Institution: University of St Andrews

Unit of Assessment: 5. Biological Sciences

a. Overview

St Andrews University is a research-intensive institution that ranks regularly in the top-10 UK and top-100 worldwide universities. The School of Biology is committed to the pursuit and delivery of research at the highest international level. Our research is organised into three major interdisciplinary centres: the **Scottish Oceans Institute (SOI), Biomedical Sciences Research Complex (BSRC)** and **Centre for Biological Diversity (CBD)**. Each has a Director with devolved decision-making responsibilities and budget; directors sit on the School Management Group. Together these centres encompass the full spectrum of research in biological sciences, spanning investigations from the properties and behaviour of individual molecules to planetary environmental dynamics. Each centre has received major investment in the REF period.

Research in Biological Sciences in St Andrews is underpinned by world-class research-led teaching with a low student:staff ratio of 9.4, high entry requirements and a generous research leave scheme. St Andrews University has one of the highest proportions of international staff, students and research collaborations in the higher education sector worldwide (source: QS rankings), ensuring a vibrant and sustainable research culture. Emphasising our international outlook, 28% of our research outputs have co-authors from other EU countries, 26% from North America and 18% from the rest of the world. Our research has wider impacts on policy, public engagement and the economy, and a leading role in national and international research networks.

b. Research strategy

Strategic Vision & Aims

We aim to be in the top 10 broadly-based Schools of Biology in the UK for research. In our RAE2008 submission, we highlighted our strategy of major investment and expansion in our infrastructure and staffing, building on our strengths to establish three cognate multi-disciplinary groupings (SOI, BSRC and CBD) that are of equal size, strength and depth, with the critical mass to catalyse a step change in both the quality and impact of biological research at St Andrews. In comparison with the equivalent period in RAE08, the REF period has seen a 10% increase in submitted FTE's and:

- *30 new academic appointments*
- *73% increase in the value of grant awards*
- *65% increase in published peer reviewed papers, and*
- *112% increase in citations of those papers.*

Scottish Oceans Institute (SOI)

In REF period: Establishment of the SOI places St Andrews' long history of excellence in marine science into a truly interdisciplinary framework. Recently, St Andrews has taken the leading role in the Scottish Marine Science Pooling (MASTS) initiative with £4.6M of new SFC funding, providing academic and administrative leadership. Eleven highly competitive academic appointments have been made under the MASTS banner placing St Andrews at the forefront of national and international marine research.

The next six years: Our strategic aim is to use our national leadership role in MASTS to strengthen collaborations both nationally and internationally, enabling participation in large multi-centre multidisciplinary projects on climate change, marine ecology and biodiversity, and marine resources including renewable energy. In addition, we recognise the critical importance of research underpinning international and national marine policy and our strategy within MASTS is helping focus research more strongly in support of societal need. A further £2-3M of University funds have been committed to the physical extension of the SOI to accommodate a

critical mass of interdisciplinary marine science.

Biomedical Sciences Research Complex (BSRC)

In REF period: Award of a £5M Wellcome Trust infrastructure grant in 2009, coupled with £10M investment from the University for construction of a new 3000 m^2 research wing, refurbishment and associated infrastructure and equipment. This was complemented by the completion of the £50M Medical and Biological Sciences research and teaching building. Together, they facilitated the establishment of the BSRC, with world-class research and facilities for structural, chemical biology and infectious disease research.

The next six years: BSRC aims to translate its fundamental discoveries into novel therapeutics through the integrated interdisciplinary environment that brings biologists, physicists, chemists and medics together. Research is focussed on the funding agency priorities of global food security, combatting antibiotic resistance and pathogen:host interactions. BSRC facilities and expertise will be used increasingly by the SOI and CBD research programmes, which are developing more molecular approaches to ecological and environmental questions.

Centre for Biological Diversity (CBD)

In REF period: Creation of the CBD, a new research initiative for the School. This is built around a redevelopment of the "Sir Harold Mitchell Building" and a doubling of the academic staff with research interests in behavioural biology, ecology and evolutionary biology.

The next 6 years: We aim to strengthen the CBD as an *internationally pre-eminent centre for the study of biodiversity, animal behaviour and evolution*. St Andrews is already widely acknowledged for international excellence in behavioural biology, evolutionary biology and the measurement of biodiversity. A series of key recent appointments of leading researchers (Ruxton, Rutz, Gardner) reinforces this trend. CBD will work with the SOI to take a leading role in the delivery of the NERC priority to understand the role of biodiversity in key ecosystem processes.

Interdisciplinary Research Groupings

Our three research centres, BSRC, SOI and CBD, are explicitly multi-disciplinary in nature, bringing together academics from Biology, Chemistry, Physics, Psychology, Geosciences, Medicine and Mathematics & Statistics in shared buildings, seminar series and research groupings. To cement these links, joint staff appointments have been made between Biology and Physics (Penedo, 2010), Psychology (Healy, 2009) and the James Hutton Institute (Torrance & Tilsner, 2011) as well as the Institute of Physical and Theoretical Chemistry at the University of Bonn (Schiemann, 2011). The appointment of a MASTS Professor in Statistical Genetics (Gaggiotti, 2013) has strengthened the interactions between the schools of Biology and Mathematics & Statistics.

Scottish Oceans Institute (SOI) soi.st-andrews.ac.uk
Director Ian Boyd FRSE (2008-12); Ian Johnston FRSE (2012-)
PI's: Brierley, **Boehme*,** Boyd, **Dornelas***, Ferrier, **Gaggiotti**, Hammond, **Harris**, Hooker, Janik, **Johnson**, Johnston, McConnell, Miller, **Papastamatiou***, Paterson, **Rendell**, **Schick***, **Smout***, **Somorjai***, **Tyack** **(**New appointments: bold, early career: asterisk.)

The SOI was created in 2009 and occupies purpose-built laboratory space including a licenced marine aquarium and a globally-unique licenced facility for captive studies of marine mammals that attracts researchers from throughout the world. With a main focus in the School of Biology, the SOI constitutes a virtual centre across the University with an Executive Board including marine components of the Schools of Geography and Geoscience, Physics, Mathematics and Statistics, and especially the Centre for Ecological and Environmental Modelling (CREEM). It also includes a group of companies that operate alongside SOI to bridge its research activities to the commercial sector. The SOI houses the Sea Mammal Research Unit (SMRU), which holds "national capability" in marine science within NERCs National Oceanography Centre. The SMRU works extensively at the boundary between science and policy and in 2012 received the Queen's Anniversary Prize for its contributions to research in the governance of the ocean. The SOI also houses the Directorate of the Marine Alliance for Science and Technology for Scotland (MASTS), coordinating research

activities across 10 institutional partners within Scotland. Across these activities, SOI supports 3 inshore vessels, one of which has been specially designed for operations to study marine mammals, and a marine instrumentation design, fabrication and manufacturing facility which produces 400 state-of-the-art animal-borne tags per annum that transmit oceanographic, behavioural and acoustic data for use by researchers throughout the world. Other infrastructure includes extensive seawater aquaria and environmental control rooms. The SOI also manages the major software package PAMGuard used by the oil and gas industry during offshore seismic surveying and has established the first non-military acoustical measurement array in coastal waters in Europe. The SOI under MASTS has invested in 11 new academic staff ranging from senior professors attracted from abroad to early career academics. The SOI is a part of the European Marine Biological Resource Centre (EMBRC), an ESFRI initiative to build Europe-wide capability in marine biology. The SOI has one of the leading groupings in bioacoustics in the world and a large-scale acoustically silent test and experimental facility is planned. We will continue to expand and invest in our marine research infrastructure in anticipation of an EU-funded access program to EMBRC starting in 2014/5.

Main achievements by SOI members

a) Selected Research Output Highlights

Scaling laws of marine predator search behavior (*Nature*, 2008); Why Copy Others: insights from the Social Learning Strategies Tournament (*Science*, 2010); Global seabird response to fish depletion (*Science*, 2011); Cultural Transmission in Humpback Whales (*Science*, 2013)

b) Major funding and leadership

Leading MASTS and hosting directorate (£4.6M, SFC, 2009); Leading CBESS consortium (£3M, NERC, 2012); £12.9M NERC funding to the Sea Mammal Research Unit; Delivered (in partnership) Scotland's Marine Atlas and the assessment of state of Scotland's Seas in conjunction with MASTS to provide background to the development of the Scottish National Marine Plan (2011); Boyd appointed Chief Scientific Advisor to DEFRA (2012)

c) Interdisciplinarity and technology

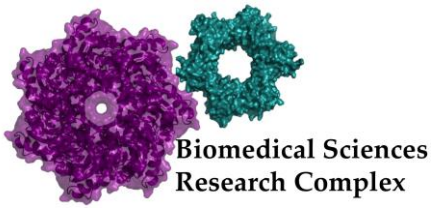
Leadership roles in several interdisciplinary consortia including MASTS, CBESS; founding partner of the European Marine Biology Resource Centre (EMBRC), comprising 10 of Europe's leading marine stations and the European Molecular Biology Laboratory (EMBL). The SOI has established spin out companies in environmental consultancy (SMRU Ltd, 2006), fish genetics (Xelect, 2013) and marine mammal behavior (Genuswave, 2012) acoustic monitoring systems (PAMbuoy, 2012) supported by patents for acoustic deterrence (Janik, 2012) and genetic markers (Johnston, 2012).

Biomedical Sciences Research Complex (BSRC)

www.st-andrews.ac.uk/bsrc

Director James Naismith FRSE FMedSci

Biology PI's: Adamson*, Bischoff*, **Ferreira***, **Gloster***, Gunn-Moore, **Jackson***, **Penedo**, Randall, Ryan, Schiemann, Schwarz-Linek, T. Smith, Taylor, **Tilsner***, White (New appointments: bold, early career: asterisk.)



The Centre for Biomolecular Science (CBMS), which opened in 1999, was one of the first academic centres in the UK to physically co-locate biologists and chemists, resulting in enhanced interactions, collaborations and publications. Its successor the BSRC is intrinsically interdisciplinary with >30 research groups (16 PIs from Biology, 9 from Chemistry, 5 from Medicine and 2 from Physics). Groups occupy space in an integrated modern, purpose built laboratory complex. The ethos of the BSRC is to break down barriers between scientific disciplines and conduct world-class research focussed on the broad theme of infection and immunity. The current director, Jim Naismith (submitted in Chemistry), is a world-leading structural biologist. In January 2012 the new 3000 m^2 BSRC Annex was completed following a £10M investment by the University coupled with £5M from a Wellcome Trust Infrastructure award and >£1M funding from the SFC. This new development has allowed the rationalisation and expansion of research groupings with large multi-group laboratories focussed on structural biology, molecular microbiology, virology, chemical

biology and molecular medicine. In addition there are state-of-the-art facilities for mass spectrometry, X-ray crystallography including crystallisation robotics, EPR, NMR and imaging. In the REF period, major new investment in research equipment has been made possible by the award of over £2M from research grants and a £1M investment in equipment by the University. Two new containment level 3 laboratories have been built and equipped, bringing the total available to four and allowing an expansion of research on pathogenic viruses, bacteria and parasites.

The BSRC operates as an autonomous research centre within the University with its own management group (populated by members of all four Schools), budget and scientific vision. There are very high levels of cross-school collaboration, publication and joint grant awards. Of particular note is the direct involvement of synthetic chemists (Florence, O'Hagan, Smith, Westwood in Chemistry) with the development of chemical tools or drug leads in collaboration with the structural and infection biologists. Recently, joint academic appointments have been made with the University of Bonn and the James Hutton Institute (formerly the Scottish Crop Research Institute) to enhance national and international links and develop research in the areas of EPR and crop pathogens, respectively.

Main achievements by BSRC members

a) Selected Research Output Highlights

Structure of the DNA repair helicase XPD (*Cell*, 2008); Identification of a novel human SSB (*Nature*, 2008); A new influenza virus virulence determinant (*PNAS*, 2008); Hijacking a biosynthetic pathway yields a glycosyltransferase inhibitor within cells (*Nat Chem Biol*, 2011); Structure of the RNA silencing CMR complex (*Mol Cell*, 2012); Stat2 deficiency and susceptibility to viral illness (*PNAS*, 2013);

b) Major funding and leadership

WT infrastructure grant (£5M, 2009) and ISSF (£1.5M 2010); WT Senior Investigator Award (£1.2M Randall 2013); WT fellowship (£.7M, Gloster, 2012); 3 WT programme grants; leading strategic LoLa on Foot and Mouth Disease Virus (£5M, Ryan, 2012).

c) Interdisciplinarity and technology

SFC/BBSRC-funded Scottish Structural Proteomics Facility produced >180 new PDB entries in REF period; Development of new technology for photoporation of cells (J. Biomedical Optics 2010 and 3 patents).

Centre for Biological Diversity (CBD) biodiversity.st-andrews.ac.uk

Director Anne Magurran FRSE

PIs: Abbott, **Bailey***, Barker, **Boogert***, Cresswell, **Gardner**, **Healy**, Laland, Magurran, **Morrissey**, Ritchie, **Rutz**, **Ruxton**, **Shuker**, **C. Smith, Spencer**, **Templeton*, Webster*,** Willmer.

(New appointments: bold, early career: asterisk.)

The CBD is a new initiative, building on St Andrews' strengths in fundamental and applied research into the origins and maintenance of biodiversity, with particular strengths in animal behaviour. The CBD's remit is interpreted broadly, and encompasses many aspects of evolutionary biology, ecology and behavioural science. Its growing standing is reflected in the appointment of 12 new staff and a strong record of recruiting senior independent fellows and internationally-recognised scientists. The core group of the CBD is based in the School of Biology, and has strong collaborative links with researchers in Psychology, Geography & GeoSciences, Mathematics & Statistics and Management. Core staff have relocated to a refurbished Sir Harold Mitchell Building, which provides a dedicated venue for the Centre with excellent facilities for animal husbandry and experimentation and molecular ecology. CBD weaves together traditionally separate strands of research, such as ecology, molecular biology and biodiversity accountancy to advance the science that underpins the diversity of life and contributes pro-actively to policy that protects it. The Centre also has well-developed strengths in evolutionary biology, behavioural and genetic analysis and biodiversity metrics. Its activities include organisation of a Royal Society Discussion Meeting on *Biological Diversity in a Changing World* in the Society's Anniversary year, and the establishment

of a Marie Curie network for Speciation, while its contributions to governance include advisory roles with DEFRA and NERC. CBD incorporates the highly regarded Centre for Social Learning and Cognitive Evolution (SLACE) which brings together researchers from Biology and Psychology with a common interest in the evolution of cognition and culture.

Main achievements by CBD members

a) Selected Research Output Highlights

Regulatory genes control a key morphological trait transferred between species (*Science*, 2008); Adaptation and the evolution of parasite virulence in a connected world (*Nature*, 2009); Ecological significance of tool use in New Caledonian crows (*Science*, 2010); Masquerade: camouflage without crypsis (*Science*, 2010); Identification of the social and cognitive processes underlying human cumulative culture (*Science*, 2012);

b) Major funding and leadership

Two ERC advanced grants (£1.3M, Laland 2009; £1.3M, Magurran 2010); Four NERC research fellowships (Shuker 2008; Bailey 2010; Templeton 2012; Gardner 2013) and 2 BBSRC David Phillips fellowships (Spencer 2008, Rutz 2009)

c) Interdisciplinarity and technology

Development of a new generation of video-logging devices for animal research (Rutz, 2013).

c. People:

Staffing strategy and staff development

Highlights:

- 30 new academics (16 Early Career) appointed in REF period
- Staff:student ratio of 9.4 one of lowest in UK; entry grades amongst highest in UK
- High levels of staff retainment; generous research leave scheme
- St Andrews University voted in top 10 international places to work (The Scientist, 2011).
- One of the highest proportions of international staff, international students and international research collaborations in the higher education sector worldwide (QS rankings)

Sustainable and International Staff Structure

Of the 30 new academic staff appointed in the REF period, 11 are UK nationals, 12 are from continental Europe and 7 are from the rest of the world, in keeping with our international profile. The age distribution of current academics reflects the high recruitment levels in the period, with 53% <45 yr; 26% 45-55yr and 21% over 55yrs.

Career Development and Mentoring

New academic staff are appointed a mentor from a cognate area. Mentors meet with mentees at least once every 3 months and as often as required. Mentors are trained and encouraged to provide constructive advice on workload balancing, career development, publication strategy and grant applications. New PIs are given a significantly reduced teaching load (typically less than 30 contact hours per annum) in the first years of their appointment to maximise their opportunities to develop research. All new staff are provided with start-up funds by the School and given priority for PhD studentships. In addition, the University runs an extensive series of mentoring and career development programmes. St Andrews has a very good track record in supporting and developing the careers of research fellows. In the period 2007-2009 we made offers of permanent posts to 9 junior staff that had joined the School through research fellowships (4 RC-UK, 2 URF, 3 others). The academic promotion scheme is fully transparent, involving an interview with a promotions board of senior academics drawn from across the science faculty.

The University *Centre for Academic, Professional and Organisational Development* (CAPOD) provides opportunities to engage in a cross-institutional mentoring scheme as well as offering a wide variety of courses to help develop research and transferable skills. Courses and workshops have been created to support the *Vitae Researcher Development Framework*, and include topics such as academic grant and paper writing, publishing in scientific journals, giving effective presentations and supervising research students and staff. CAPOD also offers the *Epigeum Research Skills Master Programme*, a series of online modules, produced by a consortium of 22

universities, for use by early career researchers as well as an *Enterprise and Entrepreneurship Programme* that delivers educational events focusing on enterprise, innovation and entrepreneurship for research staff.

Maximising research time: Contact hours and Research Leave

The School has a core of 6 dedicated teaching fellows that engage in pedagogical research and 4 dedicated teaching technicians. This allows teaching contact hours that average 130 for our research active academic staff. Furthermore, the University of St Andrews maintains a generous research leave system with the entitlement to apply for 1 semester of leave for every 4 years service. This is used strategically to promote and support research for staff at every stage of their career. Colleagues provide teaching cover during the leave period. This system is particularly highly valued by staff.

Research funding

Group leaders receive an annual class grant that includes 7% of indirect costs awarded by external grant funding in the previous year. The infrastructure costs of the three major research groupings (CBD, SOI and BSRC) are funded by a 30-50% tax on the indirect costs awarded to each PI in the group. This arrangement ensures stability and flexibility, promoting a sustainable research-funding model. In addition, the Biology Research Committee awards small pump-priming grants to allow new projects and initiatives to be developed to a point where they are competitive for major grant funding. These awards are particularly targetted towards new PIs.

Equal opportunities and diversity

St Andrews University and the School of Biology are committed to the elimination of bias and discrimination and the development of an inclusive culture that values all staff. These principles are embedded in all our working practises and exemplified by:

Athena Swan. In April 2013 St Andrews was awarded the University Athena Swan Bronze Award. Biology has organised an Athena Swan Award committee composed of a representative cross-section of the School staff, from postgraduate to Head of School level, and is progressing its application for an individual Department Award to demonstrate its commitment to promoting gender equality and addressing challenges inherent in biological science programmes.

Concordat to support the career development of researchers. In May 2012 the University was awarded the European Commission HR Excellence in Research award, which incorporates the *QAA Code of Practice for Research Degree Programmes* and the *Concordat to Support the Career Development of Researchers*. The University implements the *Concordat* through the Research and Teaching Staff Forum, which is Chaired by the Deputy Principal. Schools are represented by a PDRA and a PI, with the former encouraged to attend their School Staff Council. Members are responsible for canvassing opinion amongst their colleagues, raising issues or concerns at the Forum, and communicating feedback about Forum discussions and recommendations to their colleagues. Funding support for networking and professional development activities for research staff and teaching fellows is made available through CAPOD.

The University is involved with the **Stonewall** programme to develop best practice and Lesbian Gay Bisexual and Transgender (LGBT) friendly policies and services, attaining the ***LGBT Charter Mark*** in 2012. The University also participated in a Research Consultation (2013) that involved engagement with Stonewall about plans for establishing Equality Outcomes as part of a Single Equality Scheme for all staff and students.

Research students

Highlights:

- Innovative funding models including PhD apprentice scheme
- Award winning PGR training programme
- Diverse PGR student body with over 30 nationalities

Recruitment

Entry is competitive (>160 applications for ~25 positions annually). The majority of accepted PhD students have a 1st class undergraduate degree or a distinction at Masters level.

Student numbers

Biology has PGR students from over thirty different countries. During the REF period Biology has received i) two-competitively won BBSRC DTGs; ii) annual NERC algorithm-based quota DTGs iii) a competitively-won MRC DTG and iv) 9 MASTS studentships. These, along with other initiatives such as SULSA, ICHAIR, SMRU Ltd, University 600th scholarships and School of Biology input have helped to boost our annual PGR enrolment. St Andrews is one of five Scottish institutions forming the EastBio BBSRC DTP.

Training

Cross-university training is offered by the University's extensive generic skills programme (http://www.st-andrews.ac.uk/CAPOD) enabling PG to develop inter-disciplinary collaborations throughout the campus. Examples of PGR courses include: Research Ethics, Intellectual Property Rights, Professional Codes of Practice, Research Funding and Review, Research Publishing, Project management, Library & IT skills, Database design, Commercialisation, Media and Communication. The School has its own subject-specific induction, and training programme that runs throughout the academic year.

Presentation of research results to a specific and to a wider audience is a fundamental aspect of research training. PG students are expected to attend regular departmental seminars at which they are also able to present their research. Each year Biology organises a two-day Postgraduate Conference that simulates the academic demands of an actual conference while providing an environment of presentation, feedback and learning. PG students present their work at the conference, by poster presentations (2nd year) or by giving talks (final year). Final year PGs also present at the weekly internal seminar programs run in SOI, BSRC & CBD alongside PDRAs and PIs.

At St Andrews, enhanced training for PhD supervisors is given a high priority. Mentors advise new staff on motivating and engaging PhD students in their research. This mentoring meshes with University-level induction, mentoring and training aimed at addressing the needs of early career academics. Additionally, the university offers training days on supervision of PGR students specifically, open both to newly appointed staff and those seeking to enhance and update their skills and awareness.

PhD Apprentices Scheme

This new scheme has been developed in the REF period. Scheme members are funded for 4 years; jointly supported from the School of Biology and by part-time employment (technical grade). The programme incorporates experience in teaching and technical support and serves to greatly enhance the exit-profile of the individual with regard to transferable skills. The main (75%) part of the programme however is the undertaking of research leading to a PhD within 5 years. This is proving to be a highly successful initiative with 8 individuals appointed over a three-year period (2010-13).

Strong and integrated research student culture

The School of Biology has a wide scope and is based in five different buildings within the University infrastructure. To develop better integration of postgraduate students within the School and to create a greater awareness of research interests across each themed-building, a student-led BioPGNetwork has been established and proven a resounding success in facilitating postgraduate student connectivity and improving the postgraduate student experience in the School of Biology. The BioPGNetwork organizes events to welcome new PG students, fortnightly PG student research talks and an annual two-day conference showcasing the latest research by PGR students within the School.

Evidence of CASE awards and application of technology by research students

Since 2008 there have been CASE awards co-funded with SOI Ltd, DEFRA, Hartley Anderson Ltd, Findus UK Ltd, Kew Gardens, the National Farmers Union, Scottish Natural Heritage, the Scottish Government and international partners in the Netherlands and Canada. These projects have had impacts on: 1) advice on the design of marine protected areas, 2) acoustic disturbance on marine mammals, 3) impact of renewable energy developments on the marine ecosystem, 4) influences on the diet of harbour and grey seals, 5) improving the understanding of the ecology of Moray Firth bottlenose dolphin populations, 6) limiting whale, dolphin and porpoise by-catch in the fisheries industry, 7) control of UK tree pathogens and 8) improving sustainability and food quality in the seafood industry.

d. Income, infrastructure and facilities

Research Governance

The Research Committee is composed of a representative cross-section of the School, including both experienced senior staff and younger research fellows. This committee is responsible for an overview of research across the School. Duties include: appointment of mentors for new staff, review of research leave applications, review of grant applications prior to submission, dissemination of relevant research opportunities and policy developments. In addition, the Research Committee has a budget to fund pilot projects where pump-priming is required, particularly for new staff. The Director of Research, who sits on the School Management Group, chairs the Research Committee. In the REF period, Biological Sciences has appointed a senior School Manager with responsibility to oversee and coordinate responses to research funding opportunities and the development of technical and infrastructure support for research and the increasingly complex PGR funding schemes.

Major Grant funding in REF period

Despite the high proportion of early career researchers, research spend in the REF period is approximately £1M per FTE. Major grant awards in the period include £40M from Research Councils; £5.7M from charities; £5.7M from EU; £6M from UK and local Government; £8.3M from overseas Government and industry.

Major grant awards >£1M include:

NERC SMRU core grant (2010 £12.5M); leading BBSRC LoLa (Ryan, 2012 total £5M); ERC advanced grants (Laland 2009 £1.3M, Magurran 2010 £1.3M); Wellcome Programme/Investigator awards (Randall 2009 £1M, 2013 £1M; White 2010 £1M); MRC DPFS (Taylor 2011-14 £1.1M); Office for Naval Research USA (Miller, 2010 £1M); Strategic Environmental Research & Development Program (Miller, 2013 £1.5M); Wellcome Trust ISSF (Institutional, £1.5M 2012-2014); John Templeton Foundation (Laland, 2013 £2.6M, 2013-2016), leading NERC Consortium award CBESS (Paterson, 2013 total £3M).

Collaborative use of research infrastructure

Strategic collaborations both between disciplines and across the Scottish and UK HEI sector are one of the key defining features of research at St Andrews University. There has been a large strategic commitment from the University, backed by funds from Pooling initiatives and peer-reviewed funding from the Research Councils, to establish a suite of technologies at the cutting edge in biological research.

Scottish Universities Life Science Alliance (SULSA)

St Andrews Biology is a core member of SULSA, the research pooling initiative begun in 2008 with funding of £77M from the Scottish Funding Council and approximately £85M in matching funds from the constituent Universities. SULSA funding has helped establish a number of *key pooled facilities* in Scotland, including The Gene Pool for next-generation sequencing, High Resolution Cryo-EM and OMX microscope, Transgenics facility, drug discovery unit and several other units. St Andrews biology has full access to these facilities and is host to two key technologies: the *SSPF* for protein crystallography and the *Bioworkstation*:

Scottish Structural Proteomics Facility *(SSPF):* The SSPF is the SULSA-supported pan-Scottish centre for structural biology with core technical support and upgraded facilities from Rigaku/MSC that include crystallisation robotics with dual temperature 'hotels' and automated light/UV imaging system plus two CCD X-ray detectors, one equipped with a crystal mounting robot. Regular peer-reviewed access to Diamond and ESRF synchrotrons, mainly using remote data collection ensures optimal data for challenging projects.

Bioworkstation*:* provides novel cellular manipulation and imaging capabilities, including phototransfection of cells, optical sorting and tweezing of cells and new imaging techniques (for example: structure illumination microscopy in partnership with Nikon, light sheet microscopy and digital holographic microscopy). The Bioworkstation has been supported by SULSA with a core

technical appointment and was instrumental in the award of ~£1M from an EPSRC funded Basic Technology Translation grant. This is a joint initiative between Biology, Physics and Medicine.

***Mass spectrometry**:* a new purpose-built facility, run jointly by Biology and Chemistry in the new BSRC annex has been established with University and Wellcome Trust funding. The mass spectrometry facility works with over 30 external collaborators at 14 research institutes in the UK and as well as 9 overseas. Two major new developments in the REF period include the addition of a QTrap 4000 ESI MS/MS mass spectrometer (BBSRC funded, 2010) used for analysis including lipidomics, metabolomics and protein modification studies, and an *ABSciex 5600 Triple TOF mass spectrometer* (WT funded, 2011) equipped with an *Eskigent nanoLC ultra HPLC*. This instrument is used for the analysis of proteolytic digests of complex mixtures. Its excellent sensitivity, mass accuracy and signal resolution makes it capable of large scale proteomics analysis.

***Magnetic Resonance**:* St Andrews is widely recognised internationally as a centre of excellence in magnetic resonance. The Centre for Magnetic Resonance, led by Schiemann, was inaugurated in 2008. The Centre is both interdisciplinary and inter-institutional, being a collaboration between the Schools of Biology, Physics and Chemistry in St Andrews and cognate researchers at the Universities of Dundee and Edinburgh. The Centre has been subcontracted by the EPSRC National EPR Facility (Manchester), to run all the pulsed EPR experiments and train the members of this facility in all modern pulsed and high-field/high-frequency methods. New equipment in the REF period includes a Bruker Elexsy-II E580 cw/pulsed X-band EPR/PELDOR spectrometer Funded by grants from the BBSRC (Schiemann, 2010) and Wellcome Trust (White, 2010).

***Single-molecule imaging**:* single-molecule biophysics at St Andrews is a joint interdisciplinary initiative between the schools of Biology, Physics and Chemistry, providing access to molecular dynamics and nanometer-size distance changes in real-time from microseconds to minutes. It comprises two wide-field total-internal reflection (TIR) microscopes and a fluorescence correlation spectroscopy suite for multi-parameter fluorescence detection (MFD), funded by grants from the BBSRC, EPSRC and Wellcome Trust.

Secure animal facility: renovated to a high standard in the REF period and staffed by a dedicated manager and 5.5 animal technicians. It provides infrastructure for research on rodents, birds, amphibians and fishes and has been supported by over 40 research grants in the REF period.

e. Collaboration and contribution to the discipline or research base

Early Career Awards:

Four NERC research fellowships (Shuker 2008; Bailey 2010; Templeton 2012; Gardner 2013) and 2 BBSRC David Phillips fellowships (Spencer 2008, Rutz 2009) Biochem Soc Early Career Research Award (Gloster 2012); L'Oreal-UNESCO Women in Science Fellowship (Gloster 2013); Young Academy of Scotland (Rutz, 2013); Association for the Study of Animal Behaviour award for outstanding contributions by a new investigator (Gardner, 2010).

Other Major Awards:

Election to EMBO (White 2010); Election to the Royal Society of Edinburgh (White 2008, Laland 2008, Ruxton, 2012); RS Wolfson research merit awards (Magurran, 2012; Laland, 2013); British Trust for Ornithology award for Innovative Ornithology (Rutz, 2013); Kobe Award, Japan (Miller, 2013); Bidder Lecturer of the Society for Experimental Biology (Johnston, 2013); St Andrews scientists named in top 21 most highly cited European researchers in Animal Behaviour (Laland, Ruxton; Labtimes 2012); SMRU awarded Queen's Anniversary Prize for furthering understanding and protection of the oceans (2012);

Advisory panels and reports:

Panel Chairs:

President, the Society for Experimental Biology (Johnston, 2007-09); NERC Biomolecular Analysis Facility (Ritchie, 2008-12); NERC NEOMICS expert working group (Meagher, 2010); Scientific Advisory Board on Decommissioning for Oil and Gas UK (Boyd, 2010-13); Biophotonics theme for the Stanford-Scottish Universities Partnership (Gunn-Moore, 2011-13); Chair of Alzheimer's Research UK east-central Scotland network (Gunn-Moore, 2011-); Chair of Shetland Oil Terminal Environmental Advisory Group (Boyd, 2010-12); Research Council of Norway Biology Panel (Healy, 2011-12); DEFRA/BBSRC Tree Health and Plant Biosecurity Panel (Meagher, 2012)

Panel membership:

International Union for the Conservation on Nature (IUCN) Cetacean Specialist Group (1998-present) and Red List Authority (Hammond, 2006-); International Whaling Commission (IWC) Scientific Committee (Hammond, 1981-); International Council for the Exploration of the Sea (ICES) Working Group on Marine Mammal Ecology (Hammond, 2007-13); Scottish Science Advisory Council (Boyd, 2010-13); Scottish Government Marine Strategy Forum (Paterson 2010-); Center of Expertise for Waters (CREW) steering group (Paterson 2010-); Scientific Advisory Board for the Center for Ecological and Evolutionary Synthesis (CEES) Oslo – (Magurran, 2007-13); Board member and scientific advisor for the Centre for Invasion biology, Stellenbosch – (Magurran, 2012-14); International Advisory Board member for Norwegian Science Foundation's Arctic Ecology 'CIRCA' project (Brierley, 2010-); Society for Marine Mammalogy Committee of Scientific Advisors (Janik, 2013-); Expert Advisory for European Marine Board Working Group on Deep Sea Research (Brierley 2013-). Numerous international and national peer-reviewing duties for all major UK research councils; biomedical charities; fellowship committees; international research councils.

Major textbooks:

Vocal Communication in Birds and Mammals (Janik (ed.), 2009, 350 pp); *The Question of Animal Culture* (Laland (ed.), 2009, 351 pp); *Marine Mammal Ecology and Conservation: A Handbook of Techniques* (Boyd (ed.), 2010, 450 pp); *Pollination and Floral Ecology* (Willmer, 2011, 778 pp); *Biological Diversity: Frontiers in Measurement and Assessment* (Magurran (ed.), 2011, 345 pp); *Fish Cognition and Behavior* (Laland (ed.), 2011*, 472 pp); Sense and Nonsense: Evolutionary Perspectives on Human Behaviour, 2nd edition* (Laland, 2011*, 270 pp); Culture Evolves* (Laland (ed.), 2012, 454 pp); *Marine Biodiversity Futures and Ecosystem Functioning: Frameworks, Methodologies and Integration (Paterson (ed.), 2012, 240 pp) Social Learning: An Introduction to Mechanisms, Methods and Models* (Laland, 2013, 320 pp);

Major Editorial Activities:

Editor-in-Chief, *J Evol Biol* (Ritchie, 2011-); Editor-in-Chief, *J Zool* (Boyd, 2008); Deputy Chair, *the Biochem J* (White, 2010-); *Board of Reviewing Editors*: *Science*, (Boyd, 2011-; Magurran, 2006-); *Proc Roy Soc B* (Magurran, 2004-09; Ritchie, 2010-11; Gaggiotti, 2013-); *Marine Mammal Sci* (Hammond, 2011-); *Heredity* (Ritchie, 2000-11); *BMC Biology* (Magurran, 2013-); *BMC Evol Biol*, (Ferrier, 2011-); *Ethology*, (Janik, 2011-); *Nature Sci Rep*, (Laland 2011-2013); *Bird Study* (Cresswell, 2011-14); *Behavl Ecol* (Cresswell, 2006-10); *Marine Ecol -Prog Series* (Brierley, 2009-11); *PloS One* (Brierley, 2011-); *PloS One* (Miller, 2012-); *Amer Nat* (Gardner, 2011-).

Major New Collaborations:

The ***SULSA*** research pooling initiative has been described in section d.

Marine Alliance for Science and Technology Scotland (MASTS)

Ten of Scotland's research institutions have created the *Marine Alliance for Science and Technology for Scotland* (MASTS) that pools marine researchers and capacities across Scotland. The Scottish Funding Council has supported this initiative with £18M of new investment (£75M total) and the Directorate of MASTS is based in the SOI at St Andrews. The University takes a leading role in MASTS. St Andrews received £4.6M in support from the SFC and strategic investment through MASTS has allowed us to attract 11 new academic staff of the highest calibre to further strengthen the marine portfolio at St Andrews. Participation in MASTS has also allowed the SOI to invite three world leaders as visiting fellows (£54K of funding) to facilitate international cooperation at the highest level. MASTS is also promoting the cooperative exploitation of marine research infrastructure and capacities across Scotland including a new web-based pan-Scotland resource map, specialist training events, and post-graduate development provided through the MASTS graduate School.

Coastal biodiversity and ecosystem services (CBESS)

NERC initiated a call for detailed study of the ecosystem service flows provided by critical habitats. A consortium of experts, representing 10 academic institutions and associated bodies (RSPB, BTO, CEFAS etc) led by Paterson was chosen and funded (£3M) to investigate coastal habitats

(salt marsh and mudflats). The group employs advanced hierarchical sampling supported by integrated biodiversity and functional measures from sites linked across controlled spatial scales to provide a landscape-relevant assessment of the relationship between biodiversity and ecosystem service delivery.

SUPA2, SU2P

Due to the interdisciplinary aspects of the work in the BSRC, we also have strong connections to other pooling initiatives both Nationally and Internationally. For example, SUPA2 has a major thrust of its work in the application of novel physics to problems associated in the Life Sciences. In addition, a recently awarded £5M EPSRC programme grant to BSRC member Dholakia (Physics) is tackling the "Grand Challenge" of the "Physics of the Life" and will also be applying fundamental photonics to biological problems, specifically Gunn-Moore will Chair the Biology Opportunities panel for this major new initiative. More directly Gunn-Moore is also Chair of the Biophotonics theme from the Stanford-Scottish Universities Partnership (SU2P) (www.su2p.com) which came from a Research Councils UK Science Bridges award.

European Marine Biological Resource Centre (EMBRC)

Biological Sciences at St Andrews is an influential member of EMBRC with representation on the General Council (Boyd) and Steering Committee (Johnston). EMBRC is an ESFRI-sponsored Biological and Medical Science Research Infrastructure, which entered a 3-year preparatory phase in February 2011 with €3.9M funding from the European Commission. 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 other partners include the Alfred Wegner Institute (Germany), the SARS Institute (Norway), CNRS/University of Paris Marie Curie (France), University of Gothenburg (Sweden), Stazione Zoologica di Napoli (Italy), University of the Algarve (Portugal), the Hellenic Marine Research Centre (Greece) and the European Molecular Biology Laboratory (EMBL/EBI). EMBL will provide bioinformatics infrastructure and integration with ELIXIR. USTAN will supply world-class facilities for marine mammal research and marine instrumentation (SOI), mass spectrometry and proteomic services (BSRC) at full economic cost to an EU-funded access program in FP8 contributing to the sustainability of these facilities. In addition, membership of EMBRC provides staff with ready access to the highest level of research infrastructure and expertise available in Europe, a network of potential collaborators and a leading role in developing common data acquisition and management platforms.

Engaging end-users and Translating Research (covered in more detail in impact template)

The end users of our research are diverse, ranging from school children and the public through commercial spheres to governments and international NGO's. In the REF period, we have delivered significant impact in the public understanding of science, establishing the Bell Pettigrew Museum as an educational resource for school children (>4000 pupils visited) and participating in numerous outreach activities. We formed 7 spin-out companies ranging from *Xelect* (selection of high yielding fish broodstock) and *Genuswave* (acoustic deterrence technology) to the *SOI Group* companies (Marine environmental compliance). New collaborations with pharmaceutical companies including *Pfizer, Unilever, Morphosys* and with MRC-technology are aimed at the development of novel therapeutics for bacterial and viral disease. St Andrews biologists input on environmental polices formulated by the UK, EU and other governments such as DEFRA (Boyd is chief scientific advisor), the International Whaling commission, UK Biodiversity Committee. SMRU in 2012 received the Queen's Anniversary Prize for its contributions to research in the governance of the ocean.