
SCOTTISH
OCEANS
INSTITUTE
SCHOOL OF BIOLOGY
SCHOOL OF GEOGRAPHY & GEOSCIENCES
SCHOOL OF MATHEMATICS & STATISTICS
University of St Andrews
Scotland's first university
600 YEARS
1413 – 2013

CONTENTS

Opposite *SOI – Gatty Marine Laboratory from the sea (Ian Johnston)*

PREFACE

The mission of the SOI is to bring together the people, interdisciplinary skills and supporting scientific services necessary to deliver world class research in marine sciences. The scientific staff includes 58 research-active principal investigators, 57 research fellows and assistants, 26 technicians and engineers plus other support staff. The SOI also has a vibrant postgraduate community of 89 PhD students and delivers research-orientated teaching through MRes degrees in "Marine Mammal Science" and "Ecosystem-based Management of Marine Systems" (jointly with The Scottish Association for Marine Sciences). We host the Directorate of the Marine Alliance for Science and Technology for Scotland (MASTS), a pooling initiative of the Scottish Funding Council with £18 million funding (2010-17). We are also a founding partner in the European Marine Biology Resource Centre (EMBRC), a European Research Infrastructure comprising 10 of Europe's leading marine stations and the European Molecular Biology Laboratory (EMBL). Our research programme addresses some of the challenges in marine science of high importance to society at large including climate change, food security, biodiversity and ecosystem services, marine noise and marine mammal conservation. The SOI has particular enabling strengths in the design and manufacture of animal-borne sensors and instrumentation and in the development of statistical methods in ecology. The research undertaken by individual staff members is described under the themes of "Developmental & Evolutionary Genomics", "Ecology, Fisheries & Resource Management", "Global Change & Planetary Evolution" and "Sea Mammal Biology". The brochure also describes the main facilities available as well as various knowledge exchange and commercialisation activities pursued through spin-out and wholly-owned subsidiary companies.

The rapid industrialisation of coastal seas for aquaculture, oil & gas extraction, wind & wave power and telecommunications and the importance of ocean systems for climate and fisheries provide a strong driver for research investment in marine science by the public and private sectors. Indeed the maintenance of healthy and productive seas is a key policy objective of governments around the world. The interdisciplinary skills and infrastructure of the SOI are well placed to make a significant contribution to meeting this grand societal challenge over the coming century.

Ian A. Johnston
Director

FACILITIES & SERVICES

Location

The historic medieval town of St Andrews is situated on the Fife coast around 50 miles from Edinburgh. The University of St Andrews is Scotland's first university and the third oldest in the English-speaking world, founded in 1413. Over six centuries it has established a reputation as one of Europe's leading and most distinctive centres for teaching and research. Today the University has almost 8,000 undergraduate and 1,500 postgraduate students. The Scottish Oceans Institute (SOI) brings together all the University's research in marine science across the biological, physical and mathematical sciences.

Brief History

Marine science in the University has its origins in the St Andrews Fisheries laboratory which was established in 1884 with government funding to allow Professor William McIntosh FRS to carry out research on the life history of fishes in support of the Royal Commission on Trawling. At this time the University of St Andrews only had around 200 students. The Gatty Marine Laboratory on the East Sands was opened in 1896 following a generous gift from Charles Henry Gatty a Victorian amateur naturalist and philanthropist. The original Victorian building has been supplemented with additional buildings dating from 1958, 1960, 1963 and 1998 as research on the physiology and ecology of marine organisms expanded. In the 1960's under the direction of Adrian Horridge FRS the laboratory became a leading centre for research on the physiology of simple nervous systems using marine animals as models. Undergraduate teaching in marine biology was started by Professor Michael Laverack and Dr Christopher Todd in 1979. In 1985 the Gatty was re-constituted as an interdisciplinary centre for research and teaching in marine biology with staff from the then departments of Botany & Ecology, Physiology & Pharmacology and Zoology & Marine Biology. The Gatty became the model for a unified School of Biology & Preclinical Medicine in 1987 and there was a significant increase in staff numbers, facilities and scope of the research. The most significant part of this expansion was the result of the transfer of the NERC Sea Mammal Research Unit from the British Antarctic Survey in Cambridge to St Andrews. The Scottish Oceans Institute was formed in 2009 as an interdisciplinary Institute encompassing marine research across the Schools of Biology, Geography & Geosciences and Mathematics & Statistics.

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The SOI – Gatty Marine Laboratory

The marine laboratory occupies a beach-front location, giving small boats direct access to the sea via an adjacent slipway. A pump house on the foreshore supplies 250,000 gallons of filtered seawater each day. The aquarium comprises an ambient sea water circulation for fish and invertebrates, environmentally controlled warm water and cold water recirculation systems and a Home Office Licensed facility.

The largest seal experimental facility in Europe was completed in 1998 comprising a main 40 m pool and ancillary pools for behavioural and physiological studies. The East Sands has recently been refurbished with well-equipped laboratories for molecular, physiological, behavioural and ecological studies. Specialist facilities include a flume for sediment studies, laminar flow hoods for tissue culture and laser scanning confocal and scanning electron microscopes. There is a facility for the design and manufacture of satellite and GSM relayed data loggers for deployment on marine mammals or gliders including measurement of pressure, salinity, temperature, fluorescence and turbidity, depending on the configuration.

3

3 *Common Room, SOI – Gatty Marine Laboratory, East Sands (Ian Johnston)*

4

4 *Seal Pool at the SOI – Gatty Marine Laboratory, East Sands (Ian Johnston)*

Research Boats

There is a specialist, highly robust (7.5 m aluminium hulled) vessel for operation in shallow waters at high speeds. The vessel has been designed and equipped to capture seals. A 5 m RHIB is also available equipped with hydrophone capability for tracking whales and dolphins in coastal regions.

5

The Irvine Building

SOI staff members from the School of Geography & Geosciences are based in the Irvine Building on North Street where there are state-of-the-art XRD, MC-ICP-MS and ICP-OES mass spectrometer and diffractometer instruments.

CREEM

The Centre for Research into Ecological and Environmental Modelling (CREEM) is an interdisciplinary research centre within the SOI, and spans the Schools of Mathematics & Statistics, Biology, and Geography & Geosciences. CREEM is housed in a purpose-built facility at the old university observatory, and the group specialises in developing advanced mathematical and statistical methods to practical problems in biology, ecology and geography.

1 *The SOI – Gatty Marine Laboratory, from the sea (Ian Johnston)*

2 *Genomics Laboratory (Ian Johnston)*

5 *7 metre aluminium jet boat (Gordon Hastie)*

Research Themes

DEVELOPMENTAL & EVOLUTIONARY GENOMICS

Dr David E. K. Ferrier
Development, Genes & Evolution

Co-workers
Thomas Barton-Owen
Clara Coll Lladó
Simon Dailey
Myles Garstang
Réka Szabó

David Ferrier's group has interests in the connections between genome organisation and animal evolution. Using a variety of species, such as amphioxus, sea squirts, polychaetes, priapulids and arthropods, he is investigating how homeobox gene clusters operate and evolve, how 'muscle' genes evolve, and how the regeneration and biomineralization processes in a polychaete can illuminate the evolution of these phenomena across the animal kingdom.

1

Mendivil Ramos, O., Barker, D. and Ferrier, D.E.K. (2012). Ghost loci imply Hox and ParaHox existence in the last common ancestor of animals. *Current Biology, 22, 1951-1956.*

Hui, J.H.L., McDougall, C., Monteiro, A.S., Holland, P.W.H., Arendt, D., Balavoine, G. and Ferrier, D.E.K. (2012). Extensive chordate and annelid macrosynteny reveals ancestral homeobox gene organization. *Molecular Biology and Evolution, 29, 157-165.*

Butts, T., Holland, P.W.H. and Ferrier, D.E.K. (2010). Ancient homeobox gene loss and the evolution of chordate brain and pharynx development: deductions from amphioxus gene expression. *Proceedings of the Royal Society B, Biological Sciences, 277, 3381-3389.*

2

1 *Expression of the ParaHox genes Xlox (black) and Cdx (red) in an amphioxus neurula embryo. Expression is in gut and nervous system development (Peter Osborne)*

2 *Adult keel worm (Pomatoceros lamarckii) removed from its habitation tube (David Ferrier)*

Dr Ildiko M. L. Somorjai
Regeneration Biology

Co-workers
Thomas Barton-Owen
Simon Dailey

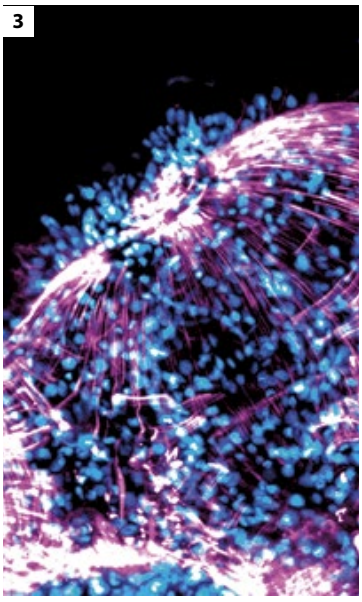
Ildiko is a newly appointed MASTS Lecturer. Her interests are in the field of evolution and development ("Evo-Devo"), including the evolution of regeneration mechanisms and stem cells. She employs a comparative framework to study the amazing diversity of regenerative ability in different systems, particularly marine organisms. The long-term goal of her research is to shed light on new facets of the regulation of stem cells in species with high regenerative potential, in an effort to improve organ regeneration in poorly regenerating species, like humans.

Somorjai, I.M.L., Escrivà, H. and Garcia-Fernàndez, J. (2012). Amphioxus makes the cut – again. *Communicative and Integrative Biology, 5, 499-502.*

Somorjai, I.M.L., Somorjai, R.L., Garcia-Fernàndez, J. and Escrivà, H. (2012). Vertebrate-like regeneration in the invertebrate chordate amphioxus. *Proceedings of the National Academy of Sciences of the USA, 109, 517-522.*

Bertrand, S., Camasses, A., Somorjai, I.M.L., Belgacem, M.R., Chabrol, O., Escande, M.L., Pontarotti, P. and Escrivà, H. (2011). Amphioxus FGF signaling predicts the acquisition of vertebrate morphological traits. *Proceedings of the National Academy of Sciences of the USA, 108, 9160-9165.*

3



3 *A confocal image of Hydra musculature around the hypostome (mouth), stained for F-actin (Ildiko Somorjai)*

Ian Johnston's group is investigating the structure, function and evolution of skeletal muscle in teleost fish. Current projects include the molecular and cellular mechanisms of development and growth, the impact of embryonic and seasonal temperature change on locomotion and growth, and the evolution of dwarfism. Research on the genetic basis of production traits in Atlantic salmon (*Salmo salar*) is aimed at producing improved strains for farming using marker assisted selection. Xelect Ltd is a spin-out company formed in February 2013 by Ian Johnston and Tom Ashton to develop and license genetic markers for broodstock selection. The commercialisation of their research was supported by BBSRC Follow-on funding.

XELECT
Genetic solutions for aquaculture

Xelect Ltd http://www.xelect.co.uk

Xelect's lead product is a genetic assay that identifies Atlantic salmon with 4.7% bigger fillets than unselected fish, worth around £680/metric tonne at current market prices. These high yield markers have been licensed to leading salmon breeders and farmers worldwide. The company has an active research pipeline to develop genetic markers for other traits and species.

Scott, G.R. and Johnston, I.A. (2012). Temperature during embryonic development has persistent effects on thermal acclimation capacity in zebrafish. *Proceedings of the National Academy of Sciences of the USA, 109, 14247-14252.*

Johnston, I.A., Kristjánsson, B.K., Paxton, C.G.M., Vieira, V.L.A., Macqueen, D.J. and Bell, M.A. (2012). Universal scaling rules predict evolutionary patterns of myogenesis in species with indeterminate growth. *Proceedings of the Royal Society B, Biological Science, 279, 2255-2261.*

Macqueen, D.J., Garcia de la Serrana, D. and Johnston, I.A. (2013). Evolution of ancient functions in the vertebrate insulin-like growth factor system uncovered by study of duplicated salmonid fish genomes. *Molecular Biology and Evolution, 30, 1060-1076.*

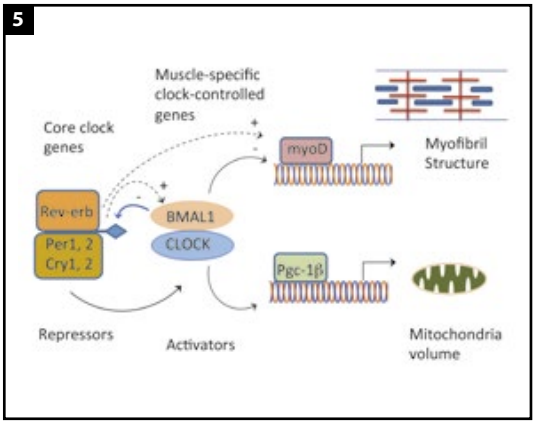
Prof Ian A. Johnston FRSE
Physiological Genomics
Aquaculture

Co-workers
Dr Tom Ashton
Dr Stephen Carmichael
Dr Eduardo Fuentes
Dr Daniel Garcia de la Serrana
Dr Vera Vieira-Johnston
Thiago Cahú
Clara Coll Lladó

4

4 *Atlantic salmon (Salmo salar L.) (Tom Ashton)*

5



5 *Model for the circadian regulation of muscle phenotype by clock genes*
From: Johnston et al. (2011). J. Exp. Biol., 214, 1617-1628

Research Themes

ECOLOGY, FISHERIES & RESOURCE MANAGEMENT

Spatiotemporal Modelling

By using vessel monitoring system data (GPS tags attached to fishing vessels), scientists at CREEM have developed statistical models that facilitate fisheries management at high spatial resolution. The methods use hidden Markov models to estimate where fishing took place, on the basis of vessel speeds and directions obtained from time series of vessel GPS locations. When combined with landings data, this allows estimation of the spatial distribution of catch, together with an associated measure of uncertainty. The figure (2) shows the estimated distribution of haddock landings in the northern North Sea.

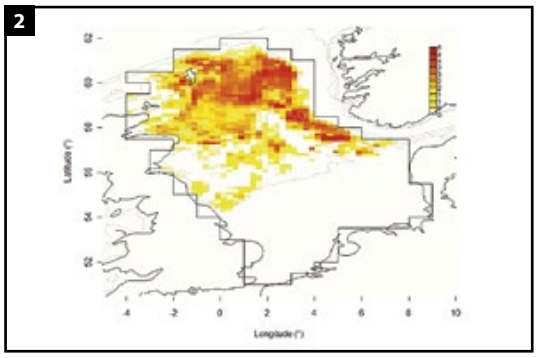
Dr David L. Borchers
Statistical Ecology

Co-workers
Dr Roland Langrock
Bruno Caneco
Greg Distiller
Colin Millar
Ben Stevenson

David's research develops statistical solutions to problems in ecological surveys that are intractable using existing methods. In addition to generalizations of distance sampling, recent research includes development of spatially explicit capture-recapture methods and current research includes development of methods for acoustic, camera trap and video surveys, for modelling animal availability on surveys, for dealing with recapture uncertainty, and for flexible modelling of special distributions from survey data with observation error.

Arranz, P., Borchers, D.L., Aguilar de Soto, N., Johnson, M. and Cox, M. (in press). A new method to study inshore whale cue distribution from land-based observations. *Marine Mammal Science, DOI:10.1111/mms.12077.*

Borchers, D.L., Marques, T.A., Gunlaugsson, T. and Jupp, P. (2010). Estimating distance sampling detection functions when distances are measured with errors. *Journal of Agricultural, Biological and Environmental Statistics, 15, 346-361.*



Borchers, D.L. and Efford, M. (2008). Spatially explicit maximum likelihood methods for capture-recapture studies. *Biometrics, 64, 377-385.*

1 *Haddock (Melanogrammus aeglefinus) (Steven Johnson)*
2 *Estimated distribution of haddock landings in the northern North Sea (David Borchers)*
3 *Tentsmuir Beach (Mark James)*

Andy Brierley studies predator-prey interactions in the open ocean, with a particular focus on how environmental change might impact these interactions in future. He is examining how fishing pressure and climate variability influence jellyfish abundance, exploring how reducing oxygen availability in a warming ocean will affect fish shoaling and krill swarming, and how loss of sea ice will influence vertical migrations by zooplankton – and hence carbon flux to the ocean. He has projects in tropical and polar seas.

Berge, J., Cottier, F., Last, K.S., Varpe, O., Leu, E., Soreide, J., Eiane, K., Falk-Petersen, S., Willis, K., Nygard, H., Vogedes, D., Griffiths, C., Johnsen, G., Lorentzen, D. and Brierley, A.S. (2009). Diel vertical migration of Arctic zooplankton during the polar night. *Biology Letters, 5, 69-72.*

Brierley, A.S. and Cox, M.J. (2010). Shapes of krill swarms and fish schools emerge as aggregation members avoid predators and access oxygen. *Current Biology, 20, 1758-1762.*

Wallace, M.I., Cottier, F.R., Berge, J., Tarling, G.A., Griffiths, C. and Brierley, A.S. (2010). Comparison of zooplankton vertical migration in an ice-free and a seasonally ice-covered Arctic fjord: an insight into the influence of sea ice cover on zooplankton behavior. *Limnology and Oceanography, 55, 831-845.*

4 *Chrisaora hysoscella (Chad Widmer)*

Prof Andrew S. Brierley
Pelagic Ecology

Co-workers
Dr Joanne Potts
Philipp Boersch Supan
Elaine Fitzcharles
Anna Kintner
Lilian Lieber
Roland Proud
Annanda Rabindranath
Clare Webster
Chad Widmer

Stephen Buckland has three main research areas: design and analysis of sightings survey methods (so-called distance sampling, Buckland et al., 2001); modelling of animal population dynamics, and fitting these models to time series of data (Buckland et al., 2007); and the development of methods for monitoring trends in biodiversity of regions (Buckland et al., in press). He is also Director of the Centre for Research into Ecological and Environmental Modelling at St Andrews, and Co-Director of the UK's National Centre for Statistical Ecology.

Buckland, S.T., Baillie, S.R., Dick, J.McP., Elston, D.A., Magurran, A.E., Scott, E.M., Smith, R.I., Somerfield, P.J., Studeny, A.C. and Watt, A. (2012). How should regional biodiversity be monitored? *Environmental and Ecological Statistics, 19, 601-626.*

Buckland, S.T., Anderson, D.R., Burnham, K.P., Laake, J.L., Borchers, D.L. and Thomas, L. (2001). Introduction to Distance Sampling. *Oxford University Press.*

Buckland, S.T., Newman, K.B., Fernández, C., Thomas, L. and Harwood, J. (2007). Embedding population dynamics models in inference. *Statistical Science, 22, 44-58.*

Prof Stephen T. Buckland
Statistical Ecology

Co-workers
Dr Phil Harrison
Dr Cornelia Oedekoven
Dr Yuan (Joyce) Yuan
Ben Swallow

Dr Carl R. Donovan
Applied Statistics

Co-workers
Prof John Harwood
Dr Catriona Harris
Dr Gordon Hastie
Dr Monique MacKenzie
Dr Lindesay Scott-Hayward
Nils Erichson
Darren Kidney

Carl Donovan's statistical research interests are in statistical simulation/programming, agent-based modelling, non-linear modelling, smoothing on complex domains, basis function methods, computer intensive methods and data mining. In terms of applications he has been involved in several projects modelling the impacts of underwater noise on marine fauna, such as military SONAR, seismic surveying and the installation of offshore renewables.

New, L., Harwood, J., Thomas, L., Donovan, C.R., Clark, J., Hastie, G., Thompson, P., Cheney, B., Scott-Hayward, L.A.S. and Lusseau., D. (2013). Modelling the biological significance of behavioural change in coastal bottlenose dolphins in response to disturbance. *Functional Ecology, 27, 314–322.*

Scott-Hayward, L.A.S., MacKenzie, M.L., Donovan, C.R., Walker, C.G. and Ashe, E. (in press). Complex Region Spatial Smoother (CReSS). *Journal of Computational and Graphical Statistics, DOI:10.1080/10618600.2012.762920.*

Walker, C.G., MacKenzie, M.L., Donovan, C.R. and O'Sullivan, M. (2011). SALSA – A Spatially Adaptive Local Smoothing Algorithm. *Journal of Statistical Computation and Simulation, 81, 179-191.*

Dr Maria Dornelas
Tropical Biodiversity

Co-workers
Dr Miguel Barbosa
Laura Antão
Isabel Marques da Silva

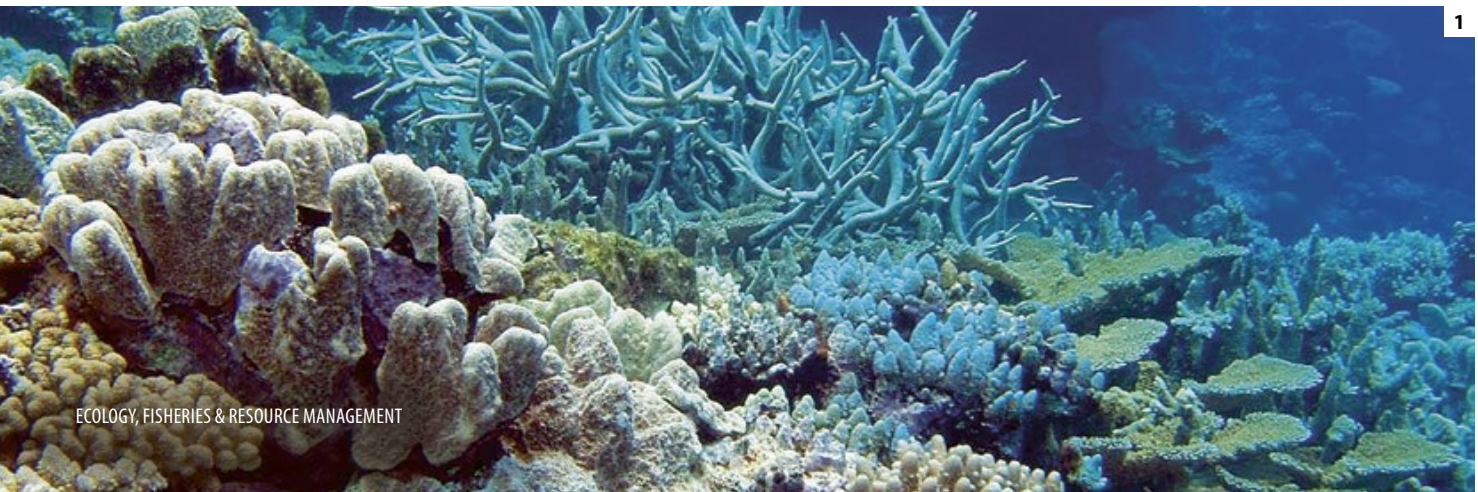
Maria is a MASTS lecturer. Her main research focus is on the causes and consequences of biodiversity patterns. She is interested in understanding what drives species coexistence and relative abundance, and has interests in biodiversity time-series, reef coral functional traits and life histories, and the effects of Marine Protected Areas on coral reef socio-ecosystems.

Dornelas, M., Magurran, A.E., Buckland, S.T., Chao, A., Chazdon, R.L., Colwell, R.K., Curtis, T., Gaston, K.J., Gotelli, N.J., Kosnik, M.A., McGill, B., McCune, J.L., Morlon, H., Mumby, P.J., Øvreås, L., Studeny, A. and Vellend, M. (2013). Quantifying temporal change in biodiversity: challenges and opportunities. *Proceedings of the Royal Society B, Biological Sciences, 280, 20121931.*

Shimadzu, H., Dornelas, M., Henderson, P.A. and Magurran, A.E. (2013). Diversity is maintained by seasonal variation in species abundance. *BMC Biology, 11: 98.*

Dornelas, M. (2010). Disturbance and change in biodiversity. *Philosophical Transactions of the Royal Society B, Biological Sciences, 365, 3719-3742.*

1 *Diversity of reef corals (Maria Dornelas)*



Oscar Gaggiotti is a newly appointed MASTS professor. His interests cover a broad range of areas that include ecology, population genetics, evolution and conservation biology. His research focuses on the study of spatial patterns of genetic diversity to better understand the evolutionary and ecological processes responsible for their origin and maintenance. To this end he develops ecologically realistic population genetics theory and methods using the metapopulation paradigm and Bayesian statistics.

He applies these methods to two research problems:

- Statistical inference of the demographic history and ecology of populations
- Study of local adaptation to understand the molecular bases of phenotypic variation

Hoban, S., Bertorelle, G. and Gaggiotti, O.E. (2012). Computer simulations: tools for population and evolutionary genetics. *Nature Reviews Genetics, 13, 110-122.*

Gaggiotti, O.E. (Editor) (2010). Recent advances in spatial population genetics. *Special Issue of Molecular Ecology Resources, Wiley-Blackwell.*

Gaggiotti, O.E., Bekkevold, D., Jørgensen, H.B.J., Foll, M., Carvalho, G.R., Andre, C. and Ruzzante, D.E. (2009). Disentangling the effects of evolutionary, demographic and environmental factors influencing the genetic structure of natural populations: Atlantic herring as a case study. *Evolution, 63, 2939-2951.*

Prof Oscar E. Gaggiotti
Molecular Ecology

Co-workers
Dr Emma Carroll
Zoe Allcock
Pierre de Villemereuil
Alexandra Vatsiou

Jeff Graves uses molecular markers to investigate parentage, relatedness and population structure in seals and cetaceans and parentage and relatedness, population structure and maternal investment in birds.

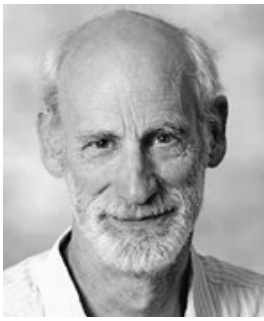
Current sea mammal projects include working on bottlenose dolphins in the North Sea (with Vincent Janik), population structure in Harbour seals around the UK (with Ailsa Hall) and the relationship between the Indus and Ganges river dolphins (Gill Braulik) and social structure and mating patterns in killer whales (with Patrick Miller). He has researched the population structure of grey seals in the Baltic, parentage and relatedness within a colony on North Rona (with Paddy Pomeroy) and is finishing a study of the population structure of ringed seals on the west coast of Svalbard.

Gilbert, L., Williamson, K.A. and Graves, J.A. (2011). Male attractiveness regulates offspring fecundity non-genetically via maternal investment. *Proceedings of the Royal Society B, Biological Sciences, 279, 523-528.*

Graves, J.A., Helyar, A., Biuw, M., Jüssi, M., Jüssi, I. and Karlsson, O. (2009). Analysis of microsatellite DNA and mtDNA in grey seals from three breeding areas of the Baltic Sea. *Conservation Genetics, 10, 59-68.*

Poland, V.F., Pomeroy, P.P., Twiss, S.D. and Graves, J.A. (2008). Fine-scale genetic structuring in breeding female grey seals. *Marine Mammal Science, 24, 371-387.*

2 *Bottlenose Dolphins (Vincent Janik)*



Dr Jeff A. Graves
Population Genetics

Co-workers
Dr Aaron Banks
Dr Gill Braulik
Dr Valentina Islas
Dr Lilian Manica
Dr Gwen Penry
Jaime Murile
Nadia Neri
Sara Taveres

Dr Neil Hazon
Osmoregulation & Endocrinology

Co-workers
Dr Svetlana Kalujnaia
Claire Dagen
Alexandra Howe
Kelly Robinson

Neil Hazon's group studies the physiological and molecular mechanisms controlling osmoregulation in both teleost and elasmobranch fish. This research also involves collaboration with Dr Gordon Cramb in the School of Medicine. He also collaborates with Chris Todd on the impact of the ectoparasitic sea louse (Leopeoptheirus salamonis) on wild and farmed salmonids and with Ailsa Hall and Paddy Pomeroy on the hormonal regulation of social recognitions in seals.

Kalujnaia, S., Gellatly, S.A., Hazon, N., Villasenor, A., Yancey, P.H. and Cramb, G. (2013). Seawater acclimation and inositol monophosphatase (IMPA) isoform expression in the European eel (Anguilla anguilla) and Nile tilapia (Orechromis niloticus). *American Journal of Physiology, 305, R369-384.*

Gargan, P.G., Forde, G., Hazon, N., Russell, D.J.F. and Todd, C.D. (2012). Evidence for sea-lice induced marine mortality of Atlantic salmon (Salmo salar) in Western Ireland from experimental releases of ranched smolts treated with emamectin benzoate. *Canadian Journal of Fisheries and Aquatic Science, 69, 343-353.*

Good, J.P., Wells, A. and Hazon, N. (2008). Measurement of blood volume in the elasmobranch fish Scyliorhinus canicula following acute and long-term salinity transfers. *Journal of Fish Biology, 73, 1301-1313.*

Dr Timothy C. Hill
Carbon Cycling

Co-workers
Dr Melanie Chocholek
Graham Hambley
Frances Manning
Michael Musgrave
Viktoria Oliver

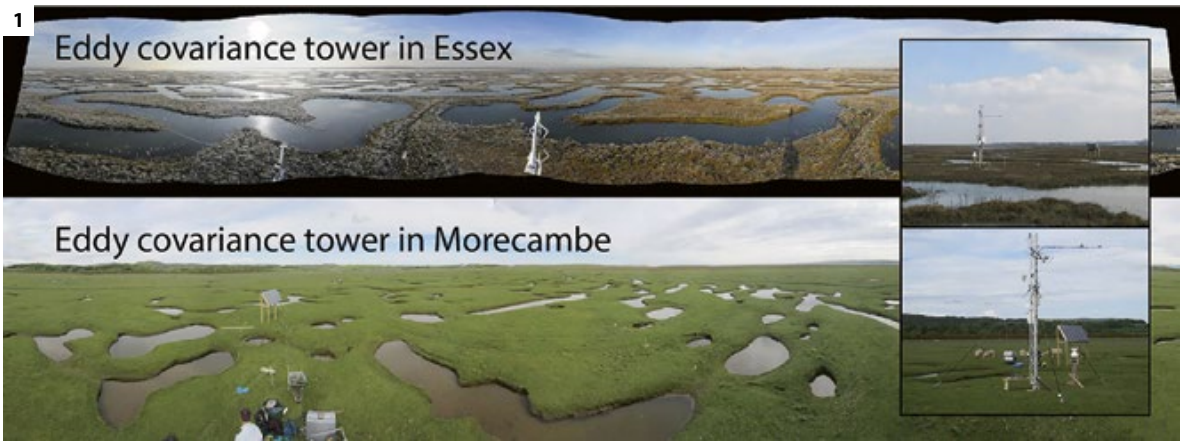
Tim Hill uses measurements and models to investigate carbon cycling in terrestrial and coastal ecosystems. As part of ongoing research, Tim is working with Prof Paterson, Dr Chocholek (and others) on the NERC Coastal Biodiversity & Ecosystem Service Sustainability (CBESS) project. CBESS is looking at the links between biodiversity and ecosystem services in tidally inundated salt marsh and intertidal mudflat ecosystems. As part of this project Tim has established two eddy covariance towers, one in Essex and one in the Morecambe bay region, to improve our understanding of carbon cycling in salt marsh ecosystems.

Hill, T.C., Williams, M., Bloom, A.A., Mitchard, E. and Ryan, C. (2013). Are inventory based and remotely sensed above-ground biomass estimates consistent? *PLOS ONE, 8, e74170.*

Hill, T.C., Ryan, E. and Williams, M. (2012). The use of CO_2 flux time series for parameter and carbon stock estimation in carbon cycle research. *Global Change Biology, 18, 179-193.*

Hill, T.C., Quaife, T. and Williams, M. (2011). A data assimilation method for using low-resolution Earth observation data in heterogeneous ecosystems. *Journal of Geophysical Research, 116, D08117.*

1 *CBESS Panoramas (Tim Hill)*



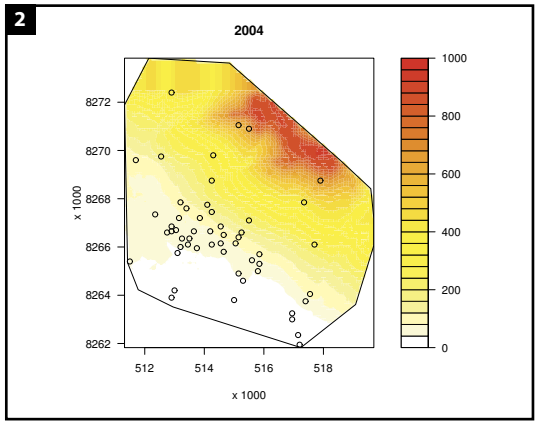
Janine's main research interests concern spatial statistical modelling in the context of spatial signals in ecological processes, ecosystem biodiversity and conservation. In particular, this involves realistically complex spatial point process models, based on computationally efficient algorithms (in particular INLA) to modelling real communities. This work has been extended to application outside ecology – for instance current work applies spatial modelling approaches to geolinguistics and crime data. In the last few years we have been running training workshops on spatial modelling with INLA, both in St Andrews and abroad to bridge the gap between theoretical method developments and the users.

Illian, J.B., Martino, S., Sørbye, S.H., Gallego-Fernandez, J.B., Zunzunegui, M., Paz Esquivias, M. and Travis, J.M.J. (2013). Fitting complex ecological point processes with integrated nested Laplace approximation (INLA). *Methods in Ecology and Evolution, 4, 305-315.*

2 *Spatial point pattern formed by muskoxen in Greenland (Janine Illian)*

Illian, J.B., Sørbye, S.H. and Rue, H. (2012). A toolbox for fitting complex spatial point process models using integrated nested Laplace approximation (INLA). *The Annals of Applied Statistics, 6, 1499-1530.*

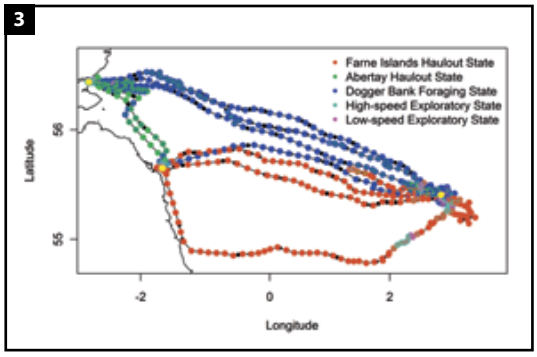
Illian, J.B., Sørbye, S.H., Rue, H. and Hendrichsen, D. (2012). Using INLA to fit a complex log Gaussian Cox process with temporally varying effects – a case study. *Journal of Environmental Statistics, 3, 1-25.*



Dr Janine B. Illian
Spatial Modelling

Co-workers
Dr Yuan (Joyce) Yuan
Linda Altieri
Rikke Ingebrigtsen
Charlotte Jones-Todd

Ruth King is investigating the development of novel statistical techniques for analysing complex ecological data including capture-recapture-recovery and related data. This includes developing novel Bayesian techniques, dealing with missing data, incorporating different levels of heterogeneity and developing integrated data models.



King, R. (2014). Statistical ecology. *Annual Review of Statistics and its Application, 1, 401-426.*

Langrock, R. and King, R. (2013). Maximum likelihood estimation of mark-recapture-recovery models in the presence of continuous covariates. *Annals of Applied Statistics, 7, 1709-1732.*

King, R., Morgan, B.J.T., Gimenez, O. and Brooks, S.P. (2009). Bayesian Analysis for Population Ecology. *Chapman and Hall/CRC.*

3 *Locations and estimated movement behaviour states for a grey seal in the North Sea and eastern coast of Great Britain (Ruth King)*

Dr Ruth King
Statistical Ecology

Co-workers
Dr Roland Langrock
Ben Swallow
Hannah Worthington

Prof Kevin N. Laland FRSE
Social Evolution & Learning

Co-workers
Dr Daniel Cownden
Dr Catherine Cross
Dr Lewis Dean
Dr Keelin Murray
Dr Stuart Murray
Dr Ana Naverrette
Dr Glenna Nightingale
Dr Daniel van der Post
Dr Mike Webster
Nicola Atton
Alice Cowie
Cara Evans
Elena Miu
Thomas Morgan
James Ounsley
Murillo Pagnotta
Sally Street
Camille Troisi
Andrew Whalen

Kevin Laland's group is investigating social learning, cultural evolution and niche construction. His group has discovered that two closely related species of sticklebacks differ in their social learning capabilities, with ninespined sticklebacks but not threespined sticklebacks being capable of public information use (the ability to assess the quality of a food patch through tracking the success and failures of others' foraging). They are currently investigating the biological basis of this species difference, taking a number of perspectives. These include mapping public information use on a stickleback phylogeny by sampling and assaying multiple populations, of multiple species, from around the world. They also include experimental investigations of the function, development and mechanisms of public information use. Finally, they are investigating how the social network structure of fish shoals can be used to determine how information diffuses through animal groups.

Webster, M.M. and Laland, K.N. (2013). The learning mechanism underlying public information use in ninespine sticklebacks (Pungitius pungitius). *Journal of Comparative Psychology, 127, 154-165.*

Webster, M.M., Atton, N., Hoppitt, W. and Laland, K.N. (2013). Environmental complexity influences association network structure and network-based diffusion of foraging information in fish shoals. *American Naturalist, 181, 235-244.*

Atton, N., Hoppitt, W., Webster, M.M., Galef, B.G. and Laland, K.N. (2012). Information flow through threespine stickleback networks without social transmission. *Proceedings of the Royal Society B, Biological Sciences, 279, 4272-4278.*

1

1 *Ninespined stickleback – exhibits public information use, a form of social learning investigated by members of the Laland lab (Sean Earnshaw)*

Dr Roland Langrock
Statistical Ecology

Co-workers
Dr David Borchers
Dr Ruth King
Dr Len Thomas

Roland's research focuses on the development of statistical methodology for latent-state models, including hidden Markov models, general state-space models and Cox point processes. These models typically comprise an observed stochastic process which in some way is driven by another stochastic process, where the latter is not directly observed. This structure renders these models ideal statistical tools in many ecological applications, where the observed process might for example correspond to the movement speed of an animal, and the unobserved process often can be interpreted as the behavioural state of the animal. In his research, Roland applies latent-state models to animal movement data, in capture-recapture studies, in animal abundance surveys and in studies of population dynamics.

Langrock, R., Borchers, D.L. and Skaug, H.J. (2013). Markov-modulated nonhomogeneous Poisson processes for modeling detections in surveys of marine mammal abundance. *Journal of the American Statistical Association, 108, 840-851.*

Langrock, R., Marques, T.A., Baird, R.W. and Thomas, L. (in press). Modeling the diving behavior of whales: a latent-variable approach with feedback and semi-Markovian components. *Journal of Agricultural, Biological and Environmental Statistics, DOI:10.1007/s13253-013-0158-6.*

Langrock, R., King, R., Matthiopoulos, J., Thomas, L., Fortin, D. and Morales, J.M. (2012). Flexible and practical modeling of animal telemetry data: hidden Markov models and extensions. *Ecology, 93, 2336-2342.*

Monique's group develops spatially adaptive modelling methods for spatially and temporally auto-correlated data. Her work recently finds application in environmental impact assessment for marine renewable energy developments which has resulted in issuing guidance (and associated software) for Scottish Government regarding the survey design and analysis for marine offshore (and nearshore) renewables.

MacKenzie, M.L., Scott-Hayward, L.A.S., Oedekoven, C.S., Skov, H., Humphreys, E. and Rexstad, E. (2013). Statistical modelling of seabird and cetacean data: guidance document and associated software. *University of St Andrews contract for Marine Scotland; SB9 (CR/2012/05). Found at: http://creem2.st-andrews.ac.uk/software.aspx.*

Scott-Hayward, L.A.S., MacKenzie, M.L., Donovan, C.R., Walker, C.G. and Ashe, E. (in press). Complex Region Spatial Smoother (CReSS). *Journal of Computational and Graphical Statistics, DOI:10.1080/10618600.2012.762920.*

Walker, C.G., MacKenzie, M.L., Donovan, C.R. and O'Sullivan, M. (2011). SALSA – A Spatially Adaptive Local Smoothing Algorithm. *Journal of Statistical Computation and Simulation, 81, 179-191.*

Dr Monique L. MacKenzie
Spatio-Temporal Modelling

Co-workers
Dr Cornelia Oedekoven
Dr Lindesay Scott-Hayward
Darren Kidney
Cameron Walker

2

2 *Amazonian flooded forest (Anne Magurran)*

Anne Magurran works on the evolution, measurement and conservation of biological diversity. Much of this research is focused on freshwater communities in the Neotropics, particularly in Brazil, Trinidad & Tobago and Mexico, but she is also interested in the diversity of marine and terrestrial communities in Scotland and elsewhere in the world, with a particular emphasis on how this diversity changes through time.

Magurran, A.E. and McGill, B.J. (Editors) (2011). Biological Diversity: Frontiers in Measurement and Assessment. *Oxford University Press.*

Magurran, A.E. and Henderson, P.A. (2012). How selection structures species abundance distributions. *Proceedings of the Royal Society B, Biological Sciences, 279, 3722-3726.*

Magurran, A.E. and Henderson, P.A. (2010). Temporal turnover and the maintenance of diversity in ecological assemblages. *Philosophical Transactions of the Royal Society B, Biological Sciences, 365, 3611-3620.*

Prof Anne E. Magurran FRSE
Biological Diversity & Evolutionary Ecology

Co-workers
Dr Miguel Barbosa
Dr Amy Deacon
Mrs Faye Moyes
Dr Hideyasu Shimadzu
Dr Caya Sievers
Grant Brown
Morelia Camacho
Alessandra Kortz
Alan Reeve

1

Dr Alfredo F. Ojanguren
Fish Behavioural Ecology

Co-workers
Prof Anne Magurran
Dr Miguel Barbosa
Dr Maria Dornelas
Morelia Camacho Cervantes
Al Reeve

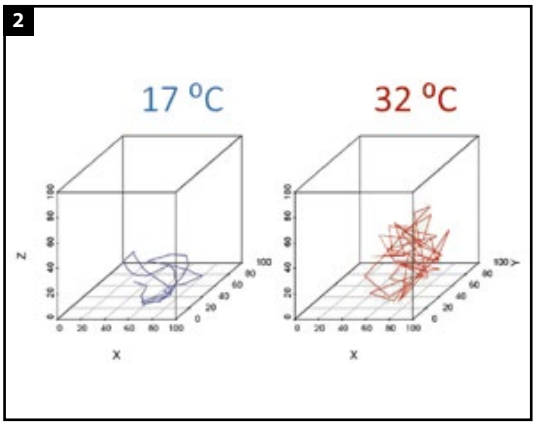
Alfredo Ojanguren studies the links between performance in whole-organism functions and patterns of distribution and abundance of species that ultimately determine biological diversity. By investigating the shape and position of thermal performance curves his group aims at understanding how some species become invasive and succeed in expanding their ranges to areas with novel thermal regimes.

Robinson, J.P.W., Dornelas, M. and Ojanguren, A.F. (2013). Interspecific synchrony of seabird population growth rate and breeding success. *Ecology and Evolution, 3, 213-219.*

Barbosa, M., Ojanguren, A.F. and Magurran, A.E. (2013). Courtship display persists despite early social deprivation. *Ethology, 119, 496-502.*

Ojanguren, A.F. and Fuiman, L.A. (2010). Seasonal variability in antipredator performance of red drum larvae. *Marine Ecology Progress Series, 413, 117-123.*

2



1 *Tiger shark, Bahamas (Yannis Papastamatiou)*

2 *Three-dimensional routine swimming trajectories of juvenile guppies at different water temperatures (Mia Kent)*

Dr Yannis P. Papastamatiou
Spatial Ecology & Behaviour of Marine Predators

Yannis is a MASTS Research Fellow based at the Scottish Oceans Institute at the University of St Andrews. He is broadly interested in the movements of fishes and the behaviours driving these movements. He is also interested in the role that physiology may play in animal habitat selection. The majority of his work has been with sharks although he has also studied bony fishes and reptile top predators. He uses a number of tools including telemetry, animal born data-loggers, and stable isotopes. An understanding of fish movement rules can be used to optimise the design of Marine Protected Areas and other fisheries management strategies. Other interests include digestive physiology of sharks and the ecology of mesophotic reefs (reefs > 50 m in depth). Current projects include: 1) The role of competition and oceanography in driving movement patterns and habitat selection by reef sharks at a remote coral atoll; 2) Bio-energetic and foraging strategies of pelagic top predators; 3) Thermal physiology of homeothermic sharks; 4) Digestive physiology of bonnethead sharks: are they facultative herbivores?; 5) Ecological roles of top predators in regulating the community structure of mesophotic reefs.

Papastamatiou, Y.P., Meyer, C.G., Carlvaho, F., Dale, J.J., Hutchinson, M.R. and Holland, K.N. (2013). Telemetry and random-walk models reveal complex patterns of partial migration in a marine predator. *Ecology, 94, 2595-2606*

Fagan, W.F., Lewis, M.A., Auger-Méthé, M., Avgar, T., Benhamou, S., Breed, G., LaDage, L., Schlägel, U.E., Tang, W., Papastamatiou, Y.P., Forester, J. and Mueller, T. (2013). Spatial memory and animal movement. *Ecology Letters, 16, 1316-1329.*

Papastamatiou, Y.P., Cartamil, D.P., Lowe, C.G., Meyer, C.G., Wetherbee, B.M. and Holland, K.N. (2011). Scales of orientation, directed walks and movement path structure in sharks. *Journal of Animal Ecology, 80, 864-874.*

3

David Paterson's group is investigating aspects of coastal ecology, biodiversity and ecosystem function. A major theme of his Sediment Ecology Research Group (SERG) is the impact of global climate change and anthropogenic exploitation on coastal systems. This research includes examination of ecosystem function-biodiversity relationships under climate change scenarios through experimental (mesocosm) and manipulative field studies (figure 2). SERG is investigating the effects of temperature, ocean acidification, hypoxia and hydrodynamic forcing, both individually and as multiple stressors. SERG uses existing (e.g. carbon uptake, primary production, nutrient turnover) and novel methods, developed by the group, (Sediment stability: Cohesive strength meter. Surface adhesion: Magnetic particle induction) to measure multiple ecosystem functions. This has allowed the group to focus on the role of organisms and microbial consortia (biofilms) as ecosystem engineers, capable of modifying their habitat. SERG and co-workers have introduced the concept of "cooperative ecosystem engineering" describing organisms acting together in shaping local environmental conditions. This area of work is partly supported by a large NERC consortium award (CBESS) led from St Andrews. SERG is also working on the effect of invasive species on ecosystem function within a European consortium (VECTORS).

4

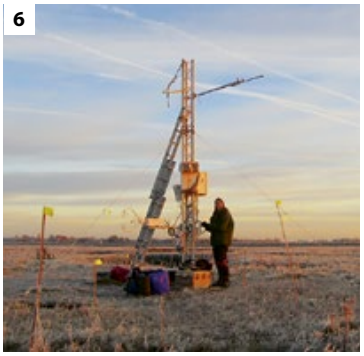
Passarelli, C., Olivier, F., Paterson, D.M., Meziane, T. and Hubas, C. (2013). Organisms as cooperative ecosystem engineers in intertidal flats. *Journal of Sea Research, 465, 85-97.*

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

Solan, M., Aspden, R.J. and Paterson, D.M. (Editors) (2012). Marine Biodiversity Futures and Ecosystem Functioning: Frameworks, Methodologies and Integration. *Oxford University Press.*

5

6



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3 *Morecambe Cartmel Sands (CBESS)*

4 *SERG members measuring the ecosystem function of mudflats in Essex as part of the NERC CBESS consortium (CBESS)*

5 *Collecting data Morecambe Bay (CBESS)*

6 *Eddy co-variance tower (CBESS)*

7 *Sediment stability data collection in Morecambe Bay (CBESS)*

Prof David M. Paterson
Sediment Ecology

Co-workers
Dr Rebecca Aspden
Dr Andrew Blight
Dr Melanie Chocholek
Dr Emma Defew
Dr Claire Golléty
Pamela Cramb
Irvine Davidson
Julie Hope
Meriem Kayoueche-Reeve
Joseph Kenworthy
Nikki Khanna
Jack Maunder
Clare Maynard
Kate Wade
Stephen Watson
Adam Wyness

1

Dr Rob S. Schick
Statistical Ecology

Co-workers
Dr John Harwood
Dr Len Thomas

Rob Schick is a MASTS Research Fellow based at the Centre for Research into Ecological and Environmental Modelling within the Scottish Oceans Institute at the University of St Andrews. He is broadly interested in the movement and organism-environment interaction of animals, with a particular focus on marine mammals. He has worked on a diverse array of systems from marine mammals to pelagic fish and recently to humans. Much of his current work focuses on the interaction between physiology and movement with an idea towards understanding the times and places in an animal's environment when their body condition will improve most rapidly. The converse of this is identifying when and where animals are likely to be in poor condition, and therefore more vulnerable to anthropogenic disturbance.

Current projects: 1) estimating latent health in individual North Atlantic right whales; 2) examining the putative effects of noise generated by the construction and operation of offshore marine renewables on marine mammals; 3) using photogrammetry to estimate body condition in harbour seals in the Moray Firth; and 4) analysing the movements and smoking behaviour in human subjects. This last project is a pilot project funded by a LEADERS award from the Scottish Universities Life Sciences Alliance.

1|2 *Northern elephant seals on the beach in Año Nuevo State Park, California, USA. Data from seals in this population were used to estimate at-sea body condition (Jason Bradley)*

3 *Right whale #1621 seen in good condition in 1997, left (Moira Brown) and again in bad condition in 1999, right (Amy Knowlton)*

Schick, R.S., Kraus, S.D., Rolland, R.M., Knowlton, A.R., Hamilton, P.K., Pettis, H.M., Kenney, R.D. and Clark, J.S. (2013a). Using hierarchical Bayes to understand movement, health, and survival in the endangered North Atlantic right whale. *PLOS ONE, 8, e64166.*

Schick, R.S., Loarie, S.R., Colchero, F., Best, B.D., Boustany, A., Conde, D.A., Halpin, P.N., Joppa, L.N., McClellan, C.M. and Clark, J.S. (2008). Understanding movement data and movement processes: current and emerging directions. *Ecology Letters, 11, 1338-1350.*

Schick, R.S., New, L.F., Thomas, L., Costa, D.P., Hindell, M.A., McMahon, C.R., Robinson, P.W., Simmons, S.E., Thums, M., Harwood, J. and Clark, J.S. (2013b). Estimating resource acquisition and at-sea body condition of a marine predator. *Journal of Animal Ecology, 82, 1300-1315.*

2

3

Carl Smith is investigating fish reproductive biology and coevolution, with particular reference to understanding the basis to mate choice decisions, male mating tactics, sperm competition and the significance of sexual conflict in mating system evolution. Recent work has focused on the role of MHC genes in mate choice decisions and the significance of olfactory cues in decision making. Research utilises bitterling, fish that lay their eggs in the gills of living mussels. Research also addresses the coevolutionary relationship between bitterling and mussels, examining how the nature of their relationship varies spatially and temporally, and the impact of invasive species on coevolutionary dynamics. Recent research addresses the link between individual intelligence and reproduction in different ecological contexts, utilising bitterling, sticklebacks, zebrafish and cichlid fishes.

Reichard, M., Bryja, J., Polačik, M. and Smith, C. (2011). No evidence for host specialization or host-race formation in the European bitterling (Rhodeus amarus), a fish that parasitizes freshwater mussels. *Molecular Ecology, 20, 3631-3643.*

Agbali, M., Reichard, M., Bryjova, A., Bryja, J. and Smith, C. (2010). Mate choice for non-additive genetic benefits correlate with MHC dissimilarity in the rose bitterling (Rhodeus ocellatus). *Evolution, 64, 1683-1696.*

Bryja, J., Smith, C., Konecny, A. and Reichard, M. (2010). Range-wide population genetic structure of the European bitterling based on microsatellites and mtDNA. *Molecular Ecology, 19, 4708-4722.*

Dr Carl Smith
Fish Reproductive Evolution

Co-workers
Martin Reichard
Andrew Warren

Bitterling-Mussel Coevolution

Bitterling are small fishes that lay their eggs in the gills of living freshwater mussels. Research over the past decade on the behaviour and evolution of bitterling fishes by Carl Smith, Rowena Spence and Martin Reichard at the University of St Andrews has examined the unusual relationship between fish and mussel, as well as using the bitterling as a model for research on mating system evolution.

The association between bitterling and mussels has hitherto been considered as a textbook example of a mutualism, whereby the interaction between two species results in a benefit to both. In the case of bitterling, the fish uses the mussel as a site for laying its eggs, with the mussel acting as a foster parent to its young. Mussels themselves produce larval stages, termed glochidia, that attach to the fins and gills of fish, and it was assumed that the mussel utilised bitterling for this purpose. Research has shown that the association is actually a host-parasite relationship. Bitterling eggs have a negative effect on mussels, and can actually kill them if a mussel is heavily infected, through competition with the mussel for oxygen and nutrients. In addition, bitterling are able to avoid infection by glochidia, though how they do so is still unclear. This relationship varies geographically, and is disrupted by invasive species of bitterling and mussel.

4 *A male European bitterling guarding a mussel in his territory (Carl Smith). Males attract females to a mussel with a courtship display, while aggressively driving away rivals. Females base spawning decisions on mussel quality and male genetic compatibility*

5 *Bitterling embryos developing on the gills of a mussel (Carl Smith). In some parts of their range bitterling are parasites of mussels, in others the mussel parasitises the fish*

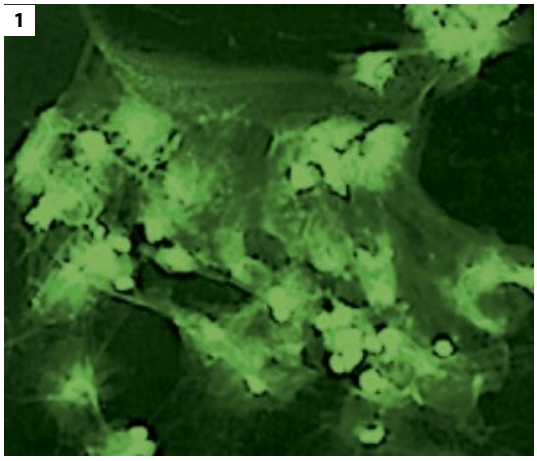
Dr Valerie J. Smith
Comparative Immunology

Valerie Smith studies immunity in decapod crustaceans and other invertebrate species. She is also interested in marine biochemistry, biotechnology and marine microbiology. She is collaborating with members of the MRC Centre for Inflammation Research, Edinburgh University and the School of Life Sciences, Heriot Watt University, on projects investigating the role of chromatin as a primordial defence agent in invertebrates. She is also collaborating with the British Antarctic Survey, to study shell repair and immunity in bivalves in relation to the effects of ocean acidification. Other projects include studying the antimicrobial properties of marine-derived fatty acids and defence strategies in single-celled eukaryotes (with the Institute of Aquaculture, University of Stirling), and the multi-functionality of whey acid protein domain-containing proteins in crustaceans (with Heriot Watt University).

Clark, K.J., Brierley, A.S. and Smith, V.J. (2013). Cloning of the retinoid X receptor (RXR) and gene expression patterns associated with diapause in Calanus finmarchicus. *General and Comparative Endocrinology, 189, 66-73.*

Desbois, A.P. and Smith, V.J. (2010). Antibacterial free fatty acids: activities, mechanisms of action and biotechnological potential. *Applied Microbiology and Biotechnology, 85, 1629-1642.*

Roulston, C. and Smith, V.J. (2010). Isolation and in vitro characterization of prohaemocytes from the spider crab, Hyas araneus. *Developmental & Comparative Immunology 35, 537-544.*



1 *Chromatin released by crab haemocytes after non-self stimulation (Sytox Green staining) (Smith V.J., Robb, C.T., Dyrynda, E.A. & Rossi, A.G.)*

Dr Timothy A. Stojanovic
Coastal Governance & Planning

Co-workers
Fiona Cunningham
Meriem Kayoueche-Reeve
Lorenzo Pergola
Samantha Rebelo

Tim Stojanovic is carrying out research on Marine and Coastal Governance and Planning at local, regional and international scales. He seeks to relate his findings to broader theories of environmental management and sustainability to build a deeper knowledge about human-environment relations in the oceans, and to contribute to the practical development in new systems of marine planning and policy. He also plays a role in interdisciplinary research teams as a social scientist conducting integrated assessments, for example on (1) adapting to climate change at the coast, and (2) cultural ecosystem services.

Stojanovic, T.A. and Farmer, C.J.Q. (2013). The development of world oceans & coasts and concepts of sustainability. *Marine Policy, 42, 157-165.*

Smith, H.D., Maes, F., Stojanovic, T.A. and Ballinger, R.C. (2011). The integration of land and marine spatial planning. *Journal of Coastal Conservation: Planning and Management, 15, 291-303.*

Stojanovic, T.A. and Ballinger, R.C. (2009). Integrated coastal management: a comparative analysis of four UK initiatives. *Applied Geography, 29, 49-62.*

Chris Templeton's research group has interests in understanding how animals communicate about their environments. Research in the lab investigates how information is encoded and transmitted in animal vocalisations and how other individuals learn to decode and use this information to make behavioural decisions. This work focuses on a variety of social interactions, including predator mobbing, song learning, aggressive signaling, and cooperative duetting, with the goal of understanding how ecological and cultural factors shape communication.

Templeton, C.N., Rios-Chelen, A., Quiros-Guerrero, E., Mann, N.I. and Slater, P.J.B. (2013). Female happy wrens select songs to cooperate with their mates rather than confront intruders. *Biology Letters, 9, 20120863.*

Templeton, C.N., Akçay, Ç., Campbell, S.E. and Beecher, M.D. (2010). Juvenile sparrows preferentially eavesdrop on song interactions. *Proceedings of the Royal Society B, Biological Sciences, 277, 447-453.*

Templeton, C.N., Greene, E. and Davis, K. (2005). Allometry of alarm calls: black-capped chickadees encode information about predator size in their mobbing calls. *Science, 308, 1934-1937.*

Dr Christopher N. Templeton
Animal Communication, Ecology & Learning

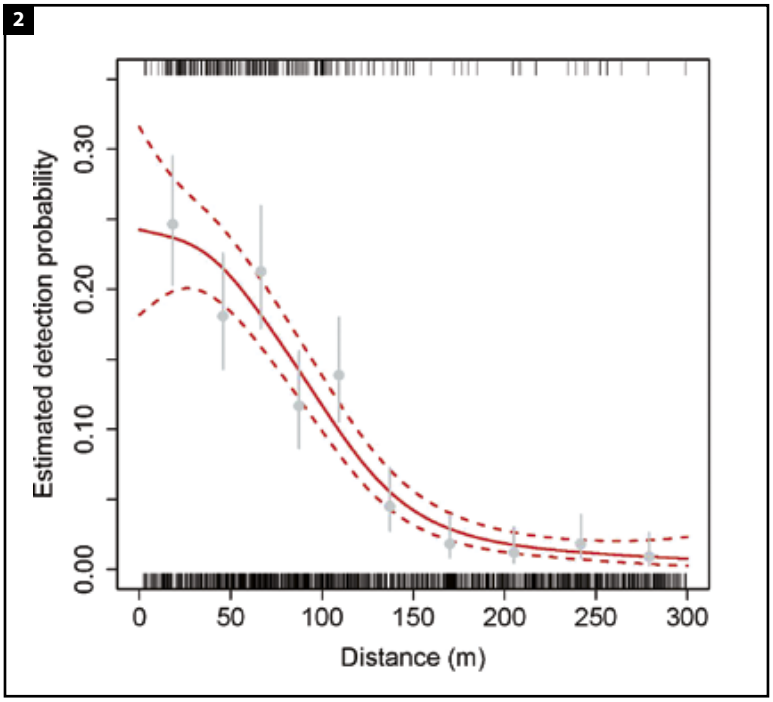
Co-worker
Nora Carlson

Len Thomas is interested in the application of statistics to solve applied ecological problems. He works on a variety of projects, in three main areas. First is the development of methods and software for estimating animal population size or density. Here, he mostly works on a group of methods called distance sampling (e.g., Thomas et al., 2010); he has also become interested in passive acoustic monitoring of whales (e.g., Marques et al., 2013). Second is the use of computer-intensive methods to fit mechanistic time series models, such as models of wildlife population dynamics or animal movement. He likes to use a class of fitting algorithms called particle filters (e.g., Thomas 2009). Third is estimation of population trends (e.g., Jewell et al., 2012).

Marques, T.A., Thomas, L., Martin, S.W., Mellinger, D.K., Ward, J.A., Moretti, D.J., Harris, D. and Tyack, P.L. (2013). Estimating animal population density using passive acoustics. *Biological Reviews, 88, 287-309.*

Thomas, L., Buckland, S.T., Rexstad, E.A., Laake, J.L., Strindberg, S., Hedley, S.L., Bishop, J.R.B., Marques, T.A. and Burnham, K.P. (2010). Distance software: design and analysis of distance sampling surveys for estimating population size. *Journal of Applied Ecology, 47, 5-14.*

Thomas, L. (2009). Grey seals red in tooth and claw: how Darwin helps model their population. *Significance, 6, 108-112.*



2 *Red line shows the estimated probability of detecting a harbour porpoise in a 15-second period using an acoustic sensor, as a function of distance of the animal from the sensor. This is one piece of information required to estimate porpoise density from passive acoustic monitoring. Joint work with Line Kyhn, Aarhaus University, Denmark*

Dr Len Thomas
Statistical Ecology

Co-workers
Dr Stacy DeRuiter
Dr Danielle Harris
Dr Roland Langrock
Dr Tiago Marques
Dr Laura Marshall
Dr David Miller
Dr Cornelia Oedekoven
Dr Dina Sadykova
Dr Robert Schick
Dr Catriona Stephenson
Rocio Gonzalez
Rebecca Jewell
David Moretti

Prof Christopher D. Todd
Marine Ecology

Co-worker
Alexandra Howe

Chris Todd has interests in ocean climate impacts on wild salmon populations and ectoparasitic copepods ("sea lice") infecting wild salmon and sea trout. The research has demonstrated a marked influence of recent ocean warming on growth condition, survivorship and run-timing of salmon in Scotland. Sea lice parasites also have proven to be a potentially significant source of mortality of wild salmon and sea trout, and this research has relevance to the development of management practices in conserving and maintaining wild salmon populations in Europe.

Hanson, N.N., Wurster, C.M., E.I.M.F. and Todd, C.D. (2012). Reconstructing thermal and metabolic histories of wild Atlantic salmon (Salmo salar) from the stable isotope composition of otoliths. *Marine Ecology Progress Series, 475, 249-266.*

1 *Parasitic sea lice on wild Atlantic salmon (Chris Todd)*

Todd, C.D., Friedland, K.D., MacLean, J.C., Russell, I. and Lonergan, M.E. (2012). Phenological and phenotypic changes in Atlantic salmon populations in response to a changing climate. *ICES Journal of Marine Science, 69, 1686-1698.*

Krkošek, M., Revie, C.W., Gargan, P., Skilbrei, O.T., Finstad, B. and Todd, C.D. (2013). Impact of parasites on salmon in the Northeast Atlantic Ocean. *Proceedings of the Royal Society B, Biological Sciences, 280, 20122359.*

1

Dr Aubrey L. Zerkle
Microbial Biogeochemistry

Co-workers
Dr Gareth Izon
Colin Mettam

Aubrey Zerkle's interests lie broadly in understanding the co-evolution of life with the earth surface environment over geologic timescales. Micro-organisms are a key driving force behind geochemical cycling in modern environments, and were even more important in elemental cycling on the ancient earth. Microbial metabolic functions can directly control the redox transformation of elements, which likely dictated the chemistry of the atmosphere and oceans through geologic time. Correspondingly, the chemical development of the earth surface has greatly influenced the pace and direction of biological evolution.

Farquhar, J., Zerkle, A.L. and Bekker, A. (2014). Geologic and Geochemical Constraints on the Earth's Early Atmosphere. *In: Treatise on Geochemistry: Reference Module in Earth Systems and Environmental Sciences, Holland, H. and Turekian, K. (Editors), 2nd edition, vol. 6: The Atmosphere - History, Elsevier, 91-138.*

Farquhar, J., Cliff, J., Zerkle, A.L., Kamyshny, A., Poulton, S.W., Claire, M., Adams, D. and Harms, B. (2013). Pathways for Neoarchean pyrite formation constrained by mass-independent sulfur isotopes. *Proceedings of the National Academy of Sciences of the USA, 110, 17638-17643.*

Zerkle, A.L., Claire, M.W., Domagal-Goldman, S.D., Farquhar, J. and Poulton, S.W. (2012). A bistable organic-rich atmosphere on the Neoarchaean Earth. *Nature Geoscience, 5, 359-363.*

Research Themes

GLOBAL CHANGE & PLANETARY EVOLUTION

The processes and systems pertaining to the form, structure and change of the planet and its oceans. From the basalts outpouring at the mid ocean ridges to the dynamic interactions of climate at the land-ocean interface, Ocean and Earth Sciences embody a holistic view of the Earth System from deepest time to present day and the future.

At the core of Ocean and Earth System Science are natural cycles such as the hydrological cycle linking marine to terrestrial spheres and the carbon cycle linking biosphere, geosphere, hydrosphere and atmosphere. In order to understand these processes, multidisciplinary scientific approaches such as those possible by collaborations within the SOI are required.

Nicky Allison studies marine biomineralisation, the geochemistry of marine biominerals (corals, foraminifera and sclerosponges) and the reconstruction of past climates from fossil carbonate geochemistry. Her group has built a sophisticated seawater pCO_2 controlled aquarium for the culture of tropical corals and our current research focuses on assessing the effects of changing atmospheric CO_2 on coral metabolic processes and skeletal geochemistry.

Allison, N., Finch, A.A. and E.I.M.F. (2012). A high resolution δ13C record in a modern Porites lobata coral: insights into controls on skeletal δ13C. *Geochimica et Cosmochimica Acta, 8, 534-542.*

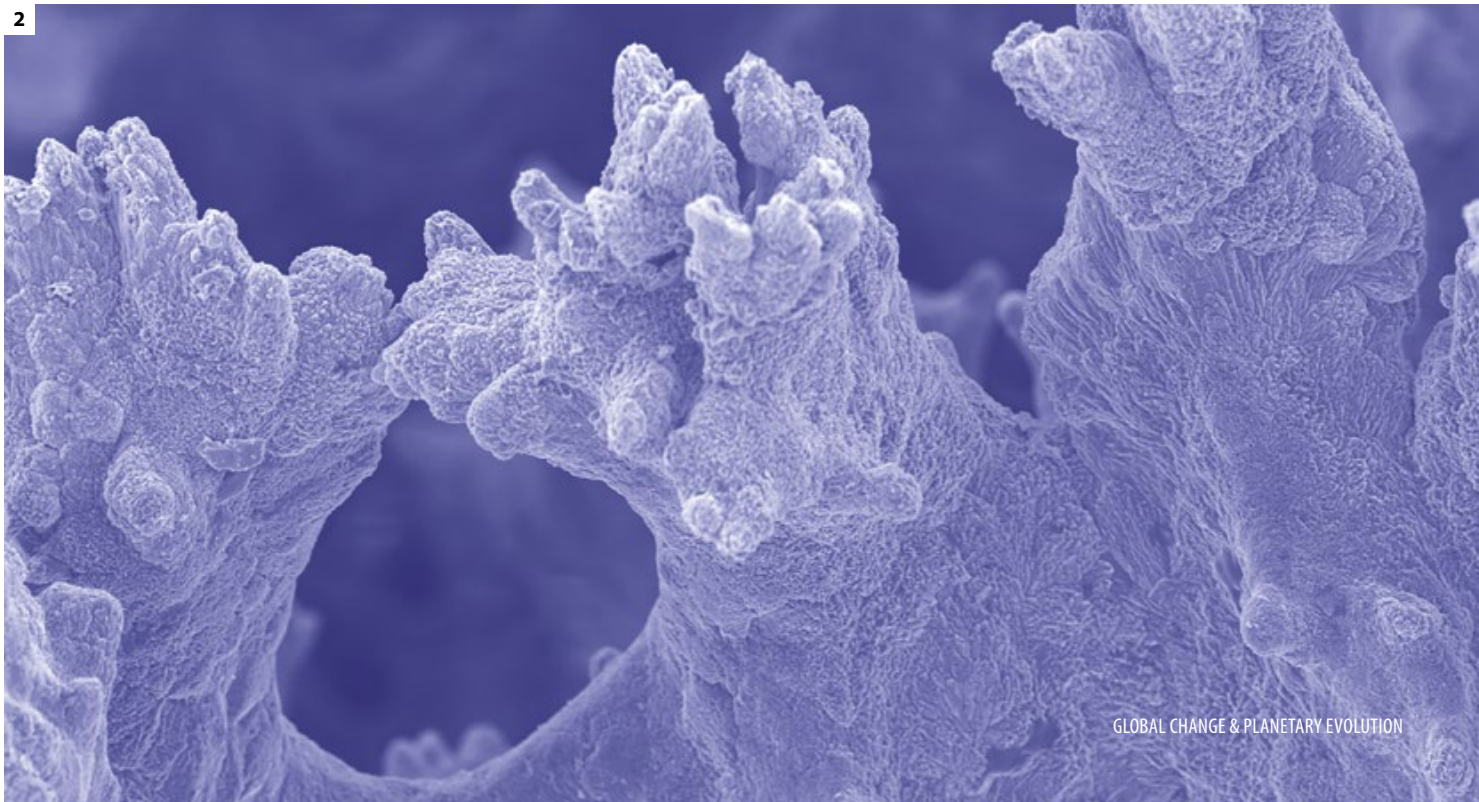
Allison, N., Cohen, I., Finch, A.A., Erez, J. and E.I.M.F. (2011). Controls on Sr/Ca and Mg/Ca in scleractinian corals: the effects of Ca-ATPase and transcellular Ca channels on skeletal chemistry. *Geochimica et Cosmochimica Acta, 7, 6350- 6360.*

Allison, N., Finch, A.A. and E.I.M.F. (2010). δ11B, Sr, Mg and B in a modern Porites coral: the relationship between calcification site pH and skeletal chemistry. *Geochimica et Cosmochimica Acta, 74, 1790-1800.*

Dr Nicola Allison
Biomineralisation & Climate Change

Co-workers
Dr Catherine Cole
Dr Adrian Finch
Dr Chris Hintz

2 *Detail of the growing surface of a Porites lobata coral skeleton (Nicola Allison)*



Dr William E. N. Austin
Climate Change

Co-workers
Prof Kate Darling
Dr Heather Austin
Dr Jeroen Groenveld
Dr David McCarthy
Riccardo Arosio
Lewis Drysdale
Nikki Khanna
Marion Kuhs
Marion Peral
Angela Roberts
Christina Sheldon
David Small
Craig Smeaton
Keziah Stott

Bill was appointed Professor of Marine Geology at SAMS on 1st September 2013, where he now holds a 0.2 FTE position; Bill remains at St Andrews on a 0.8 FTE contract. Bill was also appointed to an Honorary Professorship by UHI in June this year, in recognition of his contributions to teaching and research collaborations spanning nearly 20 years at SAMS.

Dr Heather Austin has returned part-time to work on the Swedish Research Council (VR) funded CONTEMPORARY project; she is based at SERG, SOI and will be contributing to collaborative efforts to culture benthic foraminifera at our NERC-funded facility.

Abbott, P.M., Austin, W.E.N., Davies, S.M., Pearce, N.J.G. and Hibbert, F.D. (2013). Cryptotephrochronology of the Eemian and the last interglacial-glacial transition in the North East Atlantic. *Journal of Quaternary Science, 28, 501-514.*

Reynolds, D.J., Butler, P.G., Williams, S.M., Scourse, J.D., Richardson, C.A., Wanamaker Jr., A.D., Austin, W.E.N., Cage, A.G. and Sayer, M. (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.R. (2013). Freshwater influx, hydrographic reorganization and the dispersal of ice-rafted detritus in the sub-polar North Atlantic Ocean during the last deglaciation. *Journal of Quaternary Science, 28, 527-535.*

Dr C. Richard Bates
Marine Geophysics

Co-workers
Dr Melanie Chocholek
Dr Tony Prave
Dr Tim Raub
Dr Ruth Robinson

Richard Bates is a geophysicist whose focus in the marine sector lies in the application of high-resolution geophysical acoustic methods. He is especially interested in acoustic techniques, in particular multibeam sonar for benthic habitat mapping and the new generation of 3D sonar for mid-water column modelling. He also maintains an active research interest in the combined use of multibeam and sub-bottom sonar for reconstruction of palaeo-landscapes and heritage sites for archaeology. Recent work is branching out with the integration of remote sensing, photography, LiDAR and acoustic techniques for studies on ice melt in climate change investigations.

Bates, C.R., Lawrence, M., Dean, M. and Robertson, P. (2011). Geophysical methods for wreck-site monitoring: the Rapid Archaeological Site Surveying and Evaluation (RASSE) programme. *International Journal of Nautical Archaeology, 40, 404-416.*

Neal, M., Blanchard, T., Hubbard, A., Chauche, N., Bates, C.R., Woodward, J. (2012). A hardware proof of concept for a remote controlled glacier surveying boat. *Journal of Field Robotics, 29, 880-890.*

Quartau, R., Tempera, F., Mitchell, N.C., Pinheiro, L.M., Duarte, H., Brito, P.O., Bates, C.R. and Monteiro, J.H. (2012). Morphology of the Faial Island shelf (Azores): The interplay between volcanic, erosional, depositional and mass-wasting processes. *Geochemistry Geophysics Geosystems, 13, Q04012.*

Geophysical Sensors

Geophysical sensors are the eyes, ears and noses of modern marine science. Acoustic sensors are deployed throughout the oceans in passive listening mode and also used from a wide variety of research vessels in active mode. At a range of frequencies acoustics can record everything from animal movements in behavioural studies to imaging the biological communities on the seafloor and colossal movements of continental plates that are the geological foundations of the ocean floor. From the surface, an increasingly sophisticated array of sensors are used via satellite, airborne, land and ship-based platforms to record not just the ever-changing surface of the oceans but also to penetrate into the surface ocean waters and link these to the terrestrial input to the oceans.

Within the water physical and chemical sensors are able to record 24 hours a day, 365 days a year the dynamic changes that are happening as a natural Earth cycle and also the impact we are having on the oceans. Safeguarding our future will come from not only recording what happens in the oceans today but also understanding the past record preserved in the geology of the ocean floor.

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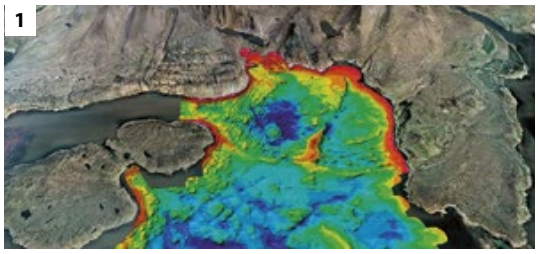


2

1 *Bathymetry model of past glacial advances Loch Scavaig, Skye*

2 *Setting up time-lapse cameras to record Store (marine terminating) glacier, Greenland*

Heidi was appointed as a MASTS Research Fellow in October 2013. Her research investigates the relationship between biogeochemical cycling and ecosystem function, particularly focusing on benthic marine habitats such as tropical and cold-water coral reefs, coralline and macroalgal beds, and seagrass meadows. To this end, she considers the importance of natural variability in driving these relationships, and the potential impact of projected climate change. Her work spans the sub-cellular to ecosystem levels, using a range of biological and geochemical techniques.

3

3 *Coastal phytoplankton bloom, Niteroi, Brazil (Heidi Burdett)*

Burdett, H.L., Donohue, P.J.C., Hatton, A.D., Alwany, M.A. and Kamenos, N.A. (2013). Spatiotemporal variability of dimethylsulphoniopropionate on a fringing coral reef: the role of reefal carbonate chemistry and environmental variability. *PLOS ONE, 8, e64651. (Winner of the 2013 Peter Jones Memorial Award from the Estuarine and Coastal Sciences Association)*

Kamenos, N.A., Burdett, H.L., Aloisio, E., Findlay, H.S., Martin, S., Longbone, C., Dunn, J., Widdicombe, S. and Calosi, P. (2013). Coralline algal structure is more sensitive to rate, rather than the magnitude, of ocean acidification. *Global Change Biology, 19, 3621-3628.*

Burdett, H.L., Kamenos, N.A. and Law, A. (2011). Using coralline algae to understand historic marine cloud cover. *Palaeogeography, Palaeoclimatology, Palaeoecology, 302, 65-70.*

4

4 *Deploying data loggers, Dahab, Egypt (Nick Kamenos)*

Dr Heidi L. Burdett
Marine Biogeochemistry

Co-workers
Prof David Paterson
Dr Clare Golléty
Dr Harry Oduro

Dr Andrea Burke
Paleoceanography, Isotope Geochemistry & Climate

Andrea is interested in the interactions between ocean circulation, chemistry, and climate on a variety of timescales. A major focus of her research uses the geochemistry of fossil deep-sea coral skeletons to provide well-dated archives of past ocean conditions, with a particular emphasis on the last glacial maximum and deglaciation (20,000-10,000 years ago). Andrea also investigates the temporal distribution and biogeography of deep-sea coral populations to understand the environmental controls on these benthic communities today and in the past.

Burke, A. and Robinson, L.F. (2012). The Southern Ocean's role in carbon exchange during the last deglaciation. *Science, 335, 557-561.*

Burke, A., Marchal, O., Bradtmiller, L.I., McManus, J.F. and Francois, R. (2011). Application of an inverse method to interpret 231Pa/230Th observations from marine sediments. *Paleoceanography, 26, PA1212.*

Burke, A., Robinson, L.F., McNichol, A.P., Jenkins, W.J., Scanlon, K.M. and Gerlach, D.S. (2010). Reconnaissance dating: a new radiocarbon method applied to assessing the temporal distribution of Southern Ocean deep-sea corals. *Deep Sea Research Part I: Oceanographic Research Papers, 57, 1510-1520.*

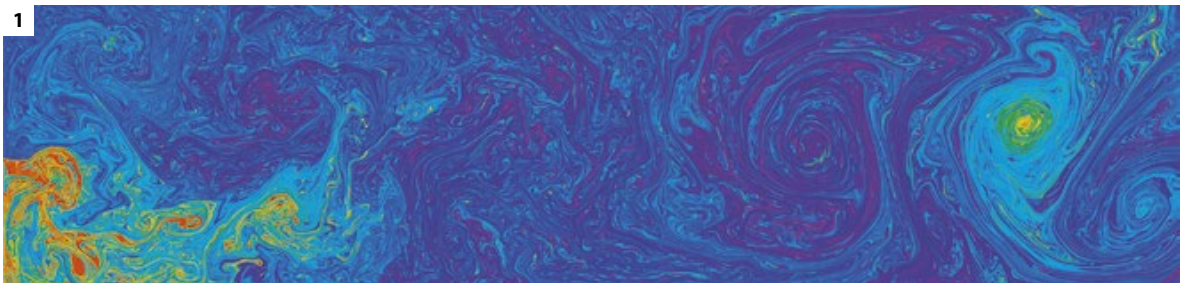
Prof David G. Dritschel FRSE
Fluid Dynamics & Ocean Circulation Modelling

David Dritschel has sought to combine theoretical analysis and numerical computation in the study of fundamental aspects of atmospheric and oceanic fluid dynamics, in particular vortex dynamics and turbulence. He has pioneered the development of a variety of numerical techniques exploiting material conservation properties of geophysical flows, most notably the "contour advection" method and a variety of extensions whose accuracy and efficiency are unparalleled. This has served as an important aid in understanding a wide range of vortex dynamical processes occurring in geophysical flows.

Dritschel, D.G. and Fontane, J. (2010). The combined Lagrangian advection method. *Journal of Computational Physics, 229, 5408-5417.*

Carr, M., King, S.E. and Dritschel, D.G. (2012). Instability in internal solitary waves with trapped cores. *Physics of Fluids, 24, 016601.*

King, S.E., Carr, M. and Dritschel, D.G. (2011). The steady-state form of large-amplitude internal solitary waves. *Journal of Fluid Mechanics, 666, 477-505.*



1 *Turbulence created by a density current impacting a wall (left) in a stratified fluid (David Dritschel)*

Adrian Finch's group studies the processes controlling the chemistry of palaeoenvironmental proxy materials, which are used to infer past climate. The group is involved in ground-truthing methods for palaeoenvironmental reconstruction e.g. by comparing geochemistry with instrumental records in modern specimens, and in the development of synchrotron methods to determine how trace elements are hosted in carbonate climate proxy materials.

Allison, N., Finch, A.A. and E.I.M.F. (2010). The potential origins and palaeoenvironmental implications of high temporal resolution δ18O heterogeneity in coral skeletons. *Geochimica et Cosmochimica Acta, 74, 5537-5548.*

Finch, A.A., Allison, N., Steaggles, H., Wood, C.V. and Mosselmans, J.F.W. (2010). Ba XAFS of Ba-rich standard minerals and the potential for determining Ba structural state in calcium carbonate. *Chemical Geology, 270, 179-185.*

Finch, A.A. and Allison, N. (2008). Mg structural state in coral aragonite and implications for the palaeoenvironmental proxy. *Geophysical Research Letters, 35, L08704.*

2 *Arcopora nana coral colony (Nicola Allison)*

Dr Adrian A. Finch
Biomineralisation

Co-workers
Dr Nicola Allison
Joshua Hughes
Emma Hunt

Tony Prave is a field geologist interested in documenting and reconstructing Earth history during times in Earth's past when the convergence of geological events drove major changes in ocean and atmosphere chemistry, climate and life.

Lepland, A., Joosu, L., Kirsimae, K., Prave, A.R. et al. (2014). Potential influence of sulphur bacteria on Palaeoproterozoic phosphogenesis. *Nature Geoscience, 7, 20-24.*

Macdonald, F.A., Prave, A.R., Petterson, R., Smith, E.F., Pruss, S.B., Oates, K., Waechter, F., Trotzuk, D. and Fallick, A.E. (2013). The Laurentian record of Neoproterozoic glaciation, tectonism, and eukaryotic evolution in Death Valley, California. *Geological Society of America Bulletin, 125, 1203-1223.*

Melezhik, V., Prave, A.R., Hanski, E., Fallick, A., Lepland, A., Kump, L. and Strauss, H. (Editors) (2012). Volumes 1-3: Reading the Archive of Earth's Oxygenation. *Springer.*

Dr Anthony R. Prave
Climate &
Metazoan Evolution

1

Dr James W. B. Rae
Geochemistry, Palaeoceanography & Climate

James studies the ocean carbon cycle and its relationship with climate change past and present. Much of his work focuses on the use of geochemical proxies to reconstruct and understand past ocean conditions, in particular past changes in pH and CO_2. Recent projects have investigated the role of deep water formation in CO_2 change, the cause of ice age cycles, and reconstructions of pH and CO_2 over the last 60 million years. He is also interested in the use of geochemistry to understand biomineralisation processes, and the vulnerability of calcifying organisms to ocean acidification.

Yu, J., Anderson, R.F., Jin, Z., Rae, J.W.B., Opdyke, B.N. and Eggins, S. (2013). Responses of the deep ocean carbonate system to carbon reorganization during the last glacial-interglacial cycle. *Quaternary Science Reviews, 76, 39-52.*

Foster, G.L., Lear, C.H. and Rae, J.W.B. (2012). The evolution of pCO_2, ice volume and climate during the Middle Miocene. *Earth and Planetary Science Letters, 341-344, 243-254.*

Rae, J.W.B., Foster, G.L., Schmidt, D.N. and Elliott, T. (2011). Boron isotopes and B/Ca ratios in benthic foraminifera: proxies for the deep ocean carbonate system. *Earth and Planetary Science Letters, 302, 403-413.*

Dr Vincent R. Rinterknecht
Paleoclimate & Geochronology

Co-worker
David Small

Vincent Rinterknecht's research is on past ice sheets and glaciers as key players at the interface of the land-ocean atmosphere system. A central questions about these ice masses is the timing of their dynamics and to this end he develops chronologies of ice margin fluctuations using cosmogenic nuclides. Recent findings show that Alpine type glaciers recorded local atmospheric conditions that could refine our understanding of the synoptic atmospheric circulation pattern in the past.

Rinterknecht, V.R., Matoshko, A., Gorokhovich, Y., Fabel, D. and Xu, S. (2012). Expression of the Younger Dryas cold event in the Carpathian Mountains, Ukraine? *Quaternary Science Reviews, 39, 106-114.*

Rinterknecht, V.R., Gorokhovich, Y., Schaefer, J. and Caffee, M. (2009). Preliminary 10Be chronology for the last deglaciation of the western margin of the Greenland Ice Sheet. *Journal of Quaternary Science, 24, 270-278.*

Rinterknecht, V.R., Clark, P.U., Raisbeck, G.M., Yiou, F., Brook, E.J., Bitinas, A., Marks, L., Zelcs, V., Lunkka, J.-P., Pavlovskaya, I.E., Piotrowski, J.A. and Raukas, A. (2006). The last deglaciation of the southeastern sector of the Scandinavian Ice Sheet. *Science, 311, 1449-1452.*

2

1 *Pack-ice in front of Store Glacier*

2 *Iceberg stranded in Disko Bay, western Greenland (September 2011) (Romain Schläppy – CNRS, France, research colleague)*

3

Ruth Robinson works on understanding the behaviour of ancient and modern sedimentary systems, particularly rivers, and the short- and long-term feedbacks between tectonics, erosion, and climate. She uses sedimentology, geochronology and geochemistry of detrital minerals to interpret and reconstruct geological histories from sedimentary rocks, and has also worked on determining water, sediment, carbon and metal fluxes for the Irrawaddy and Salween rivers of Myanmar, the Megget Reservoir catchments in the Scottish Borders, and the Halladale River catchment in the peatlands of the Flow Country, northern Scotland. She is currently working on dating the marine and non-marine sediments in Loch Sunart, Orkney and Jersey using optically stimulated luminescence, in order to develop long chronologies of marine and non-marine interactions in sea lochs, for constraining the timing of occupation of submerged archaeological sites, and to develop sea level histories.

Robinson, R.A.J., Brezina, C.A., Parrish, R.R., Horstwood, M.S.A., Win Oo, N., Bird, M.I., Thein, M., Walters, A., Oliver, G.J.H. and Zaw, K. (in press). Large rivers and orogens: the evolution of the Yarlung Tsangpo-Irrawaddy system and the eastern Himalayan syntaxis. *Gondwana Research, DOI:10.1016/j.gr.2013.07.002.*

Abesser, C.A. and Robinson, R.A.J. (2010). Mobilisation of iron and manganese from sediments of a Scottish Upland reservoir. *Journal of Limnology, 69, 42-53.*

Bird, M.I., Robinson, R.A.J., Win Oo, N., Maung Aye, M., Lu, X.X., Higgitt, D.L., Swe, A., Tun, T., Lhaing Win, S., Sandar Aye, K., Mi Mi Win, K. and Hoey, T.B. (2008). A preliminary estimate of organic carbon transport by the Irrawaddy and Salween Rivers of Myanmar. *Quaternary International, 186, 113-122.*

Dr Ruth A. J. Robinson
Evolution of Sedimentary Systems

Co-workers
Dr Bill Austin
Dr Richard Bates
Dr Adrian Finch
Dr Ed Tipper
Cynthia Brezina
Blackwell Manda
Ross Somerville

4

5

6

3|4|5|6 *Fieldwork in Myanmar on the Irrawaddy river (Ruth Robinson)*

Research Themes

SEA MAMMAL BIOLOGY

Sea Mammal Research Unit

The Sea Mammal Research Unit (SMRU) carries out interdisciplinary research into the biology of marine mammals, trains marine mammal scientists through undergraduate and postgraduate teaching and advises government, inter-governmental organisations, non-governmental organisations and industry on conservation issues. In 2012 the University of St Andrews was awarded a Queen's Anniversary Prize in recognition of SMRU's outstanding contribution to understanding and protecting the oceans.

SMRU is a National Capability partner within the UK's Natural Environment Research Council (NERC) strategic marine research theme. This central funding enables SMRU to deliver the UK's main science capability in the field of marine mammal biology. However this supports only a proportion of SMRU's overall research activities. Other significant funding is provided by the Scottish Government to provide scientific support and advice on Scottish marine mammal issues. SMRU raises the remainder of the funding to support both its strategic and curiosity driven research programme from a wide variety of other sources, including NERC responsive mode funding, Non-Governmental Organisations, European Union, Department for Environment, Food and Rural Affairs, Ministry of Defence, Department of Energy and Climate Change, Country Conservation Agencies as well as funding agencies in the US such as the Office of Naval Research.

Physical Oceanography

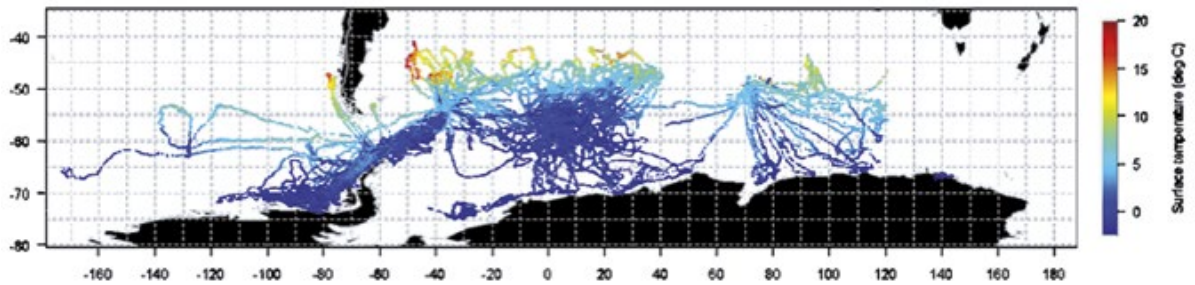
In the 19th century, the world's oceans were viewed as an unlimited resource beyond the power of man to change. In the 20th century we became aware that they were fragile ecosystems that were over exploited and threatened by human activities. By the turn of the century, we became aware that it was not only the ecosystems that were threatened, but that our activities could be affecting the physical behaviour of the oceans and the way they transport heat around our planet determining our climate. Such changes could affect all ecosystems on Earth. We now realize the need to study the oceans as a coherent, interconnected ecosystem, where physical measurements are linked with biological observations and both are viewed as an integrated whole. In response to this urgent need, the Physical Oceanography group works broadly on three main themes.

More than 64,000 oceanographic profiles were collected by CTD-SRDLs during the last International Polar Year in the Southern Ocean alone. This technology has come a long way and is now an integral part of the Southern Ocean Observing System

We operate together with the SMRU Instrumentation group to develop and integrate animal-borne oceanographic sensors into the existing behavioural tags. Over the last decade these instruments have made an enormous impact on the ocean observing systems. More than half of all oceanographic observations available from the Polar Oceans have been delivered by these tags.

We use these instruments to investigate the dynamics of the Polar Oceans. Our studies range from small scale observations in Fjord systems to broad-scale studies of the frontal systems within the Southern Ocean. We are particularly interested in variability on seasonal and shorter time scales.

We use our expertise not only to describe, but also to link this environment to the marine ecosystem. Such interdisciplinary work thrives at the SOI, and we work closely with other groups to link changes in marine animal behaviour to changes in their physical environment.



Lars Boehme is interested in the physics of the Polar Oceans and the dynamics of frontal systems in particular. His studies utilise animal-borne technology showing the usefulness of this approach in examining the sensitivity of top predators to global and regional-scale climate variability. He was appointed to a MASTS Lectureship in 2012.

Boehme, L., Lovell, P.L., Biuw, M., Roquet, F., Nicholson, J., Thorpe, S.E., Meredith, M.P. and Fedak, M.A. (2009). Animal-borne CTD-Satellite Relay Data Loggers for real-time oceanographic data collection. *Ocean Science, 5, 685-695.*

Boehme, L., Meredith, M.P., Thorpe, S.E., Biuw, M. and Fedak, M.A. (2008). The ACC frontal system in the South Atlantic: monitoring using merged Argo and animal-borne sensor data. *Journal of Geophysical Research, 113, C09012.*

1

Biuw, M., Boehme, L., Guinet, C., Hindell, M., Costa, D., Charrassin, J-B., Roquet, F., Bailleul, F., Meredith, M.P., Thorpe, S., Tremblay, Y., McDonald, B., Park, Y.-H., Rintoul, S., Bindoff, N., Goebel, M., Crocker, D., Lovell, P., Nicholson, J., Monks, F. and Fedak, M.A. (2007). Variations in behavior and condition of a Southern Ocean top predator in relation to in situ oceanographic conditions. *Proceedings of the National Academy of Sciences of the USA, 104, 13705-13710.*

Dr Lars Boehme
Physical Oceanography

Co-workers
Lauren Biermann
Samantha Gordine

1 *A Satellite-Relay-Data-Logger (SRDL) designed and built by SMRU Instrumentation attached to a Southern elephant seal on South Georgia. It will record the seals' behaviour and also the temperature and salinity of the ocean while the seal travels 1000s of miles in the Southern Ocean (Lars Boehme)*

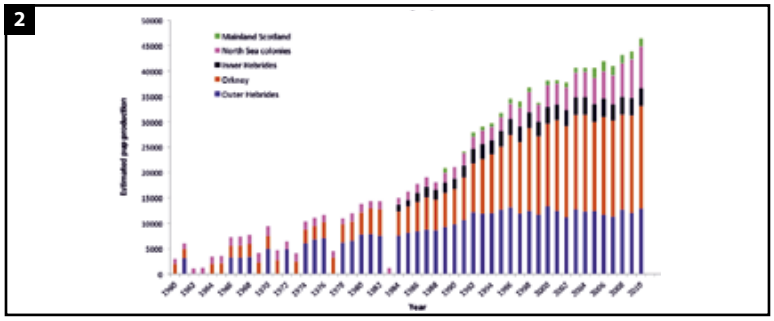
Monitoring UK seal populations has been a main component of SMRU's research programme since the 1970s and is an essential component of NERC's statutory requirement to provide to the UK government scientific advice on the management of seal populations. Grey and harbour (common) seal populations are monitored by aerial survey. Grey seals are monitored by biennial counts of pups during their autumn breeding season while harbour seals are monitored during their late summer moult (when grey seals are also counted). The information is routinely used by the Scottish Government, Defra and the Countryside Agencies, especially SNH, Natural England and the Joint Nature Conservation Committee. Survey results are available annually on SMRU's website in the reports from NERC's Special Committee on Seals.

Cordes, L.S., Duck, C.D., Mackey, B.L., Hall, A.J. and Thompson, P.M. (2011). Long-term patterns in harbour seal site-use and the consequences for managing protected areas. *Animal Conservation, 14, 430-438.*

Lonergan, M., Duck, C.D., Thompson, D. and Moss, S. (2011). British grey seal (Halichoerus grypus) numbers in 2008; an assessment based on using electronic tags to scale up from the results of aerial surveys. *ICES Journal of Marine Science, 68, 2201-2209.*

Duck, C.D. (2010). Section 3.5: Seals. *In: UKMMAS (2010) Charting Progress 2 Healthy and Biological Diverse Seas Feeder Report, Frost, M. and Hawkridge, J. (Editors), Published by Department for Environment Food and Rural Affairs on behalf of UKMMAS, 506-539. http://www.scotland.gov.uk/Resource/Doc/295194/0119667.pdf*

2



2 *UK grey seal pup production at annually monitored breeding colonies in the main island groups*

Mr Callan D. Duck
Seal Populations

Co-worker
Chris Morris

Animal-Borne Sensors

SMRU Instrumentation develops and manufactures animal-borne instrumentation used to provide data on marine animals and their immediate environment. We have over 25 years of experience working on collaborative ventures between marine biologists, oceanographers and systems engineers to extract maximum scientific value from each dataset collected.

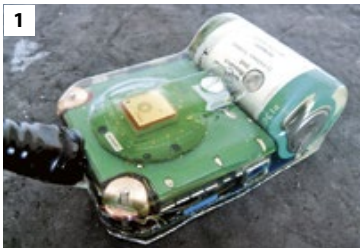
These animal-borne sensors can be equipped with a variety of sensors depending on the question being addressed. All instruments provide information on the animal's location and behaviour, but additional information about the oceanographic environment can be collected, archived and relayed by satellite or mobile phone technology. Data from such instruments are playing a major role within the ocean observing systems, particularly from the Polar Oceans.

The scientific applications for these instruments are wide ranging from investigating the ecology on a global climatic scale, down to high resolution studies looking at the detailed movements and diving patterns of animals in tidal waters in relation to commercial developments, e.g. wind farms and tidal turbines.

Our methods data, and expertise are important to biologists and climate researchers, and in conservation agencies and policy makers.

Sea Mammal Research Unit Instrumentation

1



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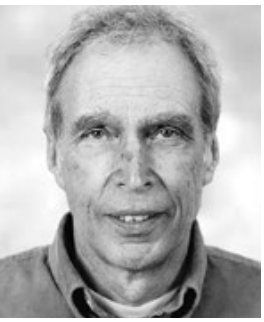


Prof Michael A. Fedak
Diving Physiology & Behaviour

Mike Fedak's research interests are directed to understanding the life history of marine mammals. This involves studies ranging from physiology and energetics to oceanography and foraging ecology. He is actively involved in the development of methodology that facilitates observation of the behaviour and resource acquisition of seals and of their immediate environment. With the engineers of SMRU Instrumentation, he develops animal-borne data loggers and telemetry devices that both monitor the behaviour and foraging success of animals while simultaneously providing ocean observations that are made freely available to the international oceanographic community.

3

Fedak, M.A., Arnbom, T. and Boyd, I.L. (1996). The relation between size of southern elephant seal mothers, the growth of their pups and the use of maternal energy, fat and protein during lactation. *Physiological Zoology, 69, 887-911.*

Biuw, M., Boehme, L., Guinet, C., Hindell, M., Costa, D., Charrassin, J-B., Roquet, F., Bailleul, F., Meredith, M.P., Thorpe, S., Tremblay, Y., McDonald, B., Park, Y.-H., Rintoul, S., Bindoff, N., Goebel, M., Crocker, D., Lovell, P., Nicholson, J., Monks, F. and Fedak, M.A. (2007). Variations in behavior and condition of a Southern Ocean top predator in relation to in situ oceanographic conditions. *Proceedings of the National Academy of Sciences of the USA, 104, 13705-13710.*

Fedak, M.A. (2013). The impact of animal platforms on polar ocean observation. *Deep Sea Research Part II: Topical Studies in Oceanography, 88-89, 7-13.*

3 *Capturing crabeater seals to attach CTD-SRDLs on ice flows off the west coast of the Antarctic Peninsula (Dave Weimer, NSF)*

Douglas Gillespie develops systems for the passive acoustic detection of marine mammals. Acoustic detection can be several times more efficient than visual detection for many species. His current research focus is developing low power systems for real time operation on remote moorings and autonomous vehicles.

1 *A SMRU Instrumentation GPS-phone tag. This instrument records behavioural information and GPS locations and is designed for species that come near shore within mobile phone coverage. The entire set of data records stored in the memory can then be relayed via the GSM mobile phone system*

2 *A CTD-SRDL records behavioural information and oceanographic data which is relayed via a satellite system in near real-time*

Gillespie, D.M., Caillat, M., Gordon, J.C.D. and White, P.R. (2013). Automatic detection and classification of odontocete whistles. *Journal of the Acoustical Society of America, 134, 2427-2437.*

Gillespie, D.M., Dunn, C.A., Gordon, J.C.D., Claridge, D., Embling, C. and Boyd, I.L. (2009). Field recordings of Gervais' beaked whales Mesoplodon europaeus from the Bahamas. *Journal of the Acoustical Society of America, 125, 3428-3433.*

Gillespie, D.M., Berggren, P., Brown, S., Kuklik, I., Lacey, C., Lewis, T., Matthews, J., McLanaghan, R., Moscrop, A. and Tregenza, N. (2005). Relative abundance of harbour porpoises (Phocoena phocoena) from acoustic and visual surveys of the Baltic Sea and adjacent waters during 2001 and 2002. *Journal of Cetacean Research and Management, 7, 51-57.*

Dr Douglas M. Gillespie
Passive Acoustics

Co-worker
Kalliopi-Charitomeni Gkikopoulou

Ailsa Hall's research interests broadly focus on factors affecting survival in marine mammals. This has included studying the individual and population impacts of disease agents, pollutants and toxins and how they interact with intrinsic factors such as energy reserves and other stressors to affect immune and endocrine function and survivorship at various life stages.

Brock, P.M., Hall, A.J., Goodman, S.J., Cruz., M. and Acevedo-Whitehouse, K. (2013). Immune activity, body condition and human-associated environmental impacts in a wild marine mammal. *PLOS ONE, 8, e67132.*

Hammond, J.A., Hauton, C., Bennett, K.A. and Hall, A.J. (2012). Phocid seal leptin: tertiary structure and hydrophobic receptor binding site preservation during distinct leptin gene evolution. *PLOS ONE, 7, e35395.*

Hall, A.J. and Frame, E. (2010). Evidence of domoic acid exposure in harbour seals from Scotland: a potential factor in the decline in abundance? *Harmful Algae, 9, 489-493.*

4

4 *Grey seal pup (Patrick Pomeroy)*

Dr Ailsa J. Hall
Ecotoxicology, Disease & Physiology

Co-workers
Johanna Baily
Helen Browning
Silje-Kristen Jensen
Joanna Kershaw

Prof Phil S. Hammond
Population Dynamics & Ecology

Co-workers
Heather Anderson
Monica Arso
Erin Ashe
Marina Costa
Tilen Genov
Kalliopi-Charitomeni Gkikopoulou
Sanna Kuningas
Claire Lacey
Lindsay Wilson

Phil Hammond studies population dynamics and ecology, in particular the applied aspects of how seals and cetaceans interact with mankind. His research activities focus on three main areas: (a) the habitat usage, foraging ecology and diet of marine mammals; (b) the estimation of abundance, survival and reproductive rates, and the modelling of marine mammal populations; and (c) the management of whaling, cetacean bycatch in fisheries, seal-fishery interactions, and the conservation of vulnerable species.

Hammond, P.S., Macleod, K., Berggren, P., Borchers, D.L., Burt, M.L., Cañadas, A., Desportes, G., Donovan, G.P., Gilles, A., Gillespie, D.M., Gordon, J., Hiby, L., Kuklik, I., Leaper, R., Lehnert, K., Leopold, M., Lovell, P., Øien, N., Paxton, C.G.M., Ridoux, V., Rogan, E., Samarra, F., Scheidat, M., Sequeira, M., Siebert, U., Skov, H., Swift, R., Tasker, M.L., Teilmann, J., Van Canneyt, O. and Vázquez, J.A. (2013). Cetacean abundance and distribution in European Atlantic shelf waters to inform conservation and management. *Biological Conservation, 164, 107-122.*

Sharples, R.J., Moss, S.E., Patterson, T.A. and Hammond, P.S. (2012). Spatial variation in foraging behaviour of a marine top predator (Phoca vitulina) determined by a large-scale satellite tagging program. *PLOS ONE, 7, e37216.*

Embling, C.B., Gillibrand, P.A., Gordon, J.C.D., Shrimpton, J., Stevick, P.T. and Hammond, P.S. (2010). Using habitat models to identify suitable sites for marine protected areas for harbour porpoises (Phocoena phocoena). *Biological Conservation, 143, 267-279.*

1 *Dolphins underwater riding bow (Phil Hammond)*

Dr Sonja Heinrich
Marine Mammal Ecology

Co-worker
Marina Costa

Sonja's main role is to look after the postgraduate taught programmes in the School of Biology, and the Master of Research in Marine Mammal Science in particular. She focuses on research-led teaching and practical skills training, including taking students on UK-based field courses as well as on expedition to the Antarctic. She is interested in marine conservation and sympatric ecology, and leads a long-term project on the population biology of dolphins and porpoises in southern Chile.

Götz, T., Antunes, R. and Heinrich, S. (2010). Echolocation clicks of free-ranging Chilean dolphins (Cephalorhynchus eutropia). *Journal of the Acoustical Society of America, 128, 563-566.*

Heinrich, S., Elwen, E. and Bräger, S. (2010). Patterns of sympatry in Lagenorhynchus and Cephalorhynchus: dolphins in different habitats. *The Dusky Dolphin: Master Acrobat off Different Shores. Würsig, B. and Würsig, M. (Editors), Elsevier Academic Press, 313-333.*

2 | 4 | 5 *Bottlenose dolphins (Vincent Janik)*

2

Sascha Hooker is interested in the foraging and diving behaviour of marine predators, the physiological limitations governing this, and how we can use this information to inform conservation planning in the ocean. She uses advanced microelectronic dataloggers to record the movements of marine mammals, and combines these with novel technologies to provide context for the interpretation of underwater behaviour. She is also interested in how best to include detail on foraging movements, together with anthropogenic threats to foraging or diving behaviour, into more rigorous ecological criteria for the designation of oceanic protected areas.

Hooker, S.K., et al. (2012). Deadly diving? Physiological and behavioural management of decompression stress in diving mammals. *Proceedings of the Royal Society B, Biological Sciences, 279, 1041-1050.*

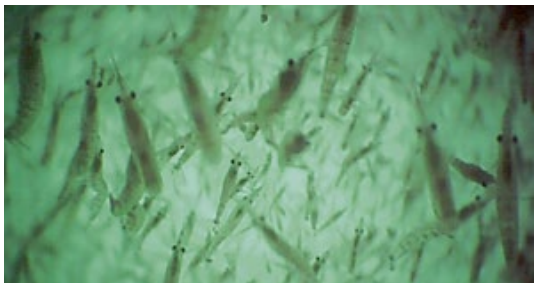
Hooker, S.K., Canadas, A., Hyrenbach, K.D., Corrigan, C., Polovina, J.J. and Reeves, R.R. (2011). Making protected area networks effective for marine top predators. *Endangered Species Research,13, 203-218.*

Hooker, S.K., Miller, P.J.O., Johnson, M.P., Cox, O.P. and Boyd, I.L. (2005). Ascent exhalations of Antarctic fur seals: a behavioural adaptation for breath-hold diving? *Proceedings of the Royal Society B, Biological Sciences, 272, 355-363.*

Dr Sascha K. Hooker
Foraging Ecology, Diving Physiology & Conservation Planning

Co-worker
Heather Anderson

3



3 *A dense swarm of krill at 13 m depth by camera attached to a diving Antarctic fur seal (Sascha Hooker)*

Vincent Janik has interests in the evolution of complexity in communication systems and how this complexity can affect social interaction. Most of his work is on bottlenose dolphins investigating functional aspects of communication signals and cognitive skills that affect or interact with communication skills.

Janik, V.M., Sayigh, L.S. and Wells, R.S. (2006). Signature whistle contour shape conveys identity information to bottlenose dolphins. *Proceedings of the National Academy of Sciences of the USA, 103, 8293-8297.*

King, S.L. and Janik, V.M. (2013). Bottlenose dolphins can use learned vocal labels to address each other. *Proceedings of the National Academy of Sciences of the USA, 110, 13216-13221.*

Quick, N.J. and Janik, V.M. (2012). Bottlenose dolphins exchange signature whistles when meeting at sea. *Proceedings of the Royal Society B, Biological Sciences, 279, 2539-2545.*

4

5

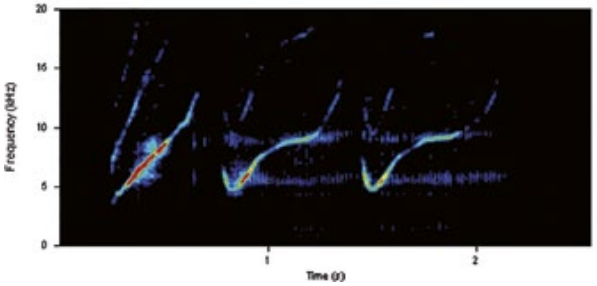
Dr Vincent M. Janik
Communication, Cognition & Bioacoustics

Co-workers
Dr Thomas Götz
Dr Gordon Hastie
Dr Deborah Russell
Braulio Leon-Lopez
Alina Loth
Bethany Roberts
Amanda Stansbury

1

Bottlenose Dolphin Signature Whistles

Vincent Janik studies signature whistles of bottlenose dolphins which are individually distinctive acoustic signals that indicate the identity of a caller. Unlike recognition signals in most other animals, identity is encoded in a frequency modulation pattern that is learned or invented early in life. Dolphins produce different frequency modulation patterns in different call types and thus not all call types carry the identity information encoded in the signature whistle. We found that the invented parts of the whistle carry the identity information and that animals regularly copy the whistles of others. Thus, the animals label other individuals which might be a rare case of referential communication with learned, arbitrary signals in the animal kingdom. Recent projects in my lab have shown that animals exchange these whistles at sea before they join up and that individuals reply if they hear a copy of their own whistle. If an animal copies another it also changes subtle features of the whistle, so that the whistle is recognisable as a copy. As a new approach we now use acoustic recording tags on the animal itself to explore the use of these whistles in even more detail.



1 *Pectrogram of a bottlenose dolphin whistle with three elements recorded from a mother and her calf as shown in image 1*

Dr Mark P. Johnson
Foraging Behaviour & Sensor Technology

Co-worker
Lucia Martin Lopez

Mark Johnson is developing high-resolution tools for studying animals in the wild. He is especially interested in quantifying the foraging behaviour of marine mammals using echolocation signals and body acceleration as cues. The passive acoustic detection of marine animals is another focus. A current challenge is to radically extend the recording duration of high-resolution tags to study the long-term consequences of increasing ambient noise on foraging success and habitat choice. Mark was appointed Senior MASTS Research Fellow in 2011.

2

2 *BA short-finned pilot whale showing off a squid captured in a deep-seachase off Tenerife (P. Aspas)*

Arranz, P., Aguilar de Soto, N., Madsen, P.T., Brito, A., Bordes, F. and Johnson, M.P. (2011). Following a foraging fish-finder: fine-scale habitat use of deep-diving Blainville's beaked whales revealed by echolocation. *PLOS ONE, 6, e28353.*

Johnson, M.P., Aguilar de Soto, N. and Madsen, P.T. (2009). Studying the behaviour and sensory ecology of marine mammals using acoustic recording tags. *Marine Ecology Progress Series, 395, 55-73.*

Johnson, M.P., Hickmott, L.S., Aguilar de Soto, N. and Madsen, P.T. (2008). Echolocation behaviour adapted to prey in foraging Blainville's beaked whale (Mesoplodon densirostris). *Proceedings of the Royal Society B, Biological Sciences, 275, 133-139.*

3

3 *DTAG recording the sounds and movements of a Blainville's beaked whale in the Canary Islands (Natacha Aguilar de Soto, ULL)*

Bernie McConnell's major interest is in the ecology of seals at sea. This starts with his involvement with the SMRU Instrumentation Group in the development of appropriate technology. These electronic tagging systems provide the raw data to answer basic biological questions about activity and distribution at sea. Recently he has focussed on more applied biological questions such as the effect of the offshore renewable industry on marine mammals, both in the UK and internationally.

McConnell, B.J., Fedak, M.A., Hooker, S.K. and Patterson, T.A. (2010). Telemetry. *In: Marine Mammal Ecology and Conservation, Boyd, I.L., Bowen, W.D. and Iverson, S.J. (Editors), Oxford University Press, 222-262.*

McConnell, B.J., Lonergan, M. and Dietz, R. (2012). Interactions between seals and offshore wind farms. *The Crown Estate.*

Morrison, C., Sparling, C., Sadler, L., Charles, A., Sharples, R. and McConnell, B.J. (2012). Postrelease dive ability in rehabilitated harbor seals. *Marine Mammal Science, 28, E110-E123.*

Dr Bernie J. McConnell
Seal Ecology

Co-workers
Dr Debbie Russell
Esther Jones

4

4 *Grey Seal (Sascha Hooker)*

1

Dr Patrick J. O. Miller
Ecology & Behaviour

Co-workers
Dr Kagari Aoki
Dr Charlotte Cure
Dr Olga Filatova
Dr Tomoko Narazaki
Dr Filipa Samarra
Sanna Isojunno
Lucia Martin Lopez
Miguel Neves
Marjoleine Roos
Rene Swift
Sara Tavares
Paul Wensveen

Patrick Miller focuses on the ecology and behaviour of marine mammals, and the advancement of methodological techniques including ocean and tagging instrumentation. Specific research interests include: acoustic communication and social behaviour, diving physiology and ecology, foraging behaviour, the role of diving predators in the marine ecosystem, and the effects of anthropogenic noise.

Miller, P.J.O., Biuw, M., Watanabe, Y.Y., Thompson, D. and Fedak, M.A. (2012). Sink fast and swim harder! Round trip cost-of-transport for buoyant divers. *Journal of Experimental Biology, 215, 3622-3630.*

Aoki, K., Watanabe, Y.Y., Crocker, D.E., Robinson, P.W., Biuw, M., Costa, D.P., Miyazaki, N., Fedak, M.A. and Miller, P.J.O. (2011). Northern elephant seals adjust gliding and stroking patterns with changes in buoyancy: validation of at-sea metrics of body density. *Journal of Experimental Biology, 214, 2973-2987.*

Miller, P.J.O., Johnson, M.P., Madsen, P.T., Biassoni, N., Quero, M. and Tyack, P.L. (2009). Using at-sea experiments to study the effects of airguns on the foraging behaviour of sperm whales in the Gulf of Mexico. *Deep Sea Research I, 56, 1168-1181.*

2

3

Dr Simon P. Northridge
Fisheries Ecology

Co-workers
Dr Gill Braulik
Dr Jonathan Gordon
Alex Coram
Al Kingston
Jamie MacAulay
Simon Tero

Simon Northridge works on issues associated with fisheries and aquaculture. He is interested in the ways in which marine mammals exploit their environment, how people and marine mammals interact, and how conflicts between them can be resolved. He runs a fishery monitoring programme on behalf of the UK government that investigates the levels of impact that fisheries have on the marine environment, and has developed ways of investigating and minimising the accidental catch of marine mammals. He is also working with the aquaculture industry to investigate patterns of seal depredation at fish farms with a view to finding non-lethal means of minimising damage to cultivated fish.

Dawson, S., Northridge, S.P., Waples, D. and Read, A. (2013). To ping or not to ping: the use of active acoustic devices in mitigating interactions between small cetaceans and gillnet fisheries. *Endangered Species Research, 19, 201-221.*

Braulik, G.T. and Northridge, S.P. (2012). Habitat use by a freshwater dolphin in the low-water season. *Aquatic Conservation: Marine and Freshwater Ecosystems, 22, 533-546.*

Northridge, S.P., Smout, S.C. and McCully, S.R. (2012). Penalising yield: MSY and bycatch. *Paper presented at ICES Annual Science Conference, Bergen, Norway, 17-21 September 2012.*

1|2 *A group of long-finned pilot whales (Globicephala melas) near the Balearic Islands in the Mediterranean (Luke Rendell / J. M. Brotons)*

3 *The big tail: A sperm whale (Physeter macrocephalus) dives near the Balearic Islands in the Mediterranean (Luke Rendell)*

4

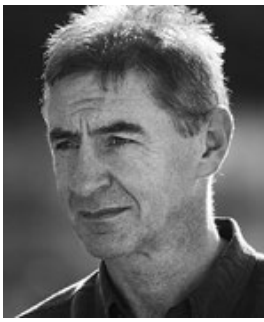
Patrick Pomeroy's main research interests lie at the interface between population biology and behavioural ecology, particularly in identifying determinants of individual reproductive success, factors affecting survival, breeding colony structure and social organisation. His comprehensive long-term (20+ years) comparative research at two Scottish grey seal colonies increasingly uses custom photo-id techniques to monitor individuals. These individual-based data are key to untangling intrinsic and extrinsic variation and have recently pointed to the importance of consistent individual differences among animals.

Smout, S.C., King, R. and Pomeroy, P. (2010). Estimating demographic parameters for capture-recapture data in the presence of multiple mark types. *Environmental and Ecological Statistics, 18, 331-347.*

Smout, S.C., King, R. and Pomeroy, P. (2011). Integrating heterogeneity of detection and mark loss to estimate survival and transience in UK grey seal colonies. *Journal of Applied Ecology, 48, 364-372.*

Twiss, S.D., Culloch, R., Pomeroy, P. (2012). An in-field experimental test of pinniped behavioral types. *Marine Mammal Science, 28, E280-E294.*

5



Dr Patrick Pomeroy
Behavioural Ecology

Co-workers
Toby Oliver
William Paterson
Kelly Robinson

4 *UAV – unmanned aerial vehicle (Patrick Pomeroy)*

5 *Grey Seal (Patrick Pomeroy)*

Luke Rendell has research interests largely centered around the evolution of learning behaviour and communication with a special focus on marine mammals. He was appointed to a MASTS Lectureship in 2012.

6

6 *A striped dolphin (Stenella coeruleoalba) jumps near the Balearic Islands in the Mediterranean (Luke Rendell)*

Rendell, L.E., Mesnick, S.L., Dalebout, M.L., Burtenshaw, J. and Whitehead, H. (2012). Can genetic differences explain vocal dialect variation in sperm whales, Physeter macrocephalus? *Behavior Genetics, 42, 332-343.*

Pirotta, E., Matthiopoulos, J., MacKenzie, M.L., Scott-Hayward, L.A.S. and Rendell, L.E. (2011). Modelling sperm whale habitat preference: a novel approach combining transect and follow data. *Marine Ecology Progress Series, 436, 257-272.*

Rendell, L.E., Boyd, R., Cownden, D., Enquist, M., Eriksson, K., Feldman, M.W., Fogarty, L., Ghirlanda, S., Lillicrap, T. and Laland, K.N. (2010). Why copy others? Insights from the social learning strategies tournament. *Science, 328, 208-213.*

Dr Luke E. Rendell
Cognition & Social Learning

Co-worker
Charlotte Dunn

Dr Sophie C. Smout
Mathematical Ecology

Co-workers
Marjolaine Caillat
Iosu Paradinas
Roman Susdorf

Sophie Smout has a strong interest in trophic interactions between species in both marine and terrestrial systems, and the consequences of these for population dynamics. Her work involves modelling the spatial and temporal distribution of predators and prey based on telemetry and survey data; modelling prey consumption and its responses to changing prey abundance; estimating population parameters through mark-recapture analysis; and investigating the consequences of predator consumption, human exploitation and by-catch for populations such as commercial fish or protected bird and mammal species.

Smout, S.C., King, R. and Pomeroy, P. (2011). Integrating heterogeneity of detection and mark loss to estimate survival and transience in UK grey seal colonies. *Journal of Applied Ecology, 48, 364-372.*

Smout, S.C., Asseburg, C., Matthiopoulos, J., Fernandez, C., Redpath, S., Thirgood, S. and Harwood, J. (2010). The functional response of a generalist predator. *PLOS ONE, 5, e10761.*

Lindstrom, U., Smout, S.C., Howell, D. and Bogstad, B. (2009). Modelling multi-species interactions in the Barents Sea ecosystem with special emphasis on minke whales and their interactions with cod, herring and capelin. *Deep Sea Research II, 56, 2068-2079.*

Dr David Thompson
Seal Population Dynamics

Co-worker
Dr Jonathan Gordon

Dave Thompson works on population dynamics of seals and sea lions and uses telemetry methods to investigate their foraging behaviour, diving behaviour and aspects of their diving physiology. In recent years his main focus has been on the application of such studies to investigate the effects of human activity on seals and sea lions at all levels from populations down to individuals. As part of this he is leading the investigation into the recent spate of "corkscrew seal" deaths among UK seal populations and working on the effects of marine renewable energy developments on the behaviour and distribution of UK seals.

Boehme, L., Thompson, D., Fedak, M.A., Bowen, D., Hammill, M.O., et al. (2012). How many seals were there? The global shelf loss during the last glacial maximum and its effect on the size and distribution of grey seal populations. *PLOS ONE, 7, e53000.*

Bexton, S., Thompson, D., Brownlow, A., Barley, J., Milne, R. and Bidewell, C. (2012). Unusual mortality of pinnipeds in the United Kingdom associated with helical (corkscrew) injuries of anthropogenic origin. *Aquatic Mammals, 38, 229-240.*

Russell, D.J., McConnell, B.J., Thompson, D., Duck, C.D., Morris, C., Harwood, J. and Matthiopoulos, J. (2013). Uncovering the links between foraging and breeding regions in a highly mobile mammal. *Journal of Applied Ecology, 50, 499-509.*

Peter Tyack has interests in acoustic communication and social behaviour in marine mammals, with particular interests in social learning, especially vocal production learning. He collaborates with engineers and acousticians to develop tags with sensors designed to sample the communication and behaviour of marine mammals at sea. He has led studies on the behavioural responses of cetaceans to anthropogenic sounds in order to understand and reduce adverse impacts of noise on marine life. He was appointed MASTS Professor in 2011.

Tyack, P.L., Zimmer, W.M.X., Moretti, D., Southall, B.L., Claridge, D.E., Durban, J.W., Clark, C.W., D'Amico, A., DiMarzio, N., Jarvis, S., McCarthy, E., Morrissey, R., Ward, J. and Boyd, I. (2011). Beaked whales respond to simulated and actual navy sonar. *PLOS ONE, 6, e17009.*

Tyack, P.L. (2009). Effects of human-generated sound on marine mammals. *Physics Today, 62, 39-44.*

Marques, T.A., Thomas, L., Ward, J., DiMarzio, N. and Tyack, P.L. (2009). Estimating cetacean population density using fixed passive acoustic sensors: an example with Blainville's beaked whales. *Journal of the Acoustical Society of America, 125, 1982-1994.*

1 *Dtagged dolphin (Nicholas Macfarlane under NMFS Scientific Research Permit No. 15543)*

Prof Peter L. Tyack
Bioacoustics

Co-worker
Kalliopi-Charitomeni Gkikopoulou
Leigh Hickmott
Rebecca Jewell

2 *Twin tagged pilot whales (Leigh Hickmott)*

POSTGRADUATE STUDY

Taught Postgraduate Courses

The SOI supports first-class Masters Programmes that provide intensive, research-oriented training of postgraduate students over 12 months. Each programme takes a holistic approach combining theoretical background with strong applied components of methodological and analytical training, laboratory work and field study.

The MRes in Marine Mammal Science explores the topical conservation and management issues surrounding marine mammals and the unique scientific challenges of marine mammal physiology, behaviour and ecology. This programme draws on the research excellence and world-class expertise provided by the members of the Sea Mammal Research Unit.

The MRes in Ecosystem-Based Management of Marine Systems helps students achieve a superior understanding of marine ecosystem function and goods-and-services. Students study the marine environment as integrated systems, exploring the interconnections between the physical environment, biodiversity and the impact of human activity and resource use. This programme is jointly organised and delivered by leading researchers at the SOI and the Scottish Association for Marine Science (SAMS) on the West Coast of Scotland.

The SOI also offers specialist online courses in Sustainable Aquaculture in collaboration with TheFishSite.com including e-learning Postgraduate Certificates, Postgraduate Diploma and MSc programmes. These part-time distance learning programmes provide flexible and advanced postgraduate level professional qualifications for those wishing to pursue and promote careers in management, research and development within the global aquaculture business. All farmed aquatic food species and regions of the world are covered, but particular focus is placed on the needs and challenges of the rapidly growing Asian and South American markets.

PhD Research Programme

Any person with a good first degree with Honours at 2:1 (UK) or the overseas equivalent can be admitted to postgraduate studies with one of the sponsoring academic Schools (Biology, Geography & Geosciences, Mathematics & Statistics). Applicants whose first language is not English must provide evidence of English proficiency as explained on the English Language Teaching webpages at: http://www.st-andrews.ac.uk/elt/entry/. Information on the various scholarships available and how to apply can be found at: http://www.st-andrews.ac.uk/admissions/pg/apply/research/.

1

1 *MRes field study – tracking dolphins from land by theodolite (Sonja Heinrich)*

2 *MRes students (in front of the SOI) (Clint Blight)*

2

THE MARINE ALLIANCE FOR SCIENCE AND TECHNOLOGY FOR SCOTLAND (MASTS)

The Marine Alliance for Science and Technology for Scotland (MASTS) is a research pooling initiative, funded by the Scottish Funding Council (SFC). It brings scientists from 9 original member organisations together with associate members to promote marine science across Scotland. The Directorate of MASTS is based at the Scottish Oceans Institute (SOI).

The Scottish Funding Council has supported MASTS with £18 million of new investment. The University takes a leading role in MASTS, receiving more than £5 million in support from the SFC. Strategic investment through MASTS will support the expansion and refurbishment of the Gatty Laboratory and has allowed St Andrews to attract new staff of the highest calibre to further strengthen our marine science portfolio. This includes two professorial appointments, four lectureships, six early-career researchers, four prize PhD students and six PhD students. In addition, marine researchers in the SOI have gained from the cooperative ethos engendered by MASTS resulting in successful new funding initiatives (e.g. Technology Strategy Board, NERC and EPSRC). SOI staff are active participants in MASTS Themes and Forums which are increasingly helping to drive the marine science agenda in Scotland.

MASTS is promoting the cooperative exploitation of marine research infrastructure and capacities across Scotland including research vessels and specialist equipment, specialist training events, and post-graduate development provided through the MASTS Graduate School. The SOI gains not only from resources and opportunities provided by MASTS but from the ability to showcase SOI talents across the community. MASTS also provides an important conduit for SOI researchers to be represented nationally and internationally and to inform government policy as it develops, enhancing the impact of relevant areas of SOI research. The strategic objectives of the SOI align closely with those of MASTS and this cooperation is highly beneficial.

Executive Director Professor David Paterson
Operations Director Dr Mark James

MASTS members

University of Aberdeen
University of Glasgow
Heriot Watt University
Marine Scotland Science
Edinburgh Napier University
University of St Andrews
University of Stirling
University of Strathclyde
University of the Highlands and Islands including:
- Scottish Association of Marine Science (Oban)
- Environmental Research Institute (Thurso)
- NAFC Marine Centre (Shetland)
- Lews Castle College

Associate Members

University of Edinburgh (and others TBC soon)
University of Dundee

Further information can be found at: http://www.masts.ac.uk/

EUROPEAN MARINE BIOLOGICAL RESOURCE CENTRE (EMBRC)

EMBRC
EUROPEAN MARINE BIOLOGICAL RESOURCE CENTRE

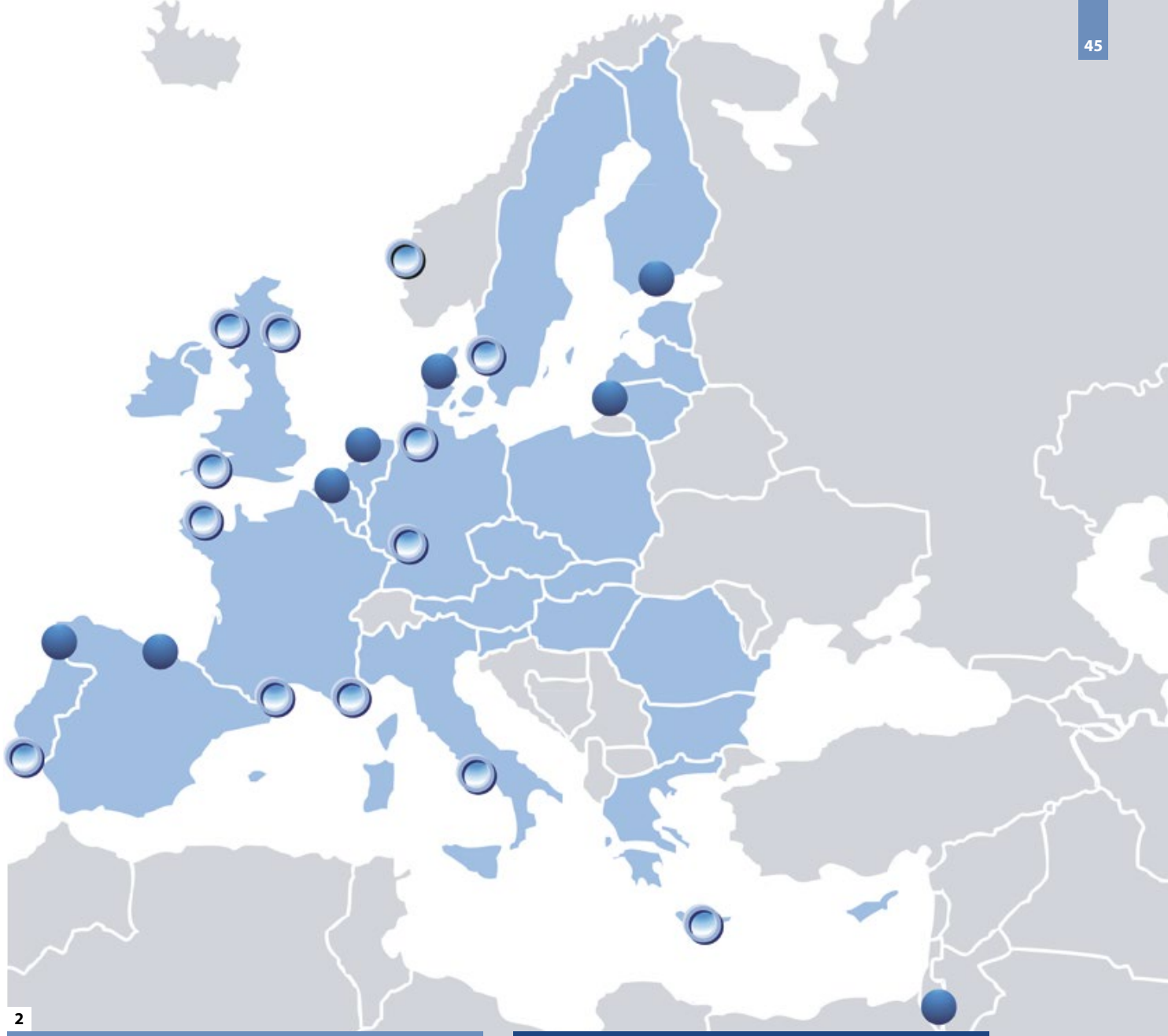
The University of St Andrews is a partner in the ESFRI-sponsored Research Infrastructure (RI) EMBRC which entered a 3-year preparatory phase in February 2011 with €3.9 million funding from the European Commission. The EMBRC is envisaged as a distributed infrastructure with a single point of access, its own legal status and governance which will provide high level research services, platforms, data, expertise and training in marine biology at the European level. The European Molecular Biology Laboratory (EMBL) will provide bioinformatics infrastructure and integration with ELIXIR. EMBRC will give access to a comprehensive range of marine ecosystems and organisms of the coastal seas of Europe and become the major European provider of marine biological research infrastructure and related services. The University of St Andrews will contribute world class facilities for marine mammal research and marine instrumentation (SOI), mass spectrometry and proteomic services (BSRC), marine aquaria and access to local ecosystems (SOI). EMBRC will attract users from across the life sciences including biological disciplines, environmental and conservation sciences, biotechnology and biomedicine as well as from industry and the technology sector. EMBRC will be central in the development of Blue Biotechnologies providing new opportunities for bio-prospecting, bioremediation, sustainable aquaculture and fisheries using gene, protein and other molecule-based techniques. Funding of EMBRC will come from multiple funding streams including membership fees, national and European public sources and gradually increasing income from service delivery and access fees during the operational phase. EMBRC access fees will be based on full economic cost for users from the public sector and commercial rates for users from the private sector.

1 *Seagrass meadow © Observatoire Océanologique de Banyuls sur mer (CNRS/UPMC)*

2 *EMBRC Partners in the preparatory phase (Founding Partners: light blue; Associate Partners: dark blue) © ppEMBRC*

1

EMBRC



2

EMBRC FOUNDING PARTNERS (light blue)

FRANCE	National Center of Scientific Research and University Pierre and Marie Curie: Station Biologique de Roscoff; Observatoire Océanologique de Villefranche sur mer; Observatoire Océanologique de Banyuls sur mer
GERMANY	Alfred Wegener Institute for Polar and Marine Research
GREECE	Hellenic Centre for Marine Research
ITALY	Stazione Zoologica Anton Dohrn
NORWAY	UNI Research A/S
PORTUGAL	Centro de Ciencias do Mar do Algarve
SWEDEN	University of Gothenburg: Sven Lovén Centre for Marine Sciences
UNITED KINGDOM	The Scottish Association for Marine Science. The University of St Andrews: Scottish Oceans Institute. Marine Biological Association of the United Kingdom
EU/INTERNATIONAL	The European Molecular Biology Laboratory

EMBRC ASSOCIATE PARTNERS (dark blue)

BELGIUM	University of Gent. Vlaams Instituut voor de Zee (VLIZ): Ostend Marine Station
DENMARK	Danish Shellfish Centre. Marine Biological Section (University of Copenhagen). Marine Biological Research Centre (SDU), Daneborg, Greenland. Marine Biology Station (Rönbjerg, Aarhus University), and Arktisk station, Greenland (University of Copenhagen)
FINLAND	University of Helsinki: Tvärminne Zoological Station
ISRAEL	Interuniversity Institute of Marine Sciences in Eilat
LITHUANIA	Klaipeda Institut
NETHERLANDS	Royal Netherlands Institute for Sea Research
SPAIN	Estación de Ciencias Marinas de Toralla. Research Centre for Experimental Marine Biology and Biotechnology "Plentziako Itsas Estazioa"

A GLOBAL LEADER IN MARINE MAMMAL CONSULTANCY

"We ought to call ourselves Homo clamorans. Noisemaking man."

In usual Terry Prachett style, he cleverly makes his point. When we build new man-made structures such as bridges, wind farms, and harbours, we make a lot of clamour pounding and digging our way into the subsea sediment.

Underwater noise travels four times faster and up to 100 times further than in open air. This noise can cause huge disruption to marine mammals which rely heavily on sound to navigate and detect prey. Innovative tools exist to measure both the noise which is disturbing the animals, and detect the vocalisations made by the animals themselves, allowing mitigation and monitoring of the marine mammals in the area of noisy working.

SMRU Marine, born out of the academic expertise of SMRU, is a scientific research and advisory consultancy with specialist knowledge of the response of sea mammals such as whales, dolphins, porpoises and seals to impacts of marine developments. We provide high quality environmental services and products to allow industry and government to understand more of what goes on in our seas. This results in evidence-based, informed decisions regarding the exploitation, development and management of the marine environment.

SMRU MARINE

SA instrumentation

understand · assess · mitigate

1

We have considerable experience with developing frameworks for the environmental assessment of the effects of anthropogenic, or man-made, activities on marine mammals. We work closely with developer teams to ensure project risks are identified and managed, from pre-consenting consultation through to post installation monitoring and reporting. SMRU Marine works closely with our academic partner the Sea Mammal Research Unit (SMRU) at the University of St Andrews.

Our first and longest-running project involved site characterisation, impact monitoring and mitigation projects of marine mammals for a tidal turbine site at Strangford Lough, Northern Ireland.

2

1 *The St Andrews Instrumentation Ltd. (SAIL), SMRU Marine's sister company, Team holding a Decimus unit*

2 *Marine Current Turbines's SeaGen Tidal Turbine*

David Ainsworth, the Business Development Director for Marine Current Turbines (MCT), developers of the tidal turbine stated, "The expertise and knowledge of the team at SMRU Limited and SMRU, as world leaders in marine mammal research, played a crucial role in assembling an evidence base that demonstrated SeaGen, the world's first commercial scale tidal stream turbine, is compatible with environmental protection in a highly sensitive and heavily protected area."

Out of the Strangford Lough monitoring experience, our own passive acoustic monitoring (PAM) device, Decimus (formerly known as PAMBuoy™) was developed. Decimus is a PAM system that is flexible in configuration, adaptable in deployment and low in power consumption. At sea it can be mounted on a variety of platforms and powered through solar panels; this allows for 24/7 monitoring of the specific site. It can process cetacean detections and noise measurements automatically, sending this processed data back to users wirelessly. Not only does this decrease the risk of data loss, it is also time saving and cost effective, ultimately increasing the client's confidence.

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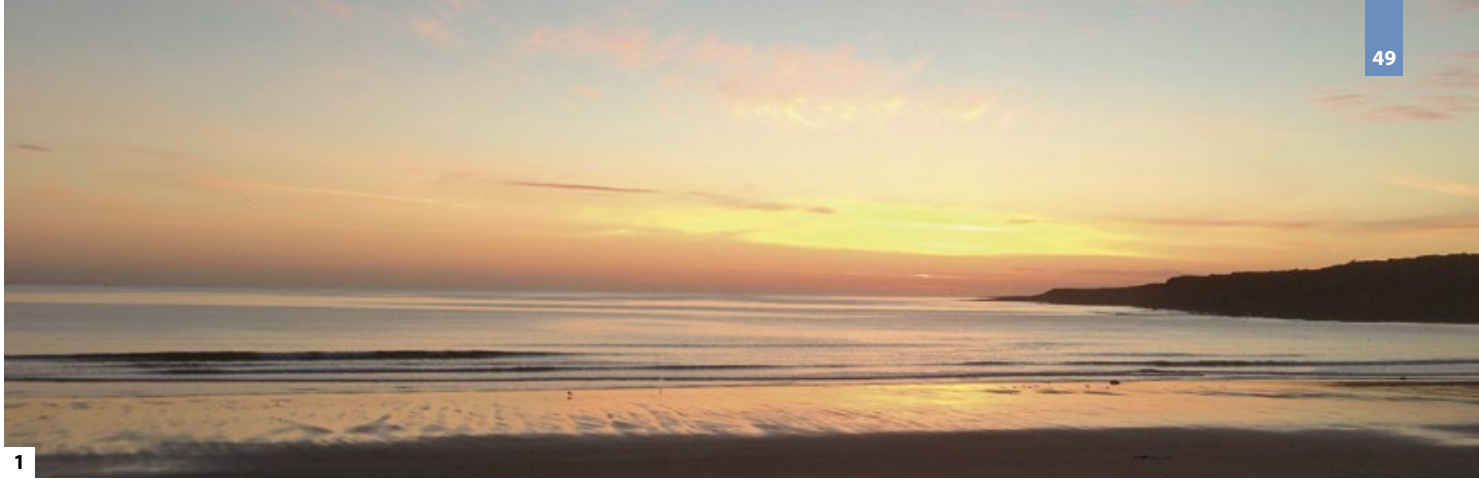

1 *Sunrise at East Sands (Jane Williamson)*

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