained larval fish from a wide range of ocean habitats, from shallow-water coral reefs to the open ocean and down into the deep sea—at no other point during their lives do these fish share an ocean habitat in this way," said Dr. Jonathan Whitney, a marine ecologist for NOAA. "Slick nurseries also concentrate lots of planktonic prey, and thereby provide an oasis of food that is critical for larval fish development and survival," said Dr. Whitney.

Larval fish in the surface slicks were larger, well-developed, and had increased swimming abilities. Larval fish that actively swim will better respond and orient to their environment, suggesting that tropical larval fish are actively seeking surface slicks to capitalise on concentrated prey.

Larval fish sampled in surface slicks are surrounded by plastics of all shapes and sizes. An inch-long triggerfish (upper left) noses up a white plastic triangular shard of plastic, while a striped larval mahi-mahi (center right), just under two inches long, turns away from the rope. Credit: Photograph courtesy of David Liittschwager

"These findings are important because they highlight how complex gradients in plankton and larval fish abundance can occur across what is often assumed to be a featureless ocean surface habitat," said Dr. Gareth Williams, Reader in Marine Biology at Bangor University's School of Ocean Sciences.

Gove, J. M., Whitney, J., McManus, M. A., Lecky, J., Carvalho, F., Lynch, J., Li, J., Neubauer, P., Smith, K., Phipps, J., Kobayashi, D., Balagso, K., Contreras, E., Manuel, M., Merrifield, M., Polovina, J., Asner, G., Maynard, J. A. & Williams, G. J., (2019). Prey-size plastics are invading larval fish nurseries. Proceedings of the National Academy of Sciences of the USA. 116(48), 24143-24149
https://www.bangor.ac.uk/news/research/prey-size-plastics-are-invading-larval-fish-nurseries-42264

Use of LED lights substantially reduce the number of unwanted fish in trawl nets

A new study by has shown that by attaching LED lights to larger holes in fishing nets, which are intended to allow unwanted species to escape, bycatch is greatly reduced.

The study was conducted off the Isle of Man, from the Prince Madog, and found that whilst existing technology to reduce bycatch was effective to depths of 40 metres, it had no impact in the deeper (darker) waters. However, once LEDs had been added to the nets to highlight larger holes, the bycatch was reduced by between 25 and 47%, depending on species.

Commenting to the Guardian newspaper, lead author Lucy Southworth said: "Traditionally, and this goes back decades and maybe even centuries, fishers used lights to attract fish.

"We are turning that on its head to try and manipulate the behavioural responses in fish and other animals, to either repel them away from gear, or to manipulate their behaviour so they can escape from the net."

She added: "We decided to attach the lights to the escape exit to try and guide fish towards it so they would escape more so than if the lights weren't there."

Southworth expressed great concern about their discovery that existing bycatch reduction devices (without LEDs) failed to reduce bycatch at the greater depths which are typical of those found in the western Irish Sea, northern North Sea and Celtic Seas.

Bycatch is a problem in fisheries worldwide and it is hoped that the LED solution could reduce the numbers of unintentionally killed dolphins, whales and porpoises.

Southworth, L., Ratcliffe, F., Bloor, I., Emmerson, J., Watson, D., Beard, D., & Kaiser, M. (2020). Artificial light improves escapement of fish from a trawl net. Journal of the Marine Biological Association of the United Kingdom, 100(2), 267-275. https://doi.org/10.1017/S0025315420000028

Antarctic Sea Ice retreat results in increased carbon dioxide uptake by the ocean

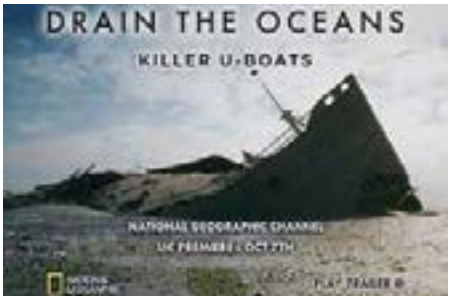
Over the past three years, Prof. Stuart Jenkins, Dr. Katrien Van Landeghem, PhD Researcher Kate Retallick and Dr Ben Lincoln have joined multidisciplinary research cruises on the RRS James Clark Ross, which is operated by the British Antarctic Survey.

Their research is focused on the West Antarctic Peninsula and is a joint UK-Chile project, called ICEBERGS, funded by NERC-CONICYT. They have surveyed three different fjords looking at variations in biological, oceanographic and geological parameters in response to the retreating glaciers in order to determine the consequences of glacial retreat on the benthic ecosystems close to the ice margin.

A new paper by the ICEBERGS team provides the first testable estimate of increased oceanic carbon sequestration in response to glacier retreat in Antarctic fjords. Such assessments underpin our growing understanding of changes in oceanic carbon sequestration (Blue Carbon) linked to climate change.

David K. A. Barnes, Chester J. Sands, Alison Cook, Floyd Howard, Alejandro Roman Gonzalez, Carlos Muñoz–Ramirez, Kate Retallick, James Scourse, Katrien Van Landeghem and Nadescha Zwerschke (2020). Blue carbon gains from glacial retreat along Antarctic fjords: What should we expect? Global Change Biology, 26, 2750-2755. https://doi.org/10.1111/gcb.15055.

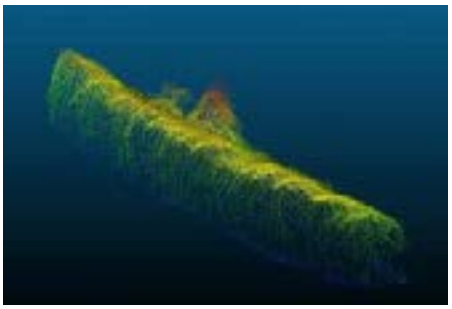
University's U-Boat research featured in "Drain the Oceans"



School of Ocean Science's research vessel the Prince Madog, has surveyed numerous shipwreck sites in the Irish Sea as part of a joint research project with the Royal Commission on Ancient & Historic Monuments in Wales's Heritage Lottery funded project: Commemorating the Forgotten U-boat War around the Welsh Coast, 1914-18.

This work has recently featured in the "Drain the Oceans" series on National Geographic TV Channel.

A team of staff from the School of Ocean Sciences, led by Dr Mike Roberts, have been using a multibeam sonar system and the latest imaging techniques to reveal underwater wrecks from the Great War.



A new image of U-87 which was damaged and sunk on Christmas Day 1917

The sonar system on the Prince Madog generates very high resolution, three-dimensional models of the seafloor as the research vessel moves through the water over it, and these models can allow researchers to identify objects at near centimetre scale. In water depths of 100 metres, typically found in the Irish Sea, the team are generating models and images of wrecks that can help marine archaeologists confirm their identity and even provide evidence of their demise.

Dr Mike Roberts explains why the information is so valuable:

"While these wartime relics can provide valuable information to historians and archaeologists, they may also help lead to the birth of a new industry. The data we're collecting is providing unique insights into how these wrecks influence physical and biological processes in the marine environment. This information is being used to support the ambitions of the marine renewable energy sector.

https://www.bangor.ac.uk/news/research/university-s-u-boat-research-featured-in-drain-the-oceans-41921

In coming months we plan a series of social media releases under the title "O Dan y Dŵr (Beneath the Water)" where we highlight other discoveries made in the seas around Anglesey.

https://www.facebook.com/sosbangor
https://twitter.com/sos_bangor_uni

Discovery of a WW2 Landing Craft off Wales ends 77 year old mystery

A collaboration between a team at the School of Ocean Sciences at Bangor University, with nautical archaeologist and historian Dr Innes McCartney from Bournemouth University, has resulted in the unexpected discovery and the identification of a landing craft which was mysteriously lost at sea during WW2.

Multibeam sonar data collected from a known shipwreck site off Bardsey Island by the Bangor team using the research vessel Prince Madog in 2019, has recently been identified as a World War 2 landing craft reportedly lost off the Isle of Man.
LCT 326 was a Mk III 'Landing Craft Tank' designed to land armoured vehicles during amphibious operations, she was built in Middlesbrough and launched in April 1942. These highly specialised vessels were built in large numbers in the last years of WW2 and were extensively used during the D-day operations of June 1944. LCT 326 disappeared while transiting from Scotland to Devon in February 1943 with the loss of fourteen crew. The Admiralty listed the cause of the loss at the time to bad weather or collision with a mine off the Isle of Man, however this new research now places the wreck over 100 miles away off Bardsey Island, North Wales.

Dr Innes McCartney said: "The wreck of LCT 326 is one of over 300 sites in Welsh waters which have been surveyed by the Prince Madog, and the aim of this particular piece of research is to identify as many offshore wrecks in Welsh waters as possible and shed light on their respective maritime heritage. This aspect of the project has resulted in many new and exciting discoveries relating to both world wars, of which LCT 326 is just one example.

The sonar data will also play a pivotal role in helping develop the offshore renewable energy sector in Wales via the Bangor University led SEACAMS2 research project, which is examining the effect that shipwrecks have on the marine environment.

Lead Bangor researcher Dr Michael Roberts said: "Establishing the identity of these offshore wrecks and thereby determining how long they have been submerged is crucial in helping us understand how structures interact with marine processes on timescales that are of great interest to the marine renewable energy industry.
"Wrecks such as LCT 326 and their associated physical and ecological 'footprints' can often provide us with preliminary insights on the nature and properties of the surrounding seabed without having to undertake more complex, challenging and expensive geoscientific surveys."

Initial analysis of the sonar data obtained from the site, including the wreck dimensions and general appearance suggested the wreck was an LCT, further archival research identified the remains as most likely being LCT 326.
This vessel appears to have foundered in heavy seas sometime some 25 miles further south than it was last seen, and probably broke in half just forward of the bridge, with both halves staying afloat long enough to have become separated by 130m. The sonar data clearly shows key features of the vessel such as its distinctive landing gangway and stern deck house and although the cause of the loss of this vessel remains unknown (mine explosion or collision cannot be absolutely ruled out), the evidence suggests this may have been nothing more than a tragic marine accident.
'Echoes from the Deep: Modern Reflections on our Maritime Past' is funded by the Leverhulme Trust and will be published in 2021.

LCT 326 was a Mk III 'Landing Craft Tank' designed to land armoured vehicles during amphibious operations.
Image courtesy Imperial War Museum

Research highlights from elsewhere in the

COLLEGE OF ENVIRONMENTAL SCIENCES AND ENGINEERING

The School of Ocean Sciences is part of Bangor University's College of Environmental Sciences and Engineering, which is one of the largest centres for environmental research in the UK.

It includes Marine Centre Wales and the Environmental Centre for Wales. It also houses a Natural History Museum, with extensive invertebrate and vertebrate collections, a research farm, Henfaes Research Centre, the BioComposites Centre and the Treborth Botanic Garden.

The Amazon rainforest could be gone within a lifetime

Large ecosystems, such as the Amazon rainforest, will collapse and disappear alarmingly quickly, once a crucial tipping point is reached, according to calculations based on real-world data.

CoESE Dr Simon Willcox, together with researchers from Southampton University and The School of Oriental & African Studies, University of London, reveal the speed at which ecosystems of different sizes will disappear, once they have reached a point beyond which they collapse – transforming into an alternative ecosystem.

Dr Simon Willcock, a Senior Lecturer in Environmental Geography at Bangor University is an expert in tropical landscapes and the benefits people receive from them. He contributed to a major piece of research, published in Nature which showed the ability of tropical forests' to act is carbon sinks is already weakening as a consequence of climate change. Commenting Simon says: "The world's tropical forests are hugely important and so these findings are alarming. To understand the impact of our changing planet, scientists from nearly 100 institutions came together to share knowledge and collaborate. If we are to solve global problems such as climate change, politicians, decision-makers, and members of the public need to do the same – to work together towards a shared goal."

Hubau et al (2020). Asynchronous carbon sink saturation in African and Amazonian tropical forests. Nature, doi. org/10.1038/s41586-020-2035-0
Cooper, G., Willcock, S. & Dearing, J. (2020). Regime shifts occur disproportionately faster in larger ecosystems. Nature Communications. 11, 1175

Packaging our foods without plastics

There is growing concern worldwide about the amount of single use plastic packaging, and in particular that used with our food shopping.

The solution lies in developing sustainable food packaging alternatives. Experts from Bangor University's BioComposites Centre have already developed a range of food packing made out of grass in partnership with UK supermarket, Waitrose, one of the UK's largest fresh food distributors. They are now collaborating with Makerere University, Uganda to work with female-led smallholders in Uganda to use their waste maize (called stover) to create biodegradable food packaging. A further advantage is the by making use of the leaves, stalks and cobs left in the field after harvesting the maize will provide smallholders with an additional income stream.

Dr Adam Charlton, Senior Research fellow at the University's BioComposites Centre said:

"The green egg boxes and other moulded food packaging produced from our original concept can be found in Waitrose supermarkets across the country and have been well received by customers.

This project is an opportunity to share our experience of collaborative research to help Uganda's emerging bioeconomy to develop further. This type of technology transfer can lead to new products, which will hopefully create a new income stream for some of Uganda's agricultural small holders."

PHOTO COMPETITION

During the winter of 2019/20 we ran a photographic competition and were extremely impressed with the high standard of entries from our talented students.

As there were so many excellent entries, we're showing half of them here and half in the next edition. Many of these photos were taken on student field trips.

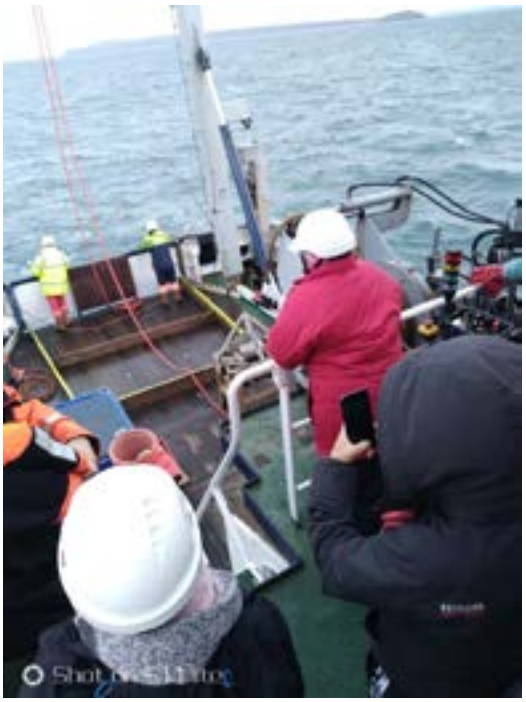
The winning entry received the most likes on www.facebook.com/sosbangor

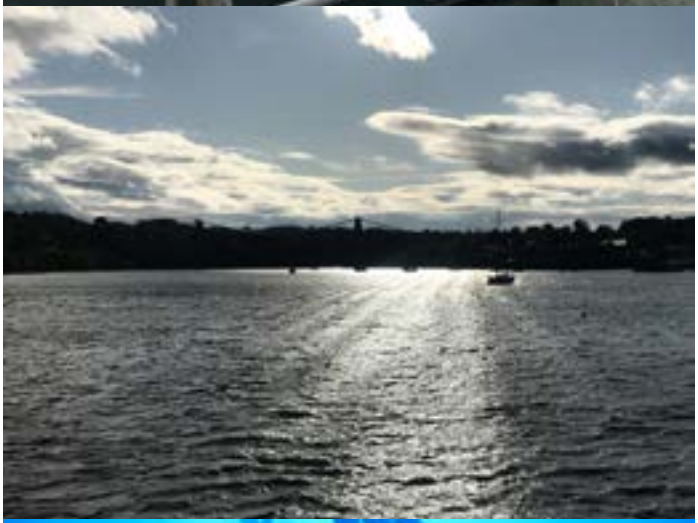
First Prize
This stunning image of a Dahlia Anemone (Urticina felina) was taken by AJ Jones, Marine Biology and Zoology undergraduate, during the annual field trip to the Anglesey Sea Zoo. During the trip the students observed many different marine species that reside around the UK.

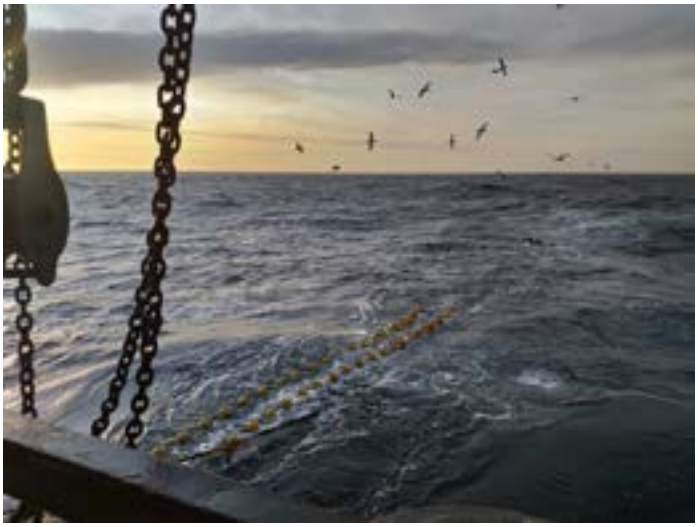
Well done AJ!

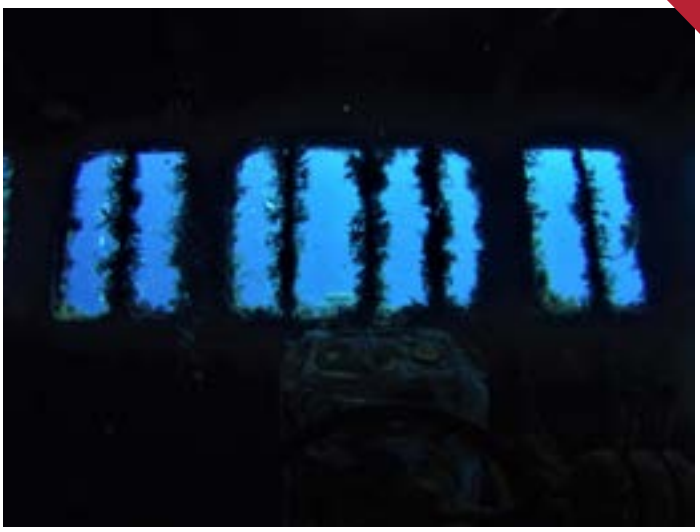
Our thanks go to everyone who took part, taking wonderful photos and supporting the competition by sharing and liking on social media.

Second and third places were both taken by Laura Giaretta, first year Marine Biology and Oceanography.
“The manta’s picture has been taken in the Lisbon Sea Zoo and it symbolises the beginning of my passion for marine creatures.
The frog’s picture shows how camouflage skills can make even the smallest animals the most fascinating.”







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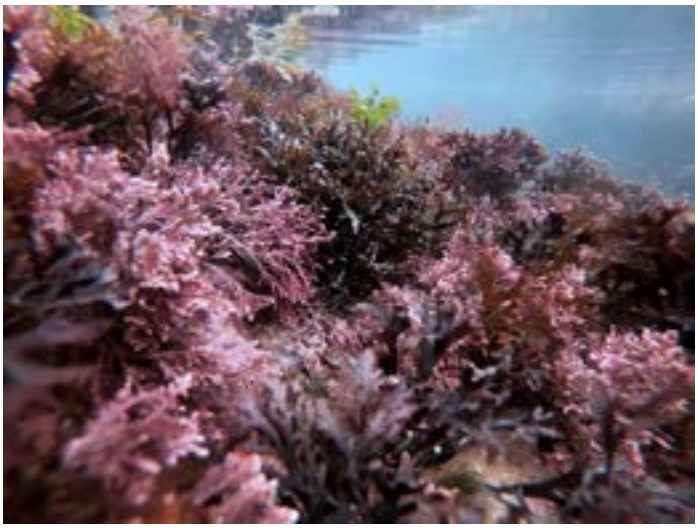


Celebrating over 50 years of *Prince Madog* science

by Katrien Van Landeghem and Tom Rippeth

This article is reproduced from Ocean Challenge, a publication of the UK Challenger Society for the Marine Sciences. Ocean Challenge aims to keep its readers up to date with what is happening in oceanography in the UK and the rest of Europe. By covering the whole range of marine-related sciences in an accessible style it should be valuable both to specialist oceanographers who wish to broaden their knowledge of marine sciences, and to informed laypersons who are concerned about the oceanic environment.

For more information on the Challenger Society please visit:
https://challenger-society.org.uk

2018 saw the 50th Anniversary of Bangor University taking delivery of its new research vessel, *Prince Madog*. Since then, this vessel and then her replacement, which came into service in 2001, have been the platform for training several generations of sea-going scientists, and been used for world-leading research, as well as for regular offshore monitoring work. As a tribute to its service to the marine science community, we provide an incomplete review of the science that has been underpinned by data collected on the *Prince Madog* over the past 50 years, and the impact that science has had.

A research vessel to support marine science in Menai Bridge

Bangor University's interest in marine science goes back to a few decades after its inception, as the University College of North Wales, in 1884. The first honours degrees in Marine Biology were awarded by the University College in the 1930s and the university's commitment to marine science was confirmed by the establishment of the Marine Science Laboratories, across the Menai Strait in Menai Bridge, in 1948. Initially, interest was focussed on helping the sea fisheries of North Wales, but by the 1960s marine science at Menai Bridge had been broadened, with physical oceanographers, marine geologists and chemists joining the developing Marine Science Laboratories, which eventually became the School of Ocean Sciences (SOS). The range of research and teaching activities expanded from near-shore and coastal ecology, to studies of shelf seas and the deep ocean, and access to a large, well equipped research vessel became imperative. The solution was the purchase and commissioning by the university of a new vessel (Figure 1), named after the great Welsh hero, Prince Madog, who is reputed to have discovered America.

Figure 1 *The original RV* Prince Madog *approaching Menai Bridge pier in 1968. The 185-tonne, 28.7-m research vessel, built on the Isle of Man, could accommodate eight scientists and had an endurance of seven days. She was named after the Welsh Prince who, legend says, set sail in 1170 on a westerly course, eventually reaching North America, where he founded a Welsh-speaking tribe.*
(Photo: School of Ocean Sciences, Bangor University)

First Prince Madog *surveys in 1968*

Within the first year of her operation in 1968, the new vessel made over 20 cruises, which ranged from student field trips to full-scale geophysical and hydrographic cruises off the west of Ireland and in the Celtic Sea, and to the west of Scotland and in Loch Ness.

A breakthrough in understanding plate tectonics

During one of the first *Prince Madog* research cruises in 1968, Denzel Taylor-Smith and Bill Bailey carried out pioneering geophysical research in the Porcupine area of the North Atlantic. At the time, plate tectonics was still a relatively recent idea and a new research project had been developed which aimed at better understanding the late Paleozoic North Atlantic supercontinent, and its subsequent break-up. The RV *Prince Madog* undertook geophysical surveys which improved understanding of the geological structure of key parts of the outer shelf to the west of Ireland (Figure 2). The study centred around an area where a new arm of the Mesozoic Atlantic Ocean, the Rockall Trough, was created. Magnetic anomaly contour maps together with seismic reflection profiles recorded during the cruises provided general support for the idea that the Slyne Ridge and Porcupine Ridge represent submerged blocks of marginal continental crust, and that the Porcupine Seabight is founded upon crust significantly different in character. The reconstructions of the crustal structural beneath the troughs and ridges to the west of Ireland implied either an early Cretaceous triple junction (where three plate boundaries met) at the southern end of the Rockall Trough, or an earlier phase of sea-floor spreading.

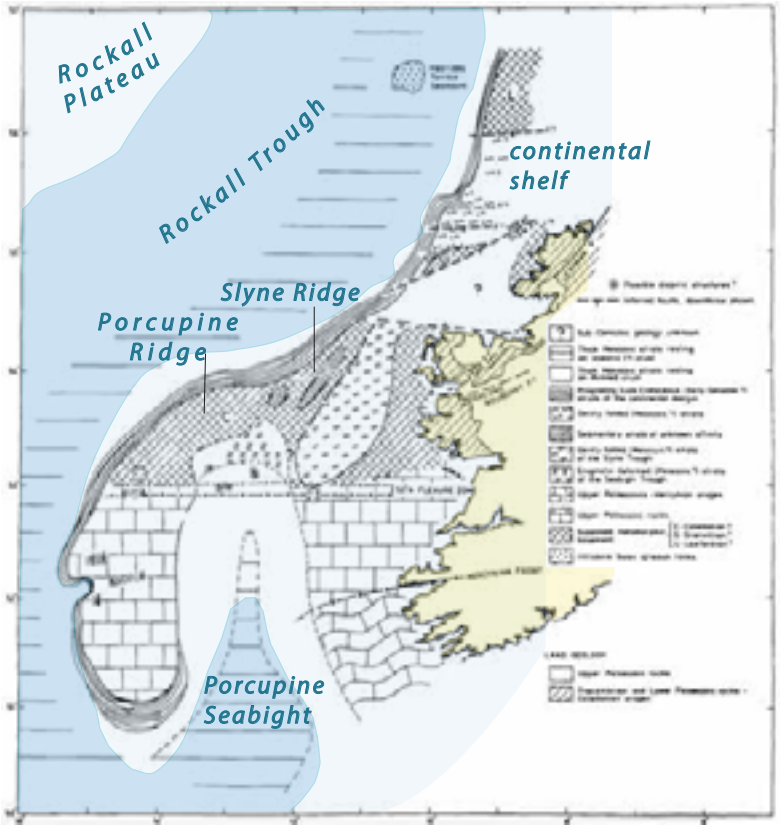


Figure 2 *Speculative offshore sub-Cenozoic geology (> 65 Myr) to the west of Ireland, based on seismic reflection, magnetometer and gravimeter profiles (reproduced from Bailey, 1975). For the purpose of this article we have added the yellow shading (land), pale blue (continental shelf/slope down to a depth of ~1500 m), and darker blue (greater depths) plus the names of some bathymetric features.*

Insight into turbulence and mixing

In September 1968, the *Prince Madog* took John Simpson, Dave Boon, John Woods and Steve Thorpe to Loch Ness via the flight of lochs known

Figure 3 *The second RV* Prince Madog. *In 1999, as a result of a Joint Infrastructure Fund bid led by Ed Hill (then at Bangor) funding became available for a new ship, which came into service in 2001. Built by Scheswerf Visser BV, the new* Prince Madog *(390 tonnes, 34.9 m in length) arrived in Menai Bridge in summer 2001. She is more spacious and stable than her predecessor, and has capacity for 11 scientists and an endurance of 10 days.*
(Photo: School of Ocean Sciences, Bangor University)

as Neptune's Staircase. They measured very fine structure (microstructure) profiles of temperature through the thermocline in this freshwater lake and discovered that the microstructure temperature patterns were very similar to those found in the ocean. Temperature and salinity microstructure had previously been measured in the ocean thermocline and had been attributed to the process of double diffusive convection, which is driven by opposing salt and temperature gradients. However there are no salinity gradients in the lake, so double diffusive convection could be discounted as a cause of microstructure, whether in the lake or the ocean. This insight helped open the way for the development of now very widely used microstructure-based techniques for the measurement of turbulence (from which mixing estimates are inferred) in the ocean.

Long-standing fisheries research

Throughout the 50 years of operation of the two *Prince Madog* vessels, fisheries have remained a core research activity. From the late 1960s the *Prince Madog* has been involved in an annual fish stock survey of target species such as plaice and dab in five contrasting sites to the east of Anglesey. This work represents one of only a few such long-term surveys in UK coastal waters and has been led by Dave Grove and Ian McCarthy.

Figure 5 *Some of the places mentioned in the article. The School of Ocean Sciences (SOS) is indicated by a green cross on the Anglesey side of the Menai Straits. The red line is the transect along which data in Figure 6 were collected.*

Over the past 20 years, fisheries work based on the *Prince Madog* has included pioneering research into the quantification of the wider ecosystem effect of fishing on sea-bed habitats, led by Mike Kaiser, Jan Hiddink and Stuart Jenkins, with Helen Beadman and other Ph.D students. Prior to this research there was virtually no evidence available for fisheries managers, conservationists and policy-makers to assess the effect of fishing. This work has assisted the local economy through improving yield and minimising environmental impacts of the Menai Strait mussel fishery, the UK's largest blue mussel fishery

Figure 4 *Blue mussels from the Menai Strait. (Photo: Bangor University)*

(Figure 4). It also demonstrated that mussel cultivation had no negative effects on other species and that, furthermore, it enhanced populations of oyster-catchers. Follow-up work provided extensive evidence-based advice of value to the Isle of Man scallop fishery and for the management of the Cardigan Bay Special Area of Conservation with regard to its scallop fishery.

Data collected from the *Prince Madog* also fed through to a global meta-analysis of fishing impacts on benthos, and underpinned ecological modelling approaches to the prediction of trawling impacts on benthic communities. For this research, cruises sampled benthic fauna in lightly and heavily fished areas in a wide range of habitats, including the limestone reefs of Lyme Bay (off south Devon and Dorset), the deep muddy bottom of the Fladen Ground in the northern North Sea, and the scalloping grounds in Cardigan Bay. The surveys used a wide range of benthic sampling techniques, such as heavy beam trawls, anchor dredging, sledges carrying cameras (Figure 7) and box cores.

Shelf-sea fronts and biogeochemistry

Through the 1970s, *Prince Madog* surveys of the western Irish Sea revealed the existence of a persistent front separating well mixed and seasonally stratified water columns (Figure 6). The location of the front and its spatial structure, confirmed by aerial survey and satellite infra-red observations, were explained in terms of the competition between surface heating and tidal stirring. This work provided the first quantitative link between the dissipation of tidal energy and mixing in the ocean.

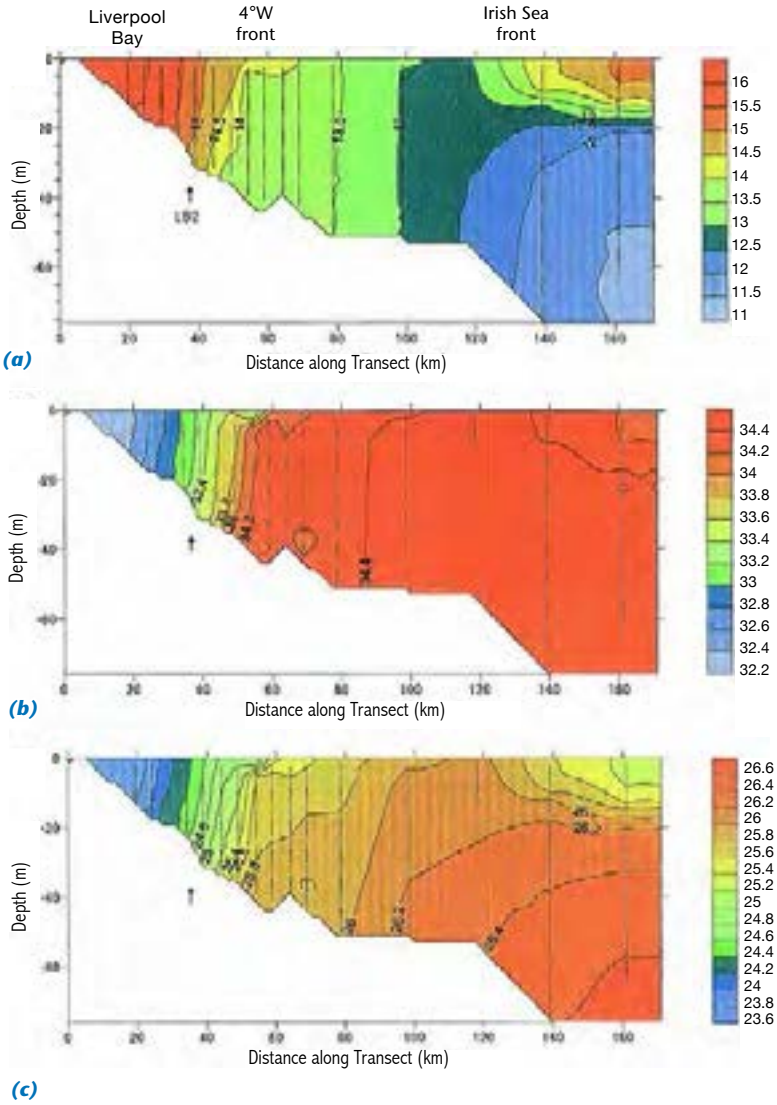
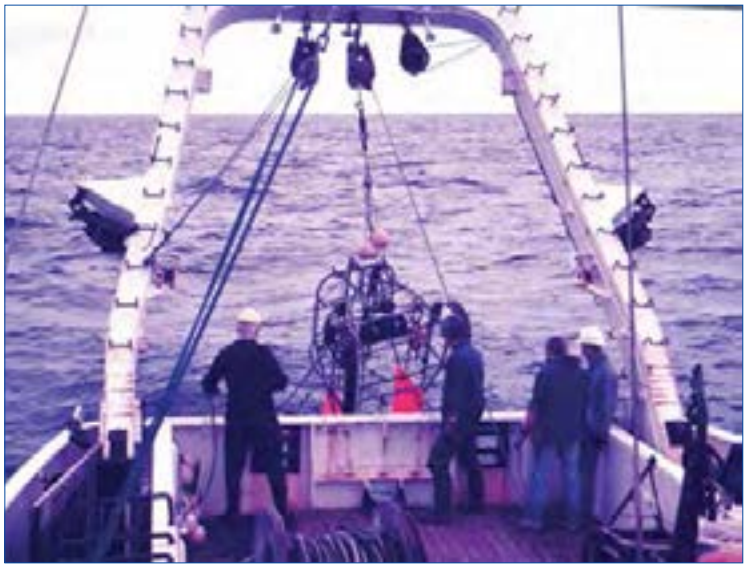


Figure 6 *The water column structure running west–north-west from the mouth of the River Mersey (left-hand side of section) to the north of Anglesey and across the western Irish Sea front to north of Lambay Island (see Figure 5). The three sections are* ***(a)*** *temperature (°C),* ***(b)*** *salinity (p.s.u.), and* ***(c)*** σ_t *(kg m^{-3}). Liverpool Bay, the 4°W front and the Irish Sea front are labelled for purposes of this article. (Reproduced from Rippeth* et al.*, 2001; © 2001 American Meteorological Society (AMS).)*

The existence of fronts in shelf seas as semi-permanent geographical features with the potential for high biological productivity was quickly recognised and led to extensive observational studies of the impact of tidal stirring on the distribution of primary production, zooplankton and seabirds over these regions of strong physical and chemical gradients. Paul Tett, who moved to Bangor from Oban, and Kath Richardson, who came with Tony Fogg from London, were amongst many scientists who joined campaigns on the *Prince Madog* to elucidate the links between physics and biogeochemistry in the shelf-sea system. Further microbiology studies by Fogg, with Karin Lochte and Carol Turley, also focussed on the 4°W front in Liverpool Bay (Figure 6). The results of these, and other frontal studies in shelf seas, were reported at a Royal Society Discussion meeting and published in a special edition of *Philosophical Transactions of the Royal Society*. This international interest helped to generate the impetus for NERC's first Marine Community Research Project, the £15m multi-institutional and interdisciplinary North Sea Project, which ran from 1988 to 1992.

In the early 1980s, shelf-sea fronts also attracted interest for their related biological effects on the sea bed. Norman Holme at the Marine Biological Association in Plymouth was one of the pioneers of the use of towed sledge camera systems (Figure 7) to help record and understand offshore sea-bed ecology. Following collaborations with Ivor Rees, he came up to Menai Bridge with his underwater TV and film camera systems for a cruise on the *Prince Madog* in the Irish Sea about 20 km off Lambay Island. Having gone across towards the Irish end of the front as there was a fresh westerly wind, Holme and Rees serendipitously documented a very rich biotope at a depth of 70 m. Their sledge was travelling over a mass of worm tubes (*Ampharete* sp.) with unusually high numbers of small bivalves and crustaceans living amongst them. The grabs and Agassiz trawl sampling confirmed this, and the tubes were thought to stabilise the sediment and help trap 'marine snow', giving rise to a rather special and localised benthic community. The experience on this cruise led to the acquisition of a second-hand 'Photosea' film camera system which was deployed on the sledge in a series of projects in various locations, from the *Modiolus* (horse mussel) beds off North Wales to Haig Fras, a rocky outcrop in the Celtic Sea, and even the muddy Fladen Ground in the northern North Sea. The sledge is still in use with digital cameras instead of the old 35 mm film camera which had to be opened in a black bag.

Figure 7 *Norman Holme deploying a 'Photosled' in the western Irish Sea in July 1985. (Photo: School of Ocean Sciences, Bangor University)*



Underpinning hydrodynamic models

In 1978, Bangor University established the Unit for Coastal and Estuarine Studies (UCES), a new commercial unit linked to the School of Ocean Sciences. The central activity of the group was numerical modelling, notably in relation to pollutant dispersion problems. As the unit grew, new staff were increasingly involved in using the *Prince Madog* for their own research. For example, Toby Sherwin, with Miguel Lavin, made a series of pioneering measurements of the evolution of seasonal stratification and time-varying currents which quantified the potential of wind-driven inertial oscillations and internal tidal motions to drive mixing in the summer regime of the stratified shelf seas. With funding from the Defence Science and Technology Laboratory, Dave Bowers used a combination of *Prince Madog* ship surveys and satellite colour imagery to study the seasonal and tidal variations in the concentration of particulates in the Irish Sea. These interests in bio-optical work developed further, with the *Prince Madog* being used to ground truth remotely sensed data, including employing ocean colour to estimate sea-surface salinity and to assess the particle size distribution of suspended sediments.

In the 1980s and early '90s, the main focus of Bangor's sea-going oceanographers was on Regions of Freshwater Influence (ROFIs) and involved Ph.D projects for Jonathan Sharples, Tom Rippeth, Graham Allen, Pat Hyder and Alex Souza and others. Observations in Liverpool Bay (Figure 5), led to the identification of the processes of periodic stratification and tidal straining which are now recognised as key factors influencing estuarine stratification and circulation (Figure 6). Numerical models need to reproduce these processes to correctly predict the dispersion of fresh water in the sea.

Observations from the *Prince Madog* in Scottish sea lochs (fjords) stimulated models of the seasonal cycle of stratification and revealed the role of internal tides in driving mixing in these fjordic environments. The improved understanding of the subtle sets of physical processes operating in these freshwater-influenced regimes led to a series of major interdisciplinary EU-funded projects ultimately aimed at improving water quality models. These involved John Simpson, Tom Rippeth, Colin Jago, Sarah Jones, Paul Tett, Tony Walne, Robin McCandliss and Mal Hearn, together with collaborators from the Proudman Oceanographic Labs (now National Oceanography Centre, Liverpool), the Scottish Association for Marine Science (SAMS) and Napier University.

Ed Hill, with Kevin Horsburgh, Liam Fernand, Juan Brown and others, made a series of drifter and other hydrographic measurements from the *Prince Madog* which they combined with state-of-the-art numerical model simulations to map the density-driven residual circulation in the north-west European shelf seas, with the specific aim of isolating its role in larval dispersal and in the spread of paralytic shellfish poisoning around the UK coast (Figure 8).

Monitoring natural marine systems from the RV Prince Madog

In addition to the more focussed studies, the two *Prince Madog* vessels have also been involved in a number of long-term monitoring campaigns. In the 1970s, with Department of the Environment support, Peter Spencer, along with Ian Millar, and later Dave Mills and others, set up a regular survey grid in Liverpool Bay for sampling nutrients and phytoplankton. The grid was subsequently adopted by the Environment Agency and later taken over as the Proudman Oceanography Laboratory Coastal Observatory, funded by NERC and Defra. This supported the Cefas SmartBuoy Programme which remains operational today.

The long time series of data collected in Liverpool Bay contributed to the radically improved scientific evidence base that underpinned the successful UK Government defence against the EU infraction proceedings mounted under the *Urban Waste Water Treatment Directive*. In essence, the data and evidence supported the UK position that while some UK coastal waters were enriched with river-derived nutrients, this did not lead to eutrophication. The reason was that the coastal waters around the larger UK estuaries are highly turbid, and in consequence the phytoplankton were light-limited in these regions, and so did not show enhanced growth or an undesirable disturbance to the balance of organisms indicative of eutrophication.

Figure 8 *Schematic map of principal summer thermohaline transport pathways on the north-western European shelf and the cold and high salinity pools that drive them. Orange: regions where seasonally formed dense bottom pools are influenced by both low winter temperatures and high salinity oceanic water which has penetrated the outer shelf. Light blue: regions where only temperature is responsible for the density of water trapped below the seasonal thermocline. Green arrow: European slope current. Red arrows: frontal jets associated with bottom fronts at boundaries of dense cold and high salinity pools. (Reproduced from Hill* et al.*, 2005; © American Geophyical Union)*

Over the past 10 years the *Prince Madog* has been an important component of Bangor University's programme providing fisheries advice to the Isle of Man Government. Each spring the *Prince Madog* has provided a platform for a two-week survey of Manx scallop stocks, sampling fixed stations covering both king and queen scallop fisheries within the Isle of Man's territorial sea. A set of four survey dredges are towed at each station and the number, age and weights of scallops caught are recorded along with information on bycatch. The data collected during these surveys have been used to undertake quantitative stock assessments for scallops around the Isle of Man which in turn are used to underpin the management of these fisheries.

For nearly three decades the P*rince Madog* has been used as a platform from which to develop the UK's capacity to measure turbulence in the ocean. It has been used to test and validate new acoustic techniques for measuring time series of turbulence. It has also been used to characterise turbulence in the contrasting shelf-sea regimes around the UK (Figure 9), supported by SOS's Electronics Engineering group, and in particular Ray Wilton and Ben Powell. These measurements have since become the gold standard against which the turbulence closure schemes used in today's operational shelf-sea numerical models (ROMS and NEMO) have been rigorously tested.

Particle settling velocity tubes – a hazard for Prince Madog *crew*

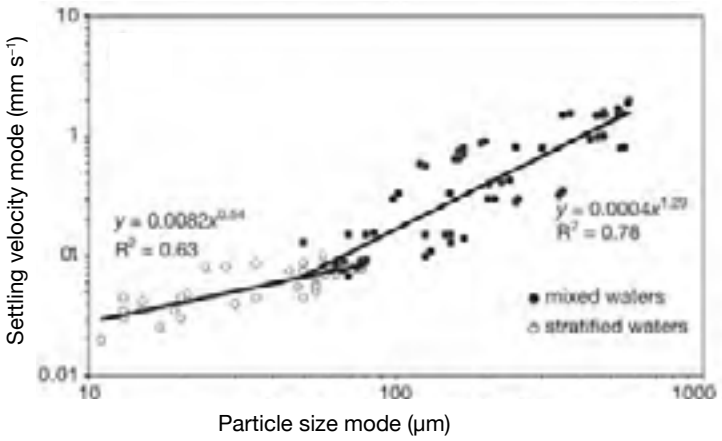
During the 1990s and early 2000s the *Prince Madog* played a key role in the research on suspended sediments in shelf seas. This was the period when optical and acoustic techniques for quantifying suspended matter were being developed, and SOS was at the vanguard of discoveries about, and understanding of, the role of suspended particulate matter (SPM) in biogeochemical cycling in tide-stirred shelf seas. Colin Jago and Sarah Jones made early measurements of SPM concentration, particle size and settling velocity, and related these properties to turbulence and microplankton. Working with Gay Kennaway of the Natural History Museum they showed how SPM settling velocity increased by two orders of magnitude during the spring bloom in the Irish Sea, which explained how rapid fallout takes organic-rich SPM to the sea bed and creates a benthic fluff layer (which in turn dictates biogeochemical fluxes across the sediment–water interface) (Figure 10). The tubes used to measure settling velocity were designed and built by Dave Boon in SOS; they were not popular with the ship's crew as if the sea was at all rough during deployment they had a propensity to crack heads, bruise feet and squash fingers simultaneously!

Working with Ph.D students Andy Campbell and Peter Sykes, Jones and Jago were able to show that the role of turbulence was more complex than previously believed: turbulence controls the

Figure 9 *Tom Rippeth deploying a turbulence profiler, together with Mark Inall, Ray Wilton and Phil 'the bosun' Jones. The* Prince Madog *was used extensively to survey turbulence across the contrasting shelf-sea regimes around the UK. These measurements allowed the testing of state-of-the-art ocean models. (Photo: School of Ocean Sciences, Bangor University)*

temporal variation of particle size through resuspension, aggregation and disaggregation of SPM at any particular location but there are superimposed variations due to advection of waters that carry a spatial signal imposed by regional gradients in turbulence.

Figure 10 *A plot of modal particle size versus modal settling velocity shows that floc strength increases with size, and that the larger, faster-sinking flocs formed in mixed waters where collisions are stronger and where the living algae probably act as a strong glue. (Reproduced from Jago* et al.*, 2007; Copyright © 2007 Inter-Research)*



Palaeoceanography and sclerochronology

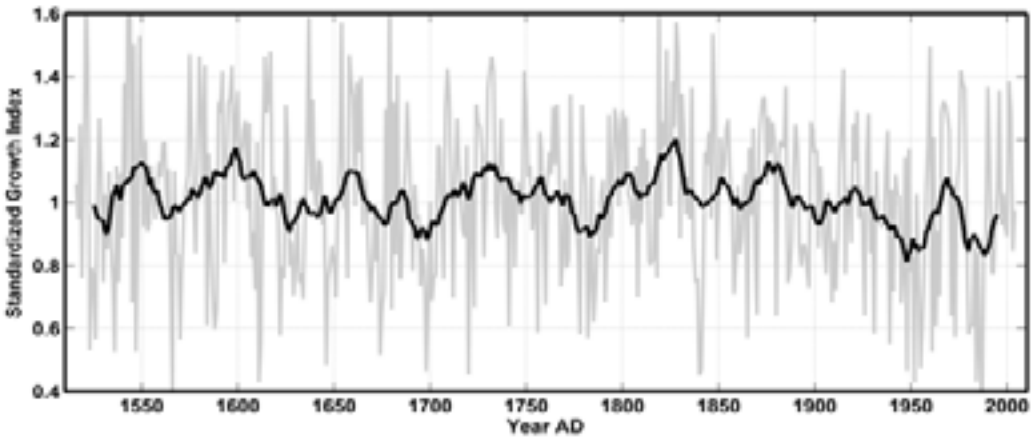
At this time there was also a growing interest in palaeoceanography in SOS, led by James Scourse. Using core samples from the Celtic Sea, the team, including Bill Austin, David Assinder and Dei Huws, was able to map the movement of the Celtic Sea tidal mixing front over the last deglacial transition. These results were to be used later by Mattias Green to validate his global tidal models, which he used for the first predictions of greatly enhanced tidal mixing in the North Atlantic during the Last Glacial Maximum. This period also saw the development of sclerochronology, a new technique for measuring the history of the marine environment (and thus past climate) using growth rings on long-lived bivalve mollusc shells.

This successful collaborations between marine biologists, geologists and geochemists, involving Chris Richardson, James Scourse, Paul Butler and others, resulted in the then longest (489-year) marine chronology based on *Arctica islandica* shells collected from the *Prince Madog* in the Irish Sea (Figure 11). Its success led to EU funding for a Marie Sklodowska Curie Initial Training Network, ARAMACC (Annually Resolved Archives of Marine Climate Change), and saw the *Prince Madog* sample for long-lived molluscs in the North Sea.

Fostering commercial links

The SEACAMS projects and the Smart Efficient Energy Centre (SEEC) use the *Prince Madog* in collaboration with low carbon energy sectors, as new equipment widens options for using the offshore environment as a natural laboratory, for example to study complex fluid dynamics and sediment transport processes.

Figure 11 ***Left*** *The ocean quahog (*Arctica islandica*), a bivalve which can live for 500 years, and which is thus a key species in sclerochronological studies. (Image by David Roberts and Chris Richardson, Bangor University)*
Below *Standardised growth indices for the 489-year chronology. The grey line shows the standardised growth index for each year and the thick black line is a 19-year running mean, used to emphasise decadal variability in the marine environment. (Reproduced from Butler* et al.*, 2009; © 2009 Elsevier BV)*



Prince Madog's contribution to the marine sciences

Over the past 50 years the *Prince Madog* has provided a key platform for the training of several generations of UK marine scientists, and provided the first sea-going experience for many in the UK marine science community today. Furthermore, marine science students across the globe learn about the key processes in the water column on the basis of the *Prince Madog* work in the Irish Sea and Menai Strait. Closer to home, work on the *Prince Madog* has supported the development of management tools, policies and strategies to sustainably harvest offshore resources and to protect vulnerable marine ecosystems.

The *Madog* has also made an important contribution to the development, testing and validation of new instruments and methodologies for observing the marine environment, from measurements of small-scale turbulence and mixing processes to ones aimed at constraining past climate change. These tried and tested instruments and techniques are now regularly used globally in the pursuance of a greater understanding of planet Earth.

Acknowledgments

Katrien Van Landeghem and Tom Rippeth gratefully acknowledge the contributions by Ivor Rees, John Simpson, Colin Jago, David Mills, Paul Butler, Tim Whitton, Jan Hiddink, Stuart Jenkins, Ian McCarthy and David Roberts.

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Tom Rippeth is the established Chair in Physical Oceanography at the Bangor University School of Ocean Sciences. He specialises in turbulence and mixing in the marine environment. T.P.Rippeth@bangor.ac.uk

WHERE ARE THEY NOW?

Bangor Marine Biology graduate Alison Towner is a star of a new Channel 4 show "Work on the Wild Side: Wildlife heroes".

The series follows conservationists in South Africa as they work to rescue, rehabilitate and return to the wild some of the world's most endangered species.

Alison is originally from Ramsbottom in Lancashire and has held a fascination for sharks and other marine life since a very early age. After graduating from Bangor, Alison moved to South Africa to take up a job with the Dyer Island Conservation Trust and works on the conservation of the "Marine Big 5" - sharks, penguins, whales, seals and dolphins, raising global awareness of their plight.

Speaking to the Bury Times Alison said: "I got my love of marine life from my late father who was an ocean enthusiast, loved sealife and even wrote a novel.

"He had a huge impact on me and really inspired me for the five years he was with me."

"The show follows a select group of Brits working in conservation, so it shows my daily work which involves going out and tagging Great White sharks, rescuing penguins and helping raise awareness."

The Channel 4 series "Work on the Wild Side: Wildlife Heroes" is currently showing at 4pm week days.

Starr Sams (BSc Marine Vertebrate Zoology) Intern at Bimini Biological Field Station (Sharklab)

I have always been crazy about sharks and I chose to come to Bangor because of the specific Marine Vertebrate Zoology degree programme that enabled me to focus my studies on the areas that interested me most. The quality of teaching exceeded my expectations and I feel very fortunate to have been taught by active researchers who are experts within their fields.

My experiences as an Undergraduate in Bangor gave me the confidence and skills required to pursue my dreams and go to work with Sharks in the Bahamas after graduation. The diversity of modules within my degree course gave me so many beneficial skills, from statistics and data collection to practical lab skills that I have used every day within this role. Working as a Peer Guide and assisting with University Open Days really boosted my confidence when interacting with potential students and parents, which prepared me well for giving tours and talks to the public here at the Sharklab.

It still amazes me that within a year I have gone from sitting in a lecture theatre learning as much as I could about sharks to taking measurements and samples from 3.5m Tiger Sharks and freediving with Great Hammerheads on a regular basis! I know that without the support I received at Bangor I would not be where I am today.

Ben Blackledge (MSci Physical Oceanography, 2019) is currently working as a research assistant at the Environmental Futures & Big Data Impact Lab University of Exeter.

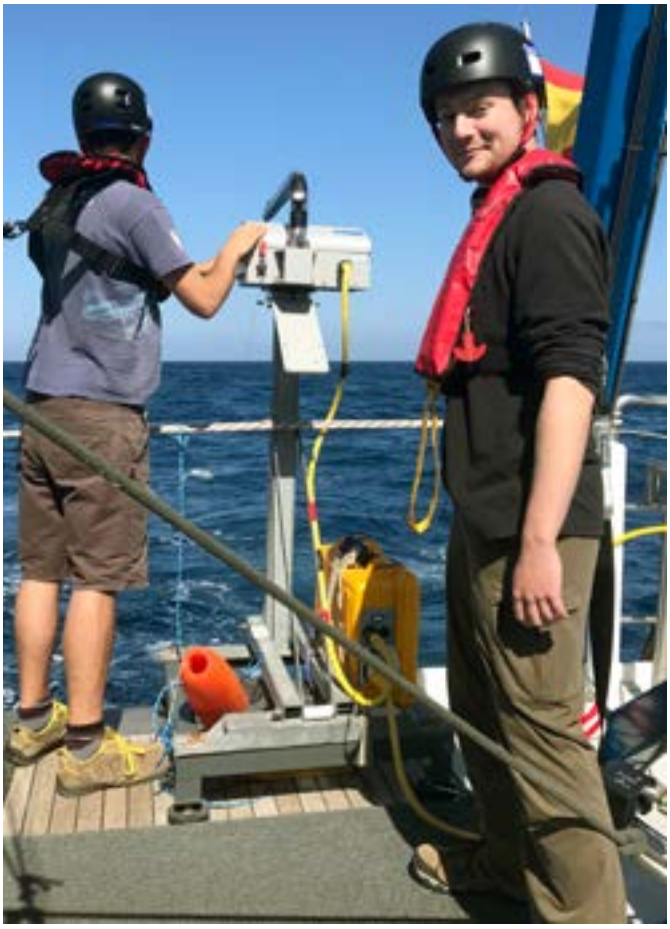
In September he is starting a PhD in Earth Sciences at Bristol University.

Ben has recently had published his 4th year research project results in the American Geophysical Union Journal, Geophysical Research Letters. His project looked at the impact of continental drift on the speed at which the moon is moving away from the earth.

Earth's ocean tides dissipate around 3.4 Terrawatts due to tidal friction. This causes the moon gradually move away from the earth (known as the recession rate), and a slowing of the earth's rotation rate (ie. an increase in day length). This recession fluctuates over time, because tectonic motion changes the shape of ocean basins and therefore tidal resonances.

However, the structure of the planet surfaces in deep-time, and potentially ocean-bearing exoplanets, are unknown. In consequence, the rate at which the tides dissipate energy and rotation slows are not known.

In his paper, Ben used a set of randomised bathymetries and continent shapes to estimate the bounds and variability of Earth's tidal dissipation, showing that this value can span ~3 orders of magnitude due to variations in continent shape and position. As such he was able to conclude that geology-driven tidal variability could be an important factor in exoplanet rotation and climatic evolution.



Matt Cooper (MSci Physical Oceanography, 2016) has just begun a KESS2 East PhD project in the School of Natural Science here in Bangor.

His project is a collaboration with Forest Research entitled 'Investigating the potential of forested lands for natural flood management in Wales'. The aim is to strengthen Forest Research's hydrological research capability and improve understanding of how forests and woodlands can help manage river peak flows. At a time when ongoing mitigation measures for the risk of severe flooding are continually being developed, it is hoped that this project will deliver modelling tools to help the wider Wales community in these times of climate uncertainty.

Matt recently published his MSci research:
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