

Institution: Swansea University
Unit of Assessment: 7 - Earth Systems and Environmental Sciences
a. Context

All four of the our research centres – the Centre for Sustainable Aquatic Research (**CSAR**), Dynamic Ecology Group (**DEG**), Swansea Lab for Animal Movement (**SLAM**) and Swansea Natural Products (**SNaP**) – see impact as an integral part of their activities. They deliver industrial and societal benefit, globally and nationally in the UK by:

- Using aquaculture-oriented techniques to develop sustainable practice and maximise benefits to industry in food production (food security) and advancing algal biotechnology for production of biomass/biofuels and added value products (**CSAR**);
- Using dynamical models to understand pest control, biofuels production, ecosystem functioning, and biogeochemical cycling, with industrial and societal impact (**DEG**);
- Developing and using bespoke, animal-attached data loggers with applications in wildlife and human tag markets, informing societal issues ranging from the detection of well-being in livestock, through conservation, and best practice in sports (**SLAM**);
- Using environmentally-friendly fungi to control crop arthropod pests, with direct impact on the agroforest, horticulture, livestock and health industries (**SNaP**).

The regional context is important for Welsh universities as Wales is among the weakest regional economies in Europe (evidenced by EU Structural Funds allocated in 2000-2006, 2007-2013, and 2014-2020). The Welsh economy is dominated by microbusinesses (1-9 staff) and small businesses (10-49 staff). Welsh Government policies and priorities therefore encourage Welsh Universities to support the development of the Welsh Knowledge Economy through close collaboration with industry, and translate research into impact (i.e. employment and societal gains).

b. Approach to impact

Our approach for enabling impact is to encourage all academics, research assistants and research students to engage with companies (see below). Specifically, and recognising the need to apply academic knowledge in practical commercial and industrial settings to support Welsh economic development, we are committed to promoting industrial engagement through five core-funded initiatives that create a dynamic culture of innovation and product diversification. Together these initiatives have supported more than **475 companies**, delivered **74 R&D projects**, and aided the establishment of **eight new companies** (EU and WEFO audited). The core funded initiatives are;

(i) **SEACAMS** [*Sustainable Expansion of the Applied Coastal and Marine Sectors*; £24m Welsh European Funding Office; 2010-2015; in partnership with Bangor & Aberystwyth Universities; 13 Swansea project staff, based in CSAR & SLAM, and Swansea Geography and Engineering Depts]. SEACAMS provides **technical advice, business workshops and R&D** assistance to companies in the marine sector in Wales. In 2011 and 2012, SEACAMS directly **assisted more than 80 companies** to improve their business products or services, **started 17 R&D projects** to assist companies with new product development, and aided **the creation of three new companies, one new service and two new products**.

(ii) **WISE2** [*Welsh Institute for Sustainable Environments*; £26M EU-funded; 2012-2015; the programme was devised in Swansea and grew into a partnership with Aberystwyth & Bangor Universities; 14 Swansea project staff, based in DEG, SLAM & SNaP]. WISE-2 is a terrestrial-facing counterpart to SEACAMS with similar remits. Since 2008, WISE2 and its predecessor WISE1 have **assisted more than 300 companies** to improve business products and services, with **40+ R&D projects** to assist companies with new product development. WISE has increased the profit of participating business partners by **>£2m**, and has helped create **5 new companies**.

(iii) **APT** [*Advanced Professional Training in Biosciences*; £1.4M European Social Fund; 2010-2013; 11 project staff; linked to all research groups]. APT provides up-skilling for industry personnel working in ecology, commercial, agency and governmental sectors, acting to enhance

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interaction between industry and academia. APT has assisted **more than 60 companies** dealing with impacts ranging from land management, IT and software to veterinary care, diversified agriculture and architecture.

(iv) **A4B** [*Academic Expertise for Business*; £1M Welsh Government and industry-funded scheme; 2009-2013; CSAR & SNaP]. The Algal Knowledge Transfer Centre worked with **43 companies** completing **17 collaborative R&D** (>£0.3m investment induced) projects, assisting **35 enterprises**, creating **10 jobs** and securing **6** others. BIOPROTECT worked with **5 companies**, inducing **£250K investment**. A successor to A4B started in October 2013.

(v) **KESS & ATM** [*Knowledge Economy Skills Scholarships & Access to Masters*; >£1m funded by Welsh Government and industry; 2009-to date; linked to all research groups.] This project promotes the engagement of high calibre research students with industry. **76 students have acquired commercial-facing skill sets and training** while studying for a higher degree (PhD, MSc, MRes), positioning them at the forefront of innovation within the commercial sector.

Pathways to impact are enhanced through:-

- **research incentives and small grants** available via the College of Science to promote industrial interfaces, especially for seed-corn opportunities;
- the **Department of Research and Innovation**, which is proactive in all stages of the acquisition of external funding, operations and reporting;
- **Swansea Innovation Ltd**, which provides support for IP exploitation and the unit's spin-out companies (*Bionema Ltd, Cambrian Phycosystems Ltd, Simple Sampling Solutions Ltd, Wildbyte Technologies Ltd, Gower Mushrooms*) and spin-ins (*Mycosolutions, Biologicistic Solutions*);
- the **University's Communications Department**, which promotes outcomes of our research to media, prospective students, and industry;
- the **University's academic career pathways scheme** which includes an enhanced strand for innovation and engagement, **recognising and rewarding staff** who demonstrate their impact through knowledge transfer.

Specialist facilities also support impact. The major resource used over the REF period has been the CSAR aquatic research facility, a £2m 750 m² controlled environment building that provides the underpinning resource for industry-facing projects including amongst others:-

- Work with Tata Steel using microalgae to reduce carbon emissions and produce carbon neutral fuels. (**ACCOMPLISH** [*Algal carbon Capture and Biomass Production Linked Supply Chain*]; £425k Welsh Government & Industry-funded, 2011-)
- An initiative to develop sustainable technologies for algal biomass production to support the commercial sector in NW Europe. (**EnAlgae** [*Energetic Algae*]; £11m, INTERREG IVB NWE, 7 EU states, 2010-15)
- Development of new techniques in hatchery and fishery enhancement for the €200M/yr *Langoustine* industry. (**NEPHROPS**, £2.1m, FP7 research for SME; 2012-15)
- Development of a system for continuous and accurate remote monitoring of weight, growth and size distributions of fish in aquaculture enclosures to improve efficiency in this important nutrition sector. (**FishScan**, £1.1m, FP7 research for SME; 2011-13)

c. Strategy and plans

The strategy for impact is driven by deriving impact from biological concepts. For instance, *Fowler's* development of alternatives to circumvent methodological artefacts in simulation methods used across biology, physics & engineering; *Wilson's* proposed metric for metabolic rate based on dynamic acceleration, now used as standard data output format by data tag suppliers worldwide.

The unit's strategy recognises three stages of impact work and plans for them accordingly.

Nascent Impact explores potential impact cases and, for industry and wealth generation schemes, is supported by the industrial engagement initiatives described above.

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Progressing Impact assesses where nascent impact activities have genuine potential and therefore justify further investment of time and resources. This is supported by government and industry sponsored KESS, CASE, and TSB projects offering training leading to MSc and PhD degrees, by WISE2 and SEACAMS as well as by industry directly.

Maturing Impact is work that has demonstrated clear impact, warranting further time/financial investment.

A good example of this chain of impact developments is that of microalgal biomass/biofuels research out of CSAR. This has its origins in over three decades of NERC, Royal Society/Leverhulme funding, leading (late '90s) to the development of adaptive models for microalgal growth. These models formed the centre-piece of the Carbon Trust **Algal Biofuels Challenge** (£0.5m). Since then, funding has been obtained for **BioAlgaeSorb** (FP7, £0.5m), **EnAlgae** (Interreg IVB, £1.4m to Swansea, which leads the project), **ACCOMPLISH** (ERDF, inc TATA Steel £0.4m), and **MacroBioCrude** (EPSRC, £0.3m). These have all been commercial-facing projects, operating in conjunction with an **A4B Algal Biotechnology KTC**. Impact is being built further through IP exploitation (bioreactor patents and software development).

The longer-term impact of our research at a Departmental level will be seen in the **exploitation of intellectual property** over the next period. During the current REF period **two patents have been filed, three are pending and one has been awarded**, in areas ranging across plant protection, methodological techniques in avian research, visualisation, and algal bioreactor design.

Our impact strategy also encourages **public engagement** activities, with staff delivering public lectures at, e.g., Public Scientific Meetings for the Zoological Society London and the Cheltenham Science Festival. *Wilson* was integral to the National Geographic's "Great Migrations" series (see Impact case studies). The unit also seeks to **advise policy makers**, with notable contributions including advice given to:

- Dutch Government on risk assessment of fungal biocontrol agents
- Government of the Falkland Islands on the potential impacts of invasive salmonids
- British Indian Ocean Territory Science Advisory Group on Marine Protected Areas
- Enhanced Research Capacity (PERC) Africa on human-wildlife conflict (advice since incorporated into City of Cape Town's Baboon Management Strategy, listed as a case study in NERC's Science Impacts Database)

Our plan is to develop further the strategy to ensure that the Department's research has direct, valuable application to industry. The **continuation of consultancy initiatives** (such as SEACAMS, WISE2) is planned beyond the projects' lifespans, sustaining the unit's industry-facing focus. By the end of the next assessment period, it is anticipated that the unit will have expanded further and will submit high quality case studies for each of the four research groups, demonstrating **reach and significance of research** across the full portfolio.

d. Relationship to case studies

The two impact case studies are illustrative of how we approach and maximize impact. Swansea University's Department of Research and Innovation helped obtain funding for the tag concept as well as for the pivotal research that led to National Geographic selecting our work to demonstrate how cutting-edge technological advances help us understand animal movement. Interaction between National Geographic and the University's Communication Department helped maximize **public engagement and outreach**. Similarly, the Department of Research and Innovation helped with EU applications for funding, specifically providing expertise with respect to legislative issues for the fungal biocontrol agents case study. This ultimately led to substantial **industrial and regulatory impact** through the risk assessment of fungal agents developed for control of pests that cause millions of pounds of damage to crops annually. The Communication Department helped raise the profile of this issue in outreach outputs that ranged from a special feature in the NERC flagship journal, Planet Earth, to the European Commission website.