Institution: University of St Andrews

Unit of Assessment: 5 – Biological Sciences

Title of case study: Enabling Industry compliance with offshore regulation

1. Summary of the impact

Research on the distribution, abundance and sensitivity to disturbance of marine predators has been translated into environmental and economic benefits via a series of spin-out companies with a global presence. The research enabled the following impacts:

- PAMGuard software enables the oil and gas industry to conduct seismic surveys within legal environmental limits, saving the industry ~$100M per annum.
- The licensing of the world's first grid-connected tidal stream power station (SeaGen) in Strangford loch and offshore developments in the wind-power industry.
- The progress of major engineering projects, including bridges (Forth Crossing and Hong Kong to Macao) and port extensions (Vancouver).

Direct company earnings were ~£6 million turnover in the assessment period and this supported 24 employees two-thirds of whom are skilled specialists.

2. Underpinning research

The research conducted at the University of St Andrews by Professors **Boyd**, **Harwood**, **Hammond** and colleagues has focussed upon resolving the general hypothesis that marine predators can be used as indicators of the state of the marine ecosystems **[1]**. This is driven by the concept that system complexity limits predictive capacity and that, in exploited systems, there is a need for high-level indicators of system state which can then be managed within a risk-based, adaptive framework. The research was focused on solving the problems associated with the capture of high quality, predictive data on marine predator populations from a very challenging experimental system: the ocean. These challenges were overcome using a spectrum of advances in data gathering, data analysis and interpretation.

Research on the distribution and abundance of marine wildlife was developed using three approaches:

a) distance sampling, which is a statistical method developed in St Andrews that allows visual observation of marine mammals from ships or aircraft to be used to estimate abundance using a robust statistical procedure **[2].**

b) detailed tracking of individual animals using electronic tags developed in St Andrews **[3]**.

c) the development of passive acoustic methods for detection and classification of marine animals **[4]**.

Calculation of total animal populations from each of these methods has required the development of statistical methods that allow inference about their use of space **[3, 5]**. The development of these methods was driven in part to answer the question "*What is the abundance and distribution of marine mammals over the European continental shelf?*" In other words, the creation of a robust distribution map for the species (fig 1). Hammond led a Europe-wide project using greatly enhanced technology developed in St Andrews to survey whales, dolphins and porpoises in the European Continental Shelf (SCANS II in 2006; http://biology.st-andrews.ac.uk/scans2/).

Building on this work, we tackled the question: "*How does species abundance and distribution change through time?*" Spatial information was gathered repeatedly to add a temporal component to better understand the dynamics of habitat use. The information has been used to improve the methods for defining areas with consistent high animal

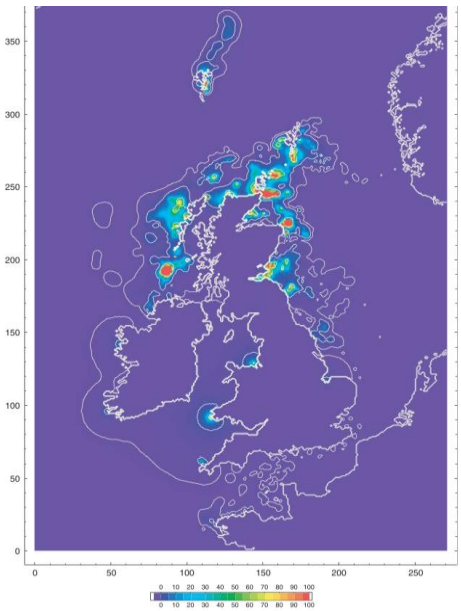

Figure 1. Grey seal population distribution at sea [3].

abundance, which predicts high quality habitat **[3, 6]** (fig 1)**.** These habitats form the basis for suggestion of protected areas for animals or their food supplies **[6]**. In addition, this spatial information has provided the foundation data for risk assessment and risk management of marine offshore activities in the presence of high uncertainty **[7]**.

3. References to the research

St Andrews contributors in BOLD. Employment dates in St Andrews: Borchers 1993-present; Boyd 2001-present; Buckland 1993-present; Duck 1996-present; Fedak 1996-present; Hammond 1996-present; Harwood 1996-present; Hooker 2001-present; Matthiopoulos 1997-2012; McConnell 1996-present.

These are all published in international, peer-reviewed journals.

[1] Boyd IL & Murray AWA (2001) Monitoring a marine ecosystem using responses of upper trophic level predators. J. Animal Ecol. 70, 747-760. DOI: 10.1046/j.0021-8790.2001.00534.x (66 citations).

[2] Borchers DL, **Buckland ST**, Goedhart PW, Clarke ED and Hedley SL (1998) Horvitz-Thompson estimators for double-platform line transect surveys. Biometrics 54, 1221-37. DOI: 10.2307/2533652 (64 citations).

[3] Matthiopoulos, J., McConnell, B.J., Duck, C.D., Fedak, M.A. (2004) Using satellite telemetry and aerial counts to estimate space use by grey seals around the British Isles. J. Appl. Ecol. 41: 476-491 DOI: 10.1111/j.0021-8901.2004.00911.x (34 citations).

[4] Evans, P.G.H., **Hammond, P.S.** (2004) Monitoring cetaceans in European waters. Mammal Review 34: 131-156 DOI: 10.1046/j.0305-1838.2003.00027.x. (63 citations).

[5] Hammond, P.S.; Berggren, P.; Benke, H.; et al. (2002) Abundance of harbour porpoise and other cetaceans in the North Sea and adjacent waters. J. Appl. Ecology 39: 361-376 DOI: 10.1046/j.1365-2664.2002.00713.x. (141 citations).

[6] Hooker, S.K., Gerber, L.R. (2004) Marine reserves as a tool for ecosystem-based management: The potential importance of megafauna. Bioscience 54: 27-39 DOI: 10.1641/0006-3568(2004)054[0027:MRAATF]2.0.CO;2. (82 citations).

[7] Harwood, J. (2000) Risk assessment and decision analysis in conservation. Biological Conservation 95: 219-226 DOI: 10.1016/S0006-3207(00)00036-7. (46 citations).

4. Details of the impact

The underpinning research carried out by SMRU on the abundance, distribution and behaviour of marine mammals has been translated during the REF period to enable a wide range of commercial activity that impinges on the marine environment to take place. The benefits are both environmental and economic and the beneficiaries include marine wildlife, renewable energy companies, oil and gas companies and major engineering projects.

a) SOI Group Ltd: products and services

The main impact of the research has been delivered through the establishment of 6 spin-out companies (SOI Ltd, SMRU Ltd, Marine Instrumentation Ltd, SMRU Ltd (Canada), SMRU Ltd (USA) and SMRU Ltd (Hong Kong)) operating under the umbrella company SOI Group Ltd. These are the translational mechanism used to deliver products, in the form of bespoke instruments and software, and services, in the form of advice about environmental impacts or data analysis, to a broad range of customers including oil and gas companies, electrical utilities, and developers such as The Crown Estate in the UK. More than 70 industry customers have been serviced since 2008. Direct company sales totalled ~£6 million (2008-2012) with a compound annualised growth rate of 16% and this supported 24 employees (with 16 skilled specialists) **[S6]**. Products derived from the research include:

i) Environmental impact assessments **[S6]**; ii) data collection, management and analysis **[S6]**; iii) **PAMGuard** open access software for acoustic detection of marine mammals, recognised by the Technical Director of the International Association of Oil and Gas Producers as a "*highly successful product*" that is "*now widely used in the industry across the world*" **[S5]**. iv) **PAMBuoy** for the automated detection and transmission of data concerning underwater acoustic targets in the marine environment.

b) Managing risks of anthropogenic marine noise in EU waters

The European Union Marine Strategy Framework Directive (MSFD) of 2010 requires each

member state to achieve good environmental status of their marine habitats, including the requirement that "*introduction of energy (including underwater noise) does not adversely affect the ecosystem.*" **[S7]**

In some circumstances, intense sound generation is unavoidable. Regulations require these activities to desist when marine animals are present within a danger zone. The development of real-time passive acoustic monitoring (**PAMGuard**) allows detection of marine mammals in many circumstances where they cannot be sighted. In the words of the Head of Marine Advice for the UK Joint Nature Conservation Committee in 2013:

> *"St Andrews researchers have developed techniques for establishing the presence of marine mammals in an area using passive monitoring for underwater sounds made by the mammals. These techniques are now part of standard mitigation around seismic surveys (…) in UK and some other EU waters."* **[S4]**

Oil and Gas Industries

The beneficial impact of PAMGuard on both marine life and the operating costs of the offshore oil and gas industries has been clearly stated by the President of the International Association of Geophysical Contractors in 2013:

> "*it is usually a condition of operating licenses that operators mitigate potential negative effects of seismic surveys on marine mammals. This tool not only allows operators to comply with their licenses, but to also minimize potential negative effects on any marine mammals in the vicinity. The (PAMGuard) tool has evolved into a highly successful product that enables a wide range of operators in the global offshore oil and gas sector to conduct seismic surveys to the satisfaction of regulators.*
>
> *It can cost >$500k per day to operate our most complex and involved surveys. We have documented cases where PAMGuard has saved many days of downtime on such surveys. In such cases its use has resulted in millions of dollars in savings. While not all surveys are this elaborate and expensive, we conservatively estimate that on a global scale,* ***PAMGuard saves hundreds of days of down-time each year, resulting in downtime savings approaching $100 million per year****. This estimate does not include the cost that could be incurred if operating licences were withheld due to inability to effectively mitigate potential negative effects from our operations. Indeed there are some circumstances in which the industry would simply be unable to operate effectively without PAMGuard."* **[S3]**

Renewable energy

The underpinning research allows measurement of marine mammal location and abundance before, during and after commission of offshore energy installations. The translation of the research has enabled renewable energy operators to comply with the requirements of environmental regulations. The Crown Estate is charged with developing the marine estate (seabed) around the UK and as such is a "*major facilitator for the development of renewable energy from the marine environment*" **[S1]**. The Chef Scientist for The Crown Estate asserts that "*the long-term activities of SMRU, as a genuine world centre of excellence in the understanding of marine mammals, continue to be very important to the Crown Estate's business*" and that "*the on-going efforts at St Andrews to understand the population consequences of developments is particularly important at this time*" **[S1]**. SMRU Ltd (UK) has used this to supply environmental impact assessments and mitigation of potential impacts of the offshore wind industry and the emerging tidal power generation industry **[S2]**. Examples of impact include the delivery of pre-development assessments for the Aberdeen Wind Farm (*AOWDC Vattenfall*), Forth and Tay wind farms (*InchCape Offshore Ltd*), and the tidal arrays at Ramsey Sound (*Tidal Energy Ltd*), Sound of Islay (*SSE renewables*) and Anglesey, Kyle Rhea, and the Pentland Firth for *MCT Ltd* **[S6]**.

SeaGen – the world's largest operational tidal stream turbine.

Marine Current Turbines (MCT) developed the world's first commercial scale tidal-stream power station, which was installed in April 2008 in Strangford Lough, Northern Ireland (fig 2). As a new technology, perceived environmental risks could easily have halted the project. SMRU developed and implemented the environmental risk management for marine mammals. This included undertaking monitoring of the engineering activities during installation and operation using a novel active sonar to detect marine mammals and thus avoid collisions. An independent report by DTZ Consulting in 2011 stated that SMRU "*played a crucial role in reassuring the regulator that the risk to marine mammals from the installation of the turbine would be low, allowing the project to go*

ahead." **[S8]**. SMRU provided the evidence required for a successful defence of infraction proceedings (essentially prosecution of a member state for infringing European Law) initiated by the European Commission. This evidence was used "*to reassure the EC that environmental interests in the area are being respected*." **[S8]**. As a result the EC dropped the infraction.

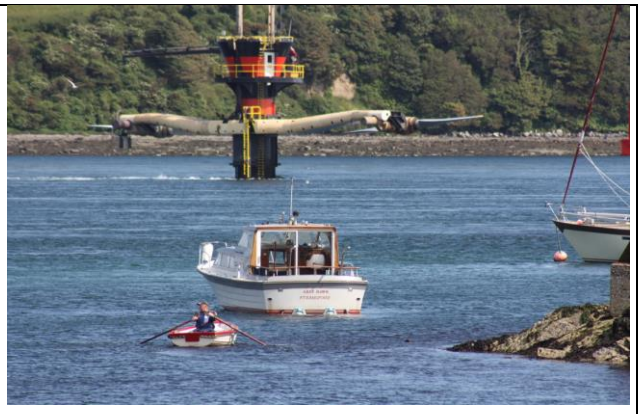

Figure 2. SeaGen installed at Strangford Lough

This project represents a "*huge step in de-risking SeaGen and making it a more attractive proposition for large-scale investors in the future*." **[S8]**. MCT has recently been bought by Siemens and now plans to deploy 500-1000 SeaGens in UK Waters by 2020. The MCT Business Development Director envisages "*a similar kind of support from SMRU for developments at Anglesey, Kyle Rhea and the Pentland Firth*" **[S2]**.

Current Major Engineering Projects [S6]

SOI Group Ltd is delivering environmental impact assessments, monitoring and risk management advice for a number of current major engineering projects. These inputs are an essential component of these construction projects, mandated by legislation from state authorities to minimise the environmental risks.

The Hong Kong – Macao Bridge. This 54 km bridge threatens the endangered population of Chinese White Dolphins. SOI Group has deployed PAMBuoy technology to provide assurance of minimal disturbance to dolphin populations.

The New Forth Road Bridge. This is currently under construction and one condition imposed by the Government is that underwater noise levels be controlled to protect salmon and lampreys. SOI Group have installed PAMBuoy technology to measure underwater noise levels in real-time on site, allowing engineers to act should the noise thresholds be breached.

Vancouver Metro Harbor. The extension of this harbour by 25% could threaten the resident population of Orca (Killer Whales). Construction beginning in summer 2013 utilises PAMBuoy technology to mitigate this danger.

5. Sources to corroborate the impact

[S1] Letter from the Chief Scientist of Crown Estates. Corroborates importance of SMRU research for offshore developments in REF period.

[S2] Letter from the Business Development Officer, Marine Current Turbines. Corroborates relationship with SMRU.

[S3] Letter from the President of the International Association of Geophysical Contractors, Houston, Texas. Corroborates importance of PAMGuard to offshore industry with value $100 million per year.

[S4] Letter from the Head of Marine Advice for the Joint Nature Conservation Committee. Corroborates role of SMRU in developing standard mitigation techniques for offshore developments.

[S5] Letter from the Technical Director of the International Association of Oil and Gas Producers. Corroborates reach and significance of PAMGuard software for offshore companies.

[S6] Statement from SOI (Group) Ltd reporting operational details, staff numbers etc.

[S7] Report from the Commission to the Council and the European Parliament. Contribution of the Marine Strategy Framework Directive (2008/56/EC) to the implementation of existing obligations, commitments and initiatives of the Member States at EU or international level in the sphere of environmental protection in marine waters. (p2, footnote 2 point 11). http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=COM:2012:0662:FIN:EN:PDF

[S8] Economic assessment by DTZ corroborating importance of SMRU research on successful deployment of SeaGen and in de-risking activities of Marine Current Turbines.