#BOUsci18

Seabirds: Towards sustainable futures for renewables energies

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ABSTRACTS

Abstracts are in alphabetical order by presenting author's surname

KEYNOTE

Bridging the gap: what the future holds for the science-policy interface of Offshore Renewables

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There has been, and will likely continue to be, considerable expansion of offshore renewable energy development in UK waters, particularly in the North Sea. This poses potential concerns for wide-ranging marine birds which travel through or forage in these areas. There are legal requirements to assess the environmental impacts of developments and such assessment requires reliable evidence, which is costly and often logistically challenging to acquire. Impacts on birds remains a key consent risk for offshore renewable developments, and this talk will discuss key challenges in ensuring maximally profitable interaction between decision makers and scientific advisors. Sticking points include clear understanding of the interaction between uncertainty and precaution, and the importance of assessment of cumulative effects, as well as the need for engagement across industries to produce meaningful cumulative assessments.

We will then highlight some areas of the science-policy interface that we hope to improve upon in order to lead to clearer understanding of risks and transparent evidence-based decision making. This includes better communication of uncertainty and risks to decision makers, and increased collaborative working across industry to address strategic evidence needs. Some steps have already been taken towards this future (e.g. The Offshore Renewables Joint Industry Programme (ORJIP) Bird Collision Avoidance (BCA) study, JNCC commissioned uncertainty communication review) but more needs to be done.

Julie Black is a senior marine industries ornithologist within the JNCC, with a background in predictive spatial mapping and SPA design, scenario modelling, and environmental economics. She has been involved in several collaborative research projects relating to offshore wind and bird interactions, including a bird collision-avoidance project funded through ORJIP, and continues to provide input both into strategic research and casework, and the interaction between these.

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Attributing seabirds at sea to breeding colonies: assessment of alternative methods

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A central part of the consenting process for proposed offshore renewable developments is to establish the colonies of origin of birds that may be affected. The majority of seabird distribution data are collected through observations at sea where the connectivity of observed birds to colonies is unknown. The current approach apportions effects to different colonies based on the distance to, and size of each colony. This assumes that foraging ranges of adjacent colonies overlap, however segregation between colonies may occur. Furthermore, it assumes the density of birds increases in relation to the inverse of the square of the distance from the colony, ignoring species specific differences, nor does it account for environmental heterogeneity.

We used existing information to produce a tool to apportion birds at sea to colonies. We used predicted spatial distributions estimated from GPS tracking data from breeding birds of three species (Black-legged Kittiwake, Common Guillemot and Razorbill) as a basis for apportioning birds. We implemented three different approaches:

i. the current rule, based on an inverse quadratic decay with distance from colony, widely used in practice;
ii. a relatively sophisticated statistical approach based upon modelling of GPS data to derive the estimated spatial distribution of birds originating from each individual colony; and
iii. a novel semi-empirical approach, which extends the first approach by allowing the rate of decay with distance to be determined in a species-specific way using foraging ranges.

Our findings suggest that the point process modelling approach should be used in preference to the other methods for species with sufficient GPS tracking data. Moreover, our results suggest that the widely used approaches based on inverse quadratic decay can yield results that differ substantially

from those obtained using more plausible methods, indicating that alternatives should be considered for species lacking in GPS tracking data.

Adam Butler is a senior environmental statistician with experience in the analysis of a wide range of ecological data. He has particular expertise in using statistical methods to model the spatial distribution, behaviour, survival and reproductive success of seabirds, and in assessing the impacts of offshore renewables upon seabirds.

2-minute wonder

Potential impacts of existing and proposed wind farms on seabirds and migrant waterbirds in the southern North Sea are assessed at the population level

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Offshore wind farms may affect birds by direct mortality through collisions, or by indirect mortality through habitat loss. The rapid growth in offshore wind farms in recent decades calls for studies into the cumulative impacts of these developments. Moreover, it is important to consider the impact at the population level. A recent cumulative impact assessment identified 15 bird species in Dutch offshore waters for which the predicted additional mortality due to offshore wind farms was close to the provisionally applied threshold as calculated by Potential Biological Removal (PBR): red-throated diver, Bewick's Swan, Brent Goose, Common Shelduck, Lesser Black-backed Gull, Great Black-backed Gull, Herring Gull, Kittiwake, Great Skua, Eurasian Curlew, Black Tern, Sandwich Tern, Common Guillemot and Razorbill.

In the current study, we developed Leslie matrix models for these species, and show how long-term effects of additional mortality can be assessed at the population level, incorporating various factors such as density dependence, stochasticity between years and uncertainty in various parameters.

Mark Collier works a bird ecologist at Bureau Waardenburg in the Netherlands. He has been involved with various ornithological projects including radar studies, satellite tracking and wind farm studies, both on land at sea. Mark is involved in collision rate modelling and has gained experience in this discipline through a range of studies including the appropriate assessments of more than 20 offshore wind farms in the North Sea, research into the first Dutch offshore wind farm and the cumulative effects of multiple offshore wind farms. Mark has made contributions to The Crown Estate's SOSS group, including review reports on methods to monitor collisions or micro-avoidance of birds with offshore wind turbines; as well as recent studies into the use of GPS data to assess the movements of birds in relation to offshore wind farms.

2-minute wonder

Can we detect population impacts from offshore wind farms at a colony level?

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The key effects of offshore wind farms on seabirds include displacement, barrier effects and collision. At a population level, these may manifest themselves through reductions in productivity or survival and ultimately in the number of breeding birds. Any impacts at a colony level must then be considered as part of a Habitats Regulations Assessment (HRA). However, the extent to which any adverse effects arising as a consequence of impacts from offshore wind farm could be detected at a colony level is unclear.

Collectively the Seabird Monitoring Programme (SMP) and the Retrapping for Adult Survival (RAS) scheme collect key demographic parameters for a range of seabird species from colonies around the UK. We assess the extent to which the impacts of wind farms are likely to be detected in changes in survival, productivity and abundance in the species and colonies identified in the HRAs for these sites, given current levels of monitoring. Based on our findings we make recommendations over how current monitoring effort can be improved in order to ensure any population changes associated with offshore wind farms can be adequately detected.

Aonghais Cook is a senior research ecologist at the British Trust for Ornithology. His work focuses on understanding the impacts of marine renewable energy on seabirds at a population level.

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KEYNOTE

Tracking seabird-prey interactions in a changing world

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In addition to mortality risks from collision with wind turbines, the spatial expansion of offshore renewable developments can impose extra costs on seabird populations. The main concern is the alteration of ecologically irreplaceable areas with high functional values for birds (e.g. foraging areas, commuting areas) leading to an unsustainable increase in foraging costs and energy expenditure. To anticipate the negative consequences of offshore developments on seabird populations, we therefore need to study drivers of their spatial foraging patterns. Studies on spatial seabird-prey interactions remain challenging due to the cryptic nature of prey distributions. We will present two case studies integrating spatial data on both seabirds and their prey, and discuss our results in a perspective of offshore renewable developments. For Scopoli's Shearwater (*Calonectris diomedea*) foraging in the Western Mediterranean, we will show how short-term prey field lability leads birds to switch foraging areas and prey type on a daily basis, resulting in low short-term foraging site fidelity. The future establishment of a windfarm expected in a valuable foraging area close to the colony will therefore impact the entire, vulnerable, shearwater population rather than some individuals. Secondly, we will use the case of Little Auks (*Alle alle*) migrating in the North Atlantic, to demonstrate the great potential of the energyscape concept coupled with prey field data, to study seabird spatial ecology. Such framework should improve the delineation of critical areas in an offshore development context. Ultimately, a better anticipation of windfarm consequences on seabird populations should aim to determine potential local changes in prey communities.

Nicolas Courbin trained as an oceanographer and a quantitative ecologist. He studies movement/spatial ecology, predator-prey interactions and population dynamic in order to improve animal conservation. During his PhD and his first post-docs, Nicolas studied the spatial ecology of large herbivores and carnivores tracked by GPS in boreal forests and African savannas, in a context of human-altered landscapes. More recently, he has taken a deep dive into seabird ecology, to investigate seabird-prey spatial relationships and seabird demography.

KEYNOTE

Seabirds and marine renewables: population and meta-population level issues

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Seabirds may be affected by offshore renewable developments (ORDs) through a number of processes, notably collisions with turbine blades and displacement from favoured habitats. Effects can either be lethal, where an event such as a collision instantly kills the bird, or sub-lethal, where an event affects the behaviour of the bird, altering its energetic budget and, in turn, demographic rates and population size. However, it is proving extremely challenging to quantify the population-level consequences of ORDs. Recording lethal mortality is logistically challenging, and quantifying sub-lethal effects is hampered by a limited understanding of the links between behaviour, energetics and demography, in particular in breeding individuals that are trading off their fitness against that of their offspring. Further, the interaction between lethal and sub-lethal effects needs to be incorporated into assessments. Finally, populations may be subject to density dependent processes and are not closed, so we must consider effects at the meta-population scale that incorporate movements between colonies. In this talk, I provide a conceptual background on the consequences of ORDs on populations and meta-populations, review the evidence to date, and propose future research priorities to improve our understanding of this critical research need.

Francis Daunt is a seabird biologist and his research links ecology, life history variation and population dynamics to understand the drivers of change in seabird populations, in particular climate change, fisheries and marine renewables. He coordinates CEH's long term seabird study on the Isle of May.

LiDAR as a tool for estimating seabird flight heights

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Collision mortality is regarded to be a key potential impact of wind farms on seabirds. An important component for assessing collision risk is an estimate of bird flight heights, in particular the proportion of birds which fly within a turbine rotor swept area. A range of methods exist for either measuring or estimating bird flight heights, but validation of these flight heights appears to be limited or lacking, resulting in questions over the accuracy of estimates.

Recent developments in the application of Light Detection and Ranging (LiDAR) technology offer the potential to collect precise estimates of seabird flight heights when combined with the use of digital imagery to identify individual birds to species level. We carried out a field trial of aircraft-mounted LiDAR as a tool to collect flight height information and develop approaches to analysing the resultant data. LiDAR has the potential to provide large spatial and temporal sample sizes of seabird flight heights on-site across multiple species and age groups. These data can be used to provide 3D maps of seabird flight heights. As a proxy for behaviour, such maps may have applications beyond the assessment of collision risk, for example in relation to Marine Spatial Planning.

Tom Evans is a marine ornithologist advising the Scottish Government on impacts on birds from offshore renewable energy developments and other issues. He has a research background studying seabird spatial foraging ecology using biologging devices.

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The way forward in addressing key challenges in seabird-renewables interactions

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I will focus on the obvious consenting risk for offshore wind farms in European seas: cumulative impacts (of collision mortality and displacement) on SPA populations and regional populations of gannets, kittiwakes, large gulls, and red-throated divers. We must reduce uncertainty in the assessment of impacts at the population level. This is because precautionary assessments may suggest that impacts have exceeded acceptable levels whereas evidence-based assessments may show that this is a result of precautionary assumptions at multiple stages in the assessment process. We must gather the key evidence required to reduce the need for precautionary assessments. This includes more accurate measures of seabird avoidance rates, flight heights, and nocturnal flight activity as inputs to collision risk models. We need to develop new technology that can provide accurate data for these metrics and I will discuss possibilities for this. We also need better understanding of seasonal movements of seabirds, including immatures, from defined populations, preferably from individual colonies in multiple years to assess influences of varying ecological conditions. Developments in tracking technology certainly allow much of that information to be gathered. We need to find ways to assess the impact of displacement of seabirds (if any) at the population level, which means better understanding of whether populations are at carrying capacity when displacement occurs, and whether increased density outside wind farms or barrier effects influence body condition and have consequences for survival or future reproduction. Finally, we need more realistic population models that incorporate evidence-based density-dependence and meta-population structure.

Professor Furness has supervised >60 PhD students, managed >50 research grants, and authored >300 papers, cited >33,000 times (h index 85). He is a Board member of SNH, chairs SNH's Scientific Advisory Committee, Principal Ornithologist at MacArthur Green, Fellow of the Royal Society of Edinburgh. He chaired IAPEME, advising Danish authorities on monitoring the first major offshore wind farms (Nysted, Horns Rev), and chaired ICES working groups on sandeels, on sprats, and on seabird ecology.

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2-minute wonder

Divers in the German Bight (North Sea): Effects of operating wind farms on distribution and numbers

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Divers (loons, Gaviidae), especially the Red-throated Diver (*Gavia stellata*), are key seabird species for evaluating possible impacts of offshore wind farms in German North Sea waters. Licensing authorities rank information on divers, especially on displacement effects, very high. This is based on their major and internationally important spring aggregation in the eastern German Bight, their status as Annex I species of the EU Birds Directive and their strong sensitivity to ship traffic and operating wind farms.

In a new analysis for the Federal Maritime and Hydrographic Agency (BSH) and the Federal Agency for Nature Conservation (BfN), all available data from 2000 to 2017 were analysed. Data originate from research projects, the national biodiversity monitoring program, environmental impact assessments and the ecological monitoring of operating wind farms. Seabird counts comprise ship-based counts, visual aerial surveys and digital aerial surveys and were analysed in a combined data base.

In the talk, changes in the distribution are shown from 2002, long before the establishment of the first wind farm, until 2017 when 14 wind farms were operating or under construction. Quantitative results from a BACI analysis on displacement behaviour of divers are presented, based on all wind farms in German EEZ waters in the North Sea.

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Satellite telemetry and digital aerial surveys confirm strong displacement of Red-throated Divers from OWFs - what's next?

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The Red-throated Diver (*Gavia stellata*) has been reported to be among the most sensitive species to offshore windfarms. We used satellite telemetry and digital aerial surveys to investigate Red-throated Divers in the German Bight with the aim of describing their distribution and displacement from OWFs. In order to do so we modelled the distribution of divers in relation to the dynamic offshore environment and anthropogenic pressures, including shipping intensity in addition to distance to windfarms. The models based on both telemetry and survey data showed a consistent displacement pattern. Divers were strongly displaced from windfarms and up to 5 km around in suitable habitat. Diver distribution was also negatively related to shipping intensity. They preferred the frontal zone between the coastal and offshore water masses according to the modelled relationships to salinity and water depth as well as a change in chlorophyll concentration. Pelagic fish as herring and sprat are known to concentrate in frontal areas, which are also preferred prey by divers. The displacement effect, although significant up to 15 km away, gradually decreased with distance from the windfarms. Areas of suitable habitats are extensive in the German Bight, which allowed divers to choose habitat far away from windfarms (up to 15 km away). In other regions where suitable habitat is limited a shorter displacement distance could be expected. Although we can document a displacement effect, we do not know what it means in terms of potential population level impacts. To further assess potential impacts we need information on fine scaled movements and diving behaviour which can be used for calculating energy budgets and further analysed in an individual based modelling framework. Before such information is obtained the best way of avoiding potential conflicts is marine spatial planning, i.e. by avoiding or limiting anthropogenic use in important diver habitats.

Stefan Heinänen is an environmental and marine biologist working mainly with distribution and movement modelling of animals in relation to human offshore activities. Other research activities include population modelling, conservation prioritisation and marine spatial planning.

2-minute wonder

Investigating the foraging habitat of Black Guillemots in relation to tidal stream turbines

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Inshore diving seabirds such as Black Guillemots *Cepphus grylle* may be vulnerable to alterations to their foraging habitat due to the construction of tidal stream turbines. During foraging, individuals are known to associate with tidal currents and dive to depths at which tidal turbines will operate, and are therefore at risk of collision with turbine blades. As well as posing a potential collision risk, these devices may alter tidal current flow, and change benthic habitats, which may alter the distribution of black guillemot prey. However, the extent to which these devices will affect Black Guillemots is unknown due to a lack of knowledge regarding their foraging ecology. This study addresses this knowledge gap by using GPS tracking to identify black guillemot foraging habitat, compared to habitat held within a tidal lease area.

Thirteen adult black guillemots were GPS tracked during the 2016 and 2017 breeding seasons from Stroma, Caithness, an island of interest due to its close proximity to the MeyGen tidal lease area within the Inner Sound of the Pentland Firth. Individuals displayed clear preference for specific foraging locations, associating strongly outside or within the Inner Sound tidal stream. Of the individuals associating with the Inner Sound, 12% of foraging locations overlapped with MeyGen, highlighting a potential difference in tidal stream foraging locations and MeyGen. This disparity is related to tidal velocity and depth preferences, with foraging occurring in shallower areas than MeyGen, at velocities significantly slower than those concurrent within MeyGen. The selection of these velocities and depths may be related to season, energetic costs, the location tidal fronts, or

benthic habitat composition. Understanding habitat associations within the tidal stream may also help assess potential changes in black guillemot foraging behaviour as flow velocity alters with the future addition of tidal devices.

Daniel Johnston is a 3rd year PhD student with an interest in seabird foraging behaviour and marine ecology. His research focuses on black guillemots with field sites in Scotland. He has a background in field work with the British Antarctic Survey and Farallon Islands Bird Observatory.

Throwing Precaution to the Wind: Uncertainty and the Precautionary Principle in Wind Farm Assessment

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There has recently been a massive expansion in the development of offshore renewable wind energy in the United Kingdom, representing an unprecedented industrialisation of the marine environment. Some expansion is crucial if we are to mitigate the effects of climate change but there is also a legal, and indeed moral, imperative to protect the marine environment and its biodiversity. Despite this imperative, the risks to wildlife and in particular seabirds have not been fully quantified, with considerable uncertainty existing as to the scale and nature of any impacts. The first step to quantifying risk is to identify the sources of uncertainty, and yet any identification, categorisation or quantification of uncertainty has rarely been carried out.

The precautionary principle ensures that where there are threats of serious or irreversible damage, lack of full scientific certainty is not used as a reason against preventative decision, thus ensuring that the existence of the risk/uncertainty is sufficient to ensure environmental protection. However due to the large uncertainties involved, it has been argued that there is an over-precautionary approach being taken to the assessment of offshore wind farm developments.

However we argue that the aim should be to reduce the uncertainty not precaution. Using examples from the UK of offshore wind farm developments, and the assessment process, both scientifically and procedurally, this talk will describe the legal and assessment requirements and how the precautionary principle can be misapplied despite the scale of uncertainty. We will also highlight the examples where positive efforts have been made to reduce the uncertainty.

Aly McCluskie is a Senior Conservation Scientist for the RSPB. His work involves both active research and review in order to provide the science required to underpin policy and casework. In particular he examines the interactions between wind farms, both terrestrial and offshore, and birds.

Understanding the Effects of Offshore Renewables on Seabird Populations: the Perspective of an Ecological Consultancy

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Major concerns continue to revolve around the potential effects of offshore renewable developments on seabird populations. These concerns are most severe in relation to offshore wind farm developments, with other wet renewable developments generally being less contentious and causing less controversy. To some extent at least this reflects differences in the scale of the developments rather than knowledge on the extent of impacts that may result from the different types of development. These concerns and the consequent effect upon the consenting process for offshore renewables highlights the critical importance of gaining a greater understanding of the interactions of seabird populations with offshore renewables, both from the perspective of the conservation of these populations and the development and advancement of the industry.

This presentation aims to demonstrate the need for a greater understanding of these interactions from the perspective of an environmental consultancy which has provided support and advice to a considerable number of offshore renewable developers across the UK (including substantial involvement with proposed tidal and wave power schemes) and which, through its involvement in the recent judicial proceedings affecting the Forth and Tay wind farms, has first-hand experience of the complex and major problems that can arise in the current situation.

Drawing upon the above experience to provide background and context, this presentation will seek to identify key areas of concern both for the conservation of seabird populations and the consenting of offshore renewable developments. Consideration will be given to the existing research priorities established within the industry, the extent to which these may resolve the key concerns, issues of considering impacts at the population-level (e.g. in terms of existing population status), and the need to reconcile what may be desirable with what is realistic to achieve in terms of supporting the industry.

Helen Riley has 25 years' professional ornithology experience, including 12 years in ecological consultancy. She has worked on a range of offshore renewable developments. She is experienced in working with developers, Regulators, statutory advisors and experts in other technical disciplines to assess potential impacts on bird populations.

Population Viability Analysis: comparison of methods used in assessing impacts of Offshore Renewable Energy Developments

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Offshore renewable developments (ORDs) have the potential to impact on seabirds, from collisions with turbine blades and displacement from important habitat. Population Viability Analysis (PVA) is considered the most appropriate method to understand the population-level consequences of these effects. However, there has been criticism of their use to inform management decisions. The quality of life-history data, which is often poor in seabirds, may determine how effectively PVAs are able to predict population changes. Currently, there is a lack of clarity on how to select the most appropriate method for constructing PVAs in seabirds in relation to the quality of input data. There is therefore an urgent need to critically compare the performance of different PVA methods across a range of seabird species and populations with differing data qualities.

We quantitatively evaluated the ability of different PVA methods to assess how accurately each method predicted observed seabird colony counts across a range of scenarios. The statistical approaches we tested vary in levels of complexity and in the data required for model fitting. We tested a wide range of commonly used PVA methods, including Bayesian state-space models, Ricker and Gompertz models, Leslie Matrix projections and trend analyses, and examined the consequences of using data from different regions to address data gaps at local colonies. We assessed both the

discrepancy between the predicted values and the observed counts and the extent to which the observed counts were consistent with the uncertainty associated with the predicted values from each method.

We provide recommendations for how PVAs should (and should not) be used, across a range of species and regions, to strengthen confidence that they perform appropriately for the population of interest.

Kate Searle is an animal ecologist with expertise in applying cutting edge statistical methods to establish robust ecological inference for how populations respond to environmental change in complex environments. Her research has spanned trophic levels and been applied across individual behaviour, population dynamics, and trophic interactions, leading to over 25 peer-reviewed papers

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Fine scale marine behaviour across multiple breeding phases: Movement of Lesser Black-backed Gulls Larus Fuscus in relation to a North Sea wind park

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Lesser Black-backed Gulls *Larus Fuscus* have been identified as a species of concern regarding their risk of interaction with offshore wind farms. While they are generally considered marine foragers, studies have shown that foraging behaviour and utilization of marine habitats may differ greatly across and within populations. Macro avoidance of wind parks by individuals may constrain foraging ranges whilst movement between turbines could increase collision risk. As the rate of developing wind energy infrastructure continues to increase, further insight is needed into the impact of such structures on foraging movements and subsequently on breeding populations.

In order to study offshore foraging behaviour in relation to wind parks, GPS and accelerometer data was gathered from 30 adult breeding birds tagged at their colony on the Wadden island of Schiermonnikoog in the Netherlands. High resolution measurements were taken in the vicinity of Gemini wind park to investigate inter-turbine movements and micro avoidance behaviours. Breeding monitoring was concurrently undertaken at the same colony and GPS data was analysed in relation

to breeding stage. Preliminary analysis indicates that birds based at this colony forage heavily inland, regularly travelling up to 80 km in one direction to feed on anthropogenic resources. Encounters occur between tagged birds and the wind park of interest but have been minimal, even though the area is within their foraging range. Marine foraging activity was higher during chick rearing compared to incubation, therefore interactions with wind parks may be more likely.

By measuring fine scale flight behaviour of gulls over their entire annual cycle we aim to identify the key environmental factors governing movements at sea compared to on land and their consequences for individuals and populations throughout varying stages of breeding. From this we can identify spatio-temporal windows during which the probability of interactions with wind parks are highest.

Elspeth Sage is a movement ecologist focusing on the fine scale flight behaviour of gulls in relation to environmental conditions and offshore wind areas, using computational methods to identify patterns in flight movement, in order to further understand and predict the behavioural response of birds in an ever changing environment.

Multi-colony tracking of gulls to understand wind farm interactions: Key findings, challenges and future perspectives

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Telemetry has become a key research tool to understand the interaction between birds and wind farms. Information can be collected on parameters most influential in determining collision risk of species, such as area use, flight height, speed and avoidance. Since 2010, two species considered sensitive to collision, Lesser Black-backed Gull *Larus fuscus* and Herring Gull *Larus argentatus*, have been tracked using long-life GPS telemetry at three UK breeding colonies to assess interactions with wind farms across different spatial and temporal scales. During the breeding season, Lesser Black-backed Gulls exhibited a high degree of individual, seasonal and annual variation in movements, with

the use of offshore wind farms peaking during chick-rearing. Herring gulls used offshore areas less than Lesser Black-backed Gulls. Lesser Black-backed Gulls flew highest over land and during the day, and modelled distributions revealed proportions of birds flying at potential risk height offshore. Analysis of data collected within operational offshore wind farms has revealed detailed behaviours, with potential value for quantifying three-dimensional avoidance. Analysis of year-round movements of Lesser Black-backed Gulls has highlighted areas where risk and vulnerability to collision may be greatest, helping inform wind farm siting and mitigation. Data from three other colonies is expanding the picture still further.

This work has not been without its challenges. Attachment methods and tag design are paramount for bird welfare, and long-term attachments of tags may be suitable for one species but not another. Current GPS systems also permit the collection of large volumes of data presenting analytical complexities. However, future applications of telemetry are numerous. To date, work has centred on adults, but less is known about the movements of juvenile or immature birds. Further work also aims to model three-dimensional distribution and movements of gulls in relation to habitat and weather to generate real-time estimates of collision risk.

Chris Thaxter is a Senior Research Ecologist with an interest in animal behaviour and conservation, specialising in marine ecosystems. He is particularly interested in seabird behaviour and movement patterns in relation to anthropogenic and environmental processes, and how fine-scale species-environment interactions link to population processes, furthering conservation and management of species.

KEYNOTE

Seabird tracking and renewables: current research and future perspectives

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Tracking has revolutionised the study of animal behaviour. It has provided remarkable insights into the study of avian biology and been used to answer important conservation questions, including the potential impact of offshore renewable developments (ORDs). ORDs may have negative impacts on seabirds via collision, displacement, or degradation of foraging habitat, or positive impacts by

creating no-take zones and increasing habitat heterogeneity. Bird-borne telemetry has providing crucial information on the distribution and behaviour of seabirds in relation to ORDs, and has thus furthered our understanding of the ecological consequences of ORDs. I will provide an overview of peer-reviewed studies on this topic, focusing on studies relating to overlap, fine-scale interaction, flight height and displacement. I will also consider some of the shortcomings of using telemetry such as sample sizes, device effects, representativeness of deployment periods and the range of species that can be safely tracked, before looking to what developments on the horizon might mean for this research area in the future. Ultimately I hope to shine some light on how effective this tool is for generating much needed insight into the way in which ORDs influence seabird populations, whether positive or negative.

Steve Votier is a seabird biologist with an interest in pure and applied research at the individual, population and ecosystem level behaviour. He established the medium-term (for now) Gannet-monitoring project on Grassholm, Wales, and is the current Chair of The Seabird Group.

Ecologically informed and dynamic distribution maps for seabird communities in the north-eastern Atlantic Ocean

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Quantifying spatial and temporal variations in the distribution of seabirds is a fundamental component of their conservation. The rapid increase in Marine Renewable Energy Installations (MREI) arguably makes this fundamental information more crucial than ever-before. A common approach uses vessels or aircraft to record animals along transect lines, and species distribution models or geostatistical interpolation to produce density surfaces. However, individual surveys cannot record distributions at annual, seasonal and continental scales. The tendency to use spatiotemporally explicit information when constructing density surfaces also produces outputs representing instantaneous distributions at the time of surveys or the intensity of survey effort, rather than overall distributions. This study uses a combination of methods to produce density surfaces of 12 species at a monthly and 10km resolution over 30 years in the north-eastern Atlantic Ocean. First, 1.6 million kilometres of surveys were collated from 15 sources. Second, ecologically informed species distribution models based on relevant environmental variables were developed. This approach

produced sensible estimations of population sizes and distributions in the study area, whereas temporal variations in these measurements were as expected from existing knowledge. This comprehensive and unprecedented analysis provides timely inputs into management strategies by identifying which and when populations are most vulnerable to interactions with MREI within the north-east Atlantic Ocean region.

James Waggitt is a lecturer at the School Of Ocean Sciences, Bangor University. His research focusses on the behavioural and environmental factors governing the distribution of cetaceans and seabirds in time and space. Much of his research uses observational surveys in combination with remote sensing/simulation models to quantify associations between animals and oceanographic processes, and use these associations to predict distributions and responses to environmental change.

The Offshore Renewables Joint Industry Programme (ORJIP) Bird Collision Avoidance Study

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Potentially one of the most significant predicted environmental impacts from offshore wind farms is the risk of birds colliding with the turbine blades. However, the evidence base available with respect to specific collision and avoidance rates to inform impact assessment for new wind farm developments is limited.

The Offshore Renewables Joint Industry Programme (ORJIP) Bird Collision Avoidance (BCA) study, which started in 2014, was a joint industry project managed by Carbon Trust, United Kingdom (UK) and funded by 15 parties. NIRAS (UK) and DHI (Denmark) were in charge of developing the sensor technologies and analytical framework necessary to improve the evidence base for seabird avoidance behaviour and collisions around offshore wind farms in order to offer better support to consenting applications for the offshore wind industry.

This presentation will describe the ORJIP BCA Study and present its main results. During two years of fieldwork from summer 2014, the Project monitored avoidance behaviour and collision impacts, using TADS camera system in digital communication with surveillance radar systems, within the Thanet offshore wind farm, and combined laser rangefinders, surveillance and high performance radars at the periphery of the wind farm. The detection system within the wind farm collected data at the species level on meso and micro avoidance, and recorded collision events automatically. The detection system at the periphery of the wind farm collected data on macro avoidance and flight altitudes, and by using observer-based radar and rangefinder tracking the vast majority of data was at the species level. The presentation will conclude in describing the analytical methods applied and the main results of the ORJIP BCA study in terms of species-specific avoidance rates at macro, meso and micro scale.

Robin Ward is a consultant ornithologist whose expertise includes the surveying and monitoring of waterbird and seabird distribution and numbers at a range of temporal and spatial scales (within site to a national level), and assessing the ornithological impact of wind farms in the marine environment.

Seabird tracking and windfarms: The role of behavioural specificity and deployment length

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Offshore wind energy is predicted to be the second fastest growing renewable energy sector in the EU by 2020. Consequently, there is an urgent need to improve our limited understanding of the vulnerability of marine wildlife to the related developments. Here we present recent results and future plans for the RSPBs multi-year seabird tracking work in the UKs largest mainland seabird colony, adjacent to some of the biggest offshore wind energy developments planned globally.

The study aims to strategically fill knowledge gaps around environmental risk assessments, initially concerning Black-legged Kittiwakes (*Rissa tridactyla*), a species predicted to be especially at risk of colliding with turbines. Results from the first year of tracking challenges current assumptions showing kittiwake distribution and vulnerability is:

i. not homogenous across space: There is a substantial variation between behaviour specific offshore distributions.
ii. not constant within distinct parts of the breeding season: There is a continuous increase of foraging range and shift in offshore distributions of birds tracked up to 30 days across chick rearing.
iii. not affected by nest failure: Although failed birds increase trip duration and distance, range is not affected, and failed birds visit the same areas as active breeders.

These results already show that basic behaviour information derived from GPS tracking and longer deployment periods have the potential to add valuable information to species risk assessments. To directly measure changes in seabird behaviour and distribution before, during and after the construction of local offshore windfarms, we are planning to continue this study, expand it to further vulnerable species such as Northern Gannets (*Morus bassanus*), and collect direct behaviour information using accelerometers and altimeters.

Saskia Wischnewski is a Marine Biologist with a very keen interest in spatial ecology and seabird conservation. At the moment she is a Conservation Scientist at the RSPB coordinating and leading the seabird tracking work within the Flamborough and Filey pSPA while simultaneously finishing her research-based Master's degree at University College Cork.

Does it matter? Population-level consequences of predicted seabird collisions with wind turbines

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ABSTRACTS

Abstracts are in alphabetical order by presenting author's surname

All UK offshore windfarms that have been consented to date have achieved planning consent on the basis that they will not have significant effects on the conservation of the UK's internationally important seabird populations. This implies that the impacts of offshore wind farms on seabirds are relatively unimportant; it doesn't really matter. It also means that, under the current regulatory framework, no action is required to offset predicted effects on seabirds.

The offshore wind industry has expanded rapidly over a relatively short timeframe, and it is logistically difficult to measure environmental impacts in the marine environment so there have been few studies that empirically measure effects on seabirds. Consequently, the effects of offshore wind farms are less well-understood than those of some other types of development. Methods of predicting likely impacts to seabirds are therefore based largely on unvalidated models (e.g. of collision risk) or expert judgement. Understanding population-level consequences brings even greater challenges, because of uncertainty about demographic rates and density dependence. Green *et al*. 2016 (doi: 10.1111/1365-2664.12731) argued that, given these significant uncertainties, the best approach to modelling effects on seabird populations is to use a density-independent Leslie matrix model to calculate the ratio of the expected population size at the end of the lifetime of the windfarm with and without the predicted effect of the wind farm on seabird demographic rates (the counterfactual of population size). We use this approach to estimate the consequences of the predicted collision risk for all consented UK offshore wind farms (using developers' own figures) for the total UK populations of 5 seabird species over a 25-year period. We argue that it DOES matter – the predicted impacts to populations cannot be dismissed as non-significant if marine renewable energy and seabirds are both to have a sustainable future.

Lucy Wright is a Principal Conservation Scientist at the RSPB Centre for Conservation Science. Her team investigates the environmental impact of proposed developments, including renewable energy installations, and the effectiveness of protected area networks for species conservation. We provide scientific evidence to underpin casework, policy and advocacy on these issues.