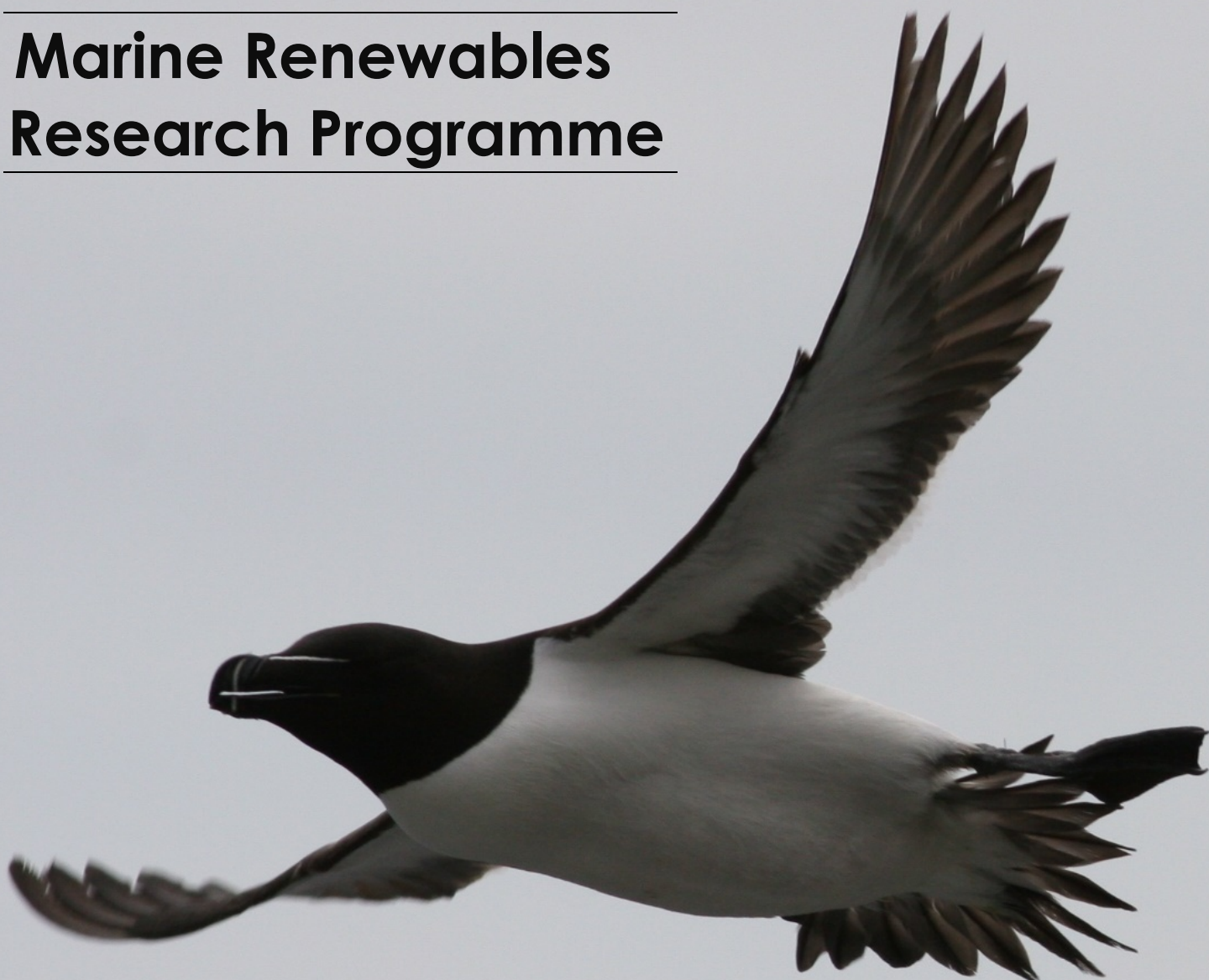

Marine Renewables Research Programme



Working with our clients to deliver a positive impact for our environment

Marine Renewables Research Programme



MacArthur Green's purpose is to work in partnership with our clients to deliver a positive impact for our environment. We achieve this by helping projects that are important to the environment succeed (such as renewable energy), supporting ecological research and guidance to inform sustainable development, and working within a carbon negative business model. Our marine renewables research programme is a key part of our commitment to delivering a positive impact on the environment.

Since 2011, we have supported nine PhD research projects, four of which have been completed. Five are ongoing at various stages from just started to near completion. We work in partnership with several key organisations to deliver this research and to train researchers in the field and in the office.

Our marine renewables research programme will help to improve evidence-based decision making by reducing the uncertainty over ornithological impacts. It will also contribute to the training of future skilled scientists who will hopefully go on to work in marine renewables. In that regard, we are delighted that Alex Robbins and Helen Wade, having completed their PhD studies, now work on marine renewables at Scottish Natural Heritage. We are also very pleased to have obtained several NERC CASE studentships to support postgraduate research, as well as funding from industry and from academia.

Professor Bob Furness

Principal Ornithologist



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VATTENFALL



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Modelling populations of seabirds affected by marine developments

NERC CASE Studentship

Student: Julie Miller

Hosts: University of Glasgow with MacArthur Green as CASE partner

University supervisor:

Professor Jason Matthiopoulos
(University of Glasgow)



University
of Glasgow



This research developed Bayesian state-space models that quantify intrinsic (density-dependence) and extrinsic (environmental stochasticity) population regulation of selected seabird populations that are the focus of concerns over impacts of offshore wind farms and for which there are long term data (gannets at Bass Rock, guillemots and kittiwakes at Isle of May).

It used these estimates to simulate population projections and to assess population-level impact of mortality caused by offshore wind farms against that baseline. It then modelled consequences of populations being open rather than closed (metapopulations), in order to assess population level impacts in a more biologically realistic way than the historical approach of assuming that colonies are closed populations that are not subject to density-dependence.

In addition to winning a Science Communication award, Julie has presented her research at several conferences, including the British Ecological Society, the Seabird Group Conference at Liverpool University, the 4th Conference on Wind Energy and Wildlife Impacts at Estoril, Portugal, the 6th International Statistical Ecology Conference, and the 3rd Strategic Ornithology Monitoring and Research Conference hosted by Scottish Power. She has also qualified as an ESAS surveyor. Julie's paper in Journal of Applied Ecology was selected as the 'Editors' choice' in 2019.

The PhD thesis resulting from this project was submitted in 2019 and Dr Miller is now working for an environmental consultancy.

Miller, J.A.O., Furness, R.W., Trinder, M. and Matthiopoulos, J. 2019. The sensitivity of seabird populations to density-dependence, environmental stochasticity and anthropogenic mortality. Journal of Applied Ecology doi: 10.1111/1365-2664.13448

Ecology of black guillemots in relation to Marine Protected Areas and tidal stream arrays

SNH/MASTS Scholarship

Student: Daniel Johnston

Hosts: University of the Highlands and Islands (Environmental Research Institute, Thurso), with external supervision from SNH and MacArthur Green

University supervisor: Dr Elizabeth Masden and Dr Mark Taggart (UHI)



Daniel used GPS tracking technology, along with camera traps and visual observations for intensive diet study to identify the foraging habitat of adult breeding black guillemots in tidally dynamic areas. He explored the links between foraging behaviour, tidal currents, prey species and benthic habitat.

GPS tags were deployed on 35 individuals on Stroma and North Ronaldsay. Tracks revealed between-individual variation in foraging locations. On Stroma, association with the tidal stream brought some individuals within close proximity to the MeyGen lease area. On the other hand, some individuals appear to prefer Scapa Flow, undertaking a journey of more than 26 km to their foraging grounds - some of the furthest foraging distances recorded for breeding black guillemots. Daniel investigated the relationship between foraging and tidal dynamics in both space and time, and benthic foraging habitat preferences. This provides an insight into the conditions associated with foraging, allowing comparison with conditions suggested to be altered by turbine installation.

Several chapters of Daniel's thesis have been published and his PhD thesis was submitted in 2019 and Dr Johnston is now working for BTO Scotland.

Johnston, D., Furness, R.W., Robbins, A.M.C., Tyler, G., Taggart, M.A. and Masden, E.A. 2018. Black guillemot ecology in relation to marine renewable energy devices: an evaluation of current knowledge and information gaps. *Marine Environmental Research*, 134, 121-129.

An individual-based model to assess impacts of offshore wind farms on the gannet population of the Bass Rock

NERC CASE Studentship

Student: Chris Pollock

Hosts: University of Leeds, with both Vattenfall and MacArthur Green as CASE partners

University supervisors: Professor Keith Hamer and Professor Tim Benton (University of Leeds)



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Chris Pollock's research has four aims:

1. Modelling gannet population dynamics – Using several decades of demographic data the work will develop individual-based models that can account for collision additional mortality and energy costs of barrier effects and displacement.
2. Assess potential effects of offshore wind farms on stage-specific mortality.
3. Predict impacts of additional mortality.
4. Inform advice on policy.

The work focuses on the Bass Rock population, the largest gannet colony in the world. Chris had a successful fieldwork season on the Bass Rock, deploying accelerometers, altimeters, GPS tags and geolocator tags on adult gannets, GPS Argos transmitters on fledglings, monitoring survival and breeding of colour marked adult gannets and building a long-term baseline of demographic parameters for this colony.

His work during 2018-19 included a placement at MacArthur Green and Vattenfall. He related aerial survey data on gannet age classes present in the southern North Sea offshore wind farm lease areas with the novel data being acquired from tracking of fledglings (and simultaneously tracked adults), in order to gain a better understanding of how seasonal behaviours differ between age classes. This provides an understanding of the consequent collision risks of juvenile gannets compared with those of adult gannets.

The PhD thesis is due to be completed in 2021.

Tracking seasonal movements of guillemots and razorbills from different colonies

Funded by
Vattenfall/EOWDC

Student: Lila
Buckingham

Hosts: University of
Liverpool and CEH
Edinburgh (Dr Francis
Daunt and Dr Maria
Bogdanova), funded
by the MacArthur
Green auk tracking
project that is part of
Vattenfall's EOWDC
research programme

University supervisors:
Dr Jon Green
(University of
Liverpool)



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This PhD studentship is a component of the auk tracking project run by MacArthur Green with funding from Vattenfall's European Offshore Wind Deployment Centre (EOWDC). Lila Buckingham is primarily based at CEH Edinburgh, and is responsible for analysis of the seasonal movements of guillemots and razorbills based on data downloaded from geolocator tags recovered from breeding adults at colonies around Scotland and northeast England. Tagging began in June 2017 and will continue into 2020, with recovery of tags continuing until 2021. In 2019, 61 time-depth-recorders (TDRs) were deployed on guillemots at four colonies which should allow comparison of diving activity between North Sea and west Scotland wintering areas.

The work is a collaboration with Hywind and SEATRACK, as well as with established local expert auk ringers who are carrying out much of the fieldwork. The aim is to understand seasonal movements of guillemots and razorbills from different colonies, with particular regard to the origins of birds seen in offshore wind farm lease areas.

Lila took part in tagging guillemots and razorbills at the Treshnish Isles, Argyll in June 2018 and 2019 and she is now analysing data extracted from over 380 geolocator tags recovered from guillemots and razorbills at colonies around Scotland and NE England. Preliminary results show clear colony-specific wintering areas of guillemots, but a much greater overlap in wintering area used by razorbills from many different colonies.

The PhD thesis is due to be completed in 2022.

Effects of wind on seabird flight and distribution: Implications for assessing impact of offshore wind farms

NERC CASE studentship

Student: Hannah
Meinertzhagen

Hosts: University of
Exeter with MacArthur
Green as CASE
partner

University supervisors:

Dr Steve Votier and
Dr Matthew Witt
(University of Exeter)
Dr Rob Thomas
(Cardiff University)



Hannah's PhD project will use existing seabird tracking data to determine the impact of wind on flight across the diversity of UK seabirds, particularly in the context of potential offshore wind farm effects.

This is an ideal system to study such effects because: (1) the UK supports 8 million breeding seabirds of 25 species; (2) with 30 offshore wind farms, the UK is the largest producer of electricity from offshore wind and (3) climate change is predicted to alter UK wind regimes. The student has access to GPS tracking data from 3,045 seabirds of 8 species, from 29 colonies, across 13 years.

Diversity and scale are important not only because wind is likely to have divergent effects depending on seabird species, but also because the wide range of sites and time periods minimises any potentially confounding effects of short-term site-specific studies. However, the first part of Hannah's research will focus on tracking data for gannets from the Grassholm colony.

The main objectives are to:

- Investigate how wind speed influences foraging metrics;
- Investigate (indirect) effects of wind speed on body condition, survival and breeding success;
- Assess how impacts of offshore wind farms vary under different wind conditions.

The PhD thesis is due to be completed in 2022.

Assessing responses of marine top predators to offshore wind farm development

Student: Aude Benhemma-Le Gall

Hosts: University of Aberdeen with external supervision from Marine Scotland Science and MacArthur Green

University supervisor: Prof. Paul Thompson

Marine Scotland Science supervisor: Dr. Kate Brookes

MacArthur Green supervisor: Dr. Mark Trinder



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Aude started her PhD at the Aberdeen University's Lighthouse Field Station in October 2018. This research project will use a combination of Hi-Def aerial imagery and passive acoustic monitoring data to assess the responses of marine top predators, including cetaceans and seabirds to offshore structures. Her research project aims to investigate whether the construction and commissioning of wind farms affects fine-scale habitat and subsequently the spatio-temporal distribution of top predators and their key prey in the Moray Firth.

Dr Mark Trinder is an external supervisor to the project, reflecting his long involvement with seabird assessment and monitoring for the Beatrice Wind Farm in the Moray Firth.

The PhD thesis is due to be completed in 2021.



Evidence-based methods for assessing non-breeding season seabird displacement risk of offshore wind farms

National Productivity Investment Fund: Innovation Placement

Student: Tamora James

Hosts (for placement): MacArthur Green & University of Sheffield

Placement

supervisors: Dr Andrew Beckerman, Dr Dylan Childs, Dr Ben Hatchwell (University of Sheffield); Dr Mark Trinder (MacArthur Green)



The University Of Sheffield.



Tamora is working on her PhD at the University of Sheffield focussing on improving conservation efforts for threatened parrot species through the development of mathematical models of population growth and extinction risk.

In 2019 she will undertake a six-month Innovation Placement at MacArthur Green, funded by the National Productivity Investment Fund. The placement will involve research and development of evidence-based methods for assessing non-breeding season seabird displacement risk of offshore wind farms. Offshore wind power is a major component in meeting UK government targets for renewable energy. With plans for offshore wind capacity to increase by as much as 200% of installed capacity in 2016 under the Clean Growth Strategy, robust impact assessments are essential to ensure that this growth takes place in a sustainable manner.

A key requirement of the environmental impact assessment process is to consider the cumulative effects of offshore wind farm installations, not simply individual project-scale effects. In some cases, cumulative effects, such as those for non-breeding season displacement of auks in the North Sea, may span many offshore wind farms. Since individual assessments include high levels of precaution, this can result in high, and potentially unrealistic, totals for cumulative impact.

The current methods of displacement impact assessment admit a wide range of possible effects. Tamora will conduct a review of displacement and its consequences which will inform potential improvements in the estimation of displacement effects, such as setting realistic bounds and reducing uncertainty in assessments.

Investigating the potential effects of marine renewable energy developments on seabirds

MaREE Project

Student: Helen M. Wade

Hosts: University of the Highlands and Islands with external supervision from MacArthur Green; PhD registered at University of Aberdeen

University supervisors: Dr Elizabeth Masden and Dr Angus Jackson (University of the Highlands and Islands)



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The aim of this research was to investigate likely interactions between seabirds and marine renewables in Orkney and Pentland Firth waters.

The study generated vulnerability and data-confidence indices to predict effects of renewables on seabirds. Tracking work was carried out in Orkney to assess overlap between great skua foraging areas and marine renewable lease areas, using GPS tags set up to transmit data to local base stations at a study colony. In addition, vantage point surveys were carried out across the Pentland Firth to investigate seabird interactions with fine-scale habitat in a leased tidal stream site where MeyGen turbines were to be deployed.

The PhD thesis was accepted (Wade, H.M. 2015 Investigating the potential effects of marine renewable energy developments on seabirds. University of Aberdeen).

This project was completed in 2015 and Dr Wade is now working on renewables casework for Scottish Natural Heritage.

- Furness, R.W., Wade, H.M., Robbins, A.M.C. and Masden, E.A. 2012. Assessing the sensitivity of seabird populations to adverse effects from tidal stream turbines and wave energy devices. *ICES Journal of Marine Science*, 69, 1466-1479.
- Furness, R.W., Wade, H. and Masden, E.A. 2013. Assessing vulnerability of seabird populations to offshore wind farms. *Journal of Environmental Management*, 119, 56-66.
- Wade, H.M., Masden, E.A., Jackson, A.C., Thaxter, C.B., Burton, N.H.K., Bouten, W. and Furness, R.W. 2014. Great skua (*Stercorarius skua*) movements at sea in relation to marine renewable energy developments. *Marine Environmental Research*, 101, 69-80.
- Thaxter, C.B., Ross-Smith, V.H., Clark, J.A., Clark, N.A., Conway, G.J., Masden, E.A., Wade, H., Leat, E.H.K., Gear, S., Marsh, M., Booth, C., Furness, R.W., Votier, S.C. and Burton, N.H.K. 2016. Contrasting effects of GPS device and harness attachment on adult survival of lesser black-backed gulls *Larus fuscus* and great skuas *Stercorarius skua*. *Ibis*, 158, 279-290.
- Wade, H.M., Masden, E.A., Jackson, A.C. and Furness, R.W. 2016. Incorporating data uncertainty when estimating potential vulnerability of Scottish seabirds to marine renewable energy developments. *Marine Policy*, 70, 108-113.
- Waggitt, J.J., Robbins, A.M.C., Wade, H.M., Masden, E. A., Furness, R.W., Jackson, A.C. and Scott, B.E. 2017. Comparative studies reveal variability in the use of tidal stream environments by seabirds. *Marine Policy*, 81, 143-152.

Seabird ecology in high-energy environments - approaches to assessing impacts of marine renewables

Glasgow University Scholarship

Student: Alexandra
M.C. Robbins

Hosts: University of
Glasgow with external
supervision from
MacArthur Green

University supervisor:
Dr David Bailey
(University of
Glasgow)



University
of Glasgow



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With a focus on fieldwork at a proposed tidal turbine site in Bluemull Sound, Shetland, the aim of this research was to address key knowledge gaps relating to our understanding of seabird ecology in high-energy marine environments. The work included assessment of EMEC data on seabirds at test tidal and wave sites (reported as SNH Commissioned Research Reports). Further outputs are a thesis and published papers. The PhD thesis was accepted and is available online (Robbins A.M.C. 2017. Seabird ecology in high-energy environments: approaches to assessing impacts of marine renewables. University of Glasgow).

This project was completed in 2017 and Dr Robbins is currently working on renewables casework for Scottish Natural Heritage.

Papers arising from the research include:

Furness, R.W., Wade, H.M., Robbins, A.M.C. and Masden, E.A. 2012. Assessing the sensitivity of seabird populations to adverse effects from tidal stream turbines and wave energy devices. *ICES Journal of Marine Science*, 69, 1466-1479.

Waggitt, J.J., Robbins, A.M.C., Wade, H.M., Masden, E. A., Furness, R.W., Jackson, A.C. and Scott, B.E. 2017. Comparative studies reveal variability in the use of tidal stream environments by seabirds. *Marine Policy*, 81, 143-152.

A further chapter of the thesis is currently being prepared for publication:

Robbins, A.M.C., Thaxter, C.B., Cook, A.S.C.P., Furness, R.W., Daunt, F. and Masden, E.A. Seabird diving behaviour to inform underwater collision risk with tidal stream turbines: a synthesis and data gaps.