15th International Seabird Group Conference

Cork 22th-26th August 2022

Conference Program Book

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Aerial Imagery of Northern Gannets *(Morus bassanus)*.
Imagery acquired by Green Rebels Aerial Imagery System, 2021.

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Welcome Message

Fáilte, and welcome to Cork for the 15th International Seabird Group Conference. It's been 4 years since the last in-person Seabird Group Conference in Liverpool, a result of accommodating the World Seabird Conference in Australia and subsequent covid rescheduling. For many, this will be the first in-person conference for some years, and I hope you take the opportunity to reconnect with your fellow seabird researchers during breaks, poster sessions and over a pint or two in one of Cork's many heritage pubs.

The number and quality of abstracts submitted for talks and posters was incredible and I hope you agree that we have an exciting lineup of plenary talks and presentations across a wide range of themes. Ensuring diversity and equality across the conference has been a priority, and we have endeavoured to ensure we have a good balance of gender and career stages across presenters, and have included what we hope will be an enlightening session reflecting on how inclusive we as a research community are.

No conference is complete without opportunity to socialise and network, and we are very grateful for the generous support from our conference sponsors and exhibitors that has enabled us to include lunches throughout the conference and catering during the poster session to help fuel lively discussions. The conference dinner will be held in the Bodega bar in town, and for those of you wanting a taste of trad, we have the services of an accomplished trad band - cèilí dancing optional and at your own risk!

After the conference, I hope you take the opportunity to visit the wider area, especially the coastline, which hosts internationally important numbers of seabirds. In Cork, we recommend the Old Head of Kinsale, Galley Head or a pelagic trip from Baltimore. Further afield, the UNESCO world heritage Skellig Islands are definitely worth a look for their impressive puffin and gannet populations (or to satisfy your inner Star Wars fan). Wherever you go, we wish you a rewarding seabird experience.

If you have any questions throughout the conference, any member of the UCC Marine Ecology Group will be happy to help – just look out for the conference t-shirts.

Is mise le meas,

Mark

Conference Organising Committee:
Mark Jessopp
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Conference Information

Venue

The conference is based in the University College Cork with all talks, including plenary sessions, taking place in the Boole Lecture Theatre. The poster session on Tuesday will be in the Hub Atrium. See page 9 for a floorplan and page 10 for a campus map.

Workshops- Monday 22nd August

What does effective management in Marine Protected Areas look like for Ireland's seabirds? Sinéad Loughran (sloughran@birdwatchireland.ie)

Fair Seas is an Irish coalition campaign that seeks to build a movement of ocean stewardship across the island of Ireland. Our aim is for Ireland to become a world leader in marine protection, giving our species, habitats and coastal communities the opportunity to thrive. Key to this is ensuring Ireland secures an ecologically coherent network of well-managed Marine Protected Areas (MPAs) in Irish waters.

On 8th June 2022, Fair Seas published a first of its kind scientific report; 'Revitalising Our Seas - Identifying Areas of Interest for Marine Protected Area Designation in Irish Waters'. The report aims to kick-start the conversation of where MPAs may be designated, using analysis of species hotspots in Irish waters.

In this workshop, attendees will be asked what they want to see in the management of MPAs in Irish waters and how effective management should be achieved for Ireland's seabird populations. An overview of the report and resources will be provided to participants, so prior reading of the report is not essential.

The Fair Seas members are Birdwatch Ireland, Coastwatch, Coomhola Salmon Trust, Friends of the Irish Environment, Irish Environmental Network, Irish Wildlife Trust, Irish Whale and Dolphin Group and Sustainable Water Network. Fair Seas is funded by Oceans 5, the Becht Family Charitable Trust, Blue Nature Alliance and Wyss Foundation.

Bioacoustics as a Research Tool for Birds - From data collection to analysis. Paul Howden-Leach (paulhl@wildlifeacoustics.com)

An interactive/hands on workshop focusing looking at bioacoustics as a research tool for the study of birds. The workshop will look at the potential of bioacoustics in general followed by a walk through of some of the audio recorders, covering specific elements such as potential deployment options to fit in with a variety of standard and non standard protocols. Case studies will be used and attendees own specific deployment needs will be addressed to design the most appropriate schedule for their potential study. Following on from this the workshop will focus on data analysis using Kaleidoscope Lite and Kaleidoscope Pro. This element of the workshop will focus on signal extraction, rapid data analysis, auto identification and building species classifiers. Attendees are encouraged to bring their own laptops to play along with the session. Data and full training licences will be provided for the session. No previous experience in bioacoustics is needed.

Offshore windfarm development : scientific issues and tools to assess the risk for seabirds. Emeline Pettex (emeline.pettex@univ-lr.fr)

The climate crisis requires a radical reduction of fossil energy reliance and a rapid shift to renewable energy sources. The European Union's strategy to decarbonise energy relies largely on development of offshore windfarms, which are expected to produce 20 times their current capacity by 2050. The expansion of offshore windfarms across Europe raises conservation issues due to potential negative effects on marine fauna. Seabirds are at risk of colliding with blades and being blocked or displaced from functional areas for foraging or migration, which means increased energy expenditure to find alternative areas. To reduce these impacts on seabirds, we need to identify lowest risk areas and prevent the installation of offshore windfarms within hotspots or preferred habitats. During this discussion-based workshop, attendees will focus on several topics, that should be addressed to assess the effects of windfarms and to inform marine spatial planning (sensivity maps); species sensitivity factors such as flight height; attraction/repulsion (light, roosting sites); changes in seabird distribution; knowledge gaps, etc. Attendees are invited to propose additional topics, bring their questions or their own expertise to foster the discussion.

Avian influenza outbreak

Early Carreer Researcher Event-Monday 22nd August

Poster reception

Our poster reception, generously sponsored by Lotek will take place in the Hub Atrium from 17:30 on Tuesday 23rd.

Conference party

On the evening of Wednesday 24th,, our conference party will be held in Bodega (Corn Market Street). Tickets for the dinner must have been purchased in advance during your registration. We hope you look forward to joinung us for dinner, a drink and music supplied by Torcan !

Prices

Best talk and poster will be award Thursday 25th thanks the generous participation of PR Statistics and Eco-Explore.

Social Media

We encourage you to tweet thoughts, experience, photos, questions and selfies over the week using the #Corkseabirds

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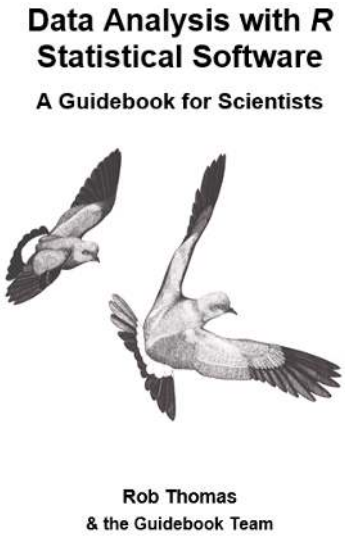

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Name	Duration
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Data Analysis for Bat researchers	3 days
Data Visualisation	1 day

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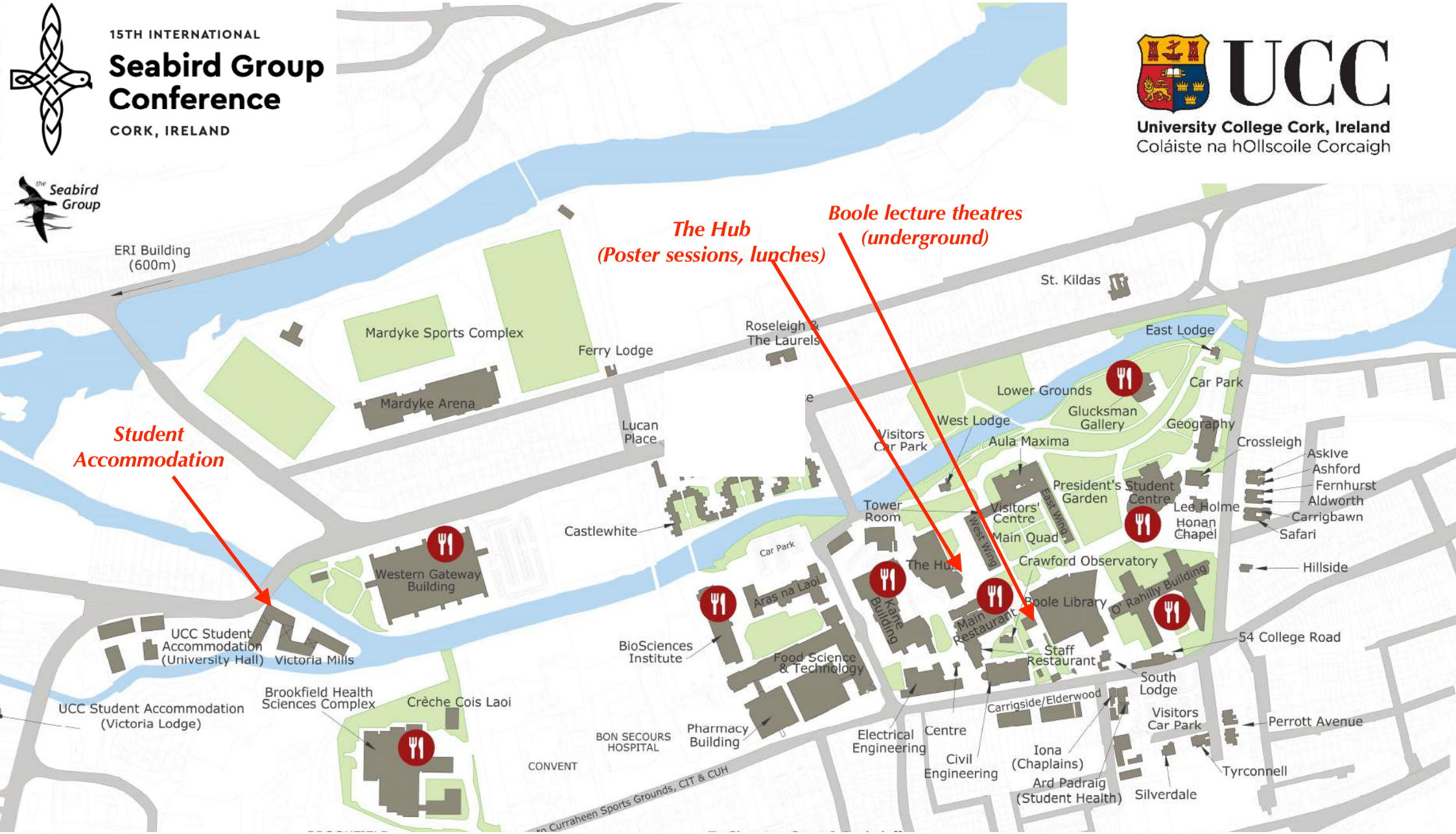

Monday 22nd August 2022

12:00		Regstration open
14:00 - 18:00	ECR Event	
14:00 - 18:00	Workshop(s)	
18:00 - 18:40	**Welcome Addess: 50 Years of seabird monitoring on the Isle of May**	

Tuesday 23rd August

08:30		Registration
09:00 - 10:00	**Prof Emily Shepard**	**Plenary: From take-off to touch down: How and when do strong winds become risky for seabirds?**
10:00 - 10:45		**Session: Biologging**
10:00 - 10:15	Natasha Gillies	Are foraging movements in wandering albatrosses consistent with infrasonic sensitivity?
10:15 - 10:30	Ashley Bennison	Handedness in northern gannets: Lateralised dive behaviour during foraging
10:30 - 10:45	Sarah Saldanha	The use of auxiliary sensors to improve the behavioural classification of hidden Markov models for the study of the foraging ecology of red-billed tropicbirds
10:45 - 11:15		**-BREAK-**
11:15 - 12:45		**Session: Fisheries**
11:15 - 11:30	Signe Christensen-Dalsgaard	Bycatch in the purse seine fishery: from beachcast to identified cause
11:30 - 11:45	Jorge Pereira	How well is the Portuguese coast protecting seabirds?
11:45 - 12:00	Mathilde Huon	Estimating the part of fishery discards consumed by scavenging seabirds in the Bay of Biscay
12:00 - 12:15	Antonio Vulcano	Seabird bycatch in European fisheries: a review
12:15 - 12:30	Vitor Paiva	Conservation implications of seasonal and inter-annual seabird-fisheries interactions within the Cabo Verde archipelago
12:30 - 12:45	Ana Carneiro	Fine-scale interactions of wandering albatrosses and fishing vessels in the southwest Atlantic Ocean
12:45 - 13:45		**-LUNCH-**
13:45 - 14:45		**Session: Renewables**
13:45 - 14:00	Lila Buckingham	An novel vulnerability assessment of non-breeding season displacement impacts of offshore wind farms on common guillemots and razorbills
14:00 - 14:15	Rob van Bemmelen	Macro-avoidance behaviour of offshore wind farms by Sandwich Terns
14:15 - 14:30	Jude Lane	Gannet avoidance rates; using tracking data to reduce error and uncertainty during the breeding season
14:30 - 14:37	Zoe Deakin	**Short**: Tracking of Leach's and European Storm-petrels reveals foraging areas and spatial overlap with protected areas and future wind farm development
14:37 - 14:45	Alexandra Dodds	**Short**: Introduction to LiDAR for accurate and precise measurement of bird flight heights
14:45 - 15:30		**Part of the flock? Creating a sense of belonging in Marine Ornithology**
15:30 - 16:00		**-BREAK-**
16:00 - 17:30		**Session: Monitoring**
16:00 - 16:15	Kendrew Colhoun	Utility of conservation detection dogs for monitoring breeding seabirds
16:15 - 16:30	Ghislain Dorémus	Variations in seabird abundance and distribution in the Bay of Biscay and the English Channel
16:30 - 16:45	Tom Hart	Timelapse camera derived measures of phenology and reproductive success in seabird research
16:45 - 1700	Manon Clairbaux	Decolonizing arctic science? Involving local communities will reinforce ecologically sound, pan-arctic seabird monitoring
17:00 - 17:15	Alice Edney	Latitudinal and climatic effects on the breeding phenology of a declining seabird
17:15 - 17:30	Bernard Cadiou	Fifty years of investigations on European storm petrel *Hydrobates pelagicus* in colonies of Molène archipelago (Brittany, France)
17:30 - 20:00	**POSTER SESSION**	

Wednesday 24th August

08:30		Registration
09:00 - 10:00	**Dr Alex Bond**	**Plenary: From individuals to communities: plastic pollution, queerness, and compassion in seabird science**
10:00 - 10:45		**Session: Pollution and toxicology**
10:00 - 10:15	Céline Albert	Tell me where you overwinter, I will tell you what toxicological risks you might face
10:15 - 10:30	Bethany Clark	Global assessment of marine plastic exposure for petrels
10:30 - 10:45	Yvan Satgé	A tale of two petrels: Recent advances in the ecological study of the endangered Diablotin Black-capped Petrel

10:45 - 11:15		**-BREAK-**
11:15 - 12:45		**Session: Foraging ecology**
11:15 - 11:30	Eleanor Maedhbh Honan	Foraging distribution and habitat use of chick-rearing snow petrels from two colonies in Dronning Maud Land, Antarctica
11:30 - 11:45	Sam Cox	Evidence of the use of memory, social information and wind by seabirds foraging across a tropical island ecosystem of the Atlantic Ocean
11:45 - 12:00	Elizabeth Pearmain	Effects of age and status on foraging behaviour of wandering albatrosses
12:00 - 12:15	Jamie Darby	Underwater visibility impacts the foraging behaviour of a diving seabird
12:15 - 12:30	Fernando Medrano	Intrinsic and extrinsic drivers of foraging movement of the White-faced Storm-Petrel in the Atlantic tropics
12:30 - 12:45	Chris Pollock	Deciphering the mechanisms driving individual foraging site fidelity in gannets with movement simulations
12:45 - 13:45		**-LUNCH-**
13:45 - 15:30		**Session: Urbanisation, Invasives and Restoration**
13:45 - 14:00	Amandine Gamble	Are introduced rodents involved in disease outbreaks threatening subantarctic seabirds?
14:00 - 14:15	Paola Forni	Response of long-tailed duck (*Clangula hyemalis*) to the change in the main prey availability in its wintering ground in the Baltic Sea
14:15 - 14:30	Ruth Dunn	Implications of habitat restoration for tropical seabirds and coral reef ecology
14:30 - 14:45	Juliet Lamb	Rapid loss of maternal immunity and increase in environmentally mediated pathogen exposure in urban gull nestlings
14:45 - 15:00	Katherine Booth Jones	Tussles for mussels? Abundance, distribution, and disturbance of Ireland's largest Eider aggregation
15:00 - 15:15	Tara Adcock	Terns nesting in Dublin Port between 1995 and 2021: responses to nesting structure availability in a dynamic industrial setting
15:15 - 15:30	Ana Norte	Are urban habitats an opportunity or a challenge to breeding yellow-legged gulls (*Larus michahellis*)?
15:30 - 16:00		**-BREAK-**
16:00 - 17:30		**Session: Demography and climate**
16:00 - 16:15	Ignacio Juarez-Martinez	Differential responses of phenology to climate change in sympatric seabird species
16:15 - 16:30	Anne Ausems	Where have all the petrels gone? 40 years of environmental change and population dynamics of Wilson's Storm-petrels
16:30 - 16:45	Morten Frederiksen	A model-based indicator of breeding productivity of European seabirds
16:45 - 17:00	Hannah Hereward	Declines in the breeding success of two sibling species of storm-petrel in the Azores over the past two decades.
17:00 - 17:15	Marianne Gousy-Leblanc	Should I stay or should I go? The cost of divorce in the thick-billed murre
17:15 - 17:22	Kate Layton-Matthews	**Short:** Contrasting pre-breeding conditions affect condition-dependent reproduction and population dynamics in Atlantic puffins
17:22 - 17:30	Samuel Langlois	**Short:** Quantifying the impacts of predation by Great Black-backed Gulls on an Atlantic Puffin population using Population Viability Analysis
19:00 - Late		**CONFERENCE DINNER - BODEGA**

Thursday 25th August

08:30		Registration
09:00 - 10:00	**Dr Annette Fayet**	**Plenary: Drivers of seabird movements and their fitness consequences**
10:00 - 10:45		**Session: Multi-colony studies**
10:00 - 10:15	Hallvard Strøm	Large-scale tracking of seabirds in the North Atlantic – SEATRACK
10:15 - 10:30	Benjamin Merkel	Importance of the Barents Sea for North Atlantic seabirds
10:30 - 10:45	Victoria Warwick-Evans	Spatial Segregation of Seabirds at South Georgia
10:45 - 11:15		**-BREAK-**
11:15 - 13:00		**Session: Movement and behaviour**
11:15 - 11:30	Kirsty Franklin	Drivers of ocean movement patterns in the Round Island petrel
11:30 - 11:45	Nina Dehnhard	Habitat predictability of European shags based on multi-year and multi-colony tracking
11:45 - 12:00	Sophie Bennett	Drivers and fitness consequences of the occupancy of breeding sites in the non-breeding season in common guillemots *Uria aalge*
12:00 - 12:15	Jack Thorley	Does personality mediate the reproductive consequences of broad climate phenomena?
12:15 - 12:30	Patrick Lewin	Balearic shearwaters use spatial cognition to facilitate range shift under climate change
12:30 - 12:45	Marion Devogel	Is vocal communication a key to coordinated parental care in a monogamous seabird, the Little Auk (*Alle alle*)?
12:45 - 13:00	Lewis Fisher-Reeves	The use of visual landmarks during homing in a critically endangered shearwater.
13:00 - 14:00		**-LUNCH-**
14:00 - 14:30		**Prizes and closing**

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Oral Abstracts

PLENARY I

From take-off to touch down: How and when do strong winds become risky for seabirds?

Prof. Emily Shepard
Swansea University

Tuesday 23rd August-09:00-10:00

At sea, wind has a profound effect on flight energetics, working with or against birds depending on their flight style and heading. Wind can also be associated with risk, including the risk of being drifted away from the goal destination and the risk of injury and mortality. In this talk I will consider when and how wind becomes risky, first taking the movements of pelagic seabirds at sea, using 11 years of tracking data from streaked Shearwaters foraging in the sea of Japan. We isolated data from 75 birds that foraged during either severe tropical storms or cyclones, which revealed flexibility in their responses to storm systems, depending on their location and the wind speeds they experienced. Remarkably, birds flew towards the eye of the storm in certain circumstances, even flying within the eye wall, where wind speeds are projected to be strongest. I will discuss what this strategy tells us about the risks associated with extreme winds, before finally considering the influence of wind on what is perhaps the most risky part of a birds daily flight routine: The landing. While landings may only amount to a few seconds of each day, the risks of injury mean that they have the potential to impact fitness and even population level processes.

BirdLife International Marine Programme

Halting seabird population declines requires action on a global scale. The **BirdLife International Marine Programme** was created to improve the conservation status of threatened seabirds by implementing grass roots practical solutions and using scientific evidence to positively influence international policy. This is only possible through collaboration with governments, the fishing industry, NGOs and communities around the world.

The Seabird Tracking Database

We host the **largest collection of seabird spatial data** through the creation of the Seabird Tracking Database, which underpins so much of our science. This powerful conservation tool contains over 1,000 datasets for **over 150 species totalling over 25 million data points** that have been contributed by more than 250 data owners. Anyone can upload data and request access to datasets, and data owners decide whether to accept or decline each request. Check it out at www.seabirdtracking.org

Identify and protect globally important areas for seabirds

We work with local partners to identify and prioritise **marine Important Bird and Biodiversity Areas** (IBAs) and **Key Biodiversity Areas** (KBAs), contributing to the largest network of sites of significance for biodiversity. BirdLife has led the development of methods for delineation based on seabird tracking data.

Influence fisheries management through the supply chain

We are increasingly working with the **seafood supply chain** to drive improvements in fisheries management – primarily through sustainability certification and with retailers to identify products sourced from fisheries with a high risk of bycatch. This work provides a strong complement to the grassroots engagement we do with industry and high-level policy work with governments.

Halt seabird bycatch in fisheries

We've demonstrated simple solutions are highly effective, with significant reductions in seabird bycatch in the South African and Namibian hake fisheries through our **Albatross Task Force**. We are extending this work into Europe and Central Asia and West Africa where we are investigating the scale of bycatch. In **international waters** we are working via engagement at tuna Regional Fisheries Management Organisations (RFMOs) to ensure regulations are now implemented and monitored effectively.

We lead **innovative research** to identify and trial solutions to reduce seabird bycatch in **gillnet and purse seine fisheries.** These fisheries are often small-scale and effective mitigation measures to reduce bycatch are proving difficult to develop, but our experience places us ahead of the game to tackle these challenges.

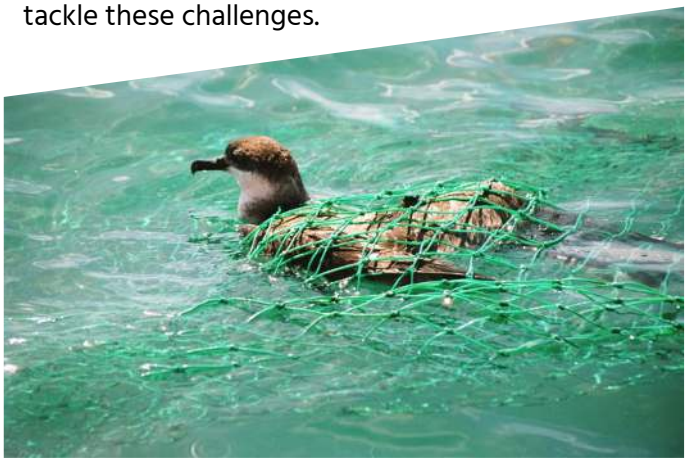

Photo credit
Top left: Light-mantled albatross @ Oli Prince
Bottom right: Great shearwater @ Leo Tamini

Twitter @BirdLifeMarine / @AlbyTaskForce
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SESSION: BIOLOGGING

Are foraging movements in wandering albatrosses consistent with infrasonic sensitivity?

Natasha Gillies*; Lucía Martina Martín López; Olivier den Ouden; Jelle Assink; Mathieu Basille; Tommy Clay; Susana Clusella-Trullas; Rocio Joo; Henri Weimerskirch; Samantha C. Patrick
**School of Environmental Sciences, University of Liverpool, Liverpool, United Kingdom*

For seabirds, the ability to predict and respond to changes in environmental conditions is essential both to locate valuable food resources and to optimise flight efficiency. It remains unclear what sensory cues underlie these movement decisions, especially over large spatial scales. Infrasound, a form of low frequency sound (<20Hz) that propagates over thousands of kilometres, may form such a cue. Infrasound is generated by topographic and weather-related features that, despite being posited as a potential sensory cue in birds as early as the 70s, has been identified in very few species and no seabirds. As infrasound propagates over extremely large ranges, the infrasonic landscape may provide reliable and useful cues for ocean-wide movement. Microbarom infrasound, generated by non-linear ocean wave interactions, is one of the most dominant sources within the marine environment and is associated with ocean storms. While many species may act to avoid these fronts, strong winds may improve flight conditions for some, such as albatrosses, which may therefore exhibit preferential movement towards areas of increased microbarom infrasound. We tested this hypothesis using high-resolution GPS tracks of wandering albatrosses (*Diomedea exulans*), in combination with microbarom infrasound maps (between 0.05-1Hz) modelled using ECMWF data at an hourly resolution and verified using in-situ data collected from INFRA-EAR biologgers. We collected data from 89 albatrosses breeding on Crozet Island, from which we obtained 101 individual foraging trips. We used conditional logistic regression models to investigate whether the movement trajectories of albatrosses during periods of commuting flight were preferentially orientated towards areas of higher microbarom infrasound. We present preliminary evidence that albatrosses select areas of higher infrasound, consistent with sensitivity to this frequency range. To our knowledge, this is the first attempt to explicitly explore infrasound sensitivity in a free-ranging bird.

Handedness in northern gannets: Lateralised dive behaviour during foraging

Ashley Bennison*; Bethany Clark, Stephen C. Votier, John L. Quinn, Jamie Darby, Mark Jessopp
**MaREI, Centre for Marine & Renewable Energy, Environmental Research Institute, University College Cork, Cork, Ireland & School of Biological, Earth and Environmental Sciences (BEES), University College Cork, Cork, Ireland*

Many vertebrates show lateralised behaviour, or handedness, where an individual preferentially uses one side of the body more than the other. This behaviour is caused by brain lateralisation and functional specialisation of, among other things, sight, locomotion, and decision-making. Here, we deploy accelerometers on northern gannets, *Morus bassanus*, to test for behavioural lateralisation during plunge dives. Accelerometry-defined dives for individuals from Great Saltee and Grassholm (n = 51). When plunge diving, gannets 'roll' to one side, and we found 94% of individuals passed criteria to be considered lateralised; they consistently rolled to one direction more than the other. Furthermore, lateralisation was highly repeatable at the population level ($R = 0.893$, $p<0.001$). There was no population-level bias, with 51% of individuals being left-sided (n=26), 43% right-sided (n=22) and 6% ambidextrous (n=3). Power analysis could not determine if this population structure was indicative of the wider population. Wind speed and offset also influenced the magnitude of the roll angle (n=14), presumably to aid stability in high winds, but did not affect lateralisation. Lateralisation in wild animals is still poorly studied and this is the first demonstration in a foraging seabird during prey capture. The causes and consequences of foraging lateralisation are unknown, but it is likely this emerging topic will influence future seabird research.

The use of auxiliary sensors to improve the behavioural classification of hidden Markov models for the study of the foraging ecology of red-billed tropicbirds

Sarah Saldanha*; Sam L. Cox; Teresa Militão; Jacob González-Solís
**Institut de Recerca de la Biodiversitat (IRBio) & Dept Biologia Evolutiva, Ecologia i Ciències Ambientals, Universitat de Barcelona, Av Diagonal 643, Barcelona 08028, Spain*

Knowledge of where and when seabirds feed is crucial for both understanding their basic biology, and effective marine conservation management. To accomplish this, researchers are increasingly using state-space models such as hidden Markov models (HMMs) to classify bird positions into behavioural states. Typically, models infer when birds rest, forage, or travel, using the speed and turning angles of successive GPS positions. However, the accuracy of behavioral classifications is rarely measured, and may be affected by seabird foraging strategies. While these models appear to efficiently classify the behaviors of species with discrete foraging areas (i.e. those which travel to exploit fronts or upwelling systems), classifications may be more erroneous for species who forage 'on the go' in more homogenous environments such as tropicbirds. Here we use wet-dry data from 31 geolocators, activity measurements from 20 accelerometers, and dive events from 20 time depth recorders (TDR) to improve the classification of HMMs of a larger GPS tracking dataset (427 deployments) of red-billed tropicbirds (*Phaethon aethereus*). By classifying certain positions as either resting or foraging using the auxiliary sensors, we semi-supervised the HMMS and evaluated the increase in overall accuracy and the sensitivity (true positive rate) and specificity (true negative rate) of foraging with the inclusion of an increasing proportion of positions with known behaviours. We demonstrate that even with a small wet-dry, accelerometer or TDR sub-dataset, we can significantly improve the behavioral classification of these models, increasing overall accuracy from 0.75±0.11 to 0.86±0.07, and the sensitivity and specificity of detecting foraging from 0.24±0.13 to 0.50±0.30 and from 0.94 ±0.02 to 0.96 ± 0.00, respectively. This study demonstrates that caution should be taken when using state space models to interpret behaviour from GPS tracking data and that the use of a small subset of auxiliary data can both validate and improve behavioural classifications.

SESSION: FISHERIES

Bycatch in the purse seine fishery: from beachcast to identified cause

Signe Christensen-Dalsgaard*; Bjørnar Ytrehus; Magdalene Langset; Jørgen R. Wiig; Kim Magnus Bærum
**Norwegian Institute for Nature Research*

Beachcast events where a large number of seabird carcases drift ashore, occur with irregular intervals. These events are due to specific situations where mass mortality of seabirds have occurred. Disentangling the cause of these events can provide valuable information on stressors that may have an impact on seabird populations.
In this study, we used a trans-disciplinary applied approach to elucidate the etiology of multiple beachcast events involving large numbers of seabirds in Northern Norway from 2015 to 2020. The study reflects the dynamic process of understanding the underlying cause of the beachcast events observed, from having no clear hypothesis of what could have led to the first episode, to progressively identifying bycatch in the purse seine fishery as the primary hypothesis to test. We based our investigation on a synthesis of citizen science observations, necropsies and monitoring of bycatch in the purse seine fishery carried out in the area. Based on these data we conclude that bycatch in purse seine fishery most probably was the cause of the mortality events.
During the study period, monitoring of the purse seine fishery was initiated. Most fishing events resulted in zero bycatch, but the few bycatch events registered involved a large number of gulls that drowned within the gear. These findings are consistent with the hypothesis that the mortality events were caused by bycatch in the purse seine fishery. The highly episodic and unpredictable nature of these events makes it demanding to achieve solid estimates of the occurrence and extent of bycatch

without a very high monitoring effort. Our study shows that systematic investigation following beachcast events can shed light on the occurrence of such extreme events. Further investigations are needed to get inference on how the likelihood changes according to different variables and how preventive measurements and awareness can mitigate the problem.

How well is the Portuguese coast protecting seabirds?

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Marine Protected Areas (MPAs) have been established across all marine environments, but their effectiveness as conservation tools is still under scrutiny. Here, we used 8-years of at-sea censuses and generated habitat suitability maps for 30 breeding and non-breeding seabird species occurring in the Portuguese coast. These maps were used to identify important areas for seabirds and to evaluate the potential influence of human pressures. We identified three areas important for seabirds along the Portuguese coast: One area for breeders in Central Portugal near the archipelago of Berlengas; and two for non- breeders in the Northern and Southern coast of Portugal. The official MPAs established along the Portuguese coast protect near 65% of the area that was identified for breeding species, but the same MPAs protect less than 4% of those areas we identified for non-breeding species. Moreover, while the area identified in the Northern coast is likely to be affected by oil pollution from the refineries and the intensive ship traffic, the area identified in the Southern coast of Portugal overlaps extensively with areas of high fishing activity. In the latter area, at-sea surveys revealed that fixed bottom nets had the highest seabird-fishery interactions, and the most abundant species were Yellow-legged and Lesser black-backed gull (27.6%), Northern gannet (23.2%) and Cory's shearwater (13.4%). Yellow-legged and Lesser black-backed gulls that interacted with fishing boats were mainly adults, while Northern gannets were mainly immatures. Moreover, seabird-fishery interactions were positively correlated with fishery catches and were more frequent during hauling operations. Fisherman interviews showed that Northern gannet was the most bycaught species (n= 29), followed by European shag (n= 16) and Yellow-legged or Lesser black-backed gull (n= 15). This study provided an effective methodology for designing management strategies in coastal areas and the highlight the importance of monitoring the conservation effectiveness of MPAs.

Estimating the part of fishery discards consumed by scavenging seabirds in the Bay of Biscay

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**UAR 3462 Observatoire Pelagis – La Rochelle Université*

The impact of fishery discards on seabird ecology has been of significant interest to the scientific community for years, particularly since the introduction of the landing obligation. While some studies estimated the quantity of discards consumed by seabirds based on bioenergetic models, few focused on the scale of the discard event, thus omitting some foraging behaviour parameters of scavenging seabirds. We used a consumption model to determine the part of discards consumed by scavenging seabirds during each discard event in the Bay of Biscay (BoB). The BoB is an area of particular interest to understand the impact of fishery discards on seabird ecology, as it is a major fishing zone as well as a major wintering area for seabirds in Europe. Parameters of the seabirds' foraging behaviour were observed on scientific trawling operations over the BoB continental shelf, to be then combined with data on the composition of discards and the flock of scavenging seabirds. We focused on the main scavenging species in this area, the northern gannet and large gulls, in spring and autumn between 2014 and 2018. All species showed a preference for round fish smaller than 30 cm. On average, individuals of all species ingested two discarded fishes with a 90 % catch success rate. Overall years, scavenging seabirds consumed on average less than 2% of discards per event in spring and less than 5% in autumn. Our results shed new light upon scavenging seabirds' ecology in the BoB, where little information exists despite a strong fishing pressure. Our method could be

replicated to determine the proportion of discards consumed by scavenging seabirds on other metiers, with parameters' calibration of the consumption model that were estimated for trawlers.

Seabird bycatch in European fisheries: a review

Iván Ramírez; **Antonio Vulcano***; Yann Rouxel; Dominik Marchowski; Ana Almeida; José Manuel Arcos; Veronica Cortés Serra; Gesine Lange; Julius Morkūnas; Nuno Oliveira; Vitor H. Paiva; Daniel Mitchell
**BirdLife International, United Kingdom*

Several studies highlighted seabird bycatch as a top threat to European seabirds; here, we present the first review of seabird bycatch data covering all fishing gears of currently active fisheries in Europe, aiming at providing an actualized number of seabirds bycaught per year in European waters, compiling country level bycatch assessments and identifying blackspots of seabird bycatch in Europe. We calculated bycatch at country level by summing estimates from non-overlapping studies, or by taking the more accurate ones, and we extrapolated estimates where reported bycatch data was sufficient. To assess reliability of seabird bycatch we used a scoring system based on: a) Age of the data b) Coverage of fishing effort c) Data collection method. Overall, approximately 190.000 seabirds (ranging from 130.000 to 378.000) are bycaught in European waters annually (over 146.000 alone in European Union waters). The great majority of the birds are bycaught in Northeast Atlantic and in the Baltic Sea. Gillnets are estimated to catch more seabirds/year than any other gear, followed by longlines. Based on the available information, the countries with the highest estimates of annual seabird bycatch are France, Poland, Portugal, Iceland, Spain, Sweden, Germany and Norway. The seabird families most affected are: Anatidae, Alcidae and Procellaridae, being the most affected species Common Murre, Northern Fulmar, Northern Gannet and Long-tailed Duck; the most threatened seabird affected is the Critically Endangered Balearic shearwater. Those numbers and rates are likely to be an underestimation of the issue (due to the lack of dedicated and reliable seabird bycatch monitoring programmes across the region, and the very limited data available), as significant data gaps remain and need to be addressed, mainly in the Mediterranean, Black Sea, Gulf of Riga and Gran Sol. The Gran Sol Fishery is estimated to catch more than 36.000 birds/year, which makes it the largest hotspot in Europe attributed to a single fishery. Combining systematic data collection and implementation of mitigation measures will be crucial to fill in knowledge gaps and tackle the issue of bycatch at regional level.

Conservation implications of seasonal and inter-annual seabird-fisheries interactions within the Cabo Verde archipelago

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Areas regularly exploited by marine top predators (e.g. seabirds) represent critical 'hotspots' of biodiversity which are often exploited by fisheries, leading to potential competition between predators and fisheries. Fisheries can supply super-abundant subsidies to some seabird species, through discards, but also may pose a direct threat when individuals perish by-caught in fishing gears. Yet, the effects of by-catch vary dramatically across species, geographical areas and fishing methods. The use of marine predators as sentinels of the oceans' health and indicators of impacts of Human stressors in the ocean is less studied in tropical regions when compared to temperate or polar systems. We tracked with GPS-loggers *Calonectris edwardsii* (n = 326 individuals), *Bulweria bulwerii* (n = 205), *Puffinus boydi* (n = 79), *Phaethon aethereus* (n = 350), *Sula leucogaster* (n = 113), *Sula sula* (n = 25), *Hydrobates jabejabe* (n=50), *Pterodroma feae* (n=23) and *Pelagodroma marina* (n=15) from 12 breeding sites, between 2017 – 2022. Contemporaneously, we deployed GPS-loggers (n = 189 vessels) and GPS-GSM transmitters (n = 10) on artisanal and semi-industrial fishing boats, respectively, from all Cabo Verde islands, to investigate seabird-fisheries spatio-temporal overlap

within the Cabo Verde archipelago. We also investigated the environmental drivers (e.g. SST) of those interactions. In general, seabird-fisheries interactions (i.e. their coexistence in less than 1 km) occurred mostly during summer (June-October) and at dawn and dusk, when compared to other seasons and day periods. Brown boobies and Cape Verde shearwaters overlapped the most (50% and 40% overlap, respectively) and Bulwer's petrels the least (15%) with artisanal fisheries. Through identifying the environmental drivers and hotspots of seabird-fisheries interactions, we envisage to help mitigate possible situations of seabird by-catch and provide crucial information for the coming process of marine protected areas designation within the Cabo Verde archipelago.

Fine-scale interactions of wandering albatrosses and fishing vessels in the southwest Atlantic Ocean

Ana P.B. Carneiro*; Bethany L. Clark; Elizabeth J. Pearmain; Richard A. Phillips
**BirdLife International*

The wandering albatrosses breeding at South Georgia are listed as a Priority Population by the Agreement on the Conservation of Albatrosses and Petrels. The main cause of decline is bycatch by fishing vessels outside local waters. Estimates of spatio-temporal overlap are an important tool for identifying areas and periods where birds are most at risk. However, current estimates are only available at relatively coarse scales using aggregated data on fishing effort. Here, we combine loggers that record the GPS position of birds at sea and scan the surroundings to detect radar transmissions from vessels, along with the positions of fishing vessels obtained from the automatic identification system, to identify bycatch hotspots and the nations fishing in those areas for wandering albatrosses of different life-history stages. We recorded a total of 157 foraging trips for adult breeders, and 94 tracks for sabbatical adults, immatures and juveniles during the breeding season. Of the 251 tracks recorded, 54.6% encountered and 42.6% attended fishing vessels (i.e. were within 30km and 5 km, respectively). Fishing vessels were of diverse gear types, and from multiple flag states. Overlap was particularly high for breeding adults during incubation and post-guard chick-rearing when birds travelled to the Patagonian Shelf break. Previous studies at coarser scales have shown that wandering albatrosses from South Georgia overlapped particularly with Taiwanese and Japanese pelagic longline vessels. However, our study found the greatest overlap was with demersal longline vessels, particularly the Korean fleet. The presence of demersal longline vessels had a positive effect on the transition probability from encounter at 30 km to attendance at 5 km. This study highlights the importance of using other approaches and fine-scale analysis to improve risk-assessments, and also points towards the need for engagement in appropriate fora with Korean fisheries managers, operators and crew.

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SESSION: RENEWABLES

A novel vulnerability assessment of non-breeding season displacement impacts of offshore wind farms on common guillemots and razorbills

Lila Buckingham*; Jonathan A. Green; Maria I. Bogdanova; Bob Furness; Francis Daunt
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The non-breeding season is a key period of the year for most seabirds, since environmental conditions are typically more severe, increasing their vulnerability to anthropogenic threats. A current priority is apportioning the impacts of offshore wind farms (OWFs) during this period to protected breeding colonies. Apportioning in the non-breeding season has only been considered in environmental assessments using relatively crude methods, which impedes sustainable development of renewable energy. We assessed potential impacts of OWFs apportioned to multiple colonies of two seabird species: common guillemot *Uria aalge* and razorbill *Alca torda*. We estimated colony-level vulnerability during the non-breeding season by integrating exposure (potential for interaction with developments) and severity (potential impact of a novel energetic challenge) to OWFs.
We tracked 413 guillemots and 131 razorbills from twelve UK colonies over three years using geolocator-immersion devices. To measure exposure, we calculated core monthly distributions and spatial overlap with OWFs for each species from each breeding colony. To quantify severity, we used behavioural activity budgets (calibrated using a sample of 41 dual-deployed time-depth recorders and geolocators) to calculate mean monthly energy expenditure for each species at each colony. Measures of exposure and severity were then combined to estimate monthly vulnerability for each breeding colony and species.
Guillemots breeding along the east coast of Scotland and razorbills from all colonies had higher exposure to OWFs than guillemots from northern and western colonies. Energy expenditure varied throughout the non-breeding season, but was highest in late February for both species from all colonies, indicating increased severity during late winter. Vulnerability to OWF developments was therefore greatest for east coast guillemot and all razorbill colonies during late winter. These findings provide new insights into colony-level risk to guillemots and razorbills during the non-breeding season, which will be of direct use for future assessments of OWF impacts.

Macro-avoidance behaviour of offshore wind farms by Sandwich Terns

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Many seabirds avoid entering Offshore Wind Farms (OWFs), effectively leading to habitat loss. Hence, assessing the magnitude of this 'macro-avoidance' behaviour is important when assessing the potential impact of OWFs on seabirds. However, robust estimates of avoidance rates are lacking for many species. We estimated macro-avoidance rates of OWFs by Sandwich Terns *Thalasseus sandvicensis* breeding in two colonies (Scolt Head, United Kingdom, and De Putten, the Netherlands) using integrated Step-Selection Functions (iSSFs) and GPS-tracking data. Multiple OWFs are within the foraging ranges of each colony. iSSFs included habitat characteristics (land, water depth and sediment grain size) and movement characteristics and indicated macro-avoidance rates of 5-22%. We also show that Sandwich Terns started to avoid directions towards OWFs already at several kilometers from the OWF, whereas they generally did not avoid the area directly surrounding OWFs. These results imply that Sandwich Terns experience habitat loss when OWFs are constructed within their foraging ranges.

Gannet avoidance rates; using tracking data to reduce error and uncertainty during the breeding season

Jude V. Lane*; Keith C. Hamer; Aly McCluskie
**Centre for Conservation Science, RSPB, UK*

The increasing demand for energy generated from renewable sources is driving unprecedented expansion of offshore wind farms (OWF) around the globe. One potential major impact on seabirds from OWFs is additional mortality through collision with turbines. Collision risk models (CRM) are used to predict the number of collisions that could be expected in the absence of reactive behaviour and are at the heart of development consenting decisions. Avoidance rates are a key component of CRMs and have a large influence on the number of predicted collisions. However, there are large uncertainties in estimating avoidance rates some of which arise from misspecification of input parameters such as flight height and flight speed.
Northern gannets have been identified as one of the species potentially at greatest risk from collision with offshore wind turbines, yet a lack of suitable data means that the current recommended avoidance rate for gannets may not be applicable during the breeding season. Therefore, there is a clear need to develop an avoidance rate for breeding gannets, to reduce uncertainty in collision risk estimates.
Avoidance rates are sensitive to both bird flight speed and flight height which are themselves influenced by a wide range of variables including behaviour, sex, age, and weather. This means that models using a single generic value for height and speed incorporate errors associated with variability and uncertainty.
We present data from GPS and pressure loggers deployed on gannets at the world's largest colony, the Bass Rock, Scotland between 2015 and 2021, to examine the influence of behaviour, sex, wind speed and direction, on flight height and speed within the footprints of OWF sites closest to the colony. We will discuss how this data could be used to improve our avoidance rate estimate for gannets during the breeding season.

Tracking of Leach's and European Storm-petrels from Scotland reveals foraging areas and spatial overlap with protected areas and future wind farm development

Mark Bolton; **Zoe Deakin***; Connie Tremlett; Saskia Wischnewski; Derren Fox; Anna Kebke; Tom Evans
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Information on marine distribution and behaviour of seabirds is crucial for understanding impacts from marine activities. Limited information is currently available on the marine distribution and behaviour of Leach's Storm-petrel *Hydrobates leucorhous* and European Storm-petrel (*H. pelagicus*), especially for West Scotland where large colonies are located. In 2021 we tracked breeding Leach's Storm-petrels from St Kilda, the largest UK colony, and European Storm-petrels from the Treshnish Isles. We found no evidence of impacts of tag deployment on trip duration (Leach's Storm-petrel) or daily nest survival rates (European Storm-petrel). Leach's Storm-petrels foraged over deep (> 1,000m) water beyond the continental shelf, whereas European Storm-petrels remained in shelf waters. During incubation, Leach's Storm-petrels' trips lasted 2-3 days, and ranged (maximum distance) on average 301 ± 60 (SD) km (n=11) from the colony, covering a total distance of 1011 ± 247 km. The small number of trips obtained during chick rearing (n=4) indicated a slightly shorter time at sea (2 days), and on average birds ranged up to 260 ± 32 km, travelling a total of 807 ± 62 km. Birds foraged extensively in protected areas designated for other marine taxa. For European Storm-petrels, trip duration, range and total distance covered differed across breeding stages, with longer trips during incubation (59 ± 26 hours, n=6) than the brooding (24 ± 2 hours, n=8) or post-brood (27 ± 10 hours, n=12) stages. The maximum distance from the colony was higher during incubation (142 ± 36 km) than the brooding (95 ± 29 km) and post-brood (89 ± 23 km) stages and the total distance travelled was higher during the incubation stage (554 ± 235 km) than during brooding (278 ± 57 km) or the post-brood stage (309 ± 103 km). Seven of 19 tracked birds used waters leased for wind farm development.

Introduction to LiDAR for accurate and precise measurement of bird flight heights

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**Apem Ltd Riverview, A17 The Embankment Business Park, Heaton Mersey, Stockport, Heaton Mersey, Stockport SK4 3GN*

A key mortality factor for avian species caused by offshore windfarm (OWF) developments is collision risk. Accurate and precise avian flight height data is required for input to collision risk models which inform mitigation, such as air-draft uplifts, and engineering design changes within the OWF development's Environmental Impact Assessment (EIA). Flight heights have been previously estimated using literature, boat-based surveys, or sized-based calculations from digital aerial still imagery, although these traditional methods can result in human error and bias within calculations. APEM are proposing to collect avian flight heights using the first species and site-specific measurement methodology using LiDAR technology.
LiDAR is an accurate survey method that measures distances using light. APEM has designed a custom-built system that concurrently captures LiDAR data of avian species alongside high-resolution digital still imagery, which is used for species-level identification of birds recorded. "Hits" from the LiDAR system are used to measure flight height and combined with digital still imagery, this methodology provides accurate species and site-specific avian flight heights. Proof of concept studies undertaken in the UK have produced confident matches between the LiDAR data and imagery, with >95% of avian species having flight height measurements within one metre accuracy. Preliminary results from matching high-resolution images with LiDAR data appear unaffected by species size and accurately depict birds captured at all heights, including those flying close to the sea surface.
APEM's methodology of simultaneously using LiDAR and digital still imagery can fill important knowledge gaps associated with site-specific avian flight heights because it provides more accurate and precise flight height measurements to inform collision risk models than traditional methods, enabling precaution around OWF developments to be reduced. Trials from early stages are promising and APEM are now testing the versatility of LiDAR across a range of environmental conditions to enhance the methodology.

Equality, Diversity and Inclusion (EDI) EVENT

Part of the flock? Creating a sense of belonging in Marine Ornithology

SESSION: MONITORING

Utility of conservation detection dogs for monitoring breeding seabirds

Kendrew Colhoun*; Caroline Finlay
**KRC Ecological Ltd*

The use of canine detection dogs in conservation work is well-established but is still relatively under-used in Europe. In the realms of seabird conservation and management, the majority of applications have documented the use of conservation detection dogs (CDDs) to either survey cryptic endangered species, or invasive species which may threaten species - such as the presence of alien invasive mammals on island endemics. Surveying largely nocturnal burrow/cavity-nesting species presents particular challenges using traditional methods. Monitoring presence/absence and assessing population trends is fraught with difficulties due to inter alia, variable response rates to playback, difficulties in defining colony extent, short breeding seasons and the relative inaccessibility of islands.
Here we describe a small project to evaluate the efficacy of CDDs to survey burrow-nesting seabirds in Ireland. In 2021 and 2022 we trialled their use through a number of approaches. Firstly, using scent samples (e.g. feathers) of focal species we trialled the ability of CDDs to signal on the focal scent in controlled field (non-colony) locations. We subsequently successfully trialled the application of the method to locate and survey European Storm Petrel and Manx Shearwater at a number of sites, encompassing a range of habitats, colony sizes and densities. The method has considerable utility in seabird research, overcoming some of the inherent difficulties of traditional approaches.

Variations in seabird abundance and distribution in the Bay of Biscay and the English Channel

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Nine years after the first cycle survey SAMM (Suivi Aérien de la Mégafaune Marine), a new dedicated aerial survey was carried out over the English Channel and Bay of Biscay to cover a large part of the French Exclusive Economic Zone and extended areas. The method was distance sampling based on visual aerial observation at low altitude (600 feet) and constant speed (90 knots) along pre-determined linear transects. A quarter of the sampling was supported by a high-resolution digital optical system to better identify seabird on a 2 x 200 m strip. This allowed an additional 10% of seabird species to be identified.
A total effort of 20 000 km was covered in winter 2021 using a sampling design close to the 2011-2012 survey. 90% of the effort was conducted with Beaufort sea state 3 or less. Gulls, kittiwakes, gannets and auks were the most frequent among all the observed taxa.
Compared to the last survey, total abundance of all species increased by one third from 1 to 1.5 million of individual in these areas. The number of large gulls remained stable but an extent of their distribution over the oceanic area was observed. Northern gannets slightly decreased with less individuals in the Atlantic part, which is also the case for procellariids or terns. However, alciids, great skuas and kittiwakes appeared more abundant everywhere.
This study supported the fact that the English Channel and the Bay of Biscay are of great importance for seabirds and subject to variations over the years. A second summer survey in 2022 will compare seasonality and the output of habitat characterization to improve our knowledge on seabird ecology and conservation in these areas.

Timelapse camera derived measures of phenology and reproductive success in seabird research

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Many of the species in decline around the world are subject to different environmental stressors across their range, so large-scale monitoring programmes, with replication of sites, are necessary to disentangle the relative impacts of these threats. For those taxa or environments where a single vantage point can observe individuals or ecological processes, time-lapse cameras can provide a cost-effective way of collecting time series data replicated at large spatial scales that would otherwise be impossible and permit landscape-scale ecological hypotheses to be tested. Networks of time-lapse cameras needed to cover the range of species or processes create a problem in that the scale of data collection easily exceeds our ability to process the raw imagery manually. While some out of the box image analyses such as optical flow do exist, citizen science and machine learning provide bespoke, adaptable solutions to scaling up data extraction (such as locating all animals in an image). Crucially, citizen science, machine learning-derived classifiers, and the intersection between them, are key to understanding how to establish monitoring systems that are sensitive to – and sufficiently powerful to detect –changes in the study system. Citizen science works relatively 'out of the box' as a first step for many systems until machine learning algorithms are sufficiently trained to automate the process. More work is needed to supplement 'out of the box' tools and we suggest advances in camera technology necessary to enable more complex time-lapse monitoring, such as on-board computer vision and decision-making.

Decolonizing arctic science? Involving local communities will reinforce ecologically sound, pan-arctic seabird monitoring

Manon Clairbaux*; Mia Rönkä; Tycho Anker-Nilssen; Yuri Artukhin; Johannis Danielsen; Maria Gavrilo; Grant Gilchrist; Erpur Snær Hansen; April Hedd; Robert Kaler; Kathy Kuletz; Bergur Olsen; Mark L. Mallory; Flemming Ravn Merkel; Hallvard Strøm; Jérôme Fort; David Grémillet
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Despite Arctic Council recommendations for a better involvement of indigenous participants in circumpolar monitoring programs, such decolonization of arctic science is still in its infancy. In this study, we assessed the adequacy of a panarctic seabird monitoring network as ecological sentinel of environmental change, and tested the hypothesis that participation of local communities can significantly improve monitoring activities, thereby empowering arctic people. We show that the existing panarctic seabird monitoring network focused on the black-legged kittiwake (*Rissa Tridactyla*) does not fully embrace current and future environmental gradients. Crucially, kittiwake monitoring sites were ten times closer to human settlements, than from research facilities. This underlines the strong potential for better involvement of arctic peoples in research activities, to decolonize arctic science whilst improving the spatio-temporal cover of monitoring seabirds as ecological sentinels of rapid environmental change. This study provides a conceptual framework to improve existing monitoring networks advocating for indigenous participation beyond logistical support in other regions of the world.

Latitudinal and climatic effects on the breeding phenology of a declining seabird

Alice J. Edney*; Matt J. Wood; Ellie Owen; Mark J. Jessopp; Tom Hart
**Department of Zoology, University of Oxford*

The timing of breeding plays a key role in determining species' reproductive success, which depends on the match between the seasonal peak in food availability and nutritional requirements of growing young. However, changes in phenology (the timing of life-cycle events) are one of the most evident responses to rising global temperatures. Phenology of species occupying higher trophic levels, such as seabirds, may be less responsive to environmental change than those occupying lower trophic levels. This can make seabirds particularly sensitive to trophic mismatch and associated declines in breeding success. There is evidence to suggest that this effect is greater at higher latitudes, and so data is needed across species' latitudinal ranges to assess which populations may be most threatened by a changing climate. In this study, we use data from the Zooniverse citizen science project, Seabird Watch, to investigate changes in the timing of breeding of a globally declining seabird species, the Black-legged Kittiwake *Rissa tridactyla*. Time-lapse cameras collect images across the species' North Atlantic range, and volunteers tag kittiwakes in these images. By extracting key phenological dates across multiple locations and years, we show how the timing of breeding is influenced by latitude and environmental variables and how it could affect reproductive success, thereby informing our understanding of species' responses to climate change. We highlight the value of cameras for essential population monitoring of declining species in remote areas, and of citizen science for processing large volumes of data, while also providing important science outreach.

Fifty years of investigations on European storm petrel *Hydrobates pelagicus* in colonies of Molène archipelago (Brittany, France)

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**Bretagne Vivante – SEPNB, 19 route de Gouesnou, F-29200 BREST, France*

The earliest censuses of European storm petrel colonies in the Molène archipelago were carried out in the late 1960s. A ringing program was initiated in the mid-1970s, and a first mapping of breeding sites was also conducted. Since the late 1990s, censuses of colonies were conducted annually. Over the last 25 years, number of AOS (apparently occupied sites) fluctuated between 400-500 and 800-900 AOS. In addition, annual fieldwork included systematic ringing of chicks, monitoring of productivity, ringing of breeders on a control colony, and monitoring of predation, i.e. by avian predators on colonies and by cats outside colonies on the inhabited Molène island. Fine scale mapping of the breeding sites had facilitated fieldwork and also allowed analyses of the spatio-temporal evolution of the distribution of AOS. More than 31,000 birds have been ringed, out of which 5,600 chicks, with multiple controls in the following years, locally or abroad and, conversely, nearly 230 birds ringed abroad have been controlled. Censuses and ringing provided data on population dynamics, age of return to the colonies and age of first breeding, inter-colony movements, and demographic parameters. Since 2020 movements of breeders during incubation have been tracked with GPS to identify spatial distribution at sea and foraging areas. Other analyses investigated diet based on vomit samples and levels of contaminants in unhatched eggs. These datasets rank among the few long-term studies carried out on European storm petrel colonies in the Atlantic or in the Mediterranean, and could be used to evaluate the response of the species facing global warming affecting the marine environment.

PLENARY 2

From individuals to communities: plastic pollution, queerness, and compassion in seabird science

Dr Alex Bond
Natural History Museum

Wednesday 24th August- 09:00-10:00

Two topics have received short shrift in conservation in the nearly two decades of my seabird research career, and while they may not appear to be immediately related, plastic pollution and those from minority groups working in seabird conservation share many similarities. Plastic pollution has been called a “distraction”, and a topic not worthy of focus in the hypercompetitive conservation funding and prioritization arena. Similarly, researchers who are not straight, white, and male face barriers in science and are often told to “get over it” or “keep it to yourself”.

I will present a synopsis of the Adrift Lab’s 15-year collaborative research programme on plastic pollution at Lord Howe Island, Australia, with a focus on how we, initially unintentionally, developed this programme and aligned it with queer science. By focusing on individual responses and sublethal effects, and collaborating with a wide array of diverse scientists, we have helped raise the profile of this pressing environmental issue and brought it to new and diverse scientific, cultural, and community audiences. I will rebut the argument, heard so often in the recent past, that plastics pose little or no threat to seabirds or the wider marine environment, and how as a group we have encountered, confronted, and combatted ecogrief, personal prejudice, and professional barriers.

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SESSION: POLLUTION AND TOXICOLOGY

Tell me where you overwinter, I will tell you what toxicological risks you might face

Céline Albert*; Hallvard Strøm; Hálfdán Helgi Helgason; Vegard Sandøy Brathen; Fannar Theyr Gudmundsson; Paco Bustamante; Jérôme Fort

**Littoral, Environnement et Sociétés (LIENSs), UMR 7266 CNRS-La Rochelle Université, 2 Rue Olympe de Gouges, 17000 La Rochelle, France & Université Paris-Saclay, CNRS, AgroParisTech, Ecologie Systématique Evolution, 91405, Orsay, France*

Our knowledge of the ecology and at-sea distribution of migratory marine species like seabirds in winter has increased substantially over the last two decades. At the same time, knowledge about pollutant contamination during this period has also recently increased. However, the understanding of their combined effects on life history traits among seabirds is still scarce. Indeed, in winter, seabirds can use very different non-breeding areas. Such overwintering strategies and distribution may expose individuals to varying degrees of pollutants. Here, we studied both the winter distribution and mercury (Hg) contamination, and their combined effects on the breeding success, of the great skua (*Stercorarius skua*) population breeding in Bjørnøya, Svalbard. We confirmed that individuals of this specific population consistently overwinter in three different areas of the North Atlantic; Africa, Europe and northwest Atlantic. While our results show that mean Hg concentrations were similar among skuas wintering in Europe and northwest Atlantic, skuas wintering off Africa accumulated significantly lower Hg concentrations. We also found that female winter distribution and accumulated Hg affect the volume of their eggs, but not the clutch size or hatching success. More specifically, our results showed a negative relationship between egg volumes and Hg concentrations for females overwintering off Africa or northwest Atlantic but a slightly positive relationship for females overwintering in Europe. Moreover, even if female body mass did not impact egg volumes, it was impacted by both winter distribution and Hg contamination. Indeed, we found a positive relationship between body mass and Hg concentrations for females wintering in northwest Atlantic but a slightly negative relationship for females overwintering off Africa only, while body mass remained stable for females wintering in Europe. This study provides new insights on the contamination risks that seabirds might face according to their winter distribution and the possible associated carry-over effects.

Global assessment of marine plastic exposure for petrels

Bethany L. Clark*; Ana P. B. Carneiro; Elizabeth J. Pearmain; Thomas A. Clay; Richard A. Phillips; Andrea Manica; Marie-Morgane Rouyer; Win Cowger; Marcus Eriksen; Carolina Hazin; Maria P. Dias

**BirdLife International*

Plastic pollution is regarded as a global threat to marine life. Plastic is unevenly distributed in the world's ocean, but the spatial variability in exposure remains poorly understood. Seabirds are important indicators of ocean health. In particular, petrels include some of the world's most threatened birds, cover vast distances during foraging and migration, and frequently ingest plastic. Here we combined marine plastic density estimates with individual movement data for 6,420 birds of 77 petrel species (64% of Oceanitidae, Hydrobatidae and Procellariidae except for Macronectes) to quantify estimate relative exposure. Plastic exposure scores varied greatly among species, with disproportionately high exposure for threatened species. Exposure also varied among populations, and between breeding and non-breeding seasons. We identified high-exposure areas within enclosed seas or mid-ocean gyres in the Mediterranean and Black seas, and the northeast Pacific, northwest Pacific, South Atlantic and southwest Indian oceans. Outside the Mediterranean and Black seas, exposure was greatest in the high seas and Exclusive Economic Zones (EEZs) of the USA, Japan, and the UK. Birds were generally more exposed to plastic outside of their breeding country's EEZ than within it. We quantify the links between the breeding country of each population and the waters where the birds had the greatest exposure to plastic. We provide a framework for assessing plastic exposure from tracking data to identify conservation. We identify species and populations for which

petrel tracking studies or ingestion studies would be most valuable. Our results highlight that international collaboration and coordinated remediation is key to addressing the impacts of marine plastic on wide-ranging species.

A tale of two petrels: Recent advances in the ecological study of the endangered Diablotin Black-capped Petrel

Yvan Satgé*; Patrick G.R. Jodice; Brad Keitt; Chris Gaskin; Gemma Clucas; Sarah E. Janssen
**South Carolina Cooperative Fish and Wildlife Research Unit, Clemson, South Carolina, USA*

The Diablotin Black-capped Petrel (*Pterodroma hasitata*) is a Caribbean gadfly petrel listed as Endangered by the IUCN. The population is estimated at ~2,000 pairs potentially nesting in 5 countries although, to date, only 100 nests have been located, in Haiti and the Dominican Republic. Two phenotypes have been described: a smaller dark form and a heavier light form. They are genetically distinct and show temporally distinct molting patterns, suggesting distinct phenologies. We report on recent advances in the study of this species. In May 2019, we captured 10 adult Black-capped Petrels (5 of each phenotype) at sea in the western North Atlantic and equipped them with satellite trackers. In April 2018 and May 2019, we also collected fecal samples and feathers for analyses of diet and contaminants, respectively. Using tracking data, we assessed differences in marine use of phenotypes. We quantified form-specific exposure to potential marine threats such as marine pollution (mercury and plastic), fisheries, ship traffic, and marine energies. Dark and light forms petrels had significantly distinct non-breeding distributions. Dark forms used a core area in Gulf Stream waters, entirely in the US EEZ. Light forms had a more northeasterly distribution, with a core area shared between US EEZ (78%) and international waters (22%). Off the coast of North America, the dark form is more exposed to mercury, plastic, and ship traffic, while the light form is more exposed to fisheries. We observed overlap with exploratory leases for hydrocarbon production and with planned leases for wind energy production. Our preliminary analysis of prey DNA showed a higher occurrence of fish than cephalopods in collected fecal samples, and more diversity of prey during breeding. Finally, we measured mean concentrations of total Hg in the top tier of concentrations measured in other Pterodroma species globally.

SESSION: FORAGING ECOLOGY

Foraging distribution and habitat use of chick-rearing snow petrels from two colonies in Dronning Maud Land, Antarctica

Eleanor Maedhbh L. Honan*; Ewan D. Wakefield; Richard A. Phillips; Erin L. McClymont
**Durham University, UK*

Antarctic sea ice is an important component in global climatic and biogeochemical cycles and though highly dynamic, provides critical habitat for some of the world's most abundant taxa. Snow petrels, *Pagodroma nivea* - fulmarine petrels endemic to Antarctica – feed predominantly in association with sea ice, either within pack ice leads, the marginal ice zone or polynyas. As such, they are potentially very useful indicators of climate change. However, little is known about their foraging ranges, spatiotemporal variation in habitat use, or the effects of the central-place constraint during the breeding season when they nest on ice-free rock, often on nunataks hundreds of kilometres inland. This hampers attempts to understand how their demography may be affected by sea-ice dynamics and wider environmental change.
In order to quantify foraging behaviour and habitat use, we tracked snow petrels during chick-rearing from 2 colonies - Svarthameren and Utsteinen – 600 km apart in Dronning Maud Land, Antarctica with GPS loggers during the 2021/22 austral summer. In this talk, I describe for the first time the foraging ranges and habitat use of snow petrels breeding in Dronning Maud Land, before going on to discuss how our findings are being used to facilitate the use of ancient snow petrel stomach-oil deposits as proxies for changes in sea-ice conditions since the Last Glacial Maximum.

Evidence of the use of memory, social information and wind by seabirds foraging across a tropical island ecosystem of the Atlantic Ocean

Sam L. Cox*; Sophie Lanco Bertrand; Leandro Bugoni; Karine Delord; Herve Demarcq; Guilherme Tavares Nunes
**Centre National d'Études Spatiales (CNES), 31400, Toulouse, France & MARBEC, Univ Montpellier, CNRS, Ifremer, IRD, Sète, France & Institut de Recherche pour le Développement (IRD), Sète, France & University College Cork, Cork, Ireland*

For seabirds inhabiting tropical regions, meeting energetic requirements in what is typically a homogenous and relatively oligotrophic environment is challenging. Compared to temperate and polar regions, prey availability is generally less seasonal and less consistently patchy (and thus less predictable) in space and time. Social foraging, ranging from cooperative hunting to local enhancement, can optimise time spent at sea, and may play an important role for seabirds exploiting these regions. Here, we investigate the use of memory, social information and wind by a seabird predator, the brown booby (*Sula leucogaster*), at a small colony in the tropical Atlantic Ocean. We use GPS tracking data from 95 birds (~half the local breeding population), tracked between the 8th July and 1st August 2014 at the tropical archipelago São Pedro e São Paulo, Brazil. Using a range of analyses, we provide evidence indicating that individuals depart the colony in a direction similar to that of the departure and return bearings of their previous trip, alongside the departure and return angles of the temporally nearest previous departing/returning bird. Consistency in departure bearings at both an individual and colony level appears to decrease with time. Foraging birds at-sea had clustered distributions. The at-sea distributions of travelling birds were less clustered, particularly during the central portion of a trip. When at sea, travelling birds were more likely to start foraging when in proximity to foraging birds, especially at close distances (< ~1 km), indicating a positive response to conspecifics. Birds generally departed the colony in a direction such that they encountered a side wind, although during strong wind conditions adjusted departure bearings to benefit from a tail wind, and avoid head winds. Together these results suggest memory, social information, and wind play an important role in shaping the foraging strategies of this tropical seabird.

Effects of age and status on foraging behaviour of wandering albatrosses

Elizabeth J. Pearmain*; Ana P. B. Carneiro; Andrea Manica; Richard A. Phillips
**British Antarctic Survey & University of Cambridge*

Competition for resources may lead to niche partitioning among and within seabird species. Differences in foraging distribution and behaviour are often documented in different stages of the breeding cycle, but far fewer studies compare foraging patterns among birds of different age and status. However, these are of considerable interest for understanding the development of foraging skills with age, and how foraging ability and breeding constraints affect the recruitment process as well as the breeding frequency of established adults.
The degree of central-place constraint is a key driver of foraging distributions during the breeding season. In albatrosses, parents perform longer trips during incubation and in later chick-rearing than in the brood-guard period. In most seabirds, immature (pre-breeders) and sabbatical (deferring) adults also attend colonies during the breeding season, possibly to find a mate, maintain their pair bond or protect the nest site. These life-history classes are rarely tracked, but are important components of the population and may have different foraging ecology or susceptibility to threats.
We present the first fine-scale comparison of the foraging behaviour and habitat preferences of adult breeders, sabbatical adults, and immature wandering albatrosses, using GPS and immersion data from birds tracked during the breeding season at Bird Island, South Georgia. We examine the roles of competition and habitat preference by comparing distributions, at-sea activity patterns and indices of foraging efficiency of different life-history stages. Contrary to predictions based on the central-place constraint, immatures and sabbaticals did not conduct longer trips or disperse more widely than breeders. As well as providing insights into the development of foraging skills and site fidelity during

recruitment, and the factors affecting individual breeding frequency in albatrosses and other long-lived seabirds, our results have important implications for the conservation of this highly threatened species.

Underwater visibility impacts the foraging behaviour of a diving seabird

Jamie Darby*; Manon Clairbaux; Ashley Bennison; John L. Quinn; Mark Jessopp
**School of Biological, Environmental and Earth Sciences, University College Cork, Cork T23 N73K, Ireland & MaREI Centre for Energy, Climate and Marine, Environmental Research Institute, University College Cork, Cork P43 C573, Ireland*

The mechanisms that seabirds use to find food influences how they respond to a changing climate. Environmental conditions that affect these mechanisms are likely to become more variable even in conservative estimates of how climate change will progress in the coming years. In this study, we investigated the diving behaviour of a pelagic seabird, the Manx shearwater (*Puffinus puffinus*), in relation to environmental variables that may affect the visibility of their prey, including water turbidity, solar angle, and cloud cover. We found that the interaction of solar angle and water turbidity was highly important for both dive rate and depth, which suggests that prey capture at a fine spatiotemporal scale was constrained by the ability to see prey underwater. However, high water visibility did not induce broad-scale search behaviour above water, suggesting that foraging at a broad scale is not initiated by direct underwater prey detection and more likely related to proximate cues at or above the water surface. Greater cloud cover also constrains dive depth, though we speculate that this effect may be moderated by Manx shearwaters' violet or ultraviolet sensitivity, allowing them to use spectra of light that are more transmissible through clouds. This novel use of dynamic environmental descriptors to assess underwater visibility suggests that this seabird species' foraging ability is partially affected by the availability of light underwater. Increasing ocean turbidity due to climate change could constrain the foraging ability of this species, and may also impact many other marine predators that rely on vision for prey capture.

Intrinsic and extrinsic drivers of foraging movement of the White-faced Storm-Petrel in the Atlantic tropics

Constanza Rivas*; Fernando Medrano, Jacob Gonzalez-Solis
**Wildlife Ecology and Conservation Group, Wageningen University, Wageningen, the Netherlands & Departament de Biología Evolutiva, Ecologia i Ciències Ambientals, Institut de Recerca de la Biodiversitat (IRBio), Facultat de Biología, Universitat de Barcelona (UB), Barcelona, Spain*

Procellariiformes, spend most of the year offshore, covering long distances searching resources in dynamic oceanic conditions, returning to land during breeding season. It is challenging to acquire energetic resources when breeding as central place foragers. The constrained foraging trip aims to fulfill their own energetic demands, as well as the growing offspring. The foraging strategy and habitat selection during each breeding stage, are paramount to ensure food availability, associated with dynamic oceanographic features such as eddies, waterfronts, and static features such as seamounts. The oceanographic features that predict resource prey, differ among species, diet and variation during the breeding stage, and the spatial-temporal resource availability. For White-faced storm-petrels subsp. eadesorum foraging strategy and habitat selection, conditioned by breeding stages, sex, and is presented for the first time. We tagged 88 individuals with GPS tags, during breeding season in 2019, 2020, and 2021 in Cabo Verde. We described length, trajectory, and max distance of trips, and the foraging strategy chosen. We explore differences in characteristics of the trips between breeding stages, sex, and body weight. Besides, we identified the oceanographic characteristics of the habitat selected, during incubation and chick rearing. We describe dual foraging strategy for the first time in storm-petrels, performing longer trips during incubation than chick rearing. Incubating individuals performed longer trips, however, in long trips there were no differences in the total distance traveled or max distance from the nest. During incubation and chick rearing, individuals selected cooler water with lower salinity in the area, with indicators of water mixing. Incubating individuals selected areas of higher levels of productivity, and closer to seamounts, contrary to chick rearing individuals selecting

less productive waters. The use of seamounts was higher when committing to longer trips, suggesting the use of seamount for individual provisioning.

Deciphering the mechanisms driving individual foraging site fidelity in gannets with movement simulations

Christopher J. Pollock*, Ruth Jeavons, Jude V. Lane, Tim Benton, Keith Hamer
**British Trust for Ornithology, The Nunnery, Thetford, Norfolk, UK*

Individual foraging site fidelity (IFSF) has strong and observable characteristic patterns in gannets, namely repeatable departure angle from the colony and overlapping use of foraging areas on consecutive trips. However, our understanding of which mechanisms are driving this phenomenon is limited. Bird-borne cameras have shown regular interaction of conspecifics at sea, while telemetry studies have shown that birds hone their use of consistent foraging locations over time indicating the use of memory. It is likely that both public and private information are contributing to the movement patterns that emerge at population-level in large seabird colonies. However, testing the influence of these drivers with field observations and experiments is challenging. Thus, we used bottom-up simulation models to inspect the consequences of individual decisions at higher levels. This presentation is about how we developed a movement model of gannets at Bass Rock and used it to run simulation experiments in which foraging individuals use different combinations of public and/or private information to locate resources. We then compared the models' outputs with several empirically derived patterns looking at IFSF and foraging efficiency. We find that recalling departure direction with a certain amount of flexibility, alongside interaction with conspecifics at sea is key to reproducing the IFSF patterns seen in empirical data. However, this did not correspond with the most efficient strategy for individuals.

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SESSION: URBANISATION, INVASIVES AND RESTORATION

Are introduced rodents involved in disease outbreaks threatening subantarctic seabirds?

Amandine Gamble*; Baudouin Des Monstiers; Lorien Boujot; Romain Dedet; Augustin Clessin; Marine Bely; Romain Garnier; Jérémy Tornos; Hubert Gantelet; Nicolas Keck; Thierry Boulinier
**University of California Los Angeles, Los Angeles, USA*

Accumulating evidence suggest that infectious diseases represent a significant threat to seabird populations. Characterizing the reservoir community of pathogenic infectious agents is key to identify, and potentially limit, pathogen re-emergence and spread. Due to their foraging behaviours, terrestrial predating and/or scavenging species have the potential to play critical roles in epidemiological dynamics by introducing, maintaining pathogens and/or enhancing their circulation within and among seabird colonies. On Amsterdam Island (Southern Indian Ocean), avian cholera, caused by *Pasteurella multocida* bacteria, has been causing recurrent die-offs of albatross and penguin nestlings since the 1980's, threatening the viability of these populations. We investigated the potential role of introduced rodents (*Rattus norvegicus* and *Mus musculus*) in avian cholera outbreaks by combining classical epidemiological tools with population and foraging ecology approaches. At the height of the avian cholera epizootics, rodents carried *P. multocida* and frequently interacted with seabirds. During winter, when most seabirds have migrated at sea, rodents still carried *P. multocida* bacteria, suggesting that they may play a critical role in the inter-annual maintenance of the bacteria on the island. Based on these empirical results, we discuss the potential management strategies that could be designed to limit pathogen re-emergence and spread in seabird communities. Overall, this study highlights the benefit of broadening field investigations beyond classical epidemiological data and beyond the obviously affected species in order to better understand epidemiological processes in seabird communities and implement efficient surveillance and management measures.

Response of long-tailed duck (*Clangula hyemalis*) to the change in the main prey availability in its wintering ground in the Baltic Sea

Paola Forni*; Julius Morkunas; Darius Daunys
**Marine Research Institute, Klaipeda University*

The long-tailed duck (*Clangula hyemalis*) is a vulnerable and declining species wintering in the Baltic Sea. The population declined around 65% during the last decades (Skov et al, 2011). The introduction of the invasive fish, the round goby (*Neogobius melanostomus*), dramatically impacted the benthic macrofauna in hard-bottom, while no significant changes occurred in soft-bottom benthic macrofauna community. Therefore, we aimed to assess the extent to which the diet of long-tailed ducks changed in two different bottom types colonized by distinct benthic communities. We analysed the stomach content of 251 long-tailed ducks bycaught in gillnets from 2016 to 2020 in hard- and soft-bottom and compared these results with data collected from 1997 to 2001 (Žydelis and Ruškyte, 2005). The results show that the long-tailed duck experienced a considerable change in diet in hard-bottom, shifting from the blue mussel to *Hediste diversicolor*, barnacles and fish. In soft-bottom, however, their diet remained similar over time and was based on *H. diversicolor*, a few bivalve species and *Saduria entomon*. There was no evidence of significant differences in diet between sex or age. Despite the changes in diet, the average body condition of the species did not change over time or between bottom types. This confirms that long-tailed ducks have high feeding flexibility and quick species response to changes in prey availability, as they can shift their diet to new prey.

Implications of habitat restoration for tropical seabirds and coral reef ecology

Ruth E. Dunn*; Cassandra E. Benkwitt; Nicholas A.J. Graham
**Lancaster Environment Centre, Lancaster University, Lancaster, LA1 4YQ, UK*

Although historically islands were viewed as havens of biodiversity, their ecosystems are fragile to threats such as invasive species, land use alterations, and climate change. The decimation of breeding seabird populations on numerous tropical islands has caused interruptions to natural nutrient flows, whereby seabirds transfer nutrients from their pelagic foraging areas to their terrestrial breeding colonies and adjacent coral reef habitats. Here, we investigate what the implications of reversing habitat degradation could be for tropical seabird populations and coral reef ecology. Initially, by comparing the influence of prey availability with breeding habitat quality across islands within the Indian Ocean, we identified the presence of mammalian predators and non-native vegetation as limiting factors of seabird density dependence. We demonstrate that when successful, rat eradications and the management of vegetation could lead to islands supporting healthy seabird populations, and that there will still be ample marine prey to support these populations. We then modelled the potential for Indian Ocean islands to support breeding seabird populations and seabird nutrient subsidies under different habitat restoration scenarios. The restoration of tropical seabird communities could also boost natural nutrient fluxes and coral reef functioning (both bioerosion and grazing) via increased reef fish biomass, particularly that of herbivorous fishes that perform these critical ecosystem functions. Given the potential benefits for both biodiversity and coral reef ecosystem functioning, the restoration of tropical island ecosystems for seabirds should be a conservation priority.

Rapid loss of maternal immunity and increase in environmentally mediated pathogen exposure in urban gull nestlings

Juliet S. Lamb*; Thierry Boulinier
**CEFE-CNRS, 1919 Route de Mende, Montpellier, France*

Urban wildlife can play an important role in disease circulation between animal and human populations. Generalist coastal marine birds such as gulls (Laridae) are highly mobile, interact regularly with human activities, and contribute to the spread of pathogens among population centers, making them promising sentinels for detecting and monitoring the circulation of zoonotic pathogens. While adult gulls may move long distances during the annual cycle, disease exposure in nestlings can provide a localized index of disease circulation. However, evaluating disease exposure in early life is complicated by the fact that antibody levels represent a combination of maternally-transferred immunity, which decreases over time, and local environmental exposure, which increases over time. To evaluate the relative contributions of maternal and environmental antibodies during development, we studied the dynamics of immune responses to three pathogens—avian influenza virus (AIV), infectious bronchitis virus (IBV), and *Toxoplasma gondii*—in nestlings of yellow-legged gulls (*Larus michahellis*). We exchanged eggs between nests and repeatedly sampled nestling antibody levels after hatch, allowing comparison of nestlings with similar innate immunity raised under differing levels of environmental exposure. We found differences in prevalence among the three pathogens, with AIV being widespread, T. gondii occasional, and IBV absent. Rates of decline in maternal antibodies were similar among pathogens; however, AIV had higher starting values and took longer to reflect environmental influences (25 days) than *T. gondii* (15 days). After this time, differences between biological and foster siblings were comparable, suggesting that environmental exposure rates are relatively consistent among nests. Our results highlight the utility of nestling antibody levels for long-term surveillance of pathogen circulation, as well as the importance of considering chick age and underlying pathogen prevalence in sampling design.

Tussles for mussels? Abundance, distribution, and disturbance of Ireland's largest Eider aggregation

Katherine A. Booth Jones*; Kerry Leonard; Dave Allen; Neil A. Calbrade; Graham E. Austin; Tom J. Evans; Rich J. Howells; Elizabeth M. Humphreys; Niall H. K. Burton
**BTO Northern Ireland, Beta Centre (Unit 15), Stirling University Innovation Park, Stirling, FK9 4NF*

Belfast Lough is a principle maritime gateway to the island of Ireland, busy with marine traffic, industry, and recreational human activity. Despite heavy human use, Belfast Lough's Special Protection Areas remain some of Northern Ireland's most important wetland sites. In particular, the lough is home to Ireland's largest wintering aggregation of Red-listed Eiders.
Many seabird surveys focus on the breeding season, but is less known about populations of wintering sea ducks. The aim of this work was to improve current knowledge of Eider numbers and distribution in Belfast Lough, to investigate their movements through diurnal and tidal cycles, and to identify and discuss potential sources of disturbance.
Analysis of existing Wetland Bird Survey data highlighted that Eider numbers in Belfast Lough increased at a greater rate than the Northern Irish population as a whole, and that this was driven by increased numbers along the northern shore of the lough.
Through-the-tide-counts (TTTCs) carried out between November and March revealed that Eider abundance and flight activity peaked in November and declined through the winter and were also shaped by tidal state. Numbers of Eider recorded were highest at low tide, likely reflecting easier foraging access to bottom-culture mussel beds in the area.
Marine traffic was the main source of potential disturbance observed during TTTCs. In 89% of cases, Eider did not respond to these by flying or swimming away. However, rare cases of apparently deliberate disturbance of Eider flocks were observed on three occasions, resulting in Eider flocks being dispersed by boats.
Due to the disturbance and conflict observed between the growing and nationally important Eider population in Belfast Lough and the economically valuable bottom-culture mussel aquaculture industry, we discuss recommendations to improve understanding of the significant wintering Eider population and the coexistence of this with human uses of the lough.

Terns nesting in Dublin Port between 1995 and 2021: responses to nesting structure availability in a dynamic industrial setting

Helen Boland; **Tara Adcock***; Brian Burke; Niamh Fitzgerald; Stephen Newton; Niall Tierney; Ricky Whelan
**BirdWatch Ireland, Bullford Business Park, Kilcoole, Co. Wicklow*

Common and Arctic Terns have been observed nesting in the Dublin docklands since at least 1949, with numbers increasing from a recorded 38 pairs in the late 1960s to a peak of 645 pairs of both species combined in 2019, the majority of which are Common Terns. Since regular monitoring began in 1994 two permanent mooring dolphins have been used annually, one of which is now included in the South Dublin Bay and River Tolka Estuary Special Protection Area (SPA) due to its significance for breeding terns. Since 2013 Dublin Port Company have funded the monitoring work carried out by BirdWatch Ireland's Dublin Bay Birds Project. In addition, Dublin Port Company deployed two purpose-built pontoons specifically to provide additional nesting space for this growing tern colony. Predation, both avian and mammalian, is currently the biggest threat to the overall colony, with losses incurred annually. Furthermore, Dublin Port handles close to 50% of all trade in the Republic of Ireland, and the associated round-the-clock activity and vessel traffic make it a highly dynamic environment with constant potential disturbance. Co-operation between, and support from, stakeholders has allowed crucial adjustments be made to relieve some of the pressures at the nesting sites. This co-operation is critical to the continued success of the colony. While the number of pairs of terns has increased notably in the port since records began, it is the developing nature of the port area that makes continued monitoring vital for assessing how newly-emerging conditions may affect the colony.

Are urban habitats an opportunity or a challenge to breeding yellow-legged gulls (*Larus michahellis*)?

Ana C. Norte*; Joana Pais de Faria; Giulia Bocelli; Sara N. Veríssimo; Rita Soares; Catarina S. Lopes; João Oliveira; Ivo dos Santos; João Silva; Francisco Neves; Filipe Veloso; Vítor H. Paiva; Jaime A. Ramos

**University of Coimbra, MARE - Marine and Environmental Sciences Centre, Department of Life Sciences, Coimbra, Portugal*

Recent increased urbanization has affected wildlife and its interactions with humans. Some plastic species may adapt to these novel environments but the quality of urban habitats is unclear as they may impose subtle or delayed detrimental effects that may only be obvious in the long term.

We used the yellow-legged gull *Larus michahellis* (LM), a flexible opportunistic species, as a model species to evaluate if there is a behavioural tolerance that may facilitate its adaptation to urban environments, and to what extent there are costs and benefits to breed in urban habitats in comparison with natural ones. We assessed this by using an integrated approach combining natural and manipulative experiments and by assessing behavioural, physiological and breeding success metrics.

Behavioural stress was assessed with dummy eggs to record heart rate of the incubating bird. There was no evidence that LM is more tolerant to direct human disturbance than a similar less plastic species (*Ichthyaetus audouinii*) when breeding in a natural habitat.

Urban LM bred more sparsely and laid smaller eggs and clutches. Although urban adult birds did not differ in their morphological body condition, and showed, together with their chicks, lower levels of inflammation, when compared with individuals from the natural habitat, they had lower blood haemoglobin, and their chicks showed slower early growth rates, suggesting a diet of low nutritional value. This suggests a trade-off between food quality and the advantages of breeding in lower density urban colonies, with less intraspecific interactions and a lower disease transmission probability.

This study contributed to show the utility of an underexplored non-invasive tool to assess behavioural stress in incubating birds. We used complementary approaches focusing on physiology and health of wild birds, in parallel with classic measures of breeding success, and highlight subtle impacts of habitat quality which need long-term studies.

SESSION: DEMOGRAPHY AND CLIMATE

Differential responses of phenology to climate change in sympatric seabird species

Ignacio Juarez-Martinez*; Alex Kacelnik; Fiona M. Jones; Jefferson Hinke; Mike Dunn; Andrea Raya Rey; Tom Hart
**Department of Zoology, University of Oxford, 11a Mansfield Road, Oxford, OX1 3SZ, UK*

The timing of breeding is an important aspect of a species' realised niche, a method of avoiding competition and a key determinant of breeding success. The flexibility of these strategies may structure community assemblages, particularly in highly seasonal environments such as the Polar Regions. Variance in a species' phenology over time and across locations is an important source of information on the species adaptability to anthropogenic changes like climate warming. Using a network of time-lapse photographic cameras to monitor a large number of colonies of three Pygoscelid species of penguins (Adélie, Gentoo and Chinstrap), we show that earlier breeding in warmer years, both at the individual colony and species levels. Adelie and Chinstrap, the two most temperature-sensitive species have shown a population decline over the roughly 10 years of our study in the Antarctic Peninsula, while Gentoo penguins have stable or increasing populations, particularly at the Southern edge of their range. Latitude was also an important determinant of the start of breeding across the same region. The sensitivity to temperature in Adélie and Chinstrap penguins is greater than previously reported. The phenological responses to temperature differed according to latitude, showing greater sensitivity to temperature at warmer, lower latitudes. Our results demonstrate that the flexibility of reproductive strategies within as well as between closely related species needs to be considered as a landscape of outcomes with some adaptation to local conditions. This study offers a starting point to understanding whether polar animals can adapt to rapid change or whether elasticity is indicative of increasing stress given the two species showing the most adaptation to changing temperatures are declining in the study area.

Where have all the petrels gone? 40 years of environmental change and population dynamics of Wilson's Storm-petrels

Anne N.M.A. Ausems*; Diego I. Archuby; Christina Braun; Andrzej Gębczyński; Anja Gladbach; Piotr Jadwiszczak; Phillipp Kraemer; Nadja D. Kuepper; Marcela M. Libertelli; Stefan Lorenz; Benjamin Richter; Anja Russ; Tim Schmoll; Simon Thorn; John Turner; Katarzyna Wojczulanis-Jakubas; Dariusz Jakubas; Petra Quillfeldt
**Department of Animal Ecology and Systematics, Justus Liebig University Giessen, Heinrich-Buff-Ring 26, D-35392 Giessen, Germany & Department of Vertebrate Ecology and Zoology, University of Gdańsk, ul. Wita Stwosza 59, 80-308, Gdańsk, Poland*

Numerous seabird species are experiencing population declines, and this trend is expected to continue or even accelerate in the future. To understand the effects of environmental change on seabird populations, long-term studies are vital, but rare. Here, we present over four decades (1979-2020) of population dynamic and reproductive performance data of Wilson's storm-petrels (*Oceanites oceanicus)* from King George Island (Isla 25 de Mayo), South Shetland Islands, Maritime Antarctic. We determined trends in population size, reproductive performance, and chick growth rates, and related the interannual variation to the environmental conditions. Our analysis revealed a substantial local decline of up to 90 % in the population size of Wilson's storm-petrels, and significant temporal changes in reproductive performance and chick growth rates. We show that these changes in reproductive performance are generally linked to variation in environmental conditions, either in food availability (particularly Antarctic krill, *Euphausia superba*) or in nest burrow accessibility due to snow blocking the entrance. With the expected rise in air and sea surface temperatures, the predicted increases in precipitation over the Antarctic Peninsula will likely lead to increased snowstorm prevalence. Additionally, the rising temperatures will likely reduce food availability due to reduced sea ice cover in the wintering grounds of Antarctic krill, or by changing phyto- and zooplankton community compositions. The ongoing environmental changes may thus lead to a further population decline, or at the very least will not allow the population to recover. Monitoring the population dynamics of Antarctic

seabirds is vital for our understanding of climate change-induced changes and its consequences for Antarctic food webs.

A model-based indicator of breeding productivity of European seabirds

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**Aarhus University, Dept. of Ecoscience*

The EU Marine Strategy Framework Directive (MSFD) requires regular assessments of Good Environmental Status of European seas. The relevant regional sea conventions, among them OSPAR in the Northeast Atlantic, develop indicators for their own regular status assessments, and these indicators are often also used for MSFD reporting. OSPAR is currently preparing the next Quality Status Report (QSR), to be published in 2023. For seabirds, an indicator of breeding productivity is considered a useful supplement to the indicator of abundance, as breeding productivity is widely monitored and more responsive to environmental drivers than abundance. As part of OSPAR's Intermediate Assessment in 2017, an indicator of the frequency of breeding failures was developed. Although useful, this indicator had weaknesses associated with the arbitrary definition of failures and the life history-dependent impact of a given frequency of failures on seabird populations.
We developed a new indicator of breeding productivity, which is being implemented as part of QSR 2023. This indicator uses demographic modelling to assess the impact of observed levels of breeding productivity on population growth. We use matrix models to calculate the expected population growth rate for each species in each OSPAR region, given the most recent observed values of breeding productivity. The threshold value of the indicator is the annual growth rate that would lead to a decline in population size of 30% over three generations, corresponding to the IUCN threshold for red-listing as Vulnerable. We present the development of the indicator, as well as some key results.

Declines in the breeding success of two sibling species of storm-petrel in the Azores over the past two decades

Hannah F. R. Hereward*; Renata Medeiros-Mirra; Joël Bried; Verónica Neves; Wiebke C. Schäfer; Petra Quillfeldt; Robert J. Thomas; Frank Hailer; Mark Bolton
**Cardiff School of Biosciences, Cardiff University, Cardiff, Wales, UK*

Long-term nest monitoring studies can identify changes in seabird breeding productivity and population dynamics in relation to the changing environment, to guide conservation actions. Here we compare, across two decades, the breeding productivity and demography of two sibling species of storm-petrel that breed in the same location, at different times of year. The Azorean endemic Monteiro's storm-petrel (*Hydrobates monteiroi*) breeds in summer (April-September), and the band-rumped storm-petrel (*Hydrobates castro*) breeds in winter (September-March). Both species breed on Praia Islet, off Graciosa in the Azores archipelago. During two time periods (2000-2002 and 2018-2020), artificial nest-boxes were checked daily for each species, to monitor the fate of the eggs laid and chicks hatched, and to measure chick growth. Less detailed productivity data was collected in the intervening years. Overall, the summer breeding *H. monteiroi* had a lower productivity than the winter breeding *H. castro*, and both species' productivity has declined. Across both periods, *H. monteiroi* breeding success showed a more pronounced decline than *H. castro*, driven largely by a substantial reduction in fledging success. *H. monteiroi* breeding attempts were more likely to fail at both egg and chick stage due to disturbance by native and non-native species in the 2018-2020 period. Chick growth curves do not obviously explain overall low breeding success rates. Across the two decades, variation in breeding performance of both species was explained by the interactive effects of regional weather conditions (temperature, rainfall and wind speed). In particular, the breeding success of *H. monteiroi* was negatively associated with temperature, which was strongest under conditions of high rainfall and low wind speed. Current levels of productivity are insufficient to maintain a stable population. Understanding species' responses to decade scale environmental changes will inform conservation actions, especially to address the rapid decline in breeding productivity of the globally vulnerable Monteiro's storm-petrel.

Should I stay or should I go? The cost of divorce in the thick-billed murre

Marianne Gousy-Leblanc*; Thomas Merkling; Shannon Whelan; Kyle Elliott
**Department of Natural Resource Sciences, McGill University, Ste-Anne-de-Bellevue, Québec, Canada*

Many species are monogamous, meaning that choosing the right partner may have an important effect on reproductive success. Pair-bond duration and increased pair familiarity often enhances reproductive success. A divorce between mates can occur as (i) an adaptative behavioral strategy for an individual with a suboptimal partner ("Incompatibility hypothesis"), (ii) a random event driven by the mistiming of mate arrival as individuals ("Musical chairs hypothesis") or (iii) an opportunistic behavioural strategy occurring when many new partners are available ("Better option hypothesis"). Divorce occurs when both partners are still alive and where subsequent breeding attempts, of at least one bird, are with another partner. The thick-billed murre (*Uria lomvia*) is a colonial long-lived seabird species with considerable bi-parental care. As the species breeds in the Arctic, birds have a short breeding season, and this constraint should add a major cost to divorce. Using monitoring data collected from 20 years at the Coats Island colony (Nunavut), we aim to access the factors that influence the probability of divorce and the impacts and costs of partner change. We found a divorce rate of 8% for our 326 murre pairs. Divorce rate decreased with breeding experience, nest site quality, and successful fledging in the previous season. Laying date also had a positive effect on the probability of divorce, which may illustrate a musical chair hypothesis of divorce. We did not find an effect of population-wide survival rate on the probability of divorce, contrary to what was found in a congener at lower latitudes. Nonetheless, fledging success was higher for faithful birds compared to divorced birds, showing the importance of mate fidelity in this species. In conclusion, for an Arctic species with a short breeding season, divorce was driven by musical chairs and increasing quality or reproductive success, rather than opportunities.

Contrasting pre-breeding conditions affect condition-dependent reproduction and population dynamics in Atlantic puffins

Kate Layton-Matthews*; Tone K. Reiertsen; Kjell Einar Erikstad; Tycho Anker-Nilssen; Francis Daunt; Mike Harris; Rob T. Barrett; Sarah Wanless
**Norwegian Institute for Nature Research, Norway*

How environmental conditions drive seabird population dynamics is a fundamental, yet complex, question. Environmental conditions may affect seabird populations through different demographic rates, in breeding and non-breeding areas. Seabird populations also differ in whether they migrate close to or far away from their breeding grounds. Seabirds can adjust their reproductive investment according to the conditions prior to breeding (i.e., condition-dependent reproduction), leading to a trade-off between survival and subsequent breeding success. Under unpredictable conditions, seabirds should be more conservative in their reproductive investment, ensuring they retain sufficient resources to survive. Such correlations between demographic rates (here survival and reproduction) are likely important, yet understudied, drivers of variation in population growth.
Using long-term demographic data of three North-Atlantic puffin populations from the UK and Norway, we developed an integrated population model and used a transient life-table response experiment to estimate how the predictability of breeding conditions affects adult survival-reproduction correlations and how this, in turn, contributes to population trends. Further, using seabird tracking data we tested whether climate conditions specific to puffins' non-breeding areas could explain part of the covariation between adult survival and reproduction.
The results show that individuals breeding at Røst migrate far from their breeding colony after breeding, compared to individuals from Hornøya and Isle of May. Breeding conditions have declined dramatically at Røst likely explaining the lack of covariance between adult survival and breeding success for this colony. Contrastingly, we found strong positive correlations for Isle of May and Hornøya breeding success and adult survival, contributing to variation in population growth rates. Winter climate conditions explained some of this covariation in survival and reproduction. We discuss

our results in relation to how the predictability of conditions in their breeding season affects a key demographic correlation in Atlantic puffins, ultimately affecting their population trends.

Quantifying the impacts of predation by Great Black-backed Gulls *Larus marinus* on an Atlantic Puffin *Fratercula arctica* population using Population Viability Analysis

Samuel Langlois*; Francis Daunt; Jared Wilson; Nina O'Hanlon; Elizabeth Masden
**Environmental Research Institute, North Highland College, University of the Highlands and Islands, Ormlie Road, Thurso, KW14 7EE, UK*

Predation of seabirds by other seabird species has been highlighted as a threat to populations at local and regional scales. The predation of adult seabirds is of particular concern because adult survival in long-lived species with low fecundity is a critical parameter for population growth. These wildlife conflicts can be particularly challenging to manage when both predator and prey are species of conservation interest. The Great Black-backed Gull *Larus marinus*, currently in global decline, has been identified as a species of concern at some seabird colonies where it predates on young and adults of other sympatrically breeding seabird species. In the study colony of the Isle of May, Scotland, the number of Great Black-backed Gull breeding pairs is increasing, and they frequently predate on adult Atlantic Puffins *Fratercula arctica*. In this study, we estimated a minimum of 500 adult Atlantic Puffins are predated per breeding season and used this estimate in combination with available long-term Atlantic Puffin demographic data to run Population Viability Analyses to investigate the effects of current and increasing Great Black-backed Gull predation. Preliminary results suggest current predation levels on the Isle of May could not drive a population decline, although growth rate (λ) was reduced from 1.037 to 1.035. Predictions showed a population decline ($\lambda<1$) was reached when predation increased to >4000 adult Atlantic Puffins per year. Based on our results, we highlight the importance of understanding the dynamics of predator-prey relationships for the management of potential wildlife conflicts and the need for their inclusion in the context of cumulative impacts and compensatory measures acting upon seabird populations due to marine anthropogenic developments.

PLENARY 3

Drivers of seabird movements and their fitness consequences

Dr Annette Fayet
Norwegian Institute for Nature Research

Thursday 24th August 09:00-10:00

Seabirds are highly mobile animals, flying vast distances across open oceans on foraging trips or migration journeys. Identifying the drivers of seabird movements, and the fitness consequences of variation in these movements, is key to understanding the mechanisms shaping their ecology and ultimately to predict how their distribution and populations may be affected by environmental change. In this talk, I will present some of my research combining biologging and field observations or experiments, often from multiple populations, on North Atlantic and tropical species. I will discuss how the findings may help us identify large-scale ecological drivers of seabird movements and understand how variation at the individual or population level may affect individual fitness and population dynamics.

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SESSION: MULTI-COLONY STUDIES

Large-scale tracking of seabirds in the North Atlantic - SEATRACK

Hallvard Strøm*; Francoise Amélineau; Vegard S. Bråthen; Sébastien Descamps; Morten Ekker; Per Fauchald; Malin Johansen; Børge Moe; Arnaud Tarroux
**Norwegian Polar Institute, Fram Centre, Postbox 6606 Langnes, 9296 Tromsø, Norway*

Many seabird species undergo extensive seasonal migrations, often across large marine ecosystems or between marine areas under different national jurisdictions. Through the advances of electronic tracking and especially the application of Global Location Sensors (GLS or geolocators), it is now possible to study the seasonal movements of seabirds and link breeding populations to non-breeding habitats. To take full advantage of this development for better management and conservation, and to broaden the scope of scientific questions that can be assessed, there is a need for large-scale and multi-species programmes. The SEATRACK project with partners from 10 countries aims to identify the year-round distribution and movements of seabirds breeding in colonies across the northern part of the North Atlantic. By 2022, 16866 loggers were deployed on 11 species in 57 colonies, and data from 6380 retrieved loggers have been analyzed and compiled. The project models and maps important marine habitats for the different populations, studies the potential overlap with offshore human activities and documents how changes in environmental conditions in non-breeding areas affect demography and population trends. We will present the design of this successful international collaboration network, the main data products and examples of the strength of this international effort in answering overarching questions in modern seabird research. Next year, SEATRACK will enter Phase III (2023-2026) and we will present the emphasis in this phase on the transition from GLS to GPS logging, the inclusion of new species, an extended effort to track immature birds and planned new data products.

Spatial segregation of seabirds at South Georgia

Victoria Warwick-Evans*; Elizabeth J. Pearmain; Andy G. Wood; Richard A. Phillips
**British Antarctic Survey*

Seabirds are amongst the most globally threatened birds, often as a consequence of incidental mortality (bycatch) in fisheries. Several species of albatrosses and petrels at South Georgia are declining, but there is marked variation in the rates of decline across breeding sites. This could reflect differences in foraging areas, which might affect the availability of natural resources or discards, or the relative overlap with different fishing fleets and hence bycatch rates. Until now, the only tracking of flying seabirds around South Georgia has been at Bird Island. We deployed satellite transmitters and GPS loggers on breeding white-chinned petrels at Cooper Island and wandering albatrosses at Prion Island, whilst simultaneously tracking both species at Bird Island. For both species, our results indicate a surprising degree of spatial segregation of foraging distributions. Both wandering albatrosses at Prion Island, and white-chinned petrels at Cooper Islands are more likely to forage as far as 1000-2000 km to the east of South Georgia than those breeding at Bird Island, even though the respective breeding populations are only c. 50km and c. 170 km apart.
We discuss the results in terms of the potential differences in habitat utilisation and preference, as well as the relative overlap and impacts of fisheries, and whether repercussions for foraging and breeding success, or survival, may explain variation in population declines around South Georgia. The results have important conservation implications given the steep population declines of these highly threatened species.

Importance of the Barents Sea for North Atlantic seabirds

Benjamin Merkel*; Francoise Amélineau; Tycho Anker-Nilssen; Jan Ove Bustnes; Vegard Sandøy Bråthen; Olivier Chastel; Signe Christensen-Dalsgaard; Sébastien Descamps; Morten Ekker; Kjell Einar Erikstad; Alexey Ezhov; Per Fauchald; Geir Wing Gabrielsen; Maria Gavrilo; Sveinn Are Hanssen; Hálfdán Helgi Helgason; Malin Kjellstadli Johansen; Yuri Krasnov; Magdalene Langset; Ivan Mizin; Børge Moe; Tone Kristin Reiertsen; Kjetil Sagerup; Geir Helge Systad; Arnaud Tarroux; Grigori Tertitski; Ekaterina Leonidovna Tolmacheva; Katarzyna Wojczulanis-Jakubas; Hallvard Strøm
**Akvaplan-niva AS, Fram Centre, 9296 Tromsø, Norway*

The Barents Sea, a shelf sea in the European Arctic, is home to a substantial part of the worlds' seabirds and one of the most productive ecosystems worldwide. Seabirds living in this area are exposed to numerous pressures including climate warming, shifting species distributions, invasive species, pollution, and the development and expansion of human activities. All have the potential of severely impacting seabird populations. Here we synthesise the knowledge gained about the Barents Sea seabird community through 8 years of SEATRACK data collection, a program designed to provide representative knowledge on the seasonal distribution of North Atlantic seabird populations. Using several datasets and modelling products developed during the program, we highlight the spatiotemporal dynamics of 11 seabird species within the Barents Sea (Atlantic puffin, black-legged kittiwake, Brünnich's guillemot, common eider, common guillemot, European shag, glaucous gull, herring gull, lesser-black backed gull, little auk, and northern fulmar). Further, seasonally important areas, migration corridors and timings are identified across the seabird community, which highlights potential vulnerabilities to novel and increasing pressures for this species group. Overall, our study highlights the strength of these international collaborative efforts, which enable us to draw general conclusions about the seabird community as well as being valuable for a holistic, sustainable planning and management of this globally important marine area.

SESSION: MOVEMENT AND BEHAVIOUR

Drivers of ocean movement patterns in the Round Island petrel

Kirsty A. Franklin*; Ken Norris; Jennifer A. Gill; Norman Ratcliffe; Simon Butler; Nik C. Cole; Carl G. Jones; Garth Holloway; Simeon Lisovski; Kevin Ruhomaun; Vikash Tatayah; Malcolm A. C. Nicoll
**School of Biological Sciences, University of East Anglia, Norwich Research Park, Norwich, UK & Institute of Zoology, Zoological Society of London, Regent's Park, London, UK*

Migratory strategies can vary within and between populations of many taxa, with potentially important consequences for individual fitness, population dynamics, and conservation. However, the mechanisms influencing which strategies are used by which individuals, and their consequences, are often poorly understood. Here, we use a rare, naturally occurring 'common garden' study system to explore both genetic and environmental drivers of individual migratory strategies in a mixed-species, tropical seabird population. This population of Pterodroma petrels breeds on Round Island, Mauritius in the western Indian Ocean and consists of at least three species: Trindade petrel *P. arminjoniana* originating from the Atlantic, and Kermadec *P. neglecta* and Herald petrel *P. heraldica* from the Pacific, and two- and three-way hybrids of these species. Previous work has revealed striking levels of between-individual variation in at-sea movements and timings, with petrel migrations covering much of the Indian Ocean, while individuals are remarkably consistent in their annual migratory routes and timings. Using geolocator data from over 200 individual petrels, we classify petrel migrations using Bayesian mixtures analysis into nine unique clusters of strategies. Here we will present how individuals within these clusters vary in relation to their genetic make-up (using microsatellite genotype data) and the environmental conditions (monsoon seasons) that they experience. These findings provide insights into the processes through which migratory ranges can form and change, and have important implications for population dynamics and the conservation of migratory species.

Habitat predictability of European shags based on multi-year and multi-colony tracking

Nina Dehnhard*; Jenny Mattisson; Arnaud Tarroux; Tycho Anker-Nilssen; Svein-Håkon Lorentsen; Signe Christensen-Dalsgaard
**Norwegian Institute for Nature Research (NINA)*

Intensified coastal development, e.g. aquaculture, kelp harvesting, fisheries, and ship traffic, poses potential threats for coastal seabirds that call for impact assessments and marine spatial planning (MSP). European shags ("shags"; *Gulosus aristotelis*) breed in colonies scattered along the coastline. Even with existing knowledge about the locations of the colonies, it remains an implausible task to track shags from each colony, although this is highly relevant information for management purposes. Predicting foraging areas of a given population based on the tracking information from birds in other colonies could be a solution to this dilemma.
We analysed tracking data from five different shag colonies in order to assess the transferability of foraging habitat models within and among colonies. Our study colonies were spread along the Norwegian coast over a latitudinal gradient of more than 1700 km. Minimum two and maximum ten years of tracking data collected during the breeding season were available for each colony.
For each colony we identified the foraging areas, extracted their corresponding environmental characteristics (depth, presence/absence of kelp forest, bottom substrate, sst and ssh) and quantified the consistency in habitat use between years (i.e. within-colony transferability). We then predicted the foraging areas of a given colony based on the results from either one or several other colonies (i.e. among-colonies transferability) and compared the modelled results with the factual data to test the performance of the predictions.
Our results show that it is possible to make sound, fine-scale predictions of important foraging areas for breeding shags without having to track birds in every colony. While multi-year and multi-colony tracking studies are a necessary first step, we can now go further and build on such studies to develop approaches that are more suited for long-term and large-scale studies that are required for effective seabird conservation and sound MSP.

Drivers and fitness consequences of the occupancy of breeding sites in the non-breeding season in common guillemots *Uria aalge*

Sophie Bennett*; Mike P. Harris; Sarah Wanless; Jonathan A. Green; Mark A. Newell; Kate R. Searle; Francis Daunt
**UK Centre for Ecology & Hydrology Edinburgh, Bush Estate, Penicuik, Midlothian EH26 0QB & School of Environmental Sciences, University of Liverpool, Liverpool L69 3GP, UK*

Competition for high quality breeding sites in colonial seabird species is often intense such that individuals invest considerable time in site occupancy even outside the breeding season. The site defence hypothesis predicts that site occupancy should be positively correlated with breeding phenology and success such that more successful sites are occupied earlier and/or more frequently. However, few studies test these predictions in populations where non-breeding season site occupancy dominates the annual cycle, limiting our understanding of potential fitness consequences. Even fewer studies investigate drivers and consequences of individual variation in site occupancy in the non-breeding season. We used time-lapse photography, and geolocators and time depth recorders to record non-breeding site occupation and foraging behaviour of common guillemots, *Uria aalge*. We collected data at c.80 breeding sites and for 35 breeding individuals, on the Isle of May, Scotland in three years between October (when birds first return to the colony) and March (the end of the non-breeding season). For each site we recorded subsequent breeding phenology and success. Higher quality sites were re-occupied earlier and occupied more often than lower quality sites. These sites had earlier laying dates and were more successful, supporting the site-defence hypothesis and highlighting fitness benefits of non-breeding occupancy. We then quantified individual variation in occupancy patterns to investigate the substantial variation in time investment in occupancy behaviour, despite the clear fitness benefits. We found that sex was unlikely to be a driver of variation as males and females did not differ in their timing of return to the colony and showed broadly similar distribution

at sea. Following this we investigated whether there is a trade-off between time spent occupying the site and time available for foraging, and the consequences of this for non-breeding distribution and energetics, enabling us to establish individual level costs of this behaviour.

Does personality mediate the reproductive consequences of broad climate phenomena?

Jack Thorley*; Henri Weimerskirch; Stephanie Jenouvrier; Joanie Van de Walle, Samantha Patrick
**University of Liverpool, UK*

Changes in climate can have far-reaching consequences for animal populations through their cascading effects on individual behaviour and vital rates. However, while individual variation in behaviour is expected to mediate the links between climate and fitness, relatively few studies have connected individual variation in behaviour in the form of personality to changes in vital rates and climate in practice, particularly in the marine environment. In this study, we investigate the role of large-scale climatic indices in the Southern Ocean on the reproductive success of an ocean sentinel species, the wandering albatross, and show that the effect of key climate anomalies on reproduction is strongly mediated by personality; with personality differences associated with how individuals forage and thus acquire resources for reproductive attempts. Our results suggest that projected changes in climate may favour bolder birds in the Crozet Island population, who stand to acquire reproductive benefits from their explorative foraging style, at the expense of more exploitative, shy birds. As personality in our population is heritable, our study also emphasizes that direct or indirect selection on personality traits can be potent driver of ecological and evolutionary change, and may provide an important source of adaptive potential for populations.

Balearic shearwaters use spatial cognition to facilitate range shift under climate change

Patrick Lewin*; Joseph Wynn; Tim Guilford et al.
**University of Oxford*

Balearic shearwaters (*Puffinus mauretanicus*) are listed as Critically Endangered due to bycatch-induced mortality, although there has been controversy about their true population size and trajectory. Here, using a decade of tracking data, we investigated the effect of climate change on the post-breeding migration of this species. We find that the shearwaters' non-breeding range is moving rapidly north in response to changing sea temperatures, and we show this shift can be explained by individual plasticity in migratory destination. We demonstrate that shearwaters migrating further compensate by flying faster on the return journey, apparently using memory of the route to estimate their migratory distance. However, despite this compensation, individuals migrating further north still reached the Mediterranean later, potentially disrupting breeding phenology and biasing estimates of population trends. We propose that plasticity in migratory destination may be an underrepresented mechanism of climate-mediated range shifts; that spatial cognition may be important and previously neglected factor in facilitating these shifts; and that longitudinal tracking of known-individuals is an essential tool when studying range shifts in long-lived species.

Is vocal communication a key to coordinated parental care in a monogamous seabird, the Little Auk (*Alle alle*)?

Marion Devogel*; Antoine Grissot; Rozenn le Fur; Dorota Kidawa; Marcelo Araya-Salas; Katarzyna Wojczulanis-Jakubas
**University of Gdańsk, Faculty of Biology, Dept of Vertebrate Ecology and Zoology, Gdańsk, Poland*

While most bird species exhibit bi-parental care, with both parents adjusting theirs workload in respect to each other, still little is known of how this adjustment is achieved. Vocal communication has recently been pointed out as a potential mechanism of such parental care adjustment in songbirds. Here we examine the role of partners' vocal interactions in the parental care of a monogamous seabird, the Little Auk (*Alle alle*). Little Auks' breeding partners share their parental duties equally and in a coordinated manner; during the whole breeding period they frequently meet at the nest and vocalize together, which all together makes it a perfect system for studying the role of vocal communication in parental coordination. Using this system, we investigate whether the temporal and acoustical structure of the partners' vocal interaction in the nest predict its output (relief or not of the incubating partner), and whether they are related to the duration of the previous and subsequent incubation bouts. Our results are the first attempt to answer such questions in seabirds, and we believe they constitute a solid background for both examining the mechanisms regulating parental care and the importance of vocal communication between avian breeding partners.

The use of visual landmarks during homing in a critically endangered shearwater

Lewis C. Fisher-Reeves*; Oliver Padget; Tim Guilford
**Zoology Department, University of Oxford, Oxford, Oxfordshire, UK*

The profound accuracy of avian navigation has intrigued natural historians for many years, and this cognitive feat is displayed no better than during the vast oceanic movements of seabirds. Many Procellariforms frequently travel hundreds of kilometres across open ocean during their natural foraging trips, and yet, are able to return home with incredible precision. For the majority of these journeys, these birds navigate in seemingly featureless environments, flying both above and within fluid mediums, whilst often without the aid of any physical waypoints to infer their relative location. This apparent absence of external positional information has prompted much study into the sensory capacities, and cognitive processes, of seabirds during their navigation, uncovering intriguing insights into their use of far-ranging environmental gradients during these long-distance movements. However, by focussing on these large-scale sensory mechanisms, researchers have left a section of their navigation relatively untouched; this being the use of emergent visual landmarks to improve their navigatory performance during the final stages of homing. During island approach, it is unlikely that these large-scale environmental gradients are of a sufficient resolution to locate the colony site, and so a more localised cue, such as landmarks, may instead be utilised to guide the bird home. Therefore, this study investigates whether the presence of visible landmarks influences the homing abilities of Balearic shearwaters foraging in the Mediterranean Sea. Here, using GPS tracks from free-ranging birds, I analyse the changes in homing performance that arise from increasing land visibility, and assess to what extent the use of these visual landmarks change as a function of varying wind conditions. I report an improvement in route efficiency and goal orientation after high-elevation landmarks become visible during homing. I also discuss the potential cognitive processes and navigational strategies that may underly these findings.

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Poster abstracts

Prey-mediated effects of environmental change on Little Terns breeding in an estuarine lagoon system

Jamie A. Ramos*; Lara Cerveira; Jorge Pereira; Vitor H. Paiva
**MARE – Marine and Environmental Sciences Centre, Department of Life Sciences, University of Coimbra, Portugal*

Climate change and anthropogenic pressures are altering marine food webs and have impacts that influence all trophic levels. Occupying apical trophic positions, terns are suitable sentinels of such changes because they are near-obligate piscivores, spend most of their time foraging and have limited ability to adapt their energy budgets. Here, we examine the role of prey-mediated effects of environmental change in the diet, reproductive and foraging ecology parameters of Little Tern *Sternula albifrons* breeding in an estuarine lagoon system, during a 20-year study (2002-2021). During this period the diet of Little Terns was dominated by sand-smelts (*Atherina* spp., usually > 40% of occurrence in pellets) and gobies (*Pomastochistus* spp. 30-50% of occurrence in pellets), but in some years marine fish species, insects and crustaceans were important in the diet. The annual changes in the proportion of the main fish species taken by adults showed significant positive relationships between: 1) breeding population size and the abundance of age0 sardines, *Sardina pilchardus* in the area; and 2) clutch size and the proportion of sand-smelts *Athrerina* spp. in the diet. Abundance of both sardines and sand-smelts was negatively related to sea surface temperature (SST). Tracking of Little Terns and stable isotopes suggest that, amid many foraging trips to the lagoon system and nearby salt-pans, sporadic foraging trips to the ocean are important for incubating Little Terns. During those foraging trips the birds should target marine prey species, which are of higher energetic value than the estuarine lagoon fish species. This study shows that prey-mediated effects of changes in coastal marine ecosystems may have strong impacts on breeding Little tern populations.

Using an Agent based model (ABM) to predict 3D distribution and behaviour of forage fish around a Tidal Stream Turbine

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Tidal Stream Energy remains largely untapped compared to its estimated global resource. This is largely due to challenges in the consenting process of new devices because of unquantified risks that these devices pose to local wildlife populations. In particular, there is a concern regarding how changes in local hydrodynamics as the result of tidal stream turbine (TST) arrays may affect foraging opportunities for pisciverous marine mammals and seabirds. The 3D behaviour and distribution of forage fish determines its availability to predators and understanding how TST alter school characteristics helps estimate impacts on foraging opportunities. However, previous methodologies used to study impacts of changing hydrodynamics on fish and top-predator populations around TST (e.g., hydroacoustics and subsea videos), have struggled to comprehensively quantify school characteristics across the water column due to the turbulent nature of tidal stream environments and the high flows experienced there. To overcome challenges, and provide insights into potential changes in foraging opportunities, this study applies an agent-based model (ABM) approach to a high-fidelity simulated TST wake, estimating responses of forage fish to installations Initial results will be presented, and indicate areas whereby foraging efficiency for top-predators may be altered, either from changes in school characteristics or anti-predatory responses. We therefore demonstrate the potential to simulate how fish and top-predators interact with a tidal turbine structure at a fine-scale, which can (once validated) be applied to understanding scaling concerns and providing a more accurate assessment of risks for legislators and planners.

Selection acts to increase efficiency in seabird navigation

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Whilst efficient movement through space is thought to increase the fitness of animals moving very long distances, evidence that selection acts upon such traits remains elusive. Here, using geolocator tracks of known-age common terns aged between 3 and 22, we find evidence that older terns navigate more efficiently on migration. By splitting variance into between- and within-individual variance, we find that within-individual navigational ability doesn't improve and the observed effect is better explained by the selective disappearance of less efficient individuals. We suggest that selection, rather than learning, might explain a surprising amount of improvements in navigational performance, particularly amongst older individuals, and that the selective disappearance of navigationally unfit individuals from the breeding population might provide a mechanism by which natural selection might occur.

Individual variation in foraging behaviour in Manx shearwaters (*Puffinus puffinus*)

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Within-species variation in behaviour is increasingly studied for a more detailed understanding of how individual animals interact with and learn about their environment, as well as for its consequences for population ecology and adaptability. Analysis of spatial behaviour is useful for investigating individual behavioural differences as it can be readily quantified using animal-borne devices such as GPS loggers. Manx shearwaters (*Puffinus puffinus*) are long-lived, pelagic, central place foragers undertaking repeated trips across a large familiar area (comprising most of the Celtic Seas for the British and Irish colonies). The Oxford Navigation Group has collected GPS data on Manx shearwaters at the Copeland Islands colony (County Down, Northern Ireland) during the breeding season since 2008, and long-term ringing efforts mean the age of many of these birds is also known. To investigate whether and to what extent these birds develop consistent foraging behaviours, we used this GPS and age data to analyse tracks collected across multiple years from the same individuals, looking at the repeatability of metrics such as trip distance and duration, angle of departure and site and route fidelity. Here we report the results of this investigation into within-individual consistency and between-individual variation, as well as the effects of age and breeding stage on these metrics.

Impacts of fishery closures on foraging African penguins *Spheniscus demersus* and their prey

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Seabird-fisheries conflict has been evident since the 1970s. While there has been much research into the interaction between seabirds and fisheries, it is often difficult to disentangle the true impact of fishing from other factors, such as climate change. A globally-unique fishery-closure experiment off South Africa has provided an opportunity to observe African penguin *Spheniscus demursus* populations and their fish prey (anchovy *Engraulis capensis* and sardine *Sardinops sagax*) with and without the pressure of localised fishing. The experiment, started in 2008, involved two pairs of islands; Robben and Dassen Islands and Bird and St Croix Islands. Fishing within a 20 km radius of one of the islands within the pair is prohibited on a 3-year cycle, while the other continued to be fished. GPS-time-depth loggers were deployed on penguins from Robben and Dassen Islands throughout the fishery closures. Small-scale prey surveys were also conducted within the experimental closure area. Foraging trip duration and path length varied between colonies but there

was no evidence of fishing effect on these parameters. Some aspects of diving behaviour (notably duration and maximum depth) were, however, significantly different between open and closed years. Penguins made deeper dives when fishing was permitted. These results were consistent with data from the small-scale surveys, which showed that fish schools were deeper in the water column when an area was open to fishing. This study shows that pelagic fishing off Cape Town alters the behaviour of prey, and results in changes in penguin foraging behaviour. Repeated deeper dives will likely have physiological and energetic consequences for the penguins, which in turn could impact breeding success and survival. In addition, changes to prey schooling behaviour may influence the foraging success of penguins. Localised fishing pressure appears to be one of multiple stressors contributing to the decline of this endangered seabird.

The foraging distribution of European Storm Petrels (Hydrobates pelagicus) breeding in the southwest of Ireland

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Ireland is an internationally important breeding location for the European storm petrel (*Hydrobates pelagicus*). With a population of approximately 100,000 pairs, Ireland holds an estimated 20% of the global breeding population. The European storm petrel breeds on islands along the entire west coast of Ireland, but the southwest supports 78% of the Irish population. Despite the large population, the European storm petrel is not well studied in Ireland and little is known about their foraging distribution and the factors that make the Irish coast such a favourable location for breeding. In a preliminary study, <1g GPS devices were deployed on European storm petrels from two breeding colonies in the west of Ireland (Illauntannig, Magharee Islands, Co. Kerry and High Island, Co. Galway) and this represents the first GPS tracking of European storm petrels in Ireland. The mean values for foraging trip duration, total distance travelled, and foraging range (maximum distance from the colony) were 38 hours, 518km, and 170km, respectively. One individual performed a foraging trip in excess of 66 hours, travelling over 1100km in the process, and ranging more than 330km from the breeding colony. Individuals from both colonies were recorded foraging at the continental shelf edge, while foraging close to the coast was also evident. Further deployments will be conducted, targeting birds breeding in the southwest of Ireland. Analysis will focus on identifying the extent to which this species interacts with the continental shelf edge, diet, and how these aspects vary within and between breeding seasons.

Identifying connectivity between black-legged kittiwake populations towards enhanced renewable energy development

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A comprehensive understanding of population connectivity in marine species is required for sustainable, ecosystem-based marine spatial planning. The black-legged kittiwake *Rissa tridactyla* is a conservation priority seabird of international importance. Historic analyses demonstrate that kittiwakes emigrate over short and long distances, yet there remains a lack of knowledge of their dispersal and colony source-sink dynamics at differing temporal and spatial scales. This is currently contributing to high uncertainty in Environmental Impact Assessments (EIAs) and Habitats Regulations Appraisals (HRAs) underpinning the planning and licensing of offshore wind developments in the North Sea.
The objectives of this project are, a) to quantify genetic connectivity locally amongst UK colonies and North Sea-wide, in particular those located within Special Protected Areas and Special Areas of Conservation, b) to characterize connectivity between onshore and offshore colonies, and c) to use this information to improve EIAs and HRAs for offshore wind development by reducing uncertainty in metapopulation modelling. We will achieve this by integrating demographic, genetic, and environmental data using hierarchical and spatially explicit Bayesian modelling approaches.

Our overarching goal is to identify, and thus facilitate the protection of, local populations with disproportionate contribution to the establishment and maintenance of UK and North Sea kittiwake colonies. Furthermore, we aim to facilitate appropriate high level management decisions towards protecting colonies likely to interact with future offshore wind developments. The outcomes of this research will have a direct impact on policy laying the foundations for the UK to become a world leader in green energy production.

Seabird eggs as an indicator of chemical pollutants in Irish marine waters

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Chemical contaminants are one of the most pervasive types of anthropogenic pollution and are ubiquitous in marine environments. The primary aim of this study was to determine the suitability of using seabird eggs as a bioindicator of pollutants in Irish marine waters. Four seabird species were selected for this study, Northern Gannet *Morus bassanus*, Common Tern *Sterna hirundo*, Arctic Tern *S. paradisaea* and Common Guillemot *Uria aalge*. Pollutant levels were measured in each egg and differences in concentrations between colonies compared. Pollutants analysed include polychlorinated biphenyls (PCBs), polybrominated diphenyl ethers (PBDEs) and other organochlorine compounds (OCs) as well as a suite of metals and contaminants of emerging concern. Stable isotope ratios of carbon (δ13C) and nitrogen (δ15N) were measured in each egg to explore the influence of diet and trophic position on contaminant levels detected.
Comprehensive baseline information on legacy pollutant concentrations in the eggs of each seabird species was determined in this study. Spatial differences were detected in each species with generally elevated concentrations of pollutants in eggs from the Dublin coast in the Irish Sea, most likely a result of the close proximity of colonies to Ireland's industrialised capital city. Pollutant levels in Irish seabird eggs are below most toxic thresholds for bird eggs and were within the lower end of the range of values for similar species reported worldwide. When compared to historical data, levels of DDT and PCBs in Guillemot and Common Tern eggs from Ireland have decreased over time according to this study, in concurrence with worldwide trends. All seabird species were shown to have potential as a bioindicator of marine pollutants in this study. This study provides essential information and recommendations that will inform potential monitoring programmes that can help Ireland achieve good environmental status under the European Union's Marine Strategy Framework Directive (MSFD).

Combining multiple sources of evidence to quantify the spatial and temporal dynamics of seabird prey fish in the North Sea

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During the breeding season seabirds are central place foragers and are critically dependent on the distribution of certain key prey fish species such as sandeels. In the North Sea populations of both seabirds and their fish prey have declined over the past 20 years. It has been shown that seabirds have been declining due to breeding season prey shortages. However, the reasons for the declining fish populations have been harder to understand. Prior to the population declines in the early 2000s sandeels were the largest single species fishery in the North Sea and overfishing and resource competition remain major concerns. To investigate the mechanistic role of overfishing on sandeel populations, a better understanding of predator-prey relationships is needed, which requires detailed prey distribution models. ICES DATRAS fishery-independent trawl surveys were combined into a single database covering the entire Greater North Sea. Newly available HERAS acoustic surveys were also available for sprat and mackerel. Using this database, we applied relatively novel Bayesian

spatial modelling techniques using R-INLA, which is a fast and efficient method to fit a Bayesian model using the Stochastic Partial Differential Equations (SPDE) approach. This method accounts for spatial and temporal autocorrelation and allows the estimation the fine scale spatial-temporal distributions of small pelagic fish biomass across the entire North Sea. This will then feed into the next stage of the project, to model seabird consumption rates using multi-species functional response models to quantify the predator-prey relationship at varying prey densities, as well as providing a public data product freely available to other research projects studying the North Sea pelagic ecosystem.

The role of individual variability on the predictive performance of machine learning applied to large bio-logging datasets

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Animal-borne (bio-logging) tags generate large and complex datasets. Specifically, accelerometer tags, which provide information on behaviour and energy expenditure of wild animals, produce high-resolution multi-dimensional data, and can be challenging to analyse. The need to efficiently extract information from these datasets inspired the development and use of Artificial Intelligence (AI) tools in ecology. We tested how commonly used AI tools performed on datasets of growing complexity, with individual variability inherently recorded for large numbers of individuals. To explore these broad research questions, we use accelerometer data collected over two breeding seasons from two species of penguins foraging in different environments as a case study: Adélie penguins (*Pygoscelis adeliae*) and little penguins (*Eudyptula minor*). We follow four main computational steps. (1) We first use an unsupervised machine learning approach to quantify the individual variability in behaviour across the datasets within seasons. (2 and 3) By randomly selecting parts of the datasets, we then include such variability in training datasets fed to a supervised approach and test its predictive performance and agreement with the unsupervised approach. For Adélie penguins, for which energetic validation is available, we compare energy expenditure estimates (4), resulting from the behavioural activity budgets estimated by both unsupervised and supervised machine learning approaches. Classified behaviours were transferable across individuals within the same population with high agreement between AI tools (> 80%) and minimal differences in energy expenditure estimates. However, 2-10% of the data had lower agreement (< 70%), indicating higher confusion. We advise the broad scientific community approaching these large datasets to be cautious when upscaling predictions, as this might cause variation in estimated behaviours and energy expenditure.

Inclusion of density dependence affects population viability analysis outcomes in multiple seabird species

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Population viability analysis (PVA) is a well-used tool in assessing anthropogenic impacts on population dynamics, and is commonly used to quantify threats to seabirds. However, impact assessments for seabirds using PVA typically do not include density dependent regulation despite evidence for its presence in multiple species. This is because the strength and direction of density dependent regulation is considered to be poorly understood. Here we quantify the strength of density dependent regulation of breeding success in 31 populations and eight species of seabird breeding in the British Isles using 10 different formulations to describe density dependence. We then use PVA to examine which formulations of density-dependence most accurately describe the observed population change, and how different formulations affect PVA predictions of the population response to a

theoretical impact scenario. We find evidence of positive and negative density dependent regulation that varies in strength and direction within and between species. While some formulations of density-dependence provide a better fit to the observed data across several populations, results are not consistent. The projected population response also differs with the formulation used to describe density dependence. Our results show that the most appropriate way to measure and include density dependent regulation in PVA varies within and between seabird species, such that a project specific approach using local population demographic data would be ideal to facilitate confidence in density dependent PVA outcomes. We clearly demonstrate that the inclusion of density dependence in PVA will provide more realistic assessments of risk for fast developing marine industries, such as offshore renewables.

Black Guillemot (*Cepphus grylle*) foraging ecology in relation to planned Marine Protected Areas within Northern Ireland and the Republic of Ireland

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The Black Guillemot (*Cepphus grylle*), is the only UK seabird included as a feature of the Marine Protected Areas (MPAs) network as it does not qualify as a Special Protection Area (SPA) feature. While Northern Ireland has one Marine Conservation Zone (MCZ) designated for Black Guillemot, further cross border MPAs with the Republic of Ireland are being planned. Currently little is known about the habitat use and movement ecology of Black Guillemots, and addressing these gaps is essential to the conservation management and protection of this species.
Tracking of breeding adult Black Guillemots using GPS and GPS/Temperature Depth Recorder (TDR) tags was conducted to quantify distribution and habitat use at two sites in Northern Ireland during the 2021 breeding season.
Birds were found to remain close inshore (<5 km) in relation to their breeding colonies and used distinct and individualistic foraging areas. Through the combination of GPS and TDR records, maximum dive depths were observed to correspond with seafloor depth profiles, indicating benthic foraging behaviour. Therefore, environmental characteristics of the seafloor including bathymetry, oceanic kinetic energy and substrate were examined in relation to areas used for foraging. Characteristics selected were often found to be individual- or colony-specific. Inter-individual variation was most frequently seen in relation to kinetic energy and substrate. Overall, birds from both colonies foraged within the infralittoral (<10 m) and shallow circalittoral (10¬ to 30 m) bathymetry zones, despite greater depths being available.
We discuss how these novel insights into Black Guillemot foraging ecology may be applied to MPA management. We highlight the future research required to better understand fine scale habitat use in benthic foraging seabirds.
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Atlantic puffins as a model for visual and social communication research

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Seabird breeding colonies are perfect environments to study animal social interactions. Many species are long-lived and philopatric, presenting the opportunity for stable long-term relationships between neighbours. Yet, we know very little about how localized interactions are mediated. Our research lab, which specializes in visual ecology, is mainly focused on investigating visual and social communication in Atlantic puffins (*Fratercula arctica*). Unlike many colonial seabirds, Atlantic puffins are relatively non-vocal, at least during the day. However, their colourful bill and rosette display several features (grooves, ridges, changes in colour) that could allow for individual recognition and thus mediate social relationships. This presentation will introduce our research group to the international seabird community by giving an overview of our activities over the last three years. By taking pictures of hundreds of individuals in 'visible' and ultraviolet light to produce model of how puffins would perceive one another, we now have solid evidence that bills are sufficiently variable to be considered unique and could thus be used for individual recognition. By introducing stuffed models to colour banded individuals, we are now intent on determining which aspects of the bill are necessary for individual recognition. In a colony of several thousand birds, individuals will only regularly interact with relatively few others. Using colour banding and proximity loggers, we are currently investigating the social networks of a targeted long-term plot. We have first focused on identifying the size of the average network, and are now looking into understanding how age, sex, and the physical landscape influences such networks. By answering questions pertaining to individual recognition and social structure, we will be positioned to determine how information travels through local areas of the colony, and how individual personality mediates collective behaviours.

Pre-laying Behaviour in a Procellariiforme Seabird

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Despite developments in biotelemetry providing insight into the annual migratory behaviour of pelagic seabirds, the period between migration ending and the egg being laid is relatively unexplored. For many monomorphic procellariiformes, the only notable sex differences in foraging behaviour occur pre-laying. Females typically take an extended foraging trip prior to laying; the pre-laying exodus. It is unknown whether exodus foraging is for specific resources for egg building, such as prey of higher calcium content, or whether it is to restore general condition. Meanwhile, pre-laying males frequently visit the colony, most likely to defend and maintain the burrow. Although males are without the energetic demands of producing an egg, they often take the first incubation stint. Therefore they too must forage pre-laying in order to build up sufficient reserves to remain on the egg for an extended period. However, as males undergo central place foraging during the pre-laying period, they may not have access to such high-quality feeding patches as females. Using a combination of geolocator (GLS) and dive loggers (TDR) deployed on pre-laying Manx shearwaters, this study will investigate sex differences in pre-laying foraging behaviour, comparing both spatial parameters and dive behaviour. We will also look for egg-specific foraging by comparing female behaviour during exodus to that of other pre-laying trips. We will then investigate individual variation in female pre-laying behaviour and its correlative impact on measures of breeding quality; egg weight and chick peak mass. With oceanographic conditions undergoing climatic changes, if foraging during pre-laying is critical towards successful breeding and requires specific resources or area usage, it is important to fully understand. Using a combination of biotelemetry and field data, this study will provide a novel exploration of both sex and individual differences in pre-laying behaviour in a procellariiforme seabird.

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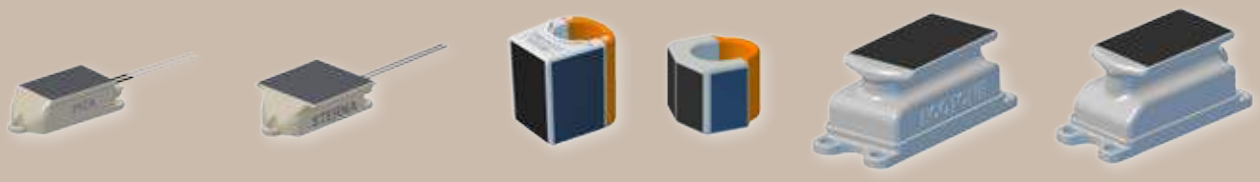

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Using GPS-accelerometry to track energy expenditure in a breeding seabird

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Reproduction is a costly event for many animals, especially birds which must deliver food to a central place. Measuring energy expenditure over the length of the breeding season can provide valuable insight on physiological limitations, for example; by highlighting periods of high demands and identifying when physiological overload might occur. Doubly-labelled water (DLW) has been widely used to assess energy expenditure in wild animals, but requires multiple recaptures at fixed intervals and only provides a single, average value for energy expenditure. Animal-borne devices offer the opportunity to measure energy expenditure at different time scales. Here, we developed a novel DLW-accelerometry calibration to measure energy expenditure in black-legged kittiwakes (*Rissa tridactyla*). Kittiwakes varied their time-activity budgets throughout the breeding season by increasing time spent in flight in chick-rearing compared to both incubation ($p = 0.0002$) and pre-laying ($p = 0.009$). Although time-activity budgets were comparable across pre-laying and incubation, kittiwakes increased significantly their energy expenditure in incubation ($p = 0.02$), averaging and 752 ± 36 kJ d-1 in incubation and 623 ± 33 kJ d-1 in pre-laying. Using measurements of energy expenditure, we created a calibration for time-activity budgets of kittiwakes. The calibration produced will facilitate estimation of DEE using only GPS-accelerometers, reducing the impact on animals, researcher effort, and expense relative to traditional DLW methods. Using broad behavioural categories, time-activity budgets can be easily obtained from free-ranging individuals to accurately track energy expenditure of wild seabirds in response to behavioural and environmental changes.

Links between population trends and non-breeding foraging conditions in thick-billed murres in the Atlantic Arctic

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The thick-billed murre (*Uria lomvia*), is an abundant pan-Arctic seabird, but several Atlantic breeding populations are rapidly declining. There is a clear relationship between over-wintering areas and population trends. All murre populations wintering around Iceland and off southwest Greenland are declining, whereas populations wintering off Labrador and Newfoundland are relatively stable. This pattern suggests that conditions in the different wintering areas play a crucial role in the population decline. Murres are hunted in winter in these areas, but a new study shows that hunting pressure alone cannot explain the observed decline. Large oceanographic changes (in temperature, strength of currents etc.) are occurring in the North Atlantic, both natural cycles and directional changes driven by global warming. Murres are deep-diving seabirds that rely on a year-round supply of high-energy pelagic prey, mainly small schooling fish and large crustaceans. These prey items are highly sensitive to changes in the marine environment, such as increasing temperatures or stronger stratification of the water mass.
We deployed time-depth recorders over winter on thick-billed murres breeding at colonies in Svalbard, Iceland, Greenland and Canada, but with distinct overwintering areas, to investigate the impact of non-breeding environmental conditions on their foraging behaviour and energetics. In particular, we use detailed data on diving behaviour to investigate spatial variation in foraging patch quality (i.e. food availability) in the non-breeding areas. Based on this, we assess whether differential access to high quality prey patches among non-breeding areas is linked to overwinter survival, and thus can help explain observed population trends.

Urban and coastal breeding lesser black-backed gulls (*Larus fuscus*) segregate by foraging habitat

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Despite urbanisation's general erosion of biodiversity, towns and cities provide novel opportunities for some species. During the 20th century, gulls (Laridae) colonised urban areas around the world where they flourished. At the same time, some coastal populations declined. Reasons for this difference are not fully understood, partly because little is known about any ecological differences between urban and non-urban gulls such as their foraging ecology. Here we compare the movement ecology and habitat selection of lesser black-backed gulls (*Larus fuscus graellsii)* breeding at two neighbouring colonies – one urban and one coastal. We use bird-borne GPS loggers to first compare colony-level movement behaviour and habitat selection and then investigate individual-level habitat use. We observed clear colony-level habitat segregation - urban breeders preferentially foraged in urban areas while coastal breeders foraged primarily in coastal habitats and avoided urban areas. Coastal breeders also had larger foraging and home ranges than urban breeders. However, we also found inter-individual differences in habitat use which may have important management implications. These findings reveal a link between nesting and foraging ecology and thus management or environmental change altering food availability will impact urban and coastal gulls differently.

Seabirds and climate change in Europe: what are the problems? What are the solutions?

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Seabirds, like many species across the globe, face unprecedented levels of threat to their long-term survival due to the direct and indirect impacts of climate change. In addition to several novel threats, climate change is exacerbating the many existing threats for species survival including prey loss, habitat loss, over exploitation of resources and the impacts of invasive species. There is an urgent need for researchers, the conservation community and policy makers to align efforts in order to prioritise and implement evidence-backed climate change adaptation practices to safeguard the future for the most vulnerable species before it's too late. However, information on climate change vulnerability and the effectiveness of potential conservation actions are yet not strategically collected or collated; although we understand many of the threats that species face from climate change, there is little information available regarding conservation actions that could mitigate their impact. This disconnect between threat level, ecological research and conservation practice is reducing opportunities to guide decision-making, and ultimately hinders effective conservation decision-making. Our project aims to collate vital information on the vulnerability of individual species to climate change and compile evidence-based assessments of the effectiveness of various conservation actions for marine birds in Western Europe. It seeks to identify priority seabird species for conservation attention in the face of climate change, formulate and share best practice guidelines based on a robust evidence-base to safeguard their future. In this talk I will discuss how we assess the vulnerability of seabird species to climate change, how we identify and assess potential conservation actions, and how we plan to use these guidelines documents to aid conservation of seabirds.

Use of geolocators for investigating the breeding ecology of a rock crevice-nesting seabird, the Little Auk, *Alle alle*

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Seabirds play a major role in both marine and terrestrial ecosystems and are commonly used as indicators of the environmental quality of oceans. The harsh environment seabirds encounter imposes bi-parental care and flexibility in parental involvement, needed to ensure successful breeding, making their breeding ecology an interesting study case. Seabirds are however, particularly hard to study as they spend most of their time at sea beyond the reach of researchers. Modern technology greatly helps to fill gaps in our knowledge of seabird ecology, thanks to devices that remotely collect data on movement and behaviour. One such device, the miniaturised light-based geolocator or GLS, is primarily used to document seabird movements and wintering grounds but extra sensors now enable us to record their activity (e.g. flight or swimming) and foraging patterns, an important factor in studies of breeding behaviour. In this study, we developed a method to study otherwise invisible behaviour in the nest chamber of a rock crevice-nesting seabird the Little Auk, *Alle alle*. We used GLS data to identify key activity within the breeding period (egg incubation, chick brooding and feeding) and to quantify breeding behaviour and parental care. We validated the method by comparing it to a well-established video recording method and considered it to be reliable to study parental care. We also assessed behavioural and fitness consequences of GLS deployment and found short-term effects on bird behaviour but no effect on reproductive success.

Do Adélie penguins care about boundaries? Spatio-temporal consistency in the wintering behaviour of Antarctic sentinel species – implications for conservation

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In polar regions, temporal variability in the ice sheet may trigger yearly shifts in seabird movements and behaviour as an adaptation to changing environments. Thus, assessing this feature is crucial to evaluate possible threats. We evaluated spatio-temporal consistency over 5 years in the wintering behaviour of Adélie penguins using geolocators with wet/dry sensor. We tracked 62 individuals from Ile des Pétrels (Terre Adélie, East Antarctica) to characterize their wintering foraging grounds and activity patterns. After breeding, individuals moved westward and started the moult on average on March 7th, lasting 15 ± 3 (mean ± SD) days. Migratory movements were mostly longitudinal and bounded by the 60°S latitude, reaching up to 1 600 km from the colony between July-August. Wintering grounds encompassed vast areas (50% kernel utilization distribution: 360 871 ± 18 700 km2). Inter-annual overlap values indicated high spatio-temporal consistency (Bhattacharyya's affinity index: 0.82 - 0.96 among all years). Individual activity budgets varied throughout the winter, but foraging was mostly restricted to daylight. Daily time spent on water was the shortest around the winter solstice (June, 5.6 ± 1 h), and increased with daylength towards the end of the wintering period (September, 11.2 ± 1.6 h). At medium-temporal scale (5 years), individuals spent a relatively small proportion of the winter time within the proposed D'Urville Sea-Mertz Marine Protected Area (DUSM MPA), as a 12.3 ± 18.9 % of individual locations were within this area. Our results highlight the need to consider multiyear tracking datasets to properly assess the appropriateness of proposed MPAs, and call to extend DUSM proposal to protect Adélie penguins in the critical winter period. More generally, the high inter-annual consistency found might imply species' vulnerability in the face of climate change. Overall, our work provides a key knowledge to conservation and policymaking in the Antarctic region.

Cross population comparison of migration strategies in a declining oceanic seabird

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Long-distance migratory seabirds occupy wide ranging locations across the annual cycle where they can encounter a range of different conditions and pressures. When individuals from different breeding populations mix during migration, they encounter similar conditions and pressures that may impact the demographic rates, and therefore population trends, of multiple breeding populations.
Using geolocators we explored the migration strategies of a long-distance migrant, the Arctic Skua *Stercorarius parasiticus* from multiple breeding populations in the northeast Atlantic - Faroe Islands, Norway, Scotland and Svalbard - between 2009 and 2019. Arctic Skuas are classified as Vulnerable on the European Red List due to recent severe declines in breeding populations. Although we have some understanding of pressures during the breeding season, very little is known about population and individual variation in migratory routes and behaviour, and therefore pressures that Arctic Skuas may also face during migration.
The majority of the deployed geolocators recorded saltwater immersion data, which we used to identify transit flights and stopovers. Using data retrieved for 244 tracks from 132 individuals, we explored individual and population variation in migration strategies and routes, as well as migratory connectivity between major staging areas. We highlight the importance of understanding a species distribution during migration to help understand population declines and where to direct conservation actions outside the breeding season.

Investigating the impacts of offshore wind developments on cliff-nesting seabirds

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Reducing carbon emissions through the development of offshore wind is crucial in tackling the climate crisis, but it is vital that such developments are designed to function in harmony with nature. Offshore wind can impact seabirds through collision, disturbance, and habitat loss, by blocking important flight pathways and loss of access to foraging areas which may increase mortality and reduce breeding success. However, considerable uncertainty exists around the nature and extent of these impacts, so research and monitoring has been urgently needed.
There are four offshore wind developments consented in the Forth and Tay region. The RSPB, in collaboration with UKCEH and Bioss, was commissioned by the developers to understand potential impacts at the potentially impacted SPAs, St. Abb's Head to Fast Castle, Forth Islands and Fowlsheugh. The work is supported by the Forth and Tay Regional Advisory Group Our key questions are:

- Is there evidence for impacts?
- Are affected individuals from colony SPAs?
- Are there consequences on SPA populations?

Our methods took a three-pronged approach:

1. We completed a review of the seabird demographic data available for the two of the SPAs. Working with reserve managers, all available historic data was collated, digitised and cleaned.
2. Enhanced monitoring: Existing productivity monitoring and population counts were enhanced for Kittiwakes, Guillemots, Razorbills and Fulmar to bring monitoring at both SPAs in line with the Isle of May and improve comparability across all sites.
3. Tagging Kittiwakes: GPS tags were deployed on Kittiwakes to gain a detailed understanding of their three-dimensional movements, and to investigate their likely interactions with and impacts by the consented offshore wind developments.

This is projected to be a five-year project. Here we present initial results for the baseline surveys and describe how this comprehensive monitoring package is a direct result of collaboration between scientists and stakeholders.

Global best practices for marine wildlife surveying to inform marine renewable energy developments

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Marine wildlife surveying has significantly evolved alongside the marine renewable energy industry, from traditional boat-based surveys, through visual aerial surveys to digital aerial still surveys, which are now the leading survey methodology in most territories worldwide. Digital aerial still surveys for marine wildlife have developed rapidly over recent years in line with advances in technology, and greater knowledge of how the data will be supplied and used. Many of these developments have been instigated to meet the needs of the marine renewable energy industry, particularly offshore windfarm (OWF) developments, to allow assessment of potential impacts to birds and marine mammals, driven by the requirement for advancement in the knowledge base for both developers and conservation bodies in order to determine the scale of impact on the environment.
APEM have created a best practice approach to marine wildlife survey design that has been developed with more than 15 years of practical experience and through completion of more than 2,000 surveys. The ultra high-resolution still imagery acquired during digital aerial surveys enables the highest identification rates to species level for birds and marine mammals recorded, producing a data set that can be used for statistically sound analysis. APEM's global best practices will be discussed from projects in the UK, Europe, USA, Vietnam and Australia, and will cover data acquisition, presentation and interpretation. Moreover, we will look at the differences in survey design and how these are employed in different situations, including wide area surveys, baseline studies, and platform surveys to inform permitting, post-consent (pre-, during and post-construction) studies, as well as custom designs, to answer specific questions on issues such as protected site connectivity, collision risk, avoidance and displacement, and colony counts.

Foraging ecology of two sympatric sister storm-petrels isolated through phenological divergence

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Phenological divergence between sympatric populations, known as allochrony, is increasingly recognized as an important evolutionary process that may lead to speciation. One taxa in which this type of speciation has frequently occurred are the Northern storm-petrels (Hydrobatidae spp.). In this study, we described the phenology of the Townsend and Ainley's storm-petrel in detail, analyzed their spatial and trophic ecology, and studied the environmental variation that might explain the foraging patterns. For doing so, we monitored nests, tracked birds with GPS. We found that the timing of breeding of both populations does not overlap, with few Townsend storm-petrel's fledgings still present at the colony at very start of the Ainley's storm-petrels incubation period. We also found certain spatial segregation between both species, equivalent to the segregation between the areas used during incubation and chick-rearing within each species. The duration of the trips of Ainley's storm-petrel were shorter, despite the covered the same distance than Townsend's storm-petrel, which might be explained by the fact that Ainley's face longer nights (up to 4 more hours) when breeding. Next steps involve to conduct DNA barcoding analyses of the feaces for both species, to

understand the resources obtained in each area, and the analysis of the overlap of the non-breeding areas through the data obtained with geolocators.

Estimating Connectivity and vulnerability in a seabird population

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Due to a lack of empirical estimates of connectivity, impact assessments of effects to seabird populations are often modelled as closed, when in fact some species we know operate as metapopulations. Using modelling techniques and empirical colony data, we provide a method for quantifying connectivity in Black-legged kittiwakes in Shetland, Scotland. By applying mortality scenarios in meta and closed population viability analysis (PVA), we indicate outcomes for populations under hypothetical threat between traditional closed and estimated metapopulation assessment methods. Our results confer recommendations and implications for assessments and for conserving vulnerable species.

Method for defining appropriate Acceptable Levels of Impact from offshore wind farms on bird populations

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Effects of offshore wind farms on bird populations are currently assessed using relatively simple thresholds like the ORNIS 1% criterion and the Potential Biological Removal (PBR). These methods are easy to apply and understand but come with limitations. Population models help to gain more insight into the current expected population trajectory and the effect of additional mortality. So far, there was no threshold for assessing the outcome of population models, potentially resulting in subjective decisions.
We developed a novel method to determine thresholds for acceptable levels of impacts (ALIs), which can be assessed using matrix population models. In our framework, the threshold ALI is formulated as:
The probability of a population decline of X% or more, relative to an unimpacted population, 30 years after the onset of a continuous prolonged impact, cannot exceed Y.
The species-specific values of X and Y can be determined using our framework.
The maximum acceptable decline (X) is based on the IUCN Red List status. Using the species-specific generation time, this relative reduction is scaled to a period of 30 years, in accordance with the ALI definition.
The X threshold can be violated even in the scenario without impact due to uncertainty in demographic rates. Within our approach, we consider the relative cause of violation (impact versus uncertainty). The Y-threshold is the acceptable probability of violating X, and is based on the acceptable species-specific risk as well as the uncertainty in the unimpacted scenario.
The choice of specific values for X and Y are made in the policy domain. The framework helps policymakers to determine species-specific thresholds based on a.o. status assessments, ecology, population trends, threats and uncertainty and/or potential for compensation.
Re-evaluations should at least take place when new European status reports are published or other relevant new knowledge becomes available.

The energetic trade-off between immunity and behavioural complexity

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Energy is a finite resource, and allocation towards different physiological processes may trade-off, hence life history is constrained by energetics. Foraging is required to gain energy, yet the act of foraging itself is costly. Foraging behaviour is also known to vary on a spectrum from deterministic to stochastic, which can alter the likelihood of prey encounter rates. With more complex stochastic behaviour thought to be biologically adaptive in heterogeneous patchy environments where they can enhance the probability of resource encounters. There is also evidence that stressed or immune compromised individuals display more deterministic behavioural sequences. Using fractal analyses of behavioural sequences it is possible to quantify the variation in foraging complexity and understand how variation in behaviour relates to extrinsic stressors. The immune system is essential in protecting an organism against disease-related mortality, and can also impose various physiological costs. While the energetic costs of immune function are well-established, few studies have linked foraging complexity to immune function.
Using a free-ranging population of breeding Adélie penguins, we investigate whether the energetic cost of foraging complexity constrains the ability to invest into immune function. We use Doubly Labelled Water to estimate energy expenditure, and fractal analysis on dive sequences as a measure of individual temporal foraging complexity. We measure three different immune function markers, collected concurrently with energetic measurements. This provides a unique understanding of the trade-off between two essential facets of life-history; investment in self-maintenance in the form of immune function, and foraging behaviour and complexity to optimise energy and nutrient input, necessary for reproduction. This mechanistic approach allows us to understand the interaction between physiological constraints and environmental limitations. Quantifying traits in a common currency, we can gain more insight into how energy is allocated and partitioned to different behaviours and processes to understand how life-history decisions are made.

Effects of two GPS logger types on foraging behaviour and breeding performance of kittiwakes vary between colonies

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Biologging is now widely used in ecology, providing unprecedented insight into movement behaviour, space use and physiology. However, an important consideration for biologging studies is the potential for negative device effects on study animals, since such effects can have implications for both animal welfare and data representativeness. The importance of minimising device effects on birds is increasingly recognised, yet their impact on different aspects of behaviour and demography and how this impact varies between populations is poorly understood.
A powerful approach of quantifying device effects on behaviour and productivity is to deploy loggers of different size on two sets of individuals and undertake observations in comparison to controls. We used this approach in kittiwakes from three colonies in eastern Scotland. We deployed 89 Pathtrack nanoFix-GEO+RF loggers (ca.4g, attached to tail) and 40 UvA-BiTS loggers (ca.9g, attached to back) on breeding adults and compared parent changeover rates (a proxy of foraging trip duration), chick attendance and productivity at nests where one parent was GPS-tagged and at control nests. We also compared foraging trip metrics (duration, distance, range) and at-sea distribution between Pathtrack and UvA-tagged birds.
Parent change-over rates and chick attendance were lower at 'UvA' nests compared to 'Pathtrack' and control nests. However, the strength of these effects varied markedly between colonies. Overall, productivity of GPS and control nests did not differ; however, at one of the colonies, 'UvA' nests tended to fledge fewer chicks. Device effects on at-sea behaviour accorded with these results, with

UvA-tagged kittiwakes making longer trips and showing core distribution further offshore compared to Pathtrack-tagged birds at one colony. Our findings reveal between-colony variation in the strength of device effects and highlight the value of detailed behavioural studies of seabirds carrying different devices to understand the potential impact of such variation on the representativeness of tracking data.

Personality and parental investment: the impact of pair members' boldness on foraging and nest shift patterns in a long-lived seabird

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Animal personalities, defined as behavioural differences that are consistent over time and between contexts, may be influential in determining individual reproductive strategy. Long-lived seabirds take turns to attend the nest. The nest-bound parent is dependent on their partner's return from foraging before they can themselves depart. An individual's personality may influence its foraging behaviour and hence the duration of its foraging trips. Consequently, whichever parent is nest-bound during incubation or chick-brooding may be impacted by their partner's behaviour, so the personality of both pair members may interact to determine their collective parental behaviour. This interaction has yet to be explored. Using VHF technology, we quantified the foraging trip and nest attendance patterns of arctic dwelling black-legged kittiwakes (*Rissa tridactyla*). These lightweight, non-invasive tags permitted the repeated measurement of both pair members' behaviour across multiple breeding stages, allowing us to examine within-season changes in individual parental behaviour. First, we investigated the impact of boldness (response to a novel object) on the duration of individual foraging trips (i.e. time at sea) and nest shifts (i.e. time on the nest), thereby considering how personality impacts an individual's own parental investment. Secondly, we explored the impact of partner boldness on individual decisions, to test if one partner's personality (i.e. the foraging or nest-bound bird) held greater influence over collective parental behaviour. It is anticipated that both partner's personalities will be influential in driving parental care behaviour, and that these effects will be stronger in incubation. We discuss the importance of personality in mediating individual and pair-level decision-making, and suggest how different personality phenotypes may lead to intraspecific variation in the lifetime division of parental investment. We also demonstrate the value of VHF tagging during data collection and show how it can be applied to measure long-term changes to parental care throughout the breeding season.

Detailed case report of puffinosis in a Manx shearwater

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Puffinosis is an infection of a range of seabirds characterised by dorsal and ventral blistering of the webbed feet that progresses to dry necrosis, conjunctivitis, leg spasticity, paralysis and death. It is most associated with Manx shearwaters (*Puffinus puffinus*) frequently affecting chicks within their damp underground nesting burrows. The aetiology of the disease is unclear but has been attributed to a type 2 coronavirus associated with Neotombicula mites as a potential vector. However, there is some uncertainty given potential contamination with mouse hepatitis virus and failure to fulfil Koch's postulates with birds infected with isolates remaining healthy. We describe a detailed case report of puffinosis in a Manx shearwater covering necropsy, histology, bacteriology and, metagenomics, including viral sequencing. We found no evidence of viral infection. Our results are consistent with an entirely environmental aetiology resulting from faecal ammonia in damp burrows causing conjunctivitis and foot dermatitis breaking the skin allowing common soil bacteria (e.g., Flavobacterium, Staphylococcus and *Serratia* spp., *Clostridia perfringens* and *Enterococcus faecalis*) to cause

opportunistic infection debilitating the bird. Pain associated with infection may have reduced foraging causing, a decline in body condition, dehydration and death. A similar condition has been reported in broiler chickens attributed to high humidity and poor environmental conditions preventable by adequate ventilation and husbandry. This is consistent with puffinosis being common in nesting burrows in tall dense vegetation but largely absent from those in well-ventilated open grassland. Our proposed aetiology accounts for the non-epizootic prevalence of disease, spatial variation within colonies, and higher frequency in chicks which are restricted to the nesting burrow.

Factors influencing mercury levels in Leach's storm-petrels at northwest Atlantic colonies

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Mercury (Hg) is a globally distributed, toxic metal which has negative effects on wildlife. Its most toxic form, methylmercury (MeHg), is predominant in aquatic systems. Marine top predators such as seabirds are subject to high levels of MeHg contamination, but these levels can vary widely among individuals and populations. Factors contributing to variation in Hg contamination among marine birds are not well understood. Leach's storm-petrels (*Hydrobates leucorhous*) have elevated levels of Hg but its role in storm-petrel population declines in unknown. In this study, we evaluated (1) patterns in THg concentrations from eggs among five northwest Atlantic colonies in relation to stable isotopes, (2) patterns in Hg concentrations in blood samples from breeding Leach's storm-petrels in relation to stable isotopes, and the relationship between THg exposure and reproductive success, and (3) how foraging conditions influence THg levels by assessing associations between blood THg values and spatial data from global positioning system loggers. We found that Hg concentrations increased with increasing colony latitude in blood, but not in eggs. Mercury concentrations in both egg and blood were positively correlated with δ34S, emphasizing the role of sulfate-reducing bacteria in the methylation of THg acquired through the marine food web. By associating tracking data from foraging trips with THg from blood, we determined that mean ocean depth at intensive search locations was positively correlated with blood Hg levels. These results suggest that spatial variation in THg concentrations observed in Leach's storm-petrels results from varied foraging strategies, at individual and colony levels. Despite such variation, we found no direct effect of THg on breeding performance. As one of the few pelagic seabird species breeding in Atlantic Canada, Leach's storm-petrels can be used as a biomonitor for less sampled offshore pelagic regions. The global trend in Hg emissions combined with legacy levels warrant continued monitoring.

Census and Productivity of Northern Gannets (*Morus bassanus*) on Great Saltee using Two Aerial Survey Methods

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Frequent censusing of colonial seabirds at their breeding sites is vital for understanding population trends and informing effective conservation efforts. Further monitoring of population dynamics including breeding success may also reveal responses to changing environmental conditions. The Northern Gannet (*Morus bassanus*) is an excellent model for biomonitoring due to their conspicuous colonies and high abundance; a species emblematic of the North Atlantic coastlines. However, such surveys have been conducted at decadal scales. Here, I report the results of an updated census at the third largest gannet colony in Ireland, Great Saltee island using two aerial photography methods; an oblique, low-elevation unmanned aerial vehicle (UAV) survey, and a high-elevation manned aircraft survey where images were taken directly above the colony. The number of Apparently Occupied Sites (AOS) in the 2021 breeding season was estimated as 5,035 – 5,532, highlighting continued growth of 0.86 – 2.14% p.a. since the previous census. Chick abundance was estimated as 2,019 – 2,441,

representing a breeding success of 40% – 44% across the colony, markedly lower than the ~ 70% reported in other gannet colonies across the range. Significantly higher breeding success was also noted at nesting sites in the centre of the colony, compared to nests at the edge. While the population has increased, the low breeding success suggests the Great Saltee gannet colony may experience a decline in the near future due to reduced production and recruitment of juveniles to the breeding population. Time-series data is required to determine whether the observed low breeding success is a regularly occurring phenomenon. Protective measures to reduce human disturbance during the gannet breeding season may be required to improve breeding success.

Local ecological knowledge about a traditional game bird in Greenland

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The thick-billed murre (*Uria lomvia*) is a culturally important seabird species in Greenland where the breeding population is declining in most areas. Scientific studies indicate that at least some of the decline can be linked to drivers in the wintering areas, whereas the role of local breeding conditions is largely unknown. In this study, we collected Local Ecological Knowledge (LEK) about murres in Southwest- (2016, 24 informants) and Northwest Greenland (2018, 24 informants), where locals are holders of valuable information about the areas they move in and the resources they use. We focused on their knowledge about local breeding populations, various aspects of human use of the areas and their view on murre management in West Greenland. The interviews had a semi-structured approach with a series of up to 54 predetermined questions. The survey showed that helicopters, marine traffic, and landslides locally are of concern particularly in Northwest Greenland, while the level of hunting, egging, and disturbances at colonies today generally is considered small and less concerning. In Northwest Greenland some questioned the reasoning behind the regional differences in murre management in West Greenland. Although most considered regulations necessary, many had suggestions to changes. Southwest informants reported that murres nowadays often are farther from the coast during winter. The dissemination level from authorities appears deficient as many seemed uninformed of murre monitoring results and unaware of the biological reasoning behind the management regulations. This study presents valuable perspectives that can be used to direct research and inform management of a valued resource.

Combining time-lapse photography and biologgers to understand population and individual-level activities of deep-diving seabirds in a tidal stream environment

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The foraging behaviour of deep-diving seabirds in fast tidal currents has been identified as a research priority, as many of these species are considered vulnerable to displacement from feeding grounds due to tidal stream energy installations and collision with turbine blades. Whilst knowledge of seabird routines and behaviours has increased in recent years, detailed information of foraging routines and diving behaviour within tidal stream environments remains scarce, linked to the challenges of studying these habitats. This study uses a combination of methods to investigate the foraging activities of common guillemots at population and individual level in North Anglesey, UK; a region earmarked for extensive tidal stream turbine deployments. Time-lapse photography across 3 months revealed fewer resting guillemots at the colony during ebb flow and low slack water and during the middle of the day, indicating that guillemots spend more time foraging during these times. Whilst limited in deployment number and duration, tracking data showed guillemots performing relatively deep and infrequent dives into strong flows in daylight hours, but relatively shallow and frequent dives across weak and strong flows in hours of darkness. The information provided support sustainable management by identifying when and where the likelihood of interactions between animals and installations are likely whilst also

providing insights into prey behaviour and demonstrating a need for more extensive studies of individual behaviour.

Seabird spatial and temporal distribution off the central Catalan coast

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The implementation of the 1979 Birds Directive (2009/147/EC) in the European Union marine waters has led to the designation of the Special Protection Areas (SPAs) for birds, within the Natura 2000 Network. Since then, more than 1,200 areas have been designated as SPAs in 23 countries of the UE. In this sense, the quality of the baseline ecological information is an essential issue to be considered to properly identify, designate and manage these protected areas. However, for many of the studies that led to the definition of these protected areas, the data were collected only for a limited time span within seasons, across seasons, and for a very limited number of years. These deficiencies may lead to the resulting protected areas suffering from inappropriate boundaries, which do not adequately cover the key areas throughout the annual cycle, nor adequately reflect inter-annual variability. In this context, we present the preliminary results of our long-term project "Plomes al Mar" where we evaluate the spatial and temporal distribution of some of the most abundant seabird species in relation to two protected areas of the Natura 2000 Network off the central Catalan coast, in Spain. Data were collected over 18 months using strip-transect techniques. Between January 2020 and December 2021, 80 dedicated boat surveys were conducted, covering a total distance of 6,710. During this time 22 seabird species have been identified in the area, totalling 2,000 observations. The study aims to gather information on seabird spatial and temporal distribution in an area with two SPAs for birds. Data collected, provides baseline information on the spatial distribution of seabird species within and outside the two SPAs, that could be used to assess the suitability of both SPAs.

Estimating breeding success on Atlantic Puffins: A methodological comparison

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Seabird populations are declining worldwide. High adult mortality and continuous low breeding success are one of the first indicators of population decline. Breeding success estimates can only be collected through monitoring of the nest contents. Collecting this data is challenging, especially in burrowing seabirds. This is the case with the Atlantic puffin (*Fratercula arctica*), a North Atlantic burrowing seabird. This species is facing major threats to its survival, with their numbers steadily decreasing. For the past decades, monitoring studies have detected low breeding success in their largest colonies in the Eastern Atlantic, especially in Iceland and Norway. However, such studies are scarce in North America. This is also true for Newfoundland (Eastern Canada), which hosts the largest Western Atlantic colonies of this species, so the trends and breeding status are unknown. Presence of an egg or chick inside a puffin burrow has been traditionally assessed either by grubbing or by cable-like, infrared burrowscopes. Despite the spread use of these methods, there is no information about their accuracy in this species burrow assessment, or if the results are comparable between methods. For my study, we have compared detection differences between grubbing and burrowscopes in Great Island, Newfoundland (Canada), the largest Atlantic puffin colony in North America. Following a mark-recapture approach, the contents of 40 burrows were checked 4 times by 4 independent observers, twice by each method. Information on the presence of an egg or a chick was recorded. This design allowed to establish and compare detection rates for the two methods. We will present preliminary results of this experiment and implications for interpretation of current and past occupancy and reproductive success estimates in Newfoundland colonies, as well as an update in breeding success estimates in five colonies across the province.

Plasticity in foraging behaviour and individual-level variation in responsiveness to environmental change

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The ability to demonstrate behavioural plasticity, the adjustment of behaviour in response to different environmental conditions, is a key predictor of an individual's capability to respond to environmental change. In species such as seabirds which forage in highly dynamic and variable environments, plasticity in foraging behaviour is particularly important to ensure sufficient resources are acquired for reproduction and survival. However, how individuals respond to changing environments, and thus their ability to demonstrate behavioural plasticity, is constrained by a suite of intrinsic factors, such as personality (defined as consistent individual differences in behaviour). Quantifying how traits such as personality relate to responsiveness to environmental heterogeneity is therefore important to understand what influences variation in plasticity. Using GPS logger data obtained from 253 individuals at 7 black-legged kittiwake (*Rissa tridactyla*) colonies in the Arctic, we quantify plasticity in foraging effort (time spent foraging in a patch) and explored the relationship with boldness. We investigated how individuals differed in their responsiveness to key dynamic environmental parameters such as sea-surface temperature and distance to the nearest glacier, both of which are rapidly changing due to sea ice melt and the increasing inflow of warm Atlantic water into the Arctic. We tested which aspects of plasticity are best explained by personality, providing insights into how individuals with different personalities may maintain resource acquisition in the face of environmental change. Future studies must quantify the potential costs of demonstrating enhanced phenotypic plasticity to better understand the capability of individuals to respond to climate change in the Arctic.

Use of drones for seabird monitoring in the Faroes – a potential gamechanger

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Unmanned Aerial Vehicles (UAVs, or drones) offer great potential for monitoring of breeding colonial seabirds. Large areas can be covered in relatively short time, even in very difficult terrains, and the obtained imagery allows for subsequent counting and reviewing of data. However, for ethical reasons it is important to avoid disturbance of the birds, which may vary significantly according to the studied species. In our study we tested UAV-based monitoring for two numerous seabird species, northern fulmar and arctic tern, each exhibiting dissimilar breeding habitats and behaviour. Based on the results, our aim was to design appropriate flight protocols to ensure reliable and unbiased counts. We found that: 1) Altered behaviour caused by UAVs could be minimized by observing strict operating protocols, including strategic and flexible flight approaches to allow for habituation, determination of optimal survey distances, and differentiation between incubating and non-breeding individuals. 2) Determination of optimal observation angles proved to be of key importance for conducting reliable surveys in often varying topography, where most often a slightly downward camera tilting yielded the highest number of visible birds. 3) Spot-checks with automated repetitions of predetermined breeding areas facilitated a labor-reduced data collection on a temporal scale, which is easily repeated both within and between consecutive seasons. 4) Utilizing UAV-based thermal imagery greatly helped to identify seabird nest sites, significantly increased the number of detected nests (in many places > 30%), and enabled differentiation between both adult birds and chicks. 5) Creation of preliminary 3D models (featuring both RGB and thermal imagery) showed great potential to enable detection and analysis of otherwise inaccessible breeding habitats on a hitherto unseen precise scale. It is our opinion that the empirical data and preliminary results in this study present a stepping-stone for more detailed explorations to design uniquely fitted flight and survey protocols, which will enable more accurate and reliable seabird counts.

Does the colourful bill of Atlantic puffins reflect parental provisioning effort?

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Carotenoid-pigmented features have been demonstrated to honestly signal an individual's quality in terms of foraging success, immune function and parasite load, and overall body condition and health across a wide range of taxa. In long-lived monogamous species with obligate bi-parental care, like the Atlantic puffin (*Fratercula arctica*), carotenoid features may indicate current condition, as well as reflect parental effort in chick rearing. In this study, we investigate whether seasonal changes in puffin bill and rosette colouration are associated with individual body condition and parental provisioning effort in a cohort of Atlantic puffins on Gull Island in Newfoundland and Labrador, Canada. Twice within the chick rearing season (1st: 5-10 days post-hatching; 2nd: 15-25 days thereafter), individuals were captured in their burrows to measure mass and take photos of the bill in the visual and ultraviolet spectrum. During the first capture only, wing length was also measured and a blood sample was collected for sexing. The photos were used to assess the colouration of five distinct regions on the bill and rosette, and body measurements were used to calculate an index of body condition (residuals of mass regressed on wing length) at each capture date. Provisioning effort for the five days prior to each capture date is approximated from radio-frequency identification (RFID) data on burrow visitation rate coupled with recordings of chick begging calls associated with food acquisition. We will present colour, condition, and provisioning data collected during the 2021 breeding season. The results of this study will provide insight into the role of the Atlantic puffin's colourful conspicuous bill, as well as contribute to the growing bodies of literature on carotenoid colouration and mutual sexual selection.

Constructing an Individual based model to explore the consequences of displacement in red-throated divers

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Globally there has been a strong push to move towards low carbon methods of energy generation and renewed commitments by governments to move towards a carbon neutral society. Studying the ecological effects of low carbon energy infrastructure on wildlife is essential in balancing the need for this type of energy generation against their potential ecological impacts. This is all the more pressing in Northern Europe, where construction of additional offshore wind farms in the North Sea is set to increase rapidly over the next few years. Studies have shown red-throated divers (*Gavia stellata*) are at a high risk of displacement from operational offshore wind farms and the associated ship activity. However, there is currently a lack of evidence on the consequences of this displacement in terms of over-winter survival and individual fitness. We have previously carried out work to form a baseline understanding of ecology of red-throated divers' during the winter, when they are most likely to encounter wind farms. These results provided the first insight into the behaviour and energetics of RTDs in the non-breeding season, revealing spatial and temporal differences in energy budgets of the species. The next stage of the work is to apply this new ecological understanding to answer questions related to the impacts of offshore wind farms on individual behaviour and population demographic rates. In this respect, we have begun to develop an individual based model (IBM) to investigate the effects of displacement and the associated changes to behaviour and energy budgets. Results from the model will look at how energy expenditure is impacted by the behavioural consequences of displacement and the possibility for populations to adapt to this displacement along with further scenarios of additional competition and resource limitation. We also attempt to describe current levels of behavioural and energetic constraint within populations in order to provide an understanding of capacity for additional stress.

Changes in the distribution and abundance of seabirds in the North Sea associated with present and future wind farm developments

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Seabirds in shelf-seas have faced a changing seascape across recent decades, with evidence for shifts in their distribution and abundance. In European waters, there have been large areas of wind-farm installations in recent decades, and even more extensive areas have been set-aside for installations in upcoming years. To date, collisions between seabirds and turbine blades has received most attention. However, large-scale developments will also alter hydrological conditions in both near- and far-field habitats. The behaviour and distribution of prey is strongly influenced by hydrological conditions, and changes in currents and water-column mixing around installations could impact seabird distributions at regional-scales. Understanding links between oceanographic processes, prey availability, and seabird distribution is key to understanding and predicting potential changes to seabird distributions. This study combines long-term seabird and prey surveys with high-resolution hydrodynamic model outputs to understand these links in the North Sea. A stepwise and mechanistic modelling approach will be taken to understand the impact of physics on prey availability, and then the impact of prey availability on seabirds. This mechanistic approach aims to: (1) identify critical habitats for seabird communities in the North Sea, (2) explain changes in abundance and distributions over recent decades, and (3) predict changes following array installations. By considering both hydrology and prey availability rather than just the former, this approach should provide detailed insights into the processes affecting seabird distribution, improving predictions across future decades, and aiding marine spatial planning and management.

A comparison of seabird species distribution modelling methods used by the offshore renewable energy industry

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We are currently facing concurrent climate and biodiversity crises. To address these issues, the UK governments have pledged to reduce carbon by producing a large proportion of energy through renewable developments by 2050. Concurrently, it is obligated to mitigate impacts to globally important UK populations of breeding and wintering seabirds. As part of the offshore development impact assessment process, density surface models are widely used to estimate abundance and distribution of seabirds. However, these models vary in their efficiency and flexibility and comparisons of various algorithms have yet to be explored in terms of their use in the offshore wind consenting process.

In the UK, guidance for the consenting process suggests the use of MRSea, which is a bespoke tool set that uses generalized additive models and spatially adaptive smoothing to generate density surfaces. The MRSea tool set has been applied in several cases in the UK but is not widely utilized outside of the offshore wind industry. More recent tool sets for density surface models, such as those utilized in the 'inlabru' package, make use of Bayesian point process models, which have a relatively large open-source community. Both methods perform similar tasks and thus it would be prudent to compare and contrast both tool sets in terms of seabirds in offshore developments. This is particularly pertinent considering the newest ScotWind leasing round, which will require the assessment process to be as efficient and robust as possible.

Here, we make use of two sets of digital aerial survey datasets taken from offshore wind development areas. We compare density surface models derived from the MRSea and inlabru packages in the context of computational efficiency, uncertainty estimates, model fit and ease of use. We present the merits of both approaches and advise on future density surface modelling for offshore wind developments.

Quantifying marine traffic intensity in Northwest Greenland and the potential disturbance of two seabird colonies

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Marine traffic represents an increasing source of noise pollution in the marine environment. Arctic seabirds may be exposed to this both when foraging at sea and when breeding in coastal colonies, as coastal areas may have high vessel densities. Yet, the impacts of marine traffic on seabirds are largely unknown. Here we investigated underwater noise monitoring as a method to quantify marine traffic intensity and disturbance of thick-billed murre (*Uria lomvia*) colonies in Greenland. Broadband underwater recordings were conducted with acoustic loggers during summer 2016 at two murre colonies; one in decline and one with population growth. A total of 307 vessels were detected during the study period, with the majority (96%) of vessels not being tracked by automatic monitoring systems. Based on estimated proximity, noise emission and boating behaviour, 23 vessels were classified as potentially disturbing for the breeding birds. The colony with the declining population trend was situated closest to the main travelling route and was disturbed five times more often than the other colony, which may suggest a negative impact of marine traffic. The study shows that underwater acoustic monitoring can be a useful method to quantify anthropogenic disturbances of seabird colonies to better understand population effects.

Trace metal blood concentrations in Scopoli's shearwater (*Calonectris diomedea*) during 2007–2014: A systematic analysis of the largest species
colony in Greece

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In this study, the concentrations of cadmium (Cd), lead (Pb), chromium (Cr), copper (Cu), cobalt (Co), nickel (Ni), manganese (Mn) and zinc (Zn) were investigated in the blood of Scopoli's shearwaters (*Calonectris diomedea*). Blood samples (N=238) were collected from both juvenile and adult individuals during seven breeding seasons between 2007 and 2014, excluding 2013. Sampling was performed in the pristine environment of the Strofades island complex, Greece, where the largest colony of Scopoli's shearwaters is located in the Eastern Mediterranean basin. The median concentrations of the toxic metals, Cd and Pb, were 0.010 and 0.24 μg/g (dry weight; dw), respectively, which were in good agreement with previous studies. The median concentrations of Co, Cr, Cu, Mn, Ni, Zn were 0.18, 1.11, 3.41, 0.29, 0.61, and 22.9 μg/g dw, respectively. Inter-annual differences were observed among the concentrations of all assessed metals, except for Ni and Cd, which demonstrated similarities among female individuals. Age-group related differences were observed in both genders for Cd, Cu and Cr, but only among males for Zn. To the best of our knowledge, this is the longest multi-year biomonitoring study of select trace metals that has been conducted thus far on blood samples from Scopoli's shearwater species.

Assortative mating in Atlantic Puffins? An approach using Geometric morphometrics, perceived bill colour, and body condition

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Assortative mating occurs when individuals with similar phenotypes are more likely to mate together than by chance. While this phenomenon has been well documented in many seabird species, the mechanisms leading to its occurrence are less clear. In long-lived monogamous species that form multi-year pair bonds, assortative mating is hypothesized to occur if the individuals in a pair develop and change in predictable ways over time. While assortative mating has been shown to exist in some alcid species, it has not yet been demonstrated in Atlantic Puffins: this project aims to expand previous work on this question. Specifically, this study makes use of calibrated puffin images, which allow precise measurements of bill structural and colour features. Between 2019 and 2021, 75 pairs of Atlantic Puffins were sampled from Gull Island, Witless Bay, NL, Canada. Data collected for each bird in the field included: mass and size, calibrated bill photos in 'visible' and UV spectrums, and a blood sample. Colouration was assessed on five regions of the bill using a model of avian colour perception. Geometric morphometrics were measured by creating a network of landmarks and pseudo-landmarks throughout the bill from which polygons and precise measurements could be taken. An index of body condition using mass and wing chord, accounting for seasonal changes, was derived. These traits were assessed to determine the presence or absence of assortative mating in Atlantic Puffins, which may give us insight into the mechanisms that drive mating behaviours in this species.

Distributions of non-breeding seabirds off the west coast of Ireland

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The acquisition of seabird distribution data over extensive marine areas is imperative to assessing seabird habitat use and monitoring species trends in areas delineated for offshore development. However, surveying these regions can be strategically difficult and labour intensive. Digital video aerial surveys, coupled with density surface modelling, have the capacity to bridge these logistical and statistical requirements.
Two large-scale surveys covering an expanse of ~10,620 km2 off the west coast of Ireland were commissioned by Marine Institute and undertaken by HiDef Aerial Surveying Limited. The project aimed to quantify the distribution and abundance of seabirds in coastal waters in the post-breeding and wintering season. A total of 51 strip transects, spaced 3.7km apart, were flown across the site using four planes simultaneously at ~550m Above Sea Level (ASL); each surveying a strip width of 250m, with a resolution of 2cm Ground Sample Distance (GSD). This provided 6.6% coverage of the site.
Density and population estimates were calculated using strip transect analysis and density surface maps were created using kernel density estimation (KDE). Bayesian point process modelling using the 'inlabru' package in R was conducted to produce density surface models for six species: kittiwake *Rissa tridactyla*, herring gull *Larus argentatus*, guillemot *Uria aalge*, razorbill *Alca torde*, great northern diver *Gavia immer* and fulmar *Fulmarus glacialis*.
We present the distributions of seabird species along the west Irish coastline, from the Blasket Islands to Slyne Head. Seabird abundance and diversity was highest in the post-breeding survey, with a total of 17,793 birds (inc. 22 seabird species) compared to 8,994 birds (inc. 16 seabird species) in the winter survey. Consistently elevated avian densities were found near the Inner Galway Bay SPA, the Inishmore SPA on the Aran Islands, the Cliffs of Moher SPA, the mouth of the Shannon Estuary and Tralee and Brandon Bay.

A comparison of GPS tracking and aerial surveys in identifying seabird hotspots at sea.

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Declining seabird populations have prompted a growing interest in designating marine protected areas for seabirds, particularly for protection during the breeding season when birds are under increased stress raising young. The identification of important marine areas for seabird conservation is often accomplished using either at-sea surveys or tracking data. At -sea surveys can sample wider seabird communities, but likely include non-breeders or transiting birds. Tracking studies enable identification of important foraging locations, but use a limited number of colonies and individuals to represent the wider population. Rarely have the two methods been compared. We undertook concurrent fine-scale aerial surveys and GPS tracking of Manx shearwaters (*Puffinus puffinus*) along the south coast of Ireland during the breeding season in June-July 2021. Aerial surveys recorded a wide range of Manx shearwater densities (0-280 individuals/km^2, mean: 5.31 ± 20.16) with clear hotspots of density. Abundances exceeded breeding population estimates along the south coast, suggesting mixing from more distant colonies and non-breeders. Kernel densities of tracking data (80 tracks from 36 individuals) also showed hotspots of occurrence along the coast. The agreement between hotspot locations identified by the two methods revealed a significant correlation (Dutilleul's modified T-test, Pearson coefficient =0.26, P=0.012). Our results suggest that despite differences in methodology and assumptions/limitations, there is broad agreement between methods, providing greater confidence in protected area designation.

Environmental influences on European Shag *Phalacrocorax aristotelis* over-winter survival rates

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Physical conditions in coastal environments are particularly suspectable to climate change, exposed to marine and terrestrial processes. Impacts of changing meteorology and oceanography on coastal seabirds are broadly divisible into direct impacts on movement and physiology, and indirect impacts on foraging successes. Amongst coastal seabirds, European shags *Phalacrocoridae aristotellis* are considered particularly vulnerable to meteorological and oceanographical conditions. As visually guided pursuit foragers, strong winds and intense precipitation could impede their ability to forage successfully. Their partially wettable plumage also makes them vulnerable to hypothermia and mortality during periods of inclement weather. Therefore, understanding responses of European shag to weather patterns is important to predict impacts of climate change on populations. This project combines long-term recoveries of ringed birds (1998-2018), meteorological measurements, and oceanographic measurements to investigate relationships between physical conditions and interannual survival rates at Puffin Island, Anglesey, UK. Adult survival rates were consistently higher than immature and juvenile survival rates. However, adult survival decreased in years with lower sea temperatures, whereas immatures seemed suspectable to both cooler sea temperatures and intense precipitation. Juvenile survival rate showed no strong association with meteorological or oceanographic conditions. When considered alongside similar studies on European shag elsewhere, these findings highlight differences in influential environmental conditions amongst locations, and the need to consider local-scale processes when estimating impacts of climate change on populations of coastal seabirds.

Are fledgling Manx shearwaters ingesting plastic?

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Plastic pollution has disastrous consequences for seabird populations worldwide, particularly at points of convergence. These mass collections of plastic waste within the ocean are of increasing concern. Foraging abilities, such as surface diving, within plastic convergence zones put Seabirds, such as Procellariforms at a higher risk of ingesting floating plastic debris, which leads to gut obstruction and the disruption of endocrine functionality. Whilst it is known that plastic ingestion affects adult seabirds in the UK, whether it is then passed on to chick's remains poorly unknown. To address this question, we investigated whether Manx shearwaters, a common UK breeding seabird, feed plastic to their offspring during chick-rearing. We collected and dissected twelve deceased Manx shearwater fledglings collected on Skomer Island, Wales and identified, weighed and separated by colour any micro-plastic (<5mm) found in proventriculus and gizzard. We found 75% of fledglings had plastic in the ventriculus with at least one plastic piece in their gastrointestinal tract. The overall majority was black plastic fragments. Foraging adults may mistake plastic as prey items and feed the debris to their young through regurgitation. Overtime the leaching of plastic contaminants will impact chick body condition and hinder growth and ultimately their survival. As plastic becomes trapped in foraging patches, it is broken up into pieces, whereby, adults have a high chance of ingesting fragments. Although based on a small sample size, our results highlight potentially widespread contamination of seabird chicks in UK waters and can form the basis of recommendations for future studies of plastic ingestion in seabird chicks. Our result also demonstrate the potential of Manx Shearwater birds environmental as bio-indicators of ocean health around the UK.

Understanding the Responses of Coastal Seabirds to Local and Daily-Scale Meteorological Variation

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Animals respond to meteorological variability occurring in their immediate environment. However, many studies investigating the responses of seabird communities to weather conditions use regional-scale (>1000km) and persistent (inter-annual, annual) processes to represent environmental conditions. Conversely, studies examining how seabirds respond to meteorological variation at fine spatiotemporal scales (10m-100m, seconds-hours) are scarce, despite the potential for local (<10km) and acute (daily) environmental conditions to influence movement decisions. Our study will address this knowledge gap by investigating responses of Phalacrocordiae (European Shag and Great Cormorant) to local and daily-scale meteorological variation in the Menai Strait and Conwy Bay, North Wales, using a suite of complementary approaches.

Year-round, a network of novel time-lapse cameras is capturing images of nocturnal and daytime roosts every half-hour, providing insight into the influence of meteorological conditions on population-level movement within the study area. During the breeding seasons, GPS tags and accelerometers will record foraging behaviour (distance, range, time and speed) and habitat choice at fine spatiotemporal scales (meters, seconds-minutes), whilst bird-borne cameras and diet analysis will provide information on habitat use, target prey species and diet composition. Nest site time-lapse photography will record attendance rates and chick provisioning at half-hour intervals. This information will be combined with concurrent meteorological and oceanographic data provided by in situ instrumentation (weather stations and CTDs) and hydrodynamic models to investigate how weather conditions influence individual-level foraging behaviour, strategies and successes.

Resultant information on influential environmental conditions will then inform analyses of long-term nest monitoring and ringing scheme data (1985-present), asking how meteorological conditions effect the demographic parameters of a coastal seabird community. The development of predictive population models will enable the potential impact of future meteorological variability and extreme weather events on a coastal seabird species to be explored.

The use of man-made structure as breeding site by the Black-legged Kittiwake (*Rissa tridactyla*): a global overview and the case study of its southernmost urban colony at Boulogne-sur-Mer (France)

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The Black-legged Kittiwake (*Rissa tridactyla*) is known to breed on cliffs in the northern hemisphere. This species is categorized as Vulnerable on the IUCN Red List and its global population is considered declining on its whole breeding range. As a pelagic seabird, its populations do not rely on landfills or on any human originated waste like some related gull species do. Nevertheless, some Black-legged Kittiwake (BLK) colonies have established on artificial grounds like urban areas, industrial buildings, and other various types of man-made structures. We first summarized the various cases of nesting recorded on such structures across the BLK's breeding range. Then we focused on the southern most urban colony known for this species, established at Boulogne-sur-Mer in France. We characterized this urban colony in relation to other populations and thanks to features of main artificial structures (exposure, ledges dimensions, elevation and distance to the shore). We also investigated the challenges this colony has to face in relation to human activities. Indeed, the establishment of BLK colonies on man-made structures often lead to conflictual interactions and human actions to deter the breeders. We explored how the various sub-colonies respond to nest removal resulting from building demolition or renovation which occurred during the nonbreeding season. We exposed the outcomes of mitigation measures implemented with regard to both urban area management and BLK population dynamics. Finally, we stress the need to turn this conflictual context into a rare opportunity for effective seabird conservation perspectives.

Assessing the population status of the Brown Booby (*Sula leucogaster*) and Red-footed Booby (*Sula sula*) at Los Roques Archipelago, Venezuela

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Los Roques Archipelago National Park is one of the Important Bird Areas (IBA) of the Venezuelan Caribbean. Nonetheless, seabirds population abundance and how this change over time remain largely unstudied in this IBA. Due to the increased infrastructure development and the lack of environmental enforcement in Los Roques Archipelago, it is urgent to take actions that promote seabird conservation. To better understand the current status of Brown Booby (*Sula leucogaster*) and Red-footed Booby (*Sula sula*) at Los Roques Archipelago we have been surveying the nesting population of these species in four localities of the archipelago (Bequeve Key, Boca de los Bobos, Gran Roque Islets and Los Canquises Keys). In January 2020, June and September 2021, and January 2022 we conducted single visit linear transects to estimate population abundance of adult individuals. Brown Booby abundance varied from 710 (95% CI: 678-764) individuals in 2020 to 552 (95% CI: 506-600) individuals in 2021, and 1,394 (95% CI: 1,321-1,469) adults in 2022, whereas Red-footed Booby abundance decreased from 550 (95% CI: 504-597) individuals in 2020 to 503 (95% CI: 459-548) individuals in 2021, and 377 (95% CI: 339-417) individuals in 2022. Our preliminary results suggest that these two species begins breeding early in the year, and we speculate that they could have two peaks during the breeding season. We did not find significant differences in Brown Booby abundance across surveys in different years but we did find a significant reduction of Red-footed Booby between 2020 and 2022. Further surveys are needed to better explain boobies abundance in Los Roques Archipelago and how this is being affected by uncontrolled human activities.

Eggshells identify drivers of heavy metal exposure in Adélie penguins around the Antarctic Peninsula

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Pollution in Antarctica has been documented for decades, but due to a lack of regular monitoring, the causes and effects of contamination on Antarctic wildlife are widely unknown. As human presence in the remote Antarctic continues to grow, it is necessary to determine and monitor the impacts of contaminants to Antarctic fauna, and to do so in a non-invasive way whenever possible. Heavy metals are sequestered into avian eggshell, and eggshell fragments can be collected from the environment after chick hatching without any handling of wildlife; however, eggshells are rarely used to measure contamination in Antarctic penguins. Adélie penguin (*Pygoscelis adeliae*) eggshell samples were collected from four distinct regions of the Antarctic peninsula and analyzed for 11 heavy metals, four of which (Fe, Ni, Se, V) have not previously been reported in Adélie penguin eggshell. Results were compared by geographic location, human activity, and trophic level differences to investigate drivers of variation. We found that the main significant factors were geographic location and foraging. The direct effects of human activity on heavy metal levels were inconclusive. These results provide a baseline for future study of heavy metal exposure in Antarctic penguins using eggshell remnants.

Early-life and migration of juvenile Audouin Gulls and their spatio-temporal overlap with fishery activities

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Juvenile and immature individuals play a key role in the dynamics of animal populations, particularly in long-lived species for which they can represent up to 50% of the total population. As opposed to adult breeders, juvenile naive individuals often disperse over long distances and can be more vulnerable than adults to some threats, such as mortality in fisheries. However, for most species the behaviour of juveniles remain almost unknown due to the difficulty in tracking young individuals for long periods. In this study, thirty-one juvenile Audouin gulls *Larus audouinii* were tracked with GPS-GSM transmitters until one year after fledging from their colony at Deserta, Algarve, Southern Portugal. Their at-sea distribution was interpreted in terms of the main habitats used for foraging and resting (as depicted by accelerometery data) during natal dispersal, outward migration, wintering distribution and inward migration. Foraging movements and habitat preferences of Audouin Gulls were crossed with fisheries distribution, as depicted by both global fishing watch and automatic identification system (AIS) data. Birds engaged in a southern migration along the West African coast in mid-July, reaching their wintering areas between early-August and mid-September. During winter they foraged mostly between lagoon (49% of the time) and coastal areas (37%), using ports mostly for resting. Return migration occurred mostly between mid-March and early-April. Overlap with fishery activities was higher during the natal dispersal phase (average 55%) when compared to the wintering period (21%) or outward/ inward migration (14%). The industrial and intensive fishing activity conducted at the southern Portuguese coast and specially at West Africa poses a tangible threat to this species known to be by-caught by fisheries in the Mediterranean. This is even more true given the considerable higher percentage of overlap with fishing activities during the natal dispersal and first winter of this population.

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Notes