Institution: University of Liverpool.

Unit of Assessment: 7 - Earth and Environmental Sciences

a. Context

The Department of Earth, Ocean and Ecological Sciences (DEOES) delivers world-class research in the processes that influence Planet Earth. The Research Strategy Group (RSG), a School Level group, oversees the Department's impact and is tasked with developing research and knowledge exchange. Each research group, Earth Sciences, Oceans and Climate and Ecology and Marine Biology, interacts with a wide range of organisations and has impact at many levels, including large and small businesses, government bodies and the media.

b. Approach to impact

Research in DEOES addresses issues of contemporary significance produced for and with a range of partners through its three research groups:

The **Earth Sciences Research Group (ES)** focuses its impact on the hydrocarbon industry and has an active network of industrial relationships with a suite of national, regional and international partners (e.g. BG, BP, Shell and ExxonMobil).

The **Oceans and Climate Research Group (OC)** is concerned with impact in the domain of climate and environment change and sea level. It provides advice to local and national government, for example through oral and written submissions to Parliamentary Committees.

The **Ecology and Marine Biology Research Group (EMB)** influences environmental policy and management practice on both land (Natural England, Natural Resources Wales and Scottish Natural Heritage) and sea (reform of the Common Fisheries Policy and Implementation of the European Marine Strategy Framework Directive). The group provides conservation and management advice to agencies in the UK (Natural Resources Wales, RSPB, APEM Ltd.) and overseas (Anguilla National Trust, National Parks Trust of the British Virgin Islands).

Our approach to impact is based on collaboration as well as direct knowledge exchange. Research Groups develop this in at least three distinct ways:

1. **Interaction with companies:** This is facilitated through research funded by companies working under Joint Industry Projects (JIP) (e.g. MM3, Kusznir, ES; CO_2 storage, Worden and Faulkner, ES), by support of Industrial-CASE studentships, as well as through consultancy with SMEs and multinational companies. DEOES has a long history of collaborative research with the hydrocarbon industry, building on work of Elliott and Watterson in the 1990's. Interaction with oil companies is facilitated through consortium-JIPs (average nine partners) where the output is targeted to the research needs of companies. Workshops and field meetings for JIPs are run for a total of 19 oil companies (e.g. Chevron, ConocoPhillips, Eni, ExxonMobil, Statoil, Total) in: Ravenglass, UK (2008, 2011, 2013), Leiravogur, Iceland (2010) as part of the Chlorite JIP and in the Karoo area, South Africa (2008, 2010 - 2012) as part of the the Lobe and Slope JIPs. DEOES uses these field meetings and JIP workshops to allow companies to: (i) absorb the outputs of the JIPs, and (ii) formulate how they will each separately and confidentially incorporate the research to inform operational decisions for global petroleum exploration, appraisal and field development.

We actively participate in the University's Knowledge Exchange (KE) Voucher scheme (a competitive scheme to fund early-stage interaction between business and the University), which enables companies with a strategic need to access the University's expertise. For example, a demonstration of novel electro-analytical techniques was given to companies (e.g. Metrohm, the Royal Mint) to improve their capabilities by van den Berg and Salaun (OC) in 2011, leading to a KE Voucher in collaboration with Metrohm. This has now led to their adoption of new technology (novel low-concentration arsenic sensor) developed by Liverpool. A second example of the KE voucher scheme is a project that has developed the commercial aspects of Stable Isotope Stratigraphy (LIFER Lab, OC & ES) in collaboration with Chemostrat Ltd. This work, which will impact the company's commercial capability and lead to new business and increased revenue, is now resourced by a Knowledge Transfer Partnership (KTP Project ID 102297) funded jointly by Chemostrat Ltd, NERC and the Welsh Government, and supported by the UK Government's Technology Strategy Board.

2. Interaction with policy makers: DEOES has delivered a sustained programme of engagement on climate and marine issues with local and national civic leaders, including members of both Houses of Parliament. Research output from DEOES has led to official policy statements by DEFRA on heather and grass burning (2007- 2012) and Natural England on bracken management

(2008). Williams (OC) has been influential on climate change, sea level, and carbon emissions, and has led meetings and given presentations on eight occasions during the REF period; e.g. he addressed civil servants and NGOs in 2009 at the Royal Irish Academy, Belfast; in 2011 at NOC to Parliamentary Under Secretary of State for the Department of Energy & Climate Change Lord Marland and Bishop James; Lord Marland stated *"I found our briefing invaluable, the information provided helped me better argue the case for climate change in the Lords."* Bishop James added that *"scientific facts underpinning the argument for climate change"*, were very useful in taking part in debates in the House of Lords. This dialogue led to a Radio 4 'Thought for the Day', attempting "*to sow the seeds*" to millions of listeners. This dissemination to civic leaders and politicians was conducted in partnership with NOC, via a joint *Research Centre in Marine Sciences and Climate Change* (www.liv.ac.uk/climate), and augmented by the University institutional research theme 'Living with Environmental Change" led by DEOES.
DEOES staff were invited to provide oral evidence on climate change and sea-level at the House of Commons Science and Technology Select Committee, chaired by Rt. Hon. Andrew Miller, MP in 2012 (Sharples, OC), and on the Common Fisheries Policy at the House of Lords Select Committee on the EU Sub-committee D in 2011 and 2013 (Frid, EMB). Furthermore, they provide direct advice to overseas government agencies (e.g. Seismic Hazard assessment for proposed sites of Nuclear Power Plants, South Africa, Rietbrock, ES), and through membership of consultative boards and committees in the EU, Norway and Qatar.

3. Interaction with the media, schools and the public: We engage with local and national press and radio (more than 100 times in the REF period), commenting on issues such as earthquakes (Faulkner, Rietbrock, Mariani, ES), fracking (Marshall, ES) and marine pollution (Preston, OC). For example, Preston (OC, now retired) provided commentary on the Gulf of Mexico Oil Spill over a period of several weeks in 2010, appearing on global TV (e.g. France 24, Bloomberg, CNN) and in the press (e.g. Guardian, Telegraph, Times), as well as partnering with the BBC Science Editor to present live coverage from the disaster. Faulkner, Rietbrock, and Mariani, working with the Science Media Centre, London, offered extensive commentary, including a feature on BBC Radio Four's Material World, on the New Zealand Earthquake, 2011.
Our outreach activities target local and national schools on a range of issues (>40 schools visited in REF period). For example, Royal Society Partnership grants (Sharples, OC) led to pupils' work on "*Nutrients down the Mersey*" being showcased at the Royal Society Summer Science Exhibition in 2008. In describing this contribution to the exhibition Peter Cotgreave, Director of Public Affairs at the Royal Society, wrote "*Invigorating science and mathematics education is a major part of our work and the Partnership Grants programme gives school children direct experience working with a scientist on a specific project. We take a look at the success that Childwall School in Liverpool has enjoyed with Jonathan Sharples".* Mike McAteer, teacher at Childwall School added *"Exposing students to the real world of scientific research has benefits in terms of their career aspirations."* More recently, (July, 2013), 125 visitors from schools and colleges across the North West attended an interactive workshop in the Central Teaching Laboratory on earthquake science (led by Ryder, ES).

c. Strategy and plans

We plan to build on our impact successes, systematically embedding our effective, on-going approaches. Impact and KE are recognised as an important part of our research culture and environment and are supported by the Research Support Group, via pump-priming funds. A key element within the academic selection and promotion processes is the ability of staff members to demonstrate, articulate and implement routes for KE and Impact. Workshops with industrial colleagues have been used to encourage new University colleagues to visit companies (e.g. Duller developing a Brazilian multi-PhD student programme with BG Group following his attendance at a field meeting for Worden's consortium JIP, ES). DEOES provide appropriate financial and logistical support to aid and facilitate these interactions (e.g. Duller funded to visit Brazil to develop joint PhD programme with Brazilian university).
In recognition of the importance of KE and impact we have identified a School "Impact Champion" (Morse in Geography and Planning) who will coordinate our activities, report to the School Management Team, liaise with Faculty and the University of Liverpool network and establish a scheme to record and document all our Impact and KE activities. We will develop an external advisory board, comprised of industrial partners, associations, action groups, policy makers, and

governmental representatives, to help plan and develop our roadmap to impact over the next five years and will work to produce an annual statement of impact, cataloguing engagement with business, industry, government and NGOs, press and schools. A statement of impact will be requested of all academic staff during annual Personal Development Review. Our engagement and impact will be highlighted on our web pages. We are holding workshops for new and existing staff on setting up JIPs and working with industry.

We will initiate a geoscientist-in-residence scheme with industry professionals (e.g. Armitage, BP; Butcher, FEI; Garden, BG; Barrie, CVS), who will have a formal honorary position within DEOES, fostering research and applied technology linkages and in return exposing them to cutting edge research and impacting on their business. This initiative draws on our experience with a Senior Professorial Fellow, Kusznir, supported half time by industry, and his leading of the Modelling of Margins Phase 2 & 3 (linked to Impact Case ♯1).

To further strengthen our Impact and KE over the next five years we will:

1) Establish by 2015 a Research Institute for Hydrocarbon and Mineral Resources which will provide a home for our numerous JIPs and a point of contact for industry, facilitate training and advise new staff wanting to work with industry, and promote cross disciplinary research with other departments of the University (e.g. Chemistry, Engineering). The aim of the institute will be to generate three new JIPs by 2016 and engage academic staff across DEOES.

2) Establish a Liverpool Centre for Coasts and Oceans by 2015, together with the National Oceanographic Centre, Geography and Planning, the School of Engineering and the Institute for Risk and Uncertainty. The unique clustering of world leading experts in sea-level, planning and environmental assessment will enable us to become the definitive authority on sea level change and its impact and engage with regional, national and international governments and NGOs.

3) Provide dedicated training events and lesson plans for school teachers (by 2014); organise school outreach events like “earthquakes in action”; provide a masterclass in microscopy at the University's Central Teaching Lab; roll out a School ambassador scheme whereby students in DEOES become science ambassadors and visit schools (by 2014).

d. Relationship to case studies

Our strategy of active engagement with industry (Impact Cases ♯1 and ♯2) and government (Impact Case ♯3) has allowed us to develop three impact cases as exemplars of our activity during the REF period.

Impact case study 1 (Global mapping of ocean-continent transition structure and location using satellite gravity anomaly Inversion for frontier deep water oil and gas exploration) involved research with numerous JIPs and led to impact with a large number of industrial companies.

Impact case study 2 (Geomechanical and geochemical studies of the caprock to a CO_2 capture and storage site) involved working closely in a JIP with three industrial companies operating the CO_2 injection programme in Algeria and led to impact on a globally-significant CO_2 capture and storage project.

Impact case study 3 (Deriving evidence-based land management practices for heathland and moorland conservation) led to impact with NGOs and government departments.