ANNUAL REPORT 2015-2016

CONTENTS

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Front cover photo:
The sea squirt, Ascidiella aspersa, as seen at 21m in the Firth of Lorne (Photo: NFSD), is part of the healthy marine ecosystem SAMS works towards.

WELCOME

PROFESSOR
NICHOLAS OWENS
SAMS DIRECTOR

Welcome to SAMS' 102nd Annual Report. I have been involved with SAMS, and its antecedents, since I was a PhD student in Dundee, back in the mists of time. I envied my contemporaries who had Dunstaffnage staff as joint supervisors and who spent time on the much more exciting west coast of Scotland. I was therefore truly excited and honoured to become Director on the 1st September last year.

It has been a challenging, demanding but highly stimulating beginning as Director. The most rewarding part of the job has been the wonderful welcome and support all the SAMS staff have given me since I started. Their talents, initiatives and enterprise are well demonstrated in this report, which is only a selection of what has been achieved this year. Something exciting and new happens nearly every day at SAMS: it is a great place to work!

Trying to identify the highlights of the year is like selecting one's 'Desert Island Discs', the choice is likely to change depending upon one's mood. A finding that caught the imagination worldwide was the work on the vertical migration of zooplankton in the polar-winter darkness of the Arctic Ocean. Dubbed the 'werewolves of the sea' by the world's media, this work attracted hundreds of media reports from all parts of the globe. Technology developments in SAMS continue apace and we report here the first flight of a hydrogen powered aerial drone, and the milestone of our sea-gliders having spent over 5 years at sea: that is a huge efficiency saving in ship-time. We also report on the developing work concerned with algal aquaculture. SAMS is unique in having both a seaweed farm and Europe's leading collection of micro-algae. Algal biotechnology is in its infancy and SAMS, through our research, is set to become a major contributor to Scotland's aim to be a leader in this new industry.

An increasingly important part of life at SAMS is our role as a partner of the University of the Highlands and Islands (UHI). Having lots of bright and inquisitive students around brings vibrancy and academic stimulation to SAMS. However, the cohort of undergraduates that graduated in September 2015 was truly outstanding: 13 of the 18 students graduated with first class honours! This was an achievement so unusual that Professor Boulton, SAMS President, was compelled to present the 'SAMS Best Student Award' to the entire class.

I will end by noting that I became Director only partway through the year. During the first part of the reporting period Professor Axel Miller was the acting Director. I would like formally to thank Axel for his outstanding leadership and dedication throughout his tenure as acting Director; he had to deal with the most difficult of times and circumstances. Furthermore, as a new Director I could not have wished for a more supportive and thoughtful Deputy.

SAMS RECOGNITION FOR SCOTTISH POLAR EXPLORER

Canadian descendants of a polar explorer, who led the first and only Scottish National Antarctic Expedition between 1902 and 1904, visited SAMS to learn of his legacy.

William Speirs Bruce is relatively unknown when compared with his contemporaries, such as Robert Falcon Scott, but was recognised in early 2016 by the naming of a laboratory at the British Antarctic Survey Research Station on Signy Island, in the South Orkney Islands.

Argyll and Bute MSP Michael Russell, who has long championed Bruce's contribution to Arctic and Antarctic research, helped arrange a commemorative plaque to be erected at the Antarctic laboratory and delivered the news to the scientist's Canadian great, great grandsons, Michael and Kyle Watson, during a meeting hosted during a meeting hosted by SAMS in its William Speirs Bruce lecture room.

Also present at the meeting in SAMS were the institute's director Prof Nicholas Owens and Henry Burgess, Head of the UK Arctic office.

Michael Watson, from Ontario, said: "It is very heartening to see so many people interested in the work of our great, great grandfather. For us, his work has always just been a family story but we are delighted to learn that it is a story for Scotland, the UK and for science in general."
Bruce led the Scottish National Antarctic Expedition from Troon on November 2, 1902 and made two voyages to the Antarctic, returning in July 1904 to the Marine Station in Millport, where he was presented with the Royal Geographical Society's Gold Medal and a telegram of congratulation from King Edward VII.

The achievements of the expedition included the establishment of a manned meteorological station, the first in Antarctic territory, and the discovery of new land to the east of the Weddell Sea. It also led to the establishment of the Scottish Oceanographical Laboratory in 1906.

GREAT, GREAT GRANDSONS, MICHAEL AND KYLE WATSON, BY THE PORTRAIT OF WILLIAM SPEIRS BRUCE

OUR PEOPLE

SAMS has a diverse staff base, originating from 19 different countries, with a near 50/50 split in male and female employees. Over the report period, Human Resources developed the first SAMS three-year HR strategy and significant progress has been made despite a very challenging time for the organisation.

Themes include:
Values, Culture and Ethos, including equality and diversity training for staff and supporting a UHI application for the Athena Swan Bronze Award
Standards, Efficiency and Effectiveness, including the development of HR scorecard and broadening the Whitley Group to improve communication with staff
Employee Compensation and Benefits, including a move to a single pay spine and developing a rewards package
Talent and Career Development, including the development of a broad framework on Learning and Development linked to the job families
Leadership, Management and Change, including two scientific leadership courses for early career researchers and lecturer level principal investigators.

A NORWEGIAN PROFESSOR

Dr Finlo Cottier, head of the Physics and Technology Department at SAMS during the report period was awarded an Adjunct Professorship at the Arctic University of Norway, Tromso. The adjunct position was in recognition for his participation in a decade of Arctic research projects and encouraging closer working links between Scottish and Norwegian researchers. He has also helped to develop the Arctic science degree run by SAMS through the University of the Highlands and Islands and alongside the University Centre in Svalbard (UNIS).

Dr Cottier is working with Norwegian colleagues on two new Arctic research programmes – Arctic ABC and FAABulous – worth a combined £4.7m.

SAGES ROLES COME TO SAMS

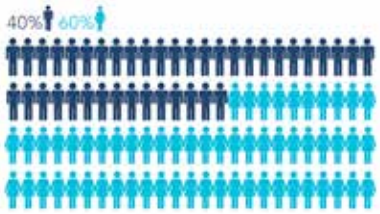
Two influential roles within Scottish research have gone to SAMS scientists.
Professor Mark Inall was appointed as Director of SAGES (Scottish Alliance for Geoscience, Environment and Society) in December 2015, followed a few months later by Dr John Howe to the position of Graduate School Convenor within the community. Professor Inall is Associate Director and Principal Investigator in Physical Oceanography at SAMS. Dr John Howe heads the Biogeochemistry and Earth Sciences Department and is SAMS UHI's BSc Marine Science Degree Programme Leader.

Dr Howe succeeded SAMS colleague Prof Bill Austin in the role of SAGES Graduate School Convenor.

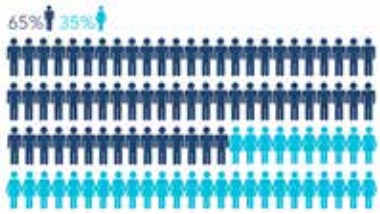
RESEARCH FORUM LEADERS

Two members of staff at SAMS each hold the position of convenor on MASTS (Marine Alliance of Science and Technology Scotland) research forums. Dr Bhavani Narayanaswamy is deep sea convenor and Lucy Greenhill is marine planning and governance convenor.

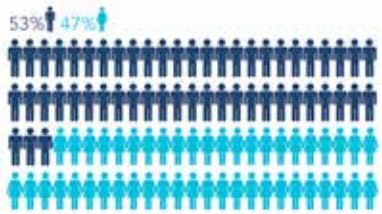
Management, Specialist and Administration: 63 staff



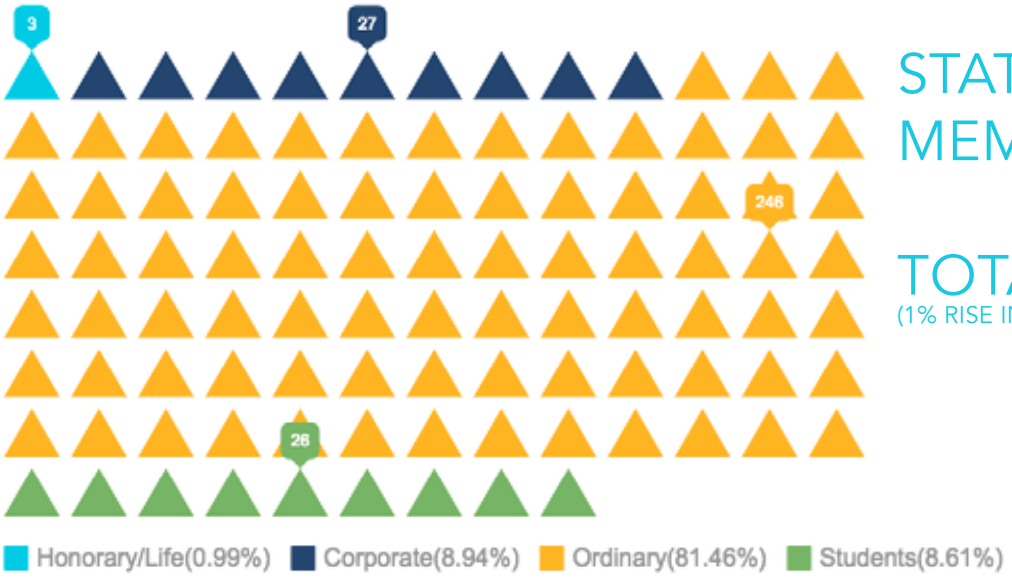
Research, Education and Enterprise: 75 staff



Technical and Experimental: 42 staff



LEARNED SOCIETY



STATE OF THE MEMBERSHIP

TOTAL: 302

(1% RISE IN REPORTING YEAR)

Danja Hohn	Examining a Scottish Aurelia aurita population, a bloom forming jellyfish with social-economical relevance	£1,000
Pedro Murua:	Diseases and defence reaction of kelps against biotic stressors	£1,000
Margaux Llapasset:	Analysis of the composition of the benthic macrofauna at Station M in the Rockall Trough (NE Atlantic) in Spring 2013	£700
Dr Bee Berx	Ocean-shelf exchange of the slope to current to the North of Scotland	£1,000
Lukas Huppe:	Circadian rhythms in swimming behaviour and oxygen consumption of the copepod Calanus finmarchicus	£1,000

SAMS research bursaries awarded to SAMS members during the reporting period:

ELAINE'S STILL IN GOOD COMPANY

After retiring in October 2015, former SAMS company secretary Elaine Walton is quickly finding that that she needs to start saying 'no' a lot more often.

The industrious Elaine, who was known for managing the Learned Society, in one of her many roles at SAMS, is now: running her own consultancy business; chairing the Group for Recycling in Argyll and Bute (GRAB) Trust; on the management board of Oban Sea Cadets; a member of the local branch of Macmillan Cancer Support; a STEM ambassador; a board member of Family Mediation for Argyll and Bute; and a volunteer at SAMS' Ocean Explorer Centre.

In March 1998 Elaine transferred from NERC to SAMS (which was then DML) as station secretary and the role evolved over the years to form a senior management position that encapsulated aspects of finance, estates, legal and HR.

Elaine is pictured, above, with SAMS Director Prof Nicholas Owens and Deputy Director Prof Axel Miller

NEWTH LECTURE

Think of the world's polar regions and we will conjure images of a harsh environment of ice and snow – but this was not always the case, as Prof Francis of the British Antarctic Survey explained during the Newth Lecture 2015.

Fossile evidence shows that around 40 million years ago natural levels of CO^2 begin to drop and the earth begins to cool. Some of the plates begin to move; Antarctica becomes isolated and alters ocean circulation, cooling the rest of the world.

50 million years ago Antarctica was particularly warm and gradually cooled; at a period around 34 million years ago glaciers would have formed at sea level on the continent as we know it now.

But the Arctic stayed warm until eight to 10 million years ago when suddenly all plants die out and glaciation occurs.

Scientists have found evidence of ferns growing in Antarctica almost identical to those found in Tasmania and New Zealand and Monkey Puzzle trees growing in Antarctica 100 million years ago were similar to ones growing in the Andes today.

We have also found fossilised plants in Antarctica that are related to plants in South America.

By comparing these specimens to modern plants we can date them, giving us a picture in time of how our polar regions once looked. Prof Francis said: "Antarctic forest fires preserved plants as charcoal and we have some amazing fossils we can put under the microscope to reconstruct them. We have found flowers that are 80 million years old.

"Using these plant fossils we have been able to produce a reconstruction of Antarctica 100 million years ago and 70 million years ago, when flowering plants are visible. There were larger dinosaurs and ducks and the warm oceans had mesosaurs and plesiosaurs.

"During the Eocene period the Arctic was also warm. In the Arctic we have found leaves and tree stumps preserved as they were, as if they have been 'mummified'. "Dawn redwood has been found in Russia and Canada and was beautifully adapted to living in the Arctic. At the turn of the century it was found as a fossil and thought to be extinct but it was found still living in valleys in China. It is a good shape, tall and thin, so as not to shade other trees in the Arctic."

Modern botanists have matched plants to different climate zones and compared fossils to make conclusions about these zones, so we know there was plenty of water in the Arctic. It was probably a basin with really big rivers, creating pseudo swamp-like conditions, said Prof Francis. "We can draw comparisons between the Everglades in Florida today and the Arctic 50 million years ago. Could there have been alligators and turtles in the Arctic 50 million years ago?" During the dark winter months the landscapes of the Arctic and Antarctica may well have been covered in ice, but there was a time when the summer sun revealed gloriously green landscapes.

NEWTH LECTURER

Prof Jane Francis
Director of British Antarctic Survey and Head of the Intergovernmental Oceanographic Commission of UNESCO from 1998-2009

HONORARY RESEARCH FELLOW
JOHN GORDON OBE

A SAMS scientist who became one of the world's foremost researchers in deep sea ecology was awarded the OBE in the Queen's Birthday Honours List 2016.

Dr John Gordon, now an Honorary Research Fellow at the institute, spent his whole research career at SAMS after completing a PhD at Edinburgh University.

Dr Gordon began his research in the shallow waters of the Firth of Lorn but, with the commissioning of the RRS Challenger in 1974, he moved into deeper waters (500 to 1,500 metres) to the west of Scotland's continental slope, working on the biology of the bottom-living fish which were later to be commercially fished. His work contributed greatly to our knowledge of food chains in the deep sea and how commercial trawling affects fish populations in deeper water.

Dr Gordon said: "In accepting this honour I have to acknowledge that none of this would have been possible without the support of the whole of SAMS community over the years. I owe a great debt of gratitude to John Mauchline for his early guidance and collaboration in later years and to Janet Duncan and Sarah Swan for dedicated scientific support. Finally, I have to thank the ship's companies of RRS Challenger for many enjoyable days at sea, many of which were before the days of satellites and instantaneous communication and navigation – the simple life."

Other key investigations by Dr Gordon helped to determine the age and stock identification of deep water commercial fish. In 1994 he was named Buckland Professor, which involved giving public lectures on deep water fisheries at venues throughout the UK. In 1995 he was appointed chairman of the International Council for the Exploration of the Sea (ICES) Study Group on the Biology and Assessment of Deep-sea Fishery Resources, a post he held until 2000 and he also provided advice and evidence to organisations such as the European Commission, the North East Atlantic Fisheries Commission (NEAFC); the Scottish Government and the House of Lords Select Committee on Science and Technology.

Dr Gordon retired in 2002 as Principal Scientific Officer at SAMS. His international reputation kept him busy as a keynote speaker and with several consultancies.

He is married to Kathleen, with whom he has two children, Hamish and Colin.

Sir Frederick Holliday

(September 22, 1935 – September 5, 2016)

A highly regarded marine biologist, academic leader and businessman, Professor Sir Frederick Holliday served as SAMS President 1980-1985 and retained his connection with SAMS until his death as a Vice-President. He also delivered the first annual Newth Lecture in 1990 on Conserving Conservation.

His talent for science recognised by David Hobson, his teacher at Bromsgrove County High School, who encouraged him to study biology, which he chose as his degree subject.

He opted to study at Sheffield University under Nobel laureate and biochemist Sir Hans Krebs, despite being offered a place at Cambridge. After graduating with a First, he moved to Aberdeen and did his National Service on defence vessels while working at the Marine Research Laboratory, where he was researching the depletion of North Sea herring stock. He was appointed scientific officer at the laboratory in 1958, a role he carried out for three years.

OBITUARIES

During this time he met his wife, Philippa, who was the chemist dealing with the water samples he brought back for examination.

In 1961 Holliday was appointed lecturer in Zoology at the University of Aberdeen. He was approached to help develop the University of Stirling where he was appointed Professor of Biology in 1967 and in 1973 he became the UK's youngest university principal by taking over the post at Stirling during times of intense student protests. His efforts at Stirling were rewarded with a CBE in 1975. He continued his research into fish stocks and was among the first to use electronic tracking devices, fitting it to species such as loch trout and basking sharks.

In 1987, as Vice-Chancellor at the University of Durham, he met Margaret Thatcher, who asked Holliday what he would do to improve things in the region. He told her that he would build a university. The result of their conversation was the building of the Queen's Campus of Durham University.

A career in the private sector followed and as chairman of Northumbrian Water he oversaw two takeovers and developed the organisation into a British Plc.

He received a knighthood for services to education in 1990. A man of great intellect and energy, Fred was also approachable, warm and humble. He is survived by his wife, son, daughter and grandchildren.

Henry Powell

(May 1925 - January 2, 2016)

Henry Powell (known as Harry), a seaweed scientist, community stalwart and campaigner, was born and brought up in Abergavenny, Wales and studied at The University of Wales, Aberystwyth during the Second World War. In 1946 he was awarded a 1st class Honours degree in Botany and worked for two years at the University of Bangor before joining the Scottish Marine Biological Association (SMBA) in Millport, Isle of Cumbrae in the Firth of Clyde in 1948.

It was at Millport that he met his future wife Grace, who was there as an undergraduate. They married in 1956 and later their two children, Anne and David, were born there. During Harry's early career he worked on barnacles, but his main interest was in seaweeds and, in particular, their ecology on rocky shores. He carried out seaweed surveys all around the Scottish coast, publishing several significant papers, including two in the highly prestigious journal Nature, and conducted important studies on Fucus species (wracks). He was the founding secretary of the British Phycological Society in 1952 and was also a founder member of the Institute of Biology.

In 1967 the SMBA relocated to Oban and Harry was a member of the small group who came to oversee the building of the laboratory at Dunstaffnage. Harry also negotiated with the council housing department to allocate a number of new homes in Dunbeg to ease the resettlement of the remaining staff from Millport. During that period he was a union rep, chairman of the Scottish Marine Biological Association (SMBA) IPCS union branch, and was active in the SMBA social club and management of the canteen.

An important piece of work led by Harry in the late 1970s was the 'Survey of the Littoral Zone of the Coast of Great Britain' for the Nature Conservancy Council, involving a large team of scientists. Following retirement in 1989 Harry was a driving force as chairman of the Lorn branch of the Scottish Wildlife Trust Support Group.

BIOGEOCHEMISTRY & EARTH SCIENCES

Exploring the deep ocean

A prototype of an autonomous robot is lifted back onto the research ship after a test dive at 600 metres.

RESEARCH HIGHLIGHT

Robots to explore deepest ocean

Scientists from SAMS will use custom-built robots to explore the deepest parts of the ocean in a bid to discover how life is sustained thousands of metres below the surface.

The research team led by Professor Ronnie N. Glud and including Dr Robert Turnewitsch, will take the unique step of studying and sampling organisms in situ, thousands of metres below sea level.

The Hades Project requires three purpose-built robots to operate at depths of up to almost 11 kilometres. Previous expeditions led by Professor Glud – most notably to the Mariana Trench (2013), the deepest part of the ocean - have revealed surprisingly high levels of biological activity at nearly 11 kilometres deep. Now the aim is to investigate how life is sustained at these depths and how its activity affects the biogeochemical functioning of the oceans and the Earth.

Various components for the new robots are being produced around the world before finally being assembled at the University of Southern Denmark. One robot will be designed to quantify the oxygen uptake by the sediments and another will be designed to investigate the different processes that may be used by sediment organisms to convert the organic material. The third instrument will be designed to collect sediment samples to be brought to the surface. This instrument will ensure the sampled microorganisms are fixed and can be retrieved without being modified during sample retrieval.

The three trenches to be visited by the researchers are in the Pacific Ocean: the Atacama Trench off Chile (max depth 8068 metres), the Japan Trench south and east of Japan (max depth 9,504 metres) and the Kermadec Trench north of New Zealand (max depth 10,047 metres).

The five-year project, launched in July 2015, has received a European Research Council (ERC) Advanced Grant of €3,185,000.

BACK TO THE FUTURE

Much of SAMS' work involves looking into the past through fossile evidence to give scientists a better understanding of how our oceans are changing – but a very new tool is now helping them with the job.

SAMS took delivery of the autonomous underwater vehicle (AUV) 'Freya' in the spring of 2016 and it was immediately used for a number of missions, using a 500 kHz GeoSwath+ sonar to survey the seabed and collect photographs from an on-board camera and strobe.

Missions have included surveys of Loch Harray and Bay of Firth in the Orkney islands. The three-metres-long Teledyne Gavia AUV was looking for evidence of submerged landscapes and possible settlements from the last 5,000 years.

It was the first time that such technology has been used to delve into, and attempt to explore, the Neolithic period in Orkney. The relatively shallow depth of the lochs made it impossible for a ship to survey the areas of interest. The work was supported by MASTS and the AUV element was led by Dr John Howe. Fraser Macdonald, Karen Wilson and Colin Abernethy are also part of the Gavia team.

The Gavia also helped the team to produce a new map of Loch Etive, the first detailed survey of the loch. Published in the Scottish journal of Geology, the map is tidally correct and was completed in conjunction with the Maritime and Coastguard Agency.

PRIZEWINNING PAPER

In March 2016, SAMS, through Dr Kirsty Crocket, was given Intercalibration Status for Dissolved Rare Earth Elements (REE) Seawater.

This allows SAMS to process undiluted seawater for a range of trace metals and has led to institute involvement in GEOTRACES, an international programme that aims to improve the understanding of biogeochemical cycles and large-scale distribution of trace elements and their isotopes in the marine environment. Scientists from 35 nations have been involved in the programme, which is designed to study all major ocean basins over the next decade.

The work with GEOTRACES led to Dr Crocket co-authoring a paper that won the UK Geochemistry Group Medal, awarded by the Geological Society of London in March 2016. 'Neodymium isotopic composition and concentration in western North Atlantic seawater: results from the GEOTRACES GA02 section' was published in Geochimica Et Cosmochimica Acta.

The western North Atlantic is important for deep water circulation and therefore strongly linked to climate change. Based on the composition there, researchers were able to produce a palaeoceanographic reconstruction of ocean circulation in the past.

Dr Crocket had three projects funded in 2015, including Iron BREW (Beyond River Etive Water), examining the role and efficiency of dissolved organic matter from peat bogs as a transport vector of trace metals across salinity gradients in Scottish sea lochs. She is also co-supervisor on a MASTS PhD Studentship, which began in April 2015, to look at linking carbon and iron cycles by investigating transport, fate and mineralogy or iron-bearing colloids from peat-draining rivers. PhD student Deborah Wood is one of three currently supervised from the department.

IMPACT

CAPTURING THE CARBON POTENTIAL

Summer of 2015 saw the publication of more papers relating to the QICS carbon capture storage project, led by Plymouth Marine Laboratory.

As part of the project, SAMS' Dr Henrik Stahl conducted a world-first carbon capture storage leak experiment in Ardmucknish Bay from 2012 - 2014.

In July 2015, the various aspects of this groundbreaking project, were published in a special issue of the International Journal of Greenhouse Gas Control.

As a PhD student, Dr Pete Taylor was lead author on two papers that summer and was co-author on another two. The two first-author papers were 'A novel sub-seabed CO^2 release experiment informing monitoring and impact assessment for geological carbon storage' and 'Impact and recovery of pH in marine sediments subject to a temporary carbon dioxide leak'.

In his papers he took the unusual step of crediting the entire population of the village of Benderloch as an acknowledgement for their understanding in allowing the carbon dioxide leak experiment to be conducted in the local area.

The carbon capture storage experiment continues to bear fruit and Dr Natalie Hicks has been looking at how bacteria and archaea could be used to monitor stored carbon dioxide and convert it into useful products, such as ethanol and acetate.

Carbon Capture

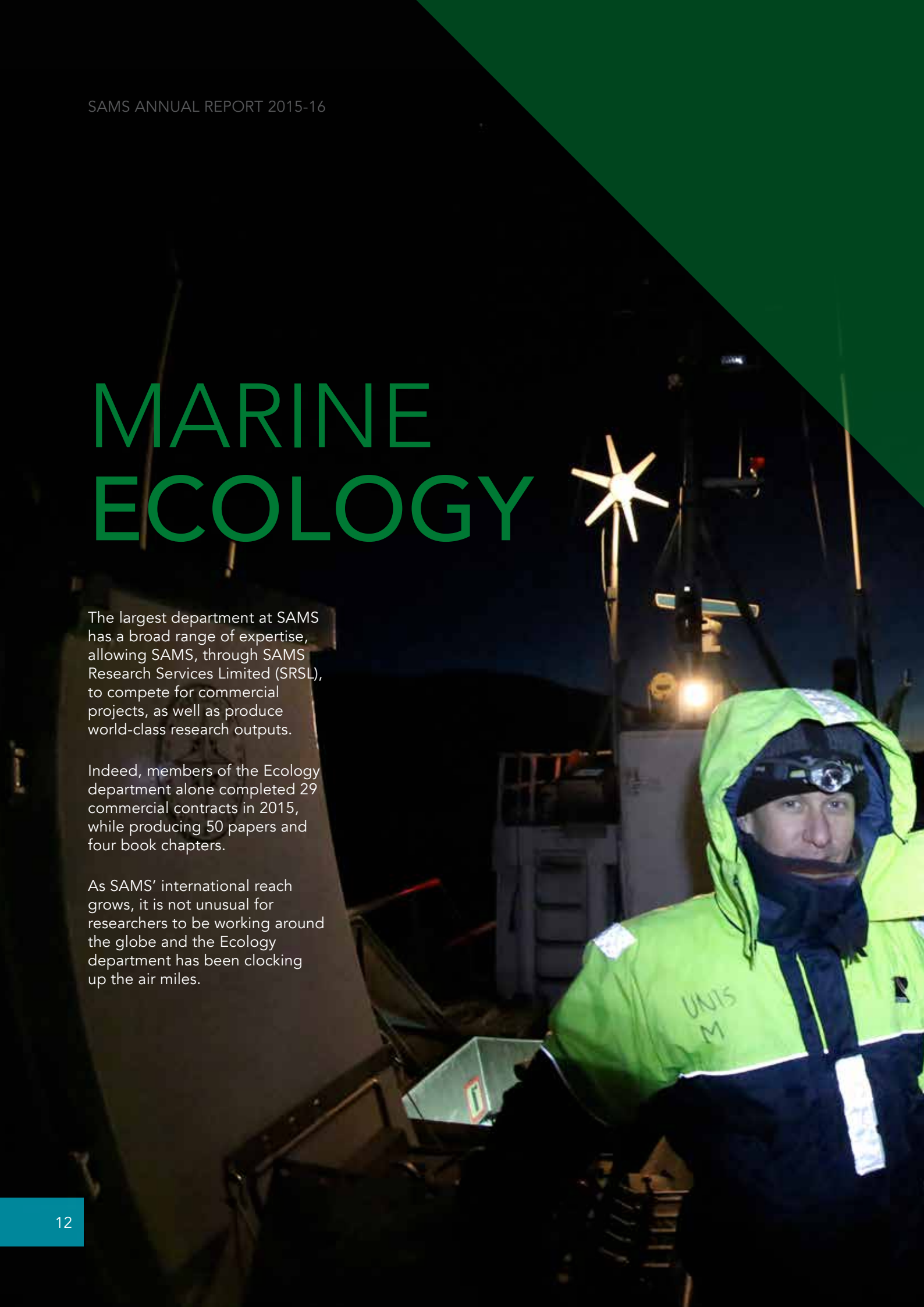
Divers from the National Facility for Scientific Diving at SAMS worked on the QICS carbon capture storage project

MARINE ECOLOGY

The largest department at SAMS has a broad range of expertise, allowing SAMS, through SAMS Research Services Limited (SRSL), to compete for commercial projects, as well as produce world-class research outputs.

Indeed, members of the Ecology department alone completed 29 commercial contracts in 2015, while producing 50 papers and four book chapters.

As SAMS' international reach grows, it is not unusual for researchers to be working around the globe and the Ecology department has been clocking up the air miles.



RESEARCH HIGHLIGHT

SAMS scientists studying the moon's effect on marine life during the constantly dark Arctic winter believe they have uncovered the 'werewolves of the ocean', which regularly gather in their billions to undertake the largest migration on Earth.

In January 2016 the team, headed by Dr Kim Last, published findings in the journal Current Biology that the actions of zooplankton respond to the moon as the main light source during the polar night.

Using echo sounders fixed to the seabed and analyses more commonly associated with studying the human biological clock, the scientists observed zooplankton moving deeper into the darkness in response to the full moon. The team believes this migration is to hide from light-dependent visual hunters, such as the voracious centimetre-long crustacean , pictured below.

This response could be seen across the entire Arctic at all water depths, ice covered and ice free, from 70°N to 90°N.

The mass migration has been detected by the team at the very high arctic, in water 4,000 metres deep and underneath thick ice. The research suggests that reducing sea-ice cover, resulting from climate change, may cause further changes in these migrations as more light penetrates the sea.

This newly-discovered response to moonlight during the Arctic winter has been described by the researchers as lunar vertical migration (LVM) and only occurs for a few days each month as the full moon rises above the horizon.

The team also discovered that zooplankton follow the rising and setting of the moon. This phenomenon results in a new kind of daily lunar migration, the cycle of which is longer (every 24.8 hours) than the standard day / night solar light response in the sunlit waters of the rest of the world.

The work was funded by the UK's Natural Environmental Research Council (NERC) and the Research Council of Norway (NRC) under projects Panarchive and Circa, respectively.

Moonlight hunter

Themisto libellula

DELVING DEEP

In May 2015 SAMS scientists carried out the first study into the impacts of mine tailings disposal into the deep sea and were subsequently published in Nature's online journal Scientific Reports.

The researchers (Dr David Hughes, Dr Tracy Shimmield, Professor Kenneth Black and Dr John Howe, representing SAMS and SRSL, conducted surveys in Papua New Guinea into the effects of deep-sea tailings placement (DSTP) on seabed biological communities. The findings in 'Ecological impacts of large-scale disposal of mining waste in the deep sea' demonstrated significant and long-term impacts on the seabed ecosystem at depths down to 2,000 metres.

At the Lihir gold mine, which discharges 100,000 megalitres of tailings slurry every year – the equivalent of 40,000 Olympic-sized swimming pools – the numbers of worms, molluscs and other small, sediment-dwelling animals are drastically reduced in areas directly affected by tailings. At Misima, where DSTP took place for 15 years, ending in 2004, their results showed that the seabed community was recolonising the area affected by tailings but its composition was still very different three-and-a-half years after the end of tailings discharge.
The paper is based on a project undertaken on behalf of the Department of Environment and Conservation of Papua New Guinea.

AQUASPACE INVESTIGATION BEGINS

A three-year project to investigate why Europe's own aquaculture industry is flat-lining, while countries outside the European Union (EU) enjoy boom time in the sector, was launched in May 2015. The AquaSpace project, led by Professor Kenny Black, will look at how we can best use our marine areas, as Europe's reliance on seafood imports increases.

The team will look at case studies across the world to find out how the EU can kick-start the industry to create more jobs and make the continent more self-sufficient. The scientists will also consider what impact planning and public perception has on the industry. The aquaculture industry within the EU has failed to grow in recent years, while countries outwith the EU, including other European countries like Norway, have expanded theirs. In China alone, the industry was worth more than $66 billion in 2012 and it continues to grow year on year. Europe produces around 2 per cent of the world's aquaculture and imports 80 per cent of all its aquatic produce.

HEATING UP

Following on from the paper 'Climate velocity and the future global redistribution of marine biodiversity', Prof Michael Burrows was invited in February 2016 to be a speaker at the Species on the Move Conference in Hobart, Australia.

The paper, led by Dr Jorge Garcia-Molinos and Prof Burrows, used climate scenarios from reports by the Intergovernmental Panel on Climate Change (IPCC) to look at the migration of 13,000 marine species.
It found that tropical marine animals that currently thrive in warm habitats around the equator will have to spread north and south to avoid extinction as global sea temperatures rise.
The study used a measurement called future climate velocity, which combines the rate and direction of movement of ocean temperature bands.

UNCOVERING MYSTERIES OF AN ANCIENT ORGANISM

In March 2016 scientists at SAMS attempted to shed some light on a mysterious deep-sea creature that can claim to be one of the longest living on earth.

The treasured black coral is protected under the Convention on International Trade in Endangered Species (CITES) and is used in medicine, jewellery and, in some cultures, as a good-luck charm. Considered to be among the oldest creatures in the ocean, one specimen of black coral collected from a depth of 300 metres off Hawaii was estimated to be 4,270 years old.

However questions remain about its abundance across the globe and its interaction with other species in the deep ocean. Part of its mystery is down to a slow evolutionary rate, which makes it difficult to detect major changes between samples of varying age. Black coral provides nursery grounds for commercially important demersal fish and a home for many other creatures, including crustaceans and polychaete worms, so is at risk of damage from trawling.

SAMS holds samples of black coral that were collected under a CITES licence during deep-sea research cruises and the institute was visited by Dr Tina Molodtsova, a world expert on black coral from the P.P. Shirshov Institute of Oceanology in Moscow. Dr Molodtsova's visit to Scotland was on the invitation of MASTS, for which Dr Bhavani Narayanaswamy is Deep Sea Convenor.

During the report year, Dr Narayanaswamy also contributed to the inaugural UN World Oceans Assessment, writing the chapters on Offshore Mining and Deep Open Ocean.

CLINGY CREATURES

SRSL and SAMS have been providing research expertise on a project led by Offshore Renewable Energy Catapult to measure growth rates of biofouling and their impact on renewable energy devices. Launched in February 2016, the project could ultimately see the creation of a detailed map to identify the type, speed of growth and prevalence of biofouling species, with the aim of better informing the operation and maintenance of sub-sea equipment.

The overall aim of the project is to map for the first time how communities of sessile creatures vary around the UK's coast and to develop a sensor to measure their growth rates, charting in detail the potential impact they have on subsea equipment and their effect on functionality.

Several members of the SAMS marine renewable energy team attended the International Conference on Ocean Energy (ICOE) in Edinburgh between the February 23 and 25, 2016. While ICOE itself is 'focused on the industrial development of renewable marine energy', many of the key challenges facing the industry can only be addressed in collaboration with a wider group of interested parties, including marine scientists.

SAMS scientists Prof Ben Wilson and Dr Raeanne Miller hosted two of three parallel workshops in advance of ICOE, focussing on three key issues: collision risk, biofouling, and the social impacts of marine renewable energy development.

SUEZ CANAL CONCERN

Marine invasive species expert Dr Elizabeth Cottier-Cook added her name to a list of international scientists calling for further investigation into the ecological effects of a second Suez Canal, which officially opened in August 2015.

Dr Cottier-Cook was the only British scientist on the team, which published a report with Association for the Sciences of Limnology and Oceanography (ASLO) Bulletin into how nearly 700 multicellular invasive species have already navigated through the existing canal from the Red Sea to the Mediterranean.

The scientists said the introduction of a second, parallel Suez Canal, the fastest shipping route between Europe and Asia, could cause an ecological setback to the ecosystem of the Mediterranean Sea, damaging native species, coastlines and industry. Since the early 1980s, a scyphozoan jellyfish, Rhopilema nomadica, has formed huge swarms every summer along the Levantine coast, adversely affecting tourism and coastal industry. There has also recently been a spread of a potentially poisonous pufferfish, *Lagocephalus sceleratus*, westwards towards Italy.

CAPTURING OUR COAST

SAMS heads up the Scottish effort in a UK-wide citizen science programme that aims to give us the best indication yet of the state of our coastal creatures.

Volunteers will receive training in monitoring and sampling coastal areas as part of Capturing Our Coast (CoCoast), the world's largest ever coastal citizen marine science project. The project co-ordinator in Scotland, Dr Hannah Grist, is based at SAMS and Prof Michael Burrows is helping to head up the project.

CoCoast, which launched in January 2016, aims to train more than 3,000 citizen scientists from across the UK to help collect data around key species such as mussels, wading birds and hermit crabs. The 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.

IMPACT

A BUDDING INDUSTRY

SAMS is at the forefront of research into the developing European seaweed industry and in August 2015 Dr Phil Kerrison set out plans to create a new seaweed farm on the site of a previous trial farm at Port a' Bhuiltin, off Lismore. The new farm would be 100 metres-squared with 25 100-metre lines. At its existing seaweed farm off Kerrera, SAMS grows a variety of seaweed: *Alaria esculenta*, commonly known as dabberlocks or badderlocks, is already a high-value food worldwide; sugar kelp; and dulse (*Palmaria palmata*). The scientists have also started growing Porphyra.

In June of 2015 SAMS co-founded a company, AT~SEA Technologies, to develop off-the-shelf seaweed farms, following Dr Adam Hughes' key role in the ground-breaking European project, AT~SEA. This project, which started in 2012 and ended in June 2015, aimed to demonstrate the feasibility of seaweed cultivation in Europe and developed seaweed cultivation 'sheets' to increase the surface area for growing and allowed for greater mechanisation.

SAMS is also a partner in a trial to test the commercial viability of a mussel hatchery in Scotland. Led by the Scottish Aquaculture Innovation Centre and Highlands and Islands Enterprise, the 30-month project could lead to higher productivity in the shellfish industry and support rural businesses and jobs.

WHAT DOES THE OCEAN SOUND LIKE?

In August 2015 Prof Ben Wilson and his team travelled to Kylerhea, a narrow gap between Skye and the mainland only 500 metres wide, to find out why it is so attractive to seals and porpoises.

Using an acoustic camera, they conducted a field campaign to look at how fish use the moving turbulent water. The camera uses sound like an echosounder but at ultra-high frequencies to produce moving images that look like those produced by a black and white film camera. The test of this specialist equipment came from IMARES, a lab in Holland that SAMS partners. Prof Wilson and his team also used 'drifting ears' equipment to see if they could map a pinging sound source on the seabed and therefore identify where the objects were. This experiment was to test how reliably we can use sound to locate echolocating (clicking) porpoises in the same habitat.

The desire to use tidal turbines in the water has prompted concern that marine mammals may be injured by the spinning blades. With these technologies being new, it's not clear what these renewable energy devices will sound like and how loud they will be. To get answers SAMS worked with Sustainable Marine Power and their recently deployed test device in the Solent in the early summer of 2015 to record their turbines in operation. It turned out that the turbines were highly audible, particularly for seals and their gearing produced highly distinctive warbling drones.

Sound transmission in the open sea is relatively well understood, but what if that water is moving, as in a tidal race, where renewable energy can be harvested? Does the passage of underwater sound suffer in the same way as a voice on a windy day? To test this Prof Wilson and his team broadcast a series of test tones across the strong tidal flows at the Falls of Lora. By broadcasting the sound during the full flow and at slack water they discovered that the flow of water does make a difference and the nature of the effect depends on which frequencies (low or high) are being transmitted.

LAURENCE MEE CENTRE

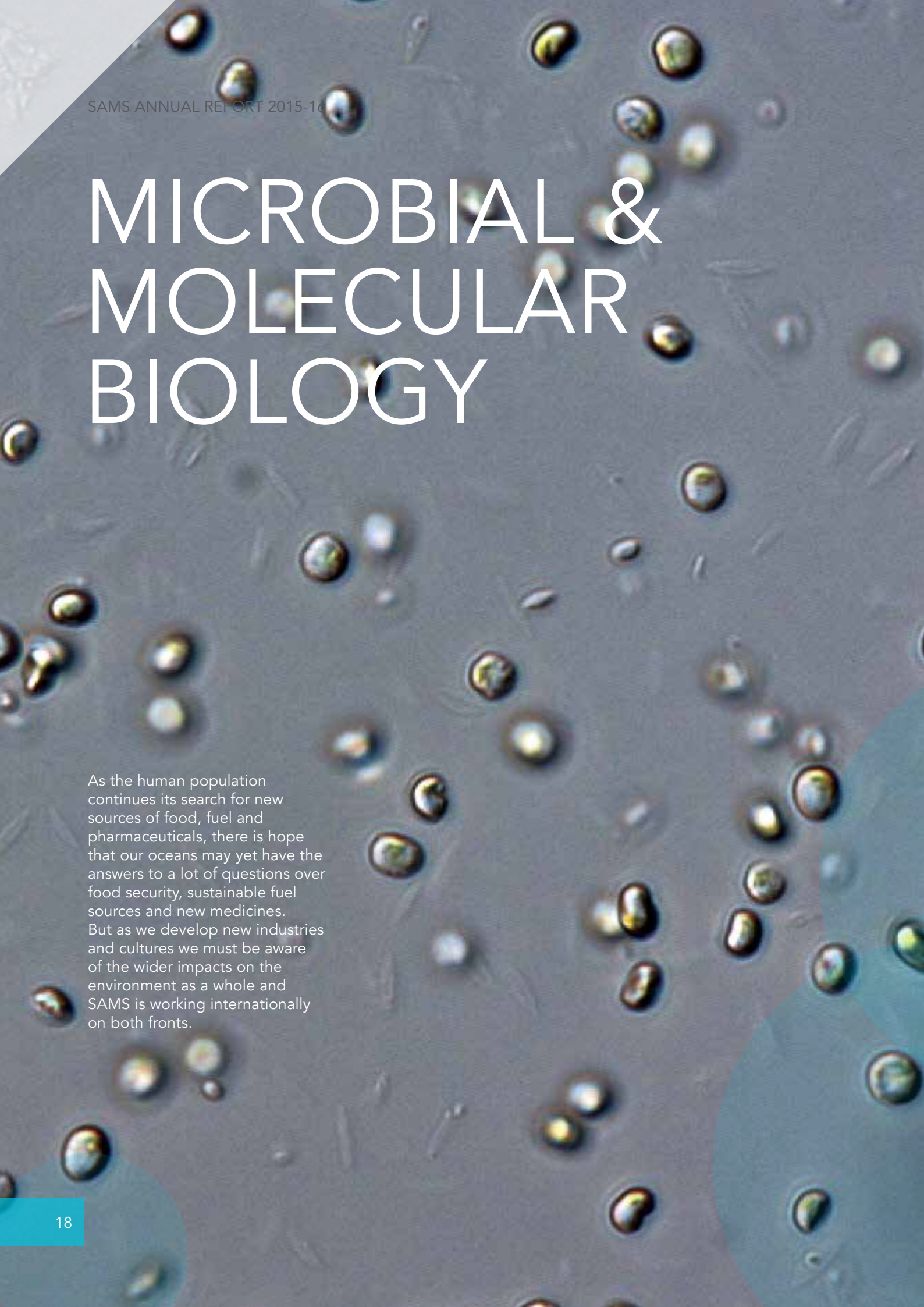
The social science team has been delivering the policy, governance, social and economic components of the EU FP7 MERIKA (Marine Energy Research Innovation and Knowledge Accelerator) project, with various exchanges with the University of Nordland (Norway), Helmholtz Zentrum Geesthacht (Germany), IMARES (Netherlands), and the National University of Ireland in Galway.

There has been a change of the watch with Dr Karen Alexander (University of Tasmania), Dr Ruth Brennan (Israel Institute of Technology) and Marcello Graziano (Assistant Professor at the University of Central Michigan) taking up roles abroad. Dr Suzi Billing also successfully defended her PhD ("The role of agents for change in the sustainable development of wave energy in the Highlands and Islands Region of Scotland") and has taken up a post at SAMS as research associate working on the MERIKA and EU H2020 Aquaspace projects.

New projects include ACIDCOAST, focussing on the governance of ocean acidification and climate change adaptation. Funded through the Norwegian Research Council, SAMS is working with the West of Norway Research Institute and other partners to enable knowledge exchange around governance mechanisms between Scotland and Norway.

There was extremely positive feedback on the IDCORE Renewables and Society summer school, where renewable energy engineers from around the country were exposed to 'eye-opening' material on understanding social impacts of developments, working stakeholders and policy makers, and more broadly providing a crash course on the basic tenets of social science research.

MICROBIAL & MOLECULAR BIOLOGY



As the human population continues its search for new sources of food, fuel and pharmaceuticals, there is hope that our oceans may yet have the answers to a lot of questions over food security, sustainable fuel sources and new medicines. But as we develop new industries and cultures we must be aware of the wider impacts on the environment as a whole and SAMS is working internationally on both fronts.

UNLOCKING THE ALGAL TREASURE CHEST

In 2015 researchers at SAMS unlocked a treasure chest of 'super-algae' that could provide a previously untapped source of oil. Using a newly devised technique, scientists examined micro-algae strains in The Culture Collection of Algae and Protozoa (CCAP) to find out which ocean-based strains had the highest oil content.

The screening revealed two marine strains, *Nannochloropis oceanica* (pictured) and *Chlorella vulgaris*, which had a dry-weight oil content of more than 50 per cent. This makes them ideal sources of biofuel for vehicles and aircraft.

The results of the screening, part of the BioMara project, were published in Nature's online journal Scientific Reports and are likely to help bring forward research into algae as a source of biodiesel and other biofuels by a number of years.

Micro-algae synthesise high levels of oil, carbohydrates and proteins from sunlight but only a few species are currently grown commercially for health foods, such as Omega-3 oils and pro-Vitamin A.

In addition to strains for making biofuel, the report, 'Unlocking nature's treasure-chest: screening for oleaginous algae' (lead author Dr Stephen Slocombe) also signposts those which could be used as sources of food, Omega-3 oils, or aquaculture feed.

The BioMara project receives support from the European Regional Development Fund through the INTERREG IVA Programme, Highlands and Islands Enterprise, Crown Estate, Northern Ireland Executive, Scottish Government and Irish Government, also with National Capability funding from NERC.

THE SEAWEED CONNECTION

The NERC-funded GlobalSeaweed project, headed by Dr Claire Gachon, ran its first workshop in 2015, followed by a summer school in 2016. Both events brought together some of the UK and Europe's foremost researchers in the emerging seaweed industry.

Worldwide, the seaweed aquaculture industry has been developing at an unabated exponential pace over the past six decades. China, Japan, and Korea are world leaders in terms of quantities produced, with other Asiatic countries having an increasingly significant contribution (e.g. Indonesia, Malaysia and Philippines). Seaweed cultivation has also been growing fast in South America and East Africa.

Conversely, the UK, Europe and North America have long traditions of excellent blue sky research in phycology, but little experience in industrial algal cultivation. GlobalSeaweed is creating a worldwide network of partners tackling emerging issues in seaweed, such as pathogens, pests, disease and invasive species.

Research activities include: pathogen identification, culture, and biobanking; identification of defense-related genes in red and brown algae; and exploitation of the model organism E.siliculosus to study algal pathology.

FUEL FOR THE FUTURE

In January 2016, the MacroFuels project was launched to advance biofuels from seaweed or macro-algae. The targeted biofuels are ethanol, butanol, furanics and biogas. The project will achieve a breakthrough in biofuel production from macroalgae by increasing biomass supply, improving the pre-treatment and storage of seaweed and increasing bio-ethanol and bio-butanol production to economically viable concentrations.

MacroFuels will develop technology for the production of fuels which are suitable as liquid fuels or precursor for the heavy transport sector as well as potentially for the aviation sector. A paper with Prof John Day as co-lead author published in June 2015, Proteomic-based biotyping reveals hidden diversity within a microalgae culture collection: An example using *Dunaliella*, showed how thousands of samples at the CCAP had to be re-labelled as a ground-breaking new screening tool revealed greater diversity than was previously known within the collection.

Analysing the protein 'fingerprint' of 32 algae which had all previously been catalogued under the same heading, experts from SAMS and Newcastle University found they actually divided into four distinct sub-groups and that one was apparently a completely new species.

The exploitation of marine and aquatic organisms for biotechnology applications - so-called 'blue biotechnology' - has risen to the forefront of the global research agenda over the past decade.

Algae and cyanobacteria have been shown to have huge potential - their ability to convert sunlight into biomass, capacity to grow in saline or hypersaline environments and their ability to metabolise industrial and domestic waste (including CO^2 and wastewater) making them attractive targets for industry.

BLOOMING ALGAE

Scientists at SAMS continue to help safeguard stocks of farmed shellfish and salmon in Scotland by continuously updating the Harmful Algae Bloom (HAB) Bulletin.

The Bulletin uses data collected for Food Standards Scotland in partnership with Centre for Environment, Fisheries, Aquaculture and Science (CEFAS). Data were also collected by satellite and by ocean drifters and used to validate a model that will more accurately predict the emergence of blooms and will complement The Bulletin, which was funded by NERC and Biotechnology and the Biological Research Sciences Council (BBRSC). This aim is to give fish and shellfish growers a reliable early warning system to the emergence of HABs, allowing them to take mitigating actions.

Two of the most relevant HABs in the UK and worldwide are the genus *Dinophysis*, which causes diarrhetic shellfish poisoning, and the species *Karenia mikimotoi* that can kill farmed fish. These organisms are both often transported to coastal aquaculture sites by oceanic currents. Satellite remote sensing can potentially be used to detect *K. mikimotoi* offshore, while blooms of *Dinophysis* can be anticipated as they tend to occur at certain

locations at certain times of the year.

In March 2016 a select group of international experts gathered at SAMS to address the global problem of HABs. The international steering committee, under the banner of GlobalHAB, is looking to help fellow researchers understand how HABs affect human health and their impacts on industries, such as aquaculture, in a changing climate. The project is sponsored by the Scientific Committee on Oceanic Research (SCOR) and the Intergovernmental Oceanographic Commission (IOC) of UNESCO.

Microbial Ecologist Prof Keith Davidson represents SAMS on GlobalHAB, which brings together experts from a range of countries in Europe, Asia, Australia and North America. GlobalHAB will follow on from work done by the GEOHAB project, which ran from 2000 – 2013.

IMPACT

MRES IN ALGAL BIOTECHNOLOGY

Over the last decade, use of microalgae as a sustainable source of food and energy has become a massive research and development activity around the globe. This was primarily driven by the urgent need to develop sustainable alternatives to petroleum-based fuels (biofuels). Marine microalgae are particularly attractive for this because they naturally produce a large quantity of their body weight as lipid. This can then be converted to biodiesel, or used as a healthy feed in the aquaculture industry, or indeed as a human food supplement.

In discussion with companies and other researchers, SAMS scientists realised there was a significant shortage of researchers who could solve the myriad of problems encountered with growing the large quantities of algae needed for commercial production. So, to address this skills shortage, SAMS decided to develop a Masters by Research (MRes) in Algal Biotechnology. As growing algae is most often a practical and technical problem, the philosophy was that the MRes in Algal Biotechnology would be based round a 1 year research project focusing on a real-world algal problem. Each student plans and carries out their research programme, leading to submission of a written thesis.

In 2015 Thomas Butler became the first student in the UK to conduct a Masters by Research in algal biotechnology, followed by four students beginning their projects in 2015:

STUDENTS

Upgrading kelp to an omega three fatty acid rich feedstock using Thraustochytrids

Joseph Penhaul Smith

Omega three fatty acids have been linked to human health benefits. The major source of omega three for humans is oily fish. Overfishing prevents the supply of omega threes from meeting demand. *Thraustochytrids* are a group of microalgae which accumulate large amounts of omega threes. Industrial cultures of

thraustochytrids use glucose as the major carbon source, but this is expensive. Research has focussed on more sustainable, low cost, glucose alternatives.

In the first study of its kind a number of different seaweed species have been tested for their suitability for *Thraustochytrid* culture, with clear success at a laboratory scale.

Suitability of different *Pleurochrysis* strains for simultaneous biofuel production and carbon capture

Jennifer Reid

Coccolithophorid algae (Haptophycea) are mainly marine unicellular phytoplankton. The coccolithophorids are of global interest as they can fix carbon by photosynthesis as well as in calcium carbonate (coccoliths).
My project will test the hypothesis that micro-algae with calcareous coccolithophores have the potential to sequester atmospheric CO_2, 'locking it up' so that it is not bio-available. The objective of this project is to explore using a biorefinery approach where algae sequester CO_2 and produce a commercially relevant product. This will involve optimisation and cultivation of up to 11 different CCAP strains of the calcifying coccolithophore *Pleurochrysis*, to select a potential production strain.

Newly discovered *Pseudoaltermonas* species

Paul Micallef

The formation of biofuels is one of the most promising (new) avenues of renewable energy where biomass is used and converted in such a way that it readily releases energy,

bioethanol being one of the more popular methods. One of the key processes in the formation of biofuels is saccharification, wherein complex sugars are processed into fermentable sugars. Pseudoalteromonas 2/50 shows the ability to process and utilise a wide range of polysaccharides such as alginates, cellulose and laminarin. In addition it has been shown that it is possible to isolate the enzymes for practical uses.

Assessment of the

Saccharification enzymes from

Alkenone production by haptophytes: production and variation analysis of a putative biofuel resource

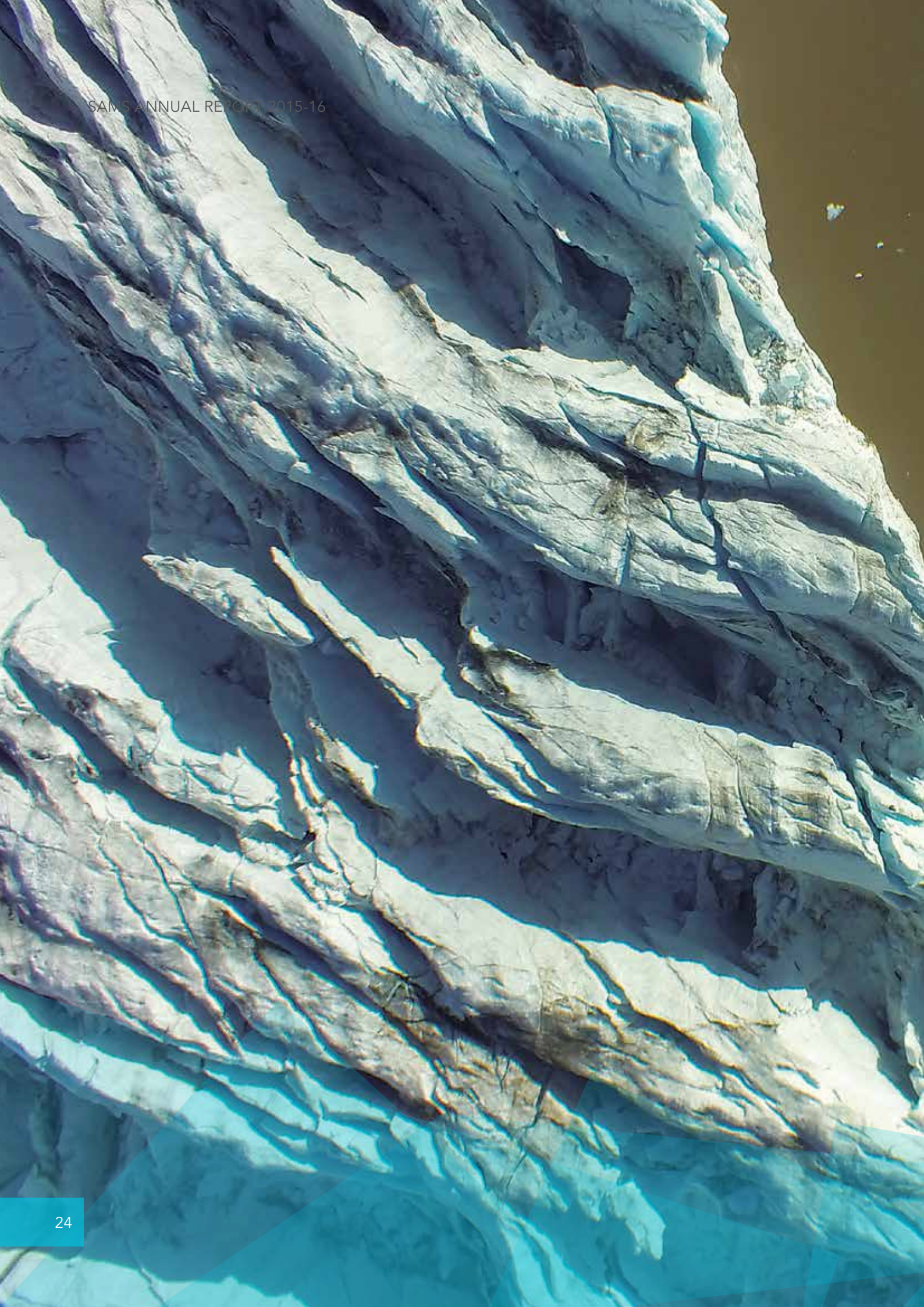
Douglas Harris

A sub-group of haptophyte algae are known to produce extremely long-chained hydrocarbons known as alkenones. Although known for their use in modelling past sea-surface temperatures, a method has been developed to catalytically crack these compounds into kerosene grade biofuel. The aims of the project were to confirm which algae these hydrocarbons were confined to and to examine the variation in production between strains. Finally a selection of algae were subjected to varying environmental conditions to observe if the production of alkenones can be optimised.

CCAP

The Culture Collection of Algae and Protozoa (CCAP) maintains a collection of almost 3,000 strains of living organisms and provides cultures and other services to customers.

In the report year (2015/16) CCAP had 703 orders and sent out a total of 1,412 cultures. Of the orders despatched, 40 per cent were to the UK, 44 per cent to Europe and 16 per cent to the rest of the world.



PHYSICS AND TECHNOLOGY

TECHNOLOGY IS KEY

The advance in marine technology has allowed researchers at SAMS to look at the ocean in a way that has never before been possible. The institute has led and assisted a number of large-scale, multi-national projects that are underpinned by SAMS' expertise in the operation of Seagliders and other autonomous underwater vehicles (AUVs) and unmanned aerial vehicles (UAVs).

This expertise has also allowed SAMS to deliver Centre for Doctoral Training courses in robotics; in October 2015 we were announced as a partner in the £2.5m Next Generation Unmanned Systems Science (NEXUSS), funded by Natural Environment Research Council (NERC) and the Engineering and Physical Science Research Council (EPSRC).

SEAGLIDERS' LANDMARK MISSION

In July 2015 robotic underwater Seagliders used by SAMS had gathered the equivalent of five years of oceanographic data, most of which was collected in the previous 18 months. The milestone highlighted a major change in how marine scientists collect information such as sea temperature, salinity, pressure and oxygen, as the six-feet-long Seagliders can spend months at sea collecting data that contributes to our understanding of climate change.

Seagliders collect data down to 1,000m as they slowly submerge towards the seabed and then rise to the surface, using fixed wings and a hydrodynamic shape to create a forward movement. To submerge, a battery-powered pump moves oil into a pressurised container, increasing the density of the glider in the water and causing it to sink. To bring the glider to the surface, oil is pumped back into a bladder to increase buoyancy. Live data is sent by the gliders via satellite to the pilots at SAMS, who can control and re-direct them remotely in near real-time. SAMS owns two Seagliders and operates another five from the NERC Marine Autonomous and Robotic Systems (MARS) instrument pool. SAMS, which is ideally situated for deep-sea Atlantic research, runs the Scottish Marine Robotics Facility, a command and control centre for Seaglider operations.

Since the first Seaglider mission in 2009, the fleet has travelled a combined distance of more than 33,000 kilometres. One of the Seagliders, Ardbeg, in July 2015 broke a SAMS distance record by completing a return trip of more than 3,400km along the Extended

Ellett Line (EEL), a route from Scotland to Iceland that has been surveyed by scientists annually for 40 years. Dr Stefan Gary was lead researcher on the EEL cruise 2016 and oversaw the deployment of Seagliders to complement the work on board the RRS Discovery.

Seagliders also supported the four-year FASTNEt (Fluxes Across Sloping Topography of the North East Atlantic) project which ended in autumn 2015. It looked at physical exchange processes between the deep ocean and shelf seas and the findings resulted in the publication of more than 20 papers. The international OSNAP project (www.ukosnap.org), which will monitor the oceanographic circulation across the subpolar North Atlantic until 2018, also relies heavily on data from Seaglider missions.

June 2015 saw the launch of another oceanographic project, AtlantOS (Atlantic Observing System), underpinned by SAMS technology. The project is one of the largest and most ambitious marine research projects of recent decades. AtlantOS brings together 62 partners from 18 countries to significantly enhance the integration and effectiveness of Atlantic Ocean data. SAMS is providing expertise through Professor Stuart Cunningham, who will use moorings to measure the warm water flow of the eastern Atlantic boundary (from the Scottish continental shelf to the Mid-Atlantic Basin), and Professor Mark Inall, who will also take measurements across the eastern boundary using Seaglider data. The EU is funding AtlantOS as part of its Horizon2020 programme with €21 million over a period of four years. The project is co-ordinated by GEOMAR Helmholtz Centre for Ocean Research, Germany.

EYES ON THE ARCTIC

The area of the planet where we can perhaps most clearly see how our climate is changing, the Arctic was an area of intense study by SAMS researchers in 2015-16. Robotic technology has been key to our winter exploration of this harsh environment but so has a 10-year time series provided by two mooring systems in Kongsfjorden and Rijpfjorden, the data from which has produced a number of high impact papers. The moorings have been supported with assistance from Norwegian research funding and this collaborative approach has led to strong ties between SAMS and the University of Tromso (UiT), the Arctic university of Norway. In September 2015, this collaborative work was recognised when Dr Finlo Cottier was awarded an adjunct professorship at the Norwegian institute. Work with Prof Jorgen Berge of UiT has resulted in three projects: Circa (Circadian rhythms of Arctic zooplankton from polar twilight to polar night – patterns, processes, and ecosystem implications) ended in 2015 and follow-up projects Marine Night and Arctic ABC got underway during the report period.

Published in October 2015 in Nature Communications, the paper 'Calving rates at tidewater glacier vary strongly with ocean temperature' relied heavily on SAMS data – Prof Adrian Luckman of Swansea University published with Dr Cottier and Prof Inall as co-authors – and showed that sub-surface water temperature plays a key role in glacial calving rates.

There was further SAMS involvement in glacial calving in September 2015 when a custom-built quadcopter by technician Shane Rodwell surveyed otherwise inaccessible Arctic terrain in an effort to better understand the processes of glacier calving. The quadcopter used a mounted laser-range finder and a camera to measure and photograph glaciers, collecting unique data to make up a 3D image of glaciers. Large crevasses open up in the glaciers as they break, so the terrain is unsafe to survey on foot and the previously accepted, but costly, alternative is a helicopter. Satellite imaging produces comparatively low resolution images.
The work, undertaken in the Svalbard archipelago, Norway, is the first time geoscience researchers have combined

a laser-range finder with photogrammetry to measure the depth and size of crevasses in the glaciers. On each of the 15 – 20-minute missions, the camera took 1,000 images and after 10 missions the team had enough still images to map the glacier in a 3D model.

IDEAL TEST SITE

In March 2016 researchers from the University of Exeter described the 'ideal' Argyll coastline was the reason for testing one of their sea-going robots, which can map the seabed from the water's surface.

Professor Peter Challenor from the College of Engineering, Mathematics and Physical Sciences and his team came to SAMS to test a computer algorithm for the autonomous surface vehicle, C-Enduro. The team spent a week at Dunstaffnage and in Ardmucknish Bay, near Benderloch and praised the testing ground available through SAMS' Scottish Marine Robotics Facility.

IMPACT

HYDROGEN-POWERED PLANE TAKES OF AT SAMS

On the afternoon of January 19, 2015, SAMS researchers completed a test flight using technology company Cella's hydrogen-based power system, a solid, lightweight hydrogen storage material capable of releasing large quantities of hydrogen when heated.

The flight, which took place at Oban Airport is believed to be the first flight of a hydrogen-powered UAV. Dr Phil Anderson, Shane Rodwell and Bernard Hagan were integral to the preparation of the aircraft. The complete system that powered the flight – a Cella gas generator along with a fuel cell supplied and integrated by Arcola Energy – is considerably lighter than the lithium ion-battery it replaced.

The work was funded by a grant from Innovate UK and enabled Cella and Arcola to design and build a power system that could be incorporated into the Raptor E1, built and designed by Trias Gkikopoulos of Raptor UAS. The flight was a proof-of-concept for the technology, which addresses the issues that surround the transportation of compressed gaseous hydrogen. Cella's material is solid and is not under compression, is stable in air and at temperatures below 50^0C.

A future version of the drone would be perfect for the environmental and climate monitoring carried out by SAMS in the Arctic and north Atlantic. Because the only by-product is water, it will assist SAMS in its work to detect trace gases. Longer term, it is possible the technology could be used in city cars and eventually provide hydrogen power for commercial aircraft.

SRSL

IN THE **COMMERCIAL WORLD...**

WE ARE SRSL

SAMS Research Services Ltd (SRSL) provides specialist marine consultancy and survey services, underpinned by cutting-edge science. The company mission is to enable clients to understand and mitigate the risks involved in industry interaction with the marine environment. Our consultancy and survey services span the breadth of marine science and are bespoke to the clients' needs, delivering reduced project risk, robust scientific methodologies and data integrity.

Driven by the commercial and social imperative to understand and manage the marine environment, SRSL facilitates international communities, governments and multi-national corporations to sustainably utilise and manage marine ecosystem services.

SRSL is accredited to ISO 9001 and has dedicated project managers and marine science expertise in-house, spanning ecology, chemistry, hydrodynamics, physical oceanography, microbiology and the social sciences.

SCOTLAND AND THE UK

This year SRSL provided Scottish Natural Heritage (SNH) with an assessment of carbon budgets and blue carbon stores in Scotland's coastal and marine environment. This project was later extended to focus on blue carbon resources in Scotland's inshore marine protected area network. This innovative marine research makes Scotland the first country in the world to carry out an assessment of this sort. The results will be used to inform the protection and management of carbon sequestering habitats in the marine environment and future mitigation of climate change.

SRSL was also a partner in a collaborative feasibility study with EDF Energy, the Scottish Salmon Producers Organisation, and the Satellite Applications Catapult, investigating techniques which could be used for observing jellyfish swarms, and modelling them so as to develop an effective "Early Warning" facility, alerting power stations and fish farms to potential events and allowing them to take preventative action. This work has the potential for huge economic benefit to industries impacted by jellyfish swarms across the UK and the World.

INTERNATIONAL

In 2016, SRSL provided diving expertise, services and facilities to support follow on science associated with the QICS Carbon Capture and Storage Experiment. The project involved a number of Japanese scientists from a range of institutions from across Japan, namely the National Institute of Advanced Industrial Science and Technology (AIST), Tokyo University of Marine Science and Technology, Central Research Institute of Electric Power Industry (CRIEPI) and the University of Tokyo.

SRSL also continues to advise governments, like that of the Seychelles and the Falklands, on environmental topics ranging from the developing a Blue Economy to environmental impacts of oil and gas extraction. In technology, international sales of Sea Ice Mass Balance Array (SIMBA) units are up on last year, with the development of a new model now underway.

IMPACTS

CHLORINE TOXICITY TESTING

SRSL is part of the British Energy Estuarine and Marine Studies (BEEMS) programme, coordinated and funded by the Centre for Environment, Fisheries & Aquaculture Science (CEFAS) on behalf of EDF Energy (formerly British Energy). SRSL provided scientific input on the lethal and sub-lethal responses of the biogenic reef forming polychaete Sabellaria alveolata to aqueous chlorine and temperature in the vicinity of potential new build nuclear power stations. This work has since been extended to include impacts on other species of interest.

OIL PLATFORM DECOMMISSIONING

This year, SRSL was commissioned by Shell to undertake a literature review to investigate the potential use of Gravity Base Structures (GBS) to act as artificial reefs. This involved exploring the associated ecosystem services that such structures could offer and ways in which they could be enhanced. Recommendations were made for future investigations that Shell could undertake to fill knowledge gaps and inform a number of management options for the decommissioned Brent GBS.

WWW.SRSL.COM

DIVING

The Diving Unit at SAMS continues to be funded mainly by NERC, through its National Facility for Scientific Diving (NFSD), and the National Health Service, through provision of an emergency recompression therapy facility. The unit also undertakes other scientific and educational roles supported by a range of other funding organisations, which augment an expanding capacity for scientific and commercial diving activity at SAMS; the unit now supports five full-time diving posts. The unit managed over 700 diving operations during the reporting year.

The NERC Facility for Scientific Diving (NFSD) at SAMS provides divers, equipment, training and scientific/technical support that underpins a wide range of interdisciplinary research in the underwater environment. The primary level of service delivers practical support for diving-related underwater scientific projects through providing additional manpower for groups with limited diving experience, total project management for scientists with no diving experience and/or specialist equipment loans for groups with diving experience but limited resources. On a secondary level, the Facility undertakes to ensure proper adherence to Health and Safety legislation as applied to diving at work activities. This can be through targeted training programmes, communicating advice and guidance for senior management with legal responsibilities for diving at work, undertaking safety audits on behalf of the NERC Health and Safety management structure and facilitating a wider interactive dialogue with others in the higher education field and the Health and Safety Executive. The NFSD is the main service provider and the major supporter of research within the UK that involves scientific diving through: support and maintenance of an extensive underwater research programme; support for the UK Scientific Diving Supervisory Committee (SDSC); interactions with other diving industry bodies; ongoing diving research and evaluation programmes; and a focussed training programme for scientists and technicians involved with working underwater (e.g. the NFSD was granted two NERC Advanced Training Programme Awards in 2015-16 jointly with Heriot Watt University through the MASTS initiative). In addition to diving services per se, the NFSD also provides support and training in associated small boat operations and in emergency diving medicine. The NFSD provided a diving support service for the UK National Tide Gauge Network up to March 2016 which, in turn, contributed to outputs of the National Tidal and Sea Level Facility (NTSLF); it also has research links with the NERC Field Spectroscopy Facility. Since 2006, NFSD support has generated 154 ISI-rated publications (IF median 2.51; mean 3.31); these have been cited 2563 times with a current H-index of 27.

Additional funding from NERC in 2015 (+£100k) permitted the complete re-build of the NERC portable recompression facility to advanced diving industry standards. In a joint design project with Mimar Marine Ltd., in Hull, the containerised system is now state of art for the whole of the diving industry, permitting support of diving operations anywhere on the planet (with temperature limits of +40 to -40°C); the chamber exceeds diving industry size guidelines for a container-based facility. The SAMS unit, through the NFSD, also obtained capital funding (+£65k) to increase its capability for the application of underwater stereophotogrammetry techniques.

The on-going projects carried out in 2015/16 continue to demonstrate the highly interdisciplinary nature of the science being supported through diving. These projects include contributing to studies investigating sea-level measurement, water-quality assessment, underwater light measurement, functional ecology, cell biology, animal genomics, paleoclimatology, ocean acidification, biogeochemistry, eco-physiology, habitat mapping and maritime science-based archaeology. Support in 2015/16 was provided to researchers from the following universities/ institutes: BAS, NOC, PML, SAMS, MBA, Aberdeen, Aberystwyth, Bangor, Bristol, Edinburgh, Exeter, Glasgow, Heriot Watt, Leeds,

WWW.NFSD.ORG.UK

Natural History Museum London, St. Andrews, Southampton, University College London and the University of the Highlands and Islands.

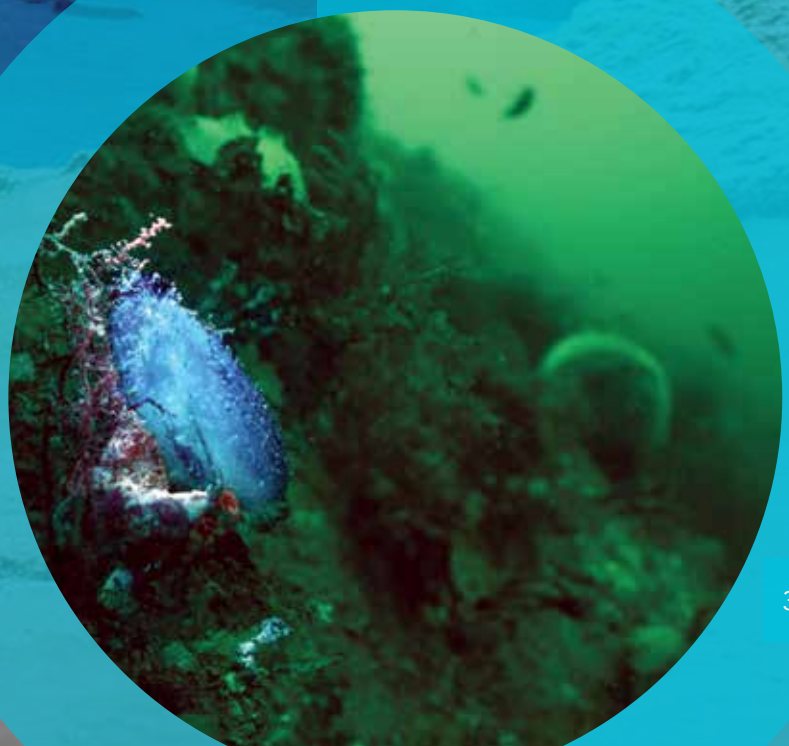
Diving support in 2015/16 has been dominated by three projects that have required significant fieldwork. Six weeks of diving was delivered in support of NE/K008439/1 at locations on the west and north coasts of Scotland examining regional-scale variability of kelp forests. A further two weeks of diving in the eastern Mediterranean supported studies of deep water algal communities. Finally, a two-week cruise to St Kilda and the outer western isles of Scotland was undertaken as part of a systematic survey of long-lived molluscs. Anchored empty shell chronologies based on growth patterns will be used to generate a multi-centennial record of the variability of the Scotland-Norway branch of the North Atlantic Current.

During 2015-16 the emergency recompression facility at SAMS, now named the West Scotland Centre for Diving and Hyperbaric Medicine, treated numerous diving emergencies on behalf of both NHS-Scotland and NHS-England/Wales; planning continues to reconfigure future service delivery to incorporate more clinical treatments in the future within NHS guidelines. The medical and technical expertise at the SAMS facility continues to lead the NHS appraisal mechanism for the whole of the British Hyperbaric Association.

On a consultation basis, the SAMS diving unit now provides advisory support for Marine Science Scotland on their client-based support for scientific diving activities, to a number of UK Universities, and the British Antarctic Survey. In 2016, the diving unit provided diving supervision services to the Falkland Islands Government to cover scientific diving operations in support of a broad-scale environmental planning programme.

AT A GLANCE

- **Five full-time posts**
- **More than 700 diving operations**
- **19 ISI-rated science papers published**
- ***Since 2006, NFSD support has generated 154 ISI-rated publications (IF median 2.51; mean 3.31); these have been cited 2563 times with a current H-index of 27.***



EDUCATION

SAMS EDUCATION IN NUMBERS 2015/16

In the last reporting period SAMS educated a total of 124 higher education students, nearly all of which studied full time on one of 5 programmes:

BSc (Hons) Marine Science (UHI): 92 students

MSc Ecosystem Based Management of Marine Systems (St Andrews): 13 students

Erasmus Mundus Joint Masters Degree in AquaCulture, Environment and Society (UHI): 4 students

MRes Algal Biotechnology (UHI): 4 students

PhD students (UHI or University of Edinburgh) – 27 students

As the number of students coming to SAMS UHI increases steadily year on year, the educational offering at Dunstaffnage has never been so important.

From first year undergraduate students making their way in the wide world of marine science to PhD students examining the most detailed of subjects, SAMS UHI lecturers pride themselves on being able to offer top class teaching in a positive environment.

The care and attention taken by education staff and the calibre of student we attract was best exemplified by the BSC Marine Science Honours students who graduated during the report year.

THE CLASS OF 2015

Of the 18 students graduating from the class of 2015, 13 gained first class honours. SAMS President, Professor Geoffrey Boulton, a former Vice Principal of Edinburgh University, described the class as the 'most exceptional' he had ever seen and subsequently awarded the SAMS Best Student Award to the entire class.

Professor Boulton, who had the previous year received the prestigious Founder's Gold Medal from the Royal Geographical Society, told the students at graduation: "I have been teaching university students for more than 50 years and you are the most exceptional class I have known. "You have all developed high technical level skills and you have developed the capacity and confidence to grapple with complexities without being overawed by them. We are proud of you."

There was individual success for two of the fourth year students: Catherine Tate was presented with the SAMS Council Award for Academic Excellence and Kevin Purves was given the SAMS UHI Award for Overall Achievement. Students were joined in their celebrations by family members who had travelled from across the UK and Europe.

Dr Pete Taylor, who went to work with SRSL, was named UHI Postgraduate student of the year, and also won SAMS' Johanna Fehling Memorial Prize for the best published paper by a PhD student.

UHI Principal and Vice-Chancellor Professor Clive Mulholland gave the principal's address at the graduation ceremony and guest speaker Guy Grieve, Director of the Ethical Shellfish Company on Mull, gave an inspirational speech reminding the graduates that they can 'give a voice for the ocean, which can't speak for itself'. SAMS UHI lecturer Dr Kirsty Crocket was presented with an award from the university after receiving the best student feedback.

AQUACULTURE ELITE

Autumn 2015 saw the arrival of the first cohort of students on the SAMS-led ACES (AquaCulture, Environment and Society) Joint Masters, a highly-ranked course in sustainable aquaculture funded by the EU's prestigious Erasmus Mundus programme.

ACES attracts elite marine science graduates from across the globe to study at SAMS UHI as well as the universities of Nantes and Crete. This allows them to study a range of specialisms, including finfish and shellfish aquaculture, and create contact networks across Europe. Fully-funded scholarships are available to high academic achievers.
Such is the demands of the course, only the best students can win a place and four students made up the first cohort. This number has risen to 25 for the second cohort starting in September 2016.

ACES aims to work hand-in-hand with industry and this has been held up as a model for the future by two internationally renowned science communication consultants who delivered a communications masterclass as part of the course: Dr Alex Bielak, Associated Fellow at the United Nations University, and Louise Shaxson, Research Fellow at the Overseas Development Institute. ACES works alongside partners such as Sainsburys, the Shellfish Association of Great Britain and the European Aquaculture Society to ensure the course is relevant to industry.

ALGAE: FRIEND OR FOE?

A PhD programme looking at the importance of algae in terms of ecology and industrial application is being run by Dr Claire Gachon, in partnership with European colleagues, and began in 2015. The Algal Microbiome: Friends or Foe (ALFF) is a four-year programme funded by the prestigious Marie Sklodowska-Curie Initial Training Networks (ITN) programme of the European Union to develop 15 outstanding researchers in algal biotechnology and aquaculture. Their work will contribute to the future development of these major growth industries.

ALFF combines multidisciplinary research-based projects, each with a focus on either pathogens, mutualistic symbionts,

endosymbiotic micro-organisms, biofilms or bioinformatics. ALFF also involves an ambitious outreach and public engagement programme in collaboration with highly renowned institutions such as the Flanders Marine Institute and the United Nations University. Part of this will be developing outreach materials for exhibitions, films, presentations and activities to help decision-makers and the public better understand the issues and opportunities relating to the sustainable use of our aquatic freshwater and marine resources.

PHD SUCCESS

A total of four PhD students: Drs Iona Campbell, Tosin Obata, Suzi Billing and Greg Moschonas, successfully defended their vivas at SAMS during the report year. Thomas Butler also became the first student in the UK to receive a Masters by Research (MRes) in algal biotechnology and went on to work in industry upon receiving the award.

LOIS LEAVES SAMS

She may be leaving her career in marine science research but Dr Lois Calder's lifelong love of the ocean endures as she starts up a new business in seaweed-based cosmetics.

SAMS' Head of Education left her role in April 2016 after 23 years on the staff at Dunstaffnage. Between 1988 and 1992 Lois completed a PhD, through London University, at the University Marine Biological Association in Millport.

There, she was supervised by Dr Jim Atkinson but her studies included an element of practical work at SAMS, so Dr Alan Ansell became her Dunstaffnage supervisor. This was the beginning of a SAMS connection that would see Lois come to work in Dunstaffnage in 1992 on finishing her PhD on the Deep bioturbation in organically enriched marine sediments.

Lois took great joy in lecturing and became Head of UHI Graduate School in 2010 and in 2015 she was appointed Dean of the MASTS Graduate School.

GRADUATION PRIZES

SAMS UHI Student of the Year –
the entire fourth year BSc Marine Science

Johanna Fehling Memorial Prize
for best PhD student publication:
Dr Pete Taylor

Prize for best Masters project at SAMS:
Elisavet Spanou

SAMS Council Award
for Academic Excellence:
Catherine Tait

SAMS UHI Award
for Overall Achievement:
Kevin Purves

Tim Body Prize for Oceanography:
Esther Wilcox

SAMS UHI Employability Skills Award:
Stacey Felgate and Holger Buchholz

ENGAGING THE OUTSIDE WORLD

SAMS IN THE NEWS

Around 500 individual media articles carried SAMS stories in the past year. We achieved 25 mentions across various BBC outlets and featured on the Discovery Channel and in the New York Times, New Scientist, ILF Science, Daily Mail and The Guardian as well as many smaller publications and local programmes.

Top stories focused on marine robotics including the first hydrogen-powered drone flight, Seaglider missions, and deep-sea exploration; the biofuel potential of CCAP 'superalgae'; moonlight-induced vertical migration of zooplankton during the polar night; stories about the large CoCoast citizen science project; and many seaweed aquaculture stories.

IN THE DIGITAL SPHERE

Our main website saw a slight reduction in recorded web sessions as users turn more to social media. Interestingly, more than half of our website visitors came from the USA and about a quarter from the UK. New social media 'friends' this year – while still mostly from the UK – increasingly come from further away, for example India and South America.

	2013-14	2014-15	2015-16
www.sams.ac.uk	138,828	192,426	181,701
www.srsl.com	895	865	447
www.oceanexplorercentre.org	948	5175	2767
www.obanseafestival.org	2016	1722	7294
@ScotMarineInst Twitter	964-1754	1754-2600	2600-3799
Facebook friends	353-594	594-889	889-1620
LinkedIn followers	208-537	537-922	922-1359

During the reporting year we decided on a new web content management system and are now working alongside our UHI partners on developing a responsive website for SAMS using Terminal Four (T4).

SAMS ON FILM

Over the past two years our part-time filmmaker, Andy Crabb, has been developing a 'SAMS news' feature and in the reporting period added four filmed news items covering marine robotics, aquaculture, seaweed research and Arctic collaborations. He was also part of the AquaSapce project, produced a successful video abstract for Dr Kim Last's paper on the "Werewolves of the Arctic", redeveloped the SAMS You Tube Channel and produced several films to support student recruitment including for the ACES Masters programme. He also contributed to skill development for students and staff.

SAMS IN THE FLESH

While the Ocean Explorer Centre - as a place for people to engage directly with SAMS - has fast become a dominant SAMS feature it has not had an easy year. The financial challenges demanded a rethink of how to manage the facility: opening hours were reduced, dedicated staff cut, the café operation outsourced to Dalrannach Foods and volunteers and interns recruited to help out. All education outreach, public event and shop management are now coordinated by one very busy 0.8 FTE while also staffing the centre.

During the reporting year we delivered 30 school workshops reaching 632 pupils from ages of 4 to 16. We also hosted three work experience pupils, one work placement pupil, and delivered numerous tours for visiting groups.

FESTIVAL OF THE SEA

SAMS organised a Festival of the Sea around Oban between May 22 – 31, 2015, delivering 28 events reaching 3,711 participants and an education programme involving 1,557 pupils. Funded by The Scottish Government, The Fishmongers' Company and the Argyll and Bute Regional Environmental Education Forum the festival aimed to celebrate the important relationship of the Oban area with the marine environment.

One highlight event was the Songs of the Scottish Sea performance that brought a Creative Scotland supported film residency at SAMS to its conclusion. Project musicians Chris Stout and Catriona McKay performed live in conjunction with large screen projections of Andy Crabb's residency films, to a rapturous reception from the sell-out audience at Oban's Phoenix Cinema.

OTHER EVENTS

SAMS also joined other UHI partners at the Belladrum Music Festival with a stand allowing people to explore the science of underwater sound and a team of science buskers entertaining festivalgoers with science magic. A similar display was put on for the Argyllshire Gathering Games in Oban.

SAMS students – both undergraduates and ACES Master students – put on a marine science fun day as part of the Oban Winter Festival, attracting nearly 300 visitors with a programme of student performances. This was part of their science communication training.

Other events included a reading by Norrie Bissell and film showing exploring George Orwell's writing of '1984' on the Isle of Jura.

FINANCE

SAMS is an independent charity without a substantial grant in aid. Most income has to be won competitively year on year. While SAMS achieved an income of circa £10 million in the reporting year (excluding capital grants) the final year position reported an operational deficit of £632k. The Association made a deficit of £1.7 m in 14/15 which resulted in a restructuring programme to concentrate resources in areas of current science priority that are also areas of SAMS strength and by reducing overheads where possible. As a result of this restructuring the deficit for 15/16 was reduced from the preceding year's deficit to one of £632k (see table below). This was achieved through an overall reduction in operating expenditure of 10%.

Table 1: Summary of SAMS' financial performance in the period 1 April 2015 – 31 March 2016

Financial Summary	2015/16 £000	2014/15 £000	Change %
Operating Income excluding capital grants	10,078	9,908	1.7 %
Operating Expenditure excluding grant funded depreciation	(10,092)	(11,225)	-10.1 %
Operating (Deficit)/Surplus before exceptional Item	(14)	(1,317)	-98.9%
Exceptional in year income/exchange rate loss	(7)	572	
Pension Deficit Obligation	(8)	(608)	
Extraordinary Items	(118)	0	
Capital Grants received	348	636	-45.3%
Depreciation funded by grants received in previous years	(816)	(983)	-17.0%
(Deficit)/Surplus transferred to reserves	(615)	(1,698)	

The group accounts for 15/16 are the first set of accounts to be prepared under FRS 102 and the FRS 102 SORP, requiring that the charity accounts for its pension deficit obligation. The pension deficit obligation must be recognised from the date of transition to FRS 102 – 1st April 2014 and is therefore recorded in the summary above.

INCOME

Total income for the Group is reported at £10.078 m. As figure 1 illustrates, income is comprised of a four streams each contributing the following, Research £7.009 m, Education £1.028 m, Diving (including Recompression) £0.326 m and Commercial £1.715 m.

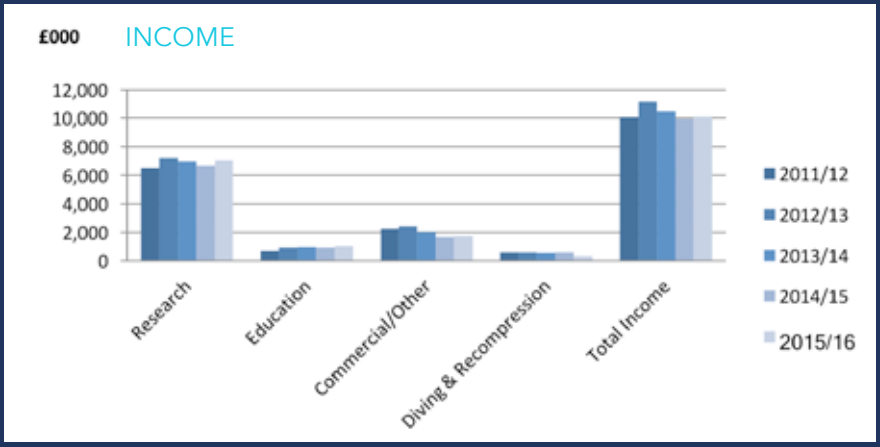


Figure 1: SAMS total income from research, education, commercial activities and diving over the past five years.

This year Research contributed 70% of total income and showed an increase of 5% over the prior year - see table 2 below for further detail . NERC continued to be our single largest research funder, contributing circa 46% of research income and 33% of total income.

Commercial activities contributed 17% (up 3% on prior year) and Education 10%, representing an increase of 8% against the prior year. Diving and recompression income dropped notably by 47% from £612k to £312k – this is due directly to changes in how the NHS pay for these services, as a central lump sum contract has now been issued to replace the individual trust holder sources – this has reduced the income that can be generated from this income funder.

Table 2: Summary of sources and amounts of research income for SAMS during the reporting year. For comparison 2013/14 figures are included as is the calculated % change.

Research income summary	2014/15 £000	2013/14 £000	Change %
NERC (including National Capability)	**3,298**	**2,949**	**12 %**
EU	**1,111**	**920**	**21 %**
***Other**	**1,980**	**1,726**	**15 %**
Research Excellence Grant	**833**	**1,080**	**-23 %**
Total research income	**7,221**	**6,675**	**8 %**

*Other Research income represents £290,000 of Government Commissions and £1,521,000 from sources such as Marine Alliance for Science and Technology for Scotland (MASTS), BBSRC, Norwegian Research Council, US Office of Naval Research and knowledge transfer initiatives through the Technology Strategy Board (TSB) and Genomia.

The Research Excellence Grant (REG) received through UHI helps fund the gap which arises from the fact that research income rarely provides full cost recovery for overheads. Typically this gap represents 20-35% of research infrastructure costs.

With our colleagues in UHI we performed very well in the 2014 assessment of research and anticipated an increase in our REG income of around £5 M over the period to REG 2021. The Scottish Government decided to phase REG settlement changes in over two years to protect universities who faced a significant reduction in income. This resulted in a 2015/16 REG return for SAMS of £800k, compared to the £1280k expected from the REF result. As this would have resulted in an £83k decrease for SAMS against 2014/15, UHI Executive Office undertook to maintain level funding at £883k for 2015/16.

EDUCATION

As an Academic Partner of the University of the Highlands and Islands, we deliver both undergraduate and postgraduate education. These activities now represent 10% of our total income, and demonstrate an increase of £78k over the prior year.

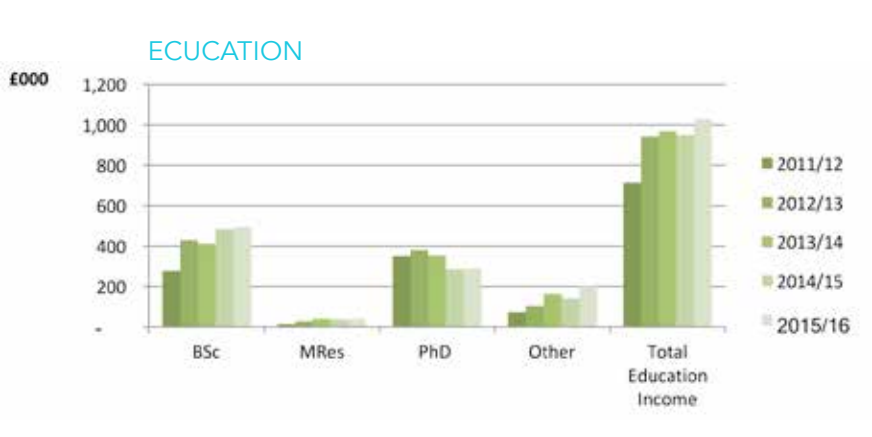


Figure 2: SAMS education income over the last five years.

Income from undergraduate courses has increased by 2% in 2015/16 and recruitment remains strong. In terms of PhD studentships, funding and recruitment remain challenging. Despite this, numbers remain relatively stable with the differences in the timing of new starts and reporting of income between research and education creating the fluctuations within years. These two areas still represent 70% of all education income.

Income from the Masters courses was increased with the successful EU ACES programme. Other education activities, such as field courses and short CPD courses continue to decrease as we re-focus on our main education programmes.

EXPENDITURE

62% of SAMS operation costs is staff costs. Total staff cost for the year being £6.739 m. This is a reduction of 6% from the prior year. As noted previously this was achieved primarily by a staff restructure exercise during this reporting year, resulting in a number of redundancies and retirements, staff numbers having reduced from 193 to 170.

Other operating costs decreased by 20% from £5.200m to £4.175 m, the majority of this saving being reduction in spend on scientific consumables of £1.023 m.

PUBLICATIONS
1 APRIL 2015 – 31 MARCH 2016

PEER-REVIEWED PUBLICATIONS

Adams, TP, Proud, R & **Black, KD,** 2015, 'Connected networks of sea lice populations: dynamics and implications for control' AQUACULTURE ENVIRONMENT INTERACTIONS, vol 6, no. 3, pp. 273-284.

Aleynik, D. Davidson, K., Dale A. C., Porter, M. (2016) A high resolution hydrodynamic model system suitable for novel harmful algal bloom modelling in areas of complex coastline and topography. Asimuth special issue. Harmful Algae, 10.1016/j.hal.2015.11.012

Atamanchuk, D, Tengberg, A, **Aleynik, D**, Fietzek, P, Shitashima, K, Lichtschlag, A, Hall, POJ & **Stahl, H**, 2015, 'Detection of CO_2 leakage from a simulated sub-seabed storage site using three different types of pCO(2) sensors' INTERNATIONAL JOURNAL OF GREENHOUSE GAS CONTROL, vol 38, pp. 121-134.

Benjamins, S, Dale, A, Hastie, G, Waggitt, J, Lea, M-A, Scott, BE & **Wilson, B**, 2015, 'Confusion reigns? A review of marine megafauna interactions with tidal-stream environments' OCEANOGRAPHY AND MARINE BIOLOGY, vol 53, 1, pp. 1-54.

Benjamins, S, Dale, A, van Geel, N & Wilson, B, 2016, 'Riding the tide: use of a moving tidal-stream habitat by harbour porpoise' MARINE ECOLOGY-PROGRESS SERIES, vol 549, pp. 275-288.

Berdalet, E, Fleming, L, Gowen, R, **Davidson, K**, Hess, P, Backer, L, Moore, S, Hoagland, P & Enevoldsen, H, 2015, 'Marine Harmful Algal Blooms, human health and wellbeing: challenges and opportunities in the 21st centuary' JOURNAL OF THE MARINE BIOLOGICAL ASSOCIATION OF THE UNITED KINGDOM, vol 96, no. s1, pp. 61-91.

Berge, J, Renaud, PE, Darnis, G, **Cottier, F, Last, K**, Gabrielsen, TM, Johnsen, G, Seuthe, L, Weslawski, JM, Leu, E, Moline, M, Nahrgang, J, Søreide, JE, Varpe, Ø, Lønne, OJ, Daase, M & Falk-Petersen, S, 2015, 'In the dark: A review of ecosystem processes during the Arctic polar night' PROGRESS IN OCEANOGRAPHY, vol 139, pp. 258-271.

Berge, J, Daase, M, Renaud, PE, Ambrose, WG, Darnis, G, **Last, KS**, Leu, E, Cohen, JH, Johnsen, G, Moline, MA & **Cottier, F** 2015, 'Unexpected Levels of Biological Activity during the Polar Night Offer New Perspectives on a Warming Arctic' CURRENT BIOLOGY, vol 25, no 19, pp. 2555-2561.

Blackford, J., Bull, HM, Cevatoglu, M, Connelly, D, Hauton, C, James, RH, Lichtschlag, A, **Stahl, H**, Widdicombe, S, Wright, IC, 2015, 'Marine

baseline and monitoring strategies for carbon dioxide capture and storage (CCS)' INTERNATIONAL JOURNAL OF GREENHOUSE GAS CONTROL, vol. 38, 221-229.

Bourrin, F, Many, G, Durrieu De Madron, X, Martin, J, Puig, P, **Houpert, L**, Testor, P, Kunesch, S, Mahiouz, K & Beguery, L, 2015, 'Glider monitoring of shelf suspended particle dynamics and transport during storm and flooding conditions' CONTINENTAL SHELF RESEARCH, vol 109, pp. 135-149.

Brito, A, Sa, C, Mendes, C, **Brand, T**, Dias, A, Brotas, V & **Davidson, K**, 2015, 'Structure of late summer phytoplankton community in the Firth of Lorn (Scotland) using microscopy and HPLC-CHEMTAX' ESTUARINE COASTAL AND SHELF SCIENCE, Part A, vol 167, pp. 86-101.

Brown, CJ, O'Connor, MI, Poloczanska, ES, Schoeman, DS, Buckley, LB, **Burrows, MT**, Duarte, CM, Halpern, BS, Pandolfi, JM, Parmesan, C & Richardson, AJ, 2016, 'Ecological and methodological drivers of species' distribution and phenology responses to climate change' GLOBAL CHANGE BIOLOGY, vol 22, pp. 1,548-1,560.

Bull, JW, Jobstvogt, N, Böhnke-Henrichs, A, Mascarenhas, A, Sitas, N, Baulcomb, C, Lambini, CK, Rawlins, M, Baral, H, Zähringer, J, Carter-Silk, E, Balzan, MV, **Kenter, JO**, Häyhä, T, Petz, K & Koss, R, 2016, 'Strengths, Weaknesses, Opportunities and Threats: A SWOT analysis of the ecosystem services framework.' ECOSYSTEM SERVICES, vol 17, pp. 99-111.

Burdett, HL, **Hatton, AD** & Kamenos, NA, 2015, 'Effects of reduced salinity on the photosynthetic characteristics and intracellular DMSP concentrations of the red coralline alga, *Lithothamnion glaciale*' MARINE BIOLOGY, vol 162, no. 5, pp. 1077-1085.

Childs, KH, Tessarolli, LP & **Day, JG,** 2015, 'Forty years in liquid nitrogen: an investigation into cryobank management and culture viability' EUROPEAN JOURNAL OF PHYCOLOGY, vol 50, s1, p. 180-

Cohen, JH, Berge, J, Moline, MA, Sorensen, AJ, **Last, K**, Falk-Petersen, S, Renaud, PE, Leu, ES, Grenvald, J, **Cottier, F**, Cronin, H, Menze, S, Norgren, P, Varpe, O, Daase, M, Darnis, G & Johnsen, G 2015, 'Is Ambient Light during the High Arctic Polar Night Sufficient to Act as a Visual Cue for Zooplankton?' PLOS ONE, vol 10, no. 6., 10.1371/journal.pone.0126247

Coll, M, Shannon, LJ, Kleisner, KM, Juan Jordá, MJ, Bundy, A, Akoglu, AG, Banaru, D, Boldt, JL, Maria F., B, Cook, A, Diallo, I, Fu, C, **Fox, C**, Gascuel, D, Gurney, L, Hattab, T, **Heymans, JJ**, Jouffre, D, Knight, B, Kucukavsar, S, Large, SI, Lynam, C, Machias, A, Marshall, KN, Masski, H, Ojaveer, H, Piroddi, C, Tam, J, Thiao, D, Thiaw, WM, Torres, MA, Travers-Trolet, M, Tsagarakis, K, Tuck, I, Van Der Meeren, GI, Yemane, D, Zador, S & Shin, Y-J, 2015, 'Ecological indicators to capture the effects of fishing on biodiversity and conservation status of marine ecosystems' ECOLOGICAL INDICATORS, vol 60, pp. 947-962.

Cottrell, RS, **Black, KD**, **Hutchison, ZL** & **Last, KS**, 2016, 'The Influence of Organic Material and Temperature on the Burial Tolerance of the Blue Mussel, *Mytilus edulis*: Considerations for the Management of Marine Aggregate Dredging' PLOS ONE, vol 11, no. 1, e0147534

Davidson, K, Baker, C, Higgins, C, Higman, W, **Swan, S, Veszelovszki, A** & Turner, AD 2015, 'Potential Threats Posed by New or Emerging Marine Biotoxins in UK Waters and Examination of Detection Methodologies Used for Their Control: Cyclic Imines' MARINE DRUGS, vol 13, no. 12, pp. 7087-7112.

Davies, JS, Stewart, HA, **Narayanaswamy, BE**, Jacobs, C, Spicer, J, Golding, N & Howell, KL, 2015, 'Benthic Assemblages of the Anton Dohrn Seamount (NE Atlantic): Defining Deep-Sea Biotopes to Support Habitat Mapping and Management Efforts with a Focus on Vulnerable Marine Ecosystems' PLOS ONE, vol 10, no. 5., e0124815.

Day, JG & Fleck, RA, 2015, 'Cryo-injury in algae and the implications this has to the conservation of biological resourc-

es' MICROALGAE BIOTECHNOLOGY, vol 1, pp. 1-11.

Dove, D, **Arosio, R**, Finlayson, A, Bradwell, T & **Howe, JA,** 2015, 'Submarine glacial landforms record Late Pleistocene ice-sheet dynamics, Inner Hebrides, Scotland' QUATERNARY SCIENCE REVIEWS, vol 123, pp. 76-90.

Du, K, **Strittmatter, M**, Vallet, M, Prado, S & **Gachon, CMM,** 2015, 'A new bioassay to inoculate kelp sporophytes with the ascomycete fungus *Paradendryphiella arenaria*' EUROPEAN JOURNAL OF PHYCOLOGY, vol 50, pp. 189-189.

Emami, K, Hack, E, Nelson, A, Brain, CM, Lyne, FM, Mesbahi, E, **Day, JG** & Caldwell, GS, 2015, 'Proteomic-based biotyping reveals hidden diversity within a microalgae culture collection: An example using *Dunaliella*.' SCIENTIFIC REPORTS, vol 5, 10036.

Emami, K, Nelson, A, Hack, E, Zhang, J, **Green, D**, Caldwell, GS & Mesbahi, E, 2016, 'MALDI-TOF mass spectrometry discriminates known species and marine environmental isolates of *Pseudoalteromonas*' FRONTIERS IN MICROBIOLOGY, vol 7, 172461.

Firth, LB, Mieszkowska, N, Grant, LM, Bush, LE, Davies, AJ, Frost, MT, Moschella, PS, **Burrows, MT**, Cunningham, PN, Dye, SR & Hawkins, SJ, 2015, 'Historical comparisons reveal multiple drivers of decadal change of an ecosystem engineer at the range edge' ECOLOGY AND EVOLUTION, vol 5, no. 15, pp. 3,210-3,222.

Firth, LB, White, FJ, Schofield, M, Hanley, ME, **Burrows, MT**, Thompson, RC, Skov, MW, Evans, AJ, Moore, PJ & Hawkins, SJ, 2015, 'Facing the future: the importance of substratum features for ecological engineering of artificial habitats in the rocky intertidal' MARINE AND FRESHWATER RESEARCH, vol 67, no. 1, pp. 131-143.

Fondo, EN, Chaloupka, M, **Heymans, JJ** & Skilleter, GA, 2015, 'Banning Fisheries Discards Abruptly Has a Negative Impact on the Population Dynamics of Charismatic Marine Megafauna' PLOS ONE, vol 10, no. 12, e0144543.

Gerphagnon, M, MacArthur, DJ, Latour, D, **Gachon, CMM**, Van Ogtrop, F, Gleason, FH & Sime-Ngando, T, 2015, 'Microbial players involved in the decline of filamentous and colonial cyanobacterial blooms with a focus on fungal parasitism' ENVIRONMENTAL MICROBIOLOGY, vol 17, no. 8, pp. 2,573-2,587.

Gowen, RJ, Collos, Y, **Tett, P**, Scherer, C, Bec, B, Abadie, E, Allen, M & O'Brien, T, 2015, 'Response of diatom and dinoflagellate lifeforms to reduced phosphorus loading: A case study in the Thau lagoon, France' ESTUARINE COASTAL AND SHELF SCIENCE, vol 162, pp. 45-52.

Graziano, M & Gillingham, K 2015, 'Spatial Patterns of Solar Photovoltaic System Adoption: The Influence of Neighbors and the Built Environment' JOURNAL OF ECONOMIC GEOGRAPHY, vol 15, no. 4, pp. 815-839.

Green, DH, Echavarri-Bravo, V, **Brennan, D** & **Hart, MC,** 2015, 'Bacterial Diversity Associated with the Coccolithophorid Algae *Emiliania huxleyi* and *Coccolithus pelagicus f. braarudii*' BIOMED RESEARCH INTERNATIONAL, vol 2015, article ID 1944549, 15 pages, http://dx.doi.org/10.1155/2015/194540

Hawkins, SJ, Mieszkowska, N, Firth, LB, Bohn, K, **Burrows, MT**, MacLean, MA, Thompson, RC, Chan, BKK, Little, C & Williams, GA, 2015, 'Looking backwards to look forwards: the role of natural history in temperate reef ecology' MARINE AND FRESHWATER RESEARCH, vol 67, no. 1, pp. 1-13.

Hendrick, VJ, Hutchison, ZL, Last, KS & Davies, A, (ed.) 2016, 'Sediment Burial Intolerance of Marine Macroinvertebrates' PLOS ONE, vol 11, no. 2, pp. e0149114.

Hicks, N, Stahl, H, Taylor, P, Vik, U, Jakobsen, K, Ladoukakis, E, Kolisis, F & Park, J, 2015, 'Reviews and synthesis: Carbon capture and storage monitoring – an integrated biological, biophysical and chemical approach' BIOGEOSCIENCES DISCUSSION, vol 12, pp. 8909-8937.

Hobday, AJ, Alexander, LV, Perkins, SE, Smale, DA, Straub, SC, Oliver, ECJ, Benthuysen, JA, **Burrows, MT**, Donat, MG, Feng, M, Holbrook, NJ, Moore, PJ, Scannell, HA, Sen Gupta, A & Wernberg, T 2016, 'A hierarchical approach to defining marine heatwaves' PROGRESS IN OCEANOGRAPHY, vol 141, pp. 227-238.

Holliday, NP, **Cunningham, SA, Johnson, C, Gary, SF, Griffiths, C**, Read, J & **Sherwin, T,** 2015, 'Multidecadal variability of potential temperature, salinity and transport in the eastern subpolar North Atlantic' JOURNAL OF GEOPHYSICAL RESEARCH-OCEANS, vol 120, no. 9, pp. 5945-5967.

Howe, JA, Anderton, R, **Arosio, R**, Dove, D, Bradwell, T, **Crump, P**, Cooper, R & Cocuccio, A, 2015, 'The seabed geomorphology and geological structure of the Firth of Lorn, western Scotland, UK, as revealed by multibeam echo-sounder survey' EARTH AND ENVIRONMENTAL SCIENCE TRANSACTIONS OF THE ROYAL SOCIETY OF EDINBURGH, vol 105, no. 4, pp. 273-284.

Howe, JA, Stevenson, A & Gatliff, R, 2015, 'Seabed Mapping for the 21st Century - The Marine Environmental Mapping Programme (MAREMAP): Preface' EARTH AND ENVIRONMENTAL SCIENCE TRANSACTIONS OF THE ROYAL SOCIETY OF EDINBURGH, vol 105, no. 4, pp. 239-240.

Hughes, D, Shimmield, T, Black, K & Howe, J, 2015, 'Ecological impacts of large-scale disposal of mining waste in the deep sea' SCIENTIFIC REPORTS, vol 5, Article no. 9985., 10.1038/srep09985

Hutchison, ZL, Hendrick, VJ, Burrows, MT, Wilson, B, Last, KS & Davies, A, (ed.) 2016, 'Buried Alive: The Behavioural Response of the Mussels, *Modiolus modiolus* and *Mytilus edulis* to Sudden Burial by Sediment' PLOS ONE, vol 11, no. 3, pp. e0151471.

Hwang, P, Elosegui, P & Wilkinson, J 2015, 'Small-scale deformation of an Arctic sea ice floe detected by GPS and satellite imagery' DEEP-SEA RESEARCH PART II-TOPICAL STUDIES IN OCEANOGRAPHY, vol 120, pp. 3-20.

Hyder, K, Rossberg, AG, Allen, JI, Austen, MC, Barciela, RM, Bannister, HJ, Blackwell, PG, Blanchard, JL, **Burrows, MT**, Defriez, E, Dorrington, T, Edwards, KP, Garcia-Carreras, B, Heath, MR, Hembury, DJ, **Heymans, JJ**, Holt, J, Houle, JE, Jennings, S, Mackinson, S, Malcolm, SJ, McPike, R, **Mee, L**, Mills, DK, Montgomery, C, Pearson, D, Pinnegar, JK, Pollicino, M, Popova, EE, Rae, L, Rogers, SI, Speirs, D, Spence, MA, Thorpe, R, Turner, RK, van der Molen, J, Yool, A & Paterson, DM 2015, 'Making modelling count - increasing the contribution of shelf-seas community and ecosystem models to policy development and management' MARINE POLICY, vol 61, pp. 291-302.

Inall, ME, Nilsen, F, **Cottier, FR** & Daae, R 2015, 'Shelf/fjord exchange driven by coastal-trapped waves in the Arctic' JOURNAL OF GEOPHYSICAL RESEARCH-OCEANS, vol 120, no. 12, pp. 8283-8303.

Jones, AC, Mead, A, Kaiser, MJ, Austen, MCV, Adrian, AW, Auchterlonie, NA, **Black, KD**, Blow, LR, Bury, C, Brown, JH, Burnell, GM, Connolly, E, Dingwall, A, Derrick, S, Eno, NC, Gautier, DJH, Green, KA, Gubbins, M, Hart, PR, Holmyard, JM, Immink, AJ, Jarrad, DL, Katoh, E, Langley, JCR, Lee, DOC, Le Vay, L, Leftwich, CP, Mitchell, M, Moore, A, Murray, AG, McLaren, EMR, Norbury, H, Parker, D, Parry, SO, Purchase, D, Rahman, A, Sanver, F, Siggs, M, Simpson, SD, Slaski, RJ, Smith, K, Syvret, MLQ, Tibbott, C, Thomas, PC, Turnbull, J, Whiteley, R, Whittles, M, Wilcockson, MJ, Wilson, J, Dicks, LV & Sutherland, WJ, 2015, 'Prioritization of knowledge needs for sustainable aquaculture: a national and global perspective' FISH AND FISHERIES, vol 16, no. 4, pp. 668-683.

Jones, L, Norton, L, Austin, Z, Browne, A, Donovan, D, Emmett, B, Grabowski, Z, Howard, D, Jones, J, **Kenter, J**, Manley, W, Morris, C, Robinson, D, Short, C, Siriwardena, G, Stevens, C, Storkey, J, Waters, R & Willis, G, 2016, 'Stocks and flows of natural and human-derived capital in ecosystem services' LAND USE POLICY, vol 52, pp. 151-162.

Kalantzi, I, Pergantis, SA, **Black, KD, Shimmield, TM,** Papageorgiou, N, Tsapakis, M & Karakassis, I, 2016, 'Metals in tissues of seabass and seabream reared in sites with oxic and anoxic substrata and risk assessment for consumers' FOOD CHEMISTRY, vol 194, pp. 659-670.

Kerrison, PD, Stanley, MS, Edwards, MD, **Black, KD** & **Hughes, AD**, 2015, 'The cultivation of European kelp for bioenergy: Site and species selection' BIOMASS & BIOENERGY, vol 80, pp. 229-242.

Kerrison, PD, Stanley, MS, Kelly, M, Macleod, A, Black, KD & Hughes, AD, 2015, 'Optimising the settlement and hatchery culture of *Saccharina latissima* (Phaeophyta) by manipulation of growth medium and substrate surface condition' JOURNAL OF APPLIED PHYCOLOGY, vol 28, no. 2, pp. 1181-1191.

Kim, YH, Ha, HK, Lee, SH, Kim, H-C, Lee, HJ, **Hwang, P** & Park, J-H, 2015, 'Entrainment induced by near-inertial drift of sea ice and its impact on under-ice biogeochemical processes in marginal ice zones' DEEP-SEA RESEARCH PART II-TOPICAL STUDIES IN OCEANOGRAPHY, vol 120, pp. 21-34.

Kita, J, **Stahl, H**, Hayashi, M, Green, T, Watanabe, Y, Widdicombe, S, 2015, 'Benthic megafauna and CO_2 bubble dynamics observed by underwater photography during a controlled sub-seabed release of CO_2' INTERNATIONAL JOURNAL OF GREENHOUSE GAS CONTROL, vol 38, pp. 202-209.

Kleisner, KM, Coll, M, Lynam, CP, Bundy, A, Shannon, L, Shin, Y, Boldt, JL, Maria F., B, Diallo, I, **Fox, C**, Gascuel, D, **Heymans, JJ**, Juan Jordá, MJ, Jouffre, D, Large, SI, Marshall, KN, Ojaveer, H, Piroddi, C, Tam, J, Angeles Torres, M, Travers-Trolet, M, Tsagarakis, K & Van Der Meeren, GI, 2015, 'Evaluating changes in marine communities that provide ecosystem services through comparative assessments of community indicators' ECOSYSTEM SERVICES, vol 16, pp. 413-429.

Lambelet, M, Van De Flierdt, T, **Crocket, K,** Rehkaemper, M, Kreissig, K, Coles, B, Rijkenberg, M, Gerringa, LJA, de Baar, HJW & Steinfeldt, R, 2016, 'Neodymium isotopic composition and concentration in the western North Atlantic Ocean: Results from the GEOTRACES GA02 section' GEOCHIMICA ET COSMOCHIMICA ACTA, vol 177, pp. 1-29.

Last, KS, Hobbs, L, Berge, J, Brierley, AS & **Cottier, F,** 2016, 'Moonlight Drives Ocean-Scale Mass Vertical Migration of Zooplankton during the Arctic Winter' Current biology : CB, vol 26, no. 2, pp. 244-251.

Lejzerowicz, F, Esling, P, Pillet, L, **Wilding, T, Black, KD** & Pawlowski, J, 2015, 'High-throughput sequencing and morphology perform equally well for benthic monitoring of marine ecosystems' SCIENTIFIC REPORTS, vol 5, Article no 13932, doi:10.1038/srep13932

Luckman, A, Benn, DI, **Cottier, F**, Bevan, S, Nilsen, F & **Inall, M**, 2015, 'Calving rates at tidewater glaciers vary strongly with ocean temperature' NATURE COMMUNICATIONS, vol 6, Article no 8566. Doi: 10.1038/ncomms9566, 7 pages.

Mabon, L, Shackley, S, Blackford, JC, **Stahl, H, Miller, A,** 2015, 'Local perceptions of the QICS experimental offshore CO2 release: Results from social science research' INTERNATIONAL JOURNAL OF GREENHOUS GAS CONTROL, vol. 38, pp. 18-25.

Macleod, AK, Stanley, MS, Day, JG & Cook, EJ, 2016, 'Biofouling community composition across a range of environmental conditions and geographical locations suitable for floating marine renewable energy generation' BIOFOULING, vol 32, no. 3, pp. 261-76.

McDonagh, EL, King, BA, Bryden, HL, Courtois, P, Szuts, Z, Baringer, M, **Cunningham, SA**, Atkinson, C & McCarthy, G, 2015, 'Continuous Estimate of Atlantic Oceanic Freshwater Flux at 26.5° N' JOURNAL OF CLIMATE, vol 28, no. 22, pp. 8888-8906.

Marzocchi, A., J. Hirschi, J.-M, N. P. Holliday, **S. A. Cunningham**, A. T. Blaker, and A. C. Coward (2015), The North Atlantic subpolar circulation in an eddy-resolving

global ocean model, Journal of Marine Systems, 142, 126-143, doi:doi:10.1016/j.jmarsys.2014.10.007.

Molinos, JG, Halpern, BS, Schoeman, DS, Brown, CJ, Kiessling, W, Moore, PJ, Pandolfi, JM, Poloczanska, ES, Richardson, AJ & **Burrows, MT**, 2016, 'Climate velocity and the future global redistribution of marine biodiversity' NATURE CLIMATE CHANGE, vol 6, pp. 83-88.

Mori, C, Sato, T, Kano, Y, Oyama, H, **Aleynik, D**, Tsumune, D & Maeda, Y, 2015, 'Numerical study of the fate of CO_2 purposefully injected into the sediment and seeping from seafloor in Ardmucknish Bay' INTERNATIONAL JOURNAL OF GREENHOUSE GAS CONTROL, vol 38, pp. 153-161.

Moschonas, G, Gowen, RJ, Stewart, BM & **Davidson, K**, 2015, 'Nitrogen dynamics in the Irish Sea and adjacent shelf waters: An exploration of dissolved organic nitrogen' ESTUARINE COASTAL AND SHELF SCIENCE, vol 164, pp. 276-287.

Ojaveer, H, Galil, BS, Campbell, ML, Carlton, JT, Canning-Clode, J, **Cook, EJ**, Davidson, AD, Hewitt, CL, Jelmert, A, Marchini, A, McKenzie, CH, Minchin, D, Occhipinti-Ambrogi, A, Olenin, S, Ruiz, G, 2015, 'Classification of Non-Indigenous Species Based on Their Impacts: Considerations for Application in Marine Management' PLOS BIOLOGY, vol 13, no. 4, pp. e1002130.

Pratt, N, Ciotti, BJ, Morgan, EA, **Taylor, P, Stahl, H**, Hauton, C, 2015, 'No evidence for impacts to the molecular ecophysiology of ion or CO_2 regulation in tissues of selected surface-dwelling bivalves in the vicinity of a sub-seabed CO_2 release' INTERNATIONAL JOURNAL OF GREENHOUSE GAS CONTROL, vol 38, pp. 193-201.

Purves, K, Macintyre, L, **Brennan, D**, Hreggviðsson, G, Kuttner, E, Ásgeirsdóttir, M, Young, L, **Green, DH**, Edrada-Ebel, R & **Duncan, KR**, 2016, 'Using Molecular Networking for Microbial Secondary Metabolite Bioprospecting' METABOLITES, vol 6, no. 1, 10.3390/metabo6010002

Queiros, AM, **Taylor, P**, Cowles, A, Reynolds, A, Widdicombe, S, **Stahl, H**, 2015, 'Optical assessment of impact and recovery of sedimentary pH profiles in ocean acidification and carbon capture and storage research' INTERNATIONAL JOURNAL OF GREENHOUSE GAS CONTROL, vol 38, pp. 110-120.

Rad Menendez, C, Stanley, M, Green, DH, Cox, E & **Day, JG**, 2015, 'Exploring cryptic diversity in publicly available strains of the model diatom *Thalassiosira pseudonana* (Bacillariophyceae)' JOURNAL OF THE MARINE BIOLOGICAL ASSOCIATION OF THE UNITED KINGDOM, vol 95, no. 6, pp. 1081-1090.

Rad-Menendez, C, Gerphagnon, M, Sime-Ngando, T & **Gachon, CMM**, 2015, 'Some asterionella are more equal than others: diary of a chytrid-diatom pairing' EUROPEAN JOURNAL OF PHYCOLOGY, vol 50, no. s1, 4PO.8, pp. 148-148.

Schiener, P, Atack, T, Wareing, R, **Kelly, MS & Hughes, AD**, 2015, 'The by-products from marine biofuels as a feed source for the aquaculture industry: a novel example of the biorefinery approach' BIOMASS CONVERSION AND BIOREFINERY, Vol 6, no 3, pp 281-287

Scott, E, **Serpetti, N**, Steenbeek, J & **Heymans, JJ**, 2016, 'A stepwise Fitting Procedure for automated fitting of Ecopath with Ecosim models' SOFTWAREX, 10.1016/j.softx.2016.02.002

Sellami, N, Dewar, M, **Stahl, H**, Chen, B, 2015, 'Dynamics of rising CO_2 bubble plumes in the QICS field experiment, Part 1 – the experiment' INTERNATIONAL JOURNAL OF GREENHOUSE GAS CONTROL, vol 38, pp. 44-51.

Sherwin, TJ, Aleynik, D, Dumont, E & Inall, ME, 2015, 'Deep drivers of mesoscale circulation in the central Rockall Trough' OCEAN SCIENCE, vol 11, no. 3, pp. 343-359.

Sime-Ngando, T, Gerphagnon, M, Colombet, J, **Gachon, CMM** & Latour, D, 2015, 'Effects of fungal parasitism on freshwater cyanobacterial blooms' EUROPEAN JOURNAL OF PHYCOLOGY, vol 50, no. 1, 4or.7, pp. 47-48.

Slocombe, SP, Zhang, Q, Ross, M, Anderson, A, Thomas, NJ, Lapresa, A, **Rad-Menendez, C, Campbell, CN, Black, KD, Stanley, MS & Day, JG**, 2015, 'Unlocking nature's treasure-chest: screening for oleaginous algae' SCIENTIFIC REPORTS, vol 5, Article no. 9844.

Smale, DA, **Burrows, MT**, Evans, AJ, King, N, **Sayer, MDJ**, Yunnie, ALE & Moore, PJ, 2016, 'Linking environmental variables with regional-scale variability in ecological structure and standing stock of carbon within UK kelp forests' MARINE ECOLOGY-PROGRESS SERIES, vol 542, pp. 79-95.

Stahl, H, Miller, A, 2015, 'Obituary for Professor Laurence David Mee' INTERNATIONAL JOURNAL OF GREENHOUSE GAS CONTROL, vol 38, pp 2.

Sterk, HAM, Steeneveld, GJ, Vihma, T, **Anderson, PS**, Bosveld, FC & Holtslag, AAM, 2015, 'Clear-sky stable boundary layers with low winds over snow-covered surfaces. Part 1: WRF model evaluation' QUARTERLY JOURNAL OF THE ROYAL METEOROLOGICAL SOCIETY, vol 141, no. 691, pp. 2165-2184.

Strittmatter, M, Gachon, CMM, Mueller, DG, Tsirigoti, A, Wawra, S, Beckmann, M, Katsaros, C, van West, P & Küpper, FC, 2015, 'Disease resistance in brown algae: mechanisms and heritability' EUROPEAN JOURNAL OF PHYCOLOGY, vol 50, no. 10, pp. 48-49.

Strittmatter, M, Grenville-Briggs, L, Beithut, L, van West, P, **Gachon, CMM** & Küpper, FC, 2015, 'Infection of the brown alga *Ectocarpus siliculosus* by the oomycete *Eurychasma dicksonii* induces oxidative stress and halogen metabolism' PLANT CELL AND ENVIRONMENT, vol 39, no. 2, pp. 259-271.

Struve, T, Van De Flierdt, T, Robinson, LF, Bradtmiller, LI, K. Hines, S, Adkins, JF, Lambelet, M, **Crocket, K**, Kreissig, K, Coles, B & Auro, M, 2016, 'Neodymium isotope analyses after combined extraction of actinide and lanthanide elements from seawater and deep-sea coral aragonite' GEOCHEMISTRY GEOPHYSICS GEOSYSTEMS, vol 17, no. 1, pp. 232-240.

Tail, K, **Stahl, H, Taylor, P**, Widdicombe, S, 2015, 'Rapid response of the active microbial community to CO2 exposure from a controlled sub-seabed CO_2 leak in Ardmucknish Bay (Oban, Scotland)' INTERNATIONAL JOURNAL OF GREENHOUSE GAS CONTROL, vol 38, pp. 171-181.

Taylor, P, Stahl, H, Vardy, ME, Bull, JM, Akhurst, M, Hauton, C, James, RH, Lichtschlag, A, Long, D, **Aleynik, D, Toberman, M**, Naylor, M, Connelly, D, Smith, D, **Sayer, MDJ**, Widdicombe, S, Wright, IC & Blackford, J 2015, 'A novel sub-seabed CO_2 release experiment informing monitoring and impact assessment for geological carbon storage,' INTERNATIONAL JOURNAL OF GREENHOUSE GAS CONTROL, vol 38, pp. 3-17.

Taylor, P, Lichtschlag, A, **Toberman, M, Sayer, MDJ**, Reynolds, A, Sato, T & **Stahl, H**, 2015, 'Impact and recovery of pH in marine sediments subject to a temporary carbon dioxide leak' INTERNATIONAL JOURNAL OF GREENHOUSE GAS CONTROL, vol 38, pp. 93-101.

Tierney, KM, Muir, GKP, Cook, GT, MacKinnon, G, **Howe, JA, Heymans, JJ** & Xu, S, 2016, 'Accumulation of Sellafield-derived radiocarbon (C-14) in Irish Sea and West of Scotland intertidal shells and sediments' JOURNAL OF ENVIORNMENTAL RADIOACTIVITY, vol 151, no. 1, pp. 321-327.

Tsirigoti, A, Beakes, GW, Herve, C, **Gachon, CMM** & Katsaros, C 2015, 'Attachment, penetration and early host defense mechanisms during the infection of filamentous brown algae by *Eurychasma dicksonii*' PROTOPLASMA, vol 252, no. 3, pp. 845-856.

Tsirigoti, A, Katsaros, C & **Gachon, CMM**, 2015, 'Cell wall modifications and cell regeneration in brown algae resisting infection by the oomycete pathogen *Eurychasma dicksonii*' pp. 148-148.

Tsukasaki, A, Suzumura, M, Lichtschlag, A, **Stahl, H,** James, RH, 2015, 'Phosphorus behavior in sediments during a sub-seabed CO2 controlled release experiment' INTERNATIONAL

JOURNAL OF GREENHOUSE GAS CONTROL, vol, 38, pp. 102-109.

Turnewitsch, R, Lahajnar, N, Haeckel, M & Christiansen, B, 2015, 'An abyssal hill fractionates organic and inorganic matter in deep-sea surface sediments' GEOPHYSICAL RESEARCH LETTERS, vol 42, no. 18, pp. 7663-7672.

Vallet, M, Du, K, **Strittmatter, M**, Dupont, J & **Gachon, CMM**, 2015, 'Biodiversity, secondary metabolome and ecological role of fungal endophytes associated with the brown algae *Laminaria digitata*, *Ascophyllum nodosum*, *Saccharina latissima* and *Pelvetia canaliculata*' EUROPEAN JOURNAL OF PHYCOLOGY, vol 50, pp. 116-116.

van Leeuwen, S, **Tett, P**, Mills, D & van der Molen, J, 2015, 'Stratified and nonstratified areas in the North Sea: Long-term variability and biological and policy implications' JOURNAL OF GEOPHYSICAL RESEARCH-OCEANS, vol 120, no. 7, pp. 4670-4686.

Watanabe, Y, Tait, K, Gregory, S, Hayashi, M, Shimamoto, A, **Taylor, P, Stahl, H**, Green, K, Yoshingaga, I, Suwa, Y, Kita, J, 2015, 'Response of the ammonia oxidation activity of microorganisms in surface sediment to a controlled sub-seabed release of CO_2' INTERNATIONAL JOURNAL OF GREENHOUSE GAS CONTROL, vol, 38, pp. 162-170.

Wilson, B, 2016, 'Might marine protected areas for mobile megafauna suit their proponents more than the animals?: MPAs for magefauna or people?' AQUATIC CONSERVATION-MARINE AND FRESHWATER ECOSYSTEMS, vol 26, no. 1, pp. 3-8.

Wilson, CM & **Sayer, MDJ**, 2015, 'Cerebral arterial gas embolism in a professional diver with a persistent foramen ovale' DIVING AND HYPERBARIC MEDICINE, vol 45, no. 2, pp. 124-126.

REPORTS

Albalat, A, McAdam, B & **Fox, C**, 2015, Post-catch survivability of discarded under-sized Norway lobsters (*Nephrops norvegicus*): Towards a regional and ecosystems-based approach. Fisheries Innovation Scotland commissioned report.

Baker, E, Lamarche, G, Gaill, F, **Narayanaswamy, B**, Parr, J, Raharimananirina, C, Santos, RS, Sharma, R & Tuhumwire, J, 2016, 'Offshore mining industries'. Chapter 23 in: First Global Marine Assessment. 1 edn, vol. 1, Oceans and Law of the Sea, United Nations, Brussels, pp. 1-34.

Black, K., Dale, A., Fox, C., Forster, I., **Howe, J., Narayanaswamy, B., Risch, D**.(2015) A Review of Noble Energy Falklands Limited Rhea-1 Exploration Well Environmental Impact Statement V 2.0, 7th May 2015 Document No : 024-15-EHSR-EIS-PA-T4, for Falkland Islands Government, pp. 16

Fox, C, Veszelovszki, A & Valcic, L, 2015, A pilot study to define the footprint and activities of Scottish inshore fisheries by identifying target fisheries, habitats and associated fish stocks. 193 p

Ingels, J, Clark, M, Vecchione, M, Perez, JAA, Levin, LA, Priede, IG, Sutton, TT, Rowden, A, Smith, CR, Yasuhara, M, Sweetman, A, Soltwedel, T, Santos, RS, **Narayanaswamy, B**, Ruhl, HA, Fujikura, K, Amaral-Zettler, L, Jones, D, Gates, A, Snelgrove, PVR, Bernal, P & van Gaever, S, 2016, 'Open Ocean Deep Sea'. In First Global Marine Assessment. 1 edn, vol. 1, Oceans and Law of the Sea, United Nations, Brussels, pp. 1-37.

Little, A, Bailey, N, Cook, R, **Fox, C**, Curtis, H, Heath, M, Marshall, T, Mouat, B & Fernandes, P, 2015, A review of Scotland's capture fisheries: stock status, knowledge gaps, research requirements and stakeholder engagement. Fisheries Innovation Scotland.

Miller, R & Macleod, A 2016, Marine Growth Mapping and Monitoring: Feasibility of Predictive Mapping of Marine Growth. Offshore Renewable Energy Catapult, Glasgow.

BOOKS

Baztan, J, Chouinard, O, Jorgensen, B, **Tett, P**, Vanderlinden, J-P & Vasseur, L (eds), 2015, Coastal Zones: Solutions for the 21st Century. Elsevier, Amsterdam.

BOOK CHAPTERS

Jickells, TD, Andrews, J, Barnard, S, **Tett, P** & van Leeuwen, S 2015, 'Natural Sciences Modelling in Coastal and Shelf Seas'. In RK Turner & M Schaafsma (eds), Coastal zones ecosystem services: From science to values and decision making. vol. 9, Springer, pp. 41-58.

Kelly, M, **Carboni, S, Cook, E & Hughes, A**, 2015, 'Sea Urchin Aquaculture in Scotland'. In Echinoderm Aquaculture., ch9, Wiley-Blackwell., 10.1002/9781119005810.ch9

Kenter, JO, 2015, 'Deliberative and Non-Monetary Valuation: Routledge Handbook of Ecosystem Services'. In: M Potschin, R Haines-Young, R Fish & RK Turner (eds), Routledge Handbook of Ecosystem Services. Routledge Press, New York.

Tett, P & **Mee, L**, 2015, 'Scenarios explored with Delphi'. In RK Turner & M Schaafsma (eds), 'Coastal zones ecosystem services: From science to values and decision making. Studies in Ecological Economics', no. 1389-6954, vol. 9, Springer, pp. 127-144.

Jickells, T., J. Andrews, S. Barnard, **P. Tett** and S. v. Leeuwen (2015). Natural Sciences Modelling in Coastal and Shelf Seas. Chapter 3 in Coastal zones ecosystem services: From science to values and decision making. R. K. Turner and M. Schaafsma, eds., Springer. pp 41-58.

Tett, P, Black, K, Brennan, R, Cook, E & Davidson, K, 2015, 'Sustainable Mariculture at High Latitudes'. In: Coastal Zones: Solutions for the 21st Century. Chapter 5, Elsevier, pp. 71-84.

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