Institution: Heriot-Watt University

Unit of Assessment: UoA7, Earth Systems and Environmental Sciences

a. Context

Heriot-Watt University's (HWU) Environmental Sciences research encompasses marine science focussed on conservation, ecotoxicology and contamination in the environment, terrestrial ecology focussed on ecosystem processes and soils, and research at the environment-engineering interface applied to the development of marine renewable energy resources. Industrial engagement has been a feature of the marine-related research for over 50 years originating in impact assessment for the North Sea oil and gas industries, but has diversified substantially to encompass research on designation of marine protected areas and protection of the marine environment, research that aides the development of marine renewable energy, research that feeds into increasing the sustainability of marine aquaculture and other industries. In these areas there is a pull from policy makers for evidence on which to base policy decisions regarding environmental change and protection. At the same time, national and international imperatives must be met to diversify the sources and improve the sustainability of energy supply. These areas exemplify the HWU approach of focussing on the application of science and technology to the needs of society and industry. Our strategy is to deliver high impact and relevant outcomes underpinned by rigorous and innovative research, and to generate both economic and societal impact. We prioritise public engagement as a means of disseminating the benefits of research. Our impact case studies reflect our alliances with industry and policy makers, and illustrate our approach of undertaking strategically relevant science with strong foundations in scholarship.

b. Approach to impact

The basis of our Impact Strategy is partnership with the industrial and the policy sectors that addresses economic, environmental, cultural and social challenges of the modern world (multiple examples are provided below). Such interactions also extend the reach and impact of our research by providing a conduit into industry and policy. HWU's research intensification strategy has substantially increased our research capacity in the marine biological, conservation and protection area, in research to support the development of marine renewable energy, and in soils and land-use applied to agricultural and semi-natural, marginal ecosystems (see REF5). Our teams of researchers encapsulate our strategic interdisciplinary approach by bridging between environmental, sociological and engineering research in tackling issues of world-wide concern such as sustainable energy, environmental change, habitat protection and loss of biodiversity, and land management and associated food production. Knowledge exchange and impact is incorporated in HWU's reward and promotion criteria for all academic and research grades.

Support for impact development: The University's Research & Enterprise Services (RES) has provided practical support with over £6M invested since 2009 from ERDF and HWU sources to produce a further step-change in industry engagement and commercialisation of research across HWU. This programme, "Converge", gives a dedicated business development resource complemented by expert support in the delivery of marketing materials, events and development programmes for academic staff and PGRs. One successful component of this programme is "Converge Challenge", a pan-Scotland business competition organised annually by HWU and open to all staff and students of all Scottish Universities and Research Institutes incorporating training and mentoring by some of Scotland's leading entrepreneurs. This complements the national and university programmes for Proof of Concept and spin-out creation, which focus on making technology ready for the market.

Training: Knowledge exchange and impact lies at the core of early career training. "Research Futures" HWU's innovative researcher development programme, open to all academic staff and research students, offering a wide range of training related to all facets of KE (innovation, entrepreneurship, policy, public engagement). Delivered by the University's award-winning Centre for Academic Leadership and Development (Times Higher Education awards for 'Outstanding Support for Early Career Researchers', 2010 and 'Leadership & Management' 2013; EU recognition for HR Excellence in Research, 2010 & 2012), ECRs are encouraged to take part in HW Crucible, Scottish Crucible, and European Crucible research leadership programmes that develop core skills for transforming research into significant impact via collaboration, interdisciplinary and innovation. PGRSs and PDRAs receive specialist training via courses and "Entrepreneurship Summer Schools" and can enrol for "KE-Training" events for Scottish PGRSs and the "KE Scotland Conferences", all organised by the HWU Research Futures team. Since

2011, HWU has operated "the Principal's Award for Public Engagement" which supports and enables the development of engagement events. Researchers in the Environmental Sciences have received awards from the scheme each year reflecting the activities of teams, individuals, and early career researchers.

Below we outline how our current research and impact strategy are articulated.

Sustainable Marine Management: This builds on earlier work summarised in the Impact Case Study on Sustainable Marine Management Implementation. **Sanderson, Mair, Porter** and **Lyndon** have provided marine biodiversity survey, monitoring and indicator development for SNH, Marine Scotland, Joint Nature Conservation Committee and Defra. **Mair, Side** and **Kerr** have undertaken similar work including stakeholder and economic assessment with Coralina (Colombia), the Smithsonian Tropical Research Institute (Panama) and the Charles Darwin Research Foundation in the Galapagos. These collaborations contributed to the designation and sustainable management of nine Marine Protected Areas in the Northeast Atlantic, Caribbean and Eastern Pacific against the recognised by the International Convention on Biological Diversity (CBD). The contributions made by **Roberts** on Ocean Acidification is included in the Intergovernmental Panel on Climate Change assessment Climate Change assessment (September 2013). **Hennige** is co-ordinating the CBD update on ocean acidification (mid-2014). The latter draws upon **Roberts'** role leading work on calcifying biogenic habitats in the UK ocean acidification programme. NERC's Policy Initiative was used by **Porter** to Shadow the Scottish Government's Chief Science Advisor (Professor Maggie Gill) during the Scottish Government's CAMERAS initiative (Co-ordinated Agenda for Marine, Environment and Rural Affairs Research; http://www.scotland.gov.uk/Topics/Research/About/EBAR/CAMERASsite) which contributed to the development strategic research programmes for the Scottish Government.

BryoActives Ltd: A recent HWU spin-out established by **Porter** that couples fundamental knowledge about the ecology of bryozoans and their symbionts with state of the art metagenomics to prospect for novel bioactive compounds. This addresses UK Chief Medical Officer's recently elaborated concern the about the shortage of new antimicrobials under development.

Marine renewables developments: This builds on earlier work summarised in the Impact Case Study on Development of Marine Energy. The team at HWU's Orkney campus (**Side**, **Kerr**, **Woolf** and **Johnson**) occupies a unique position between the natural environment researchers, the energy engineering sectors, and the local and national planning authorities. This places us in a position where our research is a major source of information for the planning and regulatory decisions concerned with the development of marine renewable energy. The research includes supplying the information necessary to remove the environmental and socio-economic barriers to marine renewable energy development, and it was pivotal in the establishment of the Pentland Firth and Orkney Waters Marine Energy Park. This subsequently led to 1.2 GW of marine energy leases and approximately £3M of capital investment, and the establishment of the European Marine Energy Centre at Orkney. Close engagement with the government and industrial sector has thus led to significant inward investment and substantial gross value added to the local economy.

Sustaining fish health in European aquaculture: This impact builds on the aquaculture related Impact Case Study. Aquaculture is of global importance - in 2011, 84 million tonnes of fish were produced, worth $135 billion. Aquaculture is an especially vigorous aspect of the Scottish economy; salmon farming in Scotland has the largest share in the EU with an annual retail value of over £1 billion. **Lyndon** has been a pioneering exponent of probiotic and vaccine development for aquaculture. In particular, key associations with major veterinary pharmaceutical companies (for example, Schering-Plough, now MSD) have allowed the development of fruitful long-term collaborations in vaccine development and testing.

Land use and management: Hopkins' work on the ecological effects of GM plants in agricultural ecosystems and soil management now contributes to policy advice through his membership of Defra's Advisory Committee on Releases to the Environment (ACRE) (see for example the report Post Market Environmental Monitoring (www.defra.gov.uk/acre/files/pmem-final-report.pdf)). He also contributed to the Government's Foresight exercise on "The Future of Food and Farming: Challenges and Choices for Global Sustainability". He chairs the non-aligned UK Heads of Soil Science group which meets annually with leaders in the science and policy arenas (recently NERC Chief Executive [Thorpe], Government Chief Science Advisor [Beddington], and UK Government lead on Food Security [Benton]). Expertise in soil biogeochemistry and waste management land is reflected in **Aspray's** (ECR) role as consultant to the Waste & Resource Action Programme on

Defra and WRAP-funded UK-wide field trials. His work on contaminated soil treatability, testing and endpoint evaluation is now used by industry practitioners and regulators (e.g. the Environment Agency's Evidence for the Verification of Remediation of Land Contamination).

Public engagement and education: Some areas of our research are amenable to and in particular demand for public engagement and education purposes. **Roberts** successfully coupled primary and secondary school engagement with research cruises, most notably the Changing Oceans Cruise, during which they hosted school pupils on board ship. The also make regular contributions to Science festivals (e.g. the BA Festival of Science and the Edinburgh International Science Festival, which has also included contributions from **Fernandes**, **Hartl**, **Hopkins** & **Mair**). Extensive use is also made of the social electronic and broadcast media including TV news and current affairs programmes, an award-winning educational web-site (www.lophelia.org; established by **Roberts** with contributions from Sir David Attenborough), Twitter (the blog from the Antarctic; www.hw.ac.uk/news-events/news/under-antarctic-southern-sea.htm). The HW Dive team attracted intense public interest through outreach activities: they were followed by over 100,000 people on Facebook and they regularly appear in the media (e.g. www.bbc.co.uk/news/uk-scotland-north-east-orkney-shetland-22523284); in 2013 they won the Principal's Prize for Public Engagement.

Strategy and plans: Our strategy is to expand in those areas where we have demonstrated strengths through the targeted recruitment of leading exponents (in line with HWU's Research and Knowledge Exchange strategy and 5-year plan). For example, the expansion of our research capacity in ecotoxicology (**Fernandes** & **Henry**) is opening an entirely new field of research which provides evidence to support national and international toxicological policy on nanomaterials and **Fernandes** has been appointed to the European Commission Scientific Committee on Health and Environmental Risks (SCHER) ec.europa.eu/health/scientific_committees/environmental_risks/members_committee/index_en.htm. Similarly, the strengthening of research capacity in marine physics and engineering (**Woolf** & **Johnson**) at Orkney has increased our capacity to deliver underpinning research for marine renewables development. To ensure a robust research base and continued relevant impact, we invested substantially in early career researchers (e.g. **Sanderson** & **Aspray**, who were recruited from the policy and industrial sectors) and intend to grow the critical mass of research active staff to between 35 and 40 FTE. To ensure delivery of the impact we will: (1) Strengthen links with research end users by supporting new networking efforts. This will include continuing to strengthen our links with Marine Scotland Science facilitated by our membership of the MASTS consortium, building on our established links with Oil and Gas Industry, developing an integrated impact plan with the British Geological Survey, and continuing to work in an advisory capacity with the land-based rural industries; (2) In our future recruitment plan, some of which will be aligned with the new initiative with the British Geological Survey (the Sir Charles Lyell Centre), we will seek candidates with the capacity to and appetite for research that achieves high impact; (3) Maximise the benefits from our dedicated support staff (one research development manager and one part-time outreach specialist) and making full use of other available sources of institutional support for Knowledge Transfer (e.g. Converge Challenge and the Edinburgh Beltane Network).

d. Relationship to case studies

Aquaculture Vaccines: This shows the benefits to industry of a long-term association with a leading international veterinary pharmaceutical company in which HWU enjoys a conduit to current and future industry developments and the company benefits from the independent corroboration of vaccine efficacy supplied by HWU and the research underpinning the development of novel vaccines which HWU helps provide. Both strands of research are on-going and there is a recently filed patent (number PE955013GB).

Development of Marine Renewable Energy: This builds on the long-term presence and activity of ICIT in Orkney and the unique position it occupies between the natural environment researchers, the energy engineering sectors, and the local and national planning authorities, thereby acting as a catalyst for marine renewable development and significant financial and employment contributions to the Orkney community.

Sustainable marine management: This shows how HWU has positioned itself over more than 20 years as a "go-to" partner for government applied marine research to support MPA development and sustainable management. This extends from the UK to government agencies in Latin America and is built on a track-record of biodiversity impact assessment work with the oil industry dating to the 1970s.