



**ANNUAL
REPORT
2013-14**

FRONT COVER: The South Shian tern rafts in July 2013. SAMS Fellow Dr Clive Craik won RSPB Species Champion of the Year 2013 (pXX)

Photo: Nicholas Watts

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Our main partners



ABOUT US

The Scottish Association for Marine Science (SAMS) is an independent, not-for-profit, marine research institute based near Oban on the west coast of Scotland.

Founded in 1884, SAMS is Scotland's oldest oceanographic institution. It is a learned society with about 300 members and membership is open to all who share an interest in marine science.

SAMS' mission is to deliver world-class marine science that supports society with innovative solutions for developing a sustainable relationship with the marine environment. SAMS delivers this mission through research, education, services to business, public engagement and learned society activities.

The organisation maintains four strategic partnerships: it is a founding partner of the University of the Highlands and Islands (UHI); a delivery partner of the Natural Environment Research Council (NERC); the only marine research organisation in the world to be an associated institute of the United Nations University (UNU); and a member of the Marine Alliance for Science and Technology for Scotland (MASTS).

SAMS runs the Scottish Marine Institute at Dunstaffnage, three miles north east of Oban, where it employs more than 160 people. It is a registered charity (SC009206) and a Company Limited by Guarantee (SC009292).

Services to business are delivered through SAMS Research Services Ltd (SRSL), a wholly owned commercial subsidiary company (SC224404). SAMS also operates a business incubator known as the European Centre for Marine Biotechnology (SC205318) that hosts tenant companies.

The Association is governed by an independent, non-executive Council elected by SAMS' members at the Annual General Meeting. Council is supported by the Board of Council and a number of committees: research, education, finance, communications, and audit. Board and committees are made up from Council members and executive staff. The audit committee also includes independent members. SAMS business is conducted in accordance with the Articles and the Memorandum of Association.

SAMS Council members are the non-executive directors of the company and trustees of the charity.

SAMS Council members on 31 March 2014 were:

President Professor Geoffrey Boulton

Chairman of Board Michael Gibson

Council (Board of Directors)

Professor Mary Bownes
Professor Peter Burkill
Stuart Cannon
Professor Robert Ferrier
Professor Lora Fleming
Gordon McAllister
Professor David Paterson
Dr Carol Phillips
Professor Monty Priede
Commodore Angus Ross
Ken Rundle
Michael Wilkins

External members of Audit Committee

Dr Keith Duff
Marilyn Jeffcoat
Mr Paul Brennan

Director Professor Laurence Mee (deceased August 13, 2014)



Company Secretary

Elaine Walton

Vice Presidents

Professor Sir John Arbuthnott
Professor Sir Frederick Holliday
Dr John H Steele
Professor Stephen A Thorpe
Professor Andrew Hamnett
Sir David Smith (deceased November 2013)

An aerial photograph of a coastal town and harbor. The town is built on a peninsula with a mix of green fields, white buildings, and a large forest. A harbor with several sailboats is in the foreground. In the background, a large body of water stretches to a range of mountains under a clear sky.

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An eventful year

Welcome to our centenary annual report! I trust that this account demonstrates clearly how SAMS continues to thrive, despite highly challenging internal and external operating environments. We achieve this through diversification, reinvention and our determination to excel across a broad portfolio of marine science and education activities.

The reporting year, 2013-14, was characterized by several major changes. The greatest was undoubtedly the unexpected death of our Director, Professor Laurence Mee (aged 63), on 13th August 2014: strictly speaking outside the reporting period but simply too cataclysmic to exclude here. This leaves a painful gap at the heart of our organisation that will take some time to heal.

We lost a further two highly valued members of staff during a second difficult year for SAMS. First was the 'effervescent' Janet Duncan, who died from a tumour on 5th June 2013. Janet began her career

at the Association in 1969, just after the relocation from Millport to SAMS. She was first a scientific assistant in ecology, then moved with Tom Pearson and John Blackstock into commercial work for SEAS Ltd, before returning to SAMS in various functions; latterly as Recompression Chamber Supervisor at the National Facility for Scientific Diving.

Just 10 months later, our accomplished Aquarium Manager, John Kershaw, died of a heart attack (6th April 2014). John was just 51 years old, and had been a member of SAMS since December 2006. He envisioned and oversaw the transformation of the Alan Ansell aquarium into a highly technical research and teaching facility.

The cumulative effect of these deaths must not be understated. SAMS continues to mourn its other recently lost colleagues: polar oceanographer Dr Tim Boyd and research student Christopher Bell. But, what unites the SAMS family is

our love for the sea and our commitment to excellence: whether that is manifest in marine research, education, innovation, public engagement, or our dedicated infrastructure services. And, across these areas we have celebrated some notable achievements over the year.

Our scientific outputs for the reporting period amount to 152 publications, across the breadth of our research, with many in high impact journals. Prof Mike Burrows was first author on a paper in Nature, that suggests a novel way of identifying habitats and species that are particularly vulnerable due to shifting climatic conditions.

Professor Mike Meredith, who divided his time between the British Antarctic Survey and SAMS during the reporting year, co-authored a truly exceptional five publications in Nature/Nature Geoscience in the field of polar oceanography.

Our core values

Relevant
Cost-effective
Fun
Entrepreneurial
Inclusive
Dedicated
Ambitious
Caring
Innovative
High-quality
Purposeful
Exciting
and

In collaboration with colleagues across the University of the Highlands & Islands (UHI) we attracted major EU FP7 funding for the MERIKA project. This has allowed the recruitment of several new staff to form a marine social science research group, filling a long-identified, strategically important niche for SAMS.

An exciting new development has been our closer collaboration with the University of Edinburgh: SAMS became an Associate Institute of Edinburgh University and joined the Edinburgh Earth and Environment Doctoral Training Partnership. The first cohort of these NERC-funded PhD students have already begun their research training at SAMS. Also, on the education front, we passed the landmark of 100 students on campus; celebrated the achievement of 22 students graduating with Bachelor, Masters and PhD degrees; and we are working at expanding our postgraduate training provision in the coming year.

In November our honorary research fellow, Dr Clive Craik, won the coveted RSPB Nature of Scotland Species Champion of the Year award for his work to save tern colonies off the west coast of Scotland. This is a well-deserved

accolade following decades of commitment to seabird conservation come rain come shine.

UHI recognized the research excellence of three SAMS scientists - Bill Austin, David Meldrum and Stuart Cunningham - with the award of professorships. The pan-European ASIMUTH project, led at SAMS by Prof Keith Davidson, produced the forecast system to warn of impending harmful algal blooms that won 'the year's most beneficial Earth-monitoring service for European citizens', showcasing the societal benefits of some of our work.

SAMS benefits from an amazing location and world-class infrastructure. In the last year we have been fortunate to be able to expand our facilities further with our North Atlantic Glider Base, now home to a fleet of seven autonomous ocean-going gliders.

We were also in a position to procure a new remotely operated vehicle in support of our ecological research; and engineered a tank-based seaweed cultivation facility, complementary to our sea-based farm in the Sound of Kerrera.

In a bold and exciting move to widen the societal reach of our science, we opened the 'Ocean

Explorer Centre' as a dedicated outreach and visitor facility. This demonstrates our commitment to the grand goal of an 'ocean-literate' society for the 21st century, and is connected into the key European organisations promoting it.

Looking ahead, we shall continue to face our challenges with enthusiasm, focus and commitment. We recognise that our collective ability to thrive through such a sustained period of tragedy has its core in our institutional culture of support and compassion; and we shall preserve what makes SAMS a truly special place to pursue our scientific, educational and societal objectives.

Professor Axel Miller,
Acting Director



Obituary

Professor Laurence David Mee FRSC

Born: Ipswich, 14th February 1951. Died: Inverness, 13th August 2014.

A chemical oceanographer with expert negotiation experience and a multidisciplinary approach to environmental management, Laurence Mee was an environmentalist and educator deeply concerned with the destructive and unsustainable use of natural marine ecosystems by society. He searched for a new knowledge base that takes a more holistic approach to marine conservation. As a person he oozed enthusiasm, positivity and joie de vivre; he loved talking with people and was a passionate sailor, diver, kayaker and swimmer. An outstanding communicator, Laurence was an 'ideas person' who focused on the big picture. He was also an immensely proud father of four children.

Laurence's life and career were illustrious. He was born, a single child, in England and began his scientific career at the University of Liverpool. After he graduated in 1974 with a first degree in chemical oceanography, he embarked on his PhD research, investigating the chemistry and hydrography of Mexican lagoons, under the direction of Mohamed Abdullah and Professor John Riley (the father of modern chemical oceanography). His first research post after obtaining his PhD in 1977 was at the National Autonomous University of Mexico. For ten years he stayed in Mexico, initially at a field station in Mazatlán and later in Mexico City, working as a researcher and senior lecturer at the Instituto de Ciencias del Mar y Limnología. During this period Laurence was involved with the designing of the oceanographic research vessel El Puma.

In 1987 Laurence moved with his family from Mexico to Monaco when he was appointed as Head of Marine Environmental Studies at the International Atomic Energy Agency laboratory. For the next 11 years he was employed as a senior UN official in posts that took him to more than 35 countries.

From 1993 to 1998 Laurence led environmental management initiatives in the Black Sea region as coordinator of the UN's Global Environment Facility Black Sea Environment Programme, living in Istanbul, Turkey. In 1998, the 'Year of the Oceans', he was appointed as a Pew Fellow in Marine Conservation and used his fellowship to address marine degradation in the Black Sea region: developing accessible publications about how to improve the status of the Black Sea and organising workshops for environmental educators. This started a growing involvement in environmental education, which he considered a critical tool to influence human behaviour towards more sustainable values and practices.

In 1998 Laurence returned to the UK where he spent the next decade working mostly in Plymouth. The first two years he combined working as a visiting Professor at Plymouth University's Environmental Research Centre with a role as Senior Consultant at the Dutch International Centre for Water Studies Ltd. During this time he founded and led the MSc/MRes pathway in Coastal and Ocean Policy. From 2000 to 2008 Laurence was Professor of Marine and Coastal Policy at the University of Plymouth and in 2005 became the first Director of the newly formed Marine Institute at the University. Laurence built the reputation of the Marine Institute through his ability to unite interdisciplinary scientific groups. In 2007 he was a Special Advisor to the House of Commons Select Committee on Science and Technology Inquiry on Investigating the Oceans. His work with MPs and government officials contributed to bringing the Marine Bill to the Statute Book.

In 2008 he embarked on his final position, as Director of the Scottish Association for Marine Science. Under his directorship, SAMS significantly expanded its social science portfolio as well as its education provision: the Sheina Marshall Building is a physical legacy of his leadership in this area. Laurence also played an important role in the formation of the University of the Highlands and Islands within which SAMS continues to support the growth of research excellence.

Laurence was an expert at building research consortia and consequently worked with scores of outstanding marine scientists and decision makers. He was an important intellectual force working towards unification of socio-ecological systems for the marine environment. Scientifically he may be best known for his research papers identifying the ecological crises in the Black Sea and the Caspian Sea. He led several large European research projects, such as the €2.5 M 'European Lifestyle and Marine Ecosystems (ELME)' and more recently the €5.7 M EU-funded project on 'Knowledge-based Management of Europe's Seas (KNOWSEAS)'.

Laurence Mee died in service for SAMS while away on one of his many business trips. He was meeting the new University of the Highlands and Islands Principal, Professor Clive Mulholland, to discuss the future direction of the University and the role of research and SAMS therein.

Shortly after Laurence's death, we set up an online memorial site to allow his many friends, colleagues and family members across the world to share their grief and memories and we continue to encourage contributions to be added; allowing us to celebrate Laurence's outstanding life and big personality.

<http://laurence-mee.tumblr.com>.

Dr Anuschka Miller,
Head of Communications





OUR RESEARCH



Ecology

DR BHAVANI NARAYANASWAMY

Uncovering secrets of deep sea riches

Underwater mountains, or seamounts, are features that occur in all the world's oceans. It is thought that there may be tens of thousands, or even more, of these features that stand more than 1000m in height, from the seabed. They are often home to many species of coral and sponges, which in turn can harbour a great diversity of other species.

The deep-sea group has been focussing its research on seamounts in a number of different regions and has been funded through two NERC projects, "TopoDEEP" and "SWIOR".

We have concentrated mainly on the so called macrofauna—animals that are larger than 0.25mm in size. These fauna generally live in the sediment under the coral

framework structures, or in among the structure of the framework. Very little work has been done looking at the animals that actually reside within the coral and carbonate structure itself.

After collecting the coral and carbonate structures from the seamount, the material is placed in a weak acid in order to dissolve the carbonate. As the coral/carbonate dissolves, the fauna inhabiting the coral become visible and can therefore be removed and identified.

The carbonate material, especially from Ampere seamount in the Northeast Atlantic, had a surprising number of individuals living in association with it. In general there were numerous polychaete (bristle) worms, dominated by just a few

families. One species of worm appears to have modified its final few segments to allow it to burrow more readily into the coral/carbonate material.

This work highlights the potential abundance and species richness in this overlooked habitat. In the South West Indian Ocean seamounts, the number of polychaete individuals found per kilogramme of coral/carbonate material varies across the ridge, in a South to North direction, from ~30/kg to ~125/kg.

This pattern is also reflected in the polychaete biomass and the number of families found, with the highest richness appearing at the most northerly seamount investigated.

Polychaete worms extracted from carbonate material on Ampere Seamount, NE Atlantic. The tail of the worms appears to be modified and is flattened possibly to aid in boring into the carbonate material.



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Chivers AJ, Narayanaswamy BE, Lamont PA, Dale A & Turnewitsch R. (2013). Changes in polychaete standing stock and diversity on the northern side of Senghor Seamount (NE Atlantic). *Biogeosciences*, 10:

3535-3546. doi:10.5194/bg-10-3535-2013.

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RESEARCH STUDENTS

Adam Chivers (PhD): The Biodiversity and Ecology of Seamounts in the NE Atlantic. Funded by NERC & MASTS. University of the Highlands and Islands. 2010-2014

Marta Segura Aliaga (Visiting PhD): A comparative study of the macrofaunal assemblages of two contrasting Atlanto-Mediterranean deep-sea environments: Blanes Canyon and the Ampère Seamount. University of Barcelona. March-May 2014. (Visit funded through ASSEMBLE)

Alexander Schweizer (MRes): Macrobenthic community structure and diversity in the Rockall Trough: A 30 year time-series study. SAMS & St Andrews University. May-August 2013

Tom Rea (Undergraduate placement): Extraction of endo-cryolithic fauna through dissolution of coral carbonate samples in acetic acid. Funded by ERASMUS, Galway Mayo Institute of Technology. 2013 (completed)



Ecology

DR JASPER KENTER

Living the science: Feeling the benefits of coastal beauty and sea swimming at lunch

I was appointed at SAMS as Principal Investigator in Ecological Economics, after having worked at the University of Aberdeen as manager of the shared and cultural values component of the UK National Ecosystem Assessment follow on phase.

I have a broad research interest covering the way that environments benefit human well-being, and valuing the environment both in money-based terms and in terms of our health, emotional, cultural and spiritual connections.

I am also very interested in the processes people go through when they talk to each other about the environment ('deliberation'). Thus besides economics my work crosses over into fields like psychology, ethics, conservation and sustainable development.

At SAMS I will increasingly focus on marine renewable energy and marine spatial planning, considering how all these different types of values can be brought together in decision-making.

Our growing social science team includes a broad base of expertise including human geography and stakeholder engagement (Karen Alexander), economic geography and macro-economics (Marcello Graziano), social ecology and qualitative methods (Ruth Brennan), marine spatial planning and marine renewables policy and management (Lucy Greenhill and Suzi Billing) and social-ecological systems modelling (Paul Tett).

This team will become the core of a new research centre focused on understanding the links between society and the sea, which brings together social and natural scientists and the arts and humanities to better understand marine and coastal social-ecological systems, and manage them more sustainably.

The best thing for me this year was to move from the grey oil city of Aberdeen to the spectacular countryside of Argyll. Working at an institute where we can go for a lunchtime swim on an idyllic beach just behind your office is a true delight!



Attending a Forth workshop

Research Students

Derek Purdy (PhD): Community based farming of *Holothuria scabra* (sea cucumber) University of New England (Australia), 2011-2014

Josif Makris (PhD): Economic benefits of marine protected areas in Rhodes, Greece. University of Aberdeen, 2013-2016

Publications 2013-14

Albon, S., Turner, R.K., Watson, R., Anger-Kraavi, A., Bateman, I., Brown, I., Church, A., Dickie, I., Haines-Young, R., **Kenter, J.O.**, Mee, L., Russel, D., Scott, A. et al. (2014) UK National Ecosystem Assessment follow on phase, synthesis report. UNEP-WCMC, Cambridge.

Kenter, J.O., Reed, M. S., Everard, M., Irvine, K.N., O'Brien, E., Molloy, C., Bryce, R., Brady, E., Christie, M., Church, A., Collins, T., Cooper, N., Davies, A., Edwards, D., Evely, A., Fazey, I., Goto, R., Hockley, N., Jobstvogt, N., Orchard-Webb, J., Ravenscroft, N., Ryan, M., Watson, V. (2014) Shared, plural and cultural values: A handbook for decision-makers. UK National Ecosystem Assessment follow-on phase. UNEP-WCMC, Cambridge.

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Church, A., Fish, R., Haines-Young, R., Mourator, S., Tratalos, J., Stapleton, L., Willis, C., Coates, P., Gibbons, S., Leyshon, C., Potschin, M., Ravenscroft, N., Sanchis-Guarner, R., Winter, M., **Kenter, J.O.** (2014) UK National Ecosystem Assessment follow-on phase. Work Package Report 5: Cultural Ecosystem Services and Indicators. UNEP-WCMC, Cambridge.

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Reed, M.S., **Kenter, J.O.**, Bonn, A., Broad, K., Burt, T., Fazey, I., Fraser, E., Hubacek, K., Nainggolan, D., Quinn, C., Stringer, L. & Ravera, F. (2013) Participatory scenario development for environmental management: A methodological framework illustrated with experience from the UK uplands. *Journal of Environmental Management*, 128, 345-362. <http://dx.doi.org/10.1016/j.jenvman.2013.05.016>



Ecology

DR MAEVE KELLY

Culturing a taste for health

My research focuses on the culture, nutrition and ecology of commercially important marine invertebrates, such as sea urchins and sea cucumbers. I also study the culture of macroalgae (seaweeds) as a source of human food and biofuel, and for bioremediation (ie using natural organisms to "clean up" environmental pollutants).

Linking these themes is my interest in integrated aquaculture, and sustainability in marine systems (integrated multi-trophic aquaculture or IMTA). This includes researching the potential of farming seaweed for energy, via anaerobic digestion to produce biogas or methane.

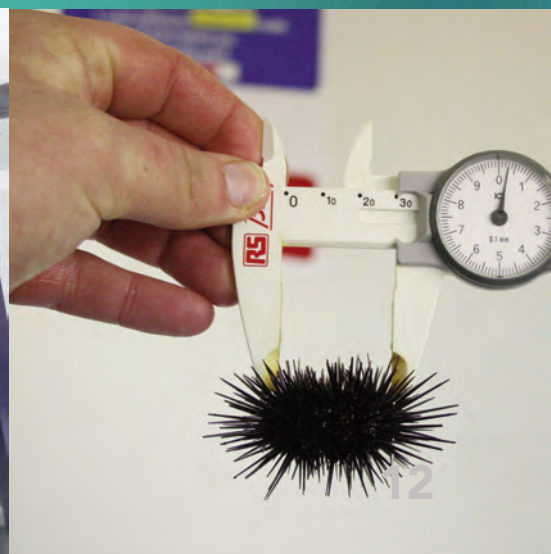
At present, I am continuing my research (with Adam Hughes, Lars Brunner and Daniel Kerrigan) into sea urchin aquaculture; perfecting diets for juvenile urchins and are trialling new diets and baskets for growing small urchins at sea.

We are also culturing a variety of healthful edible seaweeds in conjunction with our business partners, keen to market health products. I am investigating ensiling as a means of seaweed storage, preserving the sugar content.

I have also been working with the Food Standards Agency Scotland to re-examine the potential for allowing whole scallops that contain

the amnesic shellfish toxin domoic acid, to leave the processors and to be safely prepared by chefs and staff in food business outlets. This is an example of science mediating between business and legislators and of how we can contribute to policy change.

I also teach Aquaculture to 3rd year students on our Marine Science BSc course.



Publications 2013-14

Hughes, A., Black, K., Campbell, I., Heymans; Orr, K., Stanley, M., Kelly, M., 2013 Comments on 'Prospects for the use of macroalgae for fuel in Ireland and the UK: An overview of marine management issues'. Letter to editor Marine Policy. MARINE POLICY Volume: 38 Pages: 554-556 DOI: 10.1016/j.marpol.2012.08.001 Published: MAR 2013

Kelly, M.S., Hughes A.D. and Cook, E. J. 2013 The ecology of *Psammechinus miliaris*. In The Biology and Ecology of Edible Echinoid Species 3rd Edition (J. Lawrence, Editor) Elsevier Science, Amsterdam.

Kelly, M.S., Symonds R.S. Carotenoids in Sea Urchins. 2013 In The Biology and Ecology of Edible Echinoid Species 3rd Edition (J. Lawrence, Editor) Elsevier Science, Amsterdam

RESEARCH STUDENTS

Daniel Kerrigan (Intern): Aspects of shellfish and macroalgal research. School of Ocean Sciences, Bangor University.



Ecology

PROFESSOR KENNY BLACK

Modelling fish farm footprints, and lice

The farming of marine fish in floating cages continues to grow in Scotland as in the rest of the world. One of the main ways that the size of an individual farm is determined for licencing purposes is through its predicted impact on the seabed.

Over the past year we have pursued three main activities in this area:

1) continuing the recoding of SAMS-developed AutoDEPOMOD software and developing a new particle resuspension algorithm based on field studies using state-of-the-art in-situ flume technology provided by Partrac Ltd. (figure 1). Trevor Carpenter and Steven Gontarek have led the recoding effort and Thom Nickell has assisted with the field campaigns;

2) continuing our studies into the role of sulphide in the recovery of organically enriched sediments post-farming using sulphide and oxygen microelectrodes and both impacted mesocosm and field sediments (figure 2), which is an essential part of Joanna Gosling's PhD studies;

3) providing consultancy services to Marlborough District Council in New Zealand, with regard to managing their local Pacific salmon

aquaculture industry including a wide range of stakeholder interactions from farm visits (fig 3) to public presentations: my profile photo (top left) shows me addressing a public meeting on aquaculture impacts and regulation in Blenheim, NZ on 10th December 2013. Photo courtesy of: <http://www.stuff.co.nz/marlborough-express/news/9502625/Lice-kill-salmon>

In addition to this, a significant area of interest and promising future work is modelling the transmission of lice between fish farms by particle tracking and life cycle models with hydrodynamic models. This work has been done in collaboration with Tom Adams and Dmitry Aleynik at SAMS together with Sonya Brown at Loch Duart Ltd, Shona Marshall at West Sutherland Fisheries Trust, and Catherine Collins and co-workers at Marine Scotland Science.



Fig. 1 The Partrac Voyager benthic flume being deployed from SEPA's Sir John Murray



Fig. 2. Enriched mesocosm tank with white sulphide oxidising *Beggiatoa* bacteria covering the sediment.



Fig 3. A large New Zealand King Salmon farm in Queen Charlotte Sound, Marlborough, NZ

Publications 2013-14

Slocombe, S.P., Zhang, Q., Black, K.D., Day, J.G. and Stanley, M.S. (2013) Comparison of screening methods for high-throughput determination of oil yields in micro-algal biofuel strains. *Journal of Applied Phycology*. 25:961–972

Karakassis, I., Dimitriou, P.D., Papageorgiou, N., Apostolaki, E.T., Lampadariou, N. and Black, K.D. (2013) Methodological considerations on the coastal and transitional benthic indicators proposed for the Water Framework Directive. *Ecological Indicators*. 29. 26-33

Kalantzi, I., Black, K.D., Pergantis, S.A., Shimmiel TM., Papageorgiou, N., Sevastou, K., I. Karakassis, I. (2013). Metals and other elements in tissues of wild fish from fish farms and comparison with farmed species in sites with oxic and anoxic sediments. *Food Chemistry* 141: 680-694

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Schiener P, Black KD, Stanley MS, Green, DH (2014) The seasonal variation in the chemical composition of the kelp species *Laminaria digitata*, *Laminaria hyperborea*, *Saccharina latissima* and *Alaria esculenta*. *Journal of Applied Phycology*, DOI 10.1007/s10811-014-0327-1

Jones A.C., Mead A., Kaiser M.J., Austen M.C.V., Adrian A.W., Auchterlonie N.A., Black K.D., Blow L.R., Bury C., Brown J.H., Burnell G.A., Connolly E., Dingwall A., Derrick S., Eno N.C., Gautier D.J.H., Green K.A., Gubbins M., Hart P.R., Holmyard J.M., Immink A.J., Jarrad D.L., Katoh E., Langley J.C.R., Lee D. O'C., LeVay L., Leftwich C.P., Mitchell M., Moore A.P., Murray A.G., McLaren E.M.R., Norbury H., Parker D., Parry S.O., Purchase D., Rahman A., Sanver F., Siggs M., Simpson S.D., Slaski R.J., Smith K., Syvret M. LeQ., Tibbott C., Thomas P.C., Turnbull J., Whiteley R., Whittles M., Wilcockson M.J., Wilson J., Dicks L.V., & Sutherland W.J. (2014) Prioritisation of knowledge-needs for sustainable aquaculture: a national and global perspective. *Fish and Fisheries*, in press (IF 5.855)

Contract reports

Black KD (2013) Scientific Peer-review of monitoring results from New Zealand King Salmon Farms, for Marlborough District Council, Blenheim, New Zealand, SRSL 00989_P0657_001, 21 Pages.

Black KD, Nickell, TD (2014) Sediment sulphide response to organic loading. Contract report SARF085 - 1. 54 pages.

Alexander KA, Gatward I, Parker A, Black KD, Boardman A, Potts T and Thomson E (2014) Aquaculture and growth in aquaculture production. An assessment of the benefits to Scotland. A report to Scottish Government, 160 pages.

Black KD (2014) Review of Councils Preliminary assessments of compliance for 2013 results for Te Pangu, Clay Point, Otanerau and Forsyth Bay, Marlborough Sounds, New Zealand, for Marlborough District Council, SRSL 00989_P0657_002, 4 pages.

RESEARCH STUDENTS

Suzi Billing (PhD): The role of change agents in the sustainable development of marine renewable energy in the Highland and Islands region of Scotland. Funded by the European Social Fund. UHI (University of Aberdeen) 2012-2015

Joanna Gosling (PhD): The biogeochemistry of highly reducing sediments. Funded by MASTS and SAMS. UHI (University of Aberdeen). 2012-2015



Ecology

DR ELIZABETH COOK

Horizon scanning and early warning systems to detect marine invasive species

Invasive non-native species (INNS) are considered to be one of the greatest threats to biodiversity, particularly through their interactions with other drivers of change.

These species are initially transported through human intervention outside their natural range and across ecological barriers, before becoming established in a new location, where they can have negative impacts on the ecology, as well as serious economic and social impacts.

It has been estimated that over 58 marine species are established in the UK, with an estimated cost of at least £40 million per annum to marine-based industries.

A number of international and national agreements recognise the negative effects of INNS, reflecting the growing concern by government institutions, wildlife managers, scientific institutions and citizens. In a recent European Commission proposal for a Regulation on the prevention and management of the introduction and spread of INNS, three types of intervention are prescribed: prevention; early warning and rapid

response; and management.

The team at SAMS is now involved in national and European-based programmes that address each of these areas of intervention and has led the development of Marine Biosecurity Guidelines for INNS; is currently working on assessing techniques for the early detection of marine INNS as part of a UK wide marine pathways initiative; and led the recent MCCIP (Marine Climate Change Impacts Partnership) report on INNS.

On a personal level, during the year I was one of the authors in a major new horizon scanning paper published in *Global Change Biology* as well as being lead author on a MCCIP report card that reviewed the interactions between climate change and marine INNS.

I am also one of the INNS marine specialists for a European programme called "European Information System for Alien Species". This programme has over 27 participating countries and aims to provide the latest information on the distribution and likely pathways of INNS spread, to assist managers in preventing the introduction of a species to their region.



Assessing settlement panels for their effectiveness as early warning systems for INNS

Publications 2013-14

Cook, E.J., Payne, R.D., Macleod, A. (2014). Marine biosecurity planning – Identification of best practice: A review. Scottish Natural Heritage Commissioned Report No. 748. pp 45.

http://www.snh.org.uk/pdfs/publications/commissioned_reports/748.pdf

Payne, R.D., Cook, E.J. and Macleod, A. (2014). Marine Biosecurity Planning – Guidance for producing site and operation-based plans for preventing the introduction of non-native species. Report by SRS Ltd. in conjunction with Robin Payne to the Firth of Clyde Forum and Scottish Natural Heritage 39 pp.

<http://www.snh.gov.uk/docs/A1294630.pdf>

Roy, H.E., Peyton, J., Aldridge, D.C., Bantock, T., Blackburn, T.M., Bishop, J., Britton, R., Clark, P., Cook, E.J., Dehnen-Schmutz, K., Dines, T., Dobson, M., Edwards, F., Harrower, C., Harvey, M.C., Minchin, D., Noble, D.G., Parrott, D., Pocock, M.J.O., Preston, C.D., Roy, S., Salisbury, A., Schönrogge, K., Sewell, J., Shaw, R.H., Stebbing, P., Stewart, A.J.A., Walker, K.J. (2014). Collaborative approach to horizon-scanning for invasive alien species. *Global Change Biology* (IF 6.91). <http://onlinelibrary.wiley.com/doi/10.1111/gcb.12603/pdf>

Suckling, C.C., Clark, M.S., Peck, L.S., Cook, E.J. (2014). Experimental influence of pH on the early life-stages of sea urchins I: different rates of introduction give rise to different responses. *Invertebrate Reproduction and Development*. DOI: 10.1080/07924259.2013.875950

Suckling, C.C., Clark, M.S., Beveridge, C., Brunner, L., Hughes, A., Cook, E.J., Davies, A.J., Peck, L.S. (2014). Experimental influence of pH on the early life-stages of sea

urchins II: increasing parental exposure times gives rise to different responses. *Invertebrate Reproduction and Development*.

Cook, E.J., Jenkins, S., Maggs, C., Minchin, D., Mineur, F., Nall, C., Sewell, J. (2013). Non-native species IN Marine Climate Change Report Card

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Cook, E.J., Stehlikova, J, Beveridge, C. M., Burrows, M.T., Spencer-Jones, M, et al. (2013). Distribution of the invasive bryozoan *Tricellaria inopinata* d'Hondt and *Occhipinti Ambrogi*, 1985 in Scotland and a review of its European expansion. *Aquatic Invasions* 8 (3): 281-288. doi: <http://dx.doi.org/10.3391/ai.2013.8.3.04>

Miller, R.G., Hutchinson, Z. L., Macleod, A. K., Burrows, M.T., Cook, E.J., Last, K.S., Wilson, B. (2013). Marine renewable energy development: assessing the Benthic Footprint at multiple scales. *Frontiers in Ecology and the Environment*, doi:10.1890/120089

Kelly, M.S., A.D. Hughes and E. J. Cook (2013). *Psammechinus miliaris*. In *Sea Urchins: Biology and Ecology* (3rd Edition). *Developments in Aquaculture and Fisheries Science*, Volume 38 (J. Lawrence, Editor). Elsevier Science, Amsterdam. 329 – 336 pp. ISBN : 978-0-12-396491-5

RESEARCH STUDENTS

Rebecca Giesler (PhD): Biosecurity and Blue Build. SAMS and University of Edinburgh. 2014-2017

Claire Canning (PhD): Corrosion and Biofouling on offshore renewables. Director of Studies. SAMS, Universities of Exeter and Strathclyde, and EDF Renewables. 2014-2017

Chris Nall (PhD): Marine non-native taxa in the North of Scotland – Connections to Marine Renewable Energy Development. UHI (University of Aberdeen). 2011-2014

Rebecca Giesler (MRes): The Achilles' heel of marine biosecurity in the Isle of Man. SAMS/St. Andrews University. 2013 (completed)

Vicki Foster (MRes): Blue Build and Biodiversity; Designing the next generation of marinas for preventing the spread of invasives. SAMS and University of Edinburgh. 2013 (completed).



Ecology

DR KIM LAST

Finding out how marine organisms respond to natural and human influences

My main scientific interest is in determining the influence of human activity on marine organisms. By carefully replicating impacts in the laboratory and monitoring the organisms' behaviour and physiology we can determine if an environmental change is actually important or within the natural tolerance of what that organisms is accustomed to in the wild.

This work often requires expensive method development with bespoke construction of tools to answer tricky scientific questions.

My group at SAMS consists of my four PhD students who are interested in ocean acidification and its impact on calcification. Kati Michalek is working on the edible blue mussel, while Beatriz de Francisco (who completed her degree in 2013) was working on cold water coral. Zoe Hutchison is studying how mussels respond to changes in sedimentation and sediment burial, which is especially relevant to the burgeoning marine renewable industry and one of Britain's largest marine industries, aggregate dredging. Finally, Laura Hobbs is looking at polar zooplankton and what influences

their migrations on a pan-Arctic scale.

The group receives invaluable support from Chris Beveridge who maintains all the animals and aquaria and without whom little science would get done.

A research highlight this year involved an extensive Polar night campaign in Svalbard, in the Arctic, with researchers from all over the world. My profile photo (credit: Jorgen Berg) was taken during that field work.

The focus of our science was to characterize how organisms respond to complete darkness and freezing conditions. Many discoveries were made, and our contribution was that zooplanktons, which usually migrate on a daily cycle, shift to a lunar-day cycle but only during the darkest months when the moon is full and above the horizon. Considering that planktonic migrations are the biggest daily movement on the planet and play a significant role in carbon transport, this is a very novel and exciting finding.



ABOVE: Mussels (*Mytilus edulis*) have been the focus of research into the impacts of Ocean Acidifications, tolerance to chlorine and sediment smothering.



ABOVE: The Aurora Borealis over the research station at Ny Alesund, Svalbard where we spent several weeks studying how organisms respond to permanent darkness. The image was taken with a slow shutter speed: it was actually completely dark.

Photograph: Tim Winterburn

RESEARCH STUDENTS

Kati M Michalek (PhD): Adaptation of the cultured Blue Mussel (*Mytilus edulis*) to climate change. UHI (University of Aberdeen) 2014-2018.

Zoe Hutchison (PhD): Sensitivity of biogenic reef forming organisms and commercially important benthic invertebrates in an area of marine renewable development. Funded by MaREE. UHI (University of Aberdeen) 2010-2014.

Laura Hobbs (PhD): Vertical migration: a pan-Arctic perspective. UHI (University of Aberdeen) 2012-2016

Beatriz de Francisco (PhD): Effects of ocean acidification and warming on the cold-water coral *Lophelia pertusa*. Funded by the EU FP7 programme EPOCA. UHI (University of Aberdeen) 2009-2013 (completed).

Keshtav S. Ramdial (MRes) : Dissolution of metals from resuspended copper mine tailings beyond short term end points: effects on the fertilization success of the green sea urchin (*Psammechinus miliaris*). UHI.

Richard S. Cottrell (MRes): 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. UHI.

Frazer Mackay (MRes): Sediment impacts on cold water corals. UHI.

Publications 2013-14

Browne, N. K., Precht, E., Last, K. S., Todd, P. A. 2014. The photo-physiological costs associated with acute sediment stress events in three near-shore turbid water corals. MEPS 502: 129-143

Lai, S., Gillis, L. G., Mueller, C., Bouma, T. J., Guest, J. R., Last, K. S., Ziegler, A. D., Todd, P. A. 2013 First experimental evidence of corals feeding on seagrass matter. Coral Reefs. 32: 1061-1064.

Miller, R. G., Hutchison Z. L., Macleod, A. K., Burrows, M. T., Cook, E. J., Last K. S., Wilson, B. 2013 Marine renewable energy development: assessing the Benthic Footprint at multiple scales. Frontiers in Ecology and the Environment. 11: 433-440.

Schaum CE, Batty R, Last KS (2013) Smelling danger – alarm cue responses in the polychaete *Nereis (Hediste) diversicolor* (Müller, 1776) to potential fish predation. PLoS ONE 8(10): e77431. doi:10.1371/journal.pone.0077431



Ecology

DR SHEILA HEYMANS

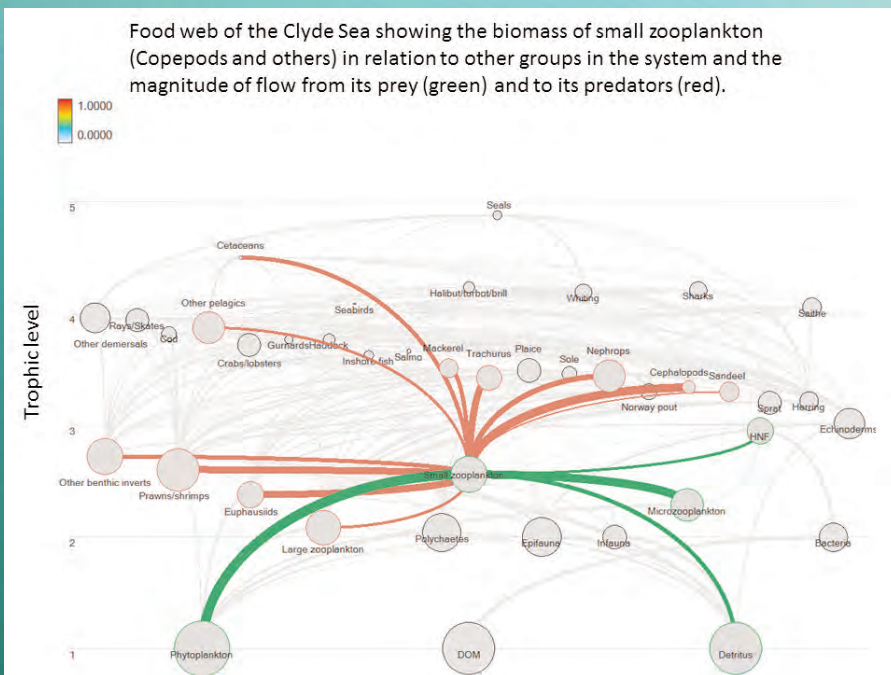
More modelling of ecosystems, no lice

My work involves the modelling of environmental impacts on marine ecosystems ranging from the ecosystem effects of fishing, indicators of ecosystem status, the reasons for species decline, to the impact of fishing subsidies on the North Sea ecosystem.

My background is ecosystem modelling approaches such as Ecopath with Ecosim and Ecological Network Analysis. I am

the Secretary of the Ecopath Consortium and teach an introductory CPD course in Ecopath with Ecosim at least once a year, although this year I have already taught it three times. I am on the organising committee of the "30 years of Ecopath" conference and will lead the cumulative impacts session and teach yet another introductory course there. I sit on the ICES Large Marine Ecosystems Working Group and the ICES

Working Group on the ecosystem based management of the Mediterranean and Atlantic Oceans (WGCOMEDA) and the International Panel for Biodiversity and Ecosystem Services (IPBES) where I lead the chapter on "Policy support tools and methodologies for scenario analysis and modelling of biodiversity and ecosystem services". At SAMS I am the Head of the Ecology Department.



Publications 2013-14

Levin N, Coll M, Francheti S, Gal G, Giakoumi S, Göke C, Heymans JJ, Katsanevakis S, Mazor T, Öztürk B, Rivol G, Gajewski J, Steenbeek J, Kark S. 2014. Review of the biodiversity data requirements for systematic conservation planning in the Mediterranean Sea. *Marine Ecology Progress Series*. In press.

Heymans JJ, Coll M, Libralato S, Morissette L, Christensen V. 2014. Global patterns in ecological indicators of marine food webs: a modelling approach. *PLoS ONE* 10.1371/journal.pone.0095845

Orr KK, Horstmeyer L, Weigl S, Wilding TA, Heymans JJ. 2014. Inshore kelp detritus: its importance to sandy beach hyperbenthic macrofauna, decapods and fish. *Estuarine Coastal and Shelf Science*. In press.

Sardà F, Coll M, Heymans JJ, Konstantinos SI. 2013. Overlooked impacts and challenges of the new European discard ban. *Fish and Fisheries*, doi:10.1111/faf.12060.

Tomczak MT, Heymans JJ, Yletyinen J, Niiranen S, Otto SA, Blenckner T. Ecological network indicators of ecosystem status and change in the Baltic Sea. *PLoS ONE* 8:e75439. doi:10.1371/journal.pone.0075439

RESEARCH STUDENTS

Kyla Orr (PhD): Predicting the ecosystem effect of harvesting beach-cast kelp for biofuel. Funded by the SEUPB BioMara project. UHI (University of Aberdeen). 2009-2013 (completed)

Ismet Saygu (PhD): Development of ecosystem based fisheries management strategies for the Turkish Seas. Dukurova Univerity, Turkey 2013-2016.

Kieran Tierney (PhD): Physical Transport and Ecosystem Uptake of Sellafield-Derived Radiocarbon (^{14}C) in the Marine Environment. Glasgow University 2013-2016.

Emma John (MRes): Testing the performance of ecological indicators in the west coast of Scotland. University of St. Andrews/SAMS 2013-2014.



Ecology

DR CLIVE FOX

Fisheries research expands and grows

My main research interest is the early life ecology of fish but since moving to SAMS this has broadened to include wider aspects of fisheries. My work on planktonic fish eggs and larvae, has also widened to look at other taxonomic groups such as the Cnidaria (jellyfish).

In 2014 we completed a project funded by The Crown Estate to develop approaches for monitoring jellyfish in relation to the potential damage they can cause to aquaculture operations.

This has involved the production of training materials for the industry and running several training workshops as well as collecting and analysing samples to build a better picture of the seasonality and species occurrence in our local waters.

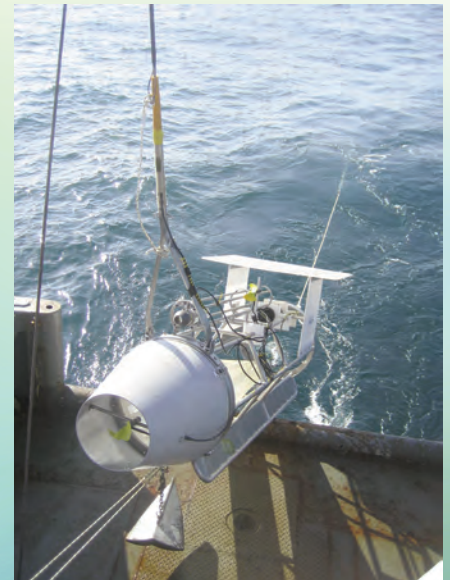
During the year I have also hosted an Erasmus student (Judith Engelke, Konstanz University, Germany) who has worked on scallop growth and supervised two Masters level research projects (Craig Morten on the benthic polyp stages of jellyfish and Eleni Livanou working on the planktonic stages).

Meri Lappalainen from Glasgow University has also been working in my laboratory on the egg and larval stages of fish found in the Firth of Lorn.

Teaching continues to be another major activity with modules on Fisheries Ecology and Marine Policy, Planning and Management being delivered.

I have also been quite busy with the Marine Alliance for Science and Technology Scotland (MASTS) sitting on the Fisheries Sub-Committee and organising a workshop in May on the impacts of the changes in EU Discards Policy for the Scottish prawn fisheries.

Although fisheries remains a relatively small part of the SAMS research portfolio I do feel that this is an exciting time with increasing opportunities in this area due to moves towards regionalisation of European fisheries management and developments in the local management of the Scottish inshore fisheries.



The photo shows the Gulf VII high-speed plankton sampler being recovered onto the SAMS research vessel Calanus during our survey of local ichthyoplankton.

Publications 2013-14

Gascuel, D., Coll, M., Fox, C., Guénette, S., Guitton, J., Kenny, A., Knittweis, L., Nielsen, R.J., Peit, G., Raid, T., Travers-Trolet, M. & Shephard, S. (2014) Fishing impact and good environmental status in European seas: a diagnosis from stock-based and ecosystem indicators. *Fish and Fisheries*. doi:10.1111/faf.12090

Fox, C.J., Targett, T.E., Ciotti, B.J., de Kroon, K., Horstmeyer, L., & Burrows, M. (2014) Size of 0-group plaice during late summer is determined by local habitat at Scottish west coast nursery grounds. *Journal of Sea Research*, 88, 59-66.

doi:10.1016/j.seares/2013.12.015

Heath, M.R., Preedy, K.F., Culling, M.A., Crozier, W.W., Fox, C.J., Gurney, W.S.C., Hutchinson, W.F., Nielsen, E.E., O'Sullivan, M., Righton, D.A., Speirs, D.C., Taylor, M.I., Wright, P.J., & Carvalho, G.R. (2014) Genetic diversity in fish populations is threatened by harvesting patterns. *ICES Journal of Marine Science*. doi:10.1093/icesjms/fst185

Fox, C.J. (2014) A workshop to address the issues surrounding a discarding ban in the Scottish Nephrops fisheries. *MASTS Report*, 37 pp.

Fox, C.J. (2014) Issues around fisheries for small pelagic fish. A report prepared for the Food and Agriculture Organization, Rome, 256 pp.

RESEARCH STUDENTS

Meri Lappalaeinan (BSc): Ichthyoplankton surveys of the Firth of Lorn. Glasgow University, sandwich year in the workplace at SAMS. 2013-2014.

Judith Engelke (Erasmus): Spatial variability in scallop growth rates. University Konstanz Germany, 2013.

Craig Morten (MRes): Polyp stages of jellyfish. University of St Andrews, 2013.

Eleni Livanou (MRes): Jellyfish in the Firth of Lorn. University of St Andrews, 2013.



Ecology

DR DAVID HUGHES

Sharing the...knowledge and expertise

Most of my time in 2013-14 has been spent working alongside other SAMS scientific staff on a series of commissioned contracts for SAMS Research Services Ltd. (SRSL).

The range of subject matter has been very wide, including a review of environmental monitoring methods at the Lihir Gold Mine, Papua New Guinea, and an analysis of biofouling on flexible oil/gas risers in the North Sea.

A particularly notable piece of work was my collaboration on a literature review of biological carbon stores in the Scottish marine environment. My focus was on biogenic reefs and associated benthic habitats (e.g. cold-water corals, tubeworm reefs, mussel and flame shell beds), and involved estimation of the total area occupied by these habitats in Scottish waters, rates of biogenic carbonate accretion and erosion, and the timescale of carbon storage in each habitat.

This collaboration with other SAMS scientists and external workers was highly successful and the final project report was mentioned in debate at the Scottish Parliament.

Three successive related contracts were also delivered for the Joint Nature Conservation Committee (JNCC), in collaboration with colleagues at SAMS, drawing on our long experience of deep-sea biological research in the Rockall Trough and Faroe-Shetland Channel.

The first contract entailed analysis of large macrofaunal datasets to define benthic biotopes for inclusion in a deep-sea section of the Marine Habitat Classification for Britain and Ireland. The second was a statistical analysis to identify appropriate indicators of temporal change in these habitats, and the third was a detailed literature review carried out to categorise the UK's deep-sea benthic fauna into ecologically-relevant groups and assess the sensitivity of key species to a range of anthropogenic pressures.

All these pieces of commissioned research drew on the expertise available at SAMS and the application of this to address practical issues in marine conservation and management.



A lecture with Dr David Hughes
 Photograph: Tim Winterburn

Publications 2013-14

Narayanaswamy, B.E., Hughes, D.J., Howell, K.L. Davies, J. & Jacobs, C. 2013. First observations of megafaunal communities inhabiting George Bligh Bank, northeast Atlantic. *Deep-Sea Research II* 92: 79-86.

Hughes, D.J., 2014. Benthic habitat and megafaunal zonation across the Hebridean Slope, western Scotland, analysed from archived seabed photographs. *Journal of the Marine Biological Association of the UK* 94: 643-658. Burrows M.T., Kamenos N.A., Hughes D.J., Stahl H., Howe J.A. & Tett P. 2014. Assessment of carbon budgets and potential blue carbon stores in Scotland's coastal and marine environment. *Scottish Natural Heritage Commissioned Report No. 761*.

Narayanaswamy, B.E., Hughes, D.J. & Nickell, T.D., 2014. Definition of deep-sea infaunal assemblages for inclusion in a deep-sea section of the Marine Habitat Classification for Britain and Ireland. Report to the Joint Nature Conservation Committee, JNCC Contract C13-0223-0670.

Serpetti, N., Narayanaswamy, B.E. and Hughes, D.J., 2014. Assessing the sensitivity of deep-sea sedimentary habitats to pressures associated with marine activities. *JNCC Report 512*.

Wilding, T.A., Nickell, T.D., Burrows, M.T., Hausrath, J., Narayanaswamy, B.E. and Hughes, D.J. 2014. Statistical advice to the Marine Habitats Monitoring project under Framework Agreement C10-206-0387.



Ecology

DR BEN WILSON

Turbine ahead: Broadcasting to porpoises

My team and I focus our research on understanding and mitigating potential conflicts between marine animals and industrial activities.

Current projects particularly target how marine mammals will interact with marine renewable energy devices, particularly tidal-stream turbines and wave energy converters. Being new renewable energy technologies, and with a global focus on Scotland, there are many opportunities to improve survey methodologies, sensor deployment and our basic understanding of animal habitat use in these highly-challenging marine energy sites.

While I help coordinate research activities across SAMS and MASTS, our group works on the relationships between marine fauna and marine renewable energy converters:

Dr Steven Benjamins looks at how top predators, such as porpoises, behave in tidal-stream environments and how they might interact with future energy extraction machines; Dr Denise Risch is working on the underwater soundscapes of these habitats with and without turbines; Jim Elliott works to make the team's field measurement-aspirations a reality

with innovative, cost-effective and safe solutions; and Dr Raeanne Miller works at the interface between research and marine renewable device developers to improve communication and opportunities for the injection of cutting edge science to industry-related challenges.

One question we've had to address is: how do you work out if harbour porpoises will be scared away from future farms of tidal-turbines if the only machine currently operating is in a place where there are few porpoises to study? Answer: Record the underwater water sound produced by a turbine and play the sound back in a place well populated with porpoises. Simple!

This was the basis of the NERC RESPONSE project, and for a few summer months a lonely boat (fig. 1) broadcast the sound of an operating tidal-turbine through an underwater speaker. A series of porpoise detectors (PODs - fig. 2) positioned at a range of distances then logged whether porpoises responded by moving away from the noise or not. The study involved a military-grade speaker and 22 porpoise detectors (PODs).

After a tense couple of months of the experiment running, all of the

valuable kit that went into the sea was successfully retrieved. We are now working through the POD data to see how the porpoises responded to the turbine noise.



Fig. 1: CetRens speaker boat

Publications 2013-14

Wilson B., Lepper P.A., Carter C., Robinson SP. (2014) Rethinking underwater sound-recording methods to work at tidal-stream and wave-energy sites. *Marine Renewable Energy Technology and Environmental Interactions*, 111-126. Springer.

Wilson L.J., Burrows M.T., Hastie G.D., Wilson B., (2014) Temporal variation and characterization of grunt sounds produced by Atlantic cod *Gadus morhua* and pollack *Pollachius pollachius* during the spawning season. *Journal of fish biology* 84 (4), 1014-1030.

Wilson, B., Benjamins, S., & Elliot, J. (2013). Using drifting passive echolocation loggers to study harbour porpoises in tidal-stream habitats. *Endangered Species Research*, 22(2), 125-143.

Miller, R.G., Hutchison, Z.L., Macleod, A.K., Burrows, M.T., Cook, E.J., Last, K.S., and Wilson, B. (2013). Marine renewable energy development: assessing the Benthic Footprint at multiple scales. *Frontiers in Ecology and the Environment*, 11:8, 433-440.

Cheney, B, Thompson, PM, Ingram, S.N., Hammond, P.S., Stevick, P.T., Durban, J.W., Culloch, R.M., Elwen, S.H., Mandlebreg, L., Janik, V.M., Quick, N.J., Islas-Villanueva, V., Robinson, K.P., Costa, M., Einfeld, S.M., Walters, A., Phillips, C., Weir, C.R., Evans, P.G.H., Anderwald, P., Reid, R.J., Reid, J.B. & Wilson, B. (2013) Integrating multiple data sources to assess the distribution and abundance of bottlenose dolphins *Tursiops truncatus* in Scottish waters. *Mammal Review*. 43 (1), 71-88

RESEARCH STUDENTS

Nienke van Geel (PhD): Understanding Scottish bottlenose dolphin movement patterns: Can visual & acoustic cues be used to ensure that dolphins & construction of marine renewables don't coincide? UHI (University of Aberdeen), 2010-2014



Ecology

DR TIM O'HIGGINS

A picture speaks a thousand words

During the year, I was selected by the EU directorate general for the seas, to host a session at European Maritime Day in Valetta, Malta, which was attended by policy makers and citizens from around the continent.

Alongside Laurence Mee, I presented the final results of our four year research into social and ecological aspects of European Marine Policy (the KnowSeas project).

I have been continuing my work on ecosystem services, social ecological systems and marine policy. I was invited speaker at the

UK Living With Environmental Change Assembly to discuss management tools for implementation of the Marine Strategy Framework Directive. I was invited to contribute an editorial article to Horizon the EU Research and Innovation magazine.

I finished writing my first book, called "It's not easy being green", which is with the publishers and I hope will reach a popular audience as well as support my teaching in marine resource management. I have also been working hard on a special issue of the journal Ecology and Society and the first articles are now going into publication.

I was also involved in designing a choice experiment to examine the potential market for the products of integrated multi-trophic aquaculture (IMTA) as part of the IDREEM project. This has formed part of a major survey on public attitudes to IMTA across Europe.

In my work I use info-graphics, which stand alone, unsupported by text and convey the all important messages. I include four here to show the scope of my research.

Publications 2013-14

O'Higgins T.G. 2013. The value of the sea can't just be measured by markets: http://horizon-magazine.eu/article/value-sea-cant-just-be-measured-markets_en.html

O'Higgins, T.G. and Gilbert, A. 2014. Embedding ecosystem services into the Marine Strategy Framework Directive: Illustrated by

eutrophication in the North Sea. Estuarine Coastal and Shelf Science 140 146-152

Goulding, I.C. Stopperubb, K.A. and O'Higgins. 2014. Potential economic impacts of achieving good environmental status in the Black Sea. Ecology and Society. 19(3) 32

RESEARCH STUDENTS

John Bainbridge (PhD): An investigation into the opportunity to develop a future policy framework to deal with policy complexity in a coastal region. Funded by MaREE. UHI (University of Aberdeen). 2010-2013 (completed).

Mohammed Al Kalbani (PhD): Integrated Environmental Assessment and Management of Water Resources in the Al Jabal Al Akhdar mountain ecosystem using the DPSIR framework, policy analysis and future scenarios for sustainable development. region. UHI (University of Aberdeen). 2011-2014

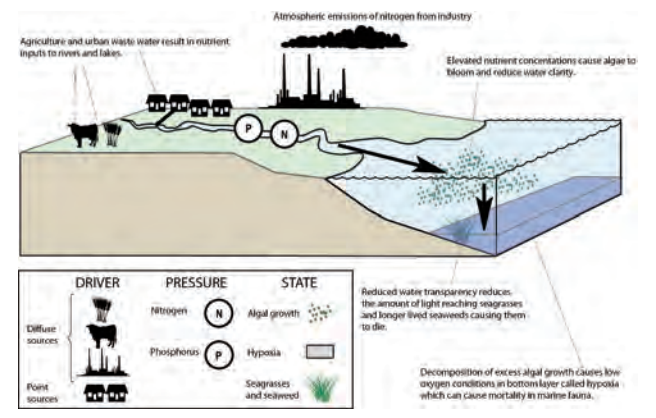
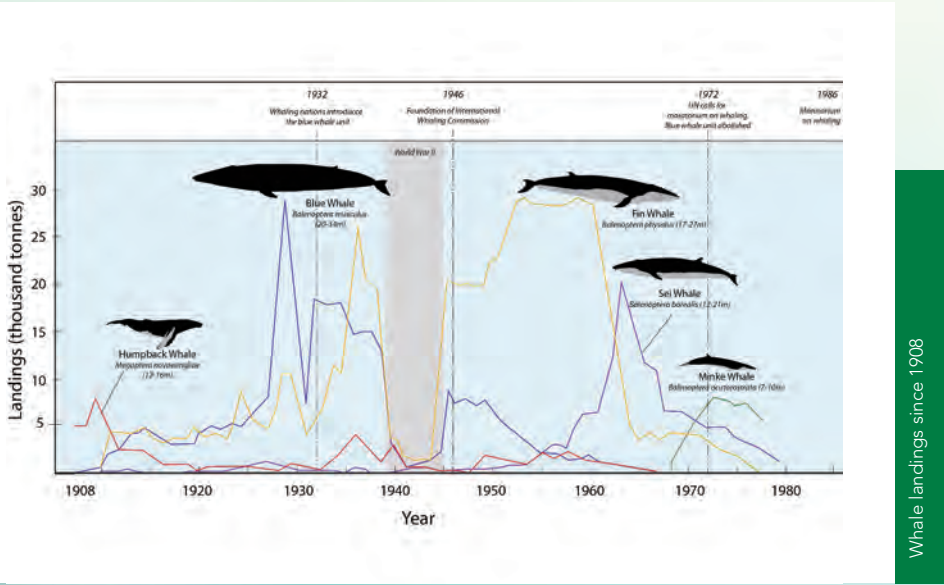
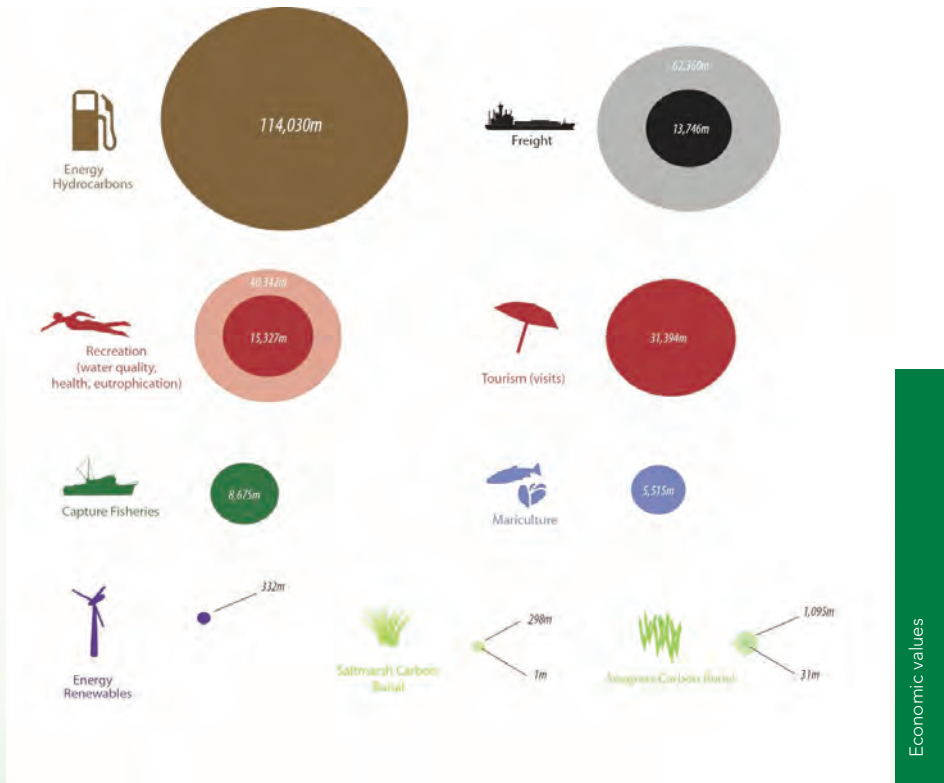


Fig 2: How we are causing oxygen depletion in our coastal seas

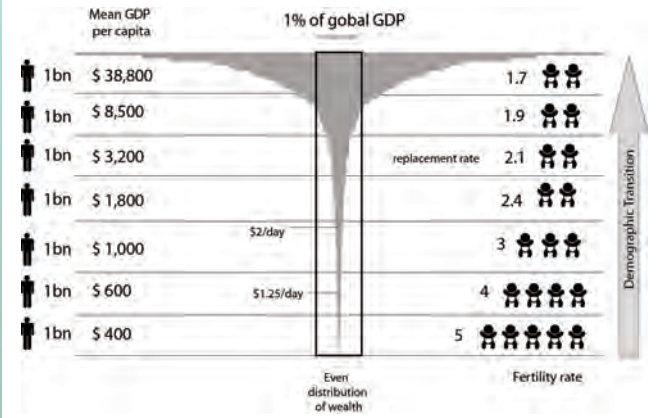


Fig 4: Poverty



Ecology

DR TOM WILDING

Ground-breaking approach offers better way to monitor benthic diversity

Fish-farms cause change in the sediment surrounding them and, consequently, the licensing authority (SEPA) obliges fish-farmers to conduct monitoring to ensure that any changes do not exceed agreed levels.

Traditionally, this monitoring has included an assessment of the diversity of organisms living in the sediments (benthos) surrounding the farm.

Measures of benthic diversity are determined by taking a benthic grab, washing the sediment collected through a 1mm sieve and then identifying and counting all the retained organisms.

This process, which needs to be replicated within farms (generally five samples per farm), is expensive

and every year the Scottish fish-farming industry spends approximately £2M on statutory monitoring.

Together with Jan Pawlowski (Department of Genetics and Evolution, University of Geneva) and Tomas Cedhagen (Department of Biological Sciences, Aarhus University, Denmark) we are developing 'next generation sequencing' techniques for assessing change in benthic community diversity.

In this ground-breaking approach, we have taken sediment samples from around fish-cages and are using 'DNA fingerprinting' techniques to assess the diversity of organisms present.

We found a highly significant correlation between 'DNA diversity' and traditional predictors of diversity, such as sedimentary oxygenation (Pawlowski et al, 2014). Initial results look very encouraging and metabarcoding may offer a highly accurate, cost-effective and commercially viable alternative technique for assessing impacts around point sources such as fish-farms and sewage outfalls.



Fig. 1: Simultaneously taking a sample for 'metagenomics' analysis and measuring sediment oxygenation status (redox) in a grab sample taken from around a fish-cage. We found that measured DNA diversity was highly correlated with redox and may offer a viable approach to benthic monitoring.

Publications 2013-14

Pawlowski, J., Esling, P., Lejzerowicz, F., Cedhagen, T. and Wilding, T. A. (2014). Environmental monitoring through protist next-generation sequencing metabarcoding: assessing the impact of fish farming on benthic foraminifera communities. *Molecular Ecology Resources*: doi: 10.1111/1755-0998.12261

Wilding, T. A. (2014). Effects of man-made structures on sedimentary oxygenation: Extent, seasonality and implications for offshore renewables. *Marine Environmental Research*. doi: 10.1016/j.marenvres.2014.01.011.

RESEARCH STUDENTS

Sally Rouse (PhD): Understanding benthic productivity on artificial structures: maximising the benefits of marine renewable energy. Funded by SAMS, UHI, Heriot-Watt and Scottish Power Renewables. UHI (University of Aberdeen). 2011-2014



Microbial and Molecular Biology

DR CLAIRE GACHON

Collaborative cooperation works wonders at winning funding

A NEW, HIGH-POWER COMPUTING FACILITY FOR SAMS

The Head of IT, Steve Gontarek, and I won £338k of NERC funding to go towards a new, high-power computing facility at SAMS.

This upgraded capability is to meet our needs for intergrating large interdisciplinary marine environmental datasets; to facilitate efficient data management; and to increase our modelling and analysis capability.

Our ageing local cluster was replaced by a far superior 320 cpu machine and a standalone high performance server, which provides processing power for Windows-based applications (GIS, image analysis and ecological modelling packages). These platforms are supported by dedicated, high capacity data storage that are optimised for high I/O availability, and protected by a fire suppressing system to maximise data safety.

We also markedly increased our internet connectivity, thus facilitating data transfer with remote collaborators and customers. Crucially, we were able to recruit a data manager, Thomas Klein, to run

the facility and establish a systematic data management policy across SAMS.

The facility is now fully operational and serves our bioinformatics, as well as oceanographic modelling needs. We are working towards making it available to outside users, for example across UHI.

IMPACT OF FUNGAL INFECTION ON DIATOM SPRING BLOOM.

A French-led, three-year consortium project is looking into the impact of fungal infections of bloom-forming diatoms on the food web in freshwater lakes.

Visiting scientist Dr Mélanie Gerphagnon and SAMS staff member Cecilia Rád-Ménendez have been working together to cultivate in controlled conditions diatom *Asterionella formosa* and a pathogenic fungus called *Rhizophyidium planktonicum*, isolated from Pavin Lake, France (Fig.1).

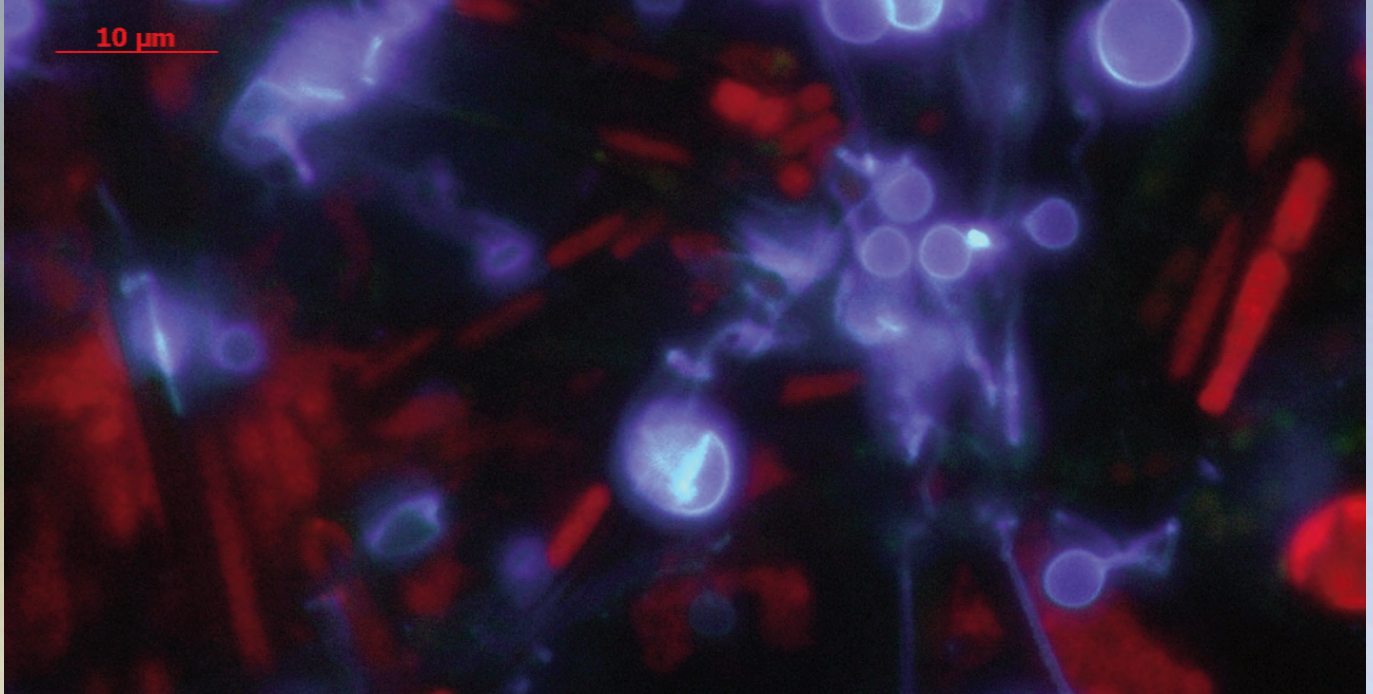
We are now applying next generation sequencing technologies and bioinformatics tools to reconstruct their gene repertoire

and identify activated metabolic pathways during epidemic outbreaks.

RESEARCH FUNDING GAINS

The best thing of the year has been my grant capture success, which underpins several new lines of research: NERC awarded Dr Liz Cook and me #400k to develop The GlobalSeaweed network that aims at connecting the worldwide seaweed community, and to tackle emerging issues in algal aquaculture (Fig. 2). In a marked turn of my research towards applied topics, three projects concerning the resistance of cultivated algae to disease were awarded by the Scottish business development fund Genomia (Fig. 3). Thanks to all this new funding, Dr Strittmatter and (soon-to-be-) Dr Badis have rejoined our group as postdoctoral researchers.

10 μ m



Infection of the diatom *Asterionella formosa*, viewed under epifluorescence microscopy. The alga chlorophyll appears in red, whereas the fungal structures of *Rhizophydium* are stained in blue



Looking for diseased kelp on the SAMS seaweed test farm off the isle of Kerrera



Visit of a kelp farm in the Wando province (Korea), as part of the GlobalSeaweed network activities

Publications 2013-14

Tsirigoti A, Küpper FC, Gachon CMM and Katsaros C (2014). Cytoskeleton organization during the infection of three brown algal species *Ectocarpus siliculosus*, *Ectocarpus crouaniorum* and *Pylaiella littoralis* by the intracellular, marine oomycete *Eurychasma dicksonii*. *Plant Biology* 16: 272-281.

Gachon CMM, Heesch S, Küpper FC, Achilles-Day UEM, Campbell CN, Clarke A, Dorrell RG, Field J, Gontarek S, Rad-Menendez C, Saxon RJ, Veszelovski A, Guiry MD, Gharbi K, Blaxter M, Day JG. (2013) The CCAP KnowledgeBase: linking protistan and cyanobacterial biological resources with taxonomic and molecular data. *Systematics and Biodiversity* 11: 407-413.

RESEARCH STUDENTS

Liridon Hoxha: Kelp aquaculture (ERASMUS, BSc, Uni Konstanz, Germany): Jan 2014-Jul 2014

Dr Mélanie Gerphagnon (postdoc) (Université Clermont-Ferrand, France) : Feb 2014 - present

Marine Vallet: the effects of fungal extracts on disease resistance of seaweeds (Muséum d'Histoire Naturelle, Paris, France)



Microbial and Molecular Biology

DR DAVID POND

Fishing for microbes with pollen for bait

Thraustochytrids are an important yet little studied group of microbial, marine decomposers.

They are an enigmatic group of marine protists, increasingly exploited by the nutraceutical (ie functional food) industry as a source of lipid, rich in omega 3 fatty acids, for human consumption and animal feeds.

Thraustochytrids have been identified in all major oceans and marine biomes (sea-ice, open-ocean environments during post-bloom conditions and in the deep sea) and are particularly abundant in coastal habitats.

Although these protists are ubiquitous in the marine environment, our knowledge of their ecology is limited. Yet it is thought that they fulfill a similar role to bacteria, being major decomposers of organic material.

Surprisingly their biomass in the marine environment can often exceed that of bacteria, suggesting a major, yet largely unstudied role in nutrient regeneration and decomposition of organic material.

In addition, specific strains of thraustochytrids are often intimately associated with a wide range of invertebrate taxa including

sponges, hydroids, bivalves and zooplankton.

An extraordinary feature of thraustochytrids is their propensity to accumulate high quantities of lipid, which at times can exceed 70% of the dry mass of culture biomass. The composition of this lipid is also unusual in containing unprecedented amounts of omega 3 fatty acids. However, the functional significance of these lipids in the life cycle of thraustochytrids is unknown.

Consequently, I have started a research programme into the ecological role of thraustochytrids in the Scottish coastal environments. Working in collaboration with Dr Silvina Rosa (University of Buenos Aires), who came to SAMS during 2014 as a MASTS visiting fellow, we isolated 20 strains of thraustochytrids from the local marine environment and are maintaining them at SAMS.

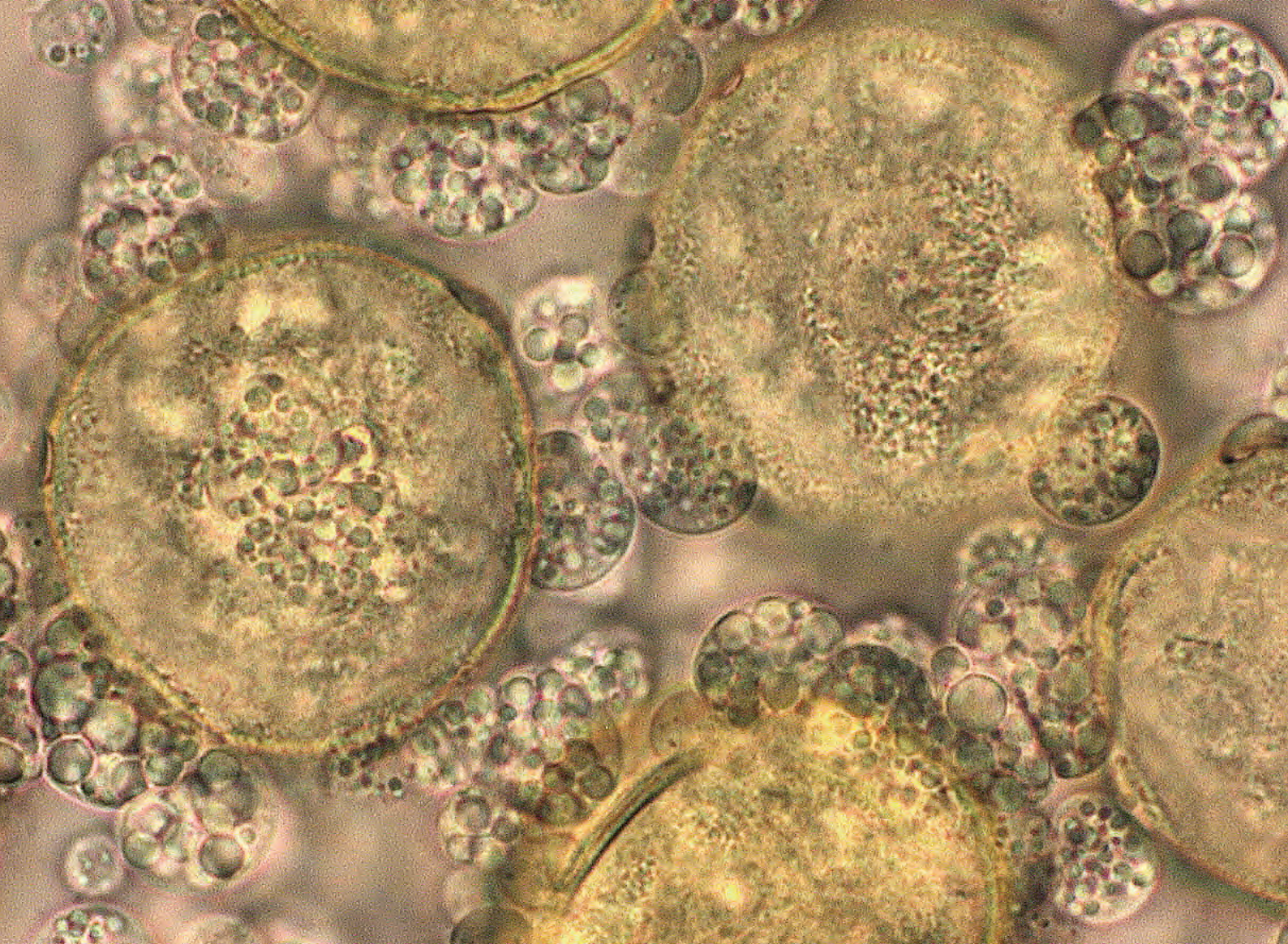
The isolation technique involves 'fishing for the microbes using plant pollen as a bait. Simply add pollen to a seawater sample and after a couple of days the pollen colonized by the microbes (see Figure). All types of pollen can be used as bait, although we found pollen from

walnut trees to be most effective. The strains we have isolated are forming the basis for ongoing studies into the role of thraustochytrids in the ecology of the seas.

RESEARCH STUDENTS

Tristan Biggs (PhD): Antarctic phytoplankton in a changing world and its consequences for the lower pelagic food web. Royal Netherland Institute for Sea Research. 2012-2016

Undine Achilles-Day (Phd): Algal-Ciliate endosymbioses: evolution, diversity and functionality. University of Bournemouth. 2014-2019 (part-time)



Thraustochytrids colonies on the surface of Walnut Tree pollen grains. The microbial colonies produce and endoplasmic net to 'mine' the nutrients contained within the pollen grains interior.

Publications 2013-14

Schmidt K, Atkinson A, **Pond DW**, Ireland LC (2014) Feeding and overwintering of Antarctic krill across its major habitats: The role of sea ice cover, water depth, and phytoplankton abundance. *Limnology and Oceanography*. 59: 17-36.

Larkin KE, Gooday AJ, Woulds C, Jeffreys RM, Schwartz M, Cowie G, Whitcraft C, Levin L, Dick JR, Pond DW (2014) Uptake of algal carbon and the likely synthesis of an "essential" fatty acid by *Uvigerina*

ex. gr. *semiornata* (Foraminifera) within the Pakistan margin oxygen minimum zone: evidence from fatty acid biomarker and C-13 tracer experiments. *Biogeosciences*. 3729-3738.

Clark KAJ, Brierley AS, Pond DW, Smith VJ (2013) Changes in seasonal expression patterns of ecdysone receptor, retinoid X receptor and an A-type allatostatin in the copepod, *Calanus finmarchicus*, in a sea loch

environment: An investigation of possible mediators of diapause. *General and Comparative Endocrinology*. 189: 66-73.

Diapause induces changes in the composition and biophysical properties of lipids in larvae of the European corn borer, *Ostrinia nubilalis* (Lepidoptera: Crambidae). *Comparative Biochemistry and Physiology B*. 165: 219-225.



Microbial and Molecular Biology

DR DAVID GREEN

Sequencing whole genomes and getting the best out of bacteria

The focus of the research we undertake is to understand bacteria that live with algae. We study fundamental processes, such as sulphur and iron biogeochemical cycling, and discover new products or processes that we can use to help our environment and ourselves.

The reason why the bacteria that live with algae are important is because we are now realising that they are hugely beneficial to the algae, which are the starting point of biological productivity in the oceans. The premise is that algae, like all living organisms, do not live in isolation of each other: in other words, they live in tightly woven communities and networks that rely on each other to stay alive and provide the oceans with energy and food.

The following two items show how we are exploring the potential of bacteria that live with algae to help us improve algal growth and lipid production, as well as bacteria that might produce novel compounds that we can develop into new products and processes.

Lipid production by algae: can bacteria influence this?

Research by Angela Hatton and me studying the production and turnover of the algal osmolyte dimethylsulphoniopropionate (DMSP) observed that when certain bacteria were growing with an alga, they could cause a marked increase in algal production of DMSP.

This indicated that bacteria have the capacity to affect algal biochemistry in ways that are measurable and biogeochemically important. But can these effects be biotechnologically useful too?

To test this idea out, Debra Brennan undertook a Masters by research (UHI/Aberdeen) project to see whether specific bacteria could enhance lipid production by algae.

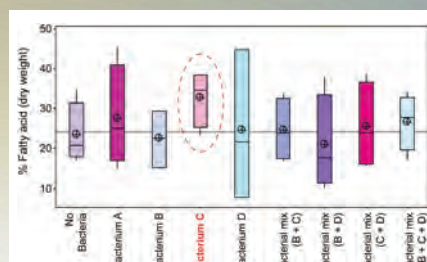


Fig 1: Total fatty acid yields of alga when grown with different combinations of bacteria. Horizontal lines denote the average fatty acid yields of all experiments (ca. 24 %) and individual treatments.

This is biotechnologically and industrially important because algal lipids can be used to make biodiesel or omega3 fatty acid extracts, but only if the process is more cost effective.

Debi's research demonstrated first, that one specific bacterium (Bacterium C; Fig. 1) had a trend of inducing higher total lipid yields. This was promising, but more notable was that Bacterium C could also stop Bacterium D killing the alga (seen in Fig. 2).

How Bacterium C interacts with and affects algal growth is not known, but clearly is of interest biotechnologically from the point of view of optimizing lipid yields, as well as blocking the algal-killing activity of harmful bacteria that can contaminate large-scale algal production.

The overall trend is for Bacterium C to induce the highest average lipid yield of all the different bacteria tested (Boxplot reproduced from D Brennan MRes thesis).



Fig 2: The effect of different bacteria on the growth of an alga. Bacterium D has killed the alga, whereas the alga is looking the healthiest (darker green) with Bacterium C.



Fig 3. Optimising gum production by the marine bacterium DG1864 (picture courtesy of Dr Mariana Fazenda, Univ. Strathclyde). A, no glucose; B-D, glucose plus growth at different temperatures).

Sequencing the bacterial "Blueprints of Life" for biotechnology

SeaBioTech is a European Union funded research programme to improve the discovery of new marine natural products, such as novel chemicals that can be used to treat antibiotic resistant infections (see <http://spider.science.strath.ac.uk/seabiotech/>).

One of SAMS tasks is to sequence the whole genomes ("Blueprint for Life") of weird and wonderful bacteria that we have in our culture collections to enable us to search for novel genes that might make new drugs, novel chemicals or powerful enzymes.

Using the latest genome sequencing technology, we have completed the whole genomes of two bacteria.

The first bacterium is biotechnologically interesting because it produces a "gum" like material (Fig. 3) that could be used in the food or healthcare industry. This bacterium's connection with algae is that my H3 Marine Biotechnology undergraduate class and I isolated this bacterium from the surface of a red seaweed found in Dunstaffnage Bay. And interestingly, the genome (Fig. 4) tells us that it possesses many

enzymes that degrade well known seaweed products such as alginate, carrageenan and cellulose—which makes sense if you live on seaweed and want to eat the sugars it produces.

The second bacterium (DG1868) was isolated from a laboratory culture of *Emiliania huxleyi*—a well-known calcifying alga responsible for the White Cliffs of Dover. This bacterium is a member of an extremely rare group of bacteria that we know almost nothing about. The bacterium is ecologically interesting because it could potentially be involved with dissolving carbonate and we know it likes to grow with light (Fig. 5), but we know nothing about its biotechnological potential.

Whole genome sequencing and annotation has been completed and the data shows that this bacterium is of significant biotechnological interest because of the presence of a remarkably high number of novel genes known to make chemical compounds that could be useful as drugs.

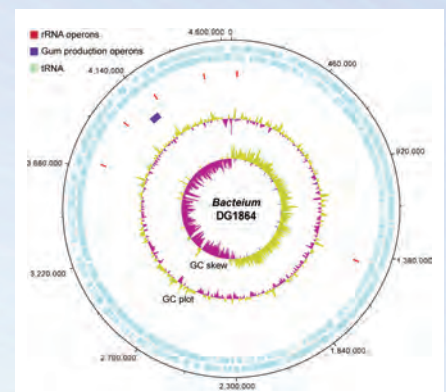


Fig 4. Schematic of the complete genome of the gum producing Bacterium DG1864. Genes for gum production have been identified (blue bar).

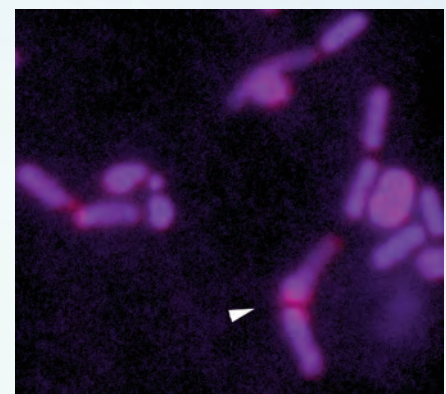


Fig 5. Epifluorescence photomicrograph of bacterium DG1868 grown in the light. Arrowhead points to an unusual cell type only observed during growth with light that looks like a "knuckle-joint". Intense red colouration at junction indicates high amounts of cellular activity in this region.

Publications 2013-14

Schiener P, Black K, Stanley M, Green DH (2014) The seasonal variation in the chemical composition of the kelp species *Laminaria digitata*, *Laminaria hyperborea*, *Saccharina latissima* and *Alaria esculenta*. *J Appl Phycol* DOI:10.1007/s10811-014-0327-1

Gärdes, A., Triana, C., Amin, S., Green, D., Romano, A., Trimble, L., and Carrano, C. (2013) Detection of photoactive siderophore biosynthetic genes in the marine environment. *Biometals*, 26(3): 507-516.

Gutierrez T, Green DH, Nichols PD, Whitman WB, Semple KT & Aitken

MD (2013) *Polycyclovorans algicola* gen. nov., sp. nov., an aromatic hydrocarbon-degrading marine bacterium found associated with laboratory cultures of marine phytoplankton. *Appl Environ Microbiol* 79(1): 205-214.

Davidson K D, Lacaze J-P and Green D H. (May, 2013). Development and Assessment of Specific Probes for the Detection and Monitoring of Toxin-Producing Phytoplankton Species in Scottish Waters. For Foods Standards Agency UK. Contract No. FS241058

RESEARCH STUDENTS

Peter Schiener (PhD): Bioethanol production from macroalgae. UHI (University of Aberdeen). 2009-2013 (completed).

Carole Shellcock (PhD): Molecular aspects of algal biofuels for the 21st century. Funded by BioMara. UHI (University of Aberdeen). 2009-2013 (completed).

Debra Brennan (MRes): The Microbial Communities of Oleaginous Algae and their Potential to Influence Oil Production. UHI (University of Aberdeen). 2012-2014 (part-time).



Photograph: Tim Winterburn



Microbial and Molecular Biology

PROFESSOR KEITH DAVIDSON

Predicting harmful algal blooms

Marine phytoplankton form the base of the marine food chain. A small subset of the phytoplankton may be harmful to human health or to human use of the ecosystem.

The species that cause harm are now widely referred to as 'Harmful Algae' with the term 'Harmful Algal Bloom' (HAB) commonly being used to describe their occurrence and effects.

In terms of human health, the most important consequence is the production, by some species, of biotoxins. Typically, biotoxin-producing phytoplankton species exist at relatively low densities of a few hundred or thousands of cells per litre. The toxins become concentrated in the flesh of organisms such as bivalve molluscs that filter feed on phytoplankton. In most cases, there are no adverse effects to these primary consumers, but this concentrating mechanism creates a risk to health if the shellfish are consumed by humans.

Human health is protected by monitoring HABs and shellfish toxins. However, better understanding of the factors that govern HAB appearance is still required to allow regulators and industry to better manage the coastal aquaculture that is affected by these events.

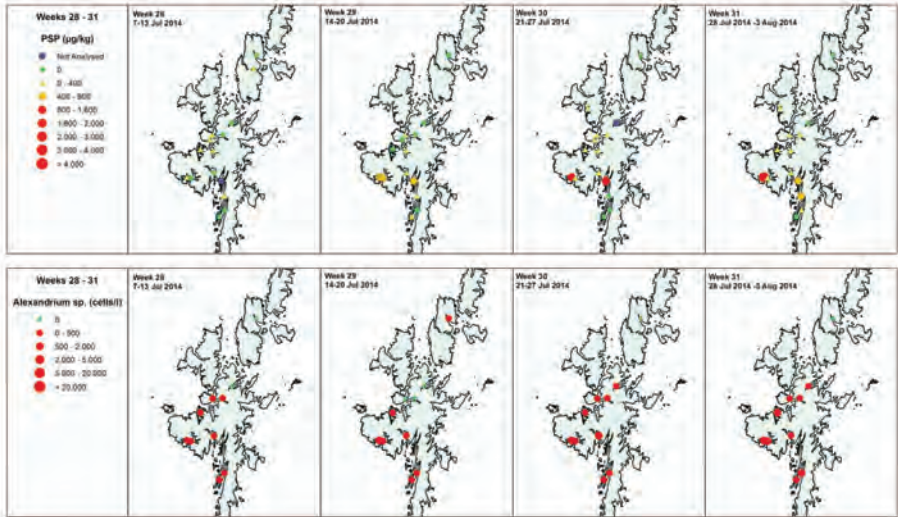
A range of research projects related to HABs and how the marine environment influences their timing, location, magnitude and toxicity are on-going at SAMS.

Increasingly we are working with industry partners to provide real time operational solutions to business problems. An example of which is the application of research initially conducted as part of the recently completed EU FP7 project "Asimuth".

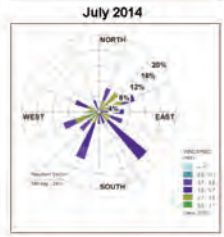
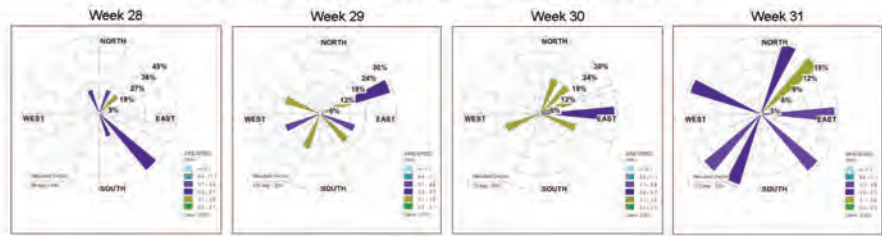
During this project SAMS developed a prototype risk assessment methodology to provide early warning of increased risk of harmful algal blooms and shellfish biotoxins for the aquaculture industry.

Subsequently, funded by the NERC PURE Associates programme and the European Fisheries Fund, we have developed these prototypes to allow the production of a weekly HAB bulletin that is issued, through our collaborators Seafood Shetland, to the shellfish aquaculture industry to allow them to better plan their harvesting operations.

Paralytic shellfish poisoning toxins & causative phytoplankton



Mean wind direction observed in Shetland- Weeks 28-31



Mean wind direction and speed observed in Shetland over the past four weeks. Higher wind speeds are shown in lighter shades. The percentage of time the wind blew from any particular direction is shown by the length of the triangle. The resultant vector represented by the thin blue line represents the average wind direction for the week.
The mean wind direction for the month of July is also shown

Status:
Over the past week the average wind direction has been very variable.

Predictions:
There is a small chance that there will be wind blown *Dinophysis* blooms in Shetland this week.
Why do we think this?
Dinophysis can bloom out at sea and at shelf fronts found off the West of Shetland. Westerly winds can then blow these blooms in to shore. Wind for the past week has been variable but has only blown from the West on one day out of the seven.
Although these variable winds are unlikely to bring *Dinophysis* in to shore from the West they can have the effect of holding *Dinophysis* in various voes and inlets depending on their geographical orientation.

Status of harmful algae & biotoxins present in Shetland

Biotoxin	Status	Location & comments
PSP	Amber	2250 µg/kg at East of Lings. Warning levels at North Flotta and East Burwick Mussels. Present in low concentrations elsewhere.
OA/DTX/PTX	Green	Warning levels in Sandsound Voe, North Flotta and Stream Sound. present in most other sites. Not detected in Inner Site 2- Nisbet.
ASP	Green	Not present
YTX	Green	Not present
AZA	Green	Not present

Species	Status	Location & comments
<i>Alexandrium</i>	Amber	Present in all sites except Inner Site 2- Nisbet
<i>Dinophysis</i>	Amber	Present in all sites except Inner Site 2- Nisbet
<i>Pseudo nitzschia</i>	Amber	Present in all sites. Still above trigger levels in Parigate and Busta Voe Lee
<i>Prorocentrum lima</i>	Amber	Above trigger levels in South Voe Mussels. Present in Sandsound Voe, East of Lings and Inner Site 2- Nisbet

Biotoxin & Species	RL	Warning	Alert	Severe
PSP	<RL	RL-400 µg/kg	400-800 µg/kg	800-4000 µg/kg
OA/DTX/PTX	<RL	1-30 µg/kg	30-100 µg/kg	100-300 µg/kg
ASP	LOQ	LOQ-10 mg/kg	10-30 mg/kg	30-100 mg/kg
YTX	<RL	1-10 mg/kg	10-75 mg/kg	75-100 mg/kg
AZA	<RL	1-10 µg/kg	10-100 µg/kg	100-1000 µg/kg
<i>Alexandrium</i>	<20 cells/l	20-100 cells/l	100-200 cells/l	200-1000 cells/l
<i>Dinophysis</i>	<20 cells/l	20-100 cells/l	100-1000 cells/l	1000-10000 cells/l
<i>Pseudo nitzschia</i>	<20 cells/l	20-40,000 cells/l	40,000-50,000 cells/l	50,000-100,000 cells/l
<i>Prorocentrum lima</i>	<10 cells/l	10-100 cells/l	100-1000 cells/l	1000-10000 cells/l

NOTE:
This page is intended as a quick overview of the situation in the Shetland Islands. If the status for a particular species or biotoxin is amber or red please check the relevant pages in the bulletin for more details and specific locations.
RL-reporting limit;
LOQ- Limit of quantification

Publications 2013-14

Davidson K. (2014) The challenges of incorporating realistic simulations of marine protists in biogeochemically based mathematical models. *Acta Protozool.* 53: 129-138

Bresnan E, Davidson K, Edward M, Fernand L, Gowen R, Hall A, Kennington K, McKinney, A, Milligan S, Raine R, Silke J (2013) Impact of climate change on harmful algal blooms. *MCCIP Science Review*

Eckford-Soper, L.K. Davidson, K., Bresnan E. (2013) Identification and quantification of toxic and non-toxic strains of the harmful dinoflagellate *Alexandrium tamarense* using fluorescence in situ hybridization and flow cytometry. *Limnology and Oceanography Methods* 11:540-548

Tweddle JF, Sharples J, Palmer MR, Davidson K, McNeill S. (2013) Enhanced nutrient fluxes at the shelf sea seasonal thermocline caused by stratified flow over a bank. *Progress in Oceanography* 117:37-47.

Davidson K, Gilpin LC, Pete R, Brennan D, McNeill S, Moschonas G, Sharples J. (2013) Phytoplankton and bacterial distribution and productivity on and around Jones

Bank in the Celtic Sea. *Progress in Oceanography* 117:48-63.

Narayanaswamy BE, Coll M, Danovaro R, Davidson K, Ojaveer H, Renaud PE (2013) Synthesis of Knowledge on Marine Biodiversity in European Seas: From Census to Sustainable Management. *PLoS ONE* 8(3): e58909.

doi:10.1371/journal.pone.0058909

Reports

Higman W, Turner A, Baker C, Higgins C, Veszelszki A, Davidson K (2013) Research to support the development of a monitoring programme for new or emerging marine biotoxins in shellfish in UK waters. Report to the Food Standards Agency. 437 pp.

Stubbs B, Swan S, Davidson K, Turner A, de Campos CJ, Algoet M (2014) Annual report on the results of the Biotxin and Phytoplankton Official Control Monitoring Programmes for Scotland 2013. Annual report to FSAS. 146 pp.

ICES (2013) Report of the ICES-IOC working group on harmful algal bloom Dynamics (WDHABD), Belfast 2013 (participating author)

RESEARCH STUDENTS

Grigorios Moschonas (PhD): Dissolved organic nitrogen dynamics and its influence on phytoplankton communities in coastal waters around the UK, with a focus on HAB species. Funded by NERC. UHI (University of Aberdeen). 2011-2015

Ruth Paterson (PhD): Understanding the factors governing *Azadinium* generated shellfish toxicity in Scottish waters. Funded by FSA/SAMS. UHI (University of Aberdeen). 2013-2017

Beatrix Siemerling (PhD): The advective transport of harmful phytoplankton in UK shelf Seas. Funded by NERC. UHI (University of Aberdeen). 2013-2017

Iona Campbell (PhD): Interactions between macroalgae aquaculture for biofuels and phytoplankton. UHI (University of Aberdeen). 2011-2015

Rebecca Weeks (PhD): Identification and tracking of harmful algal blooms using multi-spectral techniques from Remotely Piloted Aircraft platforms. Funded by NERC. UHI (University of Aberdeen). 2013-2017

Silje-Kristin Jenssen (PhD): Is biotoxin exposure from harmful algae the reason for the decline in harbour seal populations in Scotland? A view through a food chain study. MASTS prize studentship. University of St Andrews. 2011-2015



'SAMS continues to monitor Scotland's waters for harmful algae in support of public health and a thriving aquaculture industry

Photograph: Tim Winterburn



Microbial and Molecular Biology

DR PAUL TETT

LORN PELAGIC OBSERVATORY

Marine ecosystems are hard to fathom. They are underwater, and thus largely invisible. The purpose of the Lorn Pelagic Observatory (LPO) is to use information gained from water samples and electronic probes to follow seasonal changes in the plankton of the inner Firth of Lorn and its sea-lochs Creran, Etive and Spelve, and to track changes in this pelagic ecosystem over years and decades.

SMBA (the Scottish Marine Biological Association and forerunner to SAMS) started to do this in 1970, when Anton Edwards and I, and later Ken Jones and Brian Grantham, began to study the distribution of phytoplankton in relation to water movements and salinity gradients in these fjords.

Time-series work became unfashionable in the 1980s, but regular sampling was resumed in 2000 by Keith Davidson and research students. In 2013-2014, I made a case to Defra for the inclusion of the LPO in the network of stations being set up by the UK to monitor pelagic environmental status for the Marine Strategy Framework Directive, and so Callum Whyte and I have been analysing some of the existing data from LPO sites.

Results include the finding that, in Loch Creran, the season when the characteristic diatom *Skeletonema* is abundant has shortened between 1970-81 and 2006-2012 (see figure). If this diatom's contribution to primary production is not supplied by other micro-algae, the change implies a reduction in the food available to planktonic animals and to filter-feeding shellfish such as mussels.

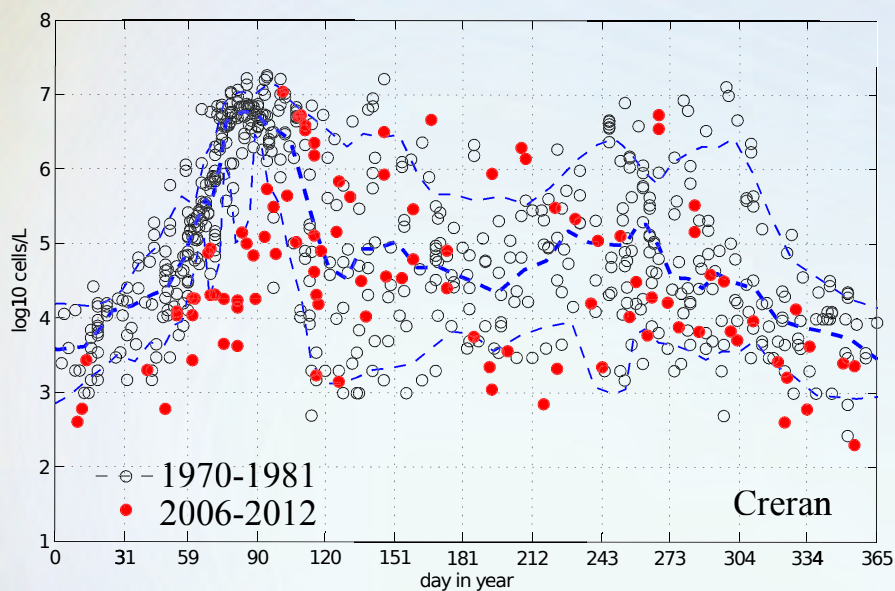


Figure legend: Upper part shows the Lorn Pelagic Observatory area and the central site at LY1 in the inner Firth of Lorne. Lower part shows the seasonal cycle of abundance of the diatom *Skeletonema* spp. in Loch Creran during 1970-1981 and in 2006-2012, plotted against a logarithmic scale. Each point results from the microscopical analysis of one water sample taken from the upper 10 metres of the loch's water column.

Publications 2013-14

Tett, P. (2014). Net Microplankton Production in loch Creran and its approaches in September 2013. SAMS Report 286, 39 pp. Oban, Scottish Association for Marine Science.

Tett, P. (2013). Creran Microplankton in 2012. SAMS Report 285, 34 pp. Oban, Scottish Association for Marine Science.

Brito, A. C., A. Newton, T. F. Fernandes and P. Tett (2013). Measuring Light Attenuation in Shallow Coastal Systems. *Journal of Ecosystem & Ecography*, 3(122), 1-4.

Tett, P., R. Gowen, S. Painting, M. Elliott, R. Foster, D. Mills, E. Bresnan, E. Capuzzo, T. Fernandes, J. Foden, R. Geider, L. Gilpin, M. Huxham, A. McQuatters-Gollop, S.

Malcolm, S. Saux-Picart, T. Platt, M.-F. Racault, S. Sathyendranath, J. van der Molen and M. Wilkinson (2013). A framework for understanding marine ecosystem health. *Marine Ecology Progress Series*, 494, 1-27.



Microbial and Molecular Biology

DR RAY LEAKEY

Algae under Arctic sea ice: important but overlooked components of food webs?

Arctic sea-ice provides a habitat for a range of microbial plants and animals that live in or on the underside of the ice. Despite low temperatures and freezing conditions, these sea-ice associated communities can be highly productive, providing an important food source for the Arctic marine ecosystem.

Recently SAMS scientists, in collaboration with colleagues from Canada, Denmark and Greenland, have observed high densities of floating algal aggregates under Arctic sea ice, which may comprise an important but overlooked component of ice-associated food webs (Glud et al. 2014).

The algal aggregates were collected by divers from a large (1.7 km²), melting ice floe in summer 2010, during the Icechaser II expedition to the Fram Strait on the RRS James Clark Ross.

The underside of the ice was covered with free-floating 5-20 cm³ large algal aggregates (see photo) that were dominated by single-celled pennate diatoms of a type found within the ice (*Navicula transitans*). Thus, we speculate that the aggregates were formed from

diatoms released from the rapidly-melting sea ice as it drifted south, and that they remained buoyant due to extensive production of exopolymers and gas bubbles.

The photosynthetic production and biomass of the floating algal aggregates were, respectively, 4.5 and 6 times greater than that of microalgae living in or on the underside of the sea ice. They therefore represent a highly concentrated food source for ice-associated animals. This contrasts with other recently described ice-associated aggregates that are dominated by centric diatoms (*Melosira sp.*), which sink to the seabed supporting benthic animals.

We do not know if the mass occurrence of algal aggregates observed in the Fram Strait during this study represents either an overlooked annually occurring event or a rare phenomenon. However, if widespread they would serve as an important component of ice-associated food webs and a potentially important export of organic carbon from the high Arctic.



Diver collecting algal aggregates from the underside of a ice flow in the Fram Strait

Publications 2013-14

Roleda, M.Y., Slocombe, S.P., Leakey, R.J.G., Day, J.G., Bell, E.M., Stanley, M.S. (2013). Effects of temperature and nutrient regimes on biomass and lipid production by six oleaginous microalgae in batch culture employing a two-phase cultivation strategy. *Bioresource Technology* 129: 439-449.

Glud, R.N., Rysgaard, S., Turner, G., McGinnis, D.F., Leakey, R.J.G. (2014).

Biological- and physical-induced oxygen dynamics in melting sea ice of the Fram Strait. *Limnology and Oceanography*.59,1097-1111

García-Martín E.E., McNeill S., Serret P., Leakey R.J.G. (2014). Primary production, community respiration and bacterial metabolism in Arctic sea ice leads during summer 2010. In press *Deep Sea Research II*. DOI: 10.1016/j.dsr.2014.06.007

García-Martín E.E., McNeill S., Serret P., Leakey R.J.G. (2014). Plankton metabolism and bacterial growth efficiency in offshore waters along a latitudinal transect between the UK and Svalbard. In Press *Deep Sea Research II*. DOI: 10.1016/j.dsr.2014.06.004



Earth Science

DR JOHN HOWE

Lo-Rise project samples radionuclides in marine sediments of the Irish Sea

In the past year SAMS, in collaboration with the Universities of Manchester, Glasgow and Edinburgh, led a sampling trip onboard the RV Prince Madog (Fig. 1).

This was part of the LO-RISE (Long-lived Radionuclides in the Surface Environment - Mechanistic Studies of Speciation, Environmental Transport and Transfer) project, which is a successful NERC consortium led by the University of Manchester. At SAMS we are involved in the marine sediment sampling and radionuclide analyses, as well as the modelling of food web uptake of radioactive ^{14}C .

The voyage successfully collected marine sediment, water samples, zooplankton, benthos and fish from offshore the Sellafield nuclear plant (Fig. 2) and around the Isle of Man.

The project examines the speciation, physico-chemical transport and ecological transfers of Uranium/Radium and ^{14}C within the near sea bed environment.

Specifically, for this part of the programme, the investigation will centre on:

(1) ^{14}C speciation and distribution in sediments; the transfer of ^{14}C to sea life; the ^{14}C transport in water within the Irish Sea and Scottish coastal waters;

(2) ^{14}C speciation and distribution and the role of organic matter in Uranium transport within NE Irish Sea saltmarsh sediments.

(3) Incorporation of this mechanistic understanding into predictive models of speciation, physico-chemical transport and ecological transfer processes, over a range of scales.

The SAMS-SUERC (Scottish Universities Environmental Research Centre) PhD student, Kieran Tierney is investigating the role of particulate and dissolved organic and inorganic carbon in ^{14}C transport from the Irish Sea to the wider oceanic environment and will also include an investigation of ^{129}I transport.

An integrated food web study, carried out in the NW Scotland, will analyse materials such as macrofauna, plankton and fish samples for ^{14}C and the data used to parameterise ecosystem models of the west coast of Scotland and the Irish Sea.



Fig. 2: The offshore view of Sellafield nuclear processing plant, Cumbria. The project sampled the seabed around the plant and the wider Irish Sea examining the dispersal of low level radioactive material in the marine environment.



Fig. 1: Lo-Rise project team onboard the RV Prince Madog in the Clyde Sea. From left: John Howe (SAMS), Graham Muir (SUERC), Katie Law (Manchester), Tim Brand (SAMS), Daisy Ray (Manchester), Colin Abernethy (SAMS), Thom Nickell (SAMS) & Kieran Tierney (SUERC).

RESEARCH STUDENTS

Riccardo Arosio (PhD): Hebrides ice stream and deglaciation of the Hebrides Shelf & Firth of Lorn. UHI (University of Aberdeen). 2013-2017

Craig Smeaton (PhD): Carbon budgets of inshore sediments, west of Scotland. University of St Andrews. 2013-2017

Kasper Weilbach (PhD): Late Quaternary glaciation of the continental shelf offshore of NW Ireland. University of Durham. 2013-2017

Jirina Stehlikova (PhD): Sediment deposition in the deep sea - from seamounts to the hadal trenches. UHI (University of Aberdeen). NERC funded. 2012-2016

Peter Taylor (PhD): Leakage of carbon dioxide from a simulated sub-seabed Carbon Capture and Storage reservoir: potential impacts on benthic biogeochemistry. UHI (University of Aberdeen). 2011-2014.



Earth Science

PROFESSOR BILL AUSTIN

Using forams to show long term changes in climate and environment

I was appointed professor of marine geology at SAMS in September 2013 and hold a fractional appointment at both SAMS (0.2 FTE) and the University of St Andrews (0.8 FTE).

My research focus is climate reconstruction, with a particular interest in the development of Foraminifera as long-term indicators of climate and environmental change.

In February 2014, I went with (Honorary) Professor Kate Darling to the University of Concepcion in Chile, to attend the International Symposium on Foraminifera (Forams 2014), at which we were both convening separate sessions.

During Forams 2014, the general assembly voted to hold the next meeting, Forams 2018, in Scotland. The International Symposium on Foraminifera Forams 2018 (Scotland) will continue to build on the tradition of the highly successful meetings previously held at regular intervals all around the world since 1975.

At St Andrews, my wife Heather (Dr Heather Austin) and I run a seawater culturing facility that was set-up with NERC-funding,

maintaining benthic foraminifera for biological and geochemical research work; we have links to both CCAP and NFSD at SAMS to maintain this facility.

At SAMS, I have recently led on a capital equipment bid to fund a new facility in the Department of Biogeochemistry and Earth Sciences for the stable isotope analysis of seawater. MASTS-funded pilot work in this area led to a collaboration with Dr Bee Berx (Marine Scotland Science) and the joint supervision of a final year dissertation student (Christine McKenna), who won the Challenger Society tripartite prize 2014 for the best Marine Sciences undergraduate dissertation in the United Kingdom.

Other research opportunities to collaborate with SAMS scientists are being explored and pursued. Recently I secured MASTS PhD funding with Keith Davidson (SAMS) and Eileen Bresnan (MSS), and we hope to appoint a candidate to this project, "A 100-year record of changing toxic algae in Scottish coastal waters related to change in land use and temperature", later in 2014.



From left to right: the organisers of Forams 2014, Tatiana Hromic (Universidad de Magallanes, Chile) and Margarita Marchant (University of Concepcion, Chile) with the happy bid-winners for Forams 2018, Bill Austin and Kate Darling

Photo: Dr Clare Bird, University of Edinburgh

Publications 2013-14

Cunningham, L.K., **Austin, W.E.N.**, Knudsen, K.L., Eiríksson, J., Scourse, J.D., Wanamaker, A.D., Jr, Butler, P.G., Cage, A., Richter, T., Husum, K., Hald, M., Andersson, C., Zorita, E., Linderholm, H.W., Gunnarson, B.E., Sicre, M.A., Sejrup, H.P., Jiang, H., and Wilson, R.J.S. (2013)

Reconstructions of surface ocean conditions from the North East Atlantic and Nordic Seas during the last millennium. *The Holocene*.

Peter M. Abbott, **William E.N. Austin**, Siwan M. Davies, Nicholas J.G. Pearce and Fiona D. Hibbert (2013). Cryptotephrochronology of the Eemian and the last interglacial-glacial transition in the North East Atlantic. *Journal of Quaternary Science*, 28(5), 501-514.

D.J. Reynolds, P.G. Butler, S.M. Williams, J.D. Scourse, C.A. Richardson, A.D. Wanamaker Jr., **W.E.N. Austin**, A.G. Cage and M. Sayer (2013). A multiproxy reconstruction of Hebridean Shelf Sea spring sea surface temperatures from 1805-2010. *Palaeogeography, Palaeoclimatology and Palaeoecology*, 386, 275-285.

Small, D., **Austin, W.E.N.** and Rinterknecht, V (2013). Freshwater influx, hydrographic reorganization and the dispersal of ice-rafted detritus in the sub-polar North Atlantic Ocean during the last. *Journal of Quaternary Science*, 28(5), 527-535.

Khanna, N., Godbold, J.A., **Austin, W.E.N.** and Paterson, D.M (2013). The impact of ocean acidification on the functional morphology of Foraminifera. *PLoS ONE* 8(12): e83118.

Doi:10.1371/journal.pone.0083118.

Joe A. Todd, **William E.N. Austin** and Peter M. Abbott (2014). Quantifying bioturbation of a simulated ash fall event. *Geological Society, London, Special Publication*, 398,.

Marion Kuhs, **William E.N. Austin**, Peter M. Abbott and David A. Hodell. (2014) Tephra in the glacial North Atlantic: iceberg-rafted or primary airborne? *Geological Society, London, Special Publication*, 398.

Hibbert, F.D., Wastegaard, S., **Austin, W.E.N.** and Gwynn, R (2014). Identification of an early MIS 6 age Icelandic tephra within a N.E. Atlantic (Rockall Trough) sediment core. *Geological Society, London, Special Publication*, 398.

Abbott, P.M., **Austin, W.E.N.**, Davies, S.M., Pearce, N.J.G., Rasmussen, T.L., Wastegard, S. and Brendryen, J (2014). Re-evaluation and extension of the Marine isotope Stage 5 tephrostratigraphy of the Faroe Islands region: The cryptotephra record. *Palaeogeography, Palaeoclimatology, Palaeoecology*, 409, 153-168.

Siwan M. Davies, Peter M. Abbott, Rhian H. Meara, Nicholas J.G. Pearce, **William E.N. Austin**, Mark R. Chapman, Anders Svensson, Matthias Bigler, Tine L. Rasmussen, Sune O. Rasmussen, Elizabeth J. Farmer (2014). A North Atlantic tephrostratigraphical framework for 130–60 ka b2k: new tephra discoveries, marine-based correlations, and future challenges. *Quaternary Science Reviews*, <http://dx.doi.org/10.1016/j.quascirev.2014.03.024>.

Alistair WR Seddon, Anson W Mackay, Ambroise G Baker, H John B Birks, Elinor Breman, Caitlin E Buck, Erle C Ellis, Cynthia A Froyd, Jacquelyn L Gill, Lindsey Gillson, Edward A Johnson, Vivienne J Jones, Stephen Juggins, Marc Macias-Fauria, Keely Mills, Jesse L Morris, David Nogués-Bravo, Surangi W Punyasena, Thomas P Roland, Andrew J Tanentzap, Kathy J Willis, Martin Aberhan, Eline N Asperen, **William EN Austin**, Rick W Battarbee, Shonil Bhagwat, Christina L Belanger, Keith D Bennett, Hilary H Birks, Christopher Bronk Ramsey, Stephen J Brooks, Mark Bruyn, Paul G Butler, Frank M Chambers, Stewart J Clarke, Althea L Davies, John A Dearing, Thomas HG Ezard, Angelica Feurdean, Roger J Flower, Peter Gell, Sonja Hausmann, Erika J Hogan, Melanie J Hopkins, Elizabeth S Jeffers, Atte A Korhola, Robert Marchant, Thorsten Kiefer, Mariusz Lamentowicz, Isabelle Larocque-Tobler, Lourdes López-Merino, Lee Hsiang Liow, Suzanne McGowan, Joshua H Miller, Encarni Montoya, Oliver Morton, Sandra Nogué, Chloe Onoufriou, Lisa Park Boush, Francisco Rodriguez-Sanchez, Neil L Rose, Carl D Sayer, Helen E Shaw, Richard Payne, Gavin Simpson, Kadri Sohar, Nicki J Whitehouse, John W Williams, Andrzej Witkowski (2014). Looking forward through the past: Identification of 50 priority research questions in palaeoecology. *Journal of Ecology*. Doi: 10.1111/1365-2745.12195.



Earth Science

DR KIRSTY CROCKET

Using cold water corals and sediments to show long term changes in climate

My research focuses on resolving past changes in Quaternary climate, and beyond, by establishing records of variation in seawater chemistry and composition and relating these to changes in the climate system.

I use marine sediments and cold water corals as archive materials from which to extract records of radiogenic isotopes (Nd, Pb, Sr) and rare earth element profiles.

These are used to investigate a number of important processes that influence or are influenced by climate, e.g. changes in deep ocean circulation and their impact on atmospheric CO₂ concentrations; variation in high

latitude continental weathering intensity as a source of nutrients to the surface ocean and the effect on biogeochemical cycles and ultimately atmospheric carbon sequestration; development of new proxies in cold water corals to identify small changes in seawater pH that can be related to the concentration of atmospheric CO₂.

Successes this year include the MASTS visiting fellowship awarded to Dr Ed Hathorne of GEOMAR (DE) to spend 6 weeks at SAMS working in collaboration with me on rare earth element concentrations in cold water corals. This provided the seed data for a grant proposal that I submitted to NERC in July 2014 for ~£600K.

Research students

Riccardo Arosio (PhD): The Hebrides Ice Stream (HIS) and the deglaciation of the Hebrides shelf and Firth of Lorn, western Scotland, UK. UHI (University of Aberdeen) 2013-2017

Publications 2013-14

Crocket, K.C., Lambelet, M., van de Flierdt, T., Rehkämper, M., Robinson, L.F., 2014. Measurement of fossil deep-sea coral Nd isotopic compositions and concentrations by TIMS as NdO⁺, with evaluation of cleaning protocols. *Chemical Geology* 374–375, 128-140.

Crocket, K.C., Foster, G.L., Vance, D., Richards, D.A., Tranter, M., 2013. A Pb isotope tracer of ocean-ice sheet interaction: the record from the NE Atlantic during the Last Glacial/Interglacial cycle. *Quaternary Science Reviews* 82, 133-144.

Crocket, K.C., Vance, D., Foster, G.L., Richards, D.A., Tranter, M., 2012. Continental weathering fluxes during the last glacial/interglacial cycle: insights from the marine

sedimentary Pb isotope record at Orphan Knoll, NW Atlantic. *Quaternary Science Reviews* 38, 89-99.

Crocket, K.C., Vance, D., Gutjahr, M., Foster, G.L., Richards, D.A., 2011. Persistent Nordic deep-water overflow to the glacial North Atlantic. *Geology* 39, 515-518.

van de Flierdt, T., Pahnke, K., Amakawa, H., Andersson, P., Basak, C., Coles, B., Colin, C., **Crocket, K.C.**, Frank, M., Frank, N., Goldstein, S.L., Goswami, V., Haley, B.A., Hathorne, E.C., Hemming, S.R., Henderson, G.M., Jeandel, C., Jones, K., Kreissig, K., Lacan, F., Lambelet, M., Martin, E.E., Newkirk, D.R., Obata, H., Pena, L., Piotrowski, A.M., Pradoux, C., Scher, H.D., Schoberg, H., Singh, S.K., Stichel, T.,

Tazoe, H., Vance, D., Yang, J.J., Partici, G.I., 2012. GEOTRACES intercalibration of neodymium isotopes and rare earth element concentrations in seawater and suspended particles. Part 1: reproducibility of results for the international intercomparison. *Limnology and Oceanography-Methods* 10, 234-251.



Earth Science

DR ROBERT TURNEWITSCH

Samples from *Horizon Deep* - one of the deepest places on earth - will enlighten us

Deep-sea sediments play a central role in a wide range of subject areas such as global biogeochemistry, biodiversity, and reconstructions of past environmental changes in Earth's history.

A number of important controls on the formation of sedimentary deposits in the deep sea have been studied. However, to date, the impact of submarine landscape geometry as a possible control has received little attention.

This seems to be particularly true for 'intermediate-scale' topographic features such as abyssal hills, seamounts and different types of valleys (canyons, fracture zones, hadal trenches), despite estimates suggesting that in the deep open oceans, away from continental margins, there could be as many as ~25 million abyssal hills, knolls and seamounts.

Building on previous expeditions to the Mariana and Japan Trenches, our work in hadal trenches of the Pacific Ocean continued in the Tonga Trench. In collaboration with colleagues from Denmark, Japan and Germany, samples were collected in October 2013 from

Horizon Deep, the second deepest location of the world ocean.

For the first time ever, sediment tracer thorium-234 will be analysed from sediment and water samples collected from such great ocean depths. The results, in turn, will provide crucial information on how sediments, carbon and food are supplied to organisms living in the deepest parts of the ocean.

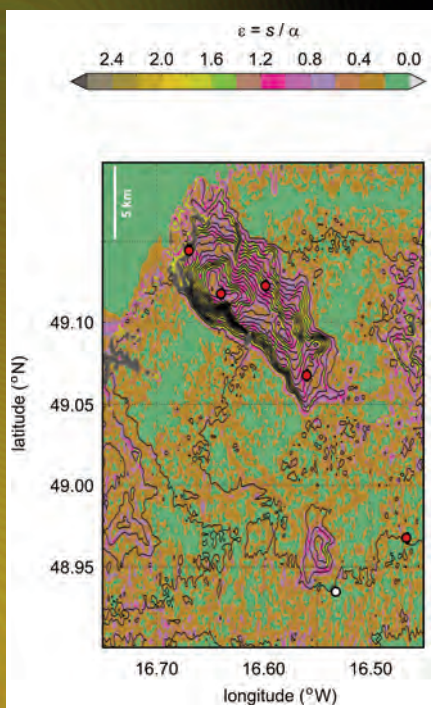
Our work on hill- and seamount-scale topography (Fig.1) led to further evidence indicating that tidal and other higher-frequency (lee-wave, near-inertial) components of deep-ocean currents can be essential for locally driving total current velocities across threshold values for non-deposition/erosion/resuspension of freshly deposited deep-sea sediments.

Moreover, there is evidence suggesting that not only maximum current speeds but also intensities of higher-frequency current-direction variability might control sediment dynamics and sediment formation. This tempers the view that current speed is the main, or even only, controlling factor for

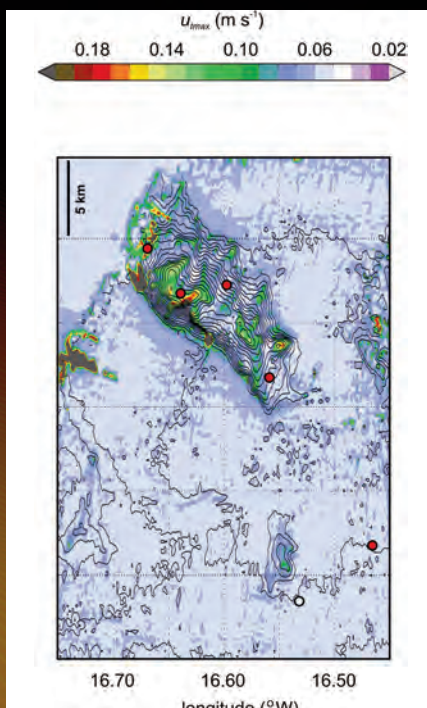
sediment dynamics and sediment formation.

These findings have implications for our mechanistic understanding of biogeochemical fluxes across the sediment/water interface and food supply to biological communities at and in the seafloor.

RESULTS FOR A SHORT (~ 900 M) SEAMOUNT ON THE PORCUPINE ABYSSAL PLAIN IN THE NORTHEAST ATLANTIC.



Slope criticality for semidiurnal tides. For values ≥ 1 , tidally related fluid dynamics become more complex and vigorous.



Maximum total tidal current speeds near the seafloor. Modified from Turnewitsch et al. (2013).

Publications 2013-14

Glud, R.N., Wenzhoefer, F., Middelboe, M., Oguri, K., Turnewitsch, R., Canfield, D.E., Kitazato, H. (2013). High rates of microbial carbon turnover in sediments in the deepest oceanic trench on Earth. *Nature Geoscience* 6, 284-288. doi:10.1038/NNGEO1773.

Chivers, A.J., Narayanaswamy, B.E., Lamont, P.A., Dale, A. Turnewitsch, R. (2013). Changes in polychaete standing stock and diversity on the northern side of Senghor Seamount

(NE Atlantic). *Biogeosciences* 10, 3535-3546.

Turnewitsch, R., Falahat, S., Nycander, J., Dale, A., Scott, R.B., Furnival, D. (2013). Deep-sea fluid and sediment dynamics - Influence of hill- to seamount-scale seafloor topography. *Earth-Science Reviews* 127, 203-241

RESEARCH STUDENTS

Jirina Stehlikova (PhD): Sediment deposition in the deep sea - from seamounts to the hadal trenches. UHI (University of Aberdeen). NERC funded. 2012-2016

Adam Chivers (PhD): The biodiversity and ecology of Senghor Seamounts in the (NE Atlantic). UHI (University of Aberdeen). NERC & MASTS funded. 2010-2014



Physics and Technology

DR ANDREW DALE

From the surface to the deep sea: exchange, flow and interaction dynamics

The highlight of the year was a highly successful cruise, with FASNET project colleagues, on RRS James Cook to the Malin shelf edge off NW of Ireland. FASNET is looking at the physical processes driving exchange across the European shelf edge.

A personal focus was two dye tracer releases in which a fluorescent dye was injected into the water column within the alongshelf current and followed as it interacted with the topography of the continental slope.

Preliminary findings confirm the recruitment from the outer shelf and upper slope to the so-called 'Ekman drain', which draws material offshore within a layer near the bed.

Efforts have also continued into the dynamical understanding and modelling of tidal flows in the Firth of Lorn, with further development of surface drifter technologies by Bernard Hagan (SAMS Martech dept) and funding obtained through the Technology Strategy Board to expand the coverage of our drifter dataset and evaluate the use of satellite products for validating numerical models of

such regions.

The Great Race, the outflow to the west of the Gulf of Corryvreckan, remains a major focus of interdisciplinary efforts to understand the interaction between physical dynamics and the ecology of such energetic environments.

A final thread during this period has been research into the physics of deep-sea interactions with seabed topography. The MIDAS project (also involving SAMS colleagues Mark Inall and Dmitry Aleynik), is looking at the impact of deep-sea mining activities, and we are working on understanding and modelling the small-scale physics of the environment into which disturbed sediment and waste materials are introduced.



Preparing dye plumbing

Publications 2013-14

Turnewitsch R, Falahat S, Nycander J, Dale AC, Scott RB, Furnival D (2013) Deep-sea fluid and sediment dynamics—Influence of hill-to seamount-scale seafloor topography. *Earth-Science Reviews* 127, 203-241.

Abell RE, Brand T, Dale AC, Tilstone GH, Beveridge C (2013) Variability of particulate flux over the Mid-Atlantic Ridge. *Deep Sea Research Part II: Topical Studies in Oceanography* 98, 257-268.

Miller PI, Read JF, Dale AC (2013) Thermal front variability along the North Atlantic Current observed

using microwave and infrared satellite data. *Deep Sea Research Part II: Topical Studies in Oceanography* 98, 244-256.

Chivers AJ, Narayanaswamy BE, Lamont PA, Dale AC, Turnewitsch R (2013) Changes in polychaete standing stock and diversity on the northern side of Senghor Seamount (NE Atlantic). *Biogeosciences* 10, 3535-3546.

RESEARCH STUDENTS

Sarah Hughes (PhD): Inflow of Atlantic water to the North Sea: seasonal variability on the East Shetland Shelf. UHI (University of Aberdeen), 2007-2013 (part-time, completed).

Mike Bedington (PhD): Developing hydrodynamic models to forecast where whales struck by tidal-turbines would strand. UHI (University of Aberdeen), 2012-2011.



Physics and Technology

DR FINLO COTTIER

Cool collaboration on high latitude systems

Much of my research is focussed on high latitude marine systems, particularly in the Arctic, but what do I mean by systems?

Systems are the interactions between the ocean, atmosphere, sea ice, glaciers, marine plants and animals and this is what particularly interests me.

Some projects are concerned with purely physical aspects of the arctic, primarily the ocean and the ice, and we are currently working on problems related to how a warmer ocean will impact glacial stability.

Other aspects of my research are more interdisciplinary in their approach; bringing together measurements of the physical environment with measurements of biological communities. In particular, I'm interested in the vertical migration behaviour of arctic zooplankton.

The majority of my Arctic research is conducted in collaboration with Norwegian research groups, mainly the University of Tromso and the University Centre in Svalbard (UNIS). Part of this collaboration is to contribute to the taught courses at UNIS on Arctic biology where we develop small research projects for masters and PhD students.

In 2010 we undertook a comprehensive study on a student

cruise of zooplankton vertical migration patterns in the Arctic and discovered using acoustic sensors migrating populations that had very complex distributions in the water. We were able to relate this to the physical environment and the occurrence of phytoplankton in the water and identify which species contributed to the migration. These combined efforts of lecturers and students on the course has led to a recent paper published this year in the *Journal of Plankton Research* titled *Arctic complexity: a case study on diel vertical migration of zooplankton*.



Finlo pictured holding a moored CTD unit - an instrument used on the Arctic Observatories.

Publications 2013-14

Inall M, Murray T, Cottier F, Scharrer K, Boyd, T, Heywood, K, Bevan S (2014) Oceanic heat delivery via Kangerlugssuaq Fjord to the south-east Greenland ice sheet. *Journal of Geophysical Research* 119 (2). 631–645

Berge J, Cottier F, Varpe Ø, Renaud PE, Falk-Petersen S, Kwasniewski S, Griffiths C, Søreide J, Aubert A, Bjærke O, Hovinen J, Juul-Madsen S, Tveit M, Markkula S (2014) Arctic complexity: a case study on diel vertical migration of zooplankton. *Journal of Plankton Research* in press 10.1093/plankt/fbu059

Tarling GA, Cottier FR, Everson I (2014) Spatial patterns in the vertical structure of euphausiids in Gullmarsfjord, Sweden: identifying influences on bilayer formation and distributions. *Marine Biology Research* 10, 6, p. 537-553

Falk-Petersen S, Pavlov V, Berge J, Cottier FR, Kovacs KM, Lydersen C (2014) At the rainbow's end – A case study of high productivity fuelled by winter upwelling along an Arctic shelf. *Polar Biology*, in press 10.1007/s00300-014-1482-1

Wallace M, Cottier F, Brierley A, Tarling G (2013) Modelling the influence of copepod behaviour on fecal pellet export at high latitudes. *Polar Biology* 36:579–592

RESEARCH STUDENTS

Lewis Drysdale (PhD): Arctic Fjords: simplified modelling and the role of freshwater. UHI (University of Aberdeen). 2013-2016

Laura Hobbs (PhD): Pan Arctic Diel Vertical Migration. Funded by the Norwegian Research Council. UHI (University of Aberdeen). 2012-2015.

Sam Jones (PhD): Shelf edge exchange and the influence on coastal oceanography. Funded by NERC. UHI (University of Aberdeen). 2012-2015.

D Slater (PhD): Investigating controls on flow variability in Greenland tidewater glaciers. University of Edinburgh. 2013-2016

N Fraser (PhD): Impact of variable ocean/shelf exchange on glacial dynamics in SE Greenland. University of Edinburgh & SAMS. 2013-2016

J Grenvald (PhD): Diel vertical migration of marine zooplankton in the polar night: who, how and why? Funded by Norwegian Research Council. University of Tromsø. 2012-2015.

A Goldsack (PhD): Oceanographic variability around South East Greenland. Swansea University. 2011-



Physics and Technology

DR STUART CUNNINGHAM

The Atlantic ocean and climate

Earth's climate is warming rapidly. Oceans are acidifying and warming, and sea levels are rising: at the present time the oceans are absorbing 40% of anthropogenic carbon dioxide emissions and 90% of the excess heat. Ocean circulation, through its long-term, global-scale transport of heat and carbon, modulates the global freshwater cycle, and affects the extent and character of climate and climate change.

Physical oceanography is one of the leading scientific disciplines in the 21st Century: an imperative is making the sustained observations necessary for testing paradigms of processes and change.

Of all oceans, the North Atlantic is most directly and intimately connected to high-latitudes allowing warm, salty water to be imported in the upper ocean and then exported as colder, fresher deeper water.

This overturning circulation is a critical path of Earth's climate because it transports heat northward, warming the atmosphere, and ultimately this is why the UK and Europe are 5-10°C warmer than otherwise. The overturning is a "fan-assisted storage heater for Europe".

Many patterns of variability have been identified around the Atlantic of which sea-surface temperature is the primary driver: these include variability in Sahel and Amazonian rainfall, tropical hurricane frequency, American and European precipitation patterns, salmon recruitment, cod populations, and coastal phytoplankton distribution.

It is believed that underlying the large-scale, decadal patterns of sea surface temperature variability is variability in the Atlantic overturning circulation (and the heat flux carried by the overturning).

SAMS, with the Atlantic on our doorstep, is building a new team to work on Atlantic circulation and climate. Two new staff have been appointed this year: Dr Stefan Gary (photo 1), a leading researcher in this topic joined SAMS from Duke University, North Carolina, and Dr Clare Johnson (photo 2) - a recent graduate of the University of Aberdeen. This team focuses on making state-of-the-art ocean observations and interpreting them, and analysing and interpreting ocean models.

We lead and contribute to a number of existing and new long-term national and international ocean climate programmes. The three major programmes in which

we are currently involved are:

1. The NERC National Capability Programme, The Extended Ellett Line (prj.noc.ac.uk/ExtendedEllettLine/) for which Dr Stefan Gary of SAMS is a co-PI with Dr Penny Holliday of the National Oceanography Centre, Southampton.

This includes a summer annual hydrographic cruise from Scotland to Iceland. Led this year by SAMS, the cruise was aboard the RRS James Cook (cruise JC086), 5th-26th May 2013 (Photo 1).

Following this SAMS deployed a Seaglider to obtain a winter hydrographic section to match the summer section along the same transect;

2. On the European level, we are partners in the EU FP7 programme, Predictability of the climate in the North Atlantic/European sector related to North Atlantic/Arctic Ocean sea surface temperature and sea ice variability and change (NACLIM, www.naclim.eu/);

3. The Overturning in the Subpolar North Atlantic programme (OSNAP, www.ukosnap.org/) aims to generate new knowledge and understanding of the North Atlantic Subpolar Gyre and its wider impacts on climate. This multi-



Photo 1: Stefan Gary after the successful recovery of Seaglider Bellatrix on the RRS James Clark Ross.

Photo: Penny Holiday, NOCS.

institute international programme will deploy moorings and gliders from Newfoundland to Greenland to Scotland in summer 2014.

SAMS is leading the observations of the critical North Atlantic Current warm-water path of the overturning through the Iceland Basin and Rockall Trough (at the time of writing moorings and gliders have been deployed across the subpolar Atlantic by SAMS staff and we eagerly await our new data, which will be retrieved in summer 2015).

THE SUBPOLAR NORTH ATLANTIC

One control on upper water properties in the subpolar North Atlantic is the strength of the large-scale ocean gyre circulation. This weakened from 1995 onwards contracting northwestward.

Work at SAMS (Johnson et al. 2013), has shown that upper waters in the east of the gyre became warmer (+0.72°C) and saltier (+0.088) between 1995 and the mid-2000s, as cooler and fresher subpolar water masses were replaced by those from the south. Further, the nutrient concentrations in the upper waters have decreased (e.g. phosphate -0.14µM) as the

proportion of the nutrient-rich subpolar waters decreased (-35%). This is the first publication of a nutrient timeseries in the subpolar gyre, and raises the possibility of effects on phytoplankton growth in the area (Fig. 1)

THE SUBTROPICAL NORTH ATLANTIC

North Atlantic Eighteen Degree Water (EDW), which has a distinct, low-stratification signature in a temperature range of about $18 \pm 1^\circ\text{C}$, is embedded within the warm, upper layer of the overturning circulation. This watermass has the potential to store heat anomalies from year to year because it is in contact with the atmosphere during the winter but sequestered beneath the surface during other seasons.

Gary et al. (2014) simulated the pathways of about a million particles launched in the EDW of an ocean model to explore the fate of EDW and the endurance of temperature anomalies along particle tracks (Fig. 2). The average residence time of particles in EDW is ~10 months and after sinking into layers beneath EDW, the particles are exported to the higher latitudes

as part of the overturning circulation. Furthermore, temperature anomalies along particle paths persist for an average of ~3 months.

These results are important because although the ~10 month residence time allows for winter-to-winter carryover of signals, anomalies along individual particle tracks are subsumed into the larger whole on much shorter timescales, suggesting that mixing plays a strong role in controlling the fate of heat anomalies within EDW. The methods and results of this work can be applied to understand the potential for the memory of heat anomalies in UK waters.

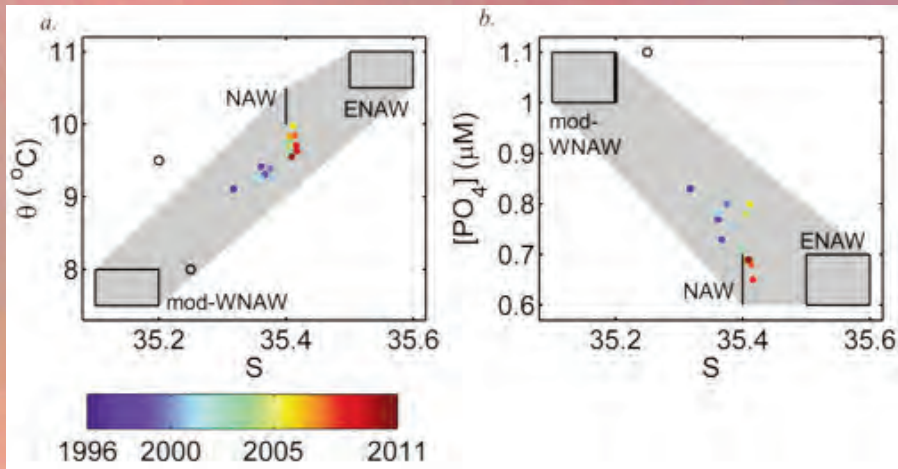


Fig. 1: Plots of upper water salinity (S) versus upper water (a) temperature (θ) and (b) phosphate (PO_4) in the eastern subpolar North Atlantic. Between 1996 and 2011 (blue to red) the upper waters became cooler, fresher and lower in phosphate as a result of increasing proportions of water masses from the south (ENAW and NAW), and decreasing influence of subpolar water masses (mod-WNAW). This is a direct result of a weakening gyre circulation in the subpolar North Atlantic.

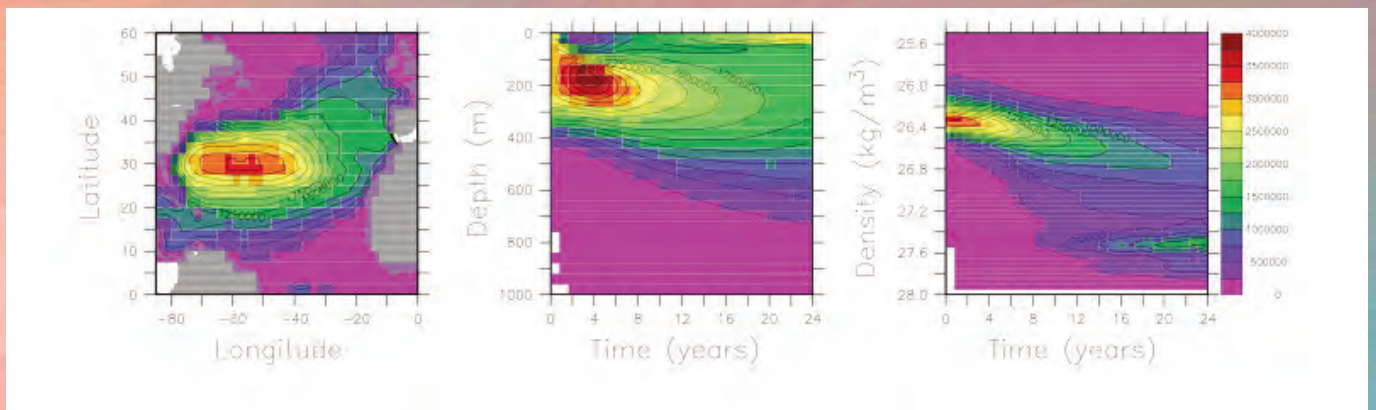


Fig. 2: Summary of 1.2 million particle trajectories. Each particle was initiated in the EDW of a high-resolution ocean model and simulated for 25 years. All the particle positions in longitude, latitude, depth, density, and time coordinates were binned and counted in $2.5^\circ \times 2.5^\circ$ (left), $40 \text{ m} \times 10 \text{ month}$ (centre), and $0.05 \text{ kg/m}^3 \times 10 \text{ month}$ (right) grids. The colour shading, which has the same scale for all panels, indicates the number of particles in each bin including repetitions. The left panel shows a high concentration of particles in the region where EDW is formed and the northeastward export of particles. The centre and right panels show that the particles sink as they are exported and at the same time they move into higher density waters, signifying their exit from EDW in the subtropics and export into the colder, denser waters of the subpolar North Atlantic.



Photo 2: Dr Clare Johnson

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Dr J C A Craik

SAMS Honorary Fellow

Seabird conservation - RSPB species champion 2013

Ground-nesting birds breed in impressive numbers and variety on the many small islands of the sealochs and sounds of west Scotland.

In the past twenty or so years, many of these islands have become empty after repeated predation of eggs and young by introduced American mink.

2013 was the nineteenth successive year of my seabird conservation project, which aims to protect the more important of the remaining colonies by local control of mink.

The study area lies along the mainland shore between Mallaig in the north and West Loch Tarbert in the south, including the Sound of Mull, Loch Fyne and (in some years) the Kyles of Bute.

In 2013, mink control was attempted at 35 sites and birds bred successfully at 18. Of the 17 failures, five of them were *definitely* caused by mink, another six were *probably* caused by mink, while the final six were caused by other predator species. Thus the work achieved its aim (to prevent mink-caused breeding failures) at 24 to 30 of the 35 sites (69-86%).

This work is aimed at terns in particular and in 2013 the tern rafts

at South Shian continued to hold one of the largest tern colonies in the British Isles, with 450 pairs of Common Terns that fledged 440 young (Fig 1). The rafts held 62% of the Common Terns breeding in the study area and 81% of the fledged young. Fences on the rafts protect tern eggs and young from their two most destructive enemies, mink and otter.

As a result of this success, the tern rafts won the species champion prize in the RSPB Nature of Scotland Awards for 2013. The work was also praised in a motion placed before the Scottish Parliament by Mike MacKenzie, MSP for Highlands and Islands, and supported by 29 other members (Motion S4M-08492 dated 3 December 2013: "Defender of Common Terns named Species Champion of the Year") (Fig 2)

Publications

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The South Shian tern rafts in July 2013

Photo: Nicholas Watts

Dr Robin Gibson

SAMS Honorary Fellow

My activities in the year 2013/4 have been restricted to the preparation of the second volume of a book that first appeared in 2005 when I was on site at Dunstaffnage. The second volume is an enlarged, revised and updated version of the first and will be published at the end of 2014. It includes two chapters written by me and the details are: R.N. Gibson, R.D.M. Nash, A.J. Geffen & H.W. van der Veer (eds).

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<http://eu.wiley.com/WileyCDA/WileyTitle/productCd-1118501195.html>

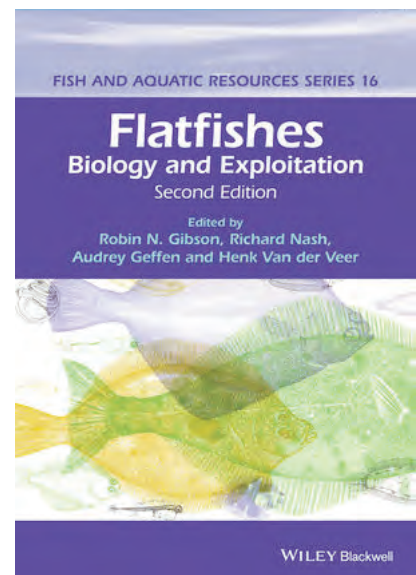


Fig. 2: Scottish Parliament Motion

Professor J Murray Roberts

SAMS Honorary Fellow

Changing oceans affect *Lophelia*, and have done for millenia

Work over the year 2013-14, has revolved around consolidating research outputs from the 2012 Changing Oceans Expedition (RRS James Cook cruise 073) and developing a new line of research by fusing marine environmental data from the Natural Environment Research Council and the oil industry (see www.northseainteractive.hw.ac.uk).

The first publications from the Changing Oceans Expedition have highlighted the variability in carbonate chemistry seen at the Mingulay cold-water coral reef complex.

This relatively shallow inshore *Lophelia* reef complex is influenced by tidally-downwelled surface waters that not only expose the reefs to warmer, phytoplankton-rich waters but to pH variability of up to 0.1 units. The corresponding change in carbon dioxide concentration over a tidal cycle is equivalent to projections of ocean conditions from 25 years in the future.

These findings help put the rapidly growing laboratory experimental literature on the effects of ocean acidification on cold-water corals into a wider context.

Similarly, work published in *Biogeosciences* and *Biological Conservation* demonstrates that these reefs play important functional roles, for instance as spawning grounds for deep-water sharks. Our study follows up observations made over many years

of egg cases of the blackmouth catshark (*Galeus melastomas*) being laid in among live coral colonies from Mingulay.

Finally, work initiated at SAMS through Melanie Douarin's PhD project supervised by Dr. Dan Sinclair has revealed both the longevity and unusually rapid growth rates of these inshore *Lophelia* reefs.

By dating with both U-series and ¹⁴C approaches this work shows that the oldest coral material collected so far dates from 7,700 years ago and that the reefs seem to have periods when their growth was suppressed and periods when they grew more rapidly.

There is an emerging picture that the optimal conditions for reef growth at Mingulay, and elsewhere in the NE Atlantic, may have been between 2,000 and 5,000 years ago. There are several possible reasons for this, mainly relating to shifts in sub-Polar Gyre dynamics, that will give us all considerable scope for further head scratching and grant writing!



The lesser spotted dogfish *Scyliorhinus canicula* resting among coral framework and zoanthids at the Mingulay Reef Complex.

Photo: JC073 Changing Oceans Expedition, Heriot-Watt University.



- Professor of Marine Biology, Heriot-Watt University
- Adjunct Faculty, University of North Carolina Wilmington

Publications

Douarin M, Elliot M, Noble SR, Sinclair D, Henry L-A, Long D, Moreton SG, **Roberts JM** (2013) Growth of north-east Atlantic cold-water coral reefs and mounds during the Holocene: a high resolution U-series and ¹⁴C chronology. *Earth & Planetary Science Letters* 375: 176-187

Findlay HS, Wicks L, Moreno Navas J, Hennige S, Huvenne V, Woodward EMS, **Roberts JM** (2013) Tidal downwelling and implications for the carbon biogeochemistry of cold-water corals in relation to future ocean acidification and warming. *Global Change Biology* 19: 2708-2719

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Professor P Geoff Moore

SAMS Honorary Fellow

Looking at marine biology through history

I have continued to research the history of marine biology in Britain, paying special attention to the history of the Millport laboratory when under the Scottish Marine Biological Association (SMBA), as well as on the short-lived laboratory at Lochbuie on the Isle of Mull.

I have highlighted the role of strategically important researches into agar production done by SMBA to assist the war effort during the Second World War. Having become interested in how marine biology has been proselytized to the public in the past, I have investigated these issues from the eighteenth century onwards and have recently focused attention on how marine natural history has been presented to the public not only via the medium of public aquaria but also in West-of-Scotland newspapers.

Publications

MOORE, P. G., 2013. The Lochbuie Marine Institute, Isle of Mull, Scotland. *Archives of natural history*, 40: 45 51.

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MOORE, P. G., 2013. Sea spiders misrepresented (1887) as crustacean parasites of cetaceans. *Archives of natural history*, 40: 325 357.

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MOORE, P. G., 2014. Another Millport / Great Barrier Reef Expedition (1928-1929) link. *Ayrshire Notes No. 47*, 37 38.

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NATIONAL CAPABILITIES

Our National Capabilities include:

Culture Collection of Algae and Protozoa

National Facility for Scientific Diving

North Atlantic Glider Base

Culture Collection of Algae and Protozoa



visit us at www.ccap.ac.uk

The Culture Collection of Algae and Protozoa (CCAP), located at SAMS, is a component of the UK's scientific infrastructure.

It is funded by NERC as a UK national service culture collection, or Biological Resource Centre (BRC), providing cultures (cyanobacterial, protistan, macro-algal), bioinformatic data, services and advice to the scientific community world-wide.

In the rapidly developing applied phycology sector these roles are particularly relevant as many new users of CCAP from both academia and the commercial sector are not traditional phycologists or protozoologists.

Over the past year, CCAP serviced in excess of 720 orders, which included the provision of >1530 strains. The use of the cultures is almost as diverse as the biodiversity of the strains held, with traditional uses such as teaching, aquaculture starter cultures and ecotoxicology being added to by a huge variety of applied and "blue skies" projects.

The cultures and their associated bioinformatic data are the

foundations of an ever-expanding scientific literature and currently CCAP materials underpin well in excess of 100 scientific publications per year.

CCAP AND EDUCATION

Customers in secondary to HE levels of education in the UK and in the biotechnology sector are provided with materials and advice. Direct training by CCAP includes teaching and supporting students at BSc, MSc & PhD levels within SAMS and UHI, as well as CPD delivery (2 courses).

In addition, the provision of e-Resources to assist the scientific community have included the development and publication of 14 method-sheets for the EU-funded ASSEMBLE tool-box see <http://www.assemblemarine.org/ass>

[ets/Uploads/Documents/tool-box/](#)

Progress in the expansion of the CCAP KnowledgeBase includes the addition of 214 GenBank links, covering 71 strains and linkage of a further 261 papers to 501 strains and 190 strain images.

The use of the KnowledgeBase continues to develop with 2013/14 usage of: 42,900 - which is an increase of 17% on 2012/13 (Fig. 2). Over the whole site, 66% of visitors/sessions are new, 33% are returnees.

The redesign/refresh of the website is complete; it is currently undergoing testing and refinement, to be re-launched in Sept 2014. This and future developments were highlighted in a paper published in

Number of publications citing use of CCAP cultures*

Publishing groups								
Year	Elsevier	Wiley	Taylor & Francis	Springer	Nature Group	PNAS	Plas	Total no.
2013	60	32	12	38	2	1	5	150
2014**	59	25	8	27	1	-	6	126

Fig 1. *Data from online searches using CCAP as search-term and manually checked for relevance

**From Jan 1st – June 30th

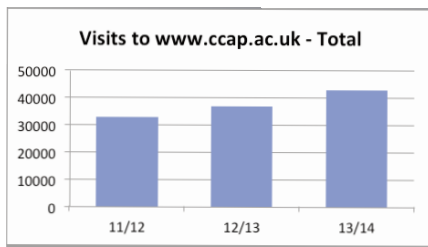


Fig 2. Growth in use of CCAP KnowledgeBase 2011 -2014

Systematics and Biodiversity on the connectivity of live materials and bioinformatic data (Gachon et al., 2013).

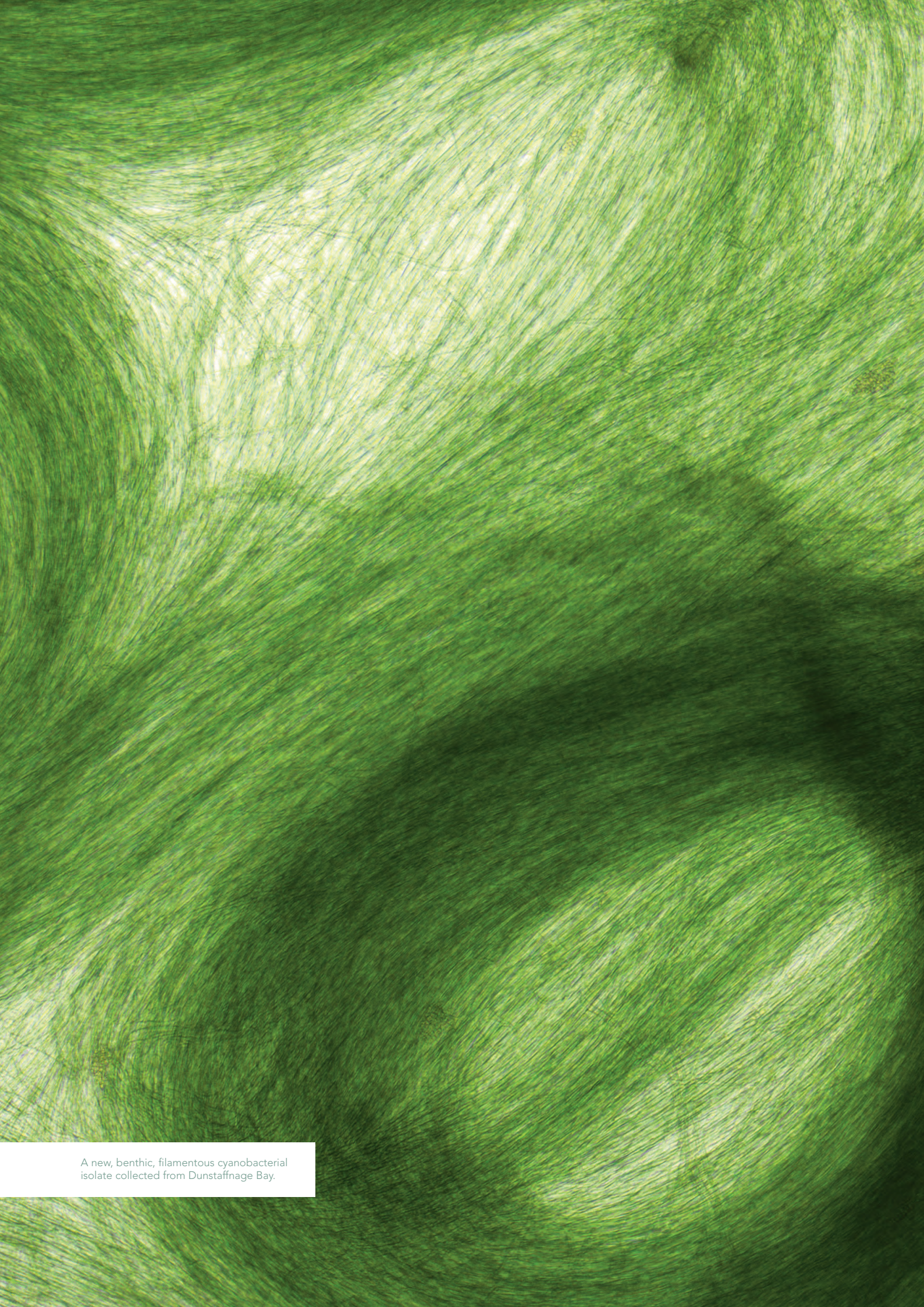
Finally, over the past year CCAP has made substantial contributions to a number of major international projects:

- for ASSEMBLE (<http://www.assemblemarine.org/>), CCAP provided cultures and hosted visiting researchers using CCAP resources;
- for SeaBioTech (<http://spider.science.strath.ac.uk/seabiotech/>), CCAP is involved in assisting the development of a drug/ pharma discovery pipe-line as a means to convert the potential of marine biotechnology into novel industrial products for the pharmaceutical (human and aquaculture), cosmetic, functional food and industrial chemistry sectors;
- for EnAlgae (<http://www.enalgae.eu/> CCAP's expertise in algal cryopreservation is being exploited to develop best-practice for the sustainable biotechnological exploitation of algae;
- and for the recently initiated UK-India BBSRC- DBT India funded project "Sustainable bioenergy from microalgae: A systems perspective", CCAP is developing the decision matrix for choice of production organism as well as researching the optimisation of productivity.

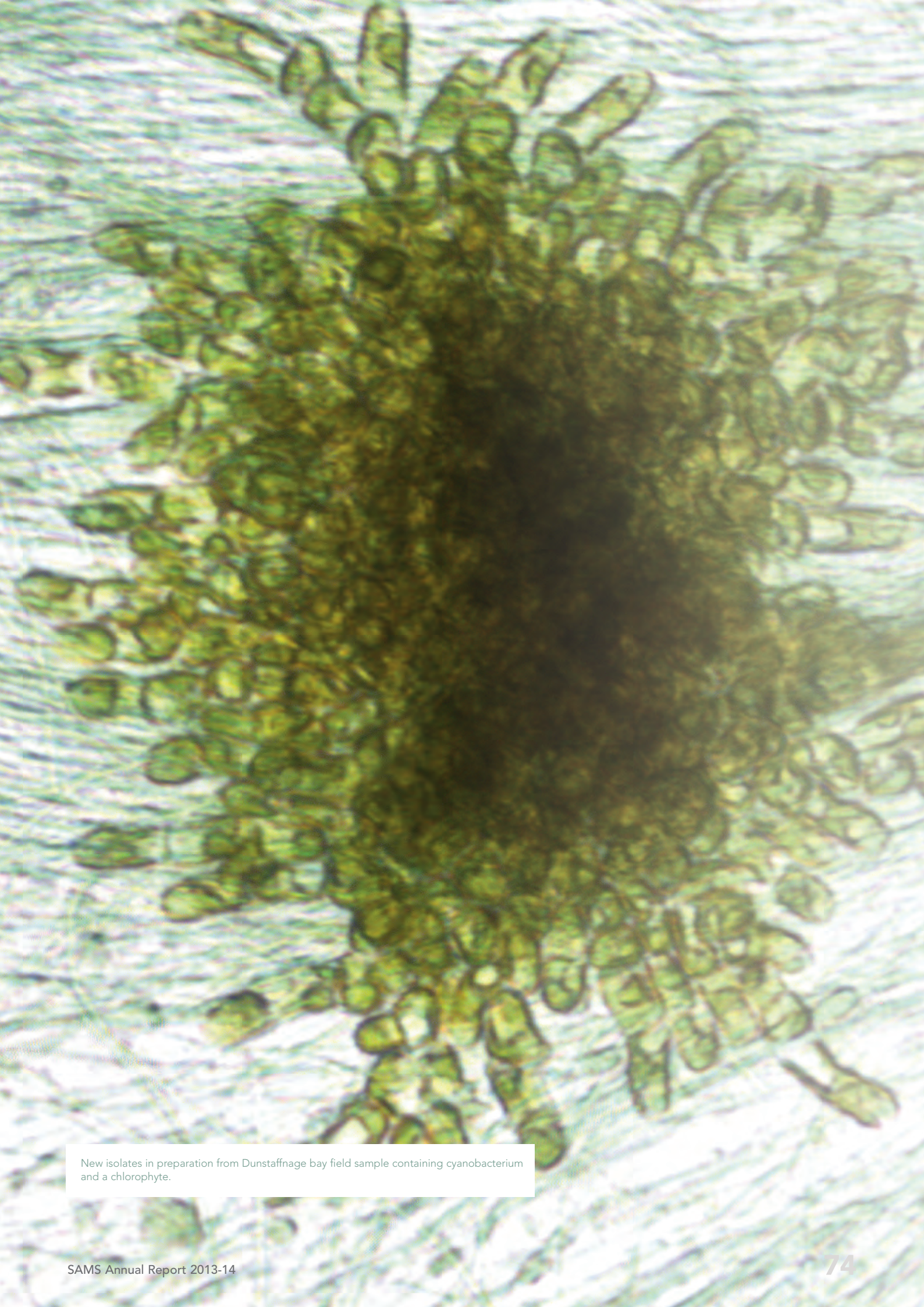
Dr John G Day
Head of CCAP



Head of CCAP, Dr John G Day



A new, benthic, filamentous cyanobacterial isolate collected from Dunstaffnage Bay.



New isolates in preparation from Dunstaffnage bay field sample containing cyanobacterium and a chlorophyte.

Publications 2013-14

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Campbell CN (2014) It's a microbial world. *Planet Earth Summer 2014*, 26-27.

Day JG (2013) Grazers – the overlooked threat to sustained production of future algal biofuels. *Biofuels* 4, 459-461.

Day JG (2014) Cryopreservation of cyanobacteria. In: *Cyanobacteria: An economic perspective*. Naveen K Sharma, Ashwani K Rai & Lucas J Stal (eds) WILEY Publications. pp 319-328.

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<http://www.assemblemarine.org/assets/Uploads/Documents/tool-box/Amoeba-maintenance-protocolSAMS.pdf>

Achilles-Day UEM (2013) Maintenance of marine ciliates. 2pp
<http://www.assemblemarine.org/assets/Uploads/Documents/tool-box/Ciliatemaintenance-protocolSAMS.pdf>

Achilles-Day UEM (2013) Isolation of algal endosymbionts from protists. 2pp
<http://www.assemblemarine.org/assets/Uploads/Documents/tool-box/Endosymbiont-isolation-protocolsSAMS.pdf>

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<http://www.assemblemarine.org/assets/Uploads/Documents/tool-box/Antibiotic-treatmentSAMS.pdf>

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<http://www.assemblemarine.org/assets/Uploads/Documents/tool-box/Isolation-tipsSAMS.pdf>

Campbell CN (2013) Medium scale culture of micro-algae in polycarbonate carboys. 2pp
<http://www.assemblemarine.org/assets/Uploads/Documents/tool-box/Medium-scale-algal-culture-SAMS.pdf>

Campbell CN (2013) Medium scale culture of micro-algae in plastic bags. 1pp

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Day JG (2013) Cryopreservation of *Ectocarpus*. 2pp
<http://www.assemblemarine.org/assets/Uploads/Documents/tool-box/Ectocarpus-cryo-protocolSAMS.pdf>

Day JG (2013) Cryopreservation of marine microalgae employing a controlled rate cooler 2pp
<http://www.assemblemarine.org/assets/Uploads/Documents/tool-box/Controlled-rate-cooling-cryo-protocolSAMS.pdf>

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<http://www.assemblemarine.org/assets/Uploads/Documents/tool-box/Barcoding-protocol-AssembleSAMS1.pdf>

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<http://www.assemblemarine.org/assets/Uploads/Documents/tool-box/AFLP-protocol-AssembleSAMS.pdf>

Thomas NJ & Day JG (2013) Use of FlowCam to enumerate and differentiate between marine protists. 2pp
<http://www.assemblemarine.org/assets/Uploads/Documents/tool-box/FlowCam-protocolSAMS.pdf>

NATIONAL FACILITY FOR SCIENTIFIC DIVING

The NERC Facility for Scientific Diving (NFSD) at SAMS is the main service provider and major supporter of scientific diving in the UK, underpinning a wide range of interdisciplinary research in the underwater environment.

NFSD offers a large, and growing, number of services based on the provision of specialist divers, equipment, training, and scientific and technical support. On a primary level, it provides practical support for diving-related, underwater scientific projects, ranging from manpower to specialist equipment loans, to total project management.

On a secondary level, the facility supports Health and Safety legislation for diving at work activities by offering targeted training programmes; providing advice and guidance for senior managers 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.

As the UK's main service provider and supporter of research involving scientific diving, NFSD maintains an extensive underwater research programme; supports the UK Scientific Diving Supervisory Committee (SDSC); interacts with other diving industry bodies; upholds ongoing diving research and evaluation programmes; and has a focussed training programme for scientists and technicians involved with working underwater.

In addition to diving services per se, the NFSD also provides support and training in associated small boat operations and emergency diving



NFSD diver replacing retaining brackets on one of the UK tide gauges.

medicine.

Starting in 2014, the NFSD provides a diving support service for the UK National Tide Gauge Network that, in turn, contributes to outputs of the National Tidal and Sea Level Facility (NTSLF).

The increased number and diversity of projects supported by the NFSD means that it now contributes to all of the NERC strategic priority areas; and it is the only diving facility in the world that supports, either directly or indirectly, such diverse topics as:

- 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.

In addition, the NFSD has maintained a research presence in the fields of diving and hyperbaric medicine. The expanded capacity over the past 2-3 years has produced a consistent publication output: since 2006 the NFSD have provided diving support that has resulted in the publication of 111 ISI-rated papers in journals with an average Impact Factor of 3.15. Those papers have been cited 1685 times, with an H-index of 22. In addition, the unit has contributed 12 ISI-papers on diving medicine, physiology and technology.

Publications 2013-14

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EDUCATION

Education @SAMS



Summary by Dr Lois Calder
Head of Education

Undergraduate Degrees

This has been another exciting year for the Education Department at SAMS, with 26 new undergraduates joining the degree programme in September.

The Sheina Marshall building was buzzing as the new arrivals enjoyed a week of induction, meeting their fellow students and SAMS staff, and bringing the total number of undergraduates to 72.

Their arrival was swiftly followed by graduation on 13th September when 22 undergraduate and postgraduate students stepped forward to receive their degree awards, concluded in the previous academic year.

Hosting induction and graduation so close together gives graduating students the chance to share their experiences and for new students to see the journey ahead and what the results of their endeavours can lead to.

It is an inspirational and exciting time for everyone, including the SAMS staff who invest so much time and energy in our degree programmes: the BSc degrees in

Marine Science and Marine Science with Arctic Studies and our Masters and postgraduate research degrees.

With the growth in student numbers has come an increasing need for students services and SAMS has worked hard to increase provision in areas such as student support, training, careers support and also in improving social aspects and strengthening our student community.

This year SAMS, in collaboration with Inverness College and UHI, ran the first Employability Skills Award for students. This award, designed in conjunction with employers, provides professional development and other activities that prepare student for the work place, equipping them with a broad set of skills that employers value. The first awards are anticipated in the autumn of 2014.

The passion and commitment of SAMS teaching staff is reflected in the continued development of the relevance and cutting edge nature of our degree programmes, providing strong links into the research culture at SAMS. This year saw five students studying in the Arctic, several undertaking research cruises and many working with SAMS staff and others on additional projects, creative activities and public engagement events, enriching the degree quality, student experience and employability of our graduates.

Research Degrees - Masters and Postgraduate

2013-14 saw the third intake of the Masters degree, delivered collaboratively with University of St Andrews.

Having spent a first semester at St Andrews, thirteen students came to SAMS in January 2014 for a semester of teaching in Ecosystem-Based Management of Marine Systems. These are capable and engaged students who flourish in the SAMS environment and twelve then elected to stay on for a third semester to undertake research projects with SAMS supervisors.

Their projects cover a variety of topics and interdisciplinary research including oceanography, acidification, aquaculture, invasive species and 'blue' renewable energy impacts.

This year, we also brought forward a new course in Algal Biotechnology and two candidates elected to join SAMS in the coming year as Masters by Research students. This topical area is experiencing rapid growth and expansion in the business sector, driven by a need for novel pharmaceuticals and nutraceuticals, as well as foods and fuels.

Marine systems provide a reservoir of resources that offer the potential to develop this industry. SAMS is ideally placed to support this activity through research projects and the growth and development of a skilled workforce aligned to sector need, and building capacity in this expanding field for Scotland and beyond.

SAMS Masters and Postgraduate students are part of the wider postgraduate community at SAMS. During the year 2013-4 there were 31 doctoral students, five of whom completed doctoral degrees.

Postgraduate Research students (PGRs) are embedded within the departmental structures at SAMS and receive both discipline specific



and broader support. While the UHI Graduate School offers support to PGRs through funding opportunities, access to training, and support services, SAMS has sought to improve its postgraduate services offered locally, including enhanced pastoral support by our Postgraduate Registry Officer, Fiona Wallace.

Consequently, this year has seen our first "longitudinal induction": three meetings covering studentship management and operational aspects; research skills; and planning and creativity.

There is also a growing portfolio of courses and activities to develop PGR and Early Career Researcher (ECR) skills, including provision in statistics and experimental design, knowledge transfer and public engagement and many other generic and professional skills. More events and activities, responding to student and employer need, will come on-line in the coming year.

SAMS continues to deliver high class degree provision with excellent translation of graduates into further study (Masters and postgraduate programmes) and good quality employment across a broad range of educational, academic and business sectors.



A student cruise on the Calanus in September 2013. The Calanus travelled to the top of Loch Creran via the Lynn of Lorn stopping at several stations to deploy a CTD, water bottles, secchi disc and various sized plankton nets.

Residential doctoral training courses at SAMS

This year we came to an agreement with the University of Strathclyde, to provide an elective module in 'Blue Biotechnology' for the new, SFC-funded (Scottish Funding Council) Industrial Biotechnology Innovation Centre (IbiolC). Students will enrol in the autumn of 2014 and come to SAMS in spring of the following year for an intensive, highly experiential, week-long residential course.

This complements similar activity already taking place. SAMS offers residential training to the EPSRC-funded Doctoral Training Centre in

Off-shore Renewables, IDCORE, through two annual courses covering environmental issues and policy aspects of renewable developments. SAMS is also a partner in the successful NERC-funded Edinburgh, Earth and Environment, E3, Doctoral Training Partnership and will deliver a residential course in the autumn of 2014 to the first cohort of PGRs in that flagship programme.



Beginning to grow: the relationship between SAMS and UNU

Having become the first and only marine research organisation in the world to be an associated research institute with United Nations University in January 2013, the relationship is already strengthening.

With successful funding for NERC International Opportunities fund project, "GlobalSeaweed", there will be two-way visits between the UNU-INWEH Canada and SAMS to develop knowledge exchange and professional development activities for algal pests and pathogen research.

Continued growth and development of strategic relationships, like these, are an important area for SAMS future, to promote collaboration and SAMS' reputation in key niche research areas.

Continuing Professional Development

In the past year, SAMS has delivered sixteen CPD courses, bringing almost 170 delegates, double the number on previous years. Training is offered in a broad range of topics including algaculture, phytoplankton identification, marine invasives, Ecopath modelling, geo-referencing, data management, Underwater Automated Vehicles (UAVs) and field methods.

SAMS has also achieved successes with NERC Advanced Skills training. These funded places are offered to NERC and other postgraduate students to develop high level skills in areas key to NERC strategic skills development plans. SAMS received funding for courses in diving and Remotely Piloted Aircraft (RPAs), with the latter attracting 25 students to SAMS and highlighting our growing expertise in this new and exciting technology area.

While surpluses remain modest, the longer term benefits are considerable, in promoting SAMS expertise and generating novel collaborations and successful funding. Education is also working closely with SAMS Research Services Ltd to maximise the commercial opportunities afforded by these activities.

There is a process of regular review of our CPD provision to ensure we are targeting the right markets and offering relevant and meaningful courses. Successful funding in a



International delegate Mette Moeller Nielsen holds a piece of giant kelp during a recent Algaculture for Biotechnology CPD course

Photo: courtesy of Peter Schmedes

number of areas will see future development of CPD in several specific area areas, including algal research, forging new collaborations and attracting increasing numbers of international students and researchers to SAMS.

"The help and attitude of the lab staff was fantastic - really friendly and understanding (and patient!)"

Delegate on SAMS 'Algaculture and Algae Research' course 2013

"Lovro is an enthusiastic teacher who, amazingly, makes Excel an interesting subject!"

Delegate on SAMS Research Data Management and How to Use Excel Courses, 2013

"It was a great course. Really broad and enjoyable."

Delegate from SMRU Ltd on our UAV Training Workshop, 2013





Arctic Circle

SIGBEE DEEP
THOULET DEEP

PEAKE DEEP

LIBBEY DEEP SUHM DEEP

KELTIE DEEP
MILL DEEP

MONACO DEEP

NARES DEEP

CHUN DEEP

HJORT DEEP
MAKAROFF DEEP

MOSELEY DEEP

BARTLETT DEEP

KRECH DEEP

TIZARD DEEP

BUCHANAN DEEP

OS DEEP

RÜMMEL DEEP

THOLOMEW DEEP

RICHARDS DEEP

HAVERGAL DEEP

HAECKEL DEEP

THE LEARNED SOCIETY

VALDIVIA DEEP

The state of the membership

This annual report is predominantly produced for SAMS members, even if it is also of interest and, once approved by the AGM, available to the general public. To keep membership subscriptions low, the decision has been taken no longer to produce printed copies but to distribute the report only digitally online.

Members are invited to meetings at SAMS including the Annual General Meeting, may attend all seminars given at SAMS, enjoy free access to the Ocean Explorer Centre and have the right to apply for a SAMS bursary, to stand for Council and to consult the SAMS library.

On 31 March 2014 the SAMS membership was composed of 274 ordinary members including students and unwaged, 1 life member and 32 corporate members. The total number is thus up by 5 on last year but overall the membership remains a cause of concern.

The future of the Learned Society is a matter of discussion and the development of the new Communications and Learned Society sub-committee is the forum that takes this matter forward. Any member who would like to make suggestions regarding the future direction of the learned society should contact a member of this

committee: Ken Rundle, Professor Geoffrey Boulton, the SAMS Director, the SAMS Head of Communications or the former Deputy Director of SAMS, Dr Ken Jones.

Emails may be submitted to communications@sams.ac.uk.

Membership meetings

Annual General Meeting

SAMS held its 99th AGM on 8 November 2013 at SAMS. Minutes of the AGM are available to all members – please contact Elaine Walton (Elaine.Walton@sams.ac.uk) if you require access to these.

24th Annual Newth Lecture

In memory of former SAMS President David Newth, SAMS holds an annual keynote lecture. The new SAMS President, Professor Geoffrey Boulton, presented the

2013 Annual Newth Lecture on 'The Open Science Imperative and its Implications for Oceanography'.

The well-attended and well-received lecture reflected on the novel challenges and opportunities posed by the increasing availability of massive and complex data volumes. The speaker highlighted the rapidly changing nature of scientific discoveries and the importance of science to remain open and accessible.

Scottish Marine Group

There have been no meetings of the Scottish Marine Group. Since the emergence of the Marine Alliance for Science and Technology for Scotland (MASTS) the remit of the SMG has been overtaken. There are currently no plans to re-constitute this group.

SAMS research bursaries

TABLE: Research bursary awards to SAMS members during the reporting period

NAME	INSTITUTION	PROJECT TITLE	AWARD
Dr Sven Thatje	National Oceanography Centre	The effects of sustained high hydrostatic pressure on the lipid composition and homeoviscous of shallow-water benthic marine invertebrates	£1,000
Dr Robert Marsh	National Oceanography Centre	Variability, Forcing and Impacts of Shelf Edge Exchange	£1,000
Nicola Everitt	Dove Marine Laboratory	Tracking the movement of crustaceans in question during exposure of B-fields	£998.75
TOTAL			£2998.75

Communications

The Communications team at SAMS has skills in web development, graphic design, filmmaking, photography, writing, presenting, event management, media relations and public engagement for an ocean literate society.

At the time of writing, the team consists of 4.8 FTE staff with a small team of additional seasonal/casual staff in the Ocean Explorer Centre facility, shop and café.

MAIN ACHIEVEMENT: OCEAN EXPLORER CENTRE

The team's main achievement was the launch of the Ocean Explorer Centre.

With support from the University of the Highlands and Islands Development Trust (fundraising), Bright 3D (design company), the SAMS estates team, Dr Kim Last and Lovro Valcic (observatory) and PhD student Sam Jones (glider model), we raised the funds, developed the concept for the exhibition and the brand, produced content and secured images, designed, built and installed the exhibition, developed marketing materials (online, social media, leaflet, posters, banner stand, adverts and signage), produced and sourced film footage, employed staff, designed the shop and cafe including merchandise and menu, and developed and coordinated a timetable of events and a range of school workshops. Read about the details of the Ocean Explorer Centre on the following pages.

TELLING OUR STORIES

SAMS has continued to tell its stories about the world of marine science on many channels: using our corporate website and numerous satellite websites, social media (Twitter, Facebook, LinkedIn),

blogs, traditional media and events. In all online platforms we see a steady increase in followers and interest. Peak interest is, however, usually associated with people rather than science stories.

We have recently started to develop a YouTube channel as well with regard to the massive interest in video for education as well as entertainment purposes – however, our YouTube channel on www.youtube.com/user/SAMSmari nescience has still limited views and may require more marketing and linking as well as more quality video footage.

other on the use of remotely piloted aircraft for marine science. Both are on show in the Ocean Explorer Centre and the RPA film has been used by the scientists to inform policy makers of the technology.

Andy also produced a film summarizing the INIS Hydro seabed mapping project that was screened to great approval at the closure event of the project at Titanic Belfast.

Dr Anuschka Miller,
Head of Communications

Stats	1/4/13-31/3/13	1/4/12-31/3/14
Website	87,997 sessions	138,828 sessions
Twitter	400-964 followers	964-1,754 followers
Facebook	202-352 likes	353-594 likes
LinkedIn	no figures available	208-537 followers

SONGS OF THE SCOTTISH SEA/ ÒRAIN NA MARA

The Creative Scotland funded residency of filmmaker Andy Crabb is coming to an end with the reporting period. During the year, Andy spent a month on board the RS James Cook in the North Atlantic documenting the work of the FASTNEt project, and a week in the Orkneys aboard the restored fishing sail boat, The Swan, with Cape Farewell's Sea Change project. Two films were produced from the latter project, one of which was featured in an exhibition at the Royal Botanic Gardens in Edinburgh.

Together with SAMS' undergraduate students two short documentary films were produced – one on seabed mapping and the

MEDIA COVERAGE

In the year 2013-2014, SAMS featured in 315 reports in the media that ranged from local, regional, national, to international outlets and included newspapers, magazines, radio, TV and online sources.

The majority appeared in online news, mainly under specialised titles (such as phys.org or innovationintextiles.com), but four reports were included on the "big" online news sites Yahoo!News and the Huffington Post that both claim to have millions of page views each day.

On a local level, we had more than 30 articles in the Oban Times and 20 on ForArgyll online news. In the main Scottish press (Press & Journal, Scotland Herald, and the

Scotsman) we had 10 reports, with another handful spread across the tabloids.

There were articles in the *Biologist*, the *Marine Scientist*, the POGO (Partnership for Observation of the Global Oceans) newsletter, *Challenger Wave* newsletter, the *Ocean Challenge* magazine and in the news section of the European Marine Biological Resource Centre (EMBRC) website.

Our scientists have contributed six different articles to the highly-regarded online news website *The Conversation*, while another six SAMS scientists featured in three NERC PlanetEarth podcasts.

Other national outlets that reported on SAMS included the *Times* and the *Guardian* (twice), with 10 separate news items on the BBC, from online news to national radio (including Radio Scotland, Radio 4 and 5 Live) to TV including breakfast and lunch news programmes (BBC1) and the News Channel.

According to Google Analytics, a comparison between the reporting years 2012-2013 and 2013-2014, shows that:

- visitors to the SAMS website have increased by 58%;
- the number of page views has increased by 42%;
- the duration of the average session has increased by 13%;
- and the number of visits to the website over the weekend, which is naturally much lower than weekdays, has also increased by 45%.

We have noticed there is a direct correlation between increased number of hits on the SAMS website and when our science is

reported. However, this depends on the outlet. For all the millions of folk who view the *Huffington Post* and *Yahoo!News*, our visitor numbers only seem to increase when our news is carried by more credible news sources.

But what remains important to SAMS is that SAMS science continues to be reported in the media, particularly where an impression can be made, and then the internet and social media help us spread the word, further and further, until everyone knows that SAMS is a byword for excellence in marine science.

Cathy Winterton,
Communications officer

SAMS opens its own visitor and outreach centre: The Ocean Explorer Centre

INTRODUCTION

Since its founding in 1884 by Sir John Murray, SAMS has been involving both academics and lay enthusiasts in marine research and education. At times, fierce debates broke out between those devoted solely to increasing knowledge about the marine environment through research and those who considered education and what we now call stakeholder engagement as an integral activity of their Association. An education remit, however, has always been enshrined in SAMS's mission.

In the past 20 years education and public engagement have once again grown in importance at SAMS, starting when the organisation joined an initiative in 1994 to create a collegiate University of the Highlands and Islands (UHI). The UHI's purpose is to be an engaged university that has a transformational impact on the development and prospects of the region, its people and its communities. This brings public engagement in its various forms to

the fore. In response SAMS has developed a range of activities and resources including a new visitor and outreach centre.

THE NEW OCEAN EXPLORER CENTRE

The OEC is based on the principles of 'edutainment', interactive engagement and sharing experience between staff and visitors. It showcases the rationale and main outcomes of SAMS' research to tourists, visiting schools and the local community. It encourages visitors to turn into explorers for the time of their visit – and hopefully beyond.

OUR MISSION

The Ocean Explorer Centre empowers audiences to contribute positively to a healthy and sustainably managed marine environment through greater awareness and understanding of the marine system and the challenges it faces.

The OEC strives to provide an outstanding visitor experience through inspirational, atmospheric

and relevant 'edutainment' and stimulating events at affordable prices."

The Centre incorporates an underwater observatory with three cameras that the audience can operate in real time, a geochemical observatory delivering data on underwater 'weather' conditions, and an associated hydrophone to create an underwater soundscape.

Algal biofuels feature in a dedicated display with an inverted microscope to explore different micro-algae and a set of six RFID-tag driven videos that introduce visitors to biofuels and algae, biofuels from microalgae and seaweeds, sourcing of seaweeds for bioenergy purposes and discusses how likely it is that our cars will drive on sunshine caught by algae.

An Arctic change zone incorporates audio-stories from six polar oceanographers and is a particular attraction for younger visitors thanks to a tunnel. Here 'tunnel crawlers' can find out what kind of animals live on, in or under sea ice by use of UV torches. The tunnel is



"Education is the most powerful weapon which you can use to change the world."

Nelson Mandela

made more exciting still with the sounds of breaking ice and creaking glaciers.

Other displays explore the seabed including modern mapping techniques and the natural history of the region as revealed by geology; a 3D globe that encourages exploration of research locations; and the story of ocean currents and the oceanographic technology employed in their study.

An Arctic-themed cinema shows short films about the marine environment and marine research, partly produced in-house or as part of research projects SAMS is part of.

Visitors are encouraged to embrace modern communication for their own exploration: Additional information about the sea and marine science can be accessed by scanning some of the exhibition images with smartphones or tablets that have downloaded an app called Layar. This technology allows SAMS to add new digital information to the Ocean Explorer Centre without additional costs for new displays.

Thanking our funders

Funding was secured with the support from the UHI Development Trust from charitable sources: The Robertson Trust, the University of the Highlands and Islands Development Trust, funding originating from the bequest by Sheina Marshall to SAMS, the Stevenson Family's Charitable Trust, the Steel Charitable Trust, the Oban Common Good Fund, the Hugh Fraser Charitable Trust, the Fishmongers' Company, the

Gordon Fraser Charitable Trust, the Susan H Guy's Charitable Trust and SAMS.

Activities and events at the Ocean Explorer Centre

A centre manager and a team of seasonal assistants look after visitors to the facility as well as after the small shop and since March 2014 also after the integrated Cafe Scientifique. The long established SAMS education officer works mostly out of the Ocean Explorer Centre since its opening.



The Ocean Explorer Centre opened in August 2013 and celebrated its opening with an event on 16 June 2014 in the presence of Michael Russell MSP, Scotland's Cabinet Secretary for Education and Lifelong Learning.

During the first season of its opening the OEC and the SAMS education team provided workshops, events, walks and talks for a total of 1,520 people during the reporting period in 42 separate events. Visiting groups ranged from 7 to over 100 and audiences ranged from nurseries, primary school groups, secondary classes, Brownies and Cubs, teacher groups, visiting undergraduate teams to tourism providers, the U3A and the general public. Additionally the team provided stands and shows at external events such as the Belladrum Festival, the Argyllshire Gathering and the Bute Astronomical Club's 'Scary Science' event in Greenock where thousands

of visitors engaged to various degrees with SAMS.

Dr Anuschka Miller
Director of the OEC





Construction site for the Perth wave energy project (Western Australia), visited by Dr Raeanne Miller during a NERC marine renewable energy knowledge exchange internship.

Knowledge Exchange

Our mission is to deliver world class marine science that supports society with innovative solutions for developing a sustainable relationship with the marine environment.

In order to achieve this mission, our cutting edge research must reach and be developed alongside non-academic organisations to ensure that the knowledge gained can be used to help organisations understand better their interaction with the marine environment; to manage their impact but also make the most of marine resources supporting economic growth; and to help to inform new policies and management strategies to help protect our marine environment.

This process of using and developing research for a range of applications is called **knowledge exchange**.

By working in collaboration with other public sector bodies and private companies we can ensure that our research has a positive economic and societal impact.

In order to achieve this, SAMS has developed a series of specific KE

programmes and has been awarded three 'Knowledge Exchange Fellowships' to provide pathways by which the knowledge gained during our research can be accessed and built upon by research 'end-users' in the private and public sectors.

Specifically, these fellowships will work with our research projects related to Aquaculture, Marine Renewable Energy and to develop our physical oceanography research undertaken in our FastNet research programme in the oil and gas sector.

The opportunities for the development of new products, services and better/more efficient working through academic-industry collaboration are demonstrated by the announcement of the new Scottish Innovation Centres. SAMS is actively engaged in Innovation Centres for Industrial Biotechnology, Aquaculture, Sensors and Imaging Systems and Oil and Gas.

Through these centres and SAMS KE programmes, our research will find application in a variety of sectors, generating opportunities for economic growth and policy

development.

For decades, for example, SAMS has researched seaweed phycology, understanding seaweed growth cycles, composition, tolerances and natural abundances. This knowledge is now being developed in several projects alongside small businesses to develop methods for growing and harvesting seaweeds for high value food ingredients. These projects will allow the businesses to develop sustainable methods for culturing seaweeds, providing them with the security of supply needed to enable them to grow and expand.

Dr Tracy Shimmield

OUR RESOURCES



RESEARCH VESSELS

On the whole, it has been a quieter year for boat use.

Calanus had 53 days at sea which was down from 122 in 2012/13. The main reason for this was the conclusion of the INIS Hydro contract, but in May 2013, Calanus assisted the authorities by making a successful sonar search for the recently lost fishing vessel 'Speedwell'.

The use of Seol Mara was up slightly on the previous year at 85 days over 82. With the resignation of the Master of Calanus in April 2013, the permanent crew is currently reduced to two, with one mate now Acting Master, and a small pool of casual crew.

Both Calanus and Seol Mara have been slipped for maintenance and minor repairs without difficulty.

John Beaton
Ships Operations Manager

IT AND INFORMATION SERVICES

ICT services

SAMS ICT continued to expand and provide high quality services and frontline support for all of SAMS and SRSL activities.

The employment of a young trainee at the start of 2013 allowed existing staff to concentrate on introducing and supporting more complex services, including newer and niche technologies, such as the increasing number of MAC computers and mobile devices: this was the first increase in ICT support staff levels in almost 10 years, although both staff and student numbers at SAMS have doubled over this same period.

ICT support staff also played a pivotal role in helping design and set up the Wi-Fi and some of the new exhibits in the new Ocean Explorer Centre.

High Performance Computing Facilities

In October 2103, in a collaborative proposal by IT and Research, SAMS were awarded £330K by NERC to replace and enhance our High performance computing facilities; these included:

- A new 320 Xeon core & 120 Phi core Computing cluster to replace our aging 32 core cluster.
- A new 40 core High Performance server with Solid state disks to support Windows based modelling
- A new 60 TB Archive server to

support Big Data storage at SAMS

- A new 500 Mb fibre internet connection to replace the existing 150Mb microwave link (though this will be retained for redundancy)
- Part funding to support a post to manage these new systems
- All new equipment was on site and installed by March 2014, with the new internet link due by summer 2014.

Data Management & Development

As a result of the NERC funding and additional funding garnered together from existing projects, a new Data Manager was employed in March 2014: their principal duties are to manage the new cluster & other new equipment, provide direct data support to PIs and help implementing MEDIN Data Standards across the institute in an attempt to meet more demanding data management requirements by funders and clients.

As well as the ongoing Depomod\AutoDepomod recode for the Scottish Government, the skills and quality of other IT staff have also allowed us to directly aid in other initiatives such as Touch table development

Library Information Services

As a result of the Library review, a plan was initiated to merge the student and research libraries by the summer of 2014. In January 2014 we began reviewing our catalogue of research books with a view to making our collection more relevant to current needs. The plan is taking into account the increasing relevance of electronic resources and aims to install new terminals and introduce new information services from the library.

Steve Gontarek
Head of ICT

FACILITIES

Minor works

We completed 746 helpdesk requests during the financial year.

Four new members of staff were successfully integrated into the Facilities team during that period and have completed all their required training.

Major projects

Installation of Gas smothering system in SMB server room

This involved the installation of gas distribution pipework, storage bottles, alterations to the fire alarm system and sealing the room space to contain the inert gas in the event of a fire.

Fit out of Ocean Explorer Centre exhibition hall and café

This involved working with the appointed design and build contractor to develop the various scheme themes for the centre.

In its first year from opening, the centre was awarded 4-star visitor attraction status by Visit Scotland.

David Mathias
Head of Facilities

HEALTH & SAFETY

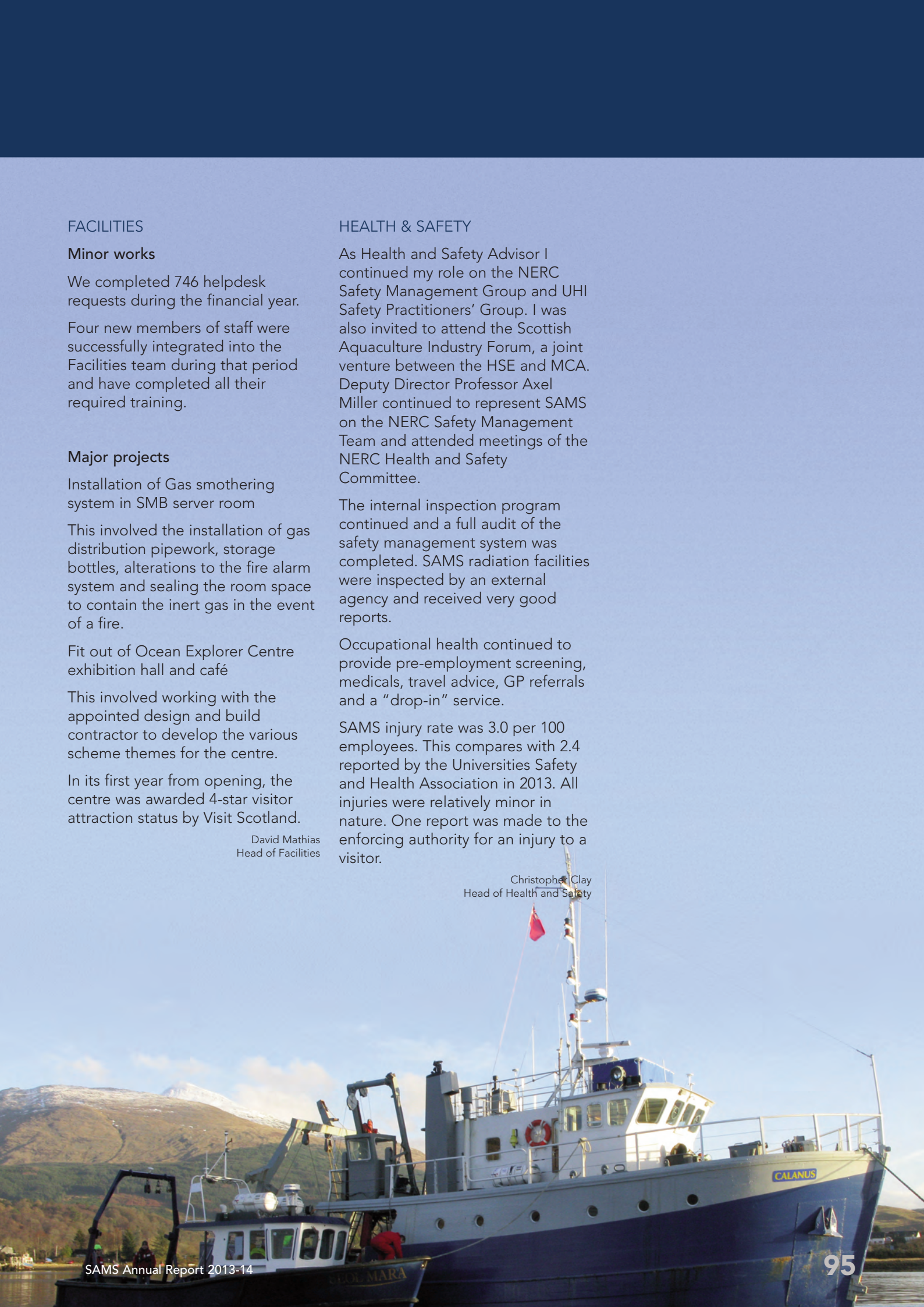
As Health and Safety Advisor I continued my role on the NERC Safety Management Group and UHI Safety Practitioners' Group. I was also invited to attend the Scottish Aquaculture Industry Forum, a joint venture between the HSE and MCA. Deputy Director Professor Axel Miller continued to represent SAMS on the NERC Safety Management Team and attended meetings of the NERC Health and Safety Committee.

The internal inspection program continued and a full audit of the safety management system was completed. SAMS radiation facilities were inspected by an external agency and received very good reports.

Occupational health continued to provide pre-employment screening, medicals, travel advice, GP referrals and a "drop-in" service.

SAMS injury rate was 3.0 per 100 employees. This compares with 2.4 reported by the Universities Safety and Health Association in 2013. All injuries were relatively minor in nature. One report was made to the enforcing authority for an injury to a visitor.

Christopher Clay
Head of Health and Safety





OUR PEOPLE

There is a unique culture at SAMS. We offer a multi-disciplinary environment that attracts people worldwide, and we operate as an extended family, offering support to each other at work as well as the integration into the local communities.

This culture and working environment reflects the type of employer we are and the staff who work here. In a recent staff survey in which 61% of staff participated, 91% stated they would recommend SAMS as a great place to work; 84% felt that SAMS has a supportive and participative culture; and 75% of staff agreed or strongly agreed they felt valued by SAMS.

The supportive and generous nature of SAMS staff goes beyond work, with many of our staff supporting charities from local ones such as the Oban Play Park and Oban Mountain Rescue Team, to national ones including the RNLI, Royal British Legion and MacMillan Cancer Support, and collectively we have run, walked, swum and cycled 1000's of miles in support of these organisations.

Not all our charitable activities are related to physical pursuits: we spend an equal amount of time and effort baking, selling and eating cakes and biscuits in support of various charities, community and voluntary groups.

Recruitment

This year our headcount has remained fairly steady with turnover at approximately 8%.

We have initiated the recruitment of a new social science team and

these posts have been created through the UHI MERIKA project.

MERIKA (Marine Energy Research Innovation and Knowledge Accelerator) is an ambitious initiative by UHI, located in Scotland and the UK's outermost regions. The project is striving to turn the UHI Faculty of Science, Health and Engineering into Europe's "reference, research and innovation hub" for marine energy.

In other areas, we have increased our Science and Research capability in all our science departments; we have bolstered our infrastructure team, recruiting facilities technicians; a manager of Ocean Explorer Centre; assistants in the Ocean Explorer Centre; a health and safety advisor; and a data manager.

Professorships

We are delighted that William Austin was awarded a personal chair from UHI. Although a reader at the University of St Andrews, Bill has a long, proven track record of research and teaching collaboration with SAMS since at least 1998. He is a specialist in foraminiferal taxonomy and isotope geochemistry, mostly working on Late Quaternary climate records from marine sediments from mid-high latitudes.

David Meldrum who has worked predominantly at SAMS for more than 35 years was also awarded a personal chair from UHI for his contribution towards the development of cutting edge technology R&D in support of ocean and polar observation. David is an internationally renowned

specialist in adapting sensors, systems and methods for use in the creation of inexpensive, effective and easily deployable autonomous instruments to enable radical changes in how we observe, understand and predict the oceans and the cryosphere. David has also been awarded the prestigious Polar Medal.

SAMS is proud of all its world class scientists and of their role in making UHI a distinctive university that contributes to the economic and social development of the region.

SAMS Group HR

There has been considerable effort in developing the strategy for SAMS Group Human Resources and this has now been approved by the management team and SAMS Board.

The three year strategy is split into five themes, which are: Values, Culture and Ethos; Standards, Efficiency and Effectiveness; Employee Compensation and Benefits; Talent and Career Development; and Leadership, Management and Change. A detailed plan will be developed, agreed and communicated on how the strategy will be delivered in the next three years.

One of the building blocks of the strategy is the introduction and implementation of Job Evaluation, which supports the whole Employee Compensation and Benefits theme.

During this reporting period, the implementation plan was developed and agreed by the SAMS job evaluation Steering group.

Sadness

Over the past two years, SAMS has lost a number of staff in tragic circumstances. This year we lost our Director Professor Laurence Mee, our aquarium manager John Kershaw, and Janet Duncan supervisor of the hyperbaric chamber. They are all missed greatly, each in a different way, yet each passing has been felt very deeply. Our sympathies are with their families whose loss is immeasurable.

Michelle Hausrath,
Head of HR

SAMS employees during 2013-14

Richard Abell	Elizabeth Campbell	Jorge Garcia Molinos	Maeve Kelly
Colin Abernethy	Karen Campbell	Stefan Gary	Fraser Kennedy
Undine Achilles-Day	Trevor Carpenter	Ronnie Glud	Philip Kerrison
Tom Adams	Brian Clark	Steven Gontarek	Bill Kersel
Karen Alexander	Alison Clarke	David Green	John Kershaw
Dmitry Aleynik	Christopher Clay	Lucy Greenhill	Shirley Kersley
Joanne Allday	Eilidh Cole	Sue Greenwood	Olga Kimmins
Angela Anderson	Lynda Coventry	Colin Griffiths	Tom Klein
Philip Anderson	Elizabeth Cottier	Bernard Hagan	Lindy Lamb
Riccardo Arosio	Finlo Cottier	Fiona Hart	Peter Lamont
Lauren Ault	Kirsty Crocket	Mark Hart	Kim Last
William Austin	Polly Crooks	Angela Hatton	Ray Leakey
Elaine Azzopardi	Philip Crump	John Hausrath	Paula Lister
John Bainbridge	Jacqueline Cullen	Michelle Hausrath	Nicola Longman
John Beaton	Rachel Culver	Sheila Heymans	Iain MacCorquodale
Steven Benjamins	Stuart Cunningham	Natalie Hicks	Fraser MacDonald
Peter Bentley	Andrew Dale	John Hill	John MacDonald
Christine Beveridge	Richard Dale	Kirsty Hill	Fraser MacDougall
Alasdair Black	Fiona Darling	John Howe	Janice MacEachen
Derek Black	Keith Davidson	Adam Hughes	Ailsa MacEwan
Kenneth Black	John Day	David Hughes	Lorna MacKinnon
Tim Brand	Arlene Ditchfield	Morgan Humphreys	Rory MacKinnon
Debra Brennan	Estelle Dumont	Zoe Hutchison	Kenny MacLean
Ruth Brennan	Janet Duncan	Phil Hwang	Adrian MacLeod
Hugh Brown	Jim Elliott	Mark Inall	Nigel MacLucas
Lars Brunner	Ivan Ezzi	Chris Ireland	Shona MacVicar
Mel Burnip	Sharyn Farmer	Alistair James	Daniel Madej
Michael Burrows	Joanne Field	Clare Johnson	Shona Magill
Lois Calder	Clive Fox	Kenneth Jones	David Mathias
Christine Campbell	Claire Gachon	John Keeney	Paul McLaren

Gillian McLuckie
Helen McNeill
Sharon McNeill
Laurence Mee
David Meldrum
Michael Meredith
Anuschka Miller
Axel Miller
Raeanne Miller
Elaine Mitchell
Andrew Mogg
John Montgomery
Leah Morrison
Sine Murray
Bhavani Narayanaswamy
Thom Nickell
Elspeth Norris
Tim O'Higgins
Ettore Pedretti
Joanne Pitt
Judith Pollock
David Pond
Marie Porter
Tavis Potts
Cecilia Rad Menendez
Shane Rodwell
Lorenzo Rovelli
Rachel Saxon
Martin Sayer

Peter Schiener
Natalia Serpetti
Carole Shellcock
Toby Sherwin
Tracy Shimmield
Stephen Slocombe
Claire Smalley
Linda Smith
Norman Smith
Henrik Stahl
Michele Stanley
Marieke Steuben
Alan Stewart
Sarah Swan
Eugene Tening
Paul Tett
Naomi Thomas
Phillip Thompson
Simon Thurston
Robert Turnewitsch
Gail Twigg
Gangi Ubbara
Swati Ubbara
Andrea Veszelovszki
Fiona Wallace
Keri Wallace
Elaine Walton
Lorna Watt
Callum Whyte

Tom Wilding
Ben Wilson
Cathy Winterton
Antonios Zambounis



SAMS Research Services Ltd

www.samsrsl.co.uk

SRSL Annual Report 2013-14

SAMS Research Services Ltd (SRSL) is the trading-subsiary of the SAMS Group and provides specialist marine consultancy and survey services, under pinned by cutting-edge science.

The SRSL mission is to enable clients to understand and mitigate the risks involved in industry interaction with the marine environment.

SRSL operates principally in Renewables, Mining, Marine Technology, and Aquaculture market sectors, mainly in Scotland but also overseas.

During the financial year 2013-14, core business areas included the provision of a wide variety of environmental management services for the government and its regulatory agencies, with key contracts in marine mammal environmental impacts, economic benefits of the aquaculture industry and biosecurity planning; the latter culminating in the production of new best-practice guidelines for Scotland in response to legislative changes.

SRSL also continued to deliver long-term programmes in microbiological and toxic phytoplankton monitoring.

Sales in Marine Technology continued to increase with international sales of SIMBA units to the USA, Germany, China and Finland.

FY2013-14 saw a significant increase in the number of contracts awarded in the aquaculture sector, with interesting studies in marine biofouling and environmental

impact assessment for Scottish fish farms, as well as consultancy services to the salmon farming industry in New Zealand.

Throughout the year, SRSL continued to maintain its reputation as an international leader in the environmental impact of deep-sea mine tailings placement (DSTP) and as a thought-leader in the emerging market of seabed mining.

SRSL Director, Dr Tracy Shimmield attended a number of summits and workshops as an invited speaker on these topics and SRSL have continued to deliver environmental consultancy services for major mining projects in Chile and Mexico, as well as closer to home in Scottish waters.

At the end of the year, SRSL was successfully awarded UKAS accreditation to ISO17025 for ICP-OES/MS analysis of metals in sediments. This award compliments that for toxic phytoplankton monitoring services, which are already accredited to this standard.

Dr Tracy Shimmield
Managing Director of SRSL



Dr Tracy Shimmield
Managing Director of SRSL

SAMS FINANCES

FINANCIAL REVIEW

The Association made a modest operating surplus in 13/14; however these results have been adversely affected by currency rate fluctuations that cancel out favourable movements over the last 5 years.

Charity accounting for capital grants dictates that the full amount of any such funding should be recognised in the year in which it is received rather than deferred to fund the depreciation over the life

of the asset. This creates a situation where net incoming resources are inflated in the year of receipt but future years' depreciation expense is unmatched.

As a result, SAMS considers net operating surplus to be a more appropriate measure in managing the business. The table below shows the reconciliation from the operating surplus to the surplus of £26k (2012/13 – deficit of £400k) transferred to reserves.

Financial summary	2013/14 £000	2012/13 £000	Change %
Summary			
Operating Income excluding capital grants	10,468	11,150	-6%
Operating Expenditure excluding grant funded depreciation	(10,460)	(11,136)	-6%
Net Operating Surplus before exceptional item	8	14	-43%
Exceptional in year exchange rate loss	(98)	-	
Capital Grants received	807	483	67%
Depreciation funded by grants received in previous years	(691)	(897)	-23%
Surplus/(Deficit) transferred to reserves	26	(400)	-106%

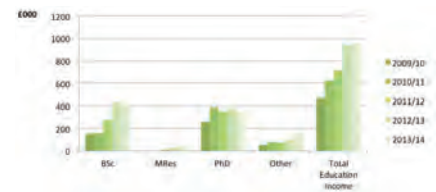
With continued competition from within the sector and the Government's flat cash budget settlement for research it is encouraging that SAMS continues

to generate even small surpluses from its operations during the financial year.

EDUCATION

As an academic partner of the University of the Highlands and Islands, we deliver both undergraduate and postgraduate education.

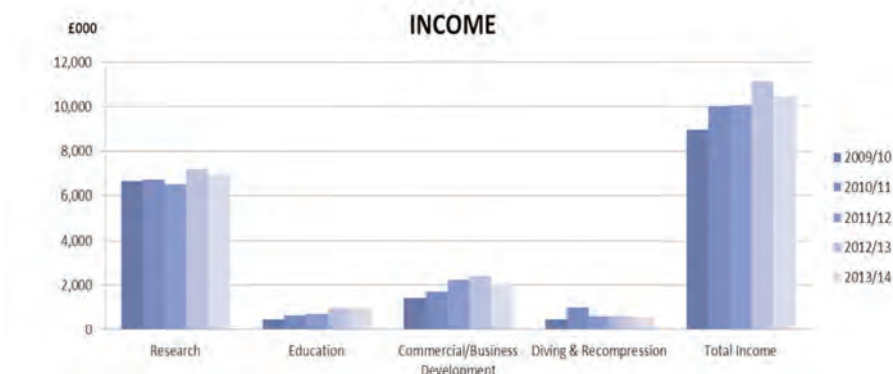
These activities now represent 9% of our total income, up from 5% in



2009/10. Income from undergraduate courses and PhD studentships has seen a slight decrease from the levels achieved in 2012/13.

However, undergraduate student numbers remain in line with targets and therefore the movement between years is due to differences in fees for Scottish and Rest of UK students plus the number of students taking advantage of the semester in Svalbard, Norway, for which we receive no funding. In terms of PhD studentships, funding and recruitment are becoming increasingly difficult. Despite this, numbers remain relatively stable with the differences in the timing of new starts creating the fluctuations within years. These two areas still represent 79% of education income.

Income from the Masters course and other education activities, such as field courses and short CPD courses, continues to grow due to our increasing reach and reputation for quality. This has offset the small decreases seen in BSc and PhD income.



COMMERCIAL & BUSINESS DEVELOPMENT ACTIVITIES

The percentage of total income generated by commercial and business development activities has fallen slightly from 22% in 2012/13 to 19% this financial year.

While these activities continue to be recognised as an integral and important part of the SAMS portfolio of activities, growth is currently difficult given the global economic climate in which we are operating.

SAMS Research Services Ltd (SRSL), our trading subsidiary, strives to enhance SAMS' international reputation for science excellence.

CAPITAL INVESTMENT

In 2013/14 we have been able to attract and secure funds for capital investment. This has allowed much needed investment in IT, research equipment, aquarium facilities and the development of our new Ocean Explorer Visitor Centre. Whilst this funding came largely from the UK Research Councils through competitively won grants we also received an allocation of research capital funding from Department of Business, Innovation and Skills via UHI for the first time in 2013/14. However, the difficult economic climate means that we are entirely reliant on external funding for investment. This is not ideal as continued investment in our infrastructure and facilities is crucial for the long term sustainability of SAMS.

Effective management of resources

Staff costs remain the highest proportion of expenditure representing 64% of operation costs (58% in 2012/13). These rose by 3% in the year largely as a result of incremental and a 1% cost of living increase.

Other operating costs fell by 18%. While an element of this was to be expected given the decrease in income, it also reflects strict prioritisation of expenditure across all areas of SAMS.

	2013/14	2012/13	2011/12	2010/11
Attributable to markets in the UK	78%	60%	64%	80%
Attributable to markets outside the UK	22%	40%	36%	20%

SAMS FINANCES

RESEARCH GRANTS & CONTRACTS

Income from research grants and contracts has fallen this year by 3% after an increase of 11% in 2012/13.

While we saw a small increase in our level of funding from the Natural Environment Research Council (NERC) back to similar levels of 2011/12, after a fall in 2012/13, we saw a decrease in funding received from the EU (46%) as significant projects came to completion and new consortium projects did not start in line with original timescales due to protracted contractual negotiations.

We have continued to be very successful in attracting research income from other sources with a 28% increase in 2013/14 (38% in 2012/13). This is positive news in an economic climate where diversification of income combined with costs control is becoming increasingly important for financial resilience and a long term sustainable operating model.

Other research income represents £727k of Government Commissions and £1,354k from sources such as Marine Alliance for Science and Technology for Scotland (MASTS), UHI SDB, Norwegian Research Council, USA Office of Naval Research and knowledge transfer initiatives through Technology Strategy Board (TSB) and Genomia. The continued increase in these areas is due to staff seeking, recognising and optimising opportunities.

Financial summary	2013/14 £000	2012/13 £000	Change %
Research income			
NERC (including National Capability)	3,092	2,975	4%
EU	870	1,626	-46%
Other	2,081	1,626	28%
RAE	894	954	-6%
Total research income	6,937	7,181	-3%

However, research income rarely provides full cost recovery for overheads and therefore there is a gap, typically 20-35%, in funding our research infrastructure costs, which has to be bridged by other income sources, including the Research Excellence Grant received through UHI.

Preparations for the 2014 Research Excellence Framework (REF) concluded in 2013/14, and submission has now taken place.

Given the current and likely future funding climate for research in the UK and Europe, SAMS will need to ensure it devotes appropriate resources to attracting funding along with improved project management to ensure a sustainable operating model and maintain SAMS' reputation for science excellence.





Innovative Independent International

“ The Scottish Association for Marine Science is a learned society committed to increasing our knowledge and stewardship of the oceans. SAMS undertakes independent marine research across the world, provides education, and delivers commercial services and knowledge exchange. ”

To apply for membership of SAMS, please visit www.sams.ac.uk/learned_society/membership

