Section A

Institution: University of St Andrews

Unit of Assessment: UoA 05: Biological Sciences

Title of case study: Enabling environmentally sustainable growth of the marine renewable energy industry

Period when the underpinning research was undertaken: 2013 - 31 December 2020

Details of staff conducting the underpinning research from the submitting unit:

Name(s):	Role(s) (e.g. job title):	Period(s) employed by submitting HEI:
Gordon Hastie	Senior Research Fellow	05 November 2012 - present
Debbie Russell	Senior Research Fellow	01 December 2008 - present
Douglas Gillespie	Senior Research Fellow	01 March 2007 - present
John Harwood	Professor	01 February 1996 - present

Period when the claimed impact occurred: 01 August 2013 - 31 December 2020

Is this case study continued from a case study submitted in 2014? No

Section B

1. Summary of the impact

Growth in marine renewable energy (MRE) generation is critical to meeting CO_2 reduction targets. Uncertainties about potential impacts of marine renewables on marine mammals have posed a key consenting risk for the MRE industry around the world.

To support balancing MRE developments with the protection of marine mammal populations, the Sea Mammal Research Unit (SMRU) developed an independent research programme on marine mammal biology and developed new methods to monitor marine mammals around MRE developments.

The research has **allowed governments in the UK, the Netherlands, and the U.S. to critically assess the potential impacts of offshore wind farm and tidal developments** and has enabled the development of strategic plans for the MRE Industry. It has **underpinned the Environmental Impact Assessments** of 16 (64%) UK MRE projects and, by removing the need to collect equivalent data at each of the projects individually, the research has saved the UK MRE industry approximately GBP4,800,000. Further, methods developed as part of the research have been essential for **progressing the tidal energy industry** by providing tidal developers with the tools to track marine mammals around their operational tidal turbines to meet their post-consent monitoring conditions.

MRE industries are undergoing rapid growth, enabled by SMRU research informing and de-risking projects. This has provided **economic benefit to the UK offshore renewable energy industry** and is helping the UK to maintain its lead in this industry. For example, the research has enabled consent in 76% of offshore wind

energy capacity in the UK, representing energy generation with a GVA amount of approximately GBP31,000,000,000.

2. Underpinning research

Management of risks to marine mammal populations associated with MRE requires (1) mapping the spatial and temporal distributions of the marine mammals in relation to developments, (2) quantifying the effects on relevant marine mammal species of MRE developments by type (windfarm, tidal turbines) and phase (construction and operation), and (3) predicting the population-level impacts using the results from (1) and (2). SMRU developed a research program between 2014 and 2019 to address each of these significant gaps in knowledge.

1. Mapping seal distribution for risk characterisation

SMRU developed a novel spatial analysis of the at-sea distribution of seals, using counts of seals hauled out on land combined with at-sea movement data from animal-borne tags developed by in-house engineers (SMRU Instrumentation), to produce maps of the seal at-sea abundance around the UK. This allowed direct characterisation of the potential risks posed by new MRE developments and informed the Environmental Impact Assessment (EIA) process, providing regulators and industry much needed data on the overlap between the impact footprint of proposed MRE developments and marine mammal distributions (**R1**).

2. Measuring effects of marine renewables on marine mammals

SMRU research revealed three main mechanisms by which MRE developments can affect marine mammal populations – pile driving during windfarm construction is loud enough to damage hearing (**R2**), noise emissions during construction or operation of wind and tidal turbines could cause animals to avoid important foraging areas (**R3**), and collisions with operational tidal turbines could cause injury or death (**R4**). In a world's first, we quantified these risks by using animal-borne tags to monitor the behaviour of seals around MRE developments. During pile driving, there was significant displacement of seals out to a range of 25 km, but this avoidance disappeared within 2 hours of cessation of piling (**R3**). Seals did not avoid operating windfarms (**R3**) but, in contrast, there was significant avoidance of operational tidal turbine sounds (**R4**) and the research demonstrated that collisions with turbine blades can be fatal for seals. Further, passive acoustic monitoring was used to track the 3D movements of harbour porpoises as they swam near an operational tidal turbine (**R5**); results revealed close approaches by both dolphins and porpoises. The tidal turbine research has fed directly into predictions of collision risk and, more generally, the results of the research are being used to predict the population level impacts of MRE developments as the industry expands (**R6**).

3. Development of analytical frameworks/tools to assist the environmental assessment process for offshore renewables

To quantify the effects of MRE developments on marine mammal populations and to assist with Appropriate Assessments under the EU Habitats Directive (https://tinyurl.com/yyqdbzc7), a framework was developed to assess population level impacts of disturbance from wind farm developments (**R6**). Maps of marine mammal distributions (**R1**) and received noise levels were integrated with results of individual studies (**R2, R3**) on the impacts of noise to predict how many individuals would be displaced or experience auditory injury. Published data and hypothetical piling scenarios were used to illustrate how the framework can been used to support EIAs and its potential application to other populations of marine mammals (**R6**).

3. References to the research

The research is a selection of a portfolio published in high-ranking international peer-reviewed journal publications. R2 is being submitted to REF2021 for UoA 05.

R1. Jones, EL, McConnell, BJ, Smout, S, Hammond, PS, Duck, CD, Morris, CD, Thompson, D, Russell, DJF, Vincent, C, Cronin, M, Sharples, RJ, & Matthiopoulos, J (2015) Patterns of space

use in sympatric marine colonial predators reveal scales of spatial partitioning. *Marine Ecology Progress Series* 534: 235-249. DOI: 10.3354/meps11370

R2. Hastie, GD, Russell, DJF, McConnell, BJ, Moss, S, Thompson, D & Janik, VM (2015) Sound exposure in harbour seals during the installation of an offshore wind farm: predictions of auditory damage. *Journal of Applied Ecology*, vol 52, no. 3, pp. 631-640. DOI: 10.1111/1365-2664.12403

R3. Russell, DJF, Hastie, GD, Thompson, D, Janik, VM, Hammond, PS, Scott-Hayward, LAS, Matthiopoulos, J, Jones, EL & McConnell, BJ (2016) Avoidance of wind farms by harbour seals is limited to pile driving activities. *Journal of Applied Ecology*, vol 53, no. 6, pp. 1642-1652. DOI: 10.1111/1365-2664.12678

R4. Hastie, GD, Russell, DJF, Lepper, P, Elliott, J, Wilson, B, Benjamins, S & Thompson, D (2018) Harbour seals avoid tidal turbine noise: implications for collision risk. *Journal of Applied Ecology*, 55(2), 684-93. DOI: 10.1111/1365-2664.12981

R5. Gillespie, D, Palmer, L, Macaulay, J, Sparling, C, & Hastie, G (2020) Passive acoustic methods for tracking the 3D movements of small cetaceans around marine structures. PLoS ONE **15**(5): e0229058. DOI: 10.1371/journal.pone.0229058

R6. King SL, Schick RS, Donovan CR, Booth CG, Burgman M, Thomas L & Harwood J (2015) An interim framework for assessing the population consequences of disturbance. *Methods in Ecology and Evolution,* 6(10), 1150-1158. DOI: 10.1111/2041-210X.12411

4. Details of the impact

The renewable energy industry must grow to meet economy-wide net 0 CO_2 emissions goals and to reduce a critical driver of climate change. This led to the proposed installation of several thousand tidal and wind turbines throughout coastal areas of Europe and the U.S. However, significant concerns about the potential impacts of MRE developments on marine mammals raised issues about compliance with environmental legislation. Uncertainty about these impacts often led to highly precautionary conditions being applied when consenting developments which risked the financial viability of MRE projects and constrained efforts to meet CO_2 reduction and energy security targets. In response, SMRU developed an independent research programme on marine mammal biology to reduce uncertainty about the potential impacts of MRE developments on marine mammals. This has underpinned EIAs, saving the UK MRE industry approximately GBP4,800,000, and is providing governments with information required to consent MRE developments. The technology developed as part of the research has also progressed the tidal energy industry by enabling them to meet UK Government regulations. Together, these activities are enabling consent of offshore wind and tidal developments and providing economic benefit to the UK renewable energy industry.

Support governments in the UK, the Netherlands and the U.S. to critically assess the potential impacts of offshore wind farm

SMRU research has provided information on the effects of MRE that has been critical for consenting processes in the UK, the Netherlands and the US. The combination of marine mammal distribution maps (**R1**), behavioural studies (**R3**), and the development of analytical frameworks to predict population level effects of MRE developments (**R6**) allowed Scottish Ministers to carry out robust assessments of the potential impacts of some of the largest offshore wind farms in the world (3.9GW, representing 13% of the global installed capacity) off the Scottish east coast. As the lead organisation in Scottish Government responsible for national marine planning, Marine Scotland (Policy and Planning) state that "*SMRU's development of analytical frameworks to predict the population level effects of disturbance has provided the Scottish Government with the confidence to consent a number of offshore wind farms on the East Coast of Scotland*" (**S1**). Such is the importance of the SMRU research to the Scottish Government, the First Minister, Nicola Sturgeon stated in September 2019 that SMRU research is "*hugely relevant to many of the biggest concerns facing our planet today*"

and that is why "*we directly support some of your research into issues such as … the impact on wildlife with offshore renewable energy*" (**S2**).

The outputs have also benefited UK statutory advisors with a duty to manage activities in the marine environment through improved advice and have allowed advisers to target conservation actions. Natural Resources Wales state that the research is "*playing an important part in the mitigation of global climate change in a manner that does not compromise the conservation of our valued marine mammal populations*" (**S3**); Natural England highlight that the research "*has provided a growing evidence base upon which to base assessments of projects and allow Natural England to provide scientifically robust, informed advice to the regulator*" (**S4**); and NatureScot (formerly Scottish Natural Heritage), as statutory advisors to the Scottish Government, state that the "*research into the interactions between marine mammals and offshore renewable energy developments has greatly informed our advice to the Scottish Ministers in relation to consenting of offshore renewable energy developments*" (**S5**).

Outside the UK, the research (**R6**) has been used by the Dutch Government "*to calculate effects on the population of harbour porpoises and set provisions for the site decisions for the windfarms at sea*" such that they "*can shape good site decisions for offshore wind farms*" (**S6**). Further, in response to a 2015 proposal by the U.S. Bureau of Ocean Energy Management (BOEM) to develop an EIA for commercial wind farm development off the east coast of the U.S., the U.S. Marine Mammal Commission specifically recommended that the SMRU research (**R2, R3**) "*should be considered in BOEM's environmental assessment"* (**S7**). BOEM now has 15 active commercial leases for offshore wind development that could support more than 21GW of generating capacity (enough to power approximately 15,000,000 homes).

Underpinned Environmental Impact Assessments which have saved the UK Marine Renewable Energy industry millions of GBP

SMRU research on marine mammal distributions around the UK has provided critical information required to deliver EIAs. Seal usage maps (**R1**) are a key source of seal distributions at scales relevant to the impact footprint for MRE developments. Between August 2013 and August 2020, 12 UK offshore wind projects (representing 64% of projects and 76% of consented offshore wind energy capacity) and 7 UK tidal energy projects (representing 57% of projects and 99% of consented tidal energy capacity) used the outputs directly to make predictions of their developments' impact during the EIA process (**S8**). Collecting equivalent data and interpreting results at each of these sites individually would have imposed significant financial costs of approximately GBP4,800,000 to developers. The Marine Management Organisation (UK Government), in their role as regulators of marine activities in the seas around the UK, have incorporated the seal maps into their marine planning evidence base to inform several marine spatial plans and ensure developments at sea are appropriately sited (**S9**).

Progressed the tidal energy industry by enabling them to meet UK Government regulations

Technology development by SMRU (**R5**) has provided industry with tools to monitor potential impacts and provided UK regulators with the confidence to consent tidal turbine developments. In particular, the development and ground-truthing of acoustic technology provided the developer of the world's largest commercial tidal turbine array (MeyGen) with the tools to track marine mammals around their operational tidal turbines (**R5**) and meet their post consent monitoring conditions (**S10**). As statutory advisors to the Scottish Government, Scottish Natural Heritage, state that the "*development of innovative monitoring tools to study marine mammals and their application at tidal energy sites are instrumental in allowing the tidal energy industry to progress*" (**S5**), and Natural Resources Wales highlight "*the development of innovative monitoring and mitigation techniques (e.g. Passive Acoustic and Active Sonar monitoring) for tidal energy*" was "*essential to NRW's advice and regulation of several Welsh renewable energy projects*" (**S3**). Further, the next phase of the MeyGen tidal project was consented in 2014 and is being installed at an estimated cost of GBP420,000,000; MeyGen state that

"*without the work that SMRU have carried out in collaboration with the MeyGen project, we would be unlikely to be able to progress to this next phase*" (**S10**).

Economic benefit to the UK renewable energy industry

By enabling consent of offshore wind and tidal developments, the impacts of the SMRU research on the consenting of MRE developments has had a financial impact to the UK economy; the reliance on SMRU research to enable project consent and development has allowed the UK to maintain a dominant global position as the industry continues to grow at a rapid rate (https://tinyurl.com/y7etqt78). Additionally, the UK economy has directly benefited from revenue generation and enhanced energy supply security, provided by a generation of indigenous electricity through MRE technologies. For example, in 2016, the renewable energy sector in Scotland had a turnover of approximately GBP5,900,000,000 and directly employed 16,000 people (**S11**). Between August 2013 and August 2020, SMRU research has enabled regulatory consent decisions or has enabled compliance with post-consent monitoring requirements in 76% of offshore wind energy capacity consented in the UK (**S8**); this represents a total of 17GW of potential energy generation (enough to power approximately 11 million homes) and a GVA amount of GBP31,000,000,000 (**S12**). Similarly, the research has underpinned 99% of consented UK tidal energy capacity, representing 127MW of potential energy capacity (**S8**). The MeyGen Project generated revenues of GBP4,100,000 through the direct sales of electricity (up to December 2019; **S13**).

5. Sources to corroborate the impact

S1. Letter of support from Marine Scotland Policy and Planning.

S2. Kingdom FM press article: https://tinyurl.com/y2bnkzmg

S3. Letter of support from Natural Resources Wales.

S4. Letter of support from Natural England.

S5. Letter of support from Scottish Natural Heritage.

S6. Letter of support from Dutch Ministry of Infrastructure and Water Management.

S7. U.S. Marine Mammal Commission formal response letter: https://tinyurl.com/y39vf4xz, p. 2.

S8. Summary of consented UK offshore wind and tidal energy project data

S9. UK Government online marine activity mapping tool: https://tinyurl.com/yyuep4eo

S10. Letter of support from MeyGen Ltd (Tidal energy developer).

S11. Scottish Government, 2018, Energy in Scotland 2018, https://tinyurl.com/ykzuoals, p. 9.

S12. The Economic Value of Offshore Wind: https://tinyurl.com/y5w294df, p. 1 and 8.

S13. Simec Atlantis Energy Preliminary Results Announcement: https://tinyurl.com/yyvpjtsb