CWW 2025
BOOK OF ABSTRACTS

Conference on Wind energy and Wildlife impacts

SEPTEMBER 8-12, 2025 - CORUM, CONVENTION CENTER OF MONTPELLIER



Co-organizers:

biotope

FRANCE renouvelables
système électrique pilotable

With the support of:

FRANCE ENERGIES MARINES

INTRODUCTION

The biennial Conference on Wind Energy and Wildlife Impact (CWW) is recognized as the biggest global conference addressing the topic of wind energy and wildlife interactions. The mission of CWW is about bringing together the global community to share knowledge, tools and best practices on wind energy and wildlife interactions. Every other year, researchers, consultants, wildlife technology companies, wind energy developers, regulators, financers and other interested parties gather to work together and share knowledge on both the state of science and science-based solutions to ecological impacts from on- and off-shore wind energy. CWW promotes a collaborative approach to resolving key ecological issues facing developers, investors, conservationists, decision makers and the public.

The scientific program of the 8th Conference on Wind Energy and Wildlife Impacts (CWW2025) held in September 2025 in Montpelier France was structured around the theme of Coexistence in a Changing World : Sharing Existing Knowledge, Challenges and Emerging Solutions. This meaningful theme incorporates important concepts that are directly aligned with CWW's objectives: seeking ways to achieve the best possible coexistence between wind power and biodiversity, based on proactive scientific approaches, while considering the parameters that influence biodiversity now and in the future, with a focus on climate change and other significant developments.

The scientific presentations and posters presented in CWW2025 were linked to 12 different topics:

- Landscape-level approaches to address wind energy/biodiversity challenges, particularly those affecting multiple land users and stakeholders
- Regulatory and planning aspects of wind energy projects (including research efforts to inform regulatory or voluntary conservation decisions)
- Applying the Mitigation Hierarchy: case studies and good practice examples of avoidance, minimization and mitigation, including off setting and restoration
- Wind energy and biodiversity in practice
- Species-specific responses of onshore and offshore wind energy projects
- Population and cumulative effects, including climate change
- Ecosystem and habitat effects of on and offshore wind energy projects
- Lessons learned in marine and terrestrial environments for wind energy development
- The Mediterranean Basin and wind development : trends, key issues and case studies
- Emerging markets and wind development: trends, key issues & case studies
- Innovation to advance wind energy and biodiversity science : novel conceptual, methodological, and technological approaches
- Future challenges, emerging solutions and technologies

Many of these topics have been routinely included in past CWW conference programs, while some topics were included in the CWW2025 program to highlight content related to the conference theme, the location of the conference and current trends in wind energy development (innovation, emerging issues).

The week-long CWW2025 conference included:

- Nine workshops
- Two keynote speeches
- Seven special sessions
- Thirty parallel sessions, including almost 135 individual presentations
- 135 posters presentations
- An opening and a closing ceremony

With almost 1100 participants from 60 different countries, CWW2025 was a major success in bringing together the scientific community to share the latest developments, best practices and emerging issues related to wind energy and biodiversity topics.

We are proud to present the community of CWW with this book of abstracts, which includes:

- A summary of the workshops
- A summary of the keynote talks
- The abstracts of the individual presentations and posters

We trust that you will consider both the abstracts and the conference at large to be insightful and inspiring.



David TIDHAR

Chair of the CWW2025 Scientific Committee



Florian LECORPS

Co-chair of the CWW2025 organizing committee



ROBIN DIXON

Co-chair of the CWW2025 organizing committee

Suggested citation:
De Rock Pauline, Lecorps Florian, Tidhar David & Dixon Robin (eds.) (2026).
CWW 2025: Book of Abstracts. Conference on Wind energy and Wildlife impacts (CWW 2025), September 8-12, 2025. Montpellier, France.

Abstract suggested citation:
Authors names (2025). Abstrat title. In: De Rock P., Lecorps F., Tidhar D. & Dixon R. (eds.) (2026).
CWW 2025: Book of Abstracts. Conference on Wind energy and Wildlife impacts (CWW 2025).
Montpellier, France.

Editorial Staff:
Pauline De Rock[1], Florian Lecorps[1], Lucia Cima Linet[1], Clémence Bories[1], Robin Dixon[2]

1: Biotope. 22 Boulevard Maréchal Foch, BP58 - 34140 Mèze, France
2: France Renouvelables. 5 avenue de la République - 75011 Paris, France

SCIENTIFIC ADVISORY COMMITTEE

ED ARNETT
Chief Executive Officer
THE WILDLIFE SOCIETY



EMMA BENNETT
Senior Research Officer
MONASH UNIVERSITY MELBOURNE



AURÉLIEN BESNARD
Senior Lecturer of l'EPHE
CNRS





ALVARO CAMINA CARDENAL
Senior Environmental Specialist
INTERNATIONAL FINANCE CORPORATION



AONGHAIS COOK
Principal Marine Biodiversity Specialist - Offshore Renewable Energy
THE BIODIVERSITY CONSULTANCY LTD.



VÉRONIQUE DE BILLY
Coordinator «Renewable Energy and Biodiversity
THE FRENCH OFFICE FOR BIODIVERSITY (OFB)

LAITH EL-MOGHRABI
Lead Ecologist
FIELDFARE ECOLOGY



WINIFRED F. FRICK
Chief Scientist
BAT CONSERVATION INTERNATIONAL



KARINE HEERAH
Researcher on marine megafauna
FRANCE ENERGIES MARINES





CRIS HEIN
Researcher V-Environmental Science
NATIONAL RENEWABLE ENERGY LABORATORY



MIRNA MAZIJA
Director
SUPERNATURAL LTD.



ROEL MAY
Senior Research Scientist
NORWEGIAN INSTITUTE FOR NATURE RESEARCH (NINA)

GEORG NEHLS
Managing Director
BIOCONSULT SH



SAMANTHA RALSTON-PATON
Birds and Renewable Energy Project Manager
BIRDLIFE SOUTH AFRICA



BOB RUMES
Aquatic ecologist
ROYAL BELGIAN INSTITUTE OF NATURAL SCIENCES





DAVID TIDHAR
Co-chair of the SAC
Biodiversity and environmental specialist
MASDAR CLEAN ENERGY



SYTSKE VAN DEN AKKER
Researcher Consultant Marine Ecology
WAARDENBURG



KATE WILLIAMS
Director of Center for Research on Offshore Wind and the Environment
BIODIVERSITY RESEARCH INSTITUTE - BRI

Other contributors and secretary of the SAC: Juliette Delavenne (France énergies marines) & Florian Lecorps (Biotope)

THE CWW 2025 WAS MADE POSSIBLE THANKS TO THE FOLLOWING SPONSORS, SUPPORTERS AND PARTNERS

Conference organizers

biotope

FRANCE renouvelables
système électrique pilotable

With the support of:

FRANCE ENERGIES MARINES

Platinium sponsors

ERWC European Renewable Energy & Wildlife Consortium

RWE

spoor

Gold sponsors

robin radar systems

écosphère

EDF power solutions

PROTECBIRD

Bio Consult SH

HiDef

wbird

Biodiv-Wind

IdentiFlight

WAARDENBURG Ecology

SENSOFLIFE

bioseco

dtbird dtbat

MINSAIT

OW OCEAN WINDS

STRIX

Silver sponsors

h2air

Iriao

wpd

swiss-birdradar.com

BORALEX

WILDLIFE ACOUSTICS

VATTENFALL

ABO ENERGY

Ørsted

QANNT

3D RADAR OFFSHORE SYSTEM

mirova

IfAÖ

ARC Marine

ECONCRETE

WILDCARE

WATER PROOF Marine Consultancy & Services BV

DeTect

Bronze sponsors

ENERTRAG

natural power

AKROCEAN

Lotek

ecocean

obsta

PLECOTUS

WEST

bat

BATLOGGER.com

hamer.

Major Nonprofit Sponsor

Wind EUROPE

Minor Nonprofit sponsor

Renewables Grid Initiative

With the financial support of:

ADEME AGENCE DE LA TRANSITION ÉCOLOGIQUE

RÉPUBLIQUE FRANÇAISE

OFB OFFICE FRANÇAIS DE LA BIODIVERSITÉ

La Région Occitanie Pyrénées · Méditerranée

Montpellier méditerranée Métropole



CONTENTS

©Adobe Stock

PLENARY SESSION 9

WORKSHOP 14

Workshop 1: Birds & Offshore Wind - collision risks /Annual Meeting of the International Collision Risk Modeling Working Group 15

Workshop 2 : Displacement - How can we best quantify changes to seabird distributions at operational offshore wind farms? 17

Workshop 3: Shutdown on-Demand for Birds: The State of Science of Observer-led and Automated Shutdown On Demand 20

Workshop 4: Mitigating Impacts of Wind Energy Development on Migratory Species through Multistakeholder Partnership 22

Workshop 5: Wildlife protection on the grid side of renewable generation 24

Workshop 6: 30 years of offshore wind: what do we know and what do we not know 26

Workshop 7: Nature Inclusive Design 28

Workshop 8: Integrating Social & Environmental Sciences to Aid in Siting & Permitting 30

Workshop 9: Engaging Innovation in Biodiversity Offsets for Wind Energy Projects and Developing Strategies to Maximize Stakeholder Engagement 32

SPECIAL SESSION 33

Special session 1: Offshore Wind Collision Detection Systems - State of Science 34

Special session 2: Wind energy and biodiversity in the tropics 36

Special session 3: Meeting the challenge of mitigating bat mortality at wind energy facilities 37

Special session 4: Offshore wind in emerging markets 40

Special session 5: Dealing with uncertainty: balancing adaptive management, the precautionary principle, and scientific advancement 43

Special session 6: Exploring blade patterning as a mitigation strategy - Results from studies across the globe, lessons learned and the way forward 47

Special session 7: From assessing to managing subsea impacts of offshore wind 51

PARALLEL SESSIONS 53

Parallel session 1: Applying the Mitigation Hierarchy: case studies and good practice examples of avoidance, minimization and mitigation, including off setting and restoration 55

Parallel session 2: Population and cumulative effects, including climate change 59

Parallel session 3: Ecosystem and habitat effects of on and offshore wind energy projects 63

Parallel session 4: Species-specific responses of onshore and offshore wind energy projects 67

Parallel session 5: Species-specific responses of onshore and offshore wind energy projects 71

Parallel session 6: Regulatory and planning aspects of wind energy projects (including research efforts to inform regulatory or voluntary conservation decisions) 75

Parallel session 7: Wind energy and biodiversity in practice 79

Parallel session 8: Future challenges, emerging solutions and technologies 83

Parallel session 9: Population and cumulative effects; Applying the Mitigation Hierarchy 87

Parallel session 10: Species-specific responses; Ecosystem and habitat effects 93

Parallel session 11: Wind energy and biodiversity in practice; Regulatory and planning aspects 99

Parallel session 12: Landscape-level approaches; Applying the Mitigation Hierarchy 105

Parallel session 13: Species-specific responses of onshore and offshore wind energy projects 111

Parallel session 14: Landscape-level approaches to address wind energy/biodiversity challenges, particularly those affecting multiple land users and stakeholders 115

Parallel session 15: Future challenges, emerging solutions and technologies 119

Parallel session 16: Ecosystem and habitat effects of on and offshore wind energy projects 123

Parallel session 17: Applying the Mitigation Hierarchy: case studies and good practice examples of avoidance, minimization and mitigation, including off setting and restoration 127

Parallel session 18: Wind energy and biodiversity in practice 131

Parallel session 19: Population and cumulative effects, including climate change 135

Parallel session 21: Lessons learned in marine and terrestrial environments for wind energy development 139

Parallel session 22: Ecosystem and habitat effects of on and offshore wind energy projects 144

Parallel session 23: Regulatory and planning aspects of wind energy projects (including research efforts to inform regulatory or voluntary conservation decisions) 149

Parallel session 24: Species-specific responses of onshore and offshore wind energy projects 154

Parallel session 25: Wind energy in practice 159

Parallel session 26: Regulatory and planning aspects of wind energy projects (including research efforts to inform regulatory or voluntary conservation decisions) 164

Parallel session 27: Applying the Mitigation Hierarchy: case studies and good practice examples of avoidance, minimization and mitigation, including off setting and restoration 169

Parallel session 28: Species-specific responses of onshore and offshore wind energy projects 174

Parallel session 29: Ecosystem and habitat effects of on and offshore wind energy projects 178

Parallel session 30: Wind energy and biodiversity in practice 183

POSTERS 188



PLENARY SESSION

CWW 2025 OPENING KEYNOTE SPEECH

By Rachel Asante-Owusu, Senior Programme Coordinator, Climate Change at IUCN

Highlights

We are living through an extraordinary moment in human history—especially in terms of energy generation. In 2024, the world added 582 gigawatts of new renewable power capacity, the largest annual increase ever recorded. Solar photovoltaics alone contributed 452 gigawatts, while wind energy added 114 gigawatts. By mid-2025, we had already installed an additional 380 gigawatts of solar capacity—a staggering 64% year-on-year increase.

While we must continue improving battery efficiency and deploying storage more effectively, these numbers are remarkable. They represent more than statistics. They represent a collective global response to the climate crisis. But they also raise a defining question: how do we achieve climate mitigation through renewable energy without accelerating biodiversity loss? How do we avoid damaging the ecosystems we depend on as natural carbon sinks?

Business as usual—continuing to rely on fossil fuels—is simply not an option. Fossil fuels account for roughly 40% of global carbon dioxide emissions. The International Energy Agency projects that renewable power must triple by 2030, compared to 2022 levels, if we are to meet our climate targets. Yet, despite progress, we are not moving fast enough.

There is, however, reason for optimism. Solar power has become the lowest-cost source of electricity in most regions, with costs falling by approximately 90% since 2010. Onshore wind is now a mature and globally deployed technology, while offshore wind offers exceptional performance, with capacity factors exceeding 50% in optimal locations. Yet rapid expansion inevitably creates ecological trade-offs that we must address responsibly.

Solar energy installations can displace semi-natural habitats that support reptiles, ground-nesting birds, and pollinators. Wind turbines pose collision risks for birds and bats, and offshore construction generates underwater noise that can disrupt marine mammals. Grid infrastructure introduces additional pressures, from overhead line collisions to impacts on coastal ecosystems. These challenges are real, and they must be managed carefully.

The solution is not to slow renewable deployment—but to improve how we deploy it. We must embrace nature-positive deployment.

This begins with robust spatial planning to avoid high-value conservation areas and migratory pathways while identifying opportunities where renewable energy can actively support conservation. It requires cumulative impact assessment, looking beyond individual projects to understand broader regional ecological effects. It demands wildlife-sensitive design, including technologies such as radar-based turbine curtailment, pollinator-friendly solar installations, and offshore noise reduction systems. And perhaps most importantly, it means integrating nature-based solutions—ensuring renewable energy projects actively contribute to ecosystem restoration, such as restoring wetlands, peatlands, or mangroves.

Encouragingly, this approach is already delivering results. Pollinator-friendly solar installations are increasing bee populations. Curtailment technologies are dramatically reducing bird mortality at wind farms. Offshore wind projects are enhancing marine biodiversity through artificial reef structures. Grid operators are transforming transmission corridors into green ecological pathways.

These examples demonstrate that renewable energy and biodiversity conservation are not competing objectives. When planned and implemented correctly, they reinforce one another.

Realizing this vision requires coordinated action. Governments must embed nature-positive requirements into permitting processes, support spatial planning, and invest in ecological research. Industry must recognize biodiversity as integral to long-term project value, share environmental performance data, and engage communities transparently. Civil society must continue advocating for solutions that address both climate and biodiversity together.

Renewable energy is indispensable for climate mitigation. But its long-term success depends on whether it also contributes to biodiversity recovery. We now have the knowledge, tools, and experience to achieve both goals simultaneously. This is our defining moment. The renewable energy revolution is already underway. The question is not whether we will transition to clean energy, but whether we will do so in a way that restores and protects the natural systems upon which all life depends.

If we act with urgency, intelligence, and collaboration, we can build an energy system that powers human progress while strengthening the living world. The choice—and the opportunity—is ours.

Key Issues from speech.

Several critical and interconnected issues arise at the intersection of climate change mitigation, renewable energy expansion, and biodiversity conservation. These issues reflect both the urgency of transforming global energy systems and the responsibility to ensure that this transformation does not unintentionally damage the natural systems it depends on.

1. The urgency of accelerating renewable energy deployment

The transition away from fossil fuels is essential to reduce greenhouse gas emissions and limit global warming. Fossil fuels remain a major contributor to carbon dioxide emissions, and renewable energy capacity must expand significantly in the coming years to meet international climate targets. Although solar and wind energy have grown rapidly and become cost-competitive, the scale of expansion required remains immense. This creates pressure to accelerate deployment while maintaining environmental and social safeguards.

2. The risk of biodiversity loss associated with renewable infrastructure

Renewable energy infrastructure can have unintended ecological consequences if not carefully planned and managed. Large-scale solar installations may displace natural habitats that support pollinators, reptiles, and birds. Wind turbines can pose collision risks for birds and bats, particularly migratory and vulnerable species. Offshore wind development can disrupt marine ecosystems through underwater noise and seabed disturbance. Transmission infrastructure, including overhead lines and subsea cables, can fragment habitats and affect wildlife movement and behaviour. These risks highlight the importance of balancing climate mitigation with biodiversity protection.

3. The need to align climate and biodiversity objectives

Climate stability and biodiversity conservation are closely linked and mutually dependent. Healthy ecosystems act as carbon sinks, regulate climate processes, and support resilience to environmental change. Damaging ecosystems in the process of building renewable energy infrastructure could undermine long-term climate goals. Ensuring that climate mitigation efforts also protect and restore biodiversity is therefore essential for achieving sustainable outcomes.

4. Limitations of current planning and environmental assessment approaches

Traditional environmental impact assessments often focus on individual projects without fully considering cumulative or regional impacts. This can lead to incremental environmental degradation when multiple projects are developed within the same landscape or ecosystem. Improved spatial planning, better ecological data, and regional-scale assessment frameworks are needed to identify suitable locations for renewable energy while avoiding areas of high ecological value.

5. The importance of technological innovation and improved design

Technological advances offer opportunities to reduce environmental impacts. Wildlife-sensitive turbine operation, improved monitoring systems, and biodiversity-friendly solar farm design can significantly reduce harm to species and habitats. Offshore construction techniques can also minimize noise and habitat disruption. Wider adoption of these innovations will be critical to ensuring environmentally responsible deployment.

6. The opportunity to integrate ecosystem restoration and nature-based solutions

Renewable energy projects can contribute positively to biodiversity when designed with ecological objectives in mind. For example, solar installations can support pollinator habitats, offshore infrastructure can enhance marine biodiversity, and renewable energy investments can help fund ecosystem restoration. This approach moves beyond minimizing harm toward actively improving environmental outcomes.

7. The need for coordinated governance and stakeholder collaboration

Effective policies, strong regulatory frameworks, industry leadership, and public engagement are essential to ensure responsible renewable energy development. Governments must provide clear guidance and planning frameworks, industry must adopt best practices and transparency, and civil society must support and monitor progress. Collaboration across sectors will be necessary to align climate, energy, and biodiversity goals.

Addressing these issues will determine whether the renewable energy transition delivers not only climate mitigation but also long-term ecological sustainability.

Plenary session - "The wind of innovation: how new ideas are changing the sustainability of wind industry"

Keynote Speakers : Florence Simonet (Vattenfall) & Umberto Binetti (RWE)

The plenary session focused on the imperative need for innovation in the development and operation of windfarm projects to coexist with the natural environment. Vattenfall and RWE shared their visions and concrete examples of innovative projects, discussing how they are implementing their strategies to increase their responsibility for environmental stewardship and shape the future of clean energy.

The session started by highlighting the long history of the use of wind as a form of energy, which humans have used to travel, process food, and power industrial processes for centuries. The modern wind energy industry, spanning both in terrestrial and marine areas, is the clear evidence of how innovations and technologies have transformed our way to harness the power of wind. The transformation, however, is not complete and there are many outstanding challenges that the sector needs to overcome: scientific gaps, fragmentation in the regulatory landscape across markets, lack of data due to the difficulty of observing the marine environment, and the lack of metrics to balance negative and positive impacts.

Industry is, however, not just passively waiting for innovations to solve the problems for them, but is engaging with many stakeholders and is committing funding, expertise and tools to develop, pilot and accelerate the adoption of new solutions. RWE and Vattenfall showed a series of examples related to:

- Monitoring: Vattenfall showed how new knowledge is pushing innovation, using the example of the bat migration over the sea to show how industry is reacting to emerging possible impacts, adopting actions such as using cameras that can track flying animals also during the night, and AI algorithms that can track movements. RWE also showed how data from these new approaches is useful for making mitigation measures more efficient, for example by changing curtailment parameters to save species of bats flying in different conditions (e.g. different air temperature). RWE also spoke about a monitoring projects that are using several new technology: on land, they are using acoustic recorders to measure the presence, abundance, and activity of birds and insects, while in the sea they are using remote cameras, underwater vehicles and eDNA to have an ecological approach to how windfarms are influencing the marine ecosystem.

- Positive actions: RWE presented a project focused on the deployment of the industry's first nature inclusive scour pad around an offshore turbine; Vattenfall showed two examples of positive actions, the first one related to the promotion of co-existence between offshore wind and seaweed production (also linked to a very successful outreach campaign, showing the importance of communication); and a second one related to the conservation of sensitive habitats such as peatland, which they are restoring around an onshore windfarm by transforming a previously forested area into a more diverse and more carbon absorbing habitat.

- Some other important messages were shared as lessons learned. For example, the analysis of the efficacy of painting the turbine blades black in decreasing the mortality rate showed how good data needs to be collected not to overestimate the effects of some new solutions. The establishment of feeding stations away from terrestrial windfarms, instead, showed how low-tech but novel solutions can have positive impacts and work as an effective mitigation measure. Last but not least, RWE and Vattenfall recognized the importance of collaboration, and the role that events like CWW have on the sector, being able to bring together several stakeholders and foster the creation of connection and the sharing of new ideas.



WORKSHOPS

BIRDS & OFFSHORE WIND - COLLISION RISKS /ANNUAL MEETING OF THE INTERNATIONAL COLLISION RISK MODELING WORKING GROUP

Organized and run by: Kate Williams Kate Williams (Biodiversity Research Institute), Aonghais Cook, Evan Adams (Biodiversity Research Institute), Grant Humphreys (BlackBawks Data Science), Michael Wethington (Biodiversity Research Institute)

Avian collisions remain a key consenting risk for wind energy developments, with implications for biodiversity conservation, regulatory decision-making, and the pace of renewable energy deployment. While collision risk models (CRMs) are widely used pre-construction, outputs are highly uncertain and sensitive to a small number of poorly constrained parameters—especially avoidance rates, flight height distributions, and exposure (flux). To address these issues, the International Collision Risk Modeling Working Group was formed at the 2023 Conference on Wind Energy and Wildlife. The group's overarching goal is not to identify a single 'best' model, but to improve transparency, interoperability, validation, and confidence so CRMs are fit for purpose in both regulatory and scientific contexts. This was the third meeting of the working group and, in addition to updates on recent work on collision risk modeling in the UK, the US and Australia, some initial outputs including a terms of reference for the group, an initial draft of a turbine parameter database, and the group website were presented. However, a key focus for the meeting were discussions on assessing the cumulative impacts of collisions at a population level, and approaches for model validation.

Cumulative Assessment of Collision Risk

A major focus was how to estimate cumulative collision risk across multiple wind farms. Discussions highlighted wide variation in baselines, spatial and temporal scales, and outputs. Key questions included whether assessments should start from a historical 'zero wind farm' baseline or from the present day, and whether outputs from legacy projects with outdated or incomparable CRMs should be rerun, corrected, or down-weighted.

There was strong scientific support for re-analysing older projects using modern methods and updated parameters to ensure comparability. However, tensions around this approach were acknowledged as regulators and developers value stability. As a pragmatic compromise, the use of transparent correction factors or hybrid baselines where full reruns are infeasible was discussed. It was suggested that priority for reanalysis could be given to projects with the greatest leverage on cumulative totals—e.g., large wind farms, sites near high-density bird-use areas, or projects with small air gaps.

It was agreed that cumulative estimates must be expressed in a population context. Raw collision numbers are insufficient without reference to population size, demographic rates, or acceptable mortality thresholds. Approaches discussed included expressing impacts as a percentage of a defined population unit, linking collision estimates to population viability analyses (PVAs), and using relative risk frameworks to compare alternative build-out scenarios. 'Birds can only die once' underscores limits of purely additive methods and points to the potential value of individual-based models (IBMs) to constrain non-additive mortality.

Model Validation and Key Uncertainties

It was agreed that end-to-end validation of collision predictions is unrealistic for most species and contexts right now, but targeted validation of high-leverage components is feasible and necessary. Avoidance rates emerged as the single most influential and problematic parameter—often treated as a correction factor rather than an empirically defined behavioural outcome. The group emphasised moving away from monolithic avoidance rates toward explicit measurement of behaviour at macro-, meso-, and micro-scales.

Flight heights were identified as a tractable priority for validation, particularly with advances in camera systems, radar, LiDAR, and tracking. However, flight heights must be measured at operational wind farms, not just in baseline surveys, and uncertainty at the level of individual detections should be explicitly accounted for. Given the financial and environmental costs associated with increasing turbine air gaps, robust empirical evidence on flight height distributions within wind farms is critical.

Validation of collision probability (P(coll)) is valuable but challenging, especially offshore where carcass recovery is not possible. Near-turbine detection systems—cameras, vibration sensors, radar—are promising, particularly if combined with standardised monitoring protocols and data sharing. Risk and validation efforts should be stratified by environmental conditions (wind speed, visibility, season), as collision risk is likely condition-dependent.

Standardisation, Data Sharing, and Governance

The need for minimum reporting standards across CRMs was stressed —including turbine geometry, avoidance assumptions, flight-height treatment, population bases, and uncertainty—to enable cumulative assessments and cross-model comparison. Without consistent inputs, outputs, and metadata, combining results across projects remains problematic.

Data availability and sharing were identified as limiting factors. Substantial post-construction monitoring exists but often remains inaccessible due to proprietary constraints. The need for stronger regulatory requirements and shared data portals (with anonymisation where needed) to enable learning across sites and regions were emphasized. Initiatives such as a turbine database and the collisionrisk.org website were highlighted as practical steps toward transparency and interoperability.

DISPLACEMENT - HOW CAN WE BEST QUANTIFY CHANGES TO SEABIRD DISTRIBUTIONS AT OPERATIONAL OFFSHORE WIND FARMS?

Organized and run by: Sue O'Brien (SLR), Aonghais Cook (The Biodiversity Consultancy), Abel Gyimesi (Waardenburg Ecology) and Alex Banks (Natural England)

Context

Globally, large-scale deployment of offshore wind farms (OWF) is underway, meaning there is an urgent need to understand environmental impacts of OWF. Seabirds can be affected by OWF through collisions with turbines and by displacement/redistribution due to the presence of an OWF. In Europe, extensive monitoring of bird distributions and behaviour at operational OWFs has taken place over the last 20 years. Studies have shown that some species avoid operational OWFs (e.g. divers, Gavia spp.), others appear to be attracted to or unaffected by OWFs (e.g. large gulls, Larus spp.) and some species, such as common guillemot (Uria aalge) show a mixed response.
However, different methods are being applied for collecting and analysing data at each OWF and so it is not apparent whether the diverse responses to OWF developments by guillemots are due to methodological differences among studies or a true variation in response. Changes in seabird distribution following construction of an OWF can be hard to discern against a background of natural changes in distribution in response to prey, tides, currents, and other environmental drivers. The focus of this workshop is on methods used to quantify seabird displacement from OWF, working towards minimising methodological differences in data collection, analysis, storage and reporting. This will then reveal where true differences in seabird response to OWF occur, e.g. with breeding versus non-breeding season and location of OWF (proximity to colonies, etc).

Aims and Objectives

The workshop aimed to agree common approaches to seabird post-construction monitoring and data analysis, to better quantify seabird displacement effects. Focussing on guillemot displacement as a case study, the objectives of the workshop were to:

1. Explore the benefits and limitations of current approaches to quantifying displacement effects, including consideration of different data collection and analytical methods;
2. Work towards agreeing common approaches for future data collection, storage and analysis to reduce methodological differences, thereby revealing the extent to which seabird displacement varies with location and time of year;
3. Consider how best to move towards better sharing of data (including ensuring compatibility of data), methodologies and new findings;
4. Develop and publish guidelines on optimal approaches for quantifying seabird displacement by OWF.

Workshop discussion:

Why is quantifying displacement caused by OWF challenging?
Seabird distributions are highly variable, particularly for species feeding on mobile prey. There are many drivers of seabird distributions operating different spatial and temporal scales. Quantifying changes to distributions is further complicated by shifting baselines caused by climate change.

What methods are available for data collection to inform displacement?

- Digital aerial survey (DAS) has a permanent record of photos/video recorded by aircraft, is least likely method to disturb birds (as can fly higher than VAS) therefore unlikely to influence bird distributions, can survey large areas quickly.
- Visual aerial survey (VAS) is limited in flight height, which can cause disturbance to some species of birds potentially influencing distributions. Also, unlike DAS, there is no permanent record. Issues of statistical independence of location of transects in operational OWF (can't fly near turbines).
- Visual boat survey (VBS) is slower and can influence bird distribution. But allows better bird ID and also allows bird behaviour to be recorded. Potential to also collect data on some covariates concurrently.
- Tracking of individual birds' flight paths and behaviour using biologging. This is a different type of data to aerial survey, probably only relevant for OWF near bird colonies
- Workshop attendees broadly agreed that DAS was generally the preferred method for data collection but that VBS might be helpful for species which are under recorded by DAS (e.g. storm-petrels). VBS is also useful to get better information on species ID and behaviour. Helpful to supplement DAS/VBS with tracking if the focal area is near a breeding colony.

What is the optimal survey design to quantify displacement effects?

Temporal

- Ideally 2-3 years pre construction data should be collected
- Ideally 3 years survey is the minimum post construction data collection required, ideally spread over a longer period (i.e. not three consecutive years) to capture any habituation
- Ideally surveys should be monthly through the relevant season(s) in both pre or post construction surveys

Spatial

- The survey area should include an adequate buffer around the OWF development area. Recommendations on buffer size vary and will depend on the bird species present but the buffer needs to be well beyond the limit of possible displacement to fully capture the extent of displacement effects

Effort

- Effort should be a minimum of 10-15% of the area of interest. Stratified sampling may be helpful. With DAS, it is possible to collect data from four camaras but only analyse data from two cameras for most of area but could analyse data from four cameras in some areas to increase effort
- Trade offs:
  - Spatial vs temporal – spatial variation is probably more important to quantify and so surveys should prioritise covering a larger area over the number of surveys undertaken
  - Effort vs spatial – spatial variation is probably more important to quantify, i.e. surveys should ideally cover a wider area with lower effort. Stratified sampling might help cover a large enough area with sufficient effort.

Covariates to explain variation in spatial distributions

Ideally covariates should be collected concurrently with bird observation data. Prey data would be useful but challenging and expensive to get and difficult to really understand the relationship between prey sampling and bird distribution, particularly for species feeding on mobile prey and

a wide prey base. Need a range of covariates to try and explain as much of the variation in bird distributions as possible, allowing any OWF effect on the distribution to be detected

Data analysis

- More than one approach to data analysis could be helpful – no single method is optimal, each has benefits
- Fine scale analysis, e.g. randomisation approach, looking at bird distribution within an OWF in relation to individual turbines is useful as it removes any comparison among surveys and the need to explain variation in these from other drivers. However, this method does not capture the broad scale changes in distribution that an OWF might cause
- Broad scale analysis outside of OWF footprint. Ideally have data from pre- and post-construction of the OWF
    - BACI: Before After Control Impact - use a control area which is surveyed at the same time as areas potentially affected by the OWF, with surveys undertaken before and after construction of the OWF
    - BAG: Before After Gradient – assess changes in distribution or density at increasing distances from turbines, ideally both before and after construction.
- BAG was a preferred approach as a 'control' is never a true control area as there are many other variables influencing bird distribution in a control area, not only presence/absence of OWF.

SHUTDOWN ON-DEMAND FOR BIRDS: THE STATE OF SCIENCE OF OBSERVER-LED AND AUTOMATED SHUTDOWN ON DEMAND

Organized and run by: David Tidhar (Masdar, Abu Dhabi Future Energy Company) & Laith El-Moghrabi (Fieldfare Ecology)

Shutdown-On-Demand (SDOD) is a mitigation measure to protect bird species from colliding with wind turbines. SDOD involves temporarily stopping the turbines' rotation in response to the detection of at-risk birds, particularly vulnerable migratory or soaring species. Implementation of SDOD can be divided into two main approaches:

- Observer-led SDOD: involves a coordinated team of field observers identifying situations when birds are at risk of colliding with turbines as they move within the wind farm and initiating a temporary shut-down of one or more turbines.
- Automated SDOD: a system that uses radar and/or camera detection technology and artificial intelligence to detect and (for some systems) classify at-risk species near wind turbines, and automatically temporarily stops the operation of the affected turbine to prevent fatalities.

SDOD is most effective for specific at-risk species, such as large raptors and vultures, and is often customized for a particular site's environmental conditions. Studies have shown that SDOD can significantly reduce bird fatalities at wind farms. Some reports indicate fatality reductions for targeted species ranging from 50% to nearly 100%. Effective SDOD protocols are designed to be triggered only when necessary, minimizing the impact on energy production. For example, some projects have achieved high fatality reductions with minimal energy loss.

The main objective of the one-day workshop was exchanging knowledge and experience on the use of SDOD to reduce bird collisions with operating wind turbines. Following an introduction and overview of SDOD and the principal elements of Observer-led and Automated SDOD provided by the workshop organizers, the workshop was divided into four main sessions:

Case Studies on Shutdown On-Demand (SDOD): Examples of both Observer-led and Automated SDOD implementation as well as Automated SDOD technology currently available. Boris Božić - Masdar Infinity Power presented a case study from West Bakr in Egypt where Observer-led SDOD has been implemented over the period of four years and highlighting the importance of the adaptive management cycle. The second presentation by Jenifer Andreu - Acciona Energia provided a comparative analysis of two Automated SDOD systems implemented in a wind farm in Spain. The last presentation was given by Esther Clausen - Protecbird presenting her company's Automated SDOD system.

Panel Discussion: It works, so why don't we use shutdown on demand on every wind farm? Moderated by Ricardo Tomé - The Biodiversity Consultancy, the panel included four stakeholder representatives involved in SDOD implementation and decision-making: Simon Hulka - IFC representing a lender, Tris Allinson - BirdLife International representing a conservation organization, Misti Sporer - Deriva Energy representing a developer, and Ahmad Khalil - RCREEE- Egypt representing a regulator. The discussion focused on the critical role that SDOD plays in bird collision avoidance and where the balance can be struck between bird conservation and energy efficiency, and the overlapping and complex roles of science, financing, technology and governance.

Models for SDOD Implementation and Standardizations: Good practice examples of SDOD implementation and standardization from three continents. Albert Froneman - Afriavian in South Africa overviewing Birdlife South Africa's Handbook of Shutdown On Demand highlighting the myriad of guidance aspects and considerations. Thilo Liesenjohann - BioConsult SH discussed the legal frameworks for the adoption of SDOD in Germany/EU. David Tidhar - Masdar provided an overview of Automated SDOD implementation in an emerging markets context with an example from Uzbekistan.

The next frontier: Expanding Automated SDOD: The final session focused on the future of Automated SDOD with five presentations starting with Zena Stevenson - Boulder Imaging who presented the advancement in implementing species-specific Automated SDOD. Misti Sporer -Deriva Energy then presented lessons learned from installing an Automated SDOD from a developer perspective, where the considerations are not limited to bird collision avoidance but also energy efficiency/loss and turbine health, and reputational risk and regulatory compliance. Emma Jane Critchley - the Norwegian Institute for Nature Research described technology advancements in coupling 3D radar systems and machine learning for species-specific SDOD. The last two presentations provided practical examples and research findings from two species-specific Automated SDOD applications: Marc Thauront - Ecosphère on Black Storks in France, and Koosje Lamers - Waardenburg Ecology on European Honey-buzzards in the Netherlands.
A facilitated audience discussion was held when concluding the workshop in which there was a consensus that SDOD will continue to be used as a measure to reduce bird mortality at wind farms, yet it is not a silver bullet that will mitigate all bird collisions. Wind farm context and size, and bird biology and ecology, influence SDOD approaches and inter-relate with the strengths and weaknesses of current technology for Automated SDOD currently available.

MITIGATING IMPACTS OF WIND ENERGY DEVELOPMENT ON MIGRATORY SPECIES THROUGH MULTISTAKEHOLDER PARTNERSHIP

Organized by: Jay Diffendorfer (U.S. Geological Survey), Winifred Frick (Bat Conservation International)

Context

The workshop addressed the urgent need for a rapid renewable energy transition to achieve a nature-positive and net-zero future, consistent with the Global Biodiversity Framework and the Paris Agreement. While wind energy plays a critical role in decarbonization, poorly planned projects can pose risks to biodiversity, particularly migratory species, during construction, operation, and decommissioning. These impacts extended beyond project boundaries and required science-based solutions and collaborative approaches to avoid undermining conservation goals.

Objectives

The session, organized and hosted by the Energy Task Force (ETF) of the UN Convention on the Conservation of Migratory Species of Wild Animals aimed to demonstrate how multistakeholder collaboration can help reconcile renewable energy development with biodiversity conservation. Specifically, the workshop sought to:

- Showcase ETF's role in fostering cooperation among governments, lenders, civil society, and technical experts.
- Present science-based tools and case studies for mitigating impacts on bats and birds.
- Explore how financial institutions integrate biodiversity safeguards into lending decisions.
- Engage participants in an interactive exercise simulating real-world financing challenges under ecological constraints.

Structure and Key Activities

The half-day workshop convened 40 participants, including scientists, lenders, consultants, and policymakers.

- **Opening**: Facilitators framed the session around the opportunity to shape nature-safe energy transitions through finance and multistakeholder engagement.
- **Session 1**: Experts from the U.S. Geological Survey and Bat Conservation International presented evidence-based mitigation strategies, including practical tools for reducing wind energy impacts on migratory species.
- **Session 2:** Representatives from Renewable Grid Initiative, European Bank for Reconstruction and Development, and the Asian Development Bank, shared perspectives on integrating biodiversity safeguards into financing and leveraging partnerships for innovative solutions.
- **Interactive Exercise – "The Lender's Dilemma":** Participants worked in small groups to decide whether to finance an anonymized, real-world wind project, balancing ecological risks and financial considerations. They proposed mitigation strategies, then switched roles to represent stakeholders such as conservation groups and local communities, negotiating solutions from new perspectives. This role reversal highlighted tensions between economic and ecological priorities and encouraged creative problem-solving.

- **Closing:** Panelists summarized 3 key takeaways from the workshop. First, Multistakeholder collaboration between developers, financiers, conservationists, and communities creates better outcomes for energy, people, and species. Second, evidence-based decision making, driven by investing in robust baseline studies, continuous monitoring, and adaptive management can ensure mitigation efforts address actual rather than perceived risks. Third, creative financial mechanisms, such as lending structures and incentives can align profit motives with conservation and community goals, encouraging innovation and impact reduction.

Outcomes

Participants left with:

- An understanding of ecological risks posed by wind energy and the current evidence supporting practical mitigation measures, including curtailment strategies, siting tools, and monitoring protocols.
- Insights into how financial institutions fold environmental information and science into decisions, and influence biodiversity outcomes through lending policies and project design requirements.
- Hands-on experience applying the mitigation hierarchy within a financing context, balancing stakeholder demands and project viability.
- Awareness of ETF resources and opportunities for engagement, including guidance documents, case studies, and tools like AVISTEP that supported informed siting and planning.

By combining technical knowledge, financial perspectives, and stakeholder engagement, the workshop advanced nature-positive renewable energy development and strengthened partnerships that safeguarded migratory species while accelerating the clean energy transition.

WILDLIFE PROTECTION ON THE GRID SIDE OF RENEWABLE GENERATION

Organized and run by: Manon Thiel (Renewables Grid Initiative), Brian McGowan (Scientias Energy), Tris Allinson (BirdLife International)

When assessing the environmental impacts of wind energy projects, attention is often focused on the generation side – particularly bird collisions with turbines and disturbance from their operation. However, a crucial yet frequently overlooked component is the electricity grid infrastructure. As most wind energy projects are located in remote areas, new overhead transmission lines are needed to deliver power to consumption centers. These necessary grid connections (comprising transmission lines, distribution lines, and substations) can are often located in nature-rich and ecologically sensitive areas. As a result, they can pose significant risks to wildlife, including electrocution and collisions of bird species, and even fire ignition. It is therefore essential to consider the grid as an integral part of wind energy infrastructure and to assess and mitigate its impacts on biodiversity with the same level of scrutiny as the turbines themselves. To address this, a half-day workshop will explore the risks for wildlife associated with grid infrastructure and present cutting-edge mitigation solutions and global best practices for reducing wildlife electrocution, collision and nesting disturbance, as well as fire risks.

Introduction to topic

- Why wildlife challenges in renewable generation grid connections are a critical consideration in delivering reliable and wildlife safe infrastructure, Brian McGowan, Scientias-Energy
- Global perspective of the issue (e.g, Bustard species, GIB from India, Macaws in Brazil, Saker in Mongolia) Tris Allinson, BirdLife International
- Panel: Early engagement for accelerated deployment. Moderator: Alvaro Camiña Cardenal.
- Manon Thiel, Renewables Grid Initiative o Intro to Mitigation hierarchy o Importance of early engagement and multi-stakeholder collaborations
- Tris Allinson, BirdLife International o Planning is key for nature-friendly infrastructure o Intro to AVISTEP and other sensitivity mapping in Belgium and French.
- Teresa Marques, CIBIO BIOPOLIS o Focus on sensitivity mapping for Steppe species in Spain

Solutions to mitigate risks for bird species

- Overhead line design, and technology solutions to reduce collision & electrocution risk and associated faults and outages. Brian McGowan, Scientias-Energy
- Case study: Austria; HV Cable undergrounding, an enabler for Great bustard conservation success. Rainer Raab, TB Raab (8 min)
- Case study: Brazil; Preventing electrocution of Lear's Macaw on distribution structures, Larissa Biasotto, BirdLife International (8 min)
- Case study: South Africa; mitigating bustard collisions with power lines in the Karoo, Matt Pretorius, EWT
- Case study: Sharing wildlife mitigation experience from Spain, Fernando Crespo Carretero, Redeia-Red Eléctrica de España.
- Case study: Impact of wind farms and associated structures on Great Bustard(Otis tarda), Gonzalo Páez Pérez, Medioambientales .

Research gaps and future prospects

- Need for comprehensive mortality data and introduction to the RISKY project. Teresa Marques, CIBIO BIOPOLIS
- SafeLines4Birds and testing new tools to reduce collision risk, Manon Thiel, Renewables Grid Initiative
- Key learnings from the assessment of wildlife-induced outages at HV substations in the U.S.A, mitigation performance analysis and optimization recommendations. Brian McGowan, Scientias-Energy

30 YEARS OF OFFSHORE WIND: WHAT DO WE KNOW AND WHAT DO WE NOT KNOW

Organized and run by: Georg Nehls (BioConsult SH) and Quirijn Schürmann & Sytske van den Akker (Waardenburg Ecology)

Description & aim of the workshop:

Since the installation of the turbines at Tunö Knob, Denmark, in 1995, our knowledge about ecological impact of offshore wind has certainly increased and clearly informed decision making in marine spatial planning. As the North Sea and the Baltic Sea are supposed to become Europe's powerhouse in the next decades, it is time to analyse whether the knowledge accumulated so far (1) allows for solid assessments of the ecological impacts of this large-scale development and (2) to ask which knowledge is needed for future developments. There were over 80 participants, from NGO's, developers, regulators and scientists/ecological consultants. Most participants had some experience with offshore wind, with also very experienced people (>10 years) and about 10% people new to the offshore wind.

Ulrike Braeckmann, Ghent University, showed that offshore foundations provide local enrichment of benthic fauna mostly unrelated to adjacent natural habitats and little promotion of protected species. Offshore windfarms are found to provide refuge for fish where fisheries are excluded.

Ansgar Diederichs, BioConsult SH, provided a broad overview of impacts on birds and marine mammals. Open questions are still possible population impacts resulting from disturbance, displacements or mortality.

Jesper Kyed Larsen, Vattenfall, shared his experiences from early research and showed that the context of ecological research is very important: you must understand the bigger picture to assess the impacts.

Zoe Crutchfield, Scottish Government, provided the regulator perspective. With the wealth of pre- and post-construction studies available there is a need for meta studies to get the big picture.

Warm-blooded animals

For migratory birds it was acknowledged that monitoring is complex and mitigation needs to consider a lot of different factors. It was mentioned that camera systems should be tested and maybe with the use of AI there could be an automatic detection system. There was an interesting point made about the difference between offshore and onshore: an additional problem offshore is that birds that need to re-route due to windfarms could become exhausted and die before reaching land.

For resting birds, there are a lot of unknowns, including how some species can detect the wind farms at 20km distance. Also, some species like the red-throated diver seem to avoid the built area but still sit at the edge of the farm. The dynamics of this all needs to be understood.
On marine mammals it was agreed that there is quite some knowledge about disturbance during construction activities, especially for the harbour porpoise. However, here are knowledge gaps on the cumulative impacts and displacement. Also, moving further offshore might start creating problem for baleen whales, which are currently not considered in studies.

Cold-blooded animals

During the discussions about the cold-blooded animals, it became clear that quite a lot is known about how benthic communities develop on the foundations. There has been more attention to nature inclusive design, aiming at increasing biodiversity/biomass and opportunities to kick off natural reef developments.

However, the impact on the larger scale is not known. Little is known about fish: do windfarms act as aggregation area or is biomass in total increasing. Another important gap in knowledge is the ecosystem effect. Offshore windfarms have an impact on hydrodynamics. It is not unclear how this will impact phytoplankton and the rest of the system, especially if the scale of offshore wind will further increase. It was discussed how to make best use of knowledge. Monitoring and research take time and meanwhile offshore wind developments go fast. Decisions need to be made based on best available knowledge. Adaptive management is needed and mitigation should be applied.

Conclusion

At the end of the workshop, Sophie de Reus (the Rich North Sea) reflected on the information shared and the outcome discussions, captured on a very informative drawing by her colleague Eline van Onselen.

The general take home message was that despite advancement, there are a lot of knowledge gaps still outstanding: gaps about effects at a larger scale, ecosystem effects, animal behaviour and the population consequences and, about technical solution for mitigation and monitoring. It was agreed that international coordination is key and spatial planning and impact assessments should be done at a regional scale and not country or even project based. Standardisation in monitoring could help and data sharing is very important to increase the knowledge base needed for making best informed decisions. However, it was also concluded that there is already a strong knowledge base and lessons learned and experiences from the North Sea and Baltic Sea can be shared with other countries that are at the start of developing offshore wind (like Australia, USA).

NATURE INCLUSIVE DESIGN

Organized and run by: Bob Rumes (Institute of Natural Sciences, Belgium), Sytske van den Akker & Quirijn Schürmann (Waardenburg Ecology, Netherlands)

Summary of the workshop

The Nature Inclusive Design (NID) workshop took place on 8 September 2025 during the 8th Conference on Wind Energy and Wildlife Impacts (CWW2025) in Montpellier. The event brought together nearly 80 participants from 21 countries, representing environmental consultancies, industry, academia, NGOs, and governmental bodies. The workshop aimed to assess the current state of knowledge on Nature Inclusive Design in offshore wind and to outline future directions for research and large-scale implementation.

The workshop's central goal was to evaluate how NID measures can improve marine ecosystems in the context of offshore wind development. For this purpose a definition of NID was proposed and later adapted based on feedback provided by the workshop participants: "Any intentional and scalable measure, backed by scientific evidence or indigenous knowledge, which optimizes man-made architecture and infrastructure and measurably improves the condition of the marine ecosystem".

Workshop presentations were divided into three thematic blocks: Setting the context, Best practices and lessons learned, and Preparing for the future.

Dan Wilhelmsson and Luca van Duren set the Context by reflecting on existing knowledge on offshore wind environmental impacts and by providing a wider view on nature restoration efforts. Dan highlighted that offshore wind farms inherently alter marine habitats—not only through physical structures but also due to fisheries exclusion. He cautioned against potential negative ecological effects of artificial reefs, such as increased predation, ecological traps, or spread of non-native species. Luca emphasized designing NID within a changing, warming climate. She stressed prioritizing passive restoration (supporting natural recovery) and warned against installing unnecessary permanent artificial reefs that could cause additional habitat loss.

The Best Practices and Lessons Learned block featured practical examples and case studies from fixed-bottom offshore wind farms. Remment ter Hofstede highlighted the importance of regionally aligned ecological goals, while Iris Menger underscored integrating monitoring of NID with ongoing operations and maintenance. Both stressed the need for close collaboration among regulators, scientists, and developers. Renate Olie presented promising results from oyster restoration efforts at Blauwwind, including oyster reproduction in cages and colonization of scour protection. Both Sam Hickling and Yaeli Rosenberg showcased the use of innovative materials, such as Reef Cubes and Econcrete, which demonstrated rapid colonization and biodiversity gains.
As part of Preparing for the Future Gilles Lecaillon presented opportunities for NID in floating offshore wind farms, with examples from the Mediterranean where floating platforms supported early life stages of marine species and developed "offshore coastal" communities. Eline van Onselen introduced The Rich North Sea Toolbox, a comprehensive resource for NID implementation. She addressed the challenges of scaling up biodiversity enhancement across multiple offshore wind farms.

The subsequent panel discussion explored several key questions:

- Monitoring NID impacts:
  Robust study designs comparing structures with and without NID are essential to quantify ecosystem benefits. However, the lack of location-specific data on biodiversity benefits should not prevent the wider rollout of proven solutions.
- Sufficiency of current knowledge for largescale application:
  Although data mostly come from small-scale studies, panellists agreed that available evidence supports scaling up—with caution and continued monitoring.
- NID and "net positive" goals:
  While wind farms are not marine protected areas and always impose some ecological costs, NID can help mitigate impacts. The concept of "net positive" was considered ambiguous, but NID is widely seen as contributing to restoration objectives.
- Benefits for birds:
  Most NID efforts focus on reef effects; measures targeted at seabirds are limited. Indirect benefits may arise through increased prey availability.
- Stakeholder cocreation:
  Collaboration with NGOs and fisheries can foster innovation, ensure practical feasibility, and promote shared ownership of NID measures.
- Regulatory barriers:
  Regulation is a key driver for NID implementation but can also impede progress if too restrictive or focused narrowly on specific species. A more holistic, ecosystem services-oriented approach was recommended. Regulatory clarity on decommissioning in NID implementation sites is also needed.

In conclusion, the potential of NID in offshore wind farms to enhance marine ecosystem health is increasingly recognized. Early results from project-level applications show promising biodiversity gains and minimal negative effects. However, the impact of most NID measures is spatially and temporally limited, requiring broader, coordinated implementation—including alignment with marine protected areas and other conservation actions. Scaling up NID will depend heavily on: coherent and robust regulatory frameworks, clear ecological objectives, sufficient monitoring and research efforts, stakeholder cooperation, and transparent data sharing. Despite identified barriers - especially regulatory complexity and limited large-scale evidence - the workshop participants expressed optimism. Most expect widespread implementation of NID across multiple offshore wind farms within the next 5–10 years, emphasizing that delaying action carries greater ecological and opportunity costs than moving forward responsibly under current knowledge.

INTEGRATING SOCIAL & ENVIRONMENTAL SCIENCES TO AID IN SITING & PERMITTING

Organized and run by: John Aston (Earning Local Support Academy; Co-lead IEA Wind Task 62), Amanda Hale (WEST), Roel May (Norwegian Institute for Nature Research), Rhoda Fofack-Garcia (France-Energies Marines), Miguel Repas-Goncalves (Strix), and Cris Hein (Lead IEA Wind Task 59)

The 'grand challenges in the science of wind energy' initially presented by Veers et al. (2019) ignored both human (Firestone 2019) and ecological (Katzner et al. 2019) challenges. These responses led to an IEA Wind Topical Expert Meeting promoting an interdisciplinary and holistic overview. Social and environmental challenges associated with siting and permitting wind energy projects are inherently multi-dimensional and require coordination and collaboration across different areas of expertise to overcome them. Environmental and social/community-related challenges are often inter-related—such as community opposition driven by environmental concerns, or facility siting preferences for environmental reasons but opposed by the community due to insufficient consideration of community concerns—which can include lack of trust in the independence of the studies or the project-community engagement process, among other issues. These issues are increasingly problematic for wind energy projects when coupled with the rise of misinformation and disinformation. The interactive workshop, initiated by the IEA Wind Tasks on environmental and social research, brought together international researchers and industry professionals in the social and environmental sciences to discuss issues that cut across these disciplines.

The setting of the workshop was introduced through a series of presentations. The concept of energy stewardship was explained, which aims at integrating the social-technical, social-ecological and eco-technical domains in support of sustainable development of wind energy. This also includes sharing of responsibility in balancing multiple interests to obtain wind energy with the least social and ecological impact per kWh. This was followed by three case study experiences providing food for thought for further discussions. This included experiences from Ireland on community perspectives on environmental-friendly siting and permitting. In France, the expectation and practice of public participation in offshore wind energy development was debated. Finally, a life-cycle timeline of conflict resolution through impact research and mitigation experimentation at the Smøla wind farm, Norway, was presented.

After these introductions, the attendants were invited to share their knowledge, thoughts and experiences with each other using a combined Strengths-Weaknesses-Opportunities-Threats (SWOT) diagnosis and solutions-oriented Actions-Transformation approach focusing on 'Community considerations of ecological concerns in wind energy project planning'.

Diagnosis (SWOT)

- Strengths (internal): What works well with the current planning system of ecological concerns?
- Weaknesses (internal): What are the challenges, tradeoffs, and blind spots that hamper trust in the current planning system?
- Opportunities (external): Which practices/trends advance community considerations of ecological concerns in project planning?
- Threats (external): Which practices/trends hinder community considerations of ecological concerns in project planning?

Solutions

- Actions (internal): How can community and ecological considerations be integrated with each other and internalized into the planning process? What research areas should the social and ecological sciences be collaborating on?
- Transformation (external): How can community and ecological concerns be communicated and mainstreamed? How do we get information to trusted communicators, and who are they?

Key messages from participants

Participants noted that when communities experience genuine influence in decisions that impact them, they are more willing to engage constructively and consider trade-offs (Strength). Conversely, when engagement feels performative, particularly when project proponents arrive with a fixed and controlled agenda, trust erodes and community concerns, including ecological concerns, become more difficult to resolve (Weakness).

Participants mentioned the importance of making projects accessible throughout the full development pathway, not only at formal, legally required consultation points (Opportunity). They also cautioned against assuming a single engagement model will work everywhere. Communities differ in history, values, capacity, and concerns, so engagement should be tailored rather than a one-size-fits-all approach (Threat).

Internally, developers can strengthen engagement by bringing in specialists to connect with communities, and by integrating social and ecological considerations together rather than separate workstreams (Action). Externally, it is necessary to identify trusted partners/communicators, but this requires time, consistency, and credibility, especially when communities are bombarded by mis- and disinformation (Transformative).

The full set of feedback from attendants will be reported back to them and finalized in a report to be made publicly available. The report will present a set of recommendations to support communicating social and environmental research considerations to various stakeholders.

ENGAGING INNOVATION IN BIODIVERSITY OFFSETS FOR WIND ENERGY PROJECTS AND DEVELOPING STRATEGIES TO MAXIMIZE STAKEHOLDER ENGAGEMENT

Organized and run by: Quentin R. Hays (GeoSystems Analysis Inc.), Adam Cernea Clark (Pattern Energy), Kari Soltau (Burns & McDonnell)

Summary

This workshop reviewed, in detail, the process of designing and implementing biodiversity offsets under International Finance Corporation Performance Standard 6 (IFC PS6), using offsets for a major wind energy and transmission project in the United States as examples that can be applied globally. The process utilized for this model project exemplifies how developers can work collaboratively with local and regional conservation stakeholders to provide for more meaningful conservation actions that increase community buy-in and leverage local and regional expertise and existing conservation efforts. Examples focused on land-based wind energy and transmission biodiversity offsets, with focuses on both birds and bats, including mitigation banking, research, and habitat creation for "net gain".

Following a review of the process of designing and implementing biodiversity offsets under IFC PS6, the workshop transitioned to a participant-led scenario exercise using a European model project. Breakout groups developed meaningful biodiversity offsets that went beyond 'checking the box' for international financing standards and leveraged local and regional expertise and stakeholder engagement. During the scenario exercise, universal challenges related to quantification of impacts and assessing efficacy of biodiversity offsets received focus.

Outcomes

Participant outcomes for this workshop included:

- Demonstrated understanding of designing and implementing biodiversity offsets for wind energy and transmission projects under IFC PS6.
- Demonstrated understanding of innovative and effective biodiversity offsets for wind energy and transmission projects.
- Devised strategies to leverage stakeholder engagement to drive development of effective biodiversity offsets.
- Improved proficiency in navigating impact and offset quantification bottlenecks to create nature positive solutions to complex wind energy and transmission project mitigation challenges.

© Quentin GAULE



SPECIAL SESSIONS

TUESDAY 9TH SEPTEMBER – 14:00-15:15

OFFSHORE WIND COLLISION DETECTION SYSTEMS - STATE OF SCIENCE

Moderators: Aonghais Cook (The Biodiversity Consultancy) and Jos de Visser (Rijkswaterstaat)

Uncertainty surrounding collision risk presents a substantial challenge to the assessment of current and future offshore wind farms. Whilst models are routinely used to assess collision risk prior to offshore wind farm construction, these models lack validation and may therefore lead to unrealistic predictions of risk. Collecting data on collision rates would help validate these models and support an understanding of the circumstances in which collisions occur, helping to reduce uncertainty associated with estimates of collision risk and facilitating the development of effective mitigation strategies. In contrast to the situation onshore, collection of such data has been a long-standing challenge for offshore wind farms. However, a number of promising new technologies and approaches have been developed to collect these data. Through this session, the organizers aimed to:

- Showcase studies across a range of technologies taking on this challenge and some of the data collected to date;
- Discuss general considerations for collecting evidence relating to collisions and how to optimize its use in advancing and validating current Collision Risk Models; and
- Acknowledge the common challenges collecting these data and discuss the key priorities for overcoming these challenges.

These aims were delivered through a combination of short presentations, panel and audience discussion.

Session chair: Jos de Visser, Rijkswaterstaat

Presentation on considerations and needs around collecting evidence suitable to improve CRM's, Aonghais Cook
Presentations on current case-studies :

- Firth of Forth Seabird Interactions Study (radar and cameras) - Miguel Repas Goncalves, Strix
- Advantages with stereovision for collision detection (daylight cameras) - Glen Sykes, Spoor
- Measuring bird and bat collisions at an offshore wind turbine (thermal cameras) - Karen Krijgsveld, Wageningen Environmental Research WUR
- Presentation on developer perspective, hosting collision studies and developing the evidence we need, Jesper Kyed Larsen, Vattenfall

Interactive debate and Q&A focusing on the priorities in terms of data needs and ways of overcoming challenges to deliver on them
Panel participants across main applied stakeholders.

Measuring bird and bat collisions at an offshore wind turbine (thermal cameras)

Dr Karen Krijgsveld[1]*, Mr Brogan Morton[2], Mr Jon Ritter[2], Ms Femke Warmer[1], Mr Martin Poot[1]
[1] Wageningen University & Research, [2] Wildlife Imaging Systems
*Corresponding author.

Collisions of birds and bats with offshore turbines have been a major topic of concern when it comes to estimating and mitigating the impact of offshore wind energy on natural values. Because quantifying collisions offshore has been so overwhelmingly difficult, most estimates of collision rates have thus far been theoret-

ical exercises.
With the improvement of thermal cameras in the previous years, combined with rapid advances in AI-technology, Wildlife Imaging Systems (WIS) has developed a technique that now enables us to measure actual collisions offshore. In a combined research project, we are testing this system offshore in the spring – and autumn migration seasons of 2025.
Collisions of passerines and bats migrating offshore are being measured at an offshore wind turbine that lies prominently in a migration route. Collisions measurements are being complemented with information on flight activity (data from cameras and bird radar) and on flight calls of birds and bats (acoustic sensors).
The study is taking place at offshore wind farm Hollandse Kust Zuid (HKZ) in the North Sea off the coast of the Netherlands. In this pilot we are deploying sixteen thermal cameras. Twelve cameras are used to measure direct mortality caused by the wind turbine. They are mounted on the transition platform, with a field of view oriented radially outward away from the turbine. The focal length of these cameras was chosen to see a 10 cm object up to 115 m away, thus covering the whole area below the rotor-swept zone for all wildlife of interest. Together they cover the full 360° around the base of the tower, 24 hours a day. The goal of these outward-looking cameras is to detect a falling object after a direct fatality. The additional four cameras are looking up, thus monitoring the rotor-swept zone. These are positioned such that they are each monitoring a side of the turbine, resulting in 360° coverage of the rotor-swept zone. The goal of these upward-looking cameras is to gain direct information of colliding birds or bats, and observe responsive flight behaviour near the rotor disc, e.g. in relation to different weather conditions.
In this presentation we share the first insights of the study, after one spring season of measurements. We show collisions that were detected, recorded flight and call activity and species composition on nights with high migration activity, and we discuss performance of the system and preliminary insights on collision rates.

TUESDAY 9TH SEPTEMBER – 14:00-15:15

WIND ENERGY AND BIODIVERSITY IN THE TROPICS

Moderators: Emma Bennett (Elmoby Ecology) and Kate MacEwan (Western EcoSystems Inc.)

Including case-study from Asia by Stephanie Sioson (Asian Development Bank) & interviews of 10+ stakeholders from various region of the world.

In this session, our hosts brought together stories and voices from across the tropics through an interactive format that combines in-person speakers with pre-recorded short talks and interviews. Home to 85% of the world's poorest people and over 80% of the world's living languages, the tropics face significant financial and linguistic barriers to participation in forums like CWW. To help bridge this gap, we harness digital technology to connect and include more of those voices. The tropics is both the most biodiverse and underdeveloped region on Earth, and over the past 30 years, its economic growth has outpaced that of the rest of the world. While wind energy development has already progressed rapidly in some tropical regions, the coming decade is expected to bring a major expansion in installed capacity—raising new wildlife conflicts in areas rich in endemic species. This session explored the lessons already learned from working in the tropics, the unique challenges faced in these regions, and the central role of people and culture in developing long-term solutions that benefit biodiversity.

Including case-study from Asia by Stephanie Sioson (Asian Development Bank) & interviews of 10+ stakeholders from various region of the world.

WEDNESDAY 10TH SEPTEMBER – 14:15-15:45

MEETING THE CHALLENGE OF MITIGATING BAT MORTALITY AT WIND ENERGY FACILITIES

Moderators: Winifred F. Frick (Bat Conservation International) & Mirna Mazija (Supernatural)

Designing and implementing effective bat mitigation is needed as wind energy expands globally, but has often lagged behind practices implemented for birds because relevant information for mitigation planning for bats is often lacking. This special session included four selected presentations that address the challenges of developing bat mitigation practices for bats in different parts of the world, including biodiverse regions of the global south. The special session also included a moderated panel discussion with speakers and experts to discuss and explore challenges and solutions to implementing mitigation practices in a global context.

Presentation of case-studies :

- Proposed Guidelines for Monitoring, Evaluation, Prevention, and Mitigation of Wind Farms' Impacts on Bats in Mexico - Minerva Angela Uribe Rivera, Universidad Autónoma de Baja California
- Population level impacts of wind energy for two fruit bat species in South Africa – Jonathan Aronson, Camissa Sustainability Consulting
- From cumulative impact assessment and threshold definition to curtailment: a four-year mitigation case study for migrating bats – Marília Barros, BE - Bioinsight & Ecoa

Proposed Guidelines for Monitoring, Evaluation, Prevention, and Mitigation of Wind Farms' Impacts on Bats in Mexico

Dr Minerva Angela Uribe Rivera[1]*, Dr Claudia Leyva[1], Dr Mariana Villada[1], Dr Carlos Peynador[1], Dr Miguel Briones[2], Dr Cris Hein[3]

[1] Universidad Autónoma de Baja California, [2] Instituto Politécnico Nacional, [3] National Renewable Energy Laboratory

*Corresponding author.

Mexico is the second-largest wind energy producer in Latin America. However, the impact of wind farms on bat mortality from wind turbine collisions remains largely unknown. There is insufficient data on the species affected and the associated mortality risks related to wind farm locations, making it challenging to create effective guidelines. In light of the lack of specific regulations in Mexico for assessing these impacts, this study proposes directives for monitoring, evaluating, preventing, and mitigating the effects of wind farms on bats.
A diagnostic assessment was conducted by analyzing monitoring reports and scientific studies, identifying 39 bat species affected by collisions, including two at-risk species: Enchisthenes hartii and Leptonycteris yerbabuenae. The three species with the highest mortality rates are migratory: Pteronotus davyi, Tadarida brasiliensis, and Lasiurus cinereus. While current mortality data is limited, findings emphasize the necessity for improved data availability to devise effective prevention and mitigation strategies.
Semi-structured interviews with key stakeholders highlighted five main issues: 1) the absence of specific monitoring guidelines, 2) inadequate compliance report analysis, 3) ineffective mitigation measures, 4) restricted public access to impact information, and 5) insufficient dialogue among developers, researchers, and authorities.
The study also reviewed existing regulations regarding bat impact assessments in wind farms, uncovering eight international treaties supporting wind energy and several Mexican regulations. However, the criteria set by the Secretary of Environment and Natural Resources are overly general and fail to address vital aspects of bat conservation.

Due to the lack of specific guidelines, the development of a Guide for Environmental Impact Statement submissions tailored to wind energy projects was prioritized. This guide was created collaboratively with academics, specialists, sector representatives, and authorities, incorporating international recommendations suited for the Mexican context.
This proposed guide is the first in Mexico to concentrate solely on the environmental impact assessment of wind farms, advocating for standardized methods for evaluating and mitigating impacts on bats. Additionally, it includes recommendations based on federal environmental policy instruments such as environmental management planning and impact assessment, aiming to enhance the evaluation and mitigation of these impacts in Mexico.
These guidelines can also serve as a foundation for other countries sharing migratory species and facing similar challenges due to the absence of specific guidelines, particularly in Latin America.

Population level impacts of wind energy for two fruit bat species in South Africa

Mr Jonathan Aronson[1]*
[1] *Camissa Sustainability Consulting*
*Corresponding author.

Wind energy development in Africa necessitates understanding its impact on bat populations, particularly fruit bats, which are ecologically important but understudied in this context. I assessed whether wind turbine-related mortality is likely to cause population-level impacts on Egyptian fruit bat and Wahlberg's epauletted fruit bat in South Africa, using a Leslie matrix model and Potential Biological Removal (PBR). The matrix model showed population growth for both species, even under low and medium fatality scenarios. Under a high fatality scenario, the probability of population decline reached 60 % for Egyptian fruit bat and 72.3 % for Wahlberg's epauletted fruit bat, with both species showing reduction in population size over 100 years. Quasi-extinction risk increased with rising fatality, reaching 21 % – 23 % at a 1 % annual fatality rate. The PBR results also showed resilience at low to medium fatality levels but a high fatality scenario could exceed sustainable removal thresholds by 636% for Egyptian fruit bat and 861% for Wahlberg's epauletted fruit bat under precautionary management. The findings indicate that while these fruit bat populations may withstand low to medium levels of turbine-related mortality, increasing fatalities pose a significant risk of long-term population decline. This underscores the need for robust monitoring and a comprehensive understanding of cumulative impacts to align wind energy expansion with biodiversity conservation objectives in Africa. The findings support species-specific, population-based thresholds that reflect demographic sensitivity and spatial exposure. This approach can guide evidence-based regulation and conservation in wind energy planning for African bats.

From cumulative impact assessment and threshold definition to curtailment: a four-year mitigation case study for migrating bats

Dr Sandra Rodrigues[1], Ms Marília Barros[1]*, Mr Paulo Cardoso[1], Dr Miguel Mascarenhas[1]
[1] *BE - Bioinsight & Ecoa*
*Corresponding author.

Migratory bats are especially vulnerable to turbine collision as they are subject to the cumulative impact of multiple wind farms along their migration routes. This study presents a four-year project aimed at reducing bat fatalities at wind turbines within an important bird and bat migration corridor along the Black Sea coast. Conducted between 2020 and 2023 at a wind power facility in the region, the project followed a structured mitigation plan designed to minimize both bat mortality and energy production losses.

In compliance with the best international practices, a mitigation plan was developed following six steps: (1) assess population-level impacts; (2) definition of target species and mortality thresholds; (3) evaluation of mitigation alternatives; (4) conducting bat acoustic monitoring at turbine height; (5) testing and adjusting curtailment; and (6) establishing a long-term mitigation plan. A Population Viability Analysis was conducted in the first two steps, considering cumulative impact of wind turbines along migration routes and different population scenarios to account for uncertainty related to population size, and define mortality thresholds. Results indicated that the migratory bat *Pipistrellus nathusii* could be negatively affected if the mortality rate exceeds a critical threshold. Adjusted curtailment (i.e., shutting down turbines during periods of high activity) was identified at the time as the best mitigation option. Activity data collected at nacelle height informed collision risk analysis and the relationships between bat activity, fatalities, and weather conditions to support the definition of an adjusted curtailment plan. After one year of monitoring, a curtailment plan was developed and incrementally refined over two more years to maintain mortality levels within the defined threshold. After 3 years, the final curtailment plan was effective at keeping mortality below the target threshold and a Before-After-Control-Impact indicated a 75% significant reduction. Following these positive results, the mitigation plan was fully implemented in all turbines, ensuring bat conservation in a key area for migratory wildlife. This project exemplifies how mitigation strategies can be integrated into wind energy projects to safeguard wildlife while maintaining economic viability.

WEDNESDAY 10TH SEPTEMBER – 14:15-15:45

OFFSHORE WIND IN EMERGING MARKETS

Moderators: Kate Williams (Biodiversity Research Institute) and Aonghais Cook (The Biodiversity Consultancy)

Summary of the session

- Short opening introductory speech
- Focus on the implementation of new approaches or technologies to inform offshore wind siting and management in new geographies.
- Presentation of SenMap report (World Bank Group): Identifying where gaps in data exist & then attempting to fill them
- Panel discussion focusing on how to develop offshore wind both quickly and in an environmentally responsible way (is it possible to balance those competing objectives?)
- Innovative approaches used in various countries to address some of the gaps in baseline data.
- Panel discussion with all speakers : How can we be creative with available resources and use emerging technologies and approaches to inform environmentally responsible offshore wind energy development in new locations?

This special session included 4 case-studies:

- SAFE and FAIR data solutions: A demonstration of the SAFE to inform marine habitat benchmarks to study the cumulative impacts of offshore wind farms – Harrison Carnody, School of Biological Sciences, The University of Western Australia, Perth
- Change of seabird diversity and abundance at offshore windfarm in Taiwan Strait - Chung Hang Hung, National Taiwan University.
- Occurrence and activity of bats in the offshore windfarm environment, a first of its kind study in South African waters – Werner Marais, Animalia Consultants
- Boosting the recognition of migratory bird flight paths over the Baltic Sea for collision risk modeling using machine learning in the analysis of ornithological radar data – Rafał Siuchno, 3BIRD

SAFE and FAIR data solutions: A demonstration of the SAFE to inform marine habitat benchmarks to study the cumulative impacts of offshore wind farms

Mr Harrison Carmody[1]*, Dr Tim Langlois[1], Dr Matthew Navarro[1], Mr Claude Spencer[2], Dr Rob De Roach[3], Mr Brendan Busch[4]

[1] School of Biological Sciences, The University of Western Australia, Perth, Western Australia 6009, Australia, [2] The Oceans Institute, Indian Ocean Marine Research Centre, Perth, Western Australia 6009, Australia, [3] BMT Commercial Australia, Level 4, 20 Parkland Road, Osborne Park, WA, 6017, [4] Western Australian Marine Science Institute, Indian Ocean Marine Research Centre, The University of Western Australia, Entrance 4, Fairway, Crawley WA 6009

*Corresponding author.

Producing robust habitat maps required for site selection of offshore wind farm (OWF) infrastructure can be expensive. Shared data frameworks that allow organisations to share data without compromising their intellectual property has the potential to vastly expand available data at low cost. The Shared Analytic Framework for the Environment (SAFE) guidance, together with the Shared Environmental Analytics Framework (SEAF), developed by the Western Australian Marine Science Institute and Western Australian Biodiversity Science Institute, enables the derivation of outputs from open and restricted datasets through a cloud-based data sharing platform. We demonstrate the Framework's capacity to enable predictive habitat mapping with open and restricted data collected following the findable, accessible, interoperable and reusable (FAIR) data principles. The demonstration focuses on the Offshore Electricity Infrastructure

(OEI) zone near Bunbury, Western Australia, where planning of multiple offshore wind farms is underway. Restricted and open access habitat composition data has been collected in the region using remote wide-field drop camera systems called Benthic Observation Survey Systems. Using generalised additive mixed modelling approaches, we predict the composition of benthic habitats across the OEI zone using both the restricted and open access datasets. Preliminary results indicate that habitat outputs are twice as reliable when produced with restricted and open access data together than open access data alone. Once finalised, these outputs can subsequently be used to set environmental benchmarks for the Bunbury OEI zone, enabling future cumulative assessments to better understand and potentially mitigate impacts associated with site selection of OWF infrastructure. The study is to our knowledge the first to evaluate how OWF infrastructure may impact benthic habitats in Western Australia, and Australia as a whole. It is also one of the first to demonstrate the capabilities of the Framework. The study showcases the usefulness of shared data frameworks as a solution to data paucity, enabling reliable cumulative assessments, particularly for the OWF industry which requires in-depth understanding of the benthic environment at a high resolution.

Change of seabird diversity and abundance at offshore windfarm in Taiwan Strait

Dr Chung Hang Hung[1]*, Mr Han-Po Chang[1], Ms Yun-Xuan Lin[1], Ms Chih-An Lee[2], Prof Hsiao-Wei Yuan[1]
[1] National Taiwan University., [2] Ørsted
*Corresponding author.

The energy transition principle of Taiwan is based on “promote green energy, increase natural gas, reduce coal-fired, achieve nuclear-free” to ensure a stable power supply and to reduce air pollution and carbon emissions. The government has announced a new target of achieving 29 gigawatts (GW) of renewable energy capacity by 2025, to be comprised primarily of solar power (20 GW) and offshore wind power (5.6 GW). In this study, we access the change of seabird diversity and abundance before and after the construction of the largest offshore windfarm in Taiwan. The Greater Changhua projects have a maximum capacity of 2.4GW to be built out from 2021 to 2025. So far, there were 111 wind turbines (8 MW) have been deployed at southern part of Greater Changhua offshore windfarm in 2024. Base on the boat transit survey data collected from 2016 to 2024, the dominated seabird species in Greater Changhua offshore windfarm were Streaked Shearwater (Calonectris leucomelas), Bulwer’s petrel (Bulweria bulwerii), Great Crested Tern (Thalasseus bergii) and Bridled Tern (Onychoprion anaethetus). We used non-metric multidimensional scaling (NMDS) and analysis of similarities (ANOSIM) to identify the change of seabird diversity and abundance before (2016-2020) and after (2021-2024) wind turbines deployed. Preliminary results showed that no significant change of seabird diversity after wind turbines deployed, but the Great Crested Tern became more dominated. The increase of Great Crested Tern in 2021-2024 might be relate to the extension of its breeding colonies and population in Penghu Island or attraction effect from offshore windfarm. Further research will be focus on the behavioural response of terns to the presence of wind turbines and foraging range of the breeding terns in Penghu Island.

Occurrence and activity of bats in the offshore windfarm environment, a first of its kind study in South African waters

Mr Werner Marais[1]*
[1] Animalia Consultants
*Corresponding author.

The occurrence, behaviour and distribution of bats at sea in South Africa is a poorly understood phenomenon, with extremely limited historical information available. The wind energy yield potential of the country’s offshore environment, and the advent of offshore wind energy technologies is necessitating the fast-tracking of research into this topic. Passive and active data collection were carried out. This was done by means of passive acoustic monitoring from

December 2022 to August 2023 with bat detectors mounted on a buoy approximately 10km from the nearest landfall, and active acoustic monitoring during 27 nocturnal boat transects between September 2023 and April 2024 up to 12.6km from the shoreline. Two of these nocturnal transects also included visual manual thermal camera surveying, targeted at possible non-echolocating fruit bat presence. Passive acoustic monitoring represents 156 nights of bat activity monitoring when the systems were operational, continuous nightly monitoring were hindered by regular theft of the systems. These results indicated bat activity in late summer, early autumn and late winter. Activity was temporally grouped and not spread out during the recording periods. Feeding buzzes were recorded that demonstrated bats were actively foraging at the buoy approximately 10km from the nearest shoreline. Active acoustic monitoring recorded a total of 104 bat passes with the most activity between 0 - 3000m from shore. Overall, 97% of bat calls were recorded within 5000m of the shore, and 3% beyond 5000m. No bat activity was detected beyond 5500m, despite transects extending as far as 12,600m offshore. The two transects that included visual thermal observations did not yield any fruit bat sightings. In conclusion, bats are present and actively feeding 10km from the shoreline, but activity levels are strongly influenced by the distance from shore. Other factors that may determine or dictate the presence and absence of bats offshore are being currently investigated. Since the South African context does not have nearby large land masses and therefore the probability of offshore migrations are low, the ecological drivers for offshore bat activity several kilometers from the coast are yet to be determined.

Boosting the recognition of migratory bird flight paths over the Baltic Sea for collision risk modeling using machine learning in the analysis of ornithological radar data:

Mr Krzysztof Gajko[1], Mr Rafał Siuchno[1]*, Mr Jacek Ksepko[1], Mr Piotr Tynecki[1], Ms Anna Suchowolec[1]
[1] 3BIRD K. Gajko J.Ksepko Sp.j. ul. Żurawia 71, 15-540, Białystok, Poland, office: +48 530 177 111
*Corresponding author.

The Baltic Sea is a key migration route for waterbirds. These birds migrate from their wintering grounds, located mainly in south-western Europe and Africa, to breeding grounds located in north-eastern Europe and Asia. On their migration route in the Polish economic zone of the Baltic Sea, offshore wind farms are planned to be built with a generating capacity of 5.9 GW by 2030 and up to 11 GW by 2040. These investments may affect migrating birds through collision risks. In order to assess the scale of this impact, a pre-investment survey is carried out which provides information on the abundance and species composition of migrating birds above the area of the planned offshore wind farm. These surveys are carried out with the use of an ornithological radar located on a floating research vessel. During the work, observers assign bird species and numbers to the radar-recorded flight paths. The data collected in this way has its limits due to the efficiency of the observer, the effectiveness of the detection of flight paths by the ornithological radar and the conduct of surveys under less favourable weather conditions. To increase the quality of data for assessing the impact of offshore wind farms on birds, including data used for collision risk modelling, manual post-processing is used to search for continuations of bird flight routes recorded by radar. This allows a larger number of observations to be included in the bird collision risk modelling process. Which translates into a higher quality result for the modelling itself. To accelerate the recognition of bird migration routes, we implemented Unsupervised Machine Learning. This involved transforming bird migration tracks, recorded by ornithological radars, into fixed-length feature vectors understandable by Artificial Intelligence (AI). Feature engineering allowed us to incorporate spatial-temporal and sequential-spatial contexts, capturing both temporal and spatial dependencies in migration paths. This enabled the identification of local and global patterns characteristic of migration flights and bird behaviors. Our approach formed the basis for applying clustering algorithms like HDBSCAN for flight detection and migration continuation analysis. In the final stage, we developed a tool featuring clustering models, feature decomposition, and interactive projections, facilitating manual post-processing and boosting the overall migration analysis process. The AI-aided process of finding the continuation of bird flight track, has resulted in more reliable data used in modelling the risk of collisions between birds and wind turbines for the environmental impact assessment of offshore wind farms

THURSDAY 11TH SEPTEMBER – 10:45-12:00

DEALING WITH UNCERTAINTY: BALANCING ADAPTIVE MANAGEMENT, THE PRECAUTIONARY PRINCIPLE, AND SCIENTIFIC ADVANCEMENT

Moderators: Sam Ralston-Paton (BirdLife South Africa)

The urgent need for the rapid rollout of wind energy means that decisions often must be made based on imperfect or incomplete data. Adopting a precautionary approach can be important for minimising risks to wildlife, but can limit opportunities for development, as well as for research and innovation into effective solutions. Conversely, adaptive management (AM)—learning by doing—allows for iterative improvements, but can increase risks both to biodiversity and to industry if implemented in the absence of a solid framework.

In this panel discussion, we explored case studies where adaptive management has been applied. We discussed what is required to ensure that the implementation of adaptive management does indeed lead to increased knowledge and that we do not inadvertently cause unacceptable harm to wildlife or undermine the viability of wind energy projects.

This special session included 4 case-studies:

- Quantifying and Enhancing Biodiversity at Irish Onshore Windfarms – Emma King, Trinity College Dublin
- Acoustics validate proper implementation of curtailment, generating ideal feedback for adaptive management – Caroline Byrne, Stantec Consulting Services Inc.
- Advancing Wind Energy Monitoring in Brazil: The Integrated Approach at Serra do Mel, Areia Branca, and São Miguel do Gostoso - Emílio Roos da Silva, BE - Bioinsight & Ecoa
- Closing the Loop: Recommending a Feedback Approach for Post-Consent Monitoring to Reduce Consenting Risk in Assessments – Esther Jones, Biomathematics & Statistics Scotland

Quantifying and Enhancing Biodiversity at Irish Onshore Windfarms
Emma King, Trinity College Dublin

To ensure climate and biodiversity obligations are met, the rapid growth of the renewable energy industry to combat climate change must be accompanied by tools to monitor, protect, and restore biodiversity. Ireland's rich wind resource has led to huge demands on the wind energy industry to build capacity, but this has meant that opportunities for biodiversity are often missed. The objective of our research is to develop an understanding of biodiversity surrounding onshore windfarms and address industry needs to bring biodiversity into decision-making.
We applied a transdisciplinary approach to develop biodiversity action plans, incorporating ecosystem accounting and stakeholder participation. We used the United Nations System of Environmental Economic Accounting–Ecosystem Accounting (SEEA–EA) framework to create biodiversity-themed ecosystem stock accounts for windfarms. We systematically reviewed both ecological surveys conducted in Environmental Impact Assessment Reports (EIARs) of granted windfarm applications in Ireland and scientific literature examining impacts biodiversity on windfarms to understand whether taxonomic focus of these surveys aligns with known impacts from scientific literature. Based on our findings, we reviewed actions to create biodiversity action plans for the wind energy sector. We conducted semi-structured interviews with industry members to collate their thoughts on biodiversity actions. Elicited information was input into a cost-effectiveness analysis to understand industry perceptions of biodiversity actions.
Our EIAR review revealed large amounts of data are collected, and the diversity of taxa included increased over time. However, taxa and impacts with low prominence in the scientific literature were also surveyed less

frequently in EIARs, highlighting that understudied biodiversity impacts are at risk of being underestimated. Applying the SEEA–EA highlighted considerable biodiversity potential of some habitats within windfarms, particularly peatland, marsh and freshwater systems. The spatially-explicit methodology clearly identified locations where improved management could enhance biodiversity. Combining these habitat assessments with scientific and stakeholder priorities we developed biodiversity action plans for the sector. Stakeholders identified several limitations of implementing biodiversity actions, including resourcing, knowledge gaps, policy requirements, and land agreements.
Our work highlights the large potential for windfarms to mitigate, protect, and enhance biodiversity on windfarms. There are large volumes of biodiversity data collected during the development stage. However, these data are underutilised. Applying the SEEA–EA could provide a standardised and iterative framework to inform management decisions and apply tailored actions for biodiversity. Collaboration with the wind energy industry was key to ensuring the feasibility of actions and guarantee win-wins for both climate and biodiversity.

Acoustics validate proper implementation of curtailment, generating ideal feedback for adaptive management

Ms Caroline Byrne[1]*, Dr Trevor Peterson[1], Ms Seta Aghababian[1]
[1] Stantec Consulting Services Inc.
*Corresponding author.

Implementing curtailment strategies to reduce bat mortality at wind energy facilities is increasingly important for managing risks to bat species globally. However, this process is complex due to the diversity of turbine makes and models, each governed by various software and hardware controls informed by different data sources. Modifying turbine control systems to adjust parameters such as cut-in speeds and implement curtailment decisions often requires customization. Consequently, applying a uniform curtailment strategy across multiple sites can lead to inconsistent outcomes. Our study aimed to compare the effectiveness of different curtailment strategies in reducing bat risk, necessitating accurate evaluation of curtailment implementation. We utilized turbine-mounted acoustic bat detectors to measure acoustic exposure, bat activity exposed to turbine operation, across 13 wind energy facilities in Iowa, USA, during 2022 and 2023. Each facility was equipped with 15 nacelle-mounted acoustic detectors. We synchronized bat acoustic data with 10-minute binned weather and turbine rotor speed measurements. Each 10-minute interval was evaluated to determine whether it met the criteria for curtailment under the implemented strategy. Comparing this curtailment assessment with acoustic exposure revealed instances where curtailment was not properly implemented at individual turbines and, in some cases, entire facilities. Acoustic exposure provided accurate, quantitative feedback on how successfully curtailment was implemented. Using this method to identify noticeable instances of improperly executed curtailment also helped in learning how to properly validate curtailment with other data sources, such as turbine rotation speed. This analysis provided specific feedback to facility operators, enabling them to identify and address hardware and software communication errors to improve curtailment implementation. It also underscores the importance of validating the execution of each strategy in curtailment studies, ensuring that differences in risk measures are due to the strategies themselves and not unaccounted-for changes to turbine operation.

Advancing Wind Energy Monitoring in Brazil: The Integrated Approach at an energy complex of 28 wind farms

Mr Emilio Roos[1]*, Mr Paulo Cardoso[1], Dr Miguel Mascarenhas[1]
[1] BE - Bioinsight & Ecoa
*Corresponding author.

Wind energy projects in Brazil have historically lacked comprehensive post-construction monitoring capable of quantifying environmental impacts at a regional scale: however, a 28-wind farm complex in Northeast Brazil represents a major shift in this paradigm and the first in Brazil to integrate Good International Industry Practices (GIIP) into a robust Post-Construction Monitoring Plan.
The project was structured around five key elements. First, an integrated approach consolidated monitoring efforts across 28 wind farms and 259 wind turbines (ranging from 8 to 47 per farm) under a single ecosystem-scale assessment, overcoming the limitations of isolated project-by-project evaluations. Second, a rigorous review of existing Post-Construction Fatality Monitoring (PCFM) led to the implementation of robust bias trials and monthly carcass searches, improving the accuracy of the existing fatality estimates. Third, an external audit by lenders confirmed compliance with IFC Performance Standards, ensuring that monitoring and mitigation measures met international financing requirements. Fourth, a long-term commitment to impact assessment was established through a five-year monitoring phase (2019–2024), providing a scientific foundation for evaluating cumulative effects and justifying a two-year extension (2025–2026) for further data refinement. This effort revealed that carcass persistence probability for 14 and 28 days was 0.106 and 0.053 for small size carcasses, 0.081 and 0.04 for medium size, 0.093 and 0.047 for large size, respectively; while searcher efficiency was estimated at 0.35 [0.199-0.538], 0.6 [0.415-0.761] and 0.8 [0.615-0.909] for small, medium, and large size carcasses. The overall corrected fatality estimate using GenEst ranged from 1.8 to 5.2 fatalities/turbine/year, with the Black Vulture being the most affected species (0.4–4.6 individuals/turbine/year). A Population Viability Analysis (PVA) of nine bird and four bat species confirmed that current fatality levels do not pose a population-level risk.
Fifth, the study demonstrated that while no critical biodiversity concerns emerged, quantifiable mortality rates now enable an adaptive management framework, where conservation actions are directly informed by evidence-based findings.
This case study illustrates that, with proactive developer engagement, international best practices can be successfully applied to large-scale projects in emerging markets. By integrating independent processes into a unified ecosystem-wide vision, developers can ensure regulatory compliance, enhance regional biodiversity insights, and improve their environmental and reputational standing. The approach implemented at this wind energy complex sets a precedent in Brazil, demonstrating that impact monitoring can evolve from a compliance-based requirement into a scientifically robust tool for sustainable wind energy development.

Closing the Loop: Recommending: a Feedback Approach for Post-Consent Monitoring to Reduce Consenting Risk in Assessments

Dr Esther Jones[1]*, Ms Eleanor Skeate[2], Dr Alice Hague[3], Prof Martin Perrow[4], Dr Kate R. Searle[5], Dr Lindesay Scott-Hayward[6], Dr Ana Couto[1], Ms Sophie Miller[3], Ms Tami Wooldridge[3], Prof Francis Daunt[5], Dr Cormac Booth[7], Dr Adam Butler[8]
[1] Biomathematics & Statistics Scotland, [2] ABPMer, [3] James Hutton Institute, [4] University College London, [5] UK Centre for Ecology & Hydrology, [6] CREEM, University of St Andrews, [7] SMRU Consulting, [8] Bioinformatics and Statistics Scotland
*Corresponding author.

In the UK offshore wind sector, developers are typically required to conduct post-consent monitoring (PCM) of offshore wind farm (OWF) impacts as part of their licence conditions, which can be costly and challenging to implement. These data, and lessons learned about OWF impacts, are invaluable in the further development of the industry, as they could help reduce uncertainty in the consenting process and are therefore crucial in the context of both cumulative and future project-based assessments. However, there is currently no strategic feedback mechanism or requirement for PCM data to be integrated into the assessment process.
The Offshore Renewables Joint Industry Programme (ORJIP) funded 'Closing the Loop: feasibility study to determine a feedback approach for post-consent monitoring to reduce consenting risk in future assessments' project, focuses on understanding barriers, identifying potential solutions, and forming recommendations to incorporate PCM data back into the consenting process using existing tools, thereby 'closing the loop' as part of the wider and essential adaptive management paradigm.
We adopted a pluralistic research approach (i.e., one problem, multiple lenses), to investigate current procedural, technical, scientific, and statistical issues, and considered potential future PCM requirements. Central to the approach was stakeholder engagement, co-developing a synthesis of evidence through semi-structured interviews and workshops, and a set of recommendations with a roadmap as the outcomes of the project.
The ornithological-focused synthesis of evidence integrated a review of current policy, process, and data availability, along with presenting case studies of historic post-consent monitoring data. A review of ornithological data, analysis and modelling approaches identified key statistical, technical and scientific challenges, including the need for meta/pooled analyses to combine information across projects; use of data integration to account for differing survey methodologies; the requirements for transferability to be evaluated across time, space, and species; and the need to link proposed solutions with the processes for developing SNCB guidance.
Focusing on key themes of (i) procedural, (ii) data management and policy, (iii) dissemination and translating data into guidance, and (iv) technical, we produced a set of potential solutions for stakeholders to consider. Exploring these further with stakeholders, we examined industry-wide resourcing issues, the implementation of data standards, and working 'smarter' to create opportunities. Ornithological and marine mammal learnings were used to form recommendations and a roadmap, which take account of the requirement for them to be resilient into the future and to be applicable across all UK administrations.

THURSDAY 11TH SEPTEMBER – 13:30-15:00

EXPLORING BLADE PATTERNING AS A MITIGATION STRATEGY - RESULTS FROM STUDIES ACROSS THE GLOBE, LESSONS LEARNED AND THE WAY FORWARD

Moderators: Shilo K. Felton (REWI) & Roel May (NINA)

In 2020, May and colleagues documented a nearly 72% decline in bird fatalities caused by collision with wind turbine blades in Norway associated with a simple manipulation, painting one blade black. The method generated considerable interest in scientific, media, and even regulatory circles as it appears to thread a very fine needle; reducing impacts to bird populations using a simple, durable, inexpensive, low maintenance solution that does not interfere with energy production. Patterning blades is thought to visually disrupt what otherwise may appear to the bird as a uniform airspace, making the turbine more visible, and eliciting avoidance behavior. However promising and well executed, the Norway study was at a single unique location and included just four of 68 turbines with painted blades. As such, there has been a widespread effort to generalize the result by replicating this study in other locations across the globe and with other species. At the same time the search for the most effective, and broadly accepted combination of colors and patterns continued. This special session brought together scientists and practitioners implementing both field and lab experiments and explores civil aviation and technical challenges in large scale application of blade pattering in other wind farms. The authors explored the potential mechanisms that may make blade patterning effective for certain avian species with sophisticated lab experiments. Presentations provided results for several relevant scientific studies and provided an overview of the regulatory, political, engineering, and funding hurdles that impact study design and potential implementation. This was followed by a moderated discussion among the presenters to answer audience questions and allow for an open dialogue on the challenges and potential solutions.

Summary

- Introduction: Joint responsibility in the development of effective wind-turbine collision-reducing solutions, Roel May
- "The search for the holy grail: one black rotor blade did not reduce bird mortality in windfarm Eemshaven", by Jonne Kleyheeg-Hartman / Erik Klop
- "Testing the efficacy of black blades in Wyoming, U.S. with a unique experimental design", by Robb Diehl / Tara Conkling / Shilo Felton
- "Crouching Tiger, Hidden Dangers: Blade patterning reduces avian impacts at a species-rich African wind farm", by Rob Simmons
- "Exploring blade patterning as a mitigation strategy: progress and perspectives from South Africa (a case study)", by Sam Ralston-Paton
- "Optimizing blade patterns for avian collision mitigation: a computer vision approach", by Graham Taylor
- Discussion moderated by Shilo Felton

The search for the holy grail: one black rotor blade did not reduce bird mortality in windfarm Eemshaven

Mrs Jonne Kleyheeg-Hartman[1]*, Dr Erik Klop[2], Ms Lizanne Jeninga[1], Dr Elena Kappers[2]
[1] Waardenburg Ecology, [2] Altenburg & Wymenga
*Corresponding author.

Note OC: included workshop 485
Following the positive results of painting one blade black to reduce collision rates among birds on the Norwegian island of Smøla, published in 2020, a follow-up study was set up in windfarm Eemshaven in the Netherlands. Here, a much broader set of species is present, and collision rates among birds are known to be relatively high.

The study consists of 14 turbines in a BACI setup (Before-After-Control-Impact). After one year of null monitoring, during which all turbines had regular white blades, half of the turbines received one black blade. The impact monitoring lasted two years, until the end of 2024. In this talk we present the final results of the study.
In total 436 collision victims of birds were found, of which 196 under control (unpainted) turbines and 240 under impact turbines (which received a black blade). The most frequently recorded species groups were songbirds and gulls, followed by waders. Unfortunately, no statistically significant effect of the black blade on the number of collision victims was found. This result holds for all bird species together, as well as for all individual species groups. Interestingly, for diurnal birds and large gull species we did find a positive effect of the black blade, although this was not statistically significant. A possible explanation for the rather disappointing results of this study, is that the single black blade might not contrast enough with the (busy) industrial background in the Eemshaven area. Another explanation is that due to the relatively small sample size in the study at Smøla, the positive effect of the black blade might have been overestimated.
For a follow-up study, we propose to study the flight behavior of different bird species in the proximity of turbines with and without a black blade in more detail, to better understand how this is influenced by the single black blade. Additionally, it would be interesting to test a different pattern and/or color aimed at enhancing contrast instead of reducing possible motion smear. However, we advise to first reach consensus on the most suitable pattern based on other ongoing field and theoretical studies. There is clearly added value in bringing together the results of all ongoing studies on the effects of colored and patterned blades. This can be used to develop a conceptual framework to increase the visibility of wind turbines for birds to reduce the number of collisions.

Crouching Tiger, Hidden Dangers: Blade patterning reduces avian impacts at a species rich African wind farm

Dr Rob Simmons[1]*, Mx Marlei Martins[2], Dr Francisco Cervantes[3]
[1] FitzPatrick Institute, University of Cape Town, [2] Birds & Bats Unlimited, [3] Pyrenean Institute of Ecology, Spanish National Research Council
*Corresponding author.

As wind farms expand into bio-diverse areas, so mitigation to reduce the increased risk of avian fatalities must accompany this expansion. Blade patterning, first explored in the lab (McIsaac 2001) and field-tested in Norway (May et al 2020), is one such mitigation but has yet to be implemented elsewhere. We tested blade-patterning at a species-rich African wind farm to explore its application in reducing avian mortality rates among the 94 species on site.
At the 37-turbine wind facility in Hopefield, South Africa, Umoya Energy patterned single blades at four high fatality turbines, in 2023 with two broad "Signal Red" stripes. We combined McIsaac's (2001) and Hodos's (2003) optimal lab results for the design and complied with Civil Aviation Authority regulations for the colour. Avian fatalities, surveyed weekly beneath the turbines, were then compared before and after painting using the Before-After-Control-Impact (BACI) approach. Seventy-five fatalities of 24 species of raptors, passerines and wetland species from two previous years were compared for the same (four) turbines after patterning with two sets of controls: (i) their four nearest neighbours (NNC) and (ii) all 16 controls (AC) over 26 months.
Barnard's Unconditional tests showed a significant reduction in fatalities between observed and expected fatalities for patterned vs AC comparisons ($p = 0.041$) and significant reduction in relation to the nearest neighbours ($p = 0.039$). There was no evidence that birds avoiding the patterned turbines veered into NNC turbines as there was no difference ($p = 0.51$) in fatality rates between the NNC and the remaining controls. A Bayesian GLM indicated a 52% - 100% mortality reduction for the patterned turbines vs NCC controls after painting, and a 55% - 100% for the 16 AC comparisons.
Ten of the 14 eagle, buzzard, harrier, kite and kestrel species recorded on site, have been killed by the turbines. Raptor fatalities at the patterned turbines dropped 87% from seven individuals (in 24 months) to one (Milvus Kite) in

26 months following treatment but continue to be killed at the control turbines. For all species, expected (13) versus observed fatalities (2) at the patterned blades indicated an 85% reduction over 26 months.
That enhanced blade visibility in two contrasting environments (boreal Scandinavia vs south-temperate Africa) both significantly reduce turbine-related fatalities indicates that blade patterning holds great promise as a cost-effective mitigation at wind facilities in avian-rich areas. We call for further tests to test its effectiveness for other species.

Exploring blade patterning as a mitigation strategy: progress and perspectives from South Africa (a case study)

Ms Samantha Ralston-Paton[1]*, Prof Arjun Amar[2], Ms Caryn Du Randt[3], Dr Francisco Cervantes[4], Ms Andrea Gibb[5], Dr Megan Murgatroyd[6], Mr Matthew Law[7], Dr Rob Simmons[8], Mr Santosh Sookgrim[9], Mr Shaun Taylor[10]
[1] BirdLife South Africa, [2] FitzPatrick Institute of African Ornithology, University of Cape Town, [3] G7 Renewable Energies, [4] Pyrenean Institute of Ecology, Spanish National Research Council, [5] Globeleq South Africa, [6] HawkWatch International / FitzPatrick Institute of African Ornithology, [7] Red-Cap Energy, [8] FitzPatrick Institute, University of Cape Town, [9] South African Wind Energy Association, [10] Mainstream Renewable Power South Africa
*Corresponding author.

NoteOC: included workshop 485
Following the encouraging results from May et al.'s 2020 study on blade patterning to reduce bird collisions at wind turbines in Norway, South African stakeholders are exploring this mitigation strategy. Compared to technological solutions, blade patterning is low-cost, simple to implement, and minimally disruptive if applied during manufacture. This case study highlights progress in facilitating further trials in South Africa.
Umoya Energy, in the Western Cape, is conducting a field trial where four turbines have been marked with two broad "Signal Red" stripes. A large-scale experiment is planned in the Eastern Cape, and several other facilities are investigating similar options.
Conservationists, the wind industry and researchers collaborated to address the practical and legislative challenges to implementation. A briefing document discussed potential issues such as turbine imbalance from the added paint, differential heating and appropriate colours and designs while meeting turbine manufacturers' restrictions and Civil Aviation Safety Standards. The latter required extensive engagement with the Civil Aviation Authority, which issued a blanket permit to developers in 2024, and a guidance document followed, standardising patterning and streamlining permitting.
Given the promising yet limited evidence, along with South Africa's rich birdlife and diverse landscapes, stakeholders recognised the need to test blade patterning locally. However, two perspectives emerged: an evidence-based approach and a pattern-all-turbines approach.
Proponents of an evidence-based approach advocated for multi-site experiments where only randomly selected turbines are patterned. With co-ordination and data sharing this approach could yield statistically robust results relatively quickly. If blade patterning proves effective, this will facilitate widespread adoption and open previously restricted areas for development.
The pattern-all-turbines approach argues for marking all turbines—or at least high-risk ones—as this could minimize impacts with minimal cost and risk to the wind farm. Factory patterning is more appealing to developers than retrofitting operational turbines due to the cost savings. However, this approach lacks control turbines on site, limiting the ability to establish clear causal relationships.
Without clear policy guidance from government or project financiers, the latter approach will likely become the default strategy in an industry dominated by independent wind power producers. To advance the science as swiftly as possible, it will be ideal to strike a balance between the pattern-all approach favoured by developers and the promotion of evidence-based decisions to facilitate rigorous scientific trials. GPS tracking studies may also yield valuable insights into the avoidance behaviour of particular species near marked and unmarked turbines.

Optimizing blade patterns for avian collision mitigation: a computer vision approach

Dr Marco Kleinheerenbrink[1], Mr Seb D'arcy Rice[1], Mr Alix Leroy[1], Prof Graham Taylor[1]*
[1] *University of Oxford, Department of Biology*
*Corresponding author.

For a quarter-of-a-century, researchers have considered the possibility of using patterned turbine blades to mitigate avian collision risk by enhancing their visibility. Interest has intensified over the past five years, after painting one blade black was found to be associated with significantly reduced collision rates on the island of Smøla in Norway. Subsequent studies have tested the efficacy of black-painted blades in other contexts, and have begun exploring whether other blade patterns or colours might be as or more effective.
Field-testing the efficacy of a single design is challenging, but the time needed to estimate collision rates makes optimizing designs through trial-and-error impractical. These challenges are amplified in the offshore context, especially given the need to test their effectiveness for different species under a range of environmental conditions. Here we present an alternative approach, combining computer vision models with 3D rendering techniques to optimize blade patterns in relation to bird vision.
Avian visual systems differ markedly from those of humans, leaving much unknown about how birds perceive such patterns. Nevertheless, birds have low contrast sensitivity, which is presumably because they trade this off against other dimensions of visual proficiency. Our research aims to better understand the parameters that determine the effectiveness of tubine blade patterns, facilitating meaningful design optimisation.
We used a digital environment to simulate the visual information available to a bird on a collision course with a wind turbine under clear or overcast conditions offshore. Drawing on neurophysiological research reporting the spatiotemporal sensitivity of avian motion vision we employed a spectral decomposition of the visual information to analyse the expected effectiveness of different patterns compared to a plain blade.
Our preliminary results confirm the effectiveness of recently recommended patterns featuring wide black bands (Martin & Banks, 2003). However, such designs only have internal contrast perpendicular to the blade's motion, making their effectiveness largely dependent on background contrast. Our research confirms that even better results can be achieved by creating internal contrast in the direction of the blade's motion, such as by applying a single stripe along the leading edge of the blade.
Black-and-white patterns offer the highest possible internal contrast across the visible spectrum, but the use of colours such as signal red can still significantly enhance the visual stimulus relative to an unpatterned blade and can provide robust background contrast. This also offers the flexibility to use colour patterns that comply with existing regulatory or engineering constraints.

THURSDAY 11TH SEPTEMBER – 13:30-15:00

FROM ASSESSING TO MANAGING SUBSEA IMPACTS OF OFFSHORE WIND

Moderators: Sytske Van den Akker (Waardenburg Ecology) and Bob Rumes (Royal Belgian Institute of Natural Sciences)

Offshore wind energy is expanding rapidly, with ambitious targets set for the near future. For proper environmental management, it's crucial to consider the impacts large-scale offshore wind development will have on the marine ecosystem. This session explored ecosystem models, tools for risk assessment, the importance of continuous monitoring, and opportunities for nature-inclusive design and ecological enhancement within offshore wind farms.

Short introduction to the special session, by Systke van den Akker

4 case-studies :

- Regional impacts of offshore wind farms on the North Sea – Luca van Duren, Deltares
- POSEIDON: introducing the new marine biodiversity risk mapping tool for offshore wind – Alex Banks, Natural England
- Impact of offshore wind farm construction on bentho-demersal fish: insights from six years of Canadian trawl surveys in the Bay of Saint-Brieuc – Raquel Marques, Setec énergie environnement
- Assessing the impacts of offshore wind development on marine food webs in the US Atlantic – Kim Lato, Biodiversity Research Institute

NID - feedback from workshop of September 8th, by Bob Rumes

Role of windfarms in restoration of natural reefs- Karin Didderen (Waardenburg Ecology)

Regional impacts of offshore wind farms on the North Sea

Dr Luca Van Duren[1]*, Dr Lauriane Vilmin[1], Ms Sonia Heye[1], Ms Sophie Crouch[2], Mr Luka Jaksic[1], Mr Leo Leummens[1]
[1] Deltares, [2] University of Bangor
*Corresponding author.

Earlier studies with state-of-the-art ecosystem models have indicated that the envisaged implementation scenarios can lead to profound changes in currents, vertical mixing, fine sediment dynamics, primary production and other ecosystem processes. Phytoplankton primary production is the foundation of the marine food web and substantial changes in this parameter, are likely to have knock-on effects for the entire ecosystem. Size and direction of impacts are strongly location dependent. In areas with strong seasonal stratification, model results indicate local increases in primary production of up to 40%, while in areas that are relatively shallow and with substantial amounts of fine sediment in the seabed, decreases of primary production within wind farms may be as large as 60%. The results also indicated that in areas with substantial reductions of primary production within wind farms, compensation effects may be observed outside the wind farm perimeters.
Most evaluation frameworks assess impacts on species with conservation targets under N2000. These are mostly apex predators, such as birds and marine mammals. It is difficult to predict the consequences of changes in primary production on individual apex predator species. As primary production changes impact the whole marine food web, it may make sense to develop "Acceptable Levels of Impact" on lower trophic levels However, this is not a trivial task.
Choosing suitable sizes and delineations of assessment areas is crucial for evaluation frameworks. We have used the OSPAR pelagic assessment areas to get a first impression of regional-scale impacts, using the most recent scenario for offshore windfarms on the North Sea. We found marked differences between regions. We also used

a modified set of assessment areas with a slightly different delineation, which showed more pronounced regional effects. Neither of these delineations may be ideal, but this is a first useful exercise to get insight in region-scale effects.
Having assessment frameworks for human exploitation of marine resources on lower trophic levels (e.g. primary production) rather than only on individual species with conservation targets, is going to be important for future sustainable use and management of marine space. Analyses such as these can be a first step towards such a framework.

POSEIDON: introducing the new marine biodiversity risk mapping tool for offshore wind

Dr Alex Banks[1]*, Dr Maija Marsh[1]
[1] *Natural England*
*Corresponding author.

Avoidance of significant impacts when planning offshore wind relies upon robust information. To be effective, data describing abundance, distribution and sensitivity of key species and habitats must be readily available, easily interpreted and sufficiently trusted by stakeholders. POSEIDON is a big data approach to this challenge, led by Natural England in partnership with others and hosted by the Crown Estate, in pursuit of the UK's ambitious targets for renewable energy and nature recovery. POSEIDON maps offshore wind risk (and, conversely, development opportunity) for benthic habitats and communities, seabirds and marine mammals within UK waters, based on millions of empirical records informing innovative predictive spatial models. Uniquely, POSEIDON integrates risk across these different receptor groups to demonstrate 'hotspots' of environmental risk at seascape scale. We will describe the development of the POSEIDON tools, setting out approaches to data collation, data collection, modelling, sensitivity scoring and integrated risk mapping across time, space and species / habitats. We will present outputs from the tools to demonstrate our findings, which will be publicly available through a dedicated dashboard. We will also discuss the potential applications of the tools within the regulatory framework, including how they may inform mitigation and compensation as well as avoidance of impact, so that decision-makers can consider application to the mitigation hierarchy with readily accessible and high-quality environmental information. Finally, we will share lessons learnt from the project for others interested in data-driven decision making for offshore wind, and discuss some of the challenges we face in the further development of POSEIDON.

Impact of offshore wind farm construction on bentho-demersal fish: insights from six years of Canadian trawl surveys in the Bay of Saint-Brieuc

Dr Gwenhael Allain[1], Ms Mathis Cambreling[1], Dr Yann Patry[1], Dr Raquel Marques[1]*, Dr Philippe Bornens[1], Dr Thomas Pommier[1]
[1] *setec energie environnement – setecinvivo , 358 ZA La Grande Halte, 29940 La Forêt-Fouesnant*
*Corresponding author.

The expansion of offshore wind energy is reshaping marine environments, bringing both opportunities and challenges for fishery resources. As wind farms become a reality, questions about their ecological responses, raised by scientists, fishing industry, and the public,continue to fuel debates. Despite growing investments in offshore renewables, empirical evidence quantifying their effects on fish communities remains scarce, particularly along the English Channel-Atlantic coastline, where the first French offshore wind farms have only recently become operational.
Since September 2018, summer surveys have been conducted across 33 fixed sampling stations spanning three spatial zones: within the wind farm, an intermediate impact area, and a control area. This comprehensive dataset,

built on six years of continuous monitoring, has allowed us to track changes in species diversity, abundance, and biomass across commercial and non-commercial bentho-demersal fish populations. To analyze this, we applied generalized linear mixed modeling (GLMM) within a Before-After Control-Impact (BACI), complemented with a functional approach (based on life history traits) to determine key ecological shifts in the community.
At onset, with the installation work and reduced fishing pressure, the overall fish abundance and biomass rose, particularly in near-field and intermediate impact zones. The overall species richness increased during installation work, yet community evenness declined throughout the monitoring period, indicating that certain species benefited disproportionately from the wind farm development. Opportunistic species (e.g., Trisopterus luscus) showed significant increases in both abundance and biomass post-impact, particularly at the impact area, while longer-lived specialist species (e.g., Raja spp.), though positively affected over time, exhibited a weaker response to the construction disturbance and the reduced fishing pressure within the wind farm.
Our results challenge common assumptions by revealing both transient and species-specific responses, emphasizing the need for continued long-term monitoring to support evidence-based marine spatial planning and sustainable offshore wind expansion.

Assessing the impacts of offshore wind development on marine food webs in the US Atlantic

Dr Kim Lato[1]*, Dr Evan Adams[1], Ms Kate Williams[1], Dr Jan Vanaverbeke[2], Dr Steven Degraer[2], Dr Ulrike Braeckman[2]
[1] Biodiversity Research Institute, [2] Royal Belgian Institute of Natural Sciences
*Corresponding author.

Offshore wind development is expanding across the US Atlantic, with over two dozen areas leased for commercial-scale offshore wind development as of 2024. Like many other ocean regions, there is concern about the impacts of such development on surrounding marine ecosystems. The "artificial reef effect", which has been well documented at European offshore wind farms, is when the colonization of fouling organisms on turbine structures and scour protection layers attracts upper trophic level animals to the area. This introduction of fouling and reef-associated species into areas that are typically dominated by soft sediment-associated organisms can alter local trophic dynamics. Food web modeling is a powerful tool to study these ecosystem-level effects as it can demonstrate how changes in the biomass of one functional group (e.g., fouling filter feeders) can propagate to the broader ecosystem. Drawing biomass and physiological data from publicly available datasets and literature, we used linear inverse modeling to describe the food web of an offshore wind lease area off the northeast coast of the US prior to offshore wind construction. Then, using expected observations of benthic fauna change adapted from existing literature, we developed a model for this area to assess how and to what extent the presence of offshore wind turbines may alter food web structure and functioning at a local scale. We focused on the potential impacts of anticipated changes in benthic faunal communities, specifically considering the hard substrate-associated species expected to colonize wind turbines and scour protection layers. Using network analysis, we found that soft-sediment benthic infaunae were some of the most important functional groups to the overall structure of the food web. In collecting data for this preliminary food model, we highlighted the large spatiotemporal data gaps that exist for benthic infauna in the US Atlantic and the nonuniform data collection methods and summarization in survey reporting. This lack of adequate benthic data greatly increased the uncertainty in our model, particularly given the ostensible importance of benthic infauna to the food web structure. Going forward, we will develop food web models for two additional wind farm areas in the US Atlantic to understand potential geographical variations in the impacts of offshore wind on local food webs. Our model outputs are not high accuracy predictions but rather can be used to guide current and future ecosystem monitoring efforts based on outcomes of potential scenarios within offshore wind areas in the US Atlantic.



PARALLEL SESSIONS

TUESDAY 9TH SEPTEMBER – 11:30-12:30

LARGE-SCALE RADAR-BASED MAPPING OF NOCTURNAL BIRD MIGRATION FOR AVOIDANCE AND MINIMISATION OF WIND ENERGY IMPACTS

Mr Bart Hoekstra[1]*, Dr Bart Kranstauber[1], Dr Maja Bradarić[1], Dr Johannes De Groeve[1], Ms Stacy Shinneman[1], Mr Berend C Wijers[1], Dr Hidde Leijnse[2], Dr Hans Van Gasteren[3], Dr Adriaan Dokter[4], Dr Emiel Van Loon[1], Prof Judy Shamoun-Baranes[1]

[1] *Institute for Biodiversity and Ecosystem Dynamics, University of Amsterdam,* [2] *Royal Netherlands Meteorological Institute,* [3] *Royal Netherlands Air Force,* [4] *Cornell Lab of Ornithology*

*Corresponding author.

Billions of nocturnally-migrating birds are increasingly navigating energy landscapes filled with wind turbines and power lines, known to create collision risks and barrier effects. Although risks for migratory birds are typically considered in environmental impact assessments, they are generally studied on a case-by-case basis during permitting and occasionally after construction.These studies provide information only for small spatial extents and short study periods, with high uncertainties due to year-to-year and seasonal fluctuations in weather and migration dynamics. This lack of large-scale, long-term information limits proactive impact avoidance through spatial planning, raises costs throughout the life-cycle of energy infrastructure and risks increasing impacts on nocturnal migrants. Here, we provide a standardized and scalable tool for spatial planning, by demonstrating a novel method of quantification of nocturnal bird migratory movements across large scales. We use data from Dutch operational weather radars, aggregating six years of observations, to quantify spatially continuous patterns of nocturnal bird movements across 33,543 km2 of onshore area for spring and autumn migration (@ 500-m resolution). Contrary to the assumption of homogeneous distributions during nighttime migration, we found bird distributions varying up to threefold across distances relevant for national and regional spatial planning. In autumn, migration occurred at lower altitudes with double the migration traffic rates of spring, suggesting greater potential for collision mitigation through careful site selection during autumn migration. Between 31-61% of nocturnal migration occurred at the altitudes of wind turbines (up to ~200m height), highlighting the importance of spatial planning in collision reduction;

Using the Netherlands' North-Holland province as a case study, we evaluated 40 candidate sites for wind energy and found substantial variation between sites in the seasonal migration intensity (356,000-798,000 birds/km in autumn). Half of all sites were located in areas with above-average bird densities, indicating suboptimal positioning from a conservation perspective.

Our methodology enables proactive consideration of wind energy's impacts on migratory birds in spatial planning procedures following the mitigation hierarchy, supporting cost-effective mitigation strategies and accelerating sustainable energy development. The approach is widely applicable as it uses existing weather radar networks worldwide, offering a scalable solution for nature-inclusive energy planning. These findings provide practical tools for policymakers, developers, and planners to optimize siting, guide mitigation efforts, and balance renewable energy goals with biodiversity conservation. By incorporating geospatial information of migratory birds early in the planning process, stakeholders can reduce both environmental impacts and project costs while supporting evidence-based decision-making in the energy transition.

TUESDAY 9TH SEPTEMBER – 11:30-12:30

NOVEL INSIGHTS FROM BAT AND BIRD FATALITY MITIGATION AT WIND FARMS IN SOUTH AFRICA

Dr Caroline Lotter[1]*, Mr Trevor Morgan[1], Ms Leandri De Kock[1], Ms Dominique Greeff[1], Dr Jarryd Alexander[1], Ms Su-Mari Swanepoel[1], Mr Myles Bushell[1]
[1] *Inkululeko Wildlife Services*
*Corresponding author.

In recent years wind energy development has rapidly expanded in South Africa, with many more projects under construction or having been approved or proposed. At existing operational wind farms in the country, annual estimated numbers of turbine-related bird and especially bat fatalities have often exceeded the recommended fatality thresholds for these facilities. Inkululeko Wildlife Services (an ecological consultancy in South Africa) has worked at several wind farms in South Africa's Eastern Cape where various forms of bat and bird fatality mitigation have been implemented. Bat fatality mitigation has included various turbine curtailment regimes, and ultrasonic bat deterrents. Bird fatality mitigation has included observer led turbine shutdown on demand, carrion removal for a priority vulture species, and acoustic bird deterrents. Results and insights from the different bat and bird mitigation measures will be presented, and the mitigation of Old-World frugivorous bat species in the Eastern Cape will also be discussed. The novel information shared should facilitate improved mitigation of bat and bird fatalities at wind farms in southern Africa and potentially further afield.

TUESDAY 9TH SEPTEMBER – 11:30-12:30

OFFSHORE WIND AND AEROFAUNA: AVOIDANCE REMAINS THE BEST BET AMID LIMITED MITIGATION EVIDENCE

Ms Kate Williams[1]*, Mx Julia Gulka[1], Mr Steve Knapp[1], Ms Anna Soccorsi[1], Dr Paul Knaga[2], Dr Stephanie Avery-Gomm[3]

[1] *Biodiversity Research Institute,* [2] *Canadian Wildlife Service, Environment and Climate Change Canada,* [3] *Science and Technology Branch, Environment and Climate Change Canada*

*Corresponding author.

Offshore wind energy development is a vital strategy for reducing global reliance on fossil fuels but also poses environmental challenges that require mitigation. A diversity of approaches exist for mitigating (e.g., avoiding, minimizing, or compensating for) the effects of offshore wind energy development on aerofauna (birds and bats), but little is known about the effectiveness of many of these approaches. As a result, some mitigation measures may be considered or implemented without reliable evidence of efficacy, potentially leading to false assurance that effects are being mitigated and to resources being wasted on ineffective mitigation measures.

To address this knowledge gap, we reviewed the scientific literature and gray literature to evaluate the evidence base for proposed mitigation approaches for offshore wind and aerofauna. Given limited data from the offshore wind energy sector, we included studies from other industries where relevant (e.g., terrestrial wind energy, offshore oil and gas industry, other maritime and terrestrial industries). Of a total of 211 mitigation approaches described in 183 source documents, most approaches focused on minimization, with far fewer addressing avoidance or compensation. Sixty-one percent (128 approaches) had no evidence of being tested in the reviewed literature. Of the 83 mitigation approaches that were field tested or implemented, we found evidence of effectiveness for only 41 approaches. This included approaches tested and implemented in other industry contexts; specific to the offshore wind sector, we found evidence of effectiveness for 10 approaches. Consequently, 86% of all the mitigation approaches identified in this review lacked any evidence of effectiveness based on the reviewed literature. For birds, minimization approaches focused on artificial lighting were the most tested and effective methods for reducing maladaptive attraction and collisions. For bats, minimization approaches involving adjustments to turbine operations (e.g., curtailment and feathering of turbine blades) were most tested and effective methods for reducing collisions. Given the limited evidence of effectiveness for most approaches, dedicated testing of mitigation measures is urgently needed to mitigate the environmental challenges posed by the offshore wind industry. Until such evidence becomes available, avoidance of effects (via careful siting of industrial activity and related measures) remains the single best available option for mitigating impacts to aerofauna. To fully address the effects of OSW development on aerofauna, compensation and offset strategies should also be further explored.

TUESDAY 9TH SEPTEMBER – 11:30-12:30

MODELING FALCO NAUMANNI (LESSER KESTREL) HABITAT SELECTION ACCORDING TO METEOROLOGICAL CONDITIONS TO MITIGATE RISK-INDUCING WIND TURBINES

Ms Lise Bartholus[1]*, Dr Yohan Sassi[2], Mr Mathieu Garcia[3], Mr Philippe Pilard[4], Mr Nicolas Saulnier[5], Dr Olivier Duriez[6]

[1] *Centre d'Écologie et des Sciences de la Conservation (CESCO), MNHN, Paris, France,* [2] *Centre d'écologie fonctionnelle et évolutive (CEFE), Univ Montpellier, CNRS, EPHE, IRD, Montpellier, France,* [3] *Micro Entreprise Mathieu Garcia, Saint Pargoire, France,* [4] *LPO France, Arles, France,* [5] *LPO Occitanie, Villeveyrac, France,* [6] *CEFE, Univ Montpellier, CNRS, EPHE, IRD, Montpellier, France*

*Corresponding author.

Raptors, relying on updrafts to soar and reduce their energy expenditure, are among the most vulnerable to collisions with wind turbines. We investigated the factors underlying the use of a wind energy facility in Southern France by Falco naumanni (Lesser kestrels), where they are the most frequent victims of collisions. As F. naumanni relies on wind updrafts to practice hovering flight when looking for prey, we hypothesized that these birds would be distributed according to the distribution of orographic updrafts. Using telemetry tracking data collected on 26 adults F. naumanni, between 2017 and 2021, we found that their presence in the wind energy facility increased with orographic updrafts velocity, with a maximum probability of presence in June. Using resource selection models, we predicted the relative probability of selection of the habitat by the kestrels, within the facility, according to environmental conditions. Based on these predictions, we identified particular turbines, where in specific wind conditions kestrel's presence was more likely to increase the risk of collision, and proposed a selective curtailment of these turbines. A first trial of mitigation measures has been applied since 2022, providing preliminary insights into their potential effectiveness in reducing mortality. This could represent a step toward a win-win situation in which a selective curtailment allows stakeholders to continue producing renewable energy while reducing the collision risk of vulnerable bird populations.

TUESDAY 9TH SEPTEMBER – 11:30-12:30

ASSESSING CUMULATIVE IMPACTS OF SEABIRD COLLISION CAUSED BY COMMERCIAL OFFSHORE WIND FARMS IN THE ENGLISH CHANNEL, NORTH SEA AND ATLANTIC COAST (BIRDRISK)

Dr James Robbins[1], Ms Camille Guillemette[1]*, Ms Morgane Ferrer[1], Ms Marie Montus[1], Ms Fiona Morton[1], Dr Gillian Vallejo[1], Mr Sylvain Michel[2], Ms Karen Bourgeois[3], Mr Nicolas Sadoul[4], Mr Antoine Chabrolle[4], Mr Etienne Boncourt[4], Mr Olivier Delmas[5], Mr Jean-Marc Brignon[5], Ms Nina Cudennec[2]
[1] *Natural Power,* [2] *Office Français de la Biodiversité - Direction des Aires Protégées et des Enjeux Marins,* [3] *Office Français de la Biodiversité - Délégation de Façade Maritime Atlantique,* [4] *Groupement d'intérêt scientifique sur les oiseaux marins (GISOM),* [5] *INERIS*
*Corresponding author.

Seabirds are highly mobile, and could encounter numerous renewable energy developments within their foraging or migratory ranges. Therefore, assessment of cumulative impacts of such developments must consider large geographic areas to understand the population-level impacts of offshore development. BIRDRISK is a novel project assessing the cumulative impacts of seabird collisions with commercial wind farms in the English Channel, North Sea and Atlantic coast. This project focuses on six seabird species (black-legged kittiwake, *Rissa tridactyla*; northern gannet, *Morus bassanus*; common guillemot, *Uria aalge*; great black-backed gull, *Larus marinus*; lesser black-backed gull, *Larus fuscus*; and Sandwich tern, *Thalasseus sandvicensis*), and 32 offshore windfarms in French (n=7), Belgian (n=8), Dutch (n=4), and UK (n=13) waters comprising approximately 16.2GW of capacity. A further 14 species are included for an additional assessment of French sites alone.
Collision risk was assessed using the stochastic Collision Risk Model tool currently used as standard in the UK. Data on bird densities, biometrics and behaviour alongside windfarm specifications were used to predict monthly collision risk estimates with associated uncertainty capturing natural variation and uncertainty in input parameters. Windfarm specifications were collated from developers and online datasets. Densities of birds in-flight were derived from either targeted baseline surveys, available regional survey data, or existing modelled density surfaces. Where data allowed, the site-specific proportion of birds flying at collision risk height was estimated from raw data, or flight height curves modelled from raw data, otherwise published generic modelled curves were used. Collision mortality was estimated for each individual windfarm and species. Cumulative risk was assessed by bootstrapping additively across collision distributions from all sites, resulting in a distribution of cumulative collision estimates.
The highest cumulative collision risk was predicted for great black-backed gull, with a median estimate of 4482 (3691 – 5459 95% confidence interval), followed by lesser black-backed gulls with 4460 (3359 - 6069), kittiwake with 1737 (1216 – 2455), northern gannet with 877 (672 – 1127), common guillemot with 124 (41 – 262), and sandwich tern, with 72 (49 – 122) predicted collisions per year.
This ambitious project forms part of a wider French-government funded project devised to understand the impacts of offshore wind farm development on seabirds across country borders, at a scale that is ecologically relevant. Results of the BIRDRISK project will be presented in the broader context of this work, and lessons learned will be shared with a view to facilitating development of similar projects elsewhere.

TUESDAY 9TH SEPTEMBER – 11:30-12:30

INTER-ANNUAL VARIATION IN SPACE USE OF BREEDING SEABIRDS: IMPLICATIONS FOR ASSESSMENT OF OFFSHORE WIND FARM IMPACTS

Dr Maria Bogdanova[1]*, Dr Charlotte Regan[1], Mr Mark Newell[1], Prof Sarah Wanless[1], Dr Sam Langlois Lopez[2], Ms Ella Benninghaus[3], Prof Francis Daunt[1], Dr Kate R. Searle[1]

[1] *UK Centre for Ecology & Hydrology,* [2] *British Trust for Ornithology,* [3] *University of Aberdeen*

*Corresponding author.

Predicting potential population level impacts of offshore wind farms (OWFs) on breeding seabirds requires understanding the extent to which local populations interact with these developments. Seabird space use may vary extensively between years and thus result in differing magnitudes of impact from OWFs. Yet this variation is not well understood and is not typically incorporated into assessments for OWFs, adding to uncertainty in the assessment process.

We used 6-9 years of GPS tracking data from common guillemots, razorbills, Atlantic puffins and black-legged kittiwakes breeding on the Isle of May, Scotland to quantify inter-annual and between-species variation in space use and its consequences for overlap with four proposed OWFs. We used a cutting edge autocorrelated kernel density approach to estimate population utilisation distributions and the overlap between them, as well as proportion of time spent within OWF footprints, in each year and across the study period.

Inter-annual variation in population distributions was apparent in all species both in size and location of areas used, but the extent of this variation differed among species, with a range of 3 to 45-fold difference in area size between years. Guillemots, razorbills and kittiwakes had more variable distributions, whereas puffin distribution was relatively consistent across years. Consequently, the extent to which the four species used the proposed OWF areas also varied. Proportion of time spent within the OWF footprints ranged from 0% to 6% in guillemots, 0% to 36% in razorbills, 1% to 17% in puffins and 1% to 14% in kittiwakes. These data, obtained from a period encompassing mostly baseline (pre-construction) years and two construction years, will be compared in the future to data collected when the OWFs are operational, to assess whether there is evidence for changes in seabird distributions in response to these developments, over and above the observed inter-annual variation.

Our findings highlight the value of long-term studies in making robust inferences regarding seabird distributions and assessing the potential impact of marine developments on protected populations via effects on space use patterns and associated energetic and demographic consequences. The current recommendation of using data from two baseline years for OWF impact assessments, with limited consideration of inter-annual variation, risks misrepresenting seabird interactions with the developments and increasing uncertainty in assessments.

TUESDAY 9TH SEPTEMBER – 11:30-12:30

CUMULATIVE LIFE-CYCLE IMPACTS OF OFFSHORE WIND ENERGY DEVELOPMENT ON SEABIRDS

Dr Thomas Kvalnes[1]*, Dr Reto Spielhofer[1], Dr Roel May[2]
[1] Norwegian Institute for Nature Research, [2] NINA
*Corresponding author.

Mitigating the negative impacts of climate change by increased renewable energy from wind energy also results in impacts on vulnerable ecosystems and may result in the loss of species richness locally. For biodiversity the most direct and lasting impacts are in-situ during the operational phase of the wind farms. To aid in the process of determining where wind farms should or should not be constructed, we have developed a life-cycle impact assessment (LCIA) method to investigate the impacts of offshore wind-power farms on species richness of seabirds and other coastal birds. Impact pathways have been developed for habitat loss, disturbance, collision and barrier effects to characterise the potentially disappeared fraction of species. Birds adapted to a life in the marine environment are a diverse group. Differences in their lifestyle, behaviour and physiology, affect their susceptibility to impacts from wind energy development. Thus, we differentiate between different groups of functionally similar species and compare the relative impact in different groups to wind farms at different locations. Here, we apply the LCIA-method for all potential new wind farm areas in the North and Norwegian Seas to estimate their cumulative impacts on seabirds and show how this approach may be helpful for avoiding the most severe impacts when new wind farms are planned. Tackling the change from fossil fuels to renewable energy is an important challenge in the coming years where both climate and nature needs to be considered simultaneously. The LCIA method we have developed can be used by decision-makers in the planning phase to avoid negative impacts on species richness in siting of new wind farms as well as directing mitigation measures within known wind farm footprints during construction and operation.

TUESDAY 9TH SEPTEMBER – 11:30-12:30

UNLOCKING THE POTENTIAL OF HARD-WON DATA: USING SPATIAL CAPTURE-RECAPTURE FOR LARGE CARNIVORE MONITORING IN WIND ENERGY AREAS

Dr Gonçalo Costa[1]*, Prof Chris Sutherland[2], Prof Carlos Fonseca[3], Dr Miguel Mascarenhas[1]
[1] BE - Bioinsight & Ecoa, [2] CREEM, University of St Andrews, [3] CESAM & Department of Biology, University of Aveiro
*Corresponding author.

The challenge of assessing the impacts of wind energy infrastructure on large carnivores lies in the species' low densities, large home ranges, and elusive behavior, making traditional monitoring approaches unreliable and often inconclusive. Environmental Impact Assessments (EIA) and Post-Construction Monitoring (PCM) have vastly relied on indices of relative abundance and absolute counts, which fail to account for imperfect detection and the spatial distribution of individuals, lacking statistical inference. This makes comparisons across time and space difficult and limits the ability to quantify real population-level impacts.
We advocate for the use of Spatial Capture-Recapture (SCR) as a transformative analytical framework for improving carnivore impact assessments in renewable energy developments. This approach explicitly models detection probability and individual spatial activity, providing robust estimates of population size, density, and space use while integrating the effect of ecological and anthropogenic covariates (windfarms included) in the estimates. Despite its advantages, standard SCR models rely on data from identifiable individuals in space, which for carnivores like wolves or bears, that don´t have distinctive hair patterns, can be obtained from genetic surveys (scats or hair). However, often individual identities are lost in the DNA amplification process, leaving a great deal of field data unavailable for SCR analysis, which can add up to much more than 50% of the samples. This loss of information can be translated into lower precision in the population estimates and a deficit in budget maximization.
Recent developments in SCR Bayesian models (Random-Thinning SCR models) allow for the use of these discarded non-ID samples along with ID samples, in a unified framework for maximizing the available information and enhancing estimate precision. To test this framework, we apply it to the Iberian wolf (Canis lupus signatus) in Portugal, a species with low densities and highly structured populations in areas where wind farm development has increased over the past two decades. Using non-invasive scat survey data from a 3-year monitoring program, where 32% of the scats confirmed as wolf produced no individual ID, we compared standard SCR results with RT-SCR outputs. Overall, RT-SCR models increased our density estimates' precision, on average, by 9.7% and detection probability estimates by 11.3%, proving their usefulness for maximizing data utilization and outputs robustness, derived from hard work and often limited budget field surveys.
This SCR methodology offers a science-based solution to better inform wind energy EIAs, ensuring that post-construction monitoring provides reliable insights into infrastructure-carnivore interactions.

TUESDAY 9TH SEPTEMBER – 11:30-12:30

QUANTIFYING THE 3D IMPACT OF RENEWABLE ENERGY INFRASTRUCTURE DEVELOPMENT ON HABITATS USING AEROLIDAR TECHNOLOGY

Dr Mirna Mazija[1]*, Dr Fran Domazetović[2]

[1] Supernatural Ltd., Koledinečka 3, 10000 Zagreb, [2] Department of Geography, Center for Geospatial Technologies, University of Zadar, Trg kneza Višeslava 9, 23000 Zadar

*Corresponding author.

The development of renewable energy infrastructure (REI) has exerted significant pressure on biodiversity, especially since these projects are more densely and often located in remote, natural areas such as mountains and forests. When assessing the impact of REI projects on biodiversity, typically only the two-dimensional (2D) habitat loss (area) is considered, while the three-dimensional (3D) impacts (volume) on forests and similar habitats have been largely overlooked. To properly assess the impact on flying and arboreal animals, it is crucial to take the vertical dimension into account. This study focuses on the quantification of 3D impacts of REI on forested habitats using high-resolution AeroLiDAR data. The study area focuses on one test wind power plant (WPP) covering an area of 111.27 ha, located in a mountainous part of Croatia. Quantification of the 3D impacts of this WPP development was conducted based on high-resolution AeroLiDAR data collected by the State Geodetic Administration (SGA) of the Republic of Croatia in 2023. The high-resolution LiDAR point cloud was used to quantify the volume of habitat loss caused by the construction of all infrastructure (roads, wind turbines, etc.) associated with the analysed WPP. Additionally, the quantified 3D habitat loss was classified by the type of infrastructure causing the loss and by the type of habitat affected. The results indicate that total volume of forest habitat loss caused by the analysed WPP amounts to 388 922 m3. Considering that the forest covers only 30.4% of the study area (3.43 ha), the mean habitat loss per hectare of forested land amounts to 113 388.33 m³/ha. The remaining portions of the study area are dominated by meadows, where the calculated volumetric habitat loss is negligible. The results reveal substantial forest habitat loss due to WPP development, emphasizing the need for more comprehensive environmental impact assessments that incorporate 3D spatial analysis. Consequently, such 3D assessment of REI impacts should be conducted prior to determination of optimal location for its construction.

TUESDAY 9TH SEPTEMBER – 11:30-12:30

DEEP LEARNING SIMULATION OF SEABIRD TRAJECTORIES TO ASSESS OFFSHORE WIND FARMS' IMPACT

Ms Sophie Benboudjema[1]*, Dr Geraldine Nogaro[1], Dr Steven Votier[2], Dr David Grémillet[3], Dr Sophie Lanco[4]
[1] EDF R&D, Paris, [2] Herriot Watt University, Edinburgh, [3] Centre d'écologie fonctionnelle et évolutive (CEFE), Univ Montpellier, CNRS, EPHE, IRD, Montpellier, France, [4] IRD, Sète
*Corresponding author.

The predicted growth of global offshore wind farms' (OWFs) capacity from 35 GW to 382 GW by 2030 has raised questions about their potential impact on seabirds, such as barrier effects, changes in the spatial distribution and collision risk. Bird-borne tracking, such as the use of miniaturised GPS loggers, has revealed much about seabird behaviour in relation to planned and operational OWFs but the data is often limited to a small proportion of individuals and colonies. We therefore propose combining existing tracking data to develop a deep learning model which will be able to generate large numbers of plausible seabird trajectories. These will be fitted to covariates likely to impact distribution and habitat choice (e.g. bathymetry, coastline, wind conditions) and offshore windfarm characteristics (e.g. size, localization). The use of a deep learning model provides a generalised model for all study sites and species and does not depend on strong assumptions about the movement process.
The model, a Generative Adversarial Network (GAN), was trained on data from five Northern Gannet (*Morus bassanus*) colonies during the breeding season when adults must return to a central place in-between foraging at-sea. Gannets are entirely marine foragers enabling us to evaluate the effect of bathymetry and land masks on simulated trajectories.
Our results indicate the GAN is able to accurately simulate gannet foraging tracks based on the bathymetric maps provided. The simulated tracks are loops whose overall characteristics (such as total distance, duration, bearing and distance to the colony) are similar to the real data. Taking bathymetry into account enables the model to avoid land in the simulated tracks, both for the studied colonies and new maps of sites without tracking data.
Further studies on other species (such as gulls) and with data of OWFs are underway and should be tested over the year. Perspectives for this work are to develop this new tool that could help assess the impact of future OWFs on seabirds by predicting possible trajectories based on wind farms scenarios and site-specific environmental conditions. As more tracking data are collected across species and site, this generalist model should improve in terms of both simulation and prediction, as deep learning approaches take advantage from large datasets.

TUESDAY 9TH SEPTEMBER – 11:30-12:30

MONITORING HARBOUR PORPOISE PRESENCE AND UNDERWATER SOUND IN AN OFFSHORE WIND FARM IN THE DUTCH NORTH SEA

Ms Irna Huisjes[1]*, Dr Janneke Ransijn[2], Mr Pepijn Van Tol[1], Mr Steve Geelhoed[2], Dr Joost Brinkkemper[1]

[1] WaterProof, [2] Wageningen Marine research

*Corresponding author.

An increasing portion of the North Sea is being allocated for offshore wind farm (OWF) development, raising concerns about their potential impact on the marine environment while also contributing to the green energy transition. The Dutch government has set ambitious targets for offshore wind energy, with a planned capacity of 21GW by 2030. The Harbour Porpoise Network Borssele (HPNB) project was initiated to study harbour porpoise (*Phocoena phocoena*) presence in and around the Borssele wind farm in the Southern part of the North Sea. The passive acoustic monitoring network consists of cetacean click detectors (Chelonia C-PODs and F-PODs) at 14 locations in and outside the windfarms, co-located with broadband hydrophones at 6 of the 14 locations. At these stations, both acoustic activity of porpoises and underwater sound are monitored. Preliminary results show seasonality in harbour porpoise acoustic activity, with higher detections with decaying sea surface temperature. This corresponds with previous monitoring studies in the Dutch North Sea and patterns in coastal sightings, aerial surveys, and strandings (i.e. higher porpoise density in winter and early spring). Porpoise acoustic activity is higher during the night and around slack tide, possibly related with enhanced foraging opportunities. Ambient sound levels inside the windfarms are dominated by low-frequency sound emitted by the turbines, while ambient sound levels outside the windfarm are higher and deemed typical for an environment dominated by shipping. This research enhances our understanding of harbour porpoise activity in wind farms, providing valuable knowledge to balance renewable energy development and marine ecosystem conservation.

This research is part of the Wozep offshore wind ecological programme of Rijkswaterstaat on behalf of the Dutch Ministry of Climate Policy and Green Growth.

TUESDAY 9TH SEPTEMBER – 11:30-12:30

MONITORING OF ATLANTIC COD (GADUS MORHUA) AND EUROPEAN LOBSTERS (HOMARUS GAMMARUS) AT TWO TYPES OF ARTIFICIAL REEFS IN AN OFFSHORE WIND FARM

Dr Benoit Berges[1]*, Dr Inge Van Der Knaap[2], Dr Jan Reubens[3], Dr Frank Jacobs[4], Mrs Eline Van Onselen[4], Dr Erwin Winter[1], Dr Marcel Jc Rozemeijer[1]

[1] Wageningen Marine research, [2] Institute of Marine Research, [3] Flanders Marine Institute (VLIZ), [4] The Rich North Sea

*Corresponding author.

Globally, biogenic temperate reefs are among the most threatened habitats. In the North Sea in particular, large shellfish reefs were lost due to fishing activities in the 1900s. Following European targets for renewable energy, the number of Offshore Wind Farms (OWFs) in the southern North Sea have rapidly increased and this trend will continue in the coming years. The impact of OWFs on marine wildlife is extensive, either beneficiary or detrimental, and it offers the possibility to reintroduce new hard substrate habitats that are protected from fisheries at a large scale. In addition to the submerged structures of OWFs, marine hard substrate habitat can be further enhanced by providing extra artificial reefs. In an operational OWF along the Dutch coast, four artificial reefs (two with a scour bed and two without) were deployed in the vicinity of a wind turbine. These reefs contained concrete pipes of various diameters. Acoustic telemetry was used to monitor fine scale movement of Atlantic cod (Gadus morhua) and European lobsters (Homarus gammarus). It allowed to investigate behaviour at the artificial reefs in relation to other habitats in the OWF at fine temporal and spatial scales, using a network of 16 acoustic receivers in 2021 and 2022.

A total of 64 juvenile cod were caught at the test reefs and tagged with acoustic transmitters with pressure and acceleration sensors. Results showed strong attraction (high site fidelity and residency) to the artificial reef, with no significant difference between the two tested types of reefs, and only few individuals staying over-winter. The animals exemplified local behaviours around the artificial reefs. In addition, cod spent a large proportion of their time hiding in the artificial reefs, suggesting that adding pipes for shelter has a beneficiary effect.

For European lobsters, the monitoring was done on translocated animals. The monitoring took place with 2 batches of 12 animals each carried out in 2021 and 2022. Only a small proportion of tagged animals showed attraction to the artificial reefs. After a period of 51 days, no European lobsters were detected, suggesting that they left the monitoring area, likely because of the effect of translocation. However, a behaviour analysis revealed that the animals residing in the area consistently hide in the artificial reef structures for extended time periods.

TUESDAY 9TH SEPTEMBER – 11:30-12:30

TEMPORAL AND LANDSCAPE DRIVERS OF BAT RESPONSES TO THE WAKE EFFECT:

Dr Fabien Verniest[1]*, Dr Kévin Barré[1], Dr Christian Kerbiriou[1], Dr Isabelle Le Viol[1], Mr Nicolas Valet[2], Dr Camille Leroux[2]

[1] Centre d'Ecologie et des Sciences de la Conservation (CESCO), Muséum national d'Histoire naturelle, Centre National de la Recherche Scientifique, Sorbonne Université, Paris ; Station Marine, Concarneau, France, [2] Auddicé biodiversité

*Corresponding author.

Wind turbines can negatively affect bats through collision mortality, which can be exacerbated by attraction behaviour, and habitat loss caused by the wind farm construction and avoidance behaviour after installation. Measures to ensure that wind energy development is compatible with biodiversity conservation and address this "green-green" dilemma are being implemented, but their effectiveness is currently limited by the lack of knowledge of the drivers and mechanisms underlying these behaviours. Indeed, although previous research has revealed the contribution of landscape variables, weather conditions, operation metrics and turbine characteristics (*e.g.*, rotor diameter, ground clearance) to the prevalence of one behaviour (attraction or avoidance) over the other, significant research gaps remain. For instance, a recent study has demonstrated the role of the wake effect in Pipistrellus pipistrellus attraction and avoidance behaviour, but this mechanism may be highly species and context-dependent.

Here, we assessed the consistency of this mechanism according to: i) the season, ii) the time since commissioning date of the wind turbine, iii) the type of landscape, and iv) the species. To this end, we acoustically monitored the activity of 8 bat species/ groups in late Spring at 347 sites in 40 wind farms of two study zones (northern and western France) with contrasting landscapes (mainly open fields and high density of hedgerows respectively). Sites were located at hedgerows and distributed along a distance gradient from the wind turbines (from 25m to 1500m) and along a circular azimuth gradient of wind incidence angle to assess bat responses to the wake effect. For sites located in western France, sampling was replicated in early Autumn at the same sites in order to compare differences in habitat use driven by the wake effect between lactation and migration periods.

Preliminary results indicate that the influence of the wake effect on bat attraction and avoidance behaviours might be season and landscape type dependant, although contrasting results were found among species/groups. Different patterns also suggest that this mechanism may be moderated by the time since commissioning date of wind turbines. Our findings provide new insights on the role of the wake effect in bat responses to wind turbines, that can contribute to improve the effectiveness of mitigation strategies and wind energy planning.

TUESDAY 9TH SEPTEMBER – 11:30-12:30

FACTORS INFLUENCING WILDLIFE MORTALITY AT WIND ENERGY FACILITIES: ACTUAL POWER PRODUCTION, NAMEPLATE RATING, AND SEASON

Dr Tara Conkling[1]*, Dr Manuela Huso[2], Ms Kara Akers[3], Ms Amy Fesnock[4], Dr Todd Katzner[1]
[1] U.S. Geological Survey, Forest and Rangeland Ecosystem Science Center, [2] United States Geological Survey, [3] None, [4] U.S. Bureau of Land Management
*Corresponding author.

With global increases in renewable energy production, efforts to reduce wildlife mortality include repowering existing wind facilities to replace smaller, lower capacity turbines with fewer higher capacity turbines. An initial investigation by Huso et al. (2021) suggested that the relative amount of energy produced has a greater impact on relative mortality rates relative to other commonly-assessed turbine metrics (e.g. size, rotor-swept area, installed nameplate capacity). We expanded the initial 1-year dataset from Huso et al. (2021) by collecting additional fatality and detection trial data for 3 additional monitoring phases from 2019 – 2022 and 1 additional turbine size category to test the generality of our earlier study. Specifically, we assessed whether Huso et al's (2021) findings still apply with a more robust dataset, and how this relationship varied across years, seasons, taxa and animal size class.
Preliminary data suggest that relative energy production, rather than turbine or installed capacity metrics, remains a primary factor impacting wildlife mortality at wind energy facilities. This pattern was consistent even when examining seasonal and temporal patterns in fatalities across all sites and turbine sizes. Additionally, mortality rates varied by taxa, with small-bodied species (e.g. bats, small birds) experiencing overall seasonal differences in fatalities that exceeded those observed for larger bird species. The preliminary results illustrate the relevance of assessing mortality relative to power production to further improve understanding of the impacts of repowering wind turbines on wildlife populations.

TUESDAY 9TH SEPTEMBER – 11:30-12:30

BIRD SURVIVAL IN WIND FARMS BY MONTE- CARLO SIMULATION MODELLING BASED ON WIDE- RANGING FLIGHT TRACKING DATA OF MULTIPLE BIRDS DURING DIFFERENT SEASONS

Mr Nikolay Yordanov[1]*, Dr Heinz Nabielek[1], Mr Kiril Bedev[1], Prof Pavel Zehtindjiev[1]
[1] *Institute of Biodiversity and Ecosystem Research Bulgarian Academy of Sciences*
*Corresponding author.

Wind energy development is a key component in the transition to a sustainable clean energy. Therefore, we need reliable predictions in assessing the potential increase in avian mortality due to an increase in wind farms and turbine power, inter alia for Environmental Impact Assessments. Bird survival in wind farms can be estimated by Monte-Carlo simulations of wind speeds, avian flight attitudes, and turbine avoidance supported by wide-ranging flight tracking data.A simulation approach, based on flight-height distributions of middle-sized raptor species, was applied to obtain accurate flight data in different life-cycle periods of the year, based on available long-term Global Positioning System (GPS) tracking data. Flight behaviour data was collected for eight common buzzards, tracked over a four year period in an area with more than 200 wind turbines.The flight altitude distribution of soaring birds has a horizontal component and an upwind component. The horizontal component altitude probability is described by a normal distribution with mean μ and standard deviation σ. The upwind component is described by a truncated exponential distribution that starts at μ and has an upward decay constant τ. The convolution integral of these two distributions results in the EMG (Exponentially Modified Gaussian) distribution with parameters μ, σ, τ. With available tracking data, the EMG distribution can be used for a wide range of soaring birds. Our model species had unimodal flight height distributions in the periods of breeding, wintering and migration. For periods of seasonal migrations with a higher flight altitude the collision probability was lower compared to breeding and wintering periods of the same species. As the potential collision probability varied between seasons, mitigation measures in wind farms can be optimized. In addition, we compared collision victims monitoring data from the same territory after six years' systematic searches. Established collision rate of our model species confirmed results from Monte-Carlo simulated collision probability. Our carcass searches data supported low collision probability for common buzzards. This optimistic result may indicate fast habituation process of middle size diurnal rapport species such as common buzzards to the changes in environment related to wind power projects.The applied Monte-Carlo simulation approach based on the EMG altitude distribution obtained from GPS tracking of birds is a reliable tool for quantitative estimation of potential additive mortality in wind farm territories.

TUESDAY 9TH SEPTEMBER – 11:30-12:30

MEASUREMENTS OF NOISE LEVELS AND PORPOISE DISTURBANCE DURING PILE-DRIVING AT MORAY WEST OFFSHORE WINDFARM; COMPARISON WITH MODEL PREDICTIONS USED IN REGULATORY ASSESSMENTS

Prof Paul Thompson[1]*, Dr Aude Benhemma-Le Gall[1], Mr Rob Lee[2], Mr Simon Stephenson[2], Mr Tim Mason[3], Ms Nuria Abad Oliva[4]

[1] University of Aberdeen, School of Biological Sciences, Lighthouse Field Station, Cromarty, Ross-shire, IV11 8YJ, Scotland, UK, [2] Seiche Ltd, [3] Subacoustech Environmental Ltd, [4] Ocean Winds

*Corresponding author.

Offshore wind farm construction requires regulatory assessment of the numbers of protected marine mammals that may experience auditory injury or disturbance from impulsive piling noise. However, there is high uncertainty within available assessment frameworks, and limited opportunities to validate outputs.

We present data on underwater noise levels and porpoise behavioural responses during construction at Ocean Winds' Moray West Windfarm in 2023. Specificially, we compare measurements of 1) underwater noise and 2) harbour porpoises responses with predictions made during regulatory assessments.

Monitoring data were collected during installation of 9.5 to 10 m diameter monopile foundations. Seiche Limited used broadband acoustic recorders to measure noise levels at 750 m and 2,000 m during impact piling of 13 monopiles, with additional opportunist recordings at up to 15 km. Harbour porpoise responses were monitored from 1 - 33.4 km from each monopile using an array of 60 echolocation detectors (CPODs). Analysis of changes in echolocation detections provided a proxy for behavioural responses during installation of seven monopiles, where detections during 24 hours after piling were compared with matched periods three days before piling started.

Measured maximum received noise levels from maximum hammer energies of between 2,280 and 4,546 kJ were 177-181 dB re 1 µPa2s (SELss) at 750m. Measurements were typically within 1 dB (range -2.4 dB to + 3 dB) of values predicted from acoustic modelling at two focal sites used in regulatory assessments. Measurements were also within or below the 1dB bands provided by Subacoustech Environmental Limited who conducted blind retrospective modelling using INSPIRE v5.2, an acoustic modelling tool used in many current UK assessments. Responses of porpoises to monopile installation at Moray West were similar to those observed in earlier studies of pin-piling at the adjacent Beatrice Offshore Windfarm in 2017, despite observed noise levels being higher at Moray West. Preliminary analyses combining noise measurements and behavioural data indicate that there was a >50% chance of disturbance to porpoises at distances of up to 5 km from piling at Moray West, which was lower than predicted from dose-response and deterrence functions used in current regulatory assessments in the UK. Together, these results provide confidence in current approaches to acoustic modelling and highlight that existing approaches to estimating disturbance to cetaceans from impact piling in UK waters are likely conservative.

TUESDAY 9TH SEPTEMBER – 15:45-16:45

SENSITIVITY TO WIND TURBINE COLLISIONS: LARGE DIFFERENCES IN TIME SPENT FLYING, PROPORTION OF FLIGHTS AT RISK HEIGHT AND DISTANCE FROM NEST AMONG RAPTOR SPECIES

Dr Tonio Schaub[1], Mrs Caroline De Zutter[2]*, Dr Raymond Klaassen[3], Mr Pascal Albert[4], Mr Jean-Luc Bourrioux[4], Dr Ralph Buij[5], Dr Joël Chadœuf[4], Dr Celia Grande[6], Mr Hubertus Illner[7], Mr Kjell Janssens[8], Mr Arthur Keller[9], Mr Simon Lee[10], Mr Aymeric Mionnet[11], Mr Gerard Müskens[12], Mr Stef Van Rijn[13], Prof Judy Shamoun-Baranes[14], Mr Geert Spanoghe[8], Mr Benoît Van Hecke[4], Prof Jonas Waldenström[15], Dr Alexandre Millon[1]

[1] Aix-Marseille University, [2] ENGIE Lab CRIGEN, [3] University of Groningen, [4] Groupe d'Études et de Protection des Busards, [5] Wageningen Environmental Research, [6] Carl von Ossietzky University of Oldenburg, [7] Arbeitsgemeinschaft Biologischer Umweltschutz, [8] Research Institute for Nature and Forest (INBO), [9] LPO Alsace, [10] Natural England, [11] LPO Champagne-Ardenne, [12] Müskens Fauna, [13] Deltamilieu Projecten, [14] University of Amsterdam, [15] Linnaeus University

*Corresponding author.

Wind energy development leads to an increased mortality of birds due to collisions with wind turbines, especially in raptors. Detailed information on the flight behaviour of different species is essential to assess sensitivity to wind turbine collisions irrespective of current exposure, improve collision risk estimations, and identify effective mitigation measures.

In this comparative study, we assessed the sensitivity to wind turbine collisions of breeding birds of six raptor species – Montagu's Harrier (MoH), Hen Harrier, Marsh Harrier, Common Buzzard (CB), Red Kite (RK) and Short-toed Eagle (STE) – based on the time spent in flight, the proportion of flights at risk height and the distance travelled from the nest location. We used GPS-tracking data collected in 15 study areas in six European countries, comprising 280 individuals, 74,501 individual tracking days and 5,786 h of high-frequency flight tracks, providing accurate flight height data.

The average time spent in flight ranged from 0.5 (CB) to 3.4 h d-1 (MoH) in females and from 1.0 (CB) to 7.4 h d-1 (MoH) in males. The proportion of flights at risk height (32-200 m above ground level) varied between 12.4% (MoH) and 56.4% (RK). In both aspects, variation between study areas was small. The largest total amount of time at risk height per year was found in RK (1.7-7.4 times more than in the other species).

The mean 90% quantile of distance from nest ranged from 0.7 km (CB) to 9.8 km (STE) in females, and from 1.0 km (CB) to 5.6 km (MoH) in males (no data from male STE available), with considerable individual variation. With increasing distance from nest, the estimated time spent at risk height per km2 decreased in all species, albeit with a species-specific slope.

Our results indicate that basic characteristics of flight behaviour could explain substantial differences in the sensitivity to wind turbine collisions among raptor species, and suggest a particularly high sensitivity in Red Kites. The collision risk for breeding birds can be substantially reduced by increasing the distance between wind turbines and nest sites.

TUESDAY 9TH SEPTEMBER – 15:45-16:45

SPECIES-SPECIFIC RISK FACTORS OF BAT FATALITIES AT ONSHORE WIND FACILITIES: INTERROGATING RELATIONSHIPS WITH TURBINE DESIGN, METEOROLOGICAL, AND LANDCOVER COVARIATES USING HIERARCHICAL MODELS

Dr Charles Labuzzetta[1]*, Mr Arnold Johnsen[2], Dr Ashton Wiens[3], Dr Teresa Bohner[2], Dr Jay Diffendorfer[4], Dr Anthony Lopez[5], Dr Trieu Mai[5], Mrs Megan Seymour[6], Dr Wayne Thogmartin[2], Dr Brad Udell[1], Mrs Bethany Straw[1]

[1] U.S. Geological Survey, Fort Collins Science Center, [2] U.S. Geological Survey, Upper Midwest Environmental Sciences Center, [3] U.S. Geological Survey, Geology, Energy and Minerals Science Center, [4] U.S. Geological Survey, Geosciences and Environmental Change Science Center, [5] National Renewable Energy Laboratory, [6] U.S. Fish and Wildlife Service, Ohio Ecological Services Field Office

*Corresponding author.

Motivations and objectives. Bat species compose the second most diverse order of mammals worldwide, but post-construction monitoring (PCM) reports of bat fatalities at onshore wind facilities often aggregate estimates across all species. Furthermore, studies that have examined relationships between bat fatalities and risk factors such as turbine design, meteorological, and habitat covariates often apply these relationships across all bat species rather than allowing for species-specific inferences. We utilized PCM reports across the United States to estimate the total fatalities per species and discover species-specific drivers of these fatalities. Evidence of species-specific fatality risk factors could be used to design siting and operational mitigation strategies for vulnerable bat species at wind facilities. Methodology. We developed novel hierarchical mixture models to estimate total fatalities of multiple bat species at two scales. First, we compiled more than 600 PCM reports documenting fatalities for 25 bat species from over 300 U.S. wind energy facilities. We leveraged the compiled data to estimate fatalities for each of 10 bat species most commonly recorded in the PCM reports across the U.S. while accounting for species-specific interactions with wind facility layouts, turbine designs, species ranges, and landcovers. Second, we analyzed a two-year dataset of fatalities reported at individual turbines across 19 facilities, which allowed us to explore specific-specific relationships for 7 bat species among finer scale meteorological and habitat covariates. Results. The national-level model can produce species-specific estimates of total fatalities at wind facilities across the U.S. as a retrospective analysis of wind energy buildout from 2001 to 2025 and under future buildout scenarios. The retrospective analysis predicts nearly 10 million bat fatalities have occurred, suggesting cumulative bat fatalities from wind energy could be on the same order of magnitude as estimated cumulative fatalities from white-nose syndrome in the U.S. Additionally, our results across both scales reveal several species-specific risk factors associated with turbine designs, nightly windspeeds, and distances to desirable habitats and foraging grounds. Conclusion. While PCM data has been widely collected at great expense and these surveys have not been standardized, our innovative methods can estimate cumulative take, support forecasting, and reveal species-specific drivers of fatalities. We intend to operationalize our analysis and iteratively run these models as additional PCM reports become available to further improve the robustness of our findings. Our open-source methodology may be adapted by other scientists and organizations seeking to study multi-species mortality at wind facilities in other regions worldwide.

TUESDAY 9TH SEPTEMBER – 15:45-16:45

SENSITIVITY ANALYSIS OF WINDFARM AND TURBINE PARAMETERS ON SEABIRD COLLISION RISK

Dr Jack Forster[1], Dr Rebecca Nagel[1]*, Ms Jaz Harker[1], Dr Kelly Macleod[1]
[1] *HiDef Aerial Surveying Ltd*
*Corresponding author.

Collision risk modelling form a key component of environmental impact assessments (EIAs) to guide wind farm planning and mitigation measures in the UK. Statutory Nature Conservation Bodies (SNCBs) recommend the use of stochastic Collision Risk Model (sCRM) as a key tool to calculate collision risk, which includes both bird species-specific and windfarm/turbine-specific parameters. Whilst previous work has explored the sensitivity of sCRMs to bird species-specific parameters, the windfarm/turbine-specific parameters have received less attention. In addition, these parameters are often subject to uncertainty and revision during the consenting process; without understanding the effect sizes associated with these parameters, consultants undertaking EIA work are not able to fully inform developers of the inherent risk associated with windfarm/turbine parameter uncertainty.

We conducted a sensitivity analysis for the sCRM tool in R by collating maximum and minimum ranges for windfarm and turbine parameters based on pre-existing and planned offshore windfarms within UK waters. We ran thousands of simulations across multiple species to generate annual collision risk estimates; these estimates were subsequently incorporated into generalised linear models, with scaled windfarm and turbine parameters used as predictors within the model with two-way interactions. Effect sizes for the main effects and interactions were calculated to allow a risk-ranked estimate for all relevant parameters. These effects incorporated within a user-friendly interface that allows consultants to determine the relative impacts of parameter changes within future projects and better inform developers.

We present the outcomes from the sensitivity analysis, highlighting those parameters that drive the largest changes in mortality and how emerging trends in future offshore developments may impact on seabird collision risk.

TUESDAY 9TH SEPTEMBER – 15:45-16:45

TRACKING A QUARTER CENTURY OF CHANGES IN COMMON SCOTER AND DIVER SPECIES' DISTRIBUTION AND ABUNDANCE IN RESPONSE TO THE SUCCESSIVE DEVELOPMENT OF THE HORNS REV I-III OFFSHORE WIND FARMS, DENMARK

Dr Lindesay Scott-Hayward[1]*, Mr Ib Krag Petersen[2], Prof Monique Mackenzie[1], Dr Claus Lunde Pedersen[2], Dr Saana Isojunno[1], Mr Rasmus Due Nielsen[2], Mr Jacob Sterup[2], Dr Heidi Thomsen[2], Prof Anthony Fox[2], Mr Rune Neergaard[3]

[1] CREEM, University of St Andrews, [2] Aarhus University, [3] NIRAS

*Corresponding author.

We evaluated 25 years of changes in the abundance and distribution of the common scoter, *Melanitta nigra*, and divers (predominantly red-throated divers *Gavia stellata*), in the Danish North Sea following the construction there of three offshore wind farms (OWF, Horns Rev I, II and III (HR I-III)). Both species are known to be sensitive to human disturbance.

From 2000 to 2025, 62 winter/spring observer-based aerial bird surveys were conducted, one of the world's longest and most consistent OWF monitoring datasets. Surveys were grouped into four main phases: Phase 0 (pre-construction), Phase 1 (post-construction HR I and pre-construction HR II/III), Phase 2, post-HR I and II, pre-construction HR III) and Phase 3 (post-construction of all three OWF's). To accommodate changing survey coverage and expansion of geographic range, we also split Phase 1 into early and late (Phase 1*), using the latter for comparisons to Phases 2 and 3. To accommodate imperfect detection of birds, species-specific distance analyses were conducted using data pooled across surveys. Abundance and distribution were estimated for each species and survey within a generalised additive model framework, using the R package MRSea, with Tweedie error distribution and accommodating for residual correlation.

Common scoters occurred at Horns Rev in high densities, divers much less so. Scoters shifted westward in distribution from Phase 0 to Phase 1, complicating assessment of HR I construction impacts. Diver density in the HR I area was unchanged during Phases 0–2 but declined during Phases 2–3. Densities of both species decreased in and around HR II after its construction (Phases 1–2) and both continued to decline at HR II during Phase 2–3. Post-HR II construction, common scoters were displaced out to ca. 3 km from the footprint, increasing to 6 km in Phase 3, though a marked study area-wide decline in scoter abundance during the second year of Phase 3 surveys may explain this increase in displacement distance. Divers were displaced initially out to ca. 6.5 km and out to ca. 9 km in Phase 3 at HR II, which also coincided with study area declines in diver density, potentially contributing to the increase in displacement distance. For both species, the displacement distances were not the same in all directions from the footprint of HR II. Interestingly, there was less convincing evidence for any declines in densities of either species post-construction of HR III (with its larger and more widely-spaced turbines compared to HR I/II).

TUESDAY 9TH SEPTEMBER – 15:45-16:45

MULTI-SEASON MONITORING OF BIRD MIGRATION AT COASTAL LOCATIONS IN NORWAY: IMPLICATIONS FOR OFFSHORE WIND FARM DEVELOPMENT

Dr Line Cordes[1]*, Dr Emma Jane Critchley[1], Dr Øyvind Hamre[1], Dr Anna Nilsson[1], Dr Roel May[1]
[1] *Norwegian Institute for Nature Research*
*Corresponding author.

Offshore wind farms are expanding globally, raising concerns about their potential impact on migratory birds. However, a limited understanding of migration patterns and flight behaviour in offshore areas hampers our ability to assess these impacts. The difficulty in monitoring bird migration in offshore environments is a key challenge. To address these concerns, it is essential to establish comprehensive monitoring of migratory behaviour. Yet, deploying the appropriate technology in such conditions presents significant hurdles.
Radar technology offers an effective means of tracking bird migration in real time, providing valuable insights into migration traffic rates (MTR), flight trajectories, directionality, speed, and altitude over large areas and extended periods. While our study was not conducted offshore, we utilised avian radar systems to monitor MTR and flight behaviour in response to atmospheric conditions at coastal locations in Norway. Specifically, Robin Max 3D radars were deployed at two key migration sites - one of which is near a planned offshore wind farm. Over the course of two years, we monitored bird migration during two spring and two autumn migrations.
Preliminary results reveal significant differences in MTR between coastal sites, as well as distinct patterns of migration behaviour in response to local weather conditions. Throughout the season, migration activity varied between sites, with some experiencing clustered periods of heavy fluxes and others showing more dispersed activity. On a daily scale, migration was most concentrated from late afternoon to early morning. Generally, at high wind speeds, MTR decreased, and birds tended to fly higher, faster, and in the direction of the wind. Additionally, a large proportion of birds flew within or just below the rotor-swept zone.
Our results will help shape mitigation strategies to minimize the impact of offshore wind farms (OWFs) on migrating birds. This includes recommending measures such as partial shutdowns during peak migration periods or increasing the airgap to reduce collision risks.

TUESDAY 9TH SEPTEMBER – 15:45-16:45

OPTIMIZING RENEWABLE ENERGY SITING TO MITIGATE ECOLOGICAL IMPACT IN COASTAL CHINA: A POLICY ANALYSIS AND MULTI-CRITERIA DECISION-MAKING APPROACH

Ms Yuechen Huang[1], Dr Chi-Yeung Choi[2]*
[1] Duke University, [2] Duke Kunshan University
*Corresponding author.

Recent technological advances have streamlined the use of autonomous vehicles, such as Unmanned Surface Vehicles (USVs) and Autonomous Underwater Vehicles (AUVs) or gliders, to collect environmental data at the surface and in the water column. Here, we present a strategy to conduct biodiversity surveys in offshore wind farm projects using a combination of surface and underwater autonomous vehicles equipped with sensors to monitor biodiversity remotely. The rationale is to improve ecosystem characterization and impact assessment for offshore wind energy projects while reducing costs, CO2 emissions generated by traditional vessels and HSE exposure. Learning on the operability of the vehicles (deployment, maintenance, piloting, autonomy) and on the integration of sensors is highly valuable for operations. The ultimate objectives of this research are to provide recommendations on survey design, to identify relevant indicators to monitor ecosystem health and to create a numerical dashboard for decision-making and data sharing. The study is being conducted in the Central North Sea, in a location where TotalEnergies will deploy a floating offshore wind turbine which will supply an existing oil & gas platform with renewable electricity. During the summer 2025, a 3 MW floating wind turbine will be installed 2 km off the Culzean platform. The scope includes a one-month survey in spring 2025 to establish a baseline, followed by a one-month survey in spring 2026, after the installation of the turbine. Both surveys will be conducted using a fleet of two USVs and two gliders equipped with instruments such as hydrophone, echosounder, camera, environmental DNA (eDNA) sampler and water quality sensors. The major innovation of this study consists in integrating an eDNA automatic sampler on a glider. This multi-instrument approach facilitates the collection of data on all trophic levels, from phytoplankton to top predators, allowing a holistic characterization of the ecosystem. The floating turbine will be equipped with similar biodiversity sensors. The expected outcomes include a comprehensive dataset on surface and underwater biodiversity as well as insights into the impacts of turbine installation. Information on the quantity, quality and accuracy of the data collected from mobile sensors compared to fixed sensors will be important to validate the approach. By leveraging autonomous vehicles and a multi-instrument approach, this research aims to provide a viable and efficient method for conducting environmental baseline studies and long-term biodiversity monitoring. The findings will contribute to supporting sustainable offshore wind farm projects.

TUESDAY 9TH SEPTEMBER – 15:45-16:45

UNDERSTANDING AVIAN SPACE USE FOR OFFSHORE WIND FARM PLANNING: CHALLENGES OF MULTI-SOURCE DATA INTEGRATION

Dr Coline Canonne[1]*, Dr Maud Quéroué[2], Dr Sébastien Roques[2], Dr Valentin Lauret[1], Mr Victor Cat[2], Mr Louis Schroll[2], Dr Nicolas Courbin[2], Dr Aurélien Besnard[2]

[1] France Energies Marines, Plouzané, France - Centre d'Ecologie Fonctionnelle et Evolutive (CEFE - CNRS), Montpellier, France, [2] Centre d'Ecologie Fonctionnelle et Evolutive (CEFE - CNRS)

*Corresponding author.

Large-scale Offshore Wind Farm (OWF) planning requires a thorough understanding of how birds use the marine environment, including feeding grounds and wintering areas for seabirds, as well as offshore migratory pathways of landbirds. However, collecting data in these areas presents significant logistical challenges due to the vastness and inaccessibility of offshore environments. To address this, various monitoring methods are employed, including telemetry, ornithological and weather radars, acoustic monitoring, and aerial and boat-based surveys.

Used independently, each of these methods provides complementary but incomplete picture of avian space use. Some methods offer high-resolution data on a small scale, while others provide broader coverage with lower precision. In theory, integrating these diverse data sources through advanced modelling approaches should improve our ability to obtain finer-scale information over a larger area. However, our experience in this field, through the MIGRALION and MIGRATLANE projects on OWF planning in France, highlights the methodological challenges of such an approach. First, data integration does not replace the need for robust and sufficient sampling effort within each dataset associated with the different methodologies used. It is also crucial to ensure that each dataset is collected using a consistent and representative sampling protocol. Simply aggregating data from multiple independent programs could introduce biases and misrepresentations of avian space use. Effective data collection strategies must then be carefully designed in anticipation of integrated modelling, rather than relying on post hoc combinations of disparate datasets. Furthermore, we show that data from different sources are sometimes difficult to integrate due to fundamental differences in the type of information they provide.

While combining multiple data sources offers valuable initial insights, it remains a complex approach that requires careful implementation, particularly in remote offshore areas where predicting and interpreting avian space use remains a challenge. Without careful methodological considerations, we may fail to produce reliable predictions of avian space use, ultimately skewing OWF planning.

TUESDAY 9TH SEPTEMBER – 15:45-16:45

A FRAMEWORK FOR MONITORING BALEEN WHALES DURING OFFSHORE CONSTRUCTION

Dr Kristen Ampela[1]*, Dr Cris Hein[1], Mr Mark Severy[2], Dr Angela Szesciorka[2], Dr Michael Richlen[2], Dr Jeff Clerc[1], Dr Joseph Haxel[2]

[1] National Renewable Energy Laboratory, [2] Pacific Northwest National Laboratory

*Corresponding author.

Offshore wind energy facilities are currently being planned and installed in waters occupied by baleen whales. Potential impacts to these species are of particular concern because of their conservation status, the overlap of their habitat with current and planned development, and their expected sensitivity to low-frequency sounds, such as those produced during pile driving. The ability to install offshore wind turbine foundations in low visibility and in darkness is of interest to developers and other stakeholders to potentially provide increased schedule flexibility and shorter durations for construction activities. Effective monitoring of baleen whales in these conditions is critical to avoid negative impacts that in some cases, such as the North Atlantic right whale, have the potential to result in population-level effects. Several available monitoring technologies can detect baleen whales in low- and no-light conditions, but no standardized approach currently exists to characterize their functional performance. To address this gap, we developed an approach to help guide offshore wind energy projects and technology developers as they evaluate the efficacy and application of monitoring tools for monitoring baleen whales around offshore activities. We engaged with relevant groups via scoping and steering committee meetings, participated in public workshops, and recruited subject matter experts for interviews and peer review. Our analysis includes documentation of key system performance metrics (e.g., efficacy, range, and data delivery), development of a potential framework to standardize technology characterization through system design, pre-test assessment, and final characterization and modeling, as well as recommendations for research, development, and sensor deployment. Although the scope of this effort is specific to baleen whale monitoring during offshore wind turbine foundation installation in low- and no-light conditions, the monitoring technologies we describe, as well as our proposed characterization framework, could be applicable to other regions, marine mammal species, and aspects of offshore wind development.

TUESDAY 9TH SEPTEMBER – 15:45-16:45

IMPACT OF WIND ENERGY TO BIRDS AND BATS IN THE COQUIMBO REGION, CHILE

Mr Alvaro Camina Cardenal[1]*
[1] *ACRENASL Environmental Consultants*
*Corresponding author.

We analyzed the baseline studies and post-construction fatality monitoring of five wind farms in the Coquimbo Region, north-central Chile. A total of 408 bird fatalities (38.16% raptors and passerines each) have been reported, including 49 species. The most relevant is the Andean condor (*Vultur gryphus*), an IUCN-vulnerable species with 12 fatalities. Another 186 bats were recorded involving six species. Among them, the Free-tailed bat *Tadarida brasilensis* comprised 74% of all casualties. The baseline studies were focused on walked transects at dawn and dusk, which are unsuitable for large soaring birds such as raptors. The current fatality monitoring protocol is discussed considering factors such as the number of wind turbines/day (>15 wtgs/person) and people in charge of monitoring (1-2), frequency of visits (a monthly or every three-month schedule), and search time per wind turbine (6-58 min). None of the studies considered the biases associated with this type of work (observer efficiency and carcass removal rates, or determination of the search area) nor made appropriate mortality estimates. For the bias analyses they used poultry, but small sample sizes and persistence was only four days, well below the search schedules. The birds and bats that collided so far are species with favorable conservation status. However, the shortcomings detected may have overlooked either the numbers or species of greater conservation concern, as has been the case with the Andean condor. There was a strong significant correlation between the time invested in the PCFM and the number of species found (r = 0.92). With the existing information, the thresholds established in the RCA's may have been exceeded but overlooked. The conclusion from the PCFM reports would be that the impact of wind energy on birds and bats is minimal in the Coquimbo Region. There is an urgent need for 1) a review of environmental monitoring protocols following international best-practice standards and 2) training at all levels of the personnel involved in the monitoring and control process, including government officials, consultants, and developers. Mitigation actions are urgent for the Andean Condor as the fatality rates may be affecting the viability of the Chilean and even more widespread the Argentinian population. Another ten individuals have been recorded in provinces other than Coquimbo, totaling twenty-two birds since 2019.

TUESDAY 9TH SEPTEMBER – 15:45-16:45

QUANTIFYING AND REDUCING AVIAN COLLISION RISK THROUGH TURBINE-LEVEL MODELLING AND ITERATIVE DESIGN

Dr Elizabeth Stark[1]*, Dr Stuart Muir[1], Mr Alex Jackson[1]
[1] *Symbolix Pty Ltd*
*Corresponding author.

Collision risk modelling is a 40 year old, increasingly standard approach to predicting the residual risk of avian collisions at a wind farm facility during the planning assessment stage. Wind farm assessments typically employ site-wide collision risk models (CRM) to quantify residual risk to birds after a layout is finalised.

While valuable for impact prediction, this approach has no opportunity to minimise risk through adjustments to the site layout. We present an alternative approach that enables proponents to quantify collision risk at individual turbines throughout the development of the final layout. This allows iterative refinement of layouts to reduce impacts on avian species of interest.

This methodology has been applied in Australia over a number of years, and we will present a Tasmanian wind farm as a case study. We demonstrate how turbine-level CRMs were integrated into project planning from 2019-2024.

Our approach combined spatial data analysis (kernel methods used to generate a 2D probability density surface) with a CRM framework. The CRM used standard Band 2009/2012 calculations for within-rotor collision risk but replaced the 'flux tube' calculation with an alternative spatial approach. This reduces the sensitivity to bird flight speed and allows a spatial turbine-level predictions.

Project engineers accessed these predictions in an interactive web app, enabling real-time assessment of how layout modifications influenced collision risk for wedge-tailed eagles. This dynamic, iterative approach allowed CRM to be integrated within a multi-criteria analysis of risk-avoidance options, benefiting the project development and the approval application.

This resulted in substantive reductions in predicted eagle collisions, while maintaining project viability, via adjustments to the development footprint. The keys to success were the proponent's early commitment to risk reduction, continuous availability of model outputs throughout the design process, and tools enabling rapid testing of layout scenarios.

We present our flexible modelling platform that supports this turbine-level approach to collision risk assessment, and discuss its strengths and applications. This method requires comprehensive spatial data on bird movements; however, emerging methods combining traditional field surveys with automated monitoring systems can cost-effectively meet these requirements. Our work demonstrates how innovative approaches to CRMs can help proponents design better projects particularly at the critical avoidance and minimisation stages.

TUESDAY 9TH SEPTEMBER – 15:45-16:45

EVALUATION OF THE TURBINE INTEGRATED MORTALITY REDUCTION (TIMRSM) TECHNOLOGY AS A SMART CURTAILMENT APPROACH

Mr Christian Newman[1]*, Mr Michael D. Whitby[2], Mr Donald Solick[3], Mrs Praanjal Nasery[3], Dr Manuela Huso[4], Mr Greg Forcey[5], Ms Isabel Gottlieb[6]

[1] EPRI, [2] Bat Conservation International, [3] Electric Power Research Institute, [4] United States Geological Survey, [5] Normandeau Associates, [6] Renewable Energy Wildlife Institute

*Corresponding author.

Wind energy is a crucial technology for achieving net-zero emissions by 2050. However, the growth and deployment of wind energy in North America have led to the deaths of many bat species due to operating wind turbines. Operational minimization, which includes feathering turbine blades and curtailment, has been documented to reduce bat fatality effectively. However, when turbines are curtailed, they do not generate power, resulting in energy loss and revenue for wind energy facilities. Building off past EPRI research into the development of Turbine Integrated Mortality Reduction (TIMRSM) Technology, an acoustic sensor-based technology that curtails turbine operation when bats are detected, EPRI aimed to validate previous TIMR study results by demonstrating the technology at a different wind energy facility. This demonstration was undertaken in 2021 and 2022 at a 500.9-MW wind energy facility in southeast Adair County, Iowa. The study used a randomized block design with three experimental treatments: TIMR, Curtailment at 5.0 m/s, and Normal Operation. The TIMR system worked as designed throughout the entire study; however, because of unexpected wind turbine operational challenges in 2021, there was limited data to evaluate the treatment differences. In 2022, there were significant differences in fatality levels between treatment types and normal operating turbines. Curtailment at 5.0 m/s reduced fatalities by 30.8% compared to normal operations, and TIMR decreased fatalities by 48.6% compared to Normal Operations. The TIMR system resulted in 1.3% to 1.6 % annual energy loss in 2021 and 1.0% to 1.2 % in 2022. Curtailment at 5.0 m/s resulted in 0.6% to 0.8 % annual energy loss in 2021 and 0.5% to 0.6 % in 2022. The project demonstrated that TIMR is an effective technology that balances bat fatality reduction with energy generation and supports the deployment of TIMR and other acoustic sensor-based technologies.

The results presented are preliminary and are being prepared for peer-reviewed publication.

TUESDAY 9TH SEPTEMBER – 15:45-16:45

MARINE LIFE INSIDE MONOPILES IN AN OFFSHORE WIND FARM AT THE NORTH SEA

Ms Sytske Van Den Akker[1]*
[1] *Waardenburg Ecology*
*Corresponding author.

coast: Hollandse Kust Zuid. One of the permit requirements was to: *make a demonstrable effort to design and build the wind farm in such a way that it actively enhances the sea's ecosystem'*. One of the Nature Inclusive (NID) measures is having four water replenishment holes in all 139 foundations.
One of Vattenfall's aims is to contribute to the knowledge building necessary for the roll-out of NID elements in future wind farms. To this end, monitoring and evaluation of these measures and cost-efficient monitoring options are included after 2, 6 and 11 years of operation. The first ecological monitoring was executed in summer 2024 as part of the maintenance and inspection scope. This study is the first of its kind that gives a good and quite comprehensive view of the marine life inside the hollow foundations.
The aim of the monitoring was to find out 1) if the inside of the foundations offers good conditions for marine life, 2) if Cod (as umbrella species) use the inside of the foundation, 3) what other fish and benthic species live inside and additionally 4) if there are differences in marine growth at the inner wall and outer wall.
In total four monopiles were monitored, both inside and outside the foundations. At 3 depths water samples were taken for eDNA analyses and dissolved oxygen (DO) samples using a multiprobe. In addition, vertical and horizontal ROV transects were collected and a baited cam (BRUV) was deployed. The ROV footage is analyzed by randomly selecting stills, identify species and use SACFOR. A standardized duration of BRUV data of 50 minutes is analyzed. DO values inside and outside are compared. The results will be complemented with the eDNA fish and benthos metabarcoding data.
Preliminary results show that:

- DO levels seem to be lower inside the foundations
- differences in the composition of the fish community inside and outside the monopile are not yet evident.
- The composition /abundance of benthic species inside seems to be different from the outside, both at the seafloor and the walls.

At the CWW we will present the final and detailed results on the monitoring, and our experiences of combining ecological monitoring with O&M inspections.

TUESDAY 9TH SEPTEMBER – 15:45-16:45

ADVANCING OFFSHORE WIND THROUGH INNOVATION AND BIODIVERSITY-POSITIVE SOLUTIONS

Ms Claire Weller[1], Dr Laura Iborra[1]*, Mr Volker Türk[1], Ms Aleksandra Kot[1], Dr Jules Selles[1], Dr Laura Huguenin[2], Mr Frédéric Mittaine[2], Dr Umberto Binetti[1]
[1] RWE Offshore Wind GmbH, [2] Cosma
*Corresponding author.

Over the past two decades, RWE has positioned itself as a global leader in offshore wind development, constructing and operating 3.3 GW across 19 sites in Europe, with an additional 20 GW under development worldwide. This extensive experience has driven the adoption of a comprehensive and responsible approach to the expansion of ocean-based renewable energy, ensuring that offshore wind development is aligned with biodiversity conservation and ecosystem resilience. To address the environmental and operational challenges posed by offshore wind expansion, RWE has established a sustainability framework based on four key pillars: enhancing biodiversity, promoting circular economy principles, mitigating climate change impacts, and delivering local benefits.

As offshore wind projects expand into deeper and more complex marine environments, the need for advanced environmental monitoring and effective impact mitigation becomes increasingly critical. Traditional biodiversity survey methods, while valuable, can be invasive, logistically challenging, time-consuming, and costly, and often lack the robustness required for large-scale, long-term assessments. These limitations hinder the ability to accurately track ecosystem changes and implement adaptive mitigation strategies.

To tackle these challenges, RWE has launched several international innovation competitions, encouraging the development of cutting-edge environmental monitoring solutions by external technology providers. Among the most recent winners of RWE's Innovation Competition is Cosma, a pioneering company specializing in large-scale benthic ecosystem monitoring. Cosma has developed an innovative approach that combines swarms of autonomous underwater drones, capable of operating at depths of up to 200 meters, with AI-powered data interpretation. These highly mobile and scalable systems generate centimeter-precision photomosaics of the seabed, significantly improving environmental impact assessments, baseline studies, and long-term monitoring protocols.

Through this collaboration, Cosma's AI-driven environmental monitoring solutions are transforming offshore biodiversity assessments by enhancing species distribution analysis, detecting habitat changes, and strengthening mitigation strategies. Compared to traditional monitoring approaches, these automated, data-driven solutions improve efficiency, scalability, and reliability, allowing for faster, more comprehensive impact assessments that support proactive biodiversity conservation throughout the entire offshore wind farm lifecycle.

Finally, this paper will address knowledge gaps and future research priorities. Strengthening collaboration between industry, research institutions, and regulators is key to refining impact assessments and developing effective mitigation measures. By sharing these insights, RWE aims to contribute to the global discussion on how offshore wind energy can scale up while actively enhancing biodiversity and ecosystem resilience.

TUESDAY 9TH SEPTEMBER – 15:45-16:45

OFFSHORE WIND DEVELOPMENT IN BRAZIL: OPPORTUNITIES, CHALLENGES, AND BIODIVERSITY CONSIDERATIONS

Ms Venina Ribeiro[1]*, Dr Domingos Leitão[1], Mr Miguel Repas-Goncalves[1]
[1] *STRIX*
*Corresponding author.

The transition to a low-carbon economy requires a technically and economically viable diversification of renewable energy sources. Offshore wind plays a crucial role in this shift, enhancing energy security and reducing emissions. With a 7,491 km coastline and 3.6 million km² of maritime space, Brazil has immense offshore wind potential, particularly in the Northeast, Southeast, and South regions.

More than 100 projects, totaling 244 GW, are under environmental licensing at IBAMA, positioning Brazil as a future leader in offshore wind. However, regulatory and infrastructure challenges remain. The enactment of Law No 576/2021 (Jan/2025) provides a legal framework for offshore energy, unlocking investments. The World Bank estimates that offshore wind could generate 516,000 jobs and contribute $168 billion to Brazil's economy by 2050.

Brazil's port infrastructure, originally developed for oil and gas, can be adapted for offshore wind, with shipyards serving as hubs for turbine assembly and maintenance. However, upgrades are needed to accommodate larger structures and deeper-water projects, increasing logistical complexity. A well-planned supply chain, port investments, and workforce training will be crucial for efficiency. Additionally, transmission grid expansion is another key challenge, requiring long-term planning to integrate offshore energy into the national system.

Beyond economic benefits, offshore wind must align with environmental sustainability. Large-scale projects in marine environments require robust biodiversity protection, as critical habitats, migration routes, and fish stocks are highly sensitive to human activity. Marine spatial planning is essential to avoid ecological conflicts, ensuring wind farms do not disrupt breeding grounds of seabirds, marine mammals, and sea turtles. Additionally, impacts on water quality, underwater noise, and electromagnetic fields must be carefully assessed to minimize harm to marine ecosystems.

Environmental licensing remains a major bottleneck. Strategic Environmental Assessments (SEAs) and Marine Spatial Planning (MSP) can improve site selection and stakeholder engagement, balancing energy expansion with conservation. Brazil's recent membership in the Global Offshore Wind Alliance (GOWA) provides a platform for international cooperation and best practices.

With the first offshore wind auctions expected in 2025, Brazil has a unique opportunity to become a global renewable energy leader while preserving its rich marine biodiversity. Strong governance, investment in research, and sustainable planning will be essential to ensuring offshore wind contributes to a cleaner, greener future.

TUESDAY 9TH SEPTEMBER – 15:45-16:45

SATELLITE-BASED MONITORING OF LARGE WHALES IN OFFSHORE WIND FARM AREAS: A NOVEL APPROACH FOR SUSTAINABLE WIND FARM DEVELOPMENT

Ms Caroline Hoeschle[1]*, Ms Julika Voß[1], Mr Recep Can[1], Dr Amel Ben Mahjoub[1], Mr Vlad Kosarev[1], Dr Kelly Macleod[2]

[1] BioConsult SH, [2] HiDef Aerial Surveying Ltd

*Corresponding author.

The global expansion of offshore wind energy presents significant opportunities for sustainable energy production but also poses challenges for marine conservation. In particular, understanding the distribution and movement patterns of large whales in these areas is crucial for mitigating potential impacts and promoting environmentally responsible development. Traditional survey methods, including ship-based and aerial surveys, as well as passive acoustic monitoring, are widely used in national monitoring programs and remain essential tools. As offshore wind farms are still primarily built in coastal areas, they remain accessible for conducting these monitoring programs effectively.

However, in more exposed environments, a novel approach to large whale monitoring can include the use of very high-resolution (VHR) satellite imagery. This method enables the detection of whales from space, utilizing sensors capable of capturing images at a resolution of 31 cm per pixel on the water surface. Unlike traditional methods, satellite-based monitoring provides 100% surface coverage of targeted areas, allowing for comprehensive and large-scale assessments.

Our service, SPACEWHALE, leverages this cutting-edge technology by tasking satellites with targeted image acquisition, taking into account environmental complexities and logistical constraints. Through a semi-automated processing pipeline, we integrate state-of-the-art artificial intelligence (AI) to detect marine mammals with high accuracy. This semi-automated process identifies the presence of large whales but also, enables species to be identified, demographic to be assessed, and generates detailed maps and data visualisations for conservation and management purposes.

Recent studies have revealed that large whales are increasingly present in areas overlapping with industrial activities, including ports and offshore wind farm zones. Many individuals exhibit strong site fidelity, returning to these locations over consecutive years, leading to growing concerns about potential risks such as entanglement in floating wind farm structures, increased vessel traffic, and potential disturbance associated with infrastructure installation.

In the coming years, advancements in satellite technology—including higher revisit rates, improved resolution, and enhanced AI-driven detection methods—are expected to further refine and expand the applicability of this approach. Satellite-based surveys can complement existing monitoring efforts by providing coverage and focusing on areas where constraints arise, addressing specific research questions, and filling gaps when traditional methods may not be available. In this work, we showcase recent case studies and explore future opportunities for employing satellite-based whale monitoring in offshore wind farm areas.

TUESDAY 9TH SEPTEMBER – 15:45-16:45

DECOMMISSIONING – UNDERWATER SOURCE CHARACTERIZATION OF MONOPILE CUTTING

Ms Joanna Sarnocińska-Kot[1]*, Ms Federica Pace[2], Mr Nuno Nunes[2], Mr Camillo Schenone[2], Mr Svenning Laier Dybdal[3], Mr Matthieu Povidis-Delefosse[1]
[1] Vattenfall, [2] JASCO Applied Sciences (Europe) GmbH, [3] Ziton
*Corresponding author.

The underwater sound generated during the decommissioning phase of offshore wind farms remains poorly understood due to the limited number of such projects conducted to date. Nevertheless, activities associated with decommissioning have the potential to impact marine life. This study is the first to focus on characterizing the underwater sound sources associated with the decommissioning of a 1.8m-diameter steel monopile and calculating their impact ranges on marine mammals.
Our research aimed to characterize the underwater sound generated during the 1.8m-diameter monopile removal operations, with a particular focus on the cutting activities. The decommissioning took place at Store Middelgrund, Denmark, in autumn 2024, over a period of two days. Two JASCO Multi-Channel Acoustic Recorders (AMARs), each equipped with two hydrophones were deployed for ~10 days to collect ambient data and ensure the full cutting process was recorded. The decommissioning of the foundation consisted of a dredging phase that lasted 2-3 days and then a cutting phase that lasted less than one day; both operations were monitored and characterized. Source levels were estimated at 164 dB re 1µPa2m2 for cutting and 177 dB re 1µPa2 m2 for dredging. Cutting noise level is comparable to the levels produced by medium-sized ferries. The main energy content for both activities was between 300Hz and 5kHz despite some differences in the overall spectral content. We will present the potential impact ranges on harbour porpoise of cutting and dredging using the National guidelines.

Our measurements enhance our understanding of underwater sound emissions associated with offshore wind farm decommissioning, and their impact on marine life. Our findings underscore the importance of integrating acoustic monitoring into decommissioning projects and will help inform environmental impact assessment of those projects.

TUESDAY 9TH SEPTEMBER – 17:00-18:00

QUANTIFYING FUTURE BIODIVERSITY IMPACTS OF RENEWABLES: ONSHORE WIND AND ITS FUTURE ROLE IN THE NORWEGIAN ELECTRICITY SYSTEM

Dr Jan Borgelt[1]*, Dr Dafna Gilad[2], Dr Roel May[2], Prof Francesca Verones[1]

[1] Norwegian University for Technology and Science (NTNU), [2] Norwegian Institute for Nature Research (NINA)

*Corresponding author.

Currently, onshore wind generates 9% of Norway's electricity production. Its contribution to the Norwegian electricity system is expected to grow in the coming decades by both onshore and offshore installations. While Norway aims to reduce its emissions and become a low-emission nation, the country remains committed to protecting its nature. We quantified habitat loss effects of future renewable energy production on species richness in Norway to address the trade-offs between climate and nature protection goals based on energy production projections for 2030, 2040, and 2050. Our results suggest that trade-offs between renewable energy growth and nature conservation can be mitigated by prioritising the construction of power plants with lower biodiversity impacts. However, the main driver for increasing pressure on biodiversity is the expected amount of generated electricity in the future, which dictates the scale of renewable energy expansion.

TUESDAY 9TH SEPTEMBER – 17:00-18:00

BAT MULTIFACTORIAL DYNAMIC VS. FIXED CURTAILMENT: MODELLING IMPACTS ON BAT ACTIVITY PRESERVATION AND PRODUCTION LOSSES IN FRENCH AND BELGIAN WIND FARMS

Dr Anne Beaudry[1]*, Mr Louis Ardilly[1], Dr Léa Etchart[1], Dr Mohammad Mohammadi[1], Ms Marie Rousseau[1], Mr William Maffre[1], Mr Luc Vuchot[1]
[1] *Sens Of Life*
*Corresponding author.

Fixed bat curtailment measures prescribed by authorities are typically based on predefined cumulative thresholds, including time periods, wind speeds, precipitation, and temperature limits. These measures aim to preserve roughly 90% of bat activity, following recommendations from environmental consultants or national studies. However, threshold-based curtailment fails to accommodate variations and sideline behavior (e.g, during migration) in bat activity, causing the 90% preservation target to not always be met and leading to unsustainable production losses due to its intrinsic limitations. Few studies have explored whether multifactorial dynamic curtailment exceeds these limits, balancing energy production and preserving bat activity.
The objective of our study is to compare fixed threshold-based curtailment with dynamic curtailment to assess their effectiveness in preserving bat activity while minimising energy losses and maintenance costs.
To this end, we developed a modelling tool to simulate preservation rates and energy losses under both fixed curtailment (as prescribed by authorities) and multifactorial dynamic curtailment (based on multifactorial risk curves and real-time bat activity) for operational wind farms in France and Belgium in 2024 (covering 15 turbines across multiple sites). Energy production is calculated using theoretical power curves from turbine manufacturers and wind data recorded by SCADA systems at one-minute intervals. All simulated stops then allow us then to estimate the associated production loss for both curtailment approaches. Preservation rates are calculated as the percentage of positive minutes covered by a stop, based on recorded activity from a bat detection system (TrackBat®) that combines a nacelle-mounted ultrasonic microphone and a Neural Network model for detection.

Preliminary results show significantly higher preservation and energy production rates for simulated multifactorial dynamic curtailment even under generic parameters compared to prescribed fixed thresholds. In addition, depending on site / periods activity profiles, tailored dynamic parameters (e.g., stop duration, overall risk thresholds, stop numbers) can enhance these results.
This study highlights the advantages of a combined multifactorial and dynamic approach, which effectively assesses bat activity levels across years, site-specific activity profiles, and seasonal patterns, including atypical activity. Such modelling tools and curtailment strategies could assist biodiversity managers in identifying and implementing optimal curtailment scenarios that align with authorities' recommendations while improving the financial and environmental sustainability of wind energy projects.
Future work may help to refine and customise factorial risk curves to provide regional tailored dynamic models around the world. In addition, a real-time species identification neural network model, currently under development, will allow species-specific dynamic parameterisation.

TUESDAY 9TH SEPTEMBER – 17:00-18:00

BIRD MIGRATION ALERTS: TOOLS, METHODOLOGY, AND POTENTIAL USES FOR MITIGATING THE IMPACTS OF WIND ENERGY ON AVIFAUNA

Dr Amédée Roy[1]*, Dr Thibault Désert[2], Dr Baptiste Schmid[3], Mr Vincent Delcourt[4], Dr Cécile Bon[5]
[1] France Energies Marines, Brest, [2] Météo-France, [3] Vogelwarte, [4] Biotope, [5] France Energies Marines
*Corresponding author.

Addressing the mitigation of bird collisions with wind turbines is a major challenge for both wildlife conservation and the energy industry. While many strategies have been proposed, few are consistently effective across all bird species. One potential solution could be to curtail wind turbine operation during strategic periods, such as migration peaks. However, this requires accurately predicting migration peaks and assessing the cost-benefit balance of such control strategies to reconcile biodiversity protection with wind energy production.
In this work, we gathered and processed data from 25 weather radars covering France. This allowed us to map migratory bird flows on a national scale over a decade and implement a bird migration forecast. This model relies on the intricate relationship between migratory bird flows and weather conditions to forecast migration fluxes several days in advance. We also simulated different wind farm control strategies and estimated the associated proportion of birds at risk and wind energy loss balance, based on existing collision models.
This study illustrates the relevance of operational bird migration forecasts to alert for nocturnal migration peaks and their potential uses for mitigating the impacts of wind energy infrastructure on migrating birds. We highlight that most nocturnal bird migration occurs during a few nights each year, generally associated with low to medium wind conditions. These results provide a better understanding of migration patterns, which could be crucial for informing wind farm control strategies.

TUESDAY 9TH SEPTEMBER – 17:00-18:00

CUMULATIVE IMPACT OF WIND ENERGY ON RED KITE POPULATION IN WALLONIA

Mr Arnaud Beckers[1]*, Mr Arnaud Vansteenkiste[2], Mr Stef Van Rijn[3], Mr Nicolas Magain[2]
[1] CSD ingénieurs, [2] Evolution and Conservation Biology, InBioS Research Center, University of Liège, Belgium, [3] Deltamilieu Projecten, Edisonweg 53/D, 4382NV Vlissingen, the Netherlands
*Corresponding author.

The impact of wind energy on European raptor populations is a matter of concern considering the high number of carcasses found under wind turbines (WT). We studied the impact of existing and planned wind turbines in Wallonia (south Belgium) on the European-endemic red kite (~550 breeding pairs, 234 WT in operation in the Walloon range of the species). Fatality rates have been measured in the Eastern part of the region where red kite density is the highest, and where carcasses have been reported in the past under wind turbines. Systematic carcass searches have been conducted around 10 turbines in 2018 (940 searches) and 2023 (60 searches). We used UAV and human-based parallel transects to look for carcasses. Mean searcher efficiency was measured with raptor-shaped lures and carcasses persistency duration with dead raptors. We found a total of 3 red kite carcasses, giving a corrected average fatality rate of 0.20 individual per WT per year in 2018 and 0.37 individual per WT per year in 2023. Considering the highest rate, we obtained an estimate of 20 red kites killed by wind turbines each year in Wallonia, which represents 1.1 % of the population. A population viability analysis was carried out using EolPop software for the period 2024-2054. Six scenarios for growth in the number of WT (596 to 1,108 WT) were combined with four demographic scenarios for the red kite population growth rate (3.7-6.8%) and carrying capacity (615-3,340 pairs). None of the 6 wind energy development scenarios studied resulted in a decline in the red kite population in Wallonia, even in the scenarios where mortality per wind turbine was conservatively increased by 50%. However, results suggest that the population in 2054 could be 8% to 20% lower than in a scenario in which the same number of WT were installed as at present. These projections are only valid if growth rates continue to follow the same trajectory and new mortality factors are not added. In conclusion, wind energy has an impact on the red kite population in Wallonia, but does not threaten its positive evolution in the medium term.

TUESDAY 9TH SEPTEMBER – 17:00-18:00

THE THIRD RENEWABLE ENERGY DIRECTIVE: FINDING A BALANCE BETWEEN ACCELERATED RENEWABLE ENERGY DEVELOPMENT AND NATURE PROTECTION

Dr Anne Lansink[1]*
[1] *Utrecht University*
*Corresponding author.

The EU recently adopted the third Renewable Energy Directive (REDIII), which aims to accelerate the energy transition by simplifying and streamlining environmental-related aspects of permit-granting procedures. This paper explores how this directive affects the balance between offshore wind energy and biodiversity protection. The discussion begins by describing the key changes to the legal regime that are relevant to offshore wind energy: the introduction of Renewables Acceleration Areas (RAAs); the introduction of infrastructure areas; the amended species protection regime outside these areas; and the overriding public interest presumption. The focus then shifts to how these changes affect the relationship between renewable energy development and nature protection, and the extent to which environmental safeguards still exist. It will be argued that whilst the EU seems to elevate the energy transition over biodiversity protection with the adoption of REDIII, the system is not rendered void of environmental safeguards. Three factors are, however, crucial in rendering these safeguards effective in practice: relevant actors, such as competent national authorities and the Court of Justice of the European Union, should engage in active data collection and adaptive management; respect absolute stopping points laid down in EU nature protection law to avoid the crossing of ecological boundaries; and conduct the remaining environmental assessments in a strict manner. Such an approach would not only serve to benefit nature as an independent entity, but also reduce the risk of overstepping ecological and legal boundaries that could lead to societal lock-ins similar to the ones caused by the nitrogen crisis and to forced interference with existing users of the sea. It is therefore argued that it would be also in the interest of Member States themselves to take nature protection seriously in future energy development.

TUESDAY 9TH SEPTEMBER – 17:00-18:00

THE EFFECTIVENESS OF EXISTING SOLUTIONS TO MITIGATE IMPACTS OF ONSHORE WIND FARMS ON FLYING VERTEBRATES AND INVERTEBRATES: A RAPID REVIEW

Dr Aurélie Quinard[1]*

[1] *Fondation pour la Recherche sur la Biodiversité*

*Corresponding author.

The urgent need for climate action has led to a rapid expansion of renewable energy sources, including onshore wind energy, which may play an essential role in reducing greenhouse gas emissions. However, the development of wind energy projects raises significant concerns regarding their impact on biodiversity, particularly flying wildlife such as birds, bats, and insects. This study, conducted by the Foundation for Biodiversity Research (FRB) in partnership with Mirova, aims to evaluate the effectiveness of mitigation measures designed to minimize impacts on terrestrial flying fauna while supporting sustainable energy transitions.

A Rapid Review (RR) of the scientific and technical literature was conducted, following guidelines from the Collaboration for Environmental Evidence. After systematically screening the literature, a total of 60 studies, primarily from North America (approximately 70%) and Europe (over 25%), were retained based on rigorous criteria. Data were analyzed qualitatively and quantitatively using narrative and meta-analytical approaches to assess the reliability and effectiveness of existing mitigation strategies.

Findings, based on final analyses, reveal that bats and birds are the most studied taxa, with measures such as acoustic deterrence, cut-in speed adjustment, and turbine painting showing varying degrees of effectiveness at reducing mortality. For instance, increasing turbine cut-in speeds resulted in an average reduction of bat mortality by 66.8%. However, studies on reducing insect mortality remain scarce, highlighting a critical research gap. Most studies focus on direct mortality, with fewer addressing broader ecological consequences or long-term population effects. Additionally, a significant underrepresentation of some regions, such as Asia, Africa, and South America was confirmed.

This review confirms the relevance of raising cut-in speed to mitigate the negative impacts on bats while emphasizing the necessity of combining multiple mitigation measures adapted to local contexts to achieve meaningful biodiversity conservation outcomes. Recommendations are provided for stakeholders, including operators, policymakers, and researchers, to harmonize wind energy development with biodiversity preservation. Collaborative efforts and innovation in technologies are essential for minimizing biodiversity impacts. Further research is urgently needed, particularly in underrepresented regions and taxa, to address gaps and refine existing strategies. By integrating these insights into planning and operations, it is possible to balance the goals of energy transition and biodiversity conservation.

TUESDAY 9TH SEPTEMBER – 17:00-18:00

OCCAM: A TOOL FOR RAPIDLY ASSESSING IMPACTS OF OFFSHORE WIND FARMS TO SEABIRDS

Dr Gillian Vallejo[1]*, Dr James Robbins[1], Dr Emily Nelson[2], Mr Graeme Cook[1], Mr Jonathan Abbatt[2]
[1] Natural Power, [2] SSE Renewables
*Corresponding author.

Offshore wind energy generation has a key role to play in reducing our reliance on fossil fuels and mitigating climate change. However, it also has the potential to negatively impact upon the environment, including seabird populations. Quantifying and minimising likely impacts of proposed wind energy projects on seabirds is necessary for ensuring compliance with environmental legislation and safeguarding seabird populations. However, assessment processes can be time-consuming and complex, and the timescales involved limit the extent to which seabird impacts can be incorporated into early stages of project design, or consultation discussions. There is therefore value in a simple and accessible framework which can be applied to rapidly generate indicative impact estimates.

OCcAM is a simple, user-friendly and transparent industry-developed tool allowing rapid assessment of broad-scale impacts on seabirds from offshore wind developments. Mortality rates of five seabird species are estimated using two UK industry standard models: the Band collision risk model (Band, 2012), for predicting mortalities from collision with turbine blades, and the matrix-based displacement approach (SNCBs, 2022), for predicting mortalities associated with displacement from wind farm footprints. Resulting predictions may also be expressed as a percentage of a focal population.

The tool facilitates comparison of up to three different parameter sets which can represent three realisations of the same scenario e.g. three different potential wind farm configurations, or to generate a single mortality estimate based on sub-strata e.g. wind farms in areas of high, medium and low bird density.

OCcAM presents a variety of opportunities to facilitate consenting, from site feasibility through to condition discharge via rapid scoping of changes to wind farm configurations and assessment parameters. Examples include scoping of potential impacts during project optioneering, comparison of predicted impacts from consented versus as-built designs, and exploration of changing seabird input parameters as new evidence or guidance emerges. The tool allows transparent and auditable analyses to be run quickly and easily with no requirement for specific technical expertise, making it accessible to all stakeholders involved in the development, planning and consenting of offshore wind energy projects.

TUESDAY 9TH SEPTEMBER – 17:00-18:00

TIMING IS EVERYTHING: IDENTIFYING PEAK BIRD MIGRATION PERIODS FOR WIND TURBINE CURTAILMENT IN THE NORTH SEA

Mr Øyvind Nyheim[1]*, Mr Bart Hoekstra[2], Prof Judy Shamoun-Baranes[2], Dr Diego Pavón-Jordán[1], Dr Roel May[3]

[1] Norwegian Institute for Nature Research, [2] Institute for Biodiversity and Ecosystem Dynamics, University of Amsterdam, [3] NINA

*Corresponding author.

The North Sea is an important bird migration corridor as well as a hotspot for offshore wind farm developments, raising concerns about bird collisions with turbines. Wind turbine curtailment (WTC) during peak migration could be an effective way to reduce collision risk for migratory birds, since migration fluxes are often highly concentrated early in the night over just a few days each season. However, assessing WTC feasibility requires a clear understanding of how concentrated the migration season is and when the peaks in migration intensity occur.

In this study, we analyzed the phenology of nocturnal bird migration in southern Norway, identifying peak migration periods for birds expected to arrive from or cross the North Sea. We extracted bird migration intensities from three coastal weather radars in Southern Norway at 10-minute intervals from 2020-2024. We calculated the number of days required to capture different proportions of the total migration in spring and autumn, when 1) selecting peak nights ranked by migration intensity and 2) identifying the shortest continuous migration period using a sliding window method. Additionally, we examined within-night peak migration timing and combined seasonal and nightly peak periods to estimate the shortest time frames containing key migration thresholds.

The shortest time window encompassing 50% of migration occurred between 27 March and 27 April in spring and between September 17 and October 21 in autumn. Ranking nights by intensity by comparison captured 50% of migration in half as many nights in autumn and 2/3 as many in spring. Migration was strongest 1-4.5 hours after sunset. When combining both seasonal and nightly peak windows, 20% and 27% of all bird migration took place within just 100 hours (2.7% of the total season duration) in spring and autumn respectively—specifically, from 75–265 minutes after sunset between March 27 and April 27 in spring, and from 65–295 minutes after sunset between September 27 and October 21 in autumn.

Our findings highlight how migration is concentrated to a few migration nights and in relatively narrow seasonal and nightly windows. Simple pre-defined seasonal and within-night peak migration time windows provide a good starting point for wind turbine curtailment, but a considerably greater proportion of migration can be captured in the same time by targeting only peak migration nights. Thus, developing reliable peak migration forecast models would further improve the cost-effectiveness of WTC.

TUESDAY 9TH SEPTEMBER – 17:00-18:00

MONITORING POTENTIAL IMPACTS OF FLOATING OFFSHORE WIND TURBINE ON BENTHIC AND PELAGIC COMMUNITIES

Ms Marine Reynaud[1], Dr Olivier Herlory[1], Mr Thomas Soulard[1]*, Dr Antoine Carlier[2], Ms Mavea Gonzalez[2], Dr Nicolas Desroy[3], Dr Mathieu Doray[4], Dr Jean-Baptiste Romagnan[4], Ms Magali Mouries[5]
[1] Fondation OPEN-C, [2] Ifremer, DYNECO-LEBCO, Centre de Bretagne, [3] Ifremer, COAST station de Dinard, [4] Ifremer, DECOD, [5] BW IDEOL
*Corresponding author.

Wind energy production is recognized as one of the most efficient and cost-effective options for mitigating climate change in the short term. Emerging technologies, such as floating offshore wind turbines (FOWTs), are striving to enhance cost effectiveness to support European and French offshore wind development ambitions.
While the development of offshore renewable technologies is expected to align with sustainability goals, eco-design has yet to become a standard practice. The VELELLA project (2023-2027, funded by the French State as part of France 2030 operated by ADEME) aims to qualify multiple technologies, each of which is guided by an eco-design approach, from life cycle analysis to recyclability including their environmental impacts.
In particular, innovations related to the floating foundation and mooring structures address the challenges associated with the biological attractivity of the FLOATGEN (© BW IDEOL) FOWT prototype, installed at SEM-REV test-site since April 2018. Within VELELLA project, the authors designed and performed a specific program focused on the benthic and pelagic communities. These compartments are poorly considered in the scientific literature dealing with floating technologies.
This presentation highlights the specifications and preliminary results of the tailored monitoring program designed to assess the relationships between the biofouling on FLOATGEN and the soft-bottom benthic communities beneath it, in terms of:

- Induced changes to the nature of the seabed habitat;Potential enrichment of sediment in organic matter;
- Impacts on the ecological trajectories of benthic communities.

A new monitoring scheme have been developed to assess the potential impact of floating windfarm on pelagic communities (zooplankton, micronekton and small pelagic fishes). The potential fish-aggregating device effect of wind turbine on small pelagic fish has been specifically assessed. The monitoring program combines ship-based surveys around the FOWT and a real-time observatory on FLOATGEN, equipped with echo sounders and environmental sensors. Ship-based surveys provide a global description of the pelagic ecosystem around the FOWT as well as ground truthing data through echo sounder measurements, fishing for macro and micronekton and zooplankton, and eDNA testing.
This initial feedback from a scale one prototype such as FLOATGEN offers insights into the potential changes in ecosystem functioning and trophic relationships at the scale of commercial floating offshore wind farms and provides guidance to monitor these effects.

TUESDAY 9TH SEPTEMBER – 17:00-18:00

FRAMEWORK FOR EVALUATING SEABIRD SPECIES FOR MITIGATION OF OFFSHORE WIND ENERGY DEVELOPMENT IMPACTS IN THE CALIFORNIA CURRENT ECOSYSTEM

Mx Aspen Ellis[1]*, Mx Emma Kelsey[2], Mx Jeffery Leirness[3], Dr Max Czapanskiy[4], Dr Josh Adams[2], Dr Lisa Ballance[5], Dr Aonghais Cook[6], Dr Nick Holmes[7], Mx Brad Keitt[8], Dr Donald Lyons[5], Mx Cotton Rockwood[5], Dr Scott Shaffer[9], Dr Robert Suryan[10], Mx Kelly Zilliacus[1], Dr Donald Croll[1]

[1] University of California, Santa Cruz, [2] United States Geological Survey, [3] CSS Inc, [4] University of California, Santa Barbara, [5] Oregon State University, [6] The Biodiversity Consultancy, [7] The Nature Conservancy, [8] American Bird Conservancy, [9] San Jose State University, [10] National Oceanic and Atmospheric Administration

*Corresponding author.

Offshore wind energy development is a large component of global renewable energy strategies, and is rapidly expanding worldwide. However, if not implemented carefully, offshore wind energy development may also pose immediate threats to marine birds, which may be impacted by collision with facilities or displacement from existing foraging habitat and migratory routes. To produce offshore wind energy responsibly, managers seek effective mitigation of these impacts to achieve no net loss or net positive impacts of offshore wind energy development to seabird populations following an avoid, minimize, and compensate mitigation hierarchy. Compensatory mitigation (funding conservation actions to alternate threats to offset the impacts of development) can be used to offset residual impacts of offshore wind energy development to particular species protected by some policies (e.g., the Endangered Species Act in the United States), however, there is not yet a structure to strategize impact offsets for the broad portfolios of species that are likely to be impacted by offshore wind energy. To inform strategic offsetting and identify priority species, we developed a framework to evaluate and rank marine bird species based on their vulnerability to offshore wind energy impacts. Our approach integrates spatial exposure to installations, sensitivity to collision and/or displacement, and IUCN population status to identify species vulnerable to offshore wind energy development at a regional level. Using existing species distribution models and vulnerability indices, we then apply this framework as a case study to 73 marine bird species commonly found in the Pacific Outer Continental Shelf region to inform seabird mitigation and address data limitations that can be applied to planned wind energy developments in California and Oregon.

TUESDAY 9TH SEPTEMBER – 17:00-18:00

BEHAVIOURAL RESPONSES OF CRUSTACEA TO ENVIRONMENTALLY RELEVANT ELECTROMAGNETIC FIELD (EMFS) FROM SUBMARINE POWER CABLES FOCUSING ON GENDER SPECIFIC IMPACT

Ms Elizabeth James[1]*
[1] *University of Portsmouth*
*Corresponding author.

The rapid expansion of offshore wind and other marine renewable energy devices (MREDs) is introducing strong anthropogenic electromagnetic fields (EMFs) via submarine power cables (SPCs). SPC-generated EMFs can exceed 8000 µT, well above the natural geomagnetic field, and may affect benthic animal behaviour. In decapod crustaceans, sex-specific habitat uses and seasonal migrations are well documented, particularly during reproduction, yet no studies have tested whether these entrenched biologically differences modulate EMF sensitivity.

Juvenile shore crabs (Carcinus maenas; n = 120; 1:1 sex ratio) to EMFs of 500, 1000 and 3200 µT using a Helmholtz coil system and tracked behavioural responses over 10-minute trials, including space use, locomotor activity, and zone transitions to detect attraction or avoidance relative to the EMF-exposed zone. Zone-specific analysis showed that females exhibited strong and consistent attraction across all EMF levels, spending up to 87-131% more time in the EMF exposed (COIL) zone and 42-48% less time in the low-field zone farthest from the coils (FAR zone), with these effects remaining significant after both Bonferroni and False Discovery Rate (FDR) corrections. Overall distance moved and mobility also differed significantly, peaking at 500 µT, but without sex-specific significance. In contrast, males showed no consistent spatial preference and exhibited indifferent activity in the highest field strength.

These sex-specific responses suggest that EMFs could interfere with key reproductive behaviours such as seasonal migrations or larval release. Breeding season movement in decapods is strongly sex-biased, with females undertaking long range migrations for mating and larval release, while males remain comparatively resident. Given this, female biased attraction to EMF could concertedly lead to disorientation, aggregation, or delays in migration; potentially disrupting reproductive timing, skewing operational sex ratios, and reducing larval export. SPCs may therefore act as partial behavioural barriers along female migration corridors.

This study provides the first evidence of sex-specific behavioural response to SPC EMFs in a non-commercial decapod species, underscoring the need to treat sex as a critical biological variable in ecological risk assessment. As offshore infrastructure expands, incorporating species-specific behavioural data into impact assessments will improve our ability to predict and manage ecological impacts, especially for species with complex life cycles and seasonally important movements.

TUESDAY 9TH SEPTEMBER – 17:00-18:00

THE HIGH VALUE OF LONG-TERM DATA: CPOD DATA INDICATE A STABLE POPULATION OF HARBOUR PORPOISES IN THE GERMAN BIGHT, NORTH SEA

Mr Ansgar Diederichs[1]*, Ms Julika Voß[1], Dr Armin Rose[1], Ms Veronika Wahl[2], Ms Melissa Moick[3], Mr Alexander Schubert[1], Ms Marika Schultz[2], Ms Anika Freund[3], Dr Alexander Braasch[3]
[1] BioConsult SH, [2] IBL Umweltplanung GmbH, [3] IBL Umweltplanung
*Corresponding author.

The increasing number of offshore wind farms (OWFs) in the German Bight, North Sea, has raised concerns about their long-term impact on the highly mobile harbour porpoise. This study analysed long-term trends in porpoise detection rates by using a Bayesian framework on passive acoustic monitoring data from 2011 to 2019, with some data extending to 2023 for specific subareas. Regarding overall trends, no overall significant trend in porpoise detection rates was observed on a yearly basis across the entire German Bight. Seasonally, positive trends or tendencies were noted in winter and spring, while summer and autumn remained stable. Trends, however, varied across five subareas. Negative trends or tendencies appeared in the Northwest (overall and winter) and Northeast (summer) of the German Bight, while a positive development was observed in the North (overall, spring and winter) and Southeast (overall, spring, summer and winter). The situation in the South remained largely unchanged. These findings suggest a partial shift in porpoise distribution within the German Bight. The North and Southeast subareas may have become more favourable, potentially due to food availability, particularly sandeels (Ammodytidae), a key prey species. This aligns with broader observations of a southward shift in harbour porpoise distribution across the North Sea over the past three decades.

TUESDAY 9TH SEPTEMBER – 17:00-18:00

BIODIVERSITY LCA FRAMEWORKS FOR OFFSHORE WIND PROJECTS

Ms Minja Mihajlovic[1]*, Ms Yuki Esser[1], Dr Benjamin Lehner[1]
[1] *Dutch Marine Energy Centre*
*Corresponding author.

Research Motivations and Objectives
This study evaluates five Biodiversity Life Cycle Assessment frameworks highlighted in the new draft tender for offshore wind in the Netherlands—ReCiPe2016, IMPACT World+, LCIMPACT, Product Biodiversity Footprint (PBF), and Biodiversity Impact Assessment (BIA+). While some are already widely used in environmental impact assessments, their suitability for offshore renewable energy projects remains underexplored. Given the complexity of biodiversity impacts in marine environments, a robust Biodiversity Life Cycle Assessment (BLCA) approach is necessary to capture both broad environmental stressors and marine-specific ecological effects. The objective is to assess the applicability of these frameworks in evaluating biodiversity impacts specific to offshore renewable energy infrastructure.
Methodology
The study builds upon existing comparative analyses, which indicate that commonly used frameworks—ReCiPe2016, IMPACT World+, and LCIMPACT—vary in their ability to assess and fail to fully capture biodiversity impact. The scope is extended by considering two other frameworks recommended in the tender, PBF and BIA+ and additionally analysing the framework's applicability to offshore renewable energy projects. Each framework was assessed based on its efficiency in measuring biodiversity impact, scope of environmental effects covered, spatial and temporal resolution, data requirements, methodological transparency, and applicability to marine environments. Each framework was scored on a scale from 1 (limited capability) to 5 (exceptional capability).
Summary of Results
ReCiPe2016 provides a well-established structure with a clear methodology but lacks regional specificity, limiting its precision for offshore assessments. LCIMPACT offers strong spatial differentiation, making it valuable for offshore installations, but lacks dedicated marine biodiversity metrics. PBF and BIA+ focus primarily on biodiversity assessment, making them particularly relevant for evaluating ecological impacts of offshore infrastructure but unlike ReCiPe2016, IMPACT World+, and LCIMPACT, which benefit from integration with the standard LCA tools continuously updated and refined by an active research community, they are not as easily applied. Overall IMPACT World+ emerges as the highest ranked framework according to set criteria due to its ability to assess regional impacts, differentiate between short- and long-term environmental damages, and include some marine acidification effects, but it could still benefit from additional biodiversity metrics.
Conclusion
For holistic assessment of offshore renewable energy projects, a combined approach would be recommended, for instance integrating the spatial and regional advantages of IMPACT World+ with the biodiversity focus of PBF or BIA+. This synthesis would enable a robust evaluation of offshore energy infrastructure, balancing environmental sustainability with biodiversity conservation.

TUESDAY 9TH SEPTEMBER – 17:00-18:00

BIODIVERSITY OF FISH ASSEMBLAGES AROUND OWF INFRASTRUCTURE 17 YEARS AFTER DEPLOYMENT IN THE SWEDISH WIND FARM LILLGRUND

Ms Johanna Bergman[1], Mr Andreas Wikström[1], Dr Mattias Sköld[1], Ms Johanna Hogvall[1], Dr Charlotte Berkstrom[1], Dr Birgit Koehler[1], Dr Lena Bergström[1]*

[1] *Swedish University of Agricultural Sciences*

*Corresponding author.

Observations of reef effects around offshore wind farms (OWFs) are increasing, showing that OWF underwater structures may benefit species across various taxa, including fish, crustaceans, and mammals. Benefits, such as shelter and food close to the infrastructure often outweigh potential deterring factors during OWF operation. However, questions remain regarding the extent to which these findings are transferable across different types of ecosystems, as well as how the reef effect appears in infrastructure that has been in place for some time. The effects on biodiversity are particularly important to monitor in areas with poor environmental status, threatened species, declining populations, or a high risk for the establishment of non-indigenous species. Here, we used baited remote underwater video systems (BRUV) to study the attraction and accumulation of fish at the Lillgrund OWF in the Sound located between the Baltic Sea and North Sea and subject to several environmental pressures. The OWF, established in 2007, provides a unique opportunity to study fish assemblages around the gravity-based foundations and scour protections 17 years after deployment. Results showed higher presence of several reef-associated species near the structures, such as gobies and labrids. This also included higher abundances of the non-indigenous round goby, which was recently established in the Sound. In the seabed between turbines, dominated by soft substrates, eelgrass, or algae, flatfishes were observed to a similar extent as in two reference sites with similar characteristics. The BRUVs demonstrated their value as a non-destructive and replicable method for quantitative observations of various fish taxa. As the approach is suitable for wind farms as well as sensitive habitats like marine protected areas, it is useful for comparative studies across habitats of different levels of protection and human influence.

TUESDAY 9TH SEPTEMBER – 17:00-18:00

HARMONISING OFFSHORE WIND AND MARINE CONSERVATION: LESSONS FROM INDICATOR SPECIES AND INTERNATIONAL NOISE REGULATIONS

Ms Ally Russell[1]*
[1] *ERM Ltd*
*Corresponding author.

- Research motivations and objectives:

The rapid expansion of offshore wind farms (OWFs) has raised concerns about their cumulative impact on marine mammal species, particularly through underwater noise generated by piling, vessel traffic, and operational activities. While many countries adopt similar guidelines, variations in protection and mitigation measures create regulatory inconsistencies. Additionally, many species in new OWFs development areas remain understudied regarding their responses to increased underwater noise. This research explores how indicator species, could help to standardise impact assessments across jurisdictions. The study also examines the challenges posed by transboundary marine mammal populations and the need for harmonised conservation policies.

- Methodology:

This work uses a comparative approach to assess how key marine mammal species, such as the harbour porpoise (Phocoena phocoena) and minke whale (Balaenoptera acutorostrata), can serve as indicator species for assessing noise impacts in OWF developments. Case studies from different regions, including a piling project in South Korea and European offshore wind farms, are analysed to identify cross-species comparisons and regulatory differences. Additionally, noise mitigation policies—such as Germany's strict noise limits during piling—are reviewed to evaluate best practices for international policy harmonisation.

- Summary of results:

Preliminary findings indicate that species from different regions exhibit comparable responses to underwater noise, supporting the use of indicator species for impact assessments in areas where data on local species are limited. For example, comparisons between finless porpoises and harbour porpoises, as well as Indo-Pacific and common bottlenose dolphins, suggest that species with similar hearing sensitivities may experience analogous impacts. Furthermore, transboundary populations, such as the North Sea harbour porpoise management unit, highlight the need for coordinated international conservation measures.

- Conclusion:

The study underscores the importance of international collaboration in OWFs, particularly in regions with overlapping marine mammal populations and differing regulatory frameworks. Standardised data collection, the use of indicator species, and best-practice noise mitigation strategies will be essential for emerging OWF markets, such as those in the Mediterranean. Establishing consistent conservation policies will help balance renewable energy expansion with the protection of sensitive marine species.

TUESDAY 9TH SEPTEMBER – 17:00-18:00

CONCURRENT TRACKING OF MULTIPLE SEABIRD SPECIES TO INFORM OFFSHORE WIND ENERGY DEVELOPMENT IN THE NEW YORK BIGHT (USA)

Dr Juliet Lamb[1]*, Dr Peter W.c. Paton[2], Mr Carl Lobue[1]
[1] The Nature Conservancy, [2] University of Rhode Island
*Corresponding author.

The mid-Atlantic coast of the United States is the site of the first operational offshore wind energy installations in North America, with plans to deploy up to 16 gigawatts of capacity in the coming years. At the same time, relatively little is known about the habitat use and offshore movements of coastal and marine birds in the region. Despite the availability of monitoring data on many shared species present at wind farms in Europe, differences in species composition and phenology limit the transferability of existing data, creatine a need for targeted study in the mid-Atlantic to inform siting, monitoring, and mitigation plans. From 2023-2025, we tracked six sensitive and/or data deficient seabird species representing a range of foraging strategies and habitat needs, including three species breeding in the region (Great black-backed gull, Common tern, Roseate tern) and three species present only during their non-breeding periods (Northern gannet, Great shearwater, Cory's shearwater). We then derived activity budgets from tracking data and compared environmental drivers of habitat use and behavior both within and outside offshore wind energy areas along the mid-Atlantic coastline. Activity budgets and use of wind energy areas varied among individuals, seasons, and species. Foraging behavior was generally concentrated outside current and planned wind energy areas with the notable exception of Great black-backed gulls, which showed disproportionate foraging activity in and around an under-construction wind energy installation during the 2024 breeding season. Wind energy areas were more frequently used during commuting flight, with birds passing through wind energy areas and leases both within and between seasons. We identified several multi-species movement corridors through wind energy areas that could represent useful targets for monitoring and curtailment during high-use periods. Finally, nearshore species such as gulls, gannets, and terns often targeted high-productivity areas with salinity gradients such as estuaries and river outflows for foraging, suggesting that onshore activities such as dam removal and marsh restoration could potentially improve foraging habitat for coastal marine birds as part of mitigation portfolios.

TUESDAY 9TH SEPTEMBER – 17:00-18:00

VERTICAL HABITAT USE OF GREAT BLACK-BACKED GULLS IN OFFSHORE HABITATS AND IMPLICATIONS FOR COLLISION RISK IN THE NORTHEAST US

Ms Esther Nosazeogie[1]*, Dr Ian Jonsen[2], Dr Kim Lato[3], Mx Julia Gulka[3], Dr Evan Adams[3], Dr Kate Williams[3], Dr Lesley Thorne[4]

[1] School of Marine and Atmospheric Sciences at Stony Brook University, [2] StochasticQC, WolfvilleDartmouth, Nova Scotia B4P2W 2L74C8, [3] Biodiversity Research Institute, [4] Stony Brook University

*Corresponding author.

Vertical habitat use and flight height are important considerations for understanding seabird ecology and their potential to interact with offshore wind energy development (OWD). In particular, understanding the flight height of seabirds in relation to the rotor-swept zone of offshore wind turbines is key to assessing collision risk for sensitive species, particularly in light of rapidly advancing OWD in the northeast US. Great black-backed gull (GBBG; Larus marinus) is considered a sensitive species to OWD due to its observed flight height (which may overlap with the rotor-swept zone) from boat-based surveys. Tagging devices are widely used to overcome the observer and weather limitations associated with estimating flight height from boat-based surveys. However, flight height is difficult to estimate from many seabird tagging devices due to measurement bias. Flight height varies through space and time as seabirds adjust their behavior to environmental conditions to reduce the energetic costs of movement. Our objectives were to (i) use state space models (SSMs) to estimate flight heights from noisy GPS tag data; and (ii) determine how environmental covariates influence the probability of occurring within a given band of altitudes that correspond with the rotor-swept zone. We deployed solar-powered OrniTrack GPS-GSM tags on 68 GBBG individuals in the northeast US using cross-wing harnesses over four years (2021-2024). SSMs provided robust estimates of flight height and considerably reduced the signal-to-noise ratio in the flight height data. Additionally, we found that the removal of stationary points, which have higher measurement bias, reduced the amount of spurious negative values present in the flight height distribution and led to more reasonable estimates. Based on these estimates, we quantified vertical habitat use, and the time spent at the altitudes of the rotor-swept zone. We used generalized linear mixed models to examine temporal patterns in flight height, and how these patterns may be associated with weather. Preliminary results show that GBBG typically flew at altitudes of less than 50m, overlapping with the rotor-swept zone only 11% of the time. However, most individuals (87%) spent some amount of time at flight heights within the rotor-swept zone. The probability of flying within the rotor-swept zone generally decreased as birds moved further offshore, with higher wind speeds, and during headwinds, and increased with higher air temperatures. We conclude that variability in flight patterns associated with weather should be considered in collision risk assessments to account for more of the inherent variability in flight height.

TUESDAY 9TH SEPTEMBER – 17:00-18:00

AN EXPERIMENTAL EVALUATION OF AIRBORNE IMAGERY AND LIDAR FOR SEABIRD FLIGHT HEIGHT DETERMINATION – INITIAL RESULTS FROM THE OWEC RESCUE PROJECT

Dr Philipp Boersch-Supan[1]*, Dr Jazz Rhoades[1], Mr Eddie Cole[2], Dr Andrew Harwood[2]
[1] British Trust for Ornithology, [2] Natural England
*Corresponding author.

The Reducing Seabirds Collisions Using Evidence (ReSCUE) project - funded by the UK's Crown Estate OWEC programme - aims to enhance understanding of seabird flight heights and collision risks with offshore wind turbines to ultimately reduce consenting risk and inform effective mitigation for nature-friendly offshore wind expansion.
To investigate sources of uncertainty associated with the use of LiDAR coupled with airborne imagery to estimate flight heights of seabirds we commissioned a series of aerial surveys – co-designed with stakeholders from industry and regulators - to capture concurrent digital still imagery and LiDAR measurements, in both onshore and offshore settings, using two different commercial survey providers. The onshore survey employed an experimental approach with a fixed array of 130 artificial seabird silhouettes of varying size, colour, and height, as well as multiple moving drones. The offshore surveys recorded free flying seabirds in the North Sea as well as information on instantaneous sea surface heights and atmospheric noise in the LiDAR point cloud.
Both surveys were performed at a range of aircraft altitudes between 300m and 860m. Targets were identified in imagery and LiDAR point clouds to yield target counts and flight height estimates using both image-based and LiDAR measurements. Flight speeds of targets could be derived for a limited subset of LiDAR data.
In the onshore experiment detection rates of targets were influenced by aircraft altitude, target size and target colour, with detection rates below 20% for small dark targets, particularly in imagery. Atmospheric noise contributed to target identification challenges near the ground and sea surface. Flight height estimates from LiDAR were precise and accurate, but size-based estimates were associated with significant uncertainties.
Our results provide important reference data to inform both abundance and flight height estimates collected from aerial survey technologies. In particular we demonstrate that imperfect detection is an important consideration for smaller-bodied and dark-plumaged seabird species, and that size-based flight height estimates are of insufficient precision to inform collision risk at the scale of typical turbine air-gaps.

TUESDAY 9TH SEPTEMBER – 17:00-18:00

RAPID BUILD-OUT OF DECARBONIZED ENERGY MAY REDUCE GLOBAL EXTINCTION RATES

Dr Paul Rabie[1]*, Dr John Lloyd[1], Dr Taber Allison[2], Dr Everett Abhainn[1], Dr Angela Hsiung[1]
[1] Western EcoSystems Technology, Inc. (WEST), [2] Renewable Energy Wildlife Institute
*Corresponding author.

Decarbonizing electricity production underpins every Intergovernmental Panel on Climate Change mitigation scenario in which humanity avoids catastrophic levels of global warming. How the pace and scale of the energy transition will shape biodiversity outcomes, however, remains to be described quantitatively. To help answer this question, we predicted global extinction rates of terrestrial plants and animals as a function of the rate at which decarbonized energy sources including wind and solar replace fossil fuels as a source of electricity. Using three estimates of the relationship between surface temperature increases and extinction risk for terrestrial plants and animals, carbon emissions data from the literature, and predictions of energy demand, we show that delaying the transition away from carbon-intensive energy sources increased the number of species committed to extinction by 2100. Slowly replacing fossil fuels such that low-carbon energy sources did not come to dominate electricity generation until late in the 21st century yielded extinction rates only modestly lower than approaches in which fossil fuels remained a large part of the energy mix. In contrast, a rapid energy transition with a rapid phase-down of fossil fuels yielded much lower predicted extinction rates that were not substantially different from a counterfactual scenario in which all fossil-fuel-generated electricity was instantaneously eliminated. Our work shows that policies slowing the capacity growth of decarbonized energy will increase the number of species driven to extinction by human-caused climate change. There is still a need to minimize direct impacts to local populations, but it will be difficult to balance negative local impacts of renewable energy against global climate risk mitigation until we develop a common currency that can simultaneously evaluate both.

TUESDAY 9TH SEPTEMBER – 17:00-18:00

INVESTIGATING THE INFLUENCE OF ONSHORE WIND FARMS ON RED KITE MOVEMENT ECOLOGY IN SCOTLAND: A MULTI-SCALE ANALYSIS

Ms Anna Costley-Wood[1]*, Prof Colin Galbraith[2], Prof Kirsty Park[1], Dr Brad Duthie[1], Dr Ian Hulbert[3]
[1] University of Stirling, [2] NatureScot, [3] Skorpa
*Corresponding author.

With the global transition towards a decarbonised energy sector, renewable developments are rapidly increasing. In the UK, one prominent player in this switch is onshore wind farms. However, this expansion poses challenges to upland areas such as Northern Scotland, which are highly ecologically sensitive. The Red Kite, a soaring raptor reintroduced only in recent decades after near-extinction in the UK, will be impacted by this increase in development, especially northernmost populations already sensitive due to illegal persecution. Slow to mature and reproduce, minor changes in mortality rates can impact population growth dramatically. Whilst habitat crossover means these populations regularly encounter wind farms, these interactions are not well understood, especially at multiple spatial scales. This study integrates meso-scale observation data with macro-scale GPS data to provide a holistic view of how the movement ecology of this species is influenced by these developments, as well as how this compares to the Common Buzzard.

At the fine scale, seven years of vantage point observations of both Red Kites and Buzzards from a 20-turbine farm south of Inverness were analysed using novel methods to assess landscape use and turbine avoidance behaviour. Flight density correlation between pre- and post-farm construction shows significant land use change by the raptors in favour of turbine proximity after development. Preliminary results from structural equation modelling reveal the influences of landscape, temporal, and turbine-related variables on this behavioural change. Null flight matrices were simulated to further explore this turbine interaction, offering insights into the scale at which these birds react to turbines in the form of flight direction change.

Increasing the scope to the broad spatial scale, telemetry analysis from 41 GPS-tagged individuals, also from Inverness-shire, will provide insights into population-level spatial dynamics with these developments. More than 90,000 fixes between 2017 and 2024 will allow analyses of home range, dispersal patterns, breeding behaviours, and landscape use in the context of onshore wind farms. Expected findings will provide understanding into how wind farms influence Red Kite movement at every life stage and spatial scale, also highlighting intraspecific differences. Habitat suitability modelling and step selection functions will explore how wind farm proliferation affects Red Kite population structure and persistence in Northern Scotland. This study integrates behavioural analysis and movement ecology to assess wind farms' impact on soaring raptors. Insights inform adaptive management, turbine placement, and policies to reduce collision risk and habitat loss, supporting Red Kite conservation in the UK.

TUESDAY 9TH SEPTEMBER – 17:00-18:00

PROJECT WOW: CHARACTERIZING MARINE COMMUNITIES AND ASSESSING RISK TO SEABIRDS FROM OFFSHORE WIND ENERGY DEVELOPMENT

Mx Julia Gulka[1]*, Dr Evan Adams[1], Dr Kevin Friedland[2], Dr Mary Mcelroy[1], Dr Kim Lato[1], Ms Esther Nosazeogie[3], Dr Lesley Thorne[3], Dr Kate Williams[1]

[1] Biodiversity Research Institute, [2] NOAA NMFS, [3] Stony Brook University

*Corresponding author.

Offshore wind energy development is a key part of efforts to reduce carbon emissions and prevent the worst effects of climate change. However, data from Europe indicate this industry also has the potential to affect wildlife. Project WOW (Wildlife and Offshore Wind) is a five-year study assessing the effects of the first commercial-scale offshore wind energy projects in the Atlantic United States on marine mammals, sea turtles, birds, and bats. Key research areas include 1) characterizing marine biotic communities and examining trophic linkages in wind energy areas using community analyses and spatial cross-correlation, and 2) assessing patterns of seabird habitat use and possible changes in relation to offshore wind energy development activities using at-sea survey data, GPS tracking data on Northern Gannets, and a range of environmental and oceanographic covariates. In characterizing biotic communities using hierarchical clustering, we found that the Gulf of Maine consistently showed distinct differences in biotic community composition from all other regions of the US Atlantic. Additionally, biotic community compositions were more similar across wind energy areas in the spring than fall for most groups. Spatial cross-correlation between seabird distributions and forage fish revealed variable patterns by species and season, even when comparing between wind energy areas within the same region, exemplifying the dynamism of marine ecosystems. In addition, we tagged Northern Gannets (n=41) over two non-breeding seasons (2023-2025) and gathered individual tracking data from a time period with one fully operational commercial-scale wind farm and four others under construction. Results revealed variable use of wind energy areas across individuals and more directed movement south by birds tagged in early winter (November) compared with those tagged later (January), suggesting potential meta-population dynamics that warrant further exploration. These analyses, combined with other Project WOW research activities, will inform risk assessments and adaptive management for offshore wind energy development in the U.S. Atlantic.

TUESDAY 9TH SEPTEMBER – 17:00-18:00

BRAIDS: A MULTI-PARTNER COLLABORATIVE STUDY OF THE INTERACTIONS BETWEEN SEABIRDS, AVIAN INFLUENZA, AND OFFSHORE WIND DEVELOPMENTS IN SCOTLAND

Dr Aly Mccluskie[1]*, Dr Claudia Tapia Harris[1], Dr Sophie Bennet[2], Dr Philipp Boersch-Supan[2], Dr Maria Bogdanova[3], Ms Emily Burton[4], Dr Niall Burton[2], Dr Sarah Burthe[3], Mr Nigel Butcher[5], Dr Adam Butler[6], Dr Ian Cleasby[1], Prof Francis Daunt[3], Dr Kirsty Franklin[1], Dr Elizabeth Humphreys[2], Dr Jana Jeglinski[7], Dr Daniel Johnston[2], Dr Esther Jones[8], Dr Jude Lane[1], Prof Jason Matthiopoulos[9], Dr Charlotte Regan[3], Dr Kate R. Searle[3], Dr Chris Thaxter[2], Dr Katherine Whyte[8], Dr Lucy Wright[1], Dr Elspeth Sage[5]

[1] RSPB Centre for Conservation Science, 2 Lochside View, Edinburgh, Scotland EH12 9DH, [2] British Trust for Ornithology, [3] UK Centre for Ecology & Hydrology, [4] Scottish Seabird Centre, [5] RSPB Centre for Conservation Science, The Lodge, Sandy, Bedfordshire SG19 2DL, [6] Bioinformatics and Statistics Scotland, [7] Århus University, [8] Biomathematics & Statistics Scotland, [9] MacArthur Green

*Corresponding author.

Seabird populations are currently facing multiple challenges, including the H5N1 Highly Pathogenic Avian Influenza (HPAI) outbreak and the rapid expansion of offshore windfarm developments. With Scotland aiming to decarbonise and achieve net zero emissions by 2045, offshore wind developments will play a crucial role in meeting this target. This, coupled with the fact that the effects of HPAI are still poorly understood, led the Scottish Government to commission BRAIDS, Bird Responses to Avian Influenza and Developments at Sea. BRAIDS brings together ecologists, statisticians, epidemiologists, developers, and Government to understand the effects of offshore wind developments on susceptible species, including Northern Gannet Morus bassanus, Black-legged Kittiwake Rissa tridactyla, Razorbill Alca torda, and Common Guillemot Uria aalge across multiple colonies in the east coast of Scotland, framed within the broader context of population change due to the recent HPAI outbreak. The project uses historical, current, and future seabird tracking data to monitor changes in seabird distribution, behaviour, as well as 3D reactive behaviour in the vicinity of turbines during different phases of windfarm construction. In addition, the project will develop innovative, cutting-edge modelling techniques as well as epidemiological studies to offer a more comprehensive understanding of these issues. This will include assessing how HPAI has impacted colony sizes and ranges, identifying the activities birds perform within these ranges, and examining individual variation in behaviour, turnover, and site fidelity. Additionally, BRAIDS will update some of the parameters used for collision risk models, such as flight height and speed.

By using current available data, most collected by collaborators themselves, initial analyses allow us to identify changes in distribution and foraging ranges arising because of the outbreak, alongside any reactive behaviour to the presence of windfarms. The presentation will focus not only on the project itself but also preliminary analysis of seabird flight behaviour and foraging ranges. These data show

- Inherent unreliability in some measures of seabird flight altitude and speed
- Individual and colony level variation in seabirds foraging rangesFlight trajectories of seabirds within operational windfarms

As such, these results are directly applicable to assessment of offshore wind farm developments.

BRAIDS represents an example of successful collaboration between different stakeholders, integrating and generating up-to-date scientific evidence to produce outputs of direct relevance to impact assessments. It bridges the critical evidence gap between scientific research and practical applications, addressing the increasingly important challenge of expanding offshore developments without causing irreversible harm to seabird populations.

TUESDAY 9TH SEPTEMBER – 17:00-18:00

CHALLENGING THE ARO SEQUENCE TO PROTECT THE SEA AND ITS BIODIVERSITY

Dr Catherine Boemare[1]*, Dr Sylvain Pioch[2]
[1] CIRED-EHESS, [2] LAGAM, Université Paul Valery, Montpellier
*Corresponding author.

The "maritimization" of human activities and the development of marine energies, are likely to exert pressures on the marine environment that could lead to alterations in its components or to conflicts of use. In order to mitigate impacts on biodiversity and ecosystems, the 2016 French Biodiversity Law requires "no net loss of biodiversity, or even a gain in biodiversity". Thus, the law mandates the conduct of an environmental impact study for projects or an environmental assessment for planning documents. These two tools must be implemented prior to the public decision to authorize the project, ensuring that the implementation of projects or plans does not lead to major damage to the ecosystems. Operationally, this means that as soon as the impacts are assessed, measures must be proposed to avoid them, and if avoidance is not possible, to reduce them, and as a last resort, to offset for them (ARO). The mitigation hierarchy (Avoid, Reduce, Offset) thus presents offset as the ultimate step. In practice, in the French marine environment context, the ARO sequence seems to be ineffective. Research conducted by Letexier et al. (2024) using the GeoMCE database shows that only 1 mitigation measure out of 3 335 recorded relates to the marine environment. In a critical review of 45 environmental impact studies on marine projects conducted between 2003 and 2015, Jacob et al. (2016) corroborates the findings of Vaissière et al. (2014) and Kermagoret (2014), identifying numerous obstacles that hinder the application of the ARO sequence at sea. What are these obstacles for a weak ARO application? Do the specificities of the marine environment explain this situation? Could the organization of the implementation of the ARO sequence itself be at fault? In this context, can we question the conceptual root of the ARO sequence and, as the law suggests, reverse the approach to move away from minimizing impacts in project development and towards an approach that promotes a gain in biodiversity from the design stage? What role and technical solution could nature-based solutions (Rendle et al., 2023), nature-inclusive design (Kingma et al., 2024) and eco-design (Lacroix and Pioch, 2011) offer? Could new forms of project governance, allowing for co-construction of projects with citizen public hearing, be explored for ARO application? (Bouzereaux et al., 2024; Pioch et al., 2022). We will present last results and original proposal for a better OWF Integration in marine environment.

TUESDAY 9TH SEPTEMBER – 17:00-18:00

POSEIDON: MAPPING OFFSHORE WIND RISK TO SEABIRDS AND OTHER RECEPTORS IN THE UK

Dr Alex Banks[1]*, Dr Maija Marsh[1]
[1] *Natural England*
*Corresponding author.

Avoidance of significant impacts when planning offshore wind relies upon robust information. To be effective, data describing abundance, distribution and sensitivity of key species and habitats must be readily available, easily interpreted and sufficiently trusted by stakeholders. POSEIDON is a big data approach to this challenge, led by Natural England in partnership with others and hosted by the Crown Estate, in pursuit of the UK's ambitious targets for renewable energy and nature recovery. POSEIDON maps offshore wind risk (and, conversely, development opportunity) for benthic habitats and communities, seabirds and marine mammals within UK waters, based on millions of empirical records informing innovative predictive spatial models. Uniquely, POSEIDON integrates risk across these different receptor groups to demonstrate 'hotspots' of environmental risk at seascape scale. We will describe the development of the POSEIDON tools, setting out approaches to data collation, data collection, modelling, sensitivity scoring and integrated risk mapping across time, space and species / habitats. We will present outputs from the tools to demonstrate our findings, which will be publicly available through a dedicated dashboard. We will also discuss the potential applications of the tools within the regulatory framework, including how they may inform mitigation and compensation as well as avoidance of impact, so that decision-makers can consider application to the mitigation hierarchy with readily accessible and high-quality environmental information. Finally, we will share lessons learnt from the project for others interested in data-driven decision making for offshore wind, and discuss some of the challenges we face in the further development of POSEIDON.

WEDNESDAY 10TH SEPTEMBER – 10:30-11:30

RADAR-BASED MONITORING OF NOCTURNAL SEABIRD ACTIVITY IN THE ATACAMA DESERT, CHILE: A CASE STUDY ON STORM-PETRELS AND ENERGY DEVELOPMENT

Ms Sara Gomes[1], Mr Rui Machado[1]*, Dr Pedro G. Nicolau[1], Mr Pedro Neves[1], Dr Pedro Cardia[1], Mr Julio Duran[2], Mr Cristofer De La Rivera[2], Ms Javiera Velásquez Araya[2], Mr Ricardo Oliveira[1], Mr David Gomes[1], Mr Pedro Garcias[1], Mr Tiago Rosinha[1], Dr Domingos Leitão[1], Mr Miguel Repas-Goncalves[1]

[1] STRIX, [2] TecNativa

*Corresponding author.

The expansion of wind energy in emerging markets across the Global South presents new challenges for wildlife conservation. In the Chilean Atacama Desert, several projects are ongoing, with potential wind farm exploration, as well as high-voltage powerlines to transport the energy. Nocturnal seabirds, particularly storm-petrels, breed inland in this region, yet their breeding phenology and nesting sites remain largely undocumented, with colonies only recently discovered through investigations conducted between 2013 and 2023. These include Markham's Storm-Petrel (Hydrobates markhami), Hornby's Storm-Petrel (Hydrobates hornbyi) and Elliot's Storm-Petrel (Oceanites gracilis), a data-deficient seabird species. As these species commute year-round between inland colonies and oceanic foraging grounds, their nocturnal flight activity poses a potential collision risk with energy infrastructures. This study aims to identify key movement patterns, including colony peak return and departure times, predominant flight directions, flight heights and important flight routes. These insights will support mitigation strategies for energy development in this particularly sensitive environment.

To monitor storm-petrel flight activity, we deployed both vertical and horizontal radar systems, complemented by thermal imaging for ground-truthing and species validation. This approach enables the tracking of flight trajectories, altitudes, and movement densities while addressing the challenge of nocturnal species identification.

Preliminary results reveal varying patterns in nocturnal flight activity, with peak movement times and directional trends varying across monitored locations. Importantly, storm-petrels appear to fly much higher when compared to the sea, where most species very rarely go above 10 meters high. As data is increasingly gathered, this will enable the collision risk assessments of these elusive species, understanding their vulnerabilities for wind energy development. By identifying consistent flight patterns, this approach should enable the detection of preferred and/or previously unknown flight corridors, and prompt adequate mitigation strategies.

This case study underscores the need for targeted nocturnal monitoring in wind energy impact assessments, particularly in emerging markets with poorly documented seabird populations. The findings highlight the importance of integrating radar technology with thermal imaging to improve nocturnal species detection. Ongoing research will be essential for refining mitigation strategies and safeguarding vulnerable species.

WEDNESDAY 10TH SEPTEMBER – 10:30-11:30

GAPS AND CHALLENGES IN ENVIRONMENTAL REGULATION OF WIND ENERGY IN SOUTH AMERICA: A FOCUS ON FLYING WILDLIFE MONITORING

Dr Natalia Rebolo[1]*, Dr Juan Manuel Pérez-García[2], Dr Sergio Lambertucci[1], Dr Francisco Santander[3], Dr Jon Morant Etxebarria[4], Dr Carlos Javier Durá[5], Dr Renzo Vargas Rodríguez[6], Dr Carolina Alves Lemos[7]

[1] Grupo de Investigaciones en Biología de la Conservación, INIBIOMA, Universidad Nacional del Comahue — CONICET, San Carlos de Bariloche., [2] Área de Ecología, Departamento de Biología Aplicada, CIAGRO — Universidad Miguel Hernández, Avda Universidad S/N, E03202. Elche, [3] Laboratorio de Ecología de Vida Silvestre, Facultad de Ciencias Forestales y de la Conservación de la Naturaleza, Universidad de Chile, La Pintana., [4] Department of Applied Biology, Miguel Hernández University of Elche, Elche., [5] Instituto de Estudios Sociales Avanzados. IESA-CSIC., [6] Departamento de Áreas Silvestre Protegidas; Corporación Nacional Forest (CONAF), Coquimbo., [7] Brazilian Institute of Environment and Renewable Natural Resources (IBAMA), Ministry of Environment, Brasília.

*Corresponding author.

As the world's population grows, onshore wind power is emerging as a key pillar of the energy transition. However, this development is not without challenges. Some of the associated risks include potential environmental impacts. These include changes to local ecosystems and the mortality of birds and bats from collisions with turbines. To mitigate these impacts, environmental monitoring regulations are essential throughout all stages of a wind energy project, from planning to decommissioning. In South America, where there is a great diversity of birds and bats and many migratory and endangered species cross borders, there is a need for standardised, even transnational, regulations that would allow cumulative impacts to be assessed and effective mitigation measures to be implemented. Our aim was to assess the current state of environmental regulation in South American countries. To do this, we developed an online survey aimed at experts in the field, such as environmental consultants, public managers and researchers, to analyse the laws that regulate the authorisation, operation and decommissioning of wind farms in all their phases, with a focus on the protection of flying vertebrates. Currently, eight South American countries have operational wind farms, yet most lack specific national regulations for bird and bat monitoring. Existing protocols vary between jurisdictions within countries. While some regions have dedicated legislation, others rely on guidelines developed by national or international authorities. We found that in the pre-construction phase, regulation is more consistent across countries, including environmental impact studies and mitigation measures; however, in the operational phase, differences are more pronounced, with non-standardised methods for monitoring collision mortality, lack of penalties for species mortality, and variability in the accessibility of mortality reports. In addition, environmental legislation has been relaxed in some countries, with more flexible environmental impact assessments facilitating the installation of wind farms. These findings highlight the need to strengthen regulation and move towards more integrated and transparent rules that effectively assess and mitigate impacts on flying wildlife in a region that is home to a great diversity of species, including migratory birds and bats, many of which are endangered. Wind energy will continue to play a key role in the South American energy matrix, so it is essential that its risks are properly managed and that clear regulations are established, based on knowledge of the problem and an effective approach to environmental governance.

WEDNESDAY 10TH SEPTEMBER – 10:30-11:30

THE ALTITUDE OF BAT FLIGHT AND WIND TURBINE FATALITY RISK EXPOSURE

Dr Teague O'mara[1]*, Mr Michael D. Whitby[1], Dr Caitlin J Campbell[1], Dr Theodore J. Weller[2], Dr Winifred F. Frick[1]

[1] Bat Conservation International, [2] USDA Forestry Service

*Corresponding author.

The risk of bat fatalities due to collisions with wind turbines varies across taxa, season, and region. However, the spatial risk across the landscape has been difficult to quantify due to limited information in how bats use the aerosphere at an individual level and how this differs from population-level measures of interactions with wind turbines. Wind turbines appear to exert both attractive and repellent forces depending on the species, region, and possibly spatial distribution of turbines. This has led to debate in the role that turbines play in attraction and induction of fatalities vs a non-attractive incidental source of mortality risk. Flight altitude can play a role in factors including turbine visibility, interaction with wake, and chance of random encounters with wind turbines, all which may compound risk. The possibility that turbine presence may also induce changes in flight altitude has received little attention, largely due to the difficulty in documenting individual-level flight altitudes. To understand how altitudinal movements of bats expose them to turbine collision risk and attraction, we synthesize the currently known available data on individual-level flight altitudes of bats and explore how the movement of an individual puts them at potential risk of turbine blade exposure. We integrate individual-level movement tracks with ground- and turbine-height acoustic monitoring to contextualize how the movement of an individual may expose them to turbine blades, and what may be needed from individual-level movement data to inform bat collision risk models.

WEDNESDAY 10TH SEPTEMBER – 10:30-11:30

ATTEMPT TO DETECT THE COMBINED IMPACT OF INTEGRATED WIND-SOLAR POWER FACILITIES ON BIRDS

Mr Masashi Barada[1], Dr Wataru Kitamura[1]*
[1] *Tokyo City University*
*Corresponding author.

The widespread adoption of renewable energy facilities has helped reduce greenhouse gas emissions. However, the availability of suitable land for new installations is decreasing. Consequently, integrated renewable energy systems are gaining attention, particularly wind-solar facilities, due to their high efficiency in emissions reduction. However, such facilities may introduce new ecological impacts on wildlife. For instance, the combined effects of wind and solar energy may increase the risk of collisions of insectivorous bird with wind turbines, as solar power facilities attract insects, such as dipterans, due to reflected light. This study examines whether bird flight frequency differs between integrated wind-solar power facilities and wind farms. Field observations were conducted in Nemuro City, Hokkaido, Japan, where bird flight frequency was recorded across wind power facilities, integrated wind-solar facilities, and control sites without energy infrastructure. Birds were classified into three groups: raptors (Accipitriformes), gulls (Charadriiformes), and passerines (excluding corvids). Flight frequency was analyzed as the response variable, with power generation facility type (wind farms, integrated facilities, or control sites) as the explanatory variable. Results showed that passerine flight frequency increased during the breeding season at both wind power and integrated facilities. In contrast, gull flight frequency declined in winter, while raptor flight frequency exhibited a year-round decrease at integrated wind-solar facilities. These findings highlight species-specific differences in responses to integrated facilities. Passerines may use solar power facilities as song posts, with their flight patterns influenced by differences in nesting and foraging environments. Future research should further investigate the specific ecological roles of these facilities for different bird species.

WEDNESDAY 10TH SEPTEMBER – 10:30-11:30

MINIMIZING CONFLICTS BETWEEN OFFSHORE WIND ENERGY AND FISHERIES: LESSONS FROM THE IBERIAN PENINSULA (PORTUGAL)

Mr Miguel Amado[1]*, Dr Maria Machado[1]
[1] *WavEC Offshore Renewables*
*Corresponding author.

The global demand for renewable energy has driven significant expansion in offshore wind energy developments, offering promising contributions to a sustainable energy future. However, these advancements also introduce challenges to marine ecosystems and traditional activities such as fisheries, raising concerns about socio-economic and biodiversity impacts among stakeholders. This study examines the recently established areas for floating offshore wind installations in the Iberian Peninsula, specifically in Portugal. It evaluates the potential impacts on the fisheries sector, incorporating socio-economic and ecological dimensions to provide actionable insights.

To achieve this, a multi-data source approach was employed. The methodology utilized Automatic Identification System (AIS) and Vessel Monitoring System (VMS) data from Global Fishing Watch (GFW), alongside supplementary data such as those from EMODnet, Copernicus and Portuguese Maritime Spatial Planning portal (PSOEM Geoportal). Geographic Information System (GIS) analysis was applied to identify spatial overlaps between fishing activities and offshore wind energy areas. This enabled detailed evaluations of displaced fishing efforts, the most affected fisheries, and in gear usage. Furthermore, the analysis explored economic and social repercussions for the fishing sector, offering essential insights to guide sustainable marine spatial planning and policy development.

This study also compares impacts on fisheries between areas proposed during the public consultation process and the final designated areas, examining how improvements in the final areas reduced potential impacts on this activity. This analysis adds value by clarifying whether stakeholder feedback has effectively minimized impacts and their corresponding magnitude. Regions of particular concern were identified based on ecosystem type and ecological sensitivity.

The findings of this study provide a deeper understanding of the socio-economic and ecological impacts of offshore renewable energy installations on fisheries in Portugal, a region with a long-standing fishing tradition. The results highlight the importance of integrating stakeholder perspectives and adopting best practices to minimize negative impacts while fostering sustainable development and public acceptance. These insights are intended to support policymakers and stakeholders in planning and managing offshore renewable energy projects.

WEDNESDAY 10TH SEPTEMBER – 10:30-11:30

THE MARINE MAPPING TOOL: SUPPORTING REGIONALLY COORDINATED AND DATA-DRIVEN ENVIRONMENTAL MITIGATION ACTIONS AROUND OFFSHORE WIND IN THE NORTHEAST REGION OF THE UNITED STATES

Mrs Tricia Jedele[1], Dr Marta Ribera[1]*
[1] *The Nature Conservancy*
*Corresponding author.

Offshore wind needs to be built fast enough and in ways that supports biodiversity across large ecosystems. The need for the simultaneous response to the climate and biodiversity crises resulted in a number of efforts across Europe and at the global scale to ensure offshore energy is designed with nature in mind. In the US, there are multiple government and organizational efforts underway to gather data, provide context, and standardize mitigation approaches. Connecting data to criteria and standard frameworks for prioritization is key to creating a pathway for decisions driven by the best science about which species and habitats will benefit from mitigation efforts, and for flagging projects that will support biodiversity across ecosystems thereby making mitigation actions more effective.

Over the past 2 years, The Nature Conservancy (TNC) has been working to adapt its Marine Mapping Tool (MMT) to facilitate the exploration of spatial data related to the selection of mitigation projects and focal species across the US Northeast and Mid-Atlantic regions. The updated version of the MMT will be available by March 21, 2025, and can be explored here: https://maps.tnc.org/marinemap/ne). To ensure a coordinated and transparent approach to this tool update, TNC initiated workshops, listening sessions, and preliminary data analyses with internal and external experts over many months. As a result of the feedback received, the updated MMT makes publicly available data about habitats and species easier to query and provides valuable context to the data. Users will see not just the numbers but also what those numbers mean relative to each species' distributions and within the regional context. The MMT is also the first to connect the International Finance Corporation's biodiversity-related performance standards to regional data. Finally, the tool will connect offshore areas to coastal habitats through its species information, so the life cycle needs of dynamic species can be considered. Next steps will include the near-term prioritization of mitigation projects across the northeast, which would shape coordinated mitigation across the Atlantic coast for years to come.

WEDNESDAY 10TH SEPTEMBER – 10:30-11:30

ASSESSING AREAS FOR POTENTIAL INTERACTION BETWEEN TRICOLORED BATS AND WIND ENERGY FACILITIES USING DISTRIBUTION MODELLING

Mr Roger Rodriguez[1]*, Dr James Robbins[2], Dr Gillian Vallejo[2]
[1] EchoSense LLC, [2] Natural Power
*Corresponding author.

The tricolored bat (Perimyotis subflavus) has suffered dramatic declines in the U.S. and Canada in recent years, primarily due to impacts arising from white-nose syndrome – a deadly fungal disease that has rapidly spread through these bat populations. This has led to a proposal to list the species as endangered by the U.S. Fish and Wildlife Service, who have also identified wind energy developments as a potential contributing factor to its decline. Due to its widespread distribution across the U.S., listing it as endangered will substantially increase the number of wind energy projects occurring within the range of an endangered bat species and result in an increased requirement for mitigatory actions (i.e., curtailment), impacting upon renewable energy production. In order to understand where areas with potential interactions between tricolored bats and wind turbines might occur, we modelled its distribution using regression-based (Generalized Linear Models and Generalized Additive Models) and machine learning (Random Forest and Boosted Regression Tree) methods, and presence-only locations from five datasets. Models predicted the probability of bat occurrence at a 4 km^2 resolution across the contiguous USA. An ensemble model predicted high occurrence throughout much of the eastern U.S. with sparse occurrence throughout the western portion (central U.S.) of the species' range. Rainfall and temperature were the best predictors of occurrence, with elevation, land cover type, distance to water, and wind speed being relatively less important.
We then compared the predictions with current onshore wind farm buildout and areas suitable for onshore wind development to understand the extent of likely interactions between tricolored bats and wind turbines. We detected a considerable degree of overlap between areas predicted to have a high probability of tricolored bat occurrence, and areas with wind turbines both currently and under future development scenarios. Results such as this can be beneficial in landscape-scale planning by increasing understanding of the current occurrence of at-risk species, and even predicting potential future distributions under contemporary climate change scenarios. Additional data (species occurrence and/or environmental and ecological variables) may help to further increase certainty and elucidate the degree to which tricolored bats occur in a particular region and the potential for interaction with wind turbines.

WEDNESDAY 10TH SEPTEMBER – 10:30-11:30

NAVIGATING THE GREEN DILEMMA: STAKEHOLDER- DRIVEN RESEARCH PRIORITIES TO CURB BIODIVERSITY LOSS IN SOUTH AFRICA'S GREEN ENERGY TRANSITION

Ms Merlyn Nkomo[1]*, Dr Megan Murgatroyd[2], Ms Samantha Ralston-Paton[3], Prof Arjun Amar[1]
[1] FitzPatrick Institute of African Ornithology, University of Cape Town, [2] HawkWatch International / FitzPatrick Institute of African Ornithology, [3] BirdLife South Africa
*Corresponding author.

The global transition to renewable energy requires the rapid expansion of wind energy infrastructure, particularly in developing countries. However, these areas are often biodiversity hotspots, making the need to minimise wind energy's impacts on species biodiversity even more acute. South Africa has the highest installed wind energy capacity in Africa and is also an important country for avian biodiversity and conservation, with several endemic and near-endemic raptor species.
The Jackal Buzzard (Buteo rufofuscus) is endemic to the region and despite being the most frequently killed species by wind turbine collisions, the species remains understudied relative to many other species in the region. This lack of information poses significant challenges for conservation planning and renewable energy development. To better understand the research needs of this species, we engaged key stakeholders in the wind energy sector, including avifaunal specialists, developers, government representatives, and conservation organizations, to identify research priorities for the species. While stakeholders expressed confidence in the existing environmental impact assessment (EIA) processes, they emphasized concerns about the potential for cumulative impacts of wind energy development on this species, and the need to better understand their movement ecology. To address this need, we first constructed a population model to explore future population trajectories under six potential wind energy development scenarios over the next 100 years, incorporating current estimates of annual collision rates. Our models suggest that, under some scenarios, this population could be impacted by wind energy expansion in the future. However, these models were highly sensitive to initial population size, and robust estimates for this species (and many others) are currently lacking making these sorts of models challenging. Additionally, to better understand this species' movements we tagged and tracked 15 individuals generating valuable insights into movement patterns and collision risk factors which should help with mitigating the risk of future wind farm development. With this new information, we hope to ensure that wind energy expansion can occur more sustainably, ensuring that South Africa's transition to renewable energy minimizes biodiversity loss.

WEDNESDAY 10TH SEPTEMBER – 10:30-11:30

A SPATIALLY EXPLICIT BIRD COLLISION RISK FRAMEWORK FOR ONSHORE WIND ENERGY DEVELOPMENTS BASED ON SEMI-AUTOMATED RADAR DATA

Dr Pedro G. Nicolau[1]*, Dr Teresa Carmo-Costa[2], Mr Nuno Cidraes-Vieira[1], Dr Pedro Cardia[1], Ms Sara Gomes[1], Mr Pedro Neves[1], Ms Patrícia Nabo[1], Mr David Gomes[1], Mr Pedro Garcias[1], Mr Ricardo Oliveira[1], Dr Domingos Leitão[1], Mr Miguel Repas-Goncalves[1], Mr Cristofer De La Rivera[3], Mr Julio Duran[3]

[1] STRIX, [2] +ATLANTIC CoLAB, [3] TecNativa

*Corresponding author.

Assessing collision risks in emerging wind energy markets is challenging due to scarce baseline information and the need for rapid, reliable wildlife impact assessments. When compared to humans, radar technology gathers vast quantities of bird trajectory and altitudinal data, with reduced effort. However, its inability to identify species and complex detection biases limit its broader application in biodiversity assessments. Moreover, standard radar methodologies operate at fixed sites, being suitable mostly for small-scale projects. However, recent wind energy plans across South America include mega-scale projects with hundreds of turbines spanning diverse habitats, requiring new methodological developments. To address these challenges and survey areas beyond a radar's bird detection range, we devised a semi-automated remote sensing framework, utilizing a single portable radar, alternating data collection at multiple sites. A BIRDTRACK radar was operated in two modes: horizontal scanning for bird trajectories and vertical scanning for flight height distributions (FHDs). This was complemented by field observations to classify and validate trajectories with species identification, flock size, and behavior. After filtering false positives, flight tracks were spatially modeled as a function of landscape features, weather, and bias covariates affecting bird detection, including altimetry and radar-detection volume. Modeling track densities and detection bias jointly enabled extrapolation to produce spatial density maps. These were converted to aerial flight densities by integrating flight time, flock size and species composition across different sites and the annual cycle. Finally, the mapped densities, combined with FHDs, speeds, and wind farm-specific characteristics, fed a stochastic collision risk model (CRM) to estimate collisions.

We applied this framework to three wind farm pre-construction assessments in the Chilean Patagonia. We obtained monthly collision estimates for multiple species, as well quantitative assessments of community-level risk for Patagonia's flying birds. Moreover, the flight density maps identified priority areas for turbine exclusion, enabling developers to adjust wind farm layouts and devise custom mitigation plans.

By combining radar technology, field data and ecological modeling, we overcame the main limitations of standard radar practices to produce informative CRM assessments for mega-scale wind projects. Our approach not only estimated collision risk based on radar data, as it provided spatially explicit information on where collisions are likely to occur. This constitutes an important methodological advancement, with significant implications for mitigation plans, scalable across large data-deficient areas. In the process, we have gathered crucial baseline information for previously unstudied species, directly applicable to any CRM studies across South America.

WEDNESDAY 10TH SEPTEMBER – 10:30-11:30

EXPLORING UNDERWATER NOISE IMPACTS OF MULTIUSE PROJECTS IN THE OFFSHORE ENVIRONMENT: A FLOATING WIND AND AQUACULTURE PROTOTYPE

Ms Luana Clementino[1]*, Dr Maria Machado[1], Dr Pedro Vinagre[1], Ms Clara Rodrigues[1], Mr Miguel Amado[1], Dr Rafael Ginés[2], Mr Pablo Marro[2], Mr Alfred Mormeneo[3], Mr Pedro Marrero[3], Ms Silvia Martin Imholz[4], Mr Carlos Navarro[4], Mr Nestor Ortega[4], Dr Nalu Franco Gerent[4], Mr Javier Fernandez[5], Dr Javier Roo[6]

[1] WavEC Offshore Renewables, [2] University of Las Palmas de Gran Canaria (ULPGC), [3] Canexmar, [4] Plataforma Oceánica de Canarias (PLOCAN), [5] EnerOcean, [6] Agencia Canaria de Investigación, Innovación y Sociedad de la Información (ACIISI)

*Corresponding author.

The rapid growth of the offshore renewable energy sector in an already busy maritime space has highlighted the need for efficient allocation of marine space. As commercial activities such as aquaculture, fishing, tourism and shipping are frequently conflicting for space use, it becomes crucial to optimize the use of marine resources.

The AquaWind project aims to demonstrate an innovative multi-use prototype that integrates offshore renewable energy production, using the W2Power floating wind technology (TRL 6), with a novel finfish aquaculture solution (TRL 4) in the Atlantic Basin. While integrating these emerging technologies shows promising results, their environmental impact, particularly in terms of underwater noise is uncertain. Additionally, the unique setting of multi-use platforms presents a challenge: underwater noise may not only affect the wider soundscape and marine species but could also alter the behavior and health of fish within the aquaculture cages.

Underwater noise was measured at an impact and a control area, to ensure the comparability between the baseline and operational phases of the prototype. Additionally, noise data were collected at a commercial aquaculture site to characterise aquaculture radiated noise. Hydrophones were deployed at 10 m and 18 m depth, monitoring for a minimum of four days to assess the temporal variations of underwater noise. This approach provided valuable insights into the noise generated by aquaculture operations, providing inputs on how the multi-use prototype may alter the overall acoustic environment.

Sound Pressure Levels (SPL) were analyzed in broadband and 1/3 octave bands, from 10 Hz - 96 kHz. Variables such as sea state, vessel and airplane activity, feeding regimes, and fish behavior were taken into account in the analysis to better understand the various contributors to the noise sources.

These preliminary findings offer key insights into the acoustic dynamics of multi-use offshore platforms, highlighting specific challenges compared to single-use systems. This study contributes to tackling uncertainties on how multi-use renewable energy and aquaculture operations influence marine environments, particularly in terms of underwater noise and its potential ecological effects. This study provides relevant insights that can influence regulatory frameworks for multi-use platforms, providing guidance for policymakers on best practices for minimizing environmental impacts associated with multi-use offshore developments.

The AquaWind project is co-funded by the European Maritime, Fisheries and Aquaculture Fund (EMFAF) under Grant Agreement No 101077600.

WEDNESDAY 10TH SEPTEMBER – 10:30-11:30

EFFICACY ANALYSIS OF THE IDENTIFLIGHT AVIAN ANTI- COLLISION SYSTEM USING FATALITY MONITORING DATA ACROSS 15 WINDFARMS IN 3 CONTINENTS

Mr Carlos Jorquera[1], Mr Caleb Putnam[2], Dr Nicholas Barendregt[1]*, Mr Alejandro Haerter[1], Mr Ian Jorquera[1], Ms Kylie Schnoor[1]

[1] Boulder Imaging Inc, [2] Real Birds LLC

*Corresponding author.

The efficacy of technologies designed to minimize collisions between wind turbines and protected bird species is notoriously difficult to assess. Multiple years of operation alongside untreated control turbines are ideally needed to collect enough data for meaningful conclusions; however, to date only relatively small sample sizes have been available for analysis.

Sufficient data to allow for meaningful efficacy analysis has become available for IdentiFlight, a machine-vision based technology used to selectively shut-down on-demand (SDOD) individual turbines when a protected bird species approaches the turbine. Here, we investigate the efficacy of IdentiFlight as well as assess potential predictive factors for fatality risk on a turbine-by-turbine basis. This is done using fatality data collected from IdentiFlight installations that have been operational for between six months and seven years, at 14 wind farms on 4 continents. The total dataset covers 500+ turbines and over 1700 turbine-years of operation.

Even with a dataset of this size, correlation analysis remains difficult because the fatality rate at turbines fully protected (or fully covered, defined below) by IdentiFlight has been very low (~0.0033 fatalities per turbine-year over 1206.9 turbine-years of operation). Therefore, we focus our several predictive factors, including the degree of coverage (defined below), turbine shutdown response time, turbine dimensional parameters, and avian flight behavior—including preferential utilization of terrain features such as orographic uplift and perch-points—derived from three-dimensional avian flight data captured by the system. Normalized avian activity levels around turbines are also considered.

Partially and fully covered turbines refer to details of system implementation. Because IdentiFlight is installed independently from turbines (allowing a single unit to "see" multiple turbines), a wind farm may choose to deploy units such that only some turbines, usually those with a history of fatalities, are fully protected while neighboring turbines have reduced protection (partial coverage). 12 of the wind farms included in this dataset chose this implementation, providing an opportunity to compare, side by side, fully covered to partially covered turbine fatality rates. The analysis shows that fatality rates are more than 20 times greater at partially covered turbines than at fully covered turbines.

WEDNESDAY 10TH SEPTEMBER – 10:30-11:30

OPTIMIZED BIODIVERSITY MONITORING SURVEYS USING AUTONOMOUS VEHICLES FOR OFFSHORE WIND PROJECTS

Dr Camille Le Guen[1]*, Ms Magali Collin[1], Mr Thomas Merzi[1], Mrs Grethe Kjeilen-Eilertsen[2], Mr Mark Grove Smith[3], Dr Lionel Camus[4], Mr Morten Thorstensen[4], Dr Technical University Of Denmark (Dtu)[5], Mr Christian Riisager-Simonsen[5]

[1] TotalEnergies OneTech SA, [2] TotalEnergies EP Norge AS, [3] TotalEnergies E&P UK, [4] Akvaplan-niva, [5] DTU Aqua

*Corresponding author.

Recent technological advances have streamlined the use of autonomous vehicles, such as Unmanned Surface Vehicles (USVs) and Autonomous Underwater Vehicles (AUVs) or gliders, to collect environmental data at the surface and in the water column. Here, we present a strategy to conduct biodiversity surveys in offshore wind farm projects using a combination of surface and underwater autonomous vehicles equipped with sensors to monitor biodiversity remotely. The rationale is to improve ecosystem characterization and impact assessment for offshore wind energy projects while reducing costs, CO2 emissions generated by traditional vessels and HSE exposure. Learning on the operability of the vehicles (deployment, maintenance, piloting, autonomy) and on the integration of sensors is highly valuable for operations. The ultimate objectives of this research are to provide recommendations on survey design, to identify relevant indicators to monitor ecosystem health and to create a numerical dashboard for decision-making and data sharing. The study is being conducted in the Central North Sea, in a location where TotalEnergies will deploy a floating offshore wind turbine which will supply an existing oil & gas platform with renewable electricity. During the summer 2025, a 3 MW floating wind turbine will be installed 2 km off the Culzean platform. The scope includes a one-month survey in spring 2025 to establish a baseline, followed by a one-month survey in spring 2026, after the installation of the turbine. Both surveys will be conducted using a fleet of two USVs and two gliders equipped with instruments such as hydrophone, echosounder, camera, environmental DNA (eDNA) sampler and water quality sensors. The major innovation of this study consists in integrating an eDNA automatic sampler on a glider. This multi-instrument approach facilitates the collection of data on all trophic levels, from phytoplankton to top predators, allowing a holistic characterization of the ecosystem. The floating turbine will be equipped with similar biodiversity sensors. The expected outcomes include a comprehensive dataset on surface and underwater biodiversity as well as insights into the impacts of turbine installation. Information on the quantity, quality and accuracy of the data collected from mobile sensors compared to fixed sensors will be important to validate the approach. By leveraging autonomous vehicles and a multi-instrument approach, this research aims to provide a viable and efficient method for conducting environmental baseline studies and long-term biodiversity monitoring. The findings will contribute to supporting sustainable offshore wind farm projects.

WEDNESDAY 10TH SEPTEMBER – 10:30-11:30

IMPACT OF OFFSHORE WIND FARM LAY-OUT ON ECOSYSTEM FUNCTIONS

Mr Luka Jaksic[1]*, Mr Firmijn Zijl[1], Mr Leo Leummens[1], Ms Natalia Aleksandrova[1], Dr Thijs Van Kessel[1], Dr Lauriane Vilmin[1], Ms Sonia Heye[1], Dr Luca Van Duren[1]
[1] *Deltares*
*Corresponding author.

In recent years, monitoring and numerical modelling studies have indicated that large-scale implementation of offshore wind can have profound effects on fundamental ecosystem functions, such as primary production. The extraction of wind energy from the atmosphere and the interaction of turbine support systems with the ambient flow affect waves, currents, mixing and fine sediment dynamics. This in turn affects the light regime and the distribution of nutrients, the main drivers of phytoplankton growth. This research is a first exploration of mitigation options for such ecosystem effects.
Studies with ecosystem-scale models have indicated that impacts of offshore wind farms on stratification, fine sediment dynamics and primary production are strongly location dependent. It can also be expected that impacts will depend on the lay-out of wind farms; factors such as the size and density of turbines, the shape and size of the farm will impact their interaction with wind and currents.
With a state-of-the-art ecosystem model, we assess several lay-out options for a large search area. This area is located in the seasonally stratified part of the Dutch Exclusive Economic Zone. Results indicate that in this part of the North Sea, the presence of wind farms increases the amount of fine sediment in the upper water layer in the winter months, when the system is fully mixed. However, in spring, when stratifications sets in, the pycnocline becomes an effective barrier for fine sediment. Hence, in the growing season there is no extra light limitation due to increased SPM concentrations in the top layers, while dissolved nutrients are still penetrating the pycnocline easier that in the situation without wind farms. Therefore, the wind farm tends to boost primary production and depth-integrated concentrations of phytoplankton biomass. Near the water surface the changes in phytoplankton concentration are relatively minor. Near the bed, the increase can be up to 100%. Lay-outs with higher turbine densities tend to incur larger impacts. A lay-out with a gap in the centre of the farm but an equal number of monopiles has on average less effect, although the effect is not homogenously distributed over the wind search area.
Although the model still needs validation, it is based on sound understanding of physical and ecological processes. These models are currently used by policy makers to select optimal lay-outs in terms of environmental impacts and provide boundary conditions for developers tendering for these wind farms.

WEDNESDAY 10TH SEPTEMBER – 10:30-11:30

CAN NEW TECHNOLOGY & METHODOLOGY SUPPORT SUSTAINABLE ECOSYSTEM MONITORING IN AN OFFSHORE WIND FARM? THE SEAME PROJECT

Dr Petra Ringeltaube[1]*, Dr Umberto Binetti[1]
[1] RWE Offshore Wind GmbH
*Corresponding author.

The monitoring programs implemented to control the environmental impacts of offshore windfarm are traditionally focused on four broad receptor groups - mammals, birds, fish and benthos, which are usually analysed independently. However, according to the ecosystem-based approach and some recent environmental legislation, monitoring should shift from a species-centric focus towards an integrated and holistic view of the marine environment. The SeaMe (Sustainable Ecosystem Approach in monitoring the Marine Environment) project adopts a variety of new technologies to implement this comprehensive ecosystem approach within offshore wind farms, adopting sustainable and technologically advanced methods for simultaneous data collection and integrated data analysis.
Methodology:

- Artificial Intelligence (AI) based stationary underwater cameras will monitor fish and epibenthos, replacing trawling & grab sampling
- Environmental DNA (eDNA) sampling will be used to assess the composition of the local and regional biodiversity recording the presence of many more species than the few sentinel ones currently considered
- Drones equipped with AI-powered cameras will monitor marine birds and mammals instead of operators on planes and ships
- AI equipped cameras installed at foundations will observe migrating birds instead of scientists on planes, ships & radar systems
- An autonomous underwater vehicle (AUV) equipped with several sensors will measure physical and biological (plankton, currently not measured) parameters; the AUV will also monitor fish and benthos with an AI-based camera system for multidirectional measurements

The above mentioned technologies will be combined and used in parallel in monthly sampling campaigns, with some technologies (underwater stationary and foundations-attached cameras) permanently installed. Lastly, a specialized data management team will interpret and analyze all collected data, and make them publicly accessible through a dedicated portal developed specifically for SeaMe.
SeaMe responds to the commitments on biodiversity protection and conservation of the offshore wind industry. By collaborating in synergy with the asset monitoring crew responsible for maintaining the structures, SeaMe will avoid using additional ships or planes for monitoring activities. The crew transfer vessels (CTVs), which operate almost daily to transport technicians, will be used for environmental and asset monitoring simultaneously, helping reducing the monitoring CO2 footprint. SeaMe will also be non-invasive and will provide insights into how to measure net positive impact on biodiversity. The new monitoring system is cost effective and goes way beyond German governmental monitoring requirements and it allows for adaptive management. All data collected will be compared to the data received via the “traditional” monitoring approaches.

WEDNESDAY 10TH SEPTEMBER – 10:30-11:30

ASSESSING FISH DISTRIBUTION AND ENVIRONMENTAL DRIVERS IN THE WAKE OF AN OFFSHORE WIND TURBINE USING MULTI- INSTRUMENT SEABED LANDERS

Dr Julie Salvetat[1]*, Prof Beth Scott[2], Dr Juliane Wihsgott[3], Dr James Waggitt[4], Dr William Schneider[5], Ms Sophie Crouch[4], Dr Morgane Declerck[2], Dr Charlotte Williams[6], Dr Rory O'hara Murray[7], Dr Jeroen Van Der Kooij[8], Dr Benjamin Williamson[1]

[1] Environmental Research Institute, The University of the Highlands and Islands, [2] University of Aberdeen, [3] Plymouth Marine Laboratory, [4] University of Bangor, [5] Bangor University, [6] National Oceanography Centre, [7] Marine Directorate, Scottish Government, [8] CEFAS

*Corresponding author.

The expansion of offshore wind farms (OWFs) necessitates a deeper understanding of their ecological effects on marine ecosystems. As part of the ECOWind PELAgIO project, this study investigates fish distribution and environmental drivers in the vicinity of an OWF in the North Sea using compact seabed landers designed for long-term, across-season monitoring of prey availability. The landers, deployed at the Seagreen OWF in the Firth of Forth, Scotland, integrate a Simrad EK80 echosounder operating at 38 and 120/200 kHz simultaneously, alternating with a 500 kHz Acoustic Doppler Current Profiler measuring horizontal and vertical velocities. These acoustic instruments are complemented by a Conductivity-Temperature-Depth sensor and a fluorometer, which continuously record environmental conditions near the seabed. This persistent, high-resolution setup is designed to enable assessments of environmental shifts and their influence on fish behaviour across seasons.

Deployments in 2023 and 2024 investigated wake-driven environmental and biological changes. The lander was positioned 500 m downstream in the wind wake of a turbine at the edge of the OWF (May 2023), followed by a redeployment 50 m from the same turbine (August 2023) to assess distance-dependent effects. In 2024, two simultaneous deployments 500 m downstream—one in the wind wake and the other in the tide wake—allowed a comparative analysis of wake dynamics on fish vertical distribution.

Acoustic bi-frequency differencing allowed the classification of three fish echo categories: (1) swimbladder-bearing schooling fish (e.g., herring, sprat), (2) individual demersal fish (e.g., cod, haddock), and (3) swimbladder-less species (e.g., sandeels, mackerel), potentially coinciding with large zooplankton. By analysing alongside time of day, horizontal velocities, bottom-mixed layer temperature, salinity, oxygen, and chlorophyll-a concentrations, we identified key environmental drivers influencing fish vertical distributions near the OWF.

Initial findings highlight biophysical interactions occurring in turbine wakes and emphasize the need for persistent in situ monitoring to understand OWF-induced ecosystem changes. This study demonstrates the effectiveness of multi-instrument seabed platforms in capturing high-resolution biophysical processes, offering valuable insights into fish behaviour, habitat use, and prey availability in OWF-affected waters. The integration of physical and biological data provides a robust foundation for ecosystem-scale OWF impact assessments, crucial for sustainable offshore wind energy expansion and marine conservation strategies.

WEDNESDAY 10TH SEPTEMBER – 10:30-11:30

BOTTLENECKS IN RESTORING BIOGENIC REEFS AT OFFSHORE WIND FARMS

Dr Zhiyuan Zhao[1]*, Mr Christiaan Van Sluis[2], Prof Tjeerd Bouma[1]
[1] Royal Netherlands Institute for Sea Research (NIOZ), [2] The Rich North Sea
*Corresponding author.

Reintroducing habitat-supporting biogenic reefs as a nature-inclusive design for offshore wind farms holds promise for kickstarting marine biodiversity recovery. Here, we investigate the mechanisms underlying the successes and failures of reef restoration in offshore regions through a pioneering North Sea experiment aimed at reintroducing the nearly extinct native flat oyster at the Gemini wind farm at a depth of 32 meters. Combined in-situ and mesocosm studies revealed that reintroduced flat oysters can adapt to long-term changes in water quality, while restoration outcomes were primarily driven by short-term hydrodynamic and sedimentation events exceeding critical thresholds. Acoustic telemetry further validated the effectiveness of these quantified thresholds in interpreting observed losses, highlighting hydrodynamic-induced dislodgement and sedimentation-caused mortality as key bottlenecks. We therefore stress the importance of addressing short-term hydro-sediment disturbances, including their climate change-driven intensification, in restoration efforts targeting offshore wind farms and advocate for innovative restoration strategies to optimize success.

WEDNESDAY 10TH SEPTEMBER – 11:45-12:45

ACHIEVING A WIN-WIN FOR WIND ENERGY AND BAT CONSERVATION: A CASE STUDY OF ADAPTIVE MITIGATION STRATEGIES FROM A PORTUGUESE WIND FARM

Dr Luís Rosa[1]*, Dr Karina Amaral[1], Dr Sandra Rodrigues[1], Ms Sílvia Mesquita[1], Dr Miguel Mascarenhas[1]

[1] BE - Bioinsight & Ecoa

*Corresponding author.

Portugal aims to expand its onshore wind capacity by 73%, from 6 GW to 10.4 GW by 2030. This growth presents a critical opportunity to integrate mitigation measures to safeguard wildlife, particularly bats. This study highlights the importance of an adaptive management approach and long-term monitoring to achieve a win-win situation both for the conservation and economic point of view.

The 60 MW Bornes Wind Farm, situated in northeast Portugal, consists of 24 Nordex N90 (2.5 MW) turbines and was expanded in 2016 with the addition of five Senvion MM100 (2 MW) turbines, totalling 29 turbines. Post-construction fatality monitoring indicated that the expansion turbines accounted for 75% of the total fatalities, with a fatality 18 time higher than the remaining turbines (36.8 fatalities/turbine/year and 2 fatalities/turbine/year, respectively). Four common Mediterranean bat species - Pipistrellus pipistrellus, Tadarida teniotis, Hypsugo savii, and P. kuhlii - comprised 96% of mortalities. Fatality estimates were obtained using GenEst and Evidence of Absence estimators.

Over three years, despite an annual decrease in fatalities, the expansion turbines continued to show a 20-fold higher mortality rate than the remaining turbines. In response, the developer voluntarily implemented an adaptive management mitigation strategy beyond regulatory requirements, supported by bat activity studies. The mitigation strategy was implemented in three phases. First, a blank curtailment strategy was introduced with a 5.8 m/s cut-in speed from April to October at one high-risk turbine for testing purposes. The BACI analysis indicated a significant 90% reduction (95% CI: 85%–93%) in fatality rates compared to control turbines. However, energy production losses underscored the need for additional mitigation strategies. Second phase was the expansion on the curtailment to a second high-risk turbine, prioritizing biodiversity conservation. Third phase comprised the installation of a bat deterrent system in one turbine, resulting in 89% reduction in fatality rates (95% CI: 76%–95%) compared to control turbines. However, the overall decreasing fatality trend and only 2 years of monitoring for the after group was likely insufficient to provide statistical significance to this mitigation treatment.

The project demonstrates that testing curtailment and deterrents through an adaptive approach, wind energy expansion and biodiversity conservation can coexist while minimizing long-term financial losses. Bornes WF serves as a best-practice example for the Mediterranean Basin, illustrating how proactive and flexible measures can reduce environmental risks while ensuring a sustainable and responsible renewable energy future.

WEDNESDAY 10TH SEPTEMBER – 11:45-12:45

UNLOCKING SUSTAINABLE ONSHORE WIND ENERGY DEVELOPMENT IN THE EASTERN CAPE THROUGH EFFECTIVE MITIGATION IMPLEMENTATION

Mrs Andisiwe Xuma[1]*, Mr Alistair Mcmaster[2]

[1] Eastern Cape Department of Economic Develeopment, Environmental Affairs and Tourism, [2] Eastern Cape Department of Economic Development, Environmental Affairs and Tourism

*Corresponding author.

The Eastern Cape is a province in South Africa with some of the highest wind energy resources, it accounts for about 50% of the total wind energy generated in the country. Studies estimate that there is ample high resource in the high lying rural areas to enable generation of a further >20 GW of wind energy, but this restricted by grid capacity and the prevalence of endemic vulture species in areas that have been legally declared as Renewable Energy Development Zones (REDZs). A concerning number of vulture fatalities have been reported in the operational WEFs in the province and conservation agencies are continuously appealing the issuance of permits to allow further development of WEFs in and around the REDZs in the province. Some agencies have called for reconsideration of the REDZ by the authority and complete shutdown of WEFs in these areas until mitigation that has been proven to be effective in South Africa can be implemented.

Thus, the province is seeking to establish the WEFs and Vultures Sustainability programme, where the province will follow a balanced approach to meeting the socioeconomic development needs and environmental conservation objectives by upholding sustainable development principles by minimizing loss of species through implementation of effective mitigation measures.

The Sustainable Energy Unit within DEDEAT is currently investigating how to harness the exceptionally high usable wind resource areas through implementation of curtailment or Shutdown on Demand (SDOD). The analysis focuses on available wind resource in the Eastern side of the province and preliminary results show that wind energy can be cost effectively generated from these areas where wind speeds averages are around 8,5 m/s with the assumption that 10% of the turbines could be shut down for 10% of the time. Further analysis will also assess the % Revenue benefit for increased wind speed with shut down on demand.

Shut down on demand adds to other emerging mitigation measures such as blade painting which has been recommended by BirdlifeSA as well regional mitigation objectives. This shows that in the near future it will be possible for the Eastern Cape to unlock further WEF development without compromising on the survival of vulture populations. This will require embedding the acceptance and implementation of mitigation measures that have been proven to be effective globally. Funding to develop a clear, coordinated programme and system of regional mitigation objectives and implementation measures will be crucial for success.

WEDNESDAY 10TH SEPTEMBER – 11:45-12:45

EVALUATING THE APPLICABILITY OF AN AI-BASED COLLISION AVOIDANCE SYSTEM FOCUSING ON ECOLOGICAL AS WELL AS ECONOMIC FACTORS – A CASE STUDY FROM GERMANY

Mr Tim Steinkamp[1], Dr Marc Reichenbach[1], Mr Jürgen Holzmüller[2], Dr Sören Greule[3], Dr Hendrik Reers[3], Ms Johanna Grimm[3], Mr Vasco Jacke[4], Ms Eva Schuster[5]*

[1] ARSU GmbH, [2] 8.2 Ingenieurbüro Holzmüller, [3] OekoFor GbR, [4] e3 IDF GmbH, [5] Boulder Imaging Inc

*Corresponding author.

Since the German Federal Nature Conservation Act (BNatSchG) had been amended in 2022, collision avoidance systems became an acknowledged mitigation measure to protect birds prone to collision with wind turbines onshore. However, independent case studies are required that validate the system performance following a strict protocol. Until today only few systems have been approved. The number of permits stipulating the implementation of detection systems to protect certain target species are constantly increasing German-wide. This circumstance allows for the evaluation of the practicability of this mitigation technology focusing not only on the effectiveness to protect certain species but also accounting for a reliable estimation of the annual yield loss. Observing the economical aspect contributes to the reduction of investment uncertainty, therefore creates a higher level of acceptance amongst operators.

This presentation focusses on two studies that had been carried out recently (Steinkamp et al. 2025; Reichenbach et al. 2024).

Steinkamp et al. (2025) aimed for the development of a robust estimation approach to calculate annual yield losses, by focussing on the enhancement of a preexisting estimation model (Reichenbach et al. 2020). Previously made assumptions were replaced by substantial high-resolution data (e.g. IdentiFlight detection data, turbine operation data, site-specific wind data) as well as including various factors of influence (i.e. air pressure, wind potential, turbine characteristics, wind farm efficiency). A reference site then had been used for verification showing a high level of accuracy (deviation 2‰). Subsequently the model was applied to eight test sites for which curtailments to protect the red kite and/or the white-tailed eagle were carried out over a relatively long period of time (mean = 161 days).

The results show that even at locations with very high flight activity or with more than one target species, the expected yield losses stayed well below 2% of the annual production. Overall, the expected yield loss for all eight sites remained within the range of 0.16 – 1.55%.

The study shows that using collision avoidance systems can lead to minor loss in energy production and therefore accounts for an effective as well as efficient mitigation solution. However, applying high-precision AI-based species recognition becomes imminent. To further enable the efficient protection of an even broader spectrum of European bird species, a new neural network featured by IdentiFlight has been developed. The applied methodology as well as preliminary results of its validation will also be shown during the presentation (Reichenbach et al. 2024).

WEDNESDAY 10TH SEPTEMBER – 11:45-12:45

CUMULATIVE EFFECTS OF OFFSHORE WIND FARM SCENARIOS ON SEABIRDS IN THE SOUTHERN NORTH SEA - OPTIONS FOR MITIGATION THROUGH SITE SELECTION

Dr Verena Peschko[1]*, Dr Kai Borkenhagen[1], Dr Volker Dierschke[1], Prof Stefan Garthe[2], Dr Nele Markones[1], Dr Moritz Mercker[3], Mrs Henriette Schwemmer[1]

[1] Federation of German Avifaunists, [2] Research and Technology Centre (FTZ), University of Kiel, [3] Bionum GmbH

*Corresponding author.

Due to the current planning and approval process of large-scale offshore wind farms, seabirds worldwide are increasingly prone to interfere with OWF while foraging, resting and migrating at sea. In a preceding study, in which we applied a 'before–after control impact' (BACI) analysis, the cumulative effect of all operating OWF on the occurrence of six seabird species in the German North Sea has been investigated. A significant and strong avoidance behaviour was detected for northern fulmar (Fulmarus glacialis), razorbills (Alca torda), northern gannets (Morus bassanus) and common guillemots (Uria aalge). Blacked-legged kittiwakes (Rissa tridactyla) and lesser black-backed gulls (Larus fuscus) showed variable reactions depending on the season that reached from attraction to avoidance. In the current study we now aim to understand if and how recent OWF plans for the German North Sea may affect the occurrence of these seabird species in the future. To approach this question, we used the results of our previous studies in combination with the current German plans for OWF implementation on the known distribution of the seabird species in the German North Sea. For many of the studied species the distribution strongly overlaps with the areas of the planned OWF in the German North Sea. Thus, large parts of the individuals occurring in that area would be affected by the plans for future OWF implementation: Depending on the species and their respective avoidance behaviour, up to 80 % of the individuals occurring in the German North Sea would experience habitat loss. Species that are attracted to OWF would experience collision risk through the planned OWF. Applying different scenarios of future OWF implementation, we furthermore demonstrate that the predicted effect on seabird occurrence can be reduced by up to 50 % through the exclusion of the most sensitive areas for seabirds for OWF development. Our study hence illustrates the increasing pressure on seabirds by the implementation of the current German OWF plans and furthermore shows that the choice of the OWF planning areas can substantially mitigate the predicted effect on seabird species in the southern North Sea.

WEDNESDAY 10TH SEPTEMBER – 11:45-12:45

EVALUATING BIODIVERSITY ASPECTS OF WIND ENERGY DEVELOPMENT FOR ASSIMILATION INTO STRATEGIC ENVIRONMENTAL ASSESSMENT (SEA): A CASE STUDY OF JHIMPIR WIND REGION, PAKISTAN

Mr Osama Zulqurnain[1]*, Mr Farooq Ali Khan[2]
[1] Z5 Enterprise, [2] HESS Sustainability Consultant
*Corresponding author.

Wind farms are a sustainable energy source; however, they pose substantial risks to biodiversity, including avifaunal collisions, habitat disruption, and species displacement. In the Jhimpir wind region of Pakistan—a hotspot for expanding wind energy projects—these pressures impact local biodiversity through habitat changes, infrastructure-driven fragmentation, and cumulative anthropogenic impacts. Strategic Environmental Assessments (SEA) offer a framework to preemptively address such challenges by integrating biodiversity considerations into energy planning. This study evaluates biodiversity impacts of wind energy development in Jhimpir, focusing on land-use changes, habitat fragmentation, and linear feature mapping to inform SEA processes. Using QGIS, we digitized three wind energy infrastructure strips (natural habitat, wind turbine area, roads, vegetation, agricultural area, construction waste/reclamation area, and substations) for 2014 and 2024 and converted them into raster layers. The LecoS plugin analyzed these infrastructure patches within a matrix of dominant, unaltered natural habitat. Habitat fragmentation metrics (patch size, connectivity) and biodiversity indices (Shannon, Simpson, Evenness) were calculated to assess impacts on the natural habitat matrix."

Key findings revealed a 21.41-hectare decline in natural habitat, a 2.58-hectare impact of vegetation, and a 2.36-hectare reduction in agricultural land over a decade, driven by wind farm infrastructure expansion (roads, substations). Habitat fragmentation analysis revealed an increase in average and maximum infrastructure patch sizes, indicating progressive conversion of natural habitat to wind energy infrastructure. Biodiversity indices for natural habitat patches showed increased diversity (Shannon: +0.18; Simpson: +0.12) but declining Evenness (-0.09), signaling uneven species distribution due to edge effects and habitat changes. Linear features (e.g., access roads) averaged 12,229.81 meters per wind farm, creating corridors for invasive species and further fragmenting landscapes.

The study underscores the need for SEA to prioritize landscape-level biodiversity drivers in rapidly developing regions like Jhimpir. Recommendations include:

1. Threshold-based planning to limit habitat loss during wind farm expansion,
2. A biodiversity conservation fund for habitat restoration,
3. A centralized data repository to track cumulative impacts,
4. Monitoring protocols for priority species and invasive spread.
5. Conservations, Rehabilitation or offsetting of habitat impacts

By integrating these measures, policymakers can balance renewable energy goals with biodiversity conservation in ecologically vulnerable regions.

WEDNESDAY 10TH SEPTEMBER – 11:45-12:45

ACOUSTIC EXPOSURE AT WIND TURBINES REVEALS VARIATION IN BAT FATALITY RISK AND CURTAILMENT EFFECTIVENESS

Dr Trevor Peterson[1]*, Ms Seta Aghababian[1], Ms Caroline Byrne[1], Ms Sydney Edwards[1]
[1] *Stantec Consulting Services Inc.*
*Corresponding author.

Curtailing turbine operation when bats are active remains one of the most effective measures to reduce bat mortality at commercial wind energy facilities. With continued increases in wind energy production as part of the global transition to renewables comes a greater need to document how effectively curtailment strategies reduce risk across geographies and among species. Detailed feedback on curtailment effectiveness will be critical to agencies responsible for managing bat populations and will also provide useful feedback for wind energy facility operators seeking to manage risk. Carcass searches remain the most widespread method to evaluate bat fatality risk in the United States but are poorly suited for determining fatality reductions due to their coarse temporal feedback and uncertainty introduced by imperfect carcass detection, scavenger removal, and search area correction. Fatality-based curtailment studies also require designating a subset of turbines as an operational control, increasing overall risk to bats. More importantly, carcass searches do not have the sensitivity to detect subtle changes in fatality that may be associated with slightly different curtailment strategies. We used turbine-mounted acoustic bat detectors and results of concurrent standardized carcass searches over a two-year period at a pair of wind energy facilities in Missouri, United States, an area with high baseline bat fatality levels, to confirm the efficacy of acoustic exposure to turbine operation as a measure of bat fatality risk and demonstrate the usefulness of acoustic exposure as a sensitive and reliable indicator of curtailment effectiveness. Biweekly acoustic exposure levels and bat fatality estimates were highly correlated, corroborating previous studies, and acoustic exposure provided far more temporally precise measures of curtailment effectiveness than carcass searches. We also simulated how different curtailment alternatives would have performed across years and facilities; this ability to compare how different strategies would have performed under the same set of conditions could not have been accomplished using carcass searches. Our study, whose results are in press, demonstrated that curtailment strategies reduced acoustic exposure by a consistent relative proportion across biweekly intervals but showed that curtailment is most useful in terms of reducing cumulative exposure when applied during times of year when bats are most active. Detailed feedback on the tradeoffs between exposure reduction and energy loss provide a quantitative basis for tailoring curtailment strategies around facility-specific or regional patterns in bat activity, enabling increased production of renewable energy while maintaining risk to bats at acceptably low levels.

WEDNESDAY 10TH SEPTEMBER – 11:45-12:45

EVALUATING IMPACTS ON BIRDS FOR A BETTER REPOWERING OF WIND FARMS

Ms Cristina Acosta[1]*, Mr Eladio García De La Morena[2]
[1] BIODIVERSITY NODE SL, [2] BIODIVERSITY NODE
*Corresponding author.

Wind energy is one of the cleanest, most cost-efficient, and most widespread forms of renewable energy in Europe. However, the rapid growth of this sector has been controversial, particularly because of its impacts on wildlife collisions in certain regions, areas, or habitats.
The repowering of wind farms leaves the door open to reduce the impacts on biodiversity. Here, we propose a new methodology to assess the best locations for the new machines in a repowering process based on the collected bird surveys and mortality records during the environmental surveillance. This methodology considers the weighted conservation status, sensitivity, and previous collision of bird species to evaluate the more dangerous areas for wildlife. We used kernel density estimation with a bandwidth according to the diameter of the new turbines to map the more conflictive areas in the occupied area by the current wind farm.
Our results show five risk categories for bird species around the currently occupied space by the wind farm and the best places to set the new turbines and the avoiding areas.
This could be the first step to setting tools for advising the developers and stakeholders in their decisions of repowering of wind farms. Further research and validation of the model is necessary to determine the accuracy of this new methodology.

WEDNESDAY 10TH SEPTEMBER – 11:45-12:45

CHANGES TO PLANT COMMUNITY COMPOSITION IN WIND ENERGY LANDSCAPES

Mr Lukas Seifert[1]*, Dr Roel May[2], Dr Dagmar Hagen[2], Dr Bente Jessen Graae[1], Mr Audun Rugstad[1], Ms Katrine Sivertsen[1]

[1] Norwegian University for Technology and Science (NTNU), [2] NINA

*Corresponding author.

Onshore wind energy is expanding rapidly to meet renewable energy targets. While wind power plants have a relatively low carbon footprint, their land use requirements can be extensive, potentially affecting ecosystems in ways that are not yet fully understood. Beyond the direct removal of vegetation for roads and turbines, indirect effects such as soil compaction, altered hydrology, and shifts in species composition may contribute to long-term ecosystem degradation. However, research on these impacts remains limited, with most studies focusing on wildlife interactions rather than foundational ecosystem components such as vegetation, soil, and hydrology.

This talk presents findings from a study on how onshore wind energy development influences vegetation in Norwegian coastal ecosystems. Here, we examine the extent and duration of disturbance effects by studying vegetation structure and species composition at varying distances from turbines and roads.

We hypothesize that vegetation recovery depends on both the distance from wind power plant infrastructure and the time since disturbance, with ruderal species playing a central role in early recolonization. We assess the spatial extent of vegetation changes by measuring species composition shifts at increasing distances from roads and turbines. Additionally, we investigate whether the effects of wind energy development are particularly pronounced in stress-tolerant plant communities compared to those with lower stress tolerance. Finally, we assess whether proximity to roads has a stronger influence on vegetation change than other environmental filters.

We found that plant communities closer to roads exhibit a higher proportion of disturbance-tolerant species, while the proximity to turbines was less important. Vegetation cover of directly disturbed plots increased over time, but ruderal species remained dominant even 20 years after construction, indicating slow or incomplete ecosystem recovery.

A better understanding of these dynamics is key to balancing renewable energy expansion with ecosystem conservation. By identifying patterns and drivers of vegetation change, this research indirectly informs strategies to minimize ecological impacts and support ecosystem restoration. Ultimately, integrating ecological considerations into wind energy planning can help ensure its sustainable development.

WEDNESDAY 10TH SEPTEMBER – 11:45-12:45

OFFSHORE WIND FARMS AS PART OF THE 'MARINE SENTINEL AREAS' NETWORK:

Prof David Mouillot[1]*
[1] *University of Montpellier*
*Corresponding author.

Coastal ecosystems are affected by numerous direct anthropogenic pressures and climate change so the long-term monitoring of their biodiversity is crucial while rarely implemented. To address this scientific gap, French organizations, including the UMR MARBEC and CEFE research labs, the Agence de l'Eau Rhône Méditerranée Corse, and the companies SpyGen and EDF have collaborated to set up the 'Marine Sentinel Areas' network as part of the VigiLife international initiative. Since 2023, 13 Marine Sentinel Areas (MSA) strategically distributed across the different European maritime fronts of France are monitored annually using environmental DNA metabarcoding (eDNA) to detect fish and crustacean species. This non-destructive, standardized and highly efficient monitoring technology is ideal for assessing coastal biodiversity in complex environments, especially in the vicinity of infrastructures such as offshore wind farms. Each MSA is centered on an area of interest (marine reserve, wind farm, thermal discharge from a nuclear power plant, artificial reef, entry point for non-native species), and several water filtrations are carried out both inside and outside the core area to provide control and treatment samples. The objectives of this program are (i) to assess the influence of each area of interest on coastal biodiversity and its evolution over time, and (ii) to establish a network of sentinel areas to monitor the effects of climate change and the arrival of new species, as well as the effects of direct human pressures, on coastal ecosystem functioning on the long term. During the first two campaigns in 2023 and 2024, DNA copies of more than 140 fish species and 200 crustacean taxa were detected across the whole network. These preliminary results have contributed to update certain species geographic ranges, such as the salema porgy Sarpa salpawhich was detected more than 500 km north of their former known northern limit. Comparison of the eDNA samples collected inside and outside the Saint-Nazaire offshore wind farm reveals distinct communities of fish and crustaceans. Investigations within this offshore wind farm open up new avenues for refining sampling methods and interpreting results with respect to the dynamics of 'habitat' vs 'reserve' effects expected from offshore wind farms. Overall, the 'Marine Sentinel Areas' network is intended to become a permanent monitoring program, in particular by empowering local partners to carry out sampling autonomously. The network will also be extended towards other areas of interest in France, including overseas territories, but also abroad.

WEDNESDAY 10TH SEPTEMBER – 11:45-12:45

APPLYING A PVA TO THE CASE OF VULTURES IN KENYA. THE EXAMPLE OF KIPETO INTEGRATED WINDFARM AND CONSERVATION PROJECT USING THE EOLPOP PACKAGE

Mr Renald Boulnois[1]*, Mr Dominic Kimani[2], Mr Nicolas Carenton[1], Mr Dorian Chauvin[1], Mr Alexandre Thouzeau[1]
[1] Biotope, [2] Kipeto Energy
*Corresponding author.

The growth of wind energy in Kenya, driven by strong resources and renewable commitments, presents some challenges for biodiversity conservation. The country hosts globally threatened raptor species that could be affected by future wind energy development through collisions with wind turbines.
Population Viability Analysis (PVA) provides a way to assess the long-term population impacts of collision fatalities, either at a single wind farm or cumulatively. The EoIPop package has been designed to integrate demographic data and fatality estimates into a PVA model. We illustrate the use of this package for two species of Critically Endangered vultures at the Kipeto wind farm in Kenya, parameterizing the model using fatality rate estimates derived from on-site monitoring, and demographic data and gain predictions from Kipeto's 'net gain feasibility study' Kipeto implements observer-led shutdown-on-demand and carcase clearance to reduce collision risks for overflying vultures. Thanks to these actions, a very low vulture fatality number onsite is currently estimated, and expected to be outweighed by predicted gains from Kipeto's offsite anti-poisoning programme.
Rüppell's and White-backed Vulture populations are in decline globally, primarily due to poisoning. Literature indicates an annual survival rate decrease of -4.8% to -8.4% for Rüppell's Vulture and -2.5% to -5.4% for the White-backed Vulture (Ogada et al., 2016).
Our PVA results show that overall, the planned conservation action at the Kipeto wind farm are likely to contribute to slowing these vulture population declines and postponing the risk of extinction for several years.
Our findings show that concerted additional efforts from other actors are needed to prevent population collapse for both species in the long-term, and that they remain vulnerable to cumulative wind-farm impacts if these are not adequately mitigated. While showing the utility of EoIPop, the analysis also highlights the need for improved and updated demographic information on raptor species whose populations are vulnerable to wind energy impacts in Africa

WEDNESDAY 10TH SEPTEMBER – 11:45-12:45

ENHANCING OFFSHORE WIND IMPACT ASSESSMENTS: TRACKING KITTIWAKE CONNECTIVITY FOR IMPROVED APPORTIONING OF MORTALITY RISK

Mr Vance Mak[1]*, Dr Richard Sherley[1], Dr Alice Trevail[1], Prof Simon Neill[2], Mr Sion Roberts[3], Prof Stuart Bearhop[1], Dr Cat Horswill[4]

[1] University of Exeter, [2] University of Bangor, [3] The Crown Estate, [4] The Institute of Zoology

*Corresponding author.

Over the next decades, offshore wind energy will rapidly expand throughout the North Atlantic, playing a key role in net zero initiatives. To ensure sustainable development, offshore wind projects must comply with legal frameworks such as the Marine Strategy Framework Directive and Birds Directive. Impact assessments conducted as part of this compliance are required to quantify and mitigate potential negative effects, including seabird collision mortality. A key challenge is determining whether, and to what extent, affected seabirds originate from protected populations—a process known as apportioning impact. During the breeding season, apportioning methods typically rely on colony size and central-place foraging range. However, the wide-ranging movements of seabirds during the non-breeding season present significant challenges to applying this approach year-round. Current apportioning methods, such as NECR164 (Non-breeding season populations of seabirds in UK waters; BDMPS), which is the default apportioning method for the UK, are based on very large spatial scales which are treated uniformly, utilise data sources including those in which connectivity cannot be ascertained (i.e. seawatching, boat-based surveys), and are based on demographic and abundance data that are limited in quantity and resolution when compared to what is available today. This introduces uncertainty in estimating population-level impacts. To address this, we analysed global location sensor (GLS) tracking data from 1527 kittiwakes across 37 colonies in 10 jurisdictions over 14 years. Utilising this positional data in conjunction with population sizes of the colony and country of origins, we quantify the number of individuals within, and time-spent by the global kittiwake population in national exclusive economic zones (EEZs) as well as a 200km tessellated hexagonal grid. We further identify connectivity networks at a population scale, determining the origin of kittiwakes within those boundaries. Our findings indicate that most kittiwakes remain within national EEZs during the non-breeding season, as opposed to dispersing into the high-seas. In addition, some colonies show year-round residency. To support impact assessments, we provide an interactive virtual application and an open-access shapefile enabling users to identify breeding colony origins and estimate kittiwake distribution during the non-breeding season. This approach significantly reduces uncertainty in apportioning impact, improving the accuracy of mortality estimates and informing effective mitigation strategies for seabird conservation in offshore wind planning.

WEDNESDAY 10TH SEPTEMBER – 11:45-12:45

COMPARING ALGORITHM-BASED VERSUS ACOUSTIC-ACTIVATED SMART CURTAILMENT METHODS FOR MITIGATING BAT RISK WITH WIND ENERGY PRODUCTION

Mr Roger Rodriguez[1]*, Dr Virginia Iorio-Merlo[2], Dr James Robbins[2], Dr Gillian Vallejo[2]
[1] *EchoSense LLC,* [2] *Natural Power*
*Corresponding author.

Onshore wind farms reduce reliance on fossil fuels and help mitigate climate change, but can cause negative environmental impacts, including bat collisions with turbine blades. Curtailment of wind turbine operation using fixed wind speed thresholds is commonly adopted to reduce the collision risk posed by wind turbines to bats. However, this strategy may result in lost energy generation when no bats are present leading to considerable losses in overall energy output. Alternative curtailment strategies using acoustic bat presence data have been developed to increase energy generation, while maintaining bat fatality reduction at wind energy projects. One method, algorithm-based informed curtailment (ABIC), employs non-probabilistic or probabilistic correlative modelling using pre-existing bat acoustic data with environmental and weather data, and sometimes power production data to predict periods of low bat risk and maximal energy production indicating times when turbines may reasonably operate. A second method, acoustic-activated smart curtailment (AASC), combines real-time bat presence data with wind speed and temperature to curtail only when bats are detected at the site. AASC has demonstrated success in simultaneously achieving bat fatality reduction and increasing energy generation compared to blanket curtailment while research is ongoing to understand the effectiveness of ABIC in these respects. This study presents the first quantitative comparison of these two methods. Bat risk and operational time was estimated by simulating curtailment scenarios using bat acoustic and weather data collected from an existing windfarm. Several ABIC methods were used in the comparison, including non-probabilistic envelope approaches, and probabilistic machine learning predictions from boosted regression trees. The simulated AASC approach was based on the commercially available EchoSense system.
AASC resulted in significantly more operational time than the non-probabilistic and probabilistic ABIC methods, while having significantly lower bat risk compared to the probabilistic ABIC method but not compared to the non-probabilistic ABIC method. The AASC method also resulted in significantly higher operational time, while offering similar bat protection to industry-standard wind speed only methods. These results suggest that use of real-time data, compared to predictive algorithms, leads to increased efficiencies in energy production, especially given fine-scale temporal variation in bat activity. Nonetheless, both methods provide improvements over traditional curtailment, resulting in comparable, if not better, reduction in bat risk while enabling increased renewable energy production, thereby helping to address climate change and its impacts on bat populations. We will discuss these benefits as well as future developments of “intelligent curtailment” that combine both methods.

WEDNESDAY 10TH SEPTEMBER – 16:15-17:30

CHALLENGES AND LESSONS FROM THE BAJGORA WIND ENERGY PROJECT, THE LARGET IN THE REPUBLIC OF KOSOVA TO DATE

Ms Amra Vuçitërna[1], Mr Bledar Pulaj[1]*, Ms Sidorela Buzhala[2], Ms Hana Zeka[2], Mr Valmir Mustafa[2], Prof Behxhet Mustafa[1]

[1] University of Prishtina, [2] OZON Space L.L.C.

*Corresponding author.

The Bajgora Wind Farm, situated in the Kopaonik mountain range of Kosovo, was developed to enhance the country's renewable energy capacity and reduce dependence on fossil fuels. With an average annual wind speed of approximately 8 m/s, the site offers optimal conditions for wind energy production. Completed in 2021, Bajgora is Kosovo's second-largest wind farm, comprising 27 turbines with a total capacity of 105 MW. Financed by the European Bank for Reconstruction and Development (EBRD), the project aligns with national and European Union regulations, emphasizing environmental compliance, biodiversity conservation, and ecological impact mitigation, particularly concerning bird and bat populations.

A phased methodology was implemented to assess and mitigate environmental impacts. Baseline biodiversity assessments were conducted in 2018–2019, followed by pre-construction surveys (2020–2021) and post-construction (2022-2024) to evaluate ecological disturbances. Special focus was placed on monitoring bird and bat populations to track mortality rates and inform adaptive management strategies.

Field surveys identified several species and habitats of conservation concern, including critical habitat (CH) and priority biodiversity feature (PBF) species. To mitigate negative impacts, management plans, such as the Biodiversity Management Plan (BMP), were developed and implemented. Notably, Centaurea kotschyana Heuff. and Centaurea melanocephala Pančić were recorded for the first time in the area in early September 2021. For many PBF, CH, and other endangered species, measures such as habitat demarcation, translocation to safer locations, and continuous monitoring were applied—an approach unprecedented in Kosovo. Additionally, protected animal species, including Testudo hermanni Gmelin, and various ant nests, were relocated to undisturbed habitats to minimize construction impacts.

Monitoring confirms that the project area does not function as a migratory corridor for birds. However, post-construction assessments of bird and bat mortality remain essential to refine mitigation strategies.

While the project successfully integrates renewable energy development with biodiversity conservation, challenges persist. Extreme weather conditions and limited baseline data for certain species have hindered the full implementation of mitigation measures. These challenges highlight the need for continued ecological monitoring and adaptive management to ensure long-term sustainability. The Bajgora Wind Farm represents a significant step in Kosovo's renewable energy transition while underscoring the importance of balancing infrastructure development with environment protection.

WEDNESDAY 10TH SEPTEMBER – 16:15-17:30

EFFICIENT PROTECTION OF MIGRATING BATS AT OFFSHORE WIND TURBINES: RESULTS FROM AN 8-YEAR STUDY IN THE GERMAN SEA

Prof Christian Voigt[1]*, Mr Lothar Bach[2], Mrs Petra Bach[2], Mr Matthias Goettsche[3], Mr Michael Goettsche[4], Mr Reinhold Hill[5], Mr Henrik Pommeranz[6], Dr Volker Runkel[3], Mrs Antje Seebens-Hoyer[7]
[1] Leibniz Institute for Zoo and Wildlife Research, [2] Bach Freilandforschung, [3] freelance expert, [4] Faunistica, [5] Avitec Research GbR, [6] Büro Nachtschwärmer, [7] NABU Mecklenburg-Vorpommern
*Corresponding author.

Wind turbines pose a major threat to migratory bats, yet it is unclear whether bats are also at risk when migrating offshore. Since 2016, a consortium of nature conservation experts and wildlife biologists led by the German Nature and Biodiversity Conservation Union (NABU) has been investigating the occurrence of bats over the German North Sea and Baltic Sea, specifically in relation to their collision risk with offshore wind turbines. We carried out acoustic surveys at 14 offshore sites. We documented seven bat species migrating over the North and Baltic Sea, with Pipistrellus nathusii being the most abundant. Over both seas, bats were mainly encountered during spring migration (mid-April to mid-June) and late summer/autumn migration (early August to mid-October). Bats generally preferred wind speeds below 7 m/s (measured at 10 m above sea level). While migratory activity in the North Sea decreased with distance from the coast, intensive migratory movements took place across the entire Baltic Sea, yet with a higher activity in the western compared with the eastern part of the Baltic Sea. During offshore migration, bats showed intensive exploratory behaviour in relation to large structures, which could increase their collision risk with the rotating blades of turbines. Accordingly, appropriate measures should be mandatory throughout the Baltic Sea and in the extended coastal waters of the North Sea. In addition to optimal spatial planning and adjustments in the turbine design, the temporary shutdown of turbine operation during periods of high bat activity is key to achieving the legally required protection of bats. As bats only migrate when conditions are favourable, i.e. when there is little wind, and only for a limited period of time, restricting the operation of offshore wind turbines promises to be extremely effective in protecting bats with relatively little loss of revenue for the companies.

WEDNESDAY 10TH SEPTEMBER – 16:15-17:30

RETEX PROJECT: A LARGE-SCALE REVIEW OF ENVIRONMENTAL EFFECTS FROM EUROPEAN OFFSHORE WIND FARMS BASED ON REGULATORY MONITORING REPORTS

Mrs Pauline De Rock[1]*, Dr Florian Lecorps[1], Mrs Magali Sabino[1]
[1] *Biotope*
*Corresponding author.

The RETEX study was commissioned by the French Ministry of Energy, Ecology and the Sea for the French national observatory of offshore wind farms (OWFs), with the support of the French Office for Biodiversity (OFB) and IFREMER. The consortium in charge of this study was made up of Biotope and its partners BioConsult SH, HiDef Aerial Surveying, BRL Ingénierie and the Royal Belgian Institute of Natural Sciences (RBINS).
The objective was to conduct a large-scale review of environmental monitoring methods used during the construction and operation phases of OWFs, to identify reported environmental effects, the implementation of mitigation measures, and their effectiveness. The study focused on regulatory monitoring reports and grey literature from European countries, excluding peer-reviewed scientific literature.
A total of 514 documents were analyzed, primarily from the UK, Belgium, the Netherlands, Denmark, Germany, and Sweden. The availability of monitoring reports varied significantly between countries. Monitoring efforts were predominantly focused on the construction phase and the first three years of operation.
Seven biological groups were studied: birds, bats, marine mammals, plankton, fish, elasmobranchs, and benthos. Birds and marine mammals were the most extensively monitored, whereas bats and plankton were scarcely addressed. The BACI (Before-After-Control-Impact) design was the most common analytical approach, while the BAG (Before-After-Gradient) approach is emerging for mobile species with large ranges.
The synthesis of 288 documents from 35 OWFs revealed varying degrees of environmental effects across taxa. For birds, displacement and attraction effects were frequently reported, especially for gulls, cormorants, and gannets, though responses varied by species and site. Migratory birds were underrepresented due to limitations in standard monitoring techniques. For marine mammals, harbour porpoises generally showed displacement during construction, with a return during operation except in a few sites with intense maintenance. For grey and harbour seals, effects were inconsistent and mostly absent during the operational phase. Fish and benthic species monitoring suffered from methodological inconsistencies. When effects were observed, they often reflected attraction to OWFs due to reef effects, particularly in soft-bottom habitats. For benthos, some studies reported changes in community composition and biomass, occasionally linked to foundation type and local hydrodynamics. Biofouling was commonly observed, but few reports addressed non-indigenous species colonization. Plankton was the least studied group, with only one OWF providing inconclusive data.
A meta-analysis of regulatory monitoring reports has never been carried out at this scale before, and provides valuable information to the public and decision-makers.

WEDNESDAY 10TH SEPTEMBER – 16:15-17:30

20 YEARS OF IMPACT MONITORING ON SEABIRDS IN THE BELGIAN NORTH SEA: INSIGHTS INTO SPECIES- SPECIFIC RESPONSES TO WIND ENERGY DEVELOPMENT AND PROSPECTS FOR FUTURE RESEARCH

Dr Robin Daelemans[1]*, Mr Nicolas Vanermen[1], Mr Wouter Courtens[1], Mr Hilbran Verstraete[1], Mr Marc Van De Walle[1], Dr Eric Stienen[1]
[1] *Research Institute for Nature and Forest (INBO)*
*Corresponding author.

Over recent decades, the Belgian part of the North Sea has become increasingly important for wind energy development, raising concerns about potential impacts on seabirds. Understanding how seabirds interact with and respond to offshore wind farms is vital for balancing renewable energy goals with biodiversity conservation. Since 1992, the Research Institute for Nature and Forest (INBO) has been monitoring seabirds in the Belgian North Sea. Using standardized, internationally recognized methods—combining transect counts for birds on the water and snapshot counts for flying birds—our research has provided a robust framework for assessing seabird distributions. Since 2005, this monitoring framework has been applied to investigate seabird displacement in relation to wind farms.

Early monitoring methodology focused on individual wind farm sites surrounded by buffer zones, enabling Before-After-Control-Impact (BACI) analyses to detect displacement effects. However, the expansion of the Belgian wind farm concession zone has resulted in increasingly larger clusters of wind farms, reducing the effectiveness of buffer zones and requiring a shift in monitoring approaches. To address these challenges, we have adopted advanced statistical methodologies, including Integrated Nested Laplace Approximation (INLA), to analyse fine-scale spatial correlations in seabird distribution.

Initial findings from the updated monitoring approach largely align with results from previous analyses or from other regions. For instance, there are indications of attraction effects for great black-backed gull and great cormorant, while northern gannets appear to avoid the wind farms. Interestingly, initially strong avoidance by common guillemots is no longer observed, and also increased numbers of razorbills, northern gannets and terns have been noted between the turbines, although it remains unclear whether these patterns reflect habituation or changes in habitat suitability. In addition to displacement responses, the revised monitoring strategy also enables the assessment of disturbance distances and the influence of turbine density on seabird displacement.

Given the rapid expansion of offshore wind farm development in the North Sea, our monitoring approach aims to address critical knowledge gaps, guiding future planning decisions on wind farm configuration and minimizing potential impacts on seabirds. Furthermore, our findings highlight the need for continued innovation in monitoring and analytical techniques.

WEDNESDAY 10TH SEPTEMBER – 16:15-17:30

SEABIRD AND SEABED COMPENSATORY MEASURES FOR OFFSHORE WIND IMPACTS - LESSONS LEARNT FROM ENGLAND

Mr Martin Kerby[1]*, Ms Louise Burton[1]
[1] *Natural England*
*Corresponding author.

Since 2020, a number of offshore windfarms in the English North Sea have been required to develop compensatory measures under the Habitats Regulations to offset their impacts on protected seabird and seabed features of designated sites. With little precedent for compensation for impacts in the marine environment, this has proved a highly challenging experience for developers, nature conservation advisers and decision-makers, requiring flexible and innovative thinking.
As one of the Statutory Nature Conservation Bodies responsible for delivering offshore wind advice in UK waters, Natural England has been involved in multiple cases impacting species and habitats such as black-legged kittiwake and sandbanks. We have worked with industry, stakeholders and central government to bring forward meaningful compensation measures, including collaborative and strategic approaches.
The presentation will explore the legislative, governance and practical challenges that have been encountered with compensation measures for marine features, and the approaches explored, discounted and progressed. We will share examples of good practice and the lessons we have learnt, to assist other jurisdictions where there is the potential for compensatory measures to be required.
The presentation will also set out the emerging approach for an improved system in England, including the proposed Marine Recovery Fund, a government-led approach to delivering strategic compensation measures at scale.

WEDNESDAY 10TH SEPTEMBER – 16:15-17:30

HABITAT AND WIND FARM FEATURES DRIVE BIRD AND BAT MORTALITY, BUT CURTAILMENT MEASURES EFFECTIVELY REDUCE BAT FATALITIES

Dr Andreas Ravache[1]*, Dr Elise Sivault[2], Mr Brice Normand[3], Dr Christian Kerbiriou[1]

[1] Centre d'Ecologie et des Sciences de la Conservation (CESCO), Muséum national d'Histoire naturelle, Centre National de la Recherche Scientifique, Sorbonne Université, Paris ; Station Marine, Concarneau, France, [2] Centre d'Ecologie et des Sciences de la Conservation (CESCO), Muséum national d'Histoire naturelle, Centre National de la Recherche Scientifique, Sorbonne Université, Paris, France, [3] Bureau d'études Ouest Am' SCOPE-SA, 1 rue des Cormiers, 35651 Le Rheu, France

*Corresponding author.

While wind energy production is a key strategy to meet rising energy demands while reducing greenhouse gas emissions, it also presents ecological challenges, leading to a complex green-green dilemma. The direct and indirect impacts of wind turbines on flying fauna have been documented for several decades and were shown to vary considerably across space and time. Bird and bat fatalities, typically estimated through post-construction mortality monitoring at wind farms, can significantly impact their populations.

By compiling data from over 1,200 surveys conducted in France following a standardized protocol and using the most robust mortality estimator, the APOCOPE project aims to identify the factors driving bird and bat fatalities at wind farms. Species were grouped using clustering methods based on their functional traits to estimate mortality within each group. Generalized linear mixed models helped disentangle the underlying mechanisms driving mortality of each group. Our results indicate a significant effect of wind farm characteristics (e.g., turbine height, ground clearance, and power) and surrounding habitat on mortality rates, enabling the formulation of recommendations for wind farm planning.

Additionally, our project assessed the effectiveness of mitigation measures aimed at reducing bat mortality. These measures rely on passive acoustic monitoring to establish wind speed and temperature thresholds under which turbines are halted at night. A before-after impact study revealed a substantial reduction in bat fatalities, with decreases of up to 88% for long-range echolocators, demonstrating the effectiveness of such strategies. We also estimated the indirect benefits for nocturnally migrating birds.

WEDNESDAY 10TH SEPTEMBER – 16:15-17:30

TEAM WORK MAKES THE DREAM WORK - ECOLOGICAL RESTORATION AT CLOCAENOG FOREST WIND FARM IN NORTH WALES, UK

Mrs Kristen Liptrot[1]*
[1] *RWE*
*Corresponding author.

RWE's Clocaenog Forest Wind Farm is located within Clocaenog Forest, Denbighshire and Conwy, in North Wales, and is located on land owned by Welsh Government and managed by Natural Resources Wales (NRW). It consists of 27 turbines, at 145m tip height, each of which is located within a 'keyhole' in the forest. As part of the consent for the Wind Farm, RWE committed to the implementation of substantial ecological restoration measures, identified within a detailed Habitat Management Plan (HMP). Implementation of the HMP commenced in 2020, and has since included a range of measures which aim 'to complement existing conservation initiatives within Clocaenog Forest, but which are additional to habitat management prescriptions currently being implemented at the site'. This includes the aim to restore ~130ha of heathland and native woodland habitat, which has reignited two previous ecological projects within the wider landscape. As well, the HMP aims to restore of ~20ha of peatland habitat and ~17ha of habitat managed specifically for the Hazel dormouse Muscardinus avellanarius. Monitoring to determine the success of the heathland, woodland and peatland restoration is underway, and surveys are ongoing for rare species, including Nightjar Caprimulgus europaeus, Black grouse Lyrurus tetrix, and Hazel dormouse. RWE funded a successful PhD from Exeter University on various aspects of Hazel dormouse ecology, the findings from which should benefit dormouse conservation elsewhere in North Wales and beyond. RWE work closely with Clocaenog Red Squirrels Trust, and contribute an annual donation to this charity working to protect the Red squirrel Sciurus vulgaris in Clocaenog Forest via habitat enhancement, reintroductions and public education/engagement. The HMP areas have all been restored by a local contractor and his team, and will be managed for the 25-year lifetime of the Wind Farm, largely via grazing by his herd of hardy upland cattle. The implementation of the HMP is overseen by an HMP Stakeholder Group, which exists to review management actions and monitoring results. This group consists of three main parties in a decision-making capacity, including RWE as the chair, NRW (the Landowner and Statutory Nature Conservation Body) and the Local Planning Authorities. However, other attendees contribute to the Group, including consultant ecologists, contractors, local volunteers and academics. The spirit of the Group is one of exemplary collaboration and working together towards positive results for nature, by adapting the HMP and updating objectives in order to reflect current conditions on site to thus deliver maximum benefit.

WEDNESDAY 10TH SEPTEMBER – 16:15-17:30

SEABIRDS AND FISH DISTRIBUTIONS AND BEHAVIOUR: UNDERSTANDING PREDATOR-PREY INTERACTIONS TO BUILD EVIDENCE FOR CUMULATIVE IMPACT ASSESSMENT

Dr Esther Jones[1]*, Dr Katherine Whyte[1], Dr Phil Bouchet[2], Dr Thomas Regnier[3], Dr Charlie Cooper[3], Dr James Dunning[3], Dr Ana Couto[1], Dr Kate R. Searle[4], Dr Christopher Pollock[4], Prof Francis Daunt[4]
[1] Biomathematics & Statistics Scotland, [2] Bioinformatics and Statistics Scotland, [3] Marine Directorate, Scottish Government, [4] UK Centre for Ecology & Hydrology
*Corresponding author.

Seabird foraging may be altered by displacement from key habitat and/or redistribution of prey due to offshore wind farm (OWF) developments and other anthropogenic pressures. To build a strong evidence base, it is vital to understand the dynamic predator-prey interactions that underpin these behaviours, although historically it has been challenging to collect data at appropriate spatial and temporal scales. The Offshore Wind and Evidence Change Programme funds the Predator and Prey Around Renewables Energy Developments (PrePARED) project, which is currently collecting concurrent data on seabirds and fish in the Firth of Forth off the east coast of Scotland. The project is utilising developer-funded GPS tags on kittiwakes, guillemots, razorbills, puffins, and gannets to collect information on seabird distribution, movement and behaviour concurrently with boat surveys collecting prey (gadoids, sandeels, clupeids) data using fisheries acoustics, demersal and pelagic trawls, as well as in situ measurements of environmental variables.
Using time series of fish distribution data collected at a regional scale, we seek to understand how environmental drivers (e.g., temperature, depth, seabed type) define broad-scale fish distributions in a "baseline" scenario (i.e. independent of OWFs). Using data collected at a finer scale within and near OWFs, we seek to understand how they may affect fish distributions. The knowledge gained from these approaches is then considered to assess the extent to which fish distributions affect seabird distributions and movements in both scenarios.
Species interactions are being studied to characterise predator-prey relationships, examine how they may alter in the presence of OWFs, and incorporate this new quantitative information into impact assessment tools. We demonstrate how we are improving the understanding of seabird drivers of movements and foraging behaviour by developing approaches that account for varying spatial, temporal, and ecological scales, and improving our ability to predict seabird movements. Using seabird tracking and prey information in a novel modelling framework we are producing (i) behavioural classifications to improve simulations of seabird foraging tracks in individual-based models (e.g. SeabORD), (ii) key metrics of predator-prey interactions that will increase the realism in simulations, and (iii) predict seabird distributions informed by prey, including uncertainty estimates to help develop improved EIA tools. To build a widely usable evidence base, we are also evaluating the extent to which estimated relationships are transferrable to other regions, improving the application of tools to new regions through more mechanistic understanding of how key processes are influenced by environmental context.

WEDNESDAY 10TH SEPTEMBER – 16:15-17:30

MARINE MAMMAL FORAGING ACTIVITY AT OFFSHORE WINDFARM SITES: DO CHANGES IN PREY FIELDS INFLUENCE MARINE MAMMAL RESPONSE TO DISTURBANCE?

Dr Aude Benhemma-Le Gall[1]*, Prof Paul Thompson[2], Mr Sam Gierhart[3], Dr Matthew Witt[3], Dr Barbara Cheney[2], Dr Anthony Bicknell[3]

[1] 2. University of Aberdeen, School of Biological Sciences, Lighthouse Field Station, Cromarty, Ross-shire, IV11 8YJ, Scotland, UK, [2] University of Aberdeen, School of Biological Sciences, Lighthouse Field Station, Cromarty, Ross-shire, IV11 8YJ, Scotland, UK, [3] University of Exeter

*Corresponding author.

Given rapid expansion in the offshore wind energy sector, a better understanding of potential ecological effects of offshore windfarm clusters on protected marine species is required to optimise future sustainable developments. On one hand, increased levels of anthropogenic disturbance associated with offshore windfarm construction, operation and maintenance activities may lead to animals temporarily leaving disturbed areas, potentially increasing their energy expenditure. On the other hand, installation of man-made structures into the marine environment may, over time, enhance prey availability, potentially increasing foraging performance of marine top predators. This study forms part of the PrePARED (Predators and Prey Around Renewable Energy Developments) project and aims to assess whether changes in prey fields within and around offshore windfarm sites influence harbour porpoise responses to disturbance.

In August 2022, an array of 64 echolocation click detectors (CPODs) was deployed within and around two operating offshore windfarms, in NE Scotland, to monitor harbour porpoise occurrence and behaviour. Parallel studies using baited remote underwater video systems (BRUV) estimated biomass of the most abundant fish species groups. To describe habitat quality around each CPOD site, data on prey availability and porpoise foraging activity were summarised, and levels of windfarm related vessel traffic were characterised using AIS-vessel tracking data. Echolocation click detections and presence of buzzing activity (a proxy for foraging) were extracted to estimate times to first harbour porpoise acoustic detection (or buzz) following close approaches by crew-transfer vessels (CTV). The extent of behavioural response following exposure to CTVs was then compared between sites of varying habitat quality.

Overall, harbour porpoise responses to CTV approaches were lower outside compared to inside operating windfarms. Following CTV passages, times to first acoustic detection and first buzz increased at sites with higher levels of vessel density but decreased at sites with higher foraging activity. These preliminary findings suggest that porpoise levels of response to disturbance may be mediated by prey availability and predictability.

As man-made structures of operating offshore windfarms may, over time, act as artificial reefs and become more attractive to predators, animals may decide to remain or return to areas with higher levels of exposure to disturbance but with increased foraging opportunities. This study highlights the value of integrating empirical data on prey fields and anthropogenic activities to better understand the long-term cumulative effects of commissioned windfarms and inform effective decision-making towards sustainable offshore wind energy development.

WEDNESDAY 10TH SEPTEMBER – 16:15-17:30

NATURE-FRIENDLY DECOMMISSIONING OF OFFSHORE WIND FARMS: CHOOSING THE BEST PATH FOR MARINE LIFE

Mr Pim Somers[1]*, Mrs Anne-Mette Jørgensen[2], Ms Sophie De Reus[1]
[1] North Sea Foundation, [2] Eco-Effective Strategies
*Corresponding author.

While new wind farm deployments have been in the spotlight, the decommissioning of offshore wind farms (OWFs) at the end of their lifecycle has received little attention. What are the environmental challenges posed by OWF decommissioning options?
Challenges stem from the lack of practical experience in decommissioning, from the potential impacts of decommissioning on marine life and the need for circularity. Though a growing suite of research suggests that partial removal may be the best option for marine nature, CO2-emissions and costs, current regulations in many countries demand the complete removal of all infrastructure after the operational phase, requiring the seabed to be restored to its "original" state. This approach may nullify any nature-inclusive design efforts applied within wind farms. The challenge lies in finding the right balance between protection of ecological values developing within wind farms versus facilitating circularity and future uses of the sea.
In the Nature-friendly decommissioning project, a collaboration between the North Sea Foundation, Natuur & Milieu, EBN, NedZero, NexStep, TenneT and ElementNL, we explore how to create policy-space to permanently leave nature-enhancing man-made structures in place in the Dutch North Sea for the benefit of underwater biodiversity. Based on clear ecological standards and requirements and without creating a precedent that would undermine the general principle of full removal of disused offshore installations.
In order to develop a set of criteria for evaluating the ecological aspects of OWF decommissioning scenarios, we performed a literature study, stakeholder interviews and an expert workshop. Key questions included: How can ecological values be quantified? Which species are 'valuable' and when is a valuable species abundant enough to warrant leaving a parts of a man-made structure in place?
Having developed preliminary criteria, we tested these in a number of case-studies. The set of criteria provide an overview and can aid in the development a flowchart for assessing the ecological value of man-made structures. The resulting scores can help decision-makers determine which decommissioning scenario is best for marine life.
The discussion around decommissioning is highly complex, particularly regarding its environmental aspects. Quantifying the ecological impact around OWFs is a significant challenge. We have initially focused on species relevant for marine protection and restoration policies in the criteria we proposed, but this is work in progress that should be further developed to better include broad ecosystem functioning, where possible. Lessons learned and new experiences must be continuously incorporated.

WEDNESDAY 10TH SEPTEMBER – 16:15-17:30

NATURE-INCLUSIVE DESIGN IN OFFSHORE RENEWABLE ENERGY: ADVANCING SUSTAINABILITY THROUGH INNOVATION

Ms Yuki Esser[1]*, Ms Minja Mihajlovic[1]
[1] *Dutch Marine Energy Centre*
*Corresponding author.

Research Motivations and Objectives
The integration of Nature-Inclusive Design (NID) in offshore renewable energy projects has become a key strategy to enhance marine biodiversity while ensuring sustainable energy production. However, the concept remains broad, with varying definitions and interpretations across stakeholders. This study aims to define NID more clearly, assess its effectiveness, and explore its role in regulatory frameworks such as non-price criteria (NPC) in offshore wind tenders. Additionally, it seeks to identify pathways for scaling NID and improving collaboration between industry, policymakers, and environmental organizations.

Methodology
The findings presented are based on discussions from the DMEC NID Conference, held in September 2024, which brought together leading experts from academia, industry, and policy sectors. The conference focused on themes such as offshore wind development, ecosystem impact mitigation, NID scalability, and environmental monitoring. Insights were synthesized from expert panels, interactive discussions, and case studies that showcased practical applications of NID measures across various European projects.
Summary of Results
The conference highlighted the evolving understanding of NID, from fundamental environmental impact reduction techniques to proactive biodiversity enhancement strategies. The discussion revealed that while regulatory incentives like NPCs promote the adoption of NID, industry-driven initiatives also contribute significantly. The lack of standardized evaluation metrics remains a challenge, as most projects are still in early stages and long-term ecological monitoring is required. Successful implementation depends on improved regulatory alignment, cross-border collaboration, and data sharing frameworks. The role of spatial and quality measures, such as species protection plans and investment funds, was emphasized as key components in achieving a healthier North Sea ecosystem.
Conclusion
The urgency of implementing NID in offshore renewable projects was a key takeaway from the conference. While uncertainties remain, taking immediate steps to integrate NID at scale is crucial to balancing energy production with ecological sustainability. Enhancing collaboration between regulators, industry stakeholders, and environmental groups will be essential for mainstreaming NID measures. Long-term monitoring programs and standardized evaluation frameworks should be prioritized to ensure the effectiveness of these measures. The future of NID will depend on a combination of regulatory support, industry leadership, and scientific advancements in nature-positive infrastructure design.

WEDNESDAY 10TH SEPTEMBER – 16:15-17:30

ESTABLISHING BASELINES OF BALEEN WHALE MOVEMENTS IN THE NEW YORK BIGHT, U.S., THROUGH SATELLITE TELEMETRY

Ms Sarah Trabue[1]*, Dr William Cioffi[2], Mrs Carissa King-Nolan[1], Dr Melinda Rekdahl[1], Ms Viola Panigada[3], Prof Douglas Nowacek[3], Dr Brandon Southall[2], Dr Howard Rosenbaum[1]
[1] Wildlife Conservation Society, [2] Southall Environmental Associates Inc, [3] Duke University
*Corresponding author.

Offshore wind (OSW) is an emerging industry in the United States, with several recently constructed windfarms already delivering clean energy and other forthcoming projects along the East Coast. In the New York Bight (NYB), construction will begin in spring 2025 for the first offshore wind energy area (WEA) being developed in the region. Several baleen whale species, including fin (Balaenoptera physalus), humpback (Megaptera novaeangliae) and North Atlantic minke whales (Balaenoptera acutorostrata acutorostrata), have been documented and studied within the NYB. Baseline data on how these federally-protected whales utilize habitats within this region is needed, particularly given the ongoing unusual mortality event (UME) for humpback and minke whales and the endangered status for fin whales. Furthermore, this information is essential for informing regulatory and management decisions, including science-based assessments of potential impacts from OSW. To better understand these movements, 16 SPOT (location) and SPLASH10 (location and depth) tags were deployed, though only 15 returned data. Eight tags (one SPOT and seven SPLASH10; duration range: 4-78 days) were deployed on fin whales, six tags (four SPOT and two SPLASH10; duration range: 0-7 days) on humpback whales, and two SPLASH10 tags on minke whales (duration range: 15-50 days). These tags yielded the first record of minke whale movements around the NYB and the first dive record for minke whales in the northwest Atlantic. Movements were characterized into area restricted search (ARS) or transit using a multi-scale straightness index, with ARS documented for all three species, suggesting that these animals were foraging within the NYB. Most tagged humpbacks remained within the general area they were tagged; however, over the course of a week, one humpback traveled between inshore (<10 km from shore) and offshore (>10 km from shore) waters, crossing major shipping lanes and several WEAs. Transitory behavior through the NYB was also documented from one fin whale and one minke whale. Additionally, both fin and minke whales showed a distinct diel trend in diving behavior, with deeper dives during the daytime compared to night, which may reflect prey behavior (e.g., sand lance availability in the water column during the day). Overall, these results indicate that all three species utilize NYB waters including WEAs and shipping lanes for at least one critical behavior (i.e., foraging), contributing needed information to manage risks to these cetaceans, including ship strikes.

WEDNESDAY 10TH SEPTEMBER – 16:15-17:30

SPECIES-SPECIFIC TEMPORAL PATTERNS OF BAT MORTALITY AT AUSTRALIAN WIND FARMS WITH RECOMMENDATIONS FOR INDUSTRY

Dr Stevie Florent[1]*, Ms Emma Bennett[2], Dr Elizabeth Stark[3], Mr Alex Jackson[3], Dr Julia Ryeland[3]
[1] University of Canterbury, [2] Elmoby Ecology, [3] Symbolix Pty Ltd
*Corresponding author.

Expansion of the renewable energy sector is critical to minimise and eventually stop anthropogenic climate change; however, wind farms pose a green-green dilemma as they adversely affect wildlife through turbine collisions. Bats are particularly susceptible, with fatalities in the hundreds of thousands per year in the USA and Canada alone. This fatality rate is unsustainable, with Northern Hemisphere evidence indicating common species that are frequently killed may be driven to extinction. Bats are an essential part of the native mammal assemblage and play an important role in agricultural pest-control, but the paucity of studies on bat-wind turbine interactions in Australia mean the consequences of any turbine collision-driven population impacts are unknown.
Curtailment, the operational restriction of turbines during periods of high bat activity, is an effective means of reducing collisions but does require productivity downtime; however, incorporating collision risk data can minimise both economic and ecological losses. We investigated the temporal patterns of bat fatalities on wind farms across Australia using an expansive multi-year mortality survey dataset to assess periods of collision risk to inform effective curtailment strategies. Our preliminary results align with Northern Hemisphere studies, highlighting distinct periods of the year when curtailment will be most effective. We will present benchmark per-turbine values for key species and taxa to highlight the species most at risk in Australia and compare that to the global context. With installed wind energy in Australia growing on average 15.4% per annum, ecologically informed curtailment strategies are key to reconciling wildlife-turbine fatalities. Given the rapid expansion of renewable energy, adopting policies of sustainable development for wind turbines to minimise wildlife conflict is critical to achieve global nature positive objectives.

WEDNESDAY 10TH SEPTEMBER – 16:15-17:30

TESTING THE EFFICACY OF AN AUTOMATED DETECTION AND AUDIO DETERRENCE SYSTEM TO REDUCE COLLISION RISK FOR GOLDEN EAGLES

Dr Shilo K. Felton[1]*, Dr Jeff Smith[2], Dr Scott Terrill[2], Dr Taber Allison[1]
[1] Renewable Energy Wildlife Institute, [2] H. T. Harvey & Associates
*Corresponding author.

Reducing Golden Eagle collision risk poses a serious challenge to the successful development and operation of wind energy in the western U.S. As a potential solution to this challenge, DTBird® is an automated detection and audio deterrent system intended to discourage birds from approaching spinning wind turbines. We evaluated DTBird's efficacy for Golden Eagles at two commercial facilities in California and Washington, conducting 1) in situ behavioral studies of eagles and soaring raptors in response to the DTBird system and 2) flight trials with UAVs to evaluate the system's detection capabilities. The Goodnoe Hills research uniquely incorporated a two-year field experiment that afforded opportunities for distinguishing between the effects of spinning turbines alone (control group) versus spinning turbines plus DTBird audio deterrents (treatment group) in discouraging eagles from approaching the RSZ of spinning turbines. The overall estimated probability of detection was similar at the two sites (64–66%), though sun positioning influenced overall detection probability, while UAV flight speed, angle, and model, cloud cover and site influenced the system's detection distance. The behavior study revealed the following trends relative to raptor responses 1) lower for all analyzed species groups at the Washington facility; 2) positive relationship with wind speed for eagles and vultures, but a negative relationship for smaller buteos; and 3) mostly highest for birds at medium risk rather than at high risk. The presumed effective deterrent responses for Golden Eagles was 79% at the California site and 61% at the Washington site. The Washington experiment further revealed the addition of audio deterrents generally at least doubled the probability of effective deterrence compared to spinning turbines alone. These final results pointed to noteworthy differences in the apparent effectiveness of the DTBird deterrence system in different landscape settings, for undetermined reasons but with species and wind-regime differences potentially important. Despite complications, the indicated relationships can help future system users understand the environmental conditions in which DTBird and similar automated systems are likely to perform best and other factors that can substantially influence the targeting accuracy of such systems.

WEDNESDAY 10TH SEPTEMBER – 16:15-17:30

MAPPING AVIAN SENSITIVITY IN A SEEMINGLY HOMOGENEOUS DESERT LANDSCAPE: A CASE STUDY FROM EGYPT

Ms Bruna Arbo-Meneses[1]*, Dr Larissa Biasotto[1], Dr Bethany Clark[1], Dr Khaled Mohamed[2], Ms Nadia Sherif[2], Dr Simon Sanghera[1], Ms Catha Auchincloss[1], Mr Tris Allinson[1]
[1] BirdLife International, [2] Nature Conservation Egypt
*Corresponding author.

Expanding renewable energy infrastructure is crucial for ending our reliance on fossil fuels. However, if not planned considering nature, it can pose significant risks: inappropriately located and poorly designed energy infrastructure can significantly impact biodiversity, particularly birds. Achieving a nature-safe energy transition requires adherence to the mitigation hierarchy and integrating biodiversity data early in the planning process. As a result, we increasingly regard avian sensitivity maps as an essential precursor to large-scale renewable energy expansion. Here, we present a detailed assessment of avian sensitivity to wind farms in Egypt, which is promising for renewable energy expansion both onshore and offshore. Egypt is also part of the East African-Eurasian bird flyways, one of the world's most important routes, playing a fundamental role in conserving hundreds of residents and migratory birds. We followed BirdLife's AVISTEP framework for mapping the Avian Sensitivity for Energy Planning, adding methods to consider a main bird migratory corridor and the Egyptian arid desert specifics. Our approach consisted of identifying priority species through a multi-criteria sensitivity index (SI), mapping species occurrence probabilities and weighted by species' SI, creating a cumulative species map, including other sensitive areas, and categorising resultant sensitivity to produce a final map. When mapping species distribution, we used area of habitat maps, mapped passage areas of migratory birds, and the potential migratory corridor based on bird tracking data. We also added a water incidence layer summarising annual precipitation and months when water is present. We identified 65 species most likely affected by wind facilities. Steppe Eagle (Aquila nipalensis), Egyptian Vulture (Neophron percnopterus) and Lappet-faced Vulture (Torgos tracheliotos) were the top priority species. Overall, the entire eastern coast of Egypt, along with the Red Sea, was classified as very high and high sensitivity, flagging the relevance of this region for birds. Decision-makers and other stakeholders can use the map to avoid the most significant areas for biodiversity, with sensitivity categories guiding landscape prioritisation. Low-sensitivity areas may be unsuitable when investigated. Similarly, there may be circumstances when appropriate mitigation can allow the installation of wind farms with less impact on birds outside of low-sensitivity areas. However, this will become more challenging as the area's sensitivity increases. This case study demonstrates that meaningful patterns of avian sensitivity can be detected in seemingly homogeneous landscapes, such as the arid deserts that predominate in Egypt, suggesting that there are no barriers to expanding these techniques to similar landscapes globally.

WEDNESDAY 10TH SEPTEMBER – 16:15-17:30

ACOUSTIC MONITORING OF BATS IN THE PACIFIC OCEAN USING AN UNCREWED SURFACE VEHICLE

Mr Donald Solick[1]*, Mr Michael D. Whitby[2], Mrs Bethany Schulze[3], Mr Robert Hamilton[4], Dr Rafael Ramos[4], Dr Trevor Peterson[5], Ms Jessie Bunkley[2], Dr Gabriel Reyes[3], Ms Caroline Byrne[5], Mr Christian Newman[1]

[1] EPRI, [2] Bat Conservation International, [3] United States Geological Survey, [4] Woods Hole Group, [5] Stantec Consulting Services Inc.

*Corresponding author.

The United States intends to install 30 gigawatts of offshore wind energy by 2030. Wind turbines on land are a major source of mortality for North American bats. Bats are known to occur over the open ocean, and little is known about bat occurrence off the Pacific coast of North America. The impact to bat populations from offshore turbines is unclear but given the rapid development of offshore wind energy and the potential for bat mortality there is much interest in learning more about the timing and occurrence of bats over the open ocean to assess their risk and reduce mortality. We used Saildrone, an uncrewed surface vehicle designed to navigate open water, to monitor for bats off the coast of Southeast Farallon Island, California. The wind-propelled, solar-powered craft was programmed to follow a path that circumnavigated the southern half of the island for 30 nights. We attached an SM4 bat detector at 6 meters and programmed it to record bat echolocation calls. Recordings were manually reviewed by an expert to determine species. The Saildrone recorded 793 bat passes representing four species. Ninety-three files (13.3%) contained more than one individual. Hoary bats (*Lasiurus* cinereus; 32.0%) and Mexican free-tailed bats (*Tadarida* brasiliensis; 18.0%), two of the main species killed at wind turbines--comprised most recordings. Bats were recorded on 60,0% of nights, with an average activity rate of 26.5 passes per night. This activity was much greater than expected. Most calls had high bandwidth, indicating close approaches to the Saildrone. In-situ weather parameters recorded by Saildrone were used to model oceanic bat activity. The relatively high activity and echolocation call characteristics suggest that bats were attracted to the Saildrone, which may make this vehicle ideal for evaluating how bats might react to other novel structures at sea, such as wind turbines.

WEDNESDAY 10TH SEPTEMBER – 16:15-17:30

CHANGES IN THE FLIGHT PATHS OF GEESE AND SWANS BEFORE AND AFTER THE CONSTRUCTION OF SEVEN ONSHORE WIND FARMS IN NORTHERN HOKKAIDO, JAPAN

Mr Tatsuya Ura[1]*, Mr Toshimitsu Nuka[1], Dr Yutaka Yamamoto[1], Mr Seiji Hayama[1], Dr Hironobu Tajiri[1]

[1] *Wild Bird Society of Japan*

*Corresponding author.

In Japan, there is no legal requirement to conduct monitoring surveys after the construction of wind farms. As a result, it is unclear whether the construction of wind farms in Japan has resulted in a barrier to the movements of migrating birds. We investigated whether wind farms form barriers to movement for geese and swans in Japan using a before-and-after construction comparison which has never been done in Japan. The study was conducted in the Soya region of Hokkaido, the northernmost tip of Japan, a key point on the country's largest bird migration route, with large existing and planned wind farms.

The Soya region's western half is East-west width 25 km, with a low altitude that attracts migration birds. Consequently, the area is a bottleneck for migratory birds in spring and autumn. Seven large wind farm projects, with an average of 20 turbines per facility, were constructed around 2023.

We surveyed the migratory routes of geese and swans prior to construction in spring and autumn 2017 and 2018, using visual observations and recording species, number of individuals, altitude and flight path. We then repeated these surveys in autumn 2023 and spring and autumn 2024, shortly after the construction of seven wind farms. Geese and swans migrated through in the western part of the Soya region, characterized by a series of hills at 100 m altitude and flat valleys, with many groups flying at altitudes of 100-150 m. Prior to the construction of the wind farm, birds migrated through an area approximately 20 km wide along a north-south axis. Following construction of the wind farm, this area narrowed to 4-6 km, suggestive of a substantial barrier effect.

If the consequences of a barrier to movement is estimated based on an increase in distance moved or energy expended, then the impact in a single area is unlikely to be significant. However, the geese and swans' wintering grounds are 700-1800 km south of the Soya region, between which there are many existing and planned wind farms. There are also plans to construct an additional 120 wind turbines in the western part of the Soya region around 2030. The cumulative impact of actions taken to avoid wind farms on energy expenditure by migrating geese and swans needs to be considered when assessing the potential impact of wind farms on individuals and at a population level.

WEDNESDAY 10TH SEPTEMBER – 16:15-17:30

MAPPING FINE-SCALE PRIORITY AREAS FOR REDUCING BIRD ELECTROCUTION: A CASE STUDY OF THE LEAR'S MACAW IN BRAZIL

Dr Larissa Biasotto[1]*, Dr Andreas Kindel[2], Dr Erica Pacifico[3], Mr Antônio Emanuel Barreto Alves De Sousa[4], Mrs Fernanda Paschotto[3], Ms Thiago Filadelfo[3], Ms Gabriela Favoretto[3], Dr Aldicir Scariot[5], Dr Fernando Ascensao[6]

[1] BirdLife, [2] Federal University of Rio Grande do Sul, [3] Lear's Macaw Research and Conservation Group, [4] Centro Nacional de Pesquisa e Conservação de Aves Silvestres (CEMAVE/ICMBio) – Cabedelo/PB, [5] Embrapa Genetic Resources and Biotechnology, Ecology and Conservation Laboratory, [6] Center for Ecology, Evolution and Environmental Changes, University of Lisbon

*Corresponding author.

Installing new powerlines is fundamental to supplying the growing energy demand, including remote human communities that still lack access to electricity. However, the expansion of the energy grid is not devoid of important impacts on biodiversity, notably bird electrocutions. While various mitigation measures have been developed to reduce electrocutions, there is limited information on how to prioritize their implementation for maximum cost-effectiveness. This gap is especially pronounced in remote, understudied areas and for species with restricted ranges, where systematic data is often lacking. Without such prioritization, financial resources risk being poorly allocated, potentially undermining conservation efforts. Cost-effective assessments are, therefore, essential to identify high-risk areas and guide mitigation efforts to where they will have the greatest impact. In this study, we developed a framework to identify high-risk electrocution areas in the Brazilian Caatinga, using Lear's Macaw as a case study. Endemic to Caatinga, Brazil, Lear's Macaw is classified as Endangered in the IUCN Red List. Due to its morphological and behavioural characteristics, it is identified at a high risk of electrocution, with numerous events of electrocutions being registered. Using the best available information related to the species' habitat, ecology, and behaviour, such as the location of main roosting areas, maximum displacement distance, and key dietary resources, our approach integrates the species' potential activity areas with the energy infrastructure hazard surface (medium voltage powerline) to produce a risk map, validated against known electrocution records. Additionally, we perform a cost-benefit analysis to determine the number of pylons that would need retrofitting to achieve specific reductions in electrocution events. Electrocution risk was unevenly distributed across the study area, with the central and southern portions of the energy grid identified as priorities for mitigation. Validation procedures confirmed that the risk map accurately represents electrocution risk. Our cost-benefit analysis revealed that retrofitting approximately 37,000 pylons could reduce known electrocution events by up to 90%. Our study identified areas with higher electrocution risk for Lear-s macaw, supporting the fact that our framework can be used even in data-scarce regions. This approach can support energy companies with an initial assessment in evaluating sites for implementing mitigation strategies, with optimal cost-benefit relation, as well can guide conservation projects by highlighting areas requiring in-depth investigation of electrocution risks and its impact on population dynamics.

WEDNESDAY 10TH SEPTEMBER – 16:15-17:30

AUKS IN THE GERMAN NORTH SEA: EFFECTS OF OFFSHORE WIND FARMS

Dr Lesley Szostek[1]*, Mr Raul Vilela[2], Dr Christina Bauch[1], Dr Claudia Burger[2], Mr Ansgar Diederichs[2], Ms Anika Freund[1], Dr Alexander Braasch[1]
[1] IBL Umweltplanung, [2] BioConsult SH
*Corresponding author.

Two species of seabirds, Common Guillemots and Razorbills, are recently in focus as potentially at risk due to disturbance from wind farms. This study investigated the effects of wind farms on the distribution of Guillemots and Razorbills in the German North Sea, with particular focus on differences between the two species, and seasonal differences between autumn and winter.
The analysis was based on a large data set from aerial and ship-based surveys collected over 8 years during post-construction monitoring of all 22 wind farms in operation in the German North Sea by 2021 and during scientific monitoring projects. Data were analysed applying the approach of integrated nested Laplace approximations (INLA) to do approximate Bayesian inference for latent Gaussian models.
Guillemots and Razorbills showed a very similar spatial distribution in autumn, with areas of higher densities in the northwestern part of the study area and in the southeast, in the vicinity of the breeding colony on the island of Helgoland. In winter, overall numbers of auks were substantially higher and the distribution more widespread than in autumn.
Both species showed avoidance effects towards wind farms, although both occurred regularly within the wind farms as well. We found high variability in the distribution and effect radii between seasons for both species. The calculated effect radius around wind farms was consistently larger in autumn (Guillemots: between 6-12 km, Razorbills: 6-11 km) than in winter (Guillemots: between 0.4-2 km, Razorbills: no significant avoidance).
Model results revealed that in both species a large proportion of the individuals avoided the area inside the wind farms and up to 5 km distance in autumn, with Guillemots showing a much higher decrease than Razorbills. In winter, the reductions were much lower and seemed to be confined to the wind farms and up to 1 km distance in Guillemots.
This study provides evidence for a seasonal difference in avoidance of wind farms by Common Guillemots and Razorbills and suggests differences in the susceptibility to OWF between the two species.

WEDNESDAY 10TH SEPTEMBER – 16:15-17:30

EFFECTS OF ACOUSTIC LOGGER ARRAY DESIGN ON STUDIES OF CETACEAN RESPONSES TO OFFSHORE WIND FARMS

Dr Gordon Hastie[1]*, Ms Madalina Matei[2], Dr Aude Benhemma-Le Gall[3], Dr Isla Graham[3], Prof Paul Thompson[3], Dr Cormac Booth[2]

[1] 1. Sea Mammal Research Unit, Scottish Oceans Institute, University of St Andrews, KY16 8LB Scotland, UK, [2] 3. SMRU Consulting, Scottish Oceans Institute, University of St Andrews, KY16 8LB Scotland, UK, [3] 2. University of Aberdeen, School of Biological Sciences, Lighthouse Field Station, Cromarty, Ross-shire, IV11 8YJ, Scotland, UK

*Corresponding author.

Underwater noise produced during pile-driving of offshore wind farm foundations has led to concerns about behavioural responses by cetaceans leading to avoidance of important habitats. To quantify impacts for Environmental Impact Assessments, species distribution data are often combined with information on the relationship between noise levels and the probability of behavioural responses to estimate the numbers of individuals impacted. Passive acoustic monitoring using autonomous acoustic logger arrays are being used increasingly to develop dose-response functions for cetacean responses to pile-driving. However, the effects of the characteristics of arrays (e.g., numbers of loggers or array spatial extents) are rarely considered at the study design stage; this has implications for dose-response results and the number of animals predicted to respond. Here, a sub-sampling approach applied to acoustic data from autonomous loggers collected during a previous study of harbour porpoise responses to pile driving (Graham *et al*. 2019) was used to investigate the effects of array design on (1) the probability of detecting behavioural responses, and (2) the shape of the derived dose-response functions, and (3) the number of porpoises predicted to respond. Results confirmed that the design of acoustic arrays can have a major effect on resultant dose-response functions. Critically, too few loggers resulted in a low probability of detecting behavioural responses and highly variable dose-response functions. Further, there was marked variation in dose-response functions and the number of porpoises predicted to respond with the spatial extent of the arrays (maximum distance between the piling and the acoustic loggers); there was clear positive relationship between the array spatial extent and the mean number of porpoises predicted to respond increasing from 41 (10 km arrays) to 2,330 individuals (80 km arrays). These results show the importance of considering study design when comparing the results between studies and highlight that the development of analytical techniques that account for differences in acoustic logger array characteristics would be particularly useful in future. This would help ensure results are robust and transferable to new developments to effectively manage levels of disturbance during offshore wind farm construction.

THURSDAY 11TH SEPTEMBER – 09:00-10:15

CUMULATIVE IMPACT ASSESSMENT OF THE RAS GHARIB WIND ENERGY (262MW) IN EGYPT: EVALUATING BIRD BEHAVIOR AND THE EFFECTIVENESS OF THE ATMP PROGRAM

Mr Ali Khazma[1]*, Mr Ahmed Khalil[1], Mr Mohamed Sherwali[1], Ms Aya Ayad[1], Mr Mahmoud El Mongy[2], Mr El Sayed Ibrahim[2], Dr Ahmed Abdullah[2], Dr Tamer Attalla[2]
[1] RCREEE, [2] Safe Soar
*Corresponding author.

The Gulf of Suez region in Egypt is a crucial migration corridor for soaring birds, with significant flyway populations passing through the area during their spring and autumn migrations. As part of Egypt's commitment to expanding renewable energy, the RGWE, located in this vital migratory pathway, has been operational since 2019. This study aims to assess the cumulative impact of the RGWE on bird behavior, focusing on their distribution, flight altitude, and the overall effectiveness of the Active Turbine Management Program (ATMP) in mitigating bird fatalities and reducing energy loss during the last five years (2020-2024). The primary objectives of this research are to evaluate how the operation of the wind farm has influenced bird flight patterns, particularly in terms of altitude and proximity to the turbines, and to assess the impact of the ATMP on reducing bird collisions and energy losses due to turbine shutdowns. The study involves long-term bird monitoring data, including observational surveys on bird distribution and flight behaviors within and around the wind farm, alongside operational data from the ATMP, which includes shutdown on demand, predictive shutdown protocols, and fatality monitoring.Preliminary results from the first five years of the wind farm's operation suggest that birds behavior and patterns have adjusted over time and the ATMP has proven effective in reducing bird fatalities, with shutdown protocols aligned with high-risk migration periods showing a significant decrease in mortality. However, some energy losses were observed, particularly during peak migration seasons, when turbine shutdowns were most frequent.
In conclusion, the ATMP has been largely successful in mitigating bird fatalities, balancing environmental concerns with energy production. This study underscores the importance of long-term, adaptive management strategies for wind energy projects located in critical migratory areas, highlighting the potential for effective mitigation through coordinated programs like the ATMP. Future efforts should focus on optimizing turbine operation to minimize energy loss while continuing to protect bird populations.

THURSDAY 11TH SEPTEMBER – 09:00-10:15

ACCOMMODATE MARINE RENEWABLE ENERGIES AND BIODIVERSITY: IMPACTS OF SUBMARINE POWER CABLE ELECTRO-MAGNETIC FIELD MODIFICATIONS ON ELECTRO-MAGNETO SENSIBLE AQUATIC SPECIES

Dr Céline Artero[1]*, Dr Julie Lucas[2], Ms Vera Meije[3], Dr Lisa Garnier[4], Ms Hélène Claudel[4], Mr François Deschamps[4], Mr Damien Einsargueix[5], Ms Laure Lailheugue[5], Mrs Anais Gudefin[5], Mr Gilles Lecaillon[5], Dr Nils Teichert[6], Dr Alexandre Carpentier[7], Dr Thomas Trancart[6]

[1] Museum National d'Histoire Naturelle, Station Marine de Dinard, Dinard, [2] Université Bretagne sud, Laboratoire de Biotechnologie et Chimie Marines - EMR CNRS 6076, [3] Sorbonne université, [4] RTE France, Paris, [5] ECOCEAN, Montpellier, [6] Museum National d'Histoire Naturelle, BOREA, Station Marine de Dinard, Dinard, [7] Université de Rennes, Laboratoire de Biologie des Organismes et Écosystèmes Aquatiques (BOREA),

*Corresponding author.

In the context of climate change, marine renewable energies such as winds, tides and currents, provide essential alternatives to fossil energies. In Europe, offshore wind farms develop quickly specifically in France that has 11 million km2 of coastal waters and where 21 ongoing or future wind farm projects are planned. Transportation of offshore energy by submarine power cables locally amplifies electromagnetic fields (EMF), which could impact EMF sensible species that use EMF to navigate and search for preys. The CEMARB project (accommodate marine renewable energies and biodiversity) aims at evaluating and quantifying the effect of electrical connections of offshore wind farms on EMF sensible elasmobranchs, such as the lesser spotted dogfish (Scyliorhinus canicula).

Early stages of lesser spotted dogfish (eggs and juveniles until 6 months) were continuously exposed to 50 Hz EMF of different intensities (control, ~10, ~100 and ~500 µT), representing respectively 10, 5 and 0 m distance to submarine power cables. This experiment, performed under controlled environment, was conducted using alternative current in 2024 and repeated with direct current in 2025. Effects of EMF exposition were assessed on the species development stages, survival, growth, metabolism and behaviours using non-invasive methodologies. Surveys of development stages and growth of eggs were made once a week by extracting information from pictures, and then once a month for the juvenile stage. Metabolism of juveniles was individually assessed with a 24h intermittent-flow respirometry test and behaviours (activity type and rate) was analysed from video taken during the juvenile phase as well.

Exposition to 50 Hz EMF under alternative current showed a reduced survival rate and growth of juveniles within the intermediate 100 µT group compared to the control group, with respectively -20% survival and -2.5 g in mass after 5 months of experiment. We hypothesised that this could be due to the inhibition of a digestive enzyme at intermediate level of EMF, resulting in a delayed growth and higher mortality. No effect of EMF exposure was found on metabolism for any of the studied group. Analysis on egg stages and behaviour as well as the analysis on the second phase of the experiment using static fields are ongoing.

Our project focused on early life stages (egg to 6 months juveniles). It would be interesting to continue EMF exposure until sexual maturity to look at longer EMF impacts on growth, as well as potential effect on the reproduction capacities of individuals.

THURSDAY 11TH SEPTEMBER – 09:00-10:15

NATURE-POSITIVE ENERGY PRINCIPLES: ENVIRONMENTALLY RESPONSIBLE RENEWABLE ENERGY SITING AND PERMITTING

Ms Giedre Viskantaite[1]*, Mr Dean Cooper[2], Mr Benoit Moreaux[3], Mr Noriaki Yamashita[4], Ms Monica Oliphant[5], Ms Andrea Wainer[6], Dr Ira Shefer[7], Ms Kelly Trumbull[8], Mr Deepak Krishnan[9], Mr Rushabh Soni[9], Mr Jinlei Feng[1], Ms Ute Collier[1]
[1] IRENA, [2] WWF, [3] GWEC, [4] ISEP, [5] WWEA, [6] REN21, [7] RGI, [8] The Nature Conservancy, [9] WRI
*Corresponding author.

In order to address intertwined climate, energy, and biodiversity crises, countries must urgently fulfil their commitments to tripling renewable energy capacity by 2030 while simultaneously halting and reversing biodiversity loss. According to IRENA, the decarbonisation of the energy sector will be primarily driven by solar and wind expansion and supporting grid infrastructure. In this process, it is essential to ensure that the rapid energy transition effectively manages impacts on biodiversity and ecosystems. The IRENA Coalition for Action and CLEANaction members have jointly developed the guiding principles to develop renewable energy in line with ecosystem conservation and restoration, providing successful case studies and policies to illustrate them.

Build upon the extensive literature on this subject, six principles are proposed, calling for governments to:
Principle 1: Accelerate positive development requires an integrated approach to identifying and designing areas with high potential for renewable energy and minimal environmental impacts, enabling more streamlined deployment
Principle 2: Co-utilise. For renewables siting, priority should be given to areas already modified.
Principle 3: Conserve, Restore and Enhance. Measures should be implemented to preserve existing biodiversity, restore impacted areas as much as possible, and strive to enhance biodiversity.
Principle 4: Extend the Useful Life concerns already existing projects, with measures to extend the planned project's life cycle to continue producing energy without additional environmental impacts of the new constructions.
Principle 5: Monitor and Adapt approach acknowledges that ecosystems are dynamic and complex. Technologies for adaptive management should be used to adjust to emerging evidence of wildlife movement or plant growth.

An overarching principle 6: Engage communities is essential for all projects throughout all the development phases. Measures for community participation and engagement are required to achieve public support and utilise local traditional and scientific knowledge, which will contribute to the feasibility and long-term sustainability of the project.
To create an enabling environment for the application of these principles, members call for more intersectoral collaboration that takes account of climate targets and NDCs, energy development plans, and ecosystem restoration objectives at regional, national, and subnational levels.

THURSDAY 11TH SEPTEMBER – 09:00-10:15

FINANCIAL IMPLICATIONS OF EXISTING US WIND FACILITIES FROM OPERATIONAL CURTAILMENT FOR BATS

Mr Christian Newman[1], Mr Bradley Hopp[1]*, Mr Donald Solick[1]
[1] *EPR*I
*Corresponding author.

Wind energy is responsible for hundreds of thousands of bat deaths annually from collisions with wind turbines. To minimize bat deaths, many wind facilities use turbine curtailment during periods of expected bat activity–mainly at night during the summer and early fall when wind speeds are low. Turbine curtailment effectively reduces bat deaths. This study simulated wind energy production at existing wind facilities across the contiguous United States (US) under varying curtailment scenarios. We evaluated annual energy production (AEP) under varying scenarios and analyzed the financial impact of each wind facility. We found a national median 0.1% to 2.0 % AEP loss with our low and high curtailment scenarios from curtailment across the US. For many wind facilities, this AEP loss could increase the cost of energy. The study also analyzed the interannual variability and regional variability, which is a critical aspect of understanding the financial ramifications. Our findings suggest that curtailment with low cut-in speeds may not alter AEP significantly, but more stringent curtailment could negatively affect wind facility financials. Future directions for this research may focus on other financial metrics for the viability of wind facilities. They could examine AEP loss from different smart curtailment technologies to better understand how wind facilities can pursue cost-effective curtailment to reduce bat fatalities.

THURSDAY 11TH SEPTEMBER – 09:00-10:15

FIRST EVIDENCE OF HABITUATION TO AN OFFSHORE WIND FARM IN A HIGHLY SENSITIVE SEABIRD ?

Dr Claudia Burger[1]*, Mr Ansgar Diederichs[1], Mr Michel Stelter[1], Mr Vlad Kosarev[1], Dr Ruth Castillo[1], Dr Georg Nehls[1]
[1] *BioConsult SH*
*Corresponding author.

Many seabirds show avoidance towards offshore wind farms (OWF) and this is an important aspect that must be taken into account in the future expansion of this technology. Strong avoidance has been shown for divers (Gavia spp.)
in the North Sea during post-construction monitoring and so far, no indication of habituation towards OWF has been found. However, so far post-construction monitoring was usually limited to a relatively short time period of a few years (max. 5 years in Germany), which makes it difficult to investigate such effects. Here, we analysed a unique dataset of 9 years of post-construction monitoring, using digital aerial surveys and focusing a high monitoring effort on the critical spring period when diver abundance (mostly red-throated divers Gavia stellata) is known to be highest in this region. We calculated displacement distances per year, as well as abundance within distance bands, relative to a reference category (14-16 km). Also baseline data was available to verify that no gradient was visible in the focal area before construction of the OWF. We found strong displacement, but the estimated displacement effect declined during the study period, suggesting habituation. Within a radius of 6 km around the OWF, analyses showed that the relative number of divers increased during the course of operational monitoring. However, the OWF footprint itself continued to be avoided almost 100% of the time. High variation was found between surveys, suggesting that environmental or anthropogenic effects play an important role. Exploring these parameters in more detail revealed that reduced ship traffic in the area of the OWF is likely a main driver of reduced displacement. These results underline the value of long-term monitoring and the need to carefully assess displacement over time to detect possible changes and adaptations. This can improve predictions on the impact of OWF on sensitive species.

THURSDAY 11TH SEPTEMBER – 09:00-10:15

BIRD SENSITIVITY INDEX AT ONSHORE WIND FARMS: A NOVEL TRAIT-BASED APPROACH TO IDENTIFY PRIORITY SPECIES

Dr Larissa Biasotto[1]*, Ms Bruna Arbo-Meneses[1], Dr Simon Sanghera[1], Dr Bethany Clark[1], Ms Catha Auchincloss[1], Mr Tris Allinson[1]

[1] *BirdLife International*

*Corresponding author.

Energy infrastructure such as onshore wind farms (OWF) can pose significant risk to birds. Collision with turbines and displacement are the most known impacts and depending on the species' conservation status and life history traits, the effect could impact population persistence over time. Because species are not equally sensitive, identifying the most prone to being affected is essential to mitigating the impacts of existing OWF and improving the planning of new infrastructures across different bird contexts. Different initiatives have proposed methods to calculate bird sensitivity indices (SI) for OWF. Previously, they have not simultaneously represented key factors such as morphology and behaviour (for collision), all impacts (collision, displacement, and population threat), and the regions or countries with the most limited data (primarily the global south). Here, we created a novel method to identify priority species facing risk at wind facilities. Our approach uses existing databases of global species traits and the development of metrics that can respond to each impact. For collision risk and, therefore, flight behaviour, we created a wing load proxy combining morphological measures such as bird wing length and body mass with intrinsic characteristics regarding vision and foraging behaviour. We assigned different categories of displacement according to family level. We then combined scores with global/national conservation status and annual adult survival to capture potential population implications. We applied the head-tail clustering algorithm to identify the priority species. We applied this method to Australia, a region with significant wind energy potential and globally important avifauna, calculating the SI for all the regularly occurring species (607). Our results captured different species at higher risk of collision compared to previous studies and appear to have new insights into the species potentially most impacted. Preliminary results indicated 161 species (SI > 0,1) most likely affected by wind facilities. There were 28 globally threatened species, and 28 bird families are represented among the priority species. Our approach allows a preliminary assessment of potential risk regarding OWF for whole bird communities over broad geographic scales and could be adapted to other energy infrastructures, such as powerlines. By identifying priority species early in the planning phase, this approach can be fundamental in directing conservation and mitigation measures efforts ensuring sustainable OWF development and minimising biodiversity impacts.

THURSDAY 11TH SEPTEMBER – 09:00-10:15

QUANTIFY BIRDS MOVEMENT PATTERN IN ONSHORE WIND FARM ALONG THE EAST COAST OF CHINA

Ms Lili Jia[1]*

[1] *Beijing Sinorobin Radar Technology Co., Ltd.*

*Corresponding author.

The year 2023 reached a new record for global wind energy with generation rose by 10%. The Rapid growth of wind power capacity in China, especially onshore and offshore wind power which surpasses 310GW, is proved to tackle the climate change issues and achieve carbon neutrality before 2060, which also poses great threat for migratory birds on the East Asia-Australian flyway, the highest number of threatened bird species flyway as well as the significant diverse flyway with over 50 million waterfowls from 280 migratory waterfowl species and 510 land bird species.Tracking birds nocturnal movement pattern is necessary for mitigating potential collision risk in onshore wind farms along this flyway.

This study firstly applied avian radar to track birds flying altitude,heading and flying route in and around onshore wind farm across years.Field survey is also conducted to validate birds roosting and breeding sites. Our result shows the dominant species,swallow,egret,gull,magpie that distribute around the wind farm. We also identified the migration flow in daily and seasonal scale: The migration often started from early March,occurred intermittently till May, with the intense migration flow lasted for 2 to 5 days in late April till early May with over 150,000 daily movement; The migration often occurs after sunset at around 18 to 19 at night and lasted for the whole night till 4 to 5 in early morning before sunrise in spring;The dominant migration heading is north and northwest in spring, south and southeast in autumn; Over 93% of nocturnal birds movement in spring happened at lower altitude below 500m, while those occurred at rotor swept altitude shifted across the year with the maximum proportion over 70% in 2019.

Based on radar tracking and field survey, we highlight potential high-risk distribution map in spatial and temporal scale to provide statistic proof for wind farm to take mitigation measures. Besides that, we also adopted a real-time warning system to identify the specific turbines with high risk of collision for wind farm to take instant measures.

Considering birds migration behavior is highly related with meteorological factors, to combine avian radar monitoring with birds tracking information and meteorological information from weather radar would help to achieve long-term accurate predication of birds collision risk in future research.

Key words: onshore wind farm, avian radar, nocturnal migration

THURSDAY 11TH SEPTEMBER – 09:00-10:15

INFLUENCE OF WEATHER CONDITIONS ON THE FLIGHT DECISIONS OF MIGRATORY BIRDS OVER FUTURE OFFSHORE WIND ENERGY FACILITIES

Mr Léo Denoual[1], Dr Jocelyn Champagnon[2]*, Dr Olivier Duriez[3], Prof Frédéric Jiguet[4], Mr Stéphan Tillo[2], Dr Paul Dufour[5]

[1] Littoral Environnement et Sociétés (LIENSs), La Rochelle University - CNRS, [2] Tour du Valat, research institute for the conservation of Mediterranean wetlands, [3] Centre of Evolutionary and Functional Ecology, Univ Montpellier, CNRS, EPHE, IRD, 1919 Route de Mende, 34293 Montpellier cedex 5, France, [4] Muséum National d'Histoire Naturelle, [5] Tour du Valat, CEFE/CNRS, Swiss ornithological institute

*Corresponding author.

In the coming decades, French authorities will develop offshore wind energy facilities on its Mediterranean waters. Yet few information is available about how these areas are used by flying fauna, particularly migratory birds. The Mediterranean Sea is of major interest, for bird conservation, as it is located at the crossroad between Europe and Africa, that is crossed twice a year by billions of birds. Terrestrial migrants must adapt the timing of their migration and develop flight strategies to minimize risks while crossing this ecological barrier. Here, we studied how weather conditions can affect departure decisions and flight strategies for crossing the Mediterranean Sea during post-nuptial migration, by analysing GPS tracking data of 163 individuals from 16 species, mainly from the MIGRALION program (2021-2025).

Five flight strategies to cross the Mediterranean Sea were identified by classifying flights over sea (n = 185) according to their characteristics, including for example time spent in various altitude layers. 80% of individuals flew below 300 m during at least 25% of flight duration. However, time spent in this critical layer regarding collision risk with wind turbines is contrasted between species: from 11% for European Roller Coracias garrulus to 90% for Greater Flamingo Phoenicopterus roseus.

A modelling analysis helped to identify the meteorological factors influencing the sea crossings. The probability of individual departure decision was affected by four key weather factors: atmospheric pressure, temperature, rainfall and wind direction. While some particular weather conditions influenced the choice of a given strategy (for instance crossing from Southern France to the Southeast (Sardinia in Italy) when winds are favourable), species migratory habits also appeared to play a crucial role. Some species showed great flexibility in strategy choice (e.g. Squacco Heron Ardeola ralloides) while individuals from other species seem to use a unique strategy (e.g. Coracias garrulus), underlining the need for further investigations. Besides fundamental advances in our understanding of how migratory birds cope with ecological barriers, this study provides important insights into possible solutions to reduce collision risks at future offshore wind turbines, by identifying time periods when meteorological conditions are more likely to drive large numbers of migratory birds across the Mediterranean Sea, for a possible curtailment of wind turbines.

THURSDAY 11TH SEPTEMBER – 09:00-10:15

INTEGRATING DIVERSE DATA STREAMS TO RAPIDLY ASSESS SEABIRD DISTRIBUTIONS IN RESPONSE TO AN EMERGING OFFSHORE WIND INDUSTRY

Mr Nicholas Pattison[1]*, Dr Mark Miller[1], Dr Rohan Clarke[1]
[1] *School of Biological Sciences, Monash University*
*Corresponding author.

As offshore wind infrastructure proliferates globally, the impact such structures will have on many seabirds is unknown. In south-eastern Australian waters, this is especially evident, with limited understanding of seabird communities in the region and a rapidly developing offshore wind industry. To assess the possible impacts of offshore wind farms on seabirds, species distribution models are the first step in evaluating a species' exposure to future offshore development. However, the exceptionally wide ranges of many seabirds mean traditional methods like transect surveys offer limited utility for distribution modelling. To address this, the extraordinary observational scale of citizen-science initiatives can be leveraged to provide sampling across a species range. However, biased sampling and unknown observer skill can make sole reliance on citizen-science datasets tenuous. Integrated species distribution models respond to this concern, providing a framework to unite the observational heft of citizen-science with the observational rigour of systematic surveying. Further, recent advancements have allowed for integrated models to bring together telemetry and observational data to model the distribution of wide-ranging marine species where systematic surveys are limited. Here, we combined observational data from citizen-science repositories with telemetry datasets to create integrated species distribution models. We produced these models for a group of seabird species off south-eastern Australia, providing insights into seabird-environment relationships and the seasonal distributions of the species. Our results reveal species' varied relationships to the region and its environmental conditions, along with the existence of seasonally dynamic seabird hotspots. With offshore wind infrastructure off south-eastern Australia set for rapid expansion, our approach provides a cost-effective and repeatable method for producing seabird distribution models over large spatial scales, informing stakeholders of the spatially varying risk of offshore development to seabirds.

THURSDAY 11TH SEPTEMBER – 09:00-10:15

HARBOUR PORPOISES AND OPERATIONAL WIND FARMS: A LARGE-SCALE STUDY IN THE GERMAN BIGHT

Ms Veronika Wahl[1]*, Ms Melissa Moick[1], Ms Marika Schultz[1], Dr Moritz Mercker[2], Dr Armin Rose[3], Dr Andreas Michalik[1], Mr Alexander Schubert[3], Mr Ansgar Diederichs[3], Ms Julika Voß[3], Ms Anika Freund[1], Dr Alexander Braasch[1]

[1] IBL Umweltplanung GmbH, [2] Bionum GmbH, [3] BioConsult SH

*Corresponding author.

General patterns of harbour porpoise distribution around operational offshore wind farms (OWFs) can only be identified by large-scale studies which had not been carried out to date.

For our study, we analysed a suitably large dataset of passive acoustic monitoring (PAM) data from Cetacean and Porpoise Detectors (CPODs), spanning a period from 2010 to 2021. We combined data from 62 CPOD positions from across OWFs in the German Bight, in order to evaluate the difference in detection rates of harbour porpoises within OWFs and in their vicinity (2.5 km around OWF borders).

Two GAMM model approaches were designed: a factor model using the spatial OWF reference as a binary factor; and a continuous model using the distance to OWF, allowing to describe nonlinear dependencies of harbour porpoise detections. We excluded all days when piling events took place within a radius of 20 km around respective CPODs. As a response variable, DP10M/5d (detection-positive ten minutes per five days) was chosen.

Results from the factor model show slightly higher detection rates within OWFs compared to CPOD data from OWF vicinity (statistically significant), with an overall difference of 10.6 %. No significant increase was detected by the continuous model within OWFs with respect to the average, however in the vicinity of OWFs detections decreased. It appears that OWFs in operation compared to their direct vicinity may attract rather than deter harbour porpoises, though the size of the effect differs among OWFs.

Potential reef and refugium effects created by OWFs, possibly facilitated by fishing prohibitions within German OWFs, may partly account for our findings. Slightly higher detection rates of harbour porpoises within most OWFs compared to their immediate surroundings, point towards slight attraction effects of OWFs in operation in the German Bight.

THURSDAY 11TH SEPTEMBER – 09:00-10:15

BENEFITS AND COSTS OF PREDICTIVE WIND TURBINE CURTAILMENT FOR MITIGATING THE COLLISION RISK OF RAPTORS DURING THE BREEDING SEASON

Dr Tonio Schaub[1]*, Dr Raymond Klaassen[2], Mrs Caroline De Zutter[3], Dr Alexandre Millon[1]
[1] Aix-Marseille University, [2] University of Groningen, [3] ENGIE Lab CRIGEN
*Corresponding author.

Wind energy development leads to an increased mortality of birds due to collisions with wind turbines, unless effective mitigation measures are put in place. Among the proposed approaches to reduce collision risk, predictive wind turbine curtailment, i.e. the curtailment of wind turbines during the time periods when the predicted collision risk of the target species is highest, appears promising. For this approach to be efficient, it is essential to optimise curtailment schemes so that the wind turbines' energy production is reduced as little as possible. In this way, economic viability can be maintained and the need for additional wind turbines to meet the set renewable energy targets is minimised.
For bats, predictive wind turbine curtailment has proved to effectively reduce collision mortality at low costs. However, for birds, the potential of this approach is largely unknown to date. To fill this knowledge gap, we are currently conducting a study on the benefits and costs of predictive wind turbine curtailment based on season, time of day and weather conditions for raptors, a bird family sensitive to wind turbine collisions, during the breeding season. The study combines data on the flight behaviour of several European raptor species (including the particularly collision-prone Red Kite), weather data and wind turbine production data.
The effects of season, time of day and weather on flight behaviour are studied using an extensive GPS-tracking dataset. As response variables, we consider the probability of being in flight and the probability of flying within the rotor height range of wind turbines. The product of these two variables serves as a proxy for wind turbine collision risk. To obtain accurate flight height data, we rely on high-frequency GPS tracking and barometric altimetry. As weather parameters, temperature, wind speed and precipitation are considered.
Finally, we identify the curtailment schemes (defined by a set of curtailment thresholds for the different predictor variables) providing a set level of collision risk reduction at the lowest cost. This information will enrich the practitioners' toolbox of complementary measures to mitigate bird collision risk while maintaining renewable energy production. The study is currently ongoing and we will present the first results at the conference.

THURSDAY 11TH SEPTEMBER – 09:00-10:15

MEASURES TO REDUCE GRIFFON VULTURE MORTALITY AT A WIND FARM IN GUADALAJARA

Ms Cristina Acosta[1]*
[1] *BIODIVERSITY NODE*
*Corresponding author.

The Fuentelsaz wind farm complex, consisting of 4 wind farms and 60 wind turbines, is located in the central area of the province of Guadalajara and started its operation phase in 2009. The area is characterised by the presence of several herds and some 7,000 head of cattle in extensive farming. The Environmental Impact Statement established the need to carry out an environmental monitoring plan to record mortality and applied financial penalties for the deceased specimens, the amount depending on the category of threat to the species detected.
In view of the results obtained in the first 8 years of operation, the decision was taken to implement measures to reduce collisions with griffon vultures, this being the species with the highest number of collisions recorded. The focus of the measures is centred on two aspects. On the one hand, different studies are being carried out to increase knowledge of the movements of the species and the populations in the area through the marking of 57 adult specimens with GPS and/or remote reading tags and the census of breeding pairs in the main colonies in the area. On the other hand, work is being carried out with the local population to detect the needs and problems that could be affecting the presence of the species in the area. Within this block, the main measures carried out have been the renovation of water troughs to prevent the entry of vultures, the closure of conflictive dumping points due to their location, the creation of a new dumping point and the management of dead livestock both in the livestock facilities and in the field, removing all the animals and depositing them in the new dumping point.
The project is now in its 7th year and the measures, especially carrion management, are still being implemented. The results obtained are fluctuating, with years in which collisions have been reduced and years with high values in line with the initial ones.
Although it has been shown that livestock management is key to the system, it is considered that there are uncontrollable variables, such as the weather, which affect the movements of the species and the risk of collision. Years with a higher proportion of fog, lower maximum temperatures and strong winds would mean higher collision risks.

THURSDAY 11TH SEPTEMBER – 09:00-10:15

SPREADING OUR WINGS: PIONEERING BIRD FLYWAY RESEARCH FOR WIND ENERGY IN MPUMALANGA, SOUTH AFRICA

Dr Mervyn Lotter[1]*, Ms Robyn Luyt[2], Mr Gavin Cowden[2], Mr Matt Pretorius[3]
[1] Mpumalanga Tourism and Parks Agency, [2] Mpumalanga Department of Agriculture, Rural Development, Land and Environmental Affairs, [3] Endangered Wildlife Trust
*Corresponding author.

Mpumalanga Province has been touted as the "New Frontier" for wind energy in South Africa. Unfortunately, the only viable wind resource in the province coincides with Mesic and High-Altitude Grasslands - vital habitat for several threatened bird species. Relevant authorities evaluate the sensitivity of all development applications against the Mpumalanga Biodiversity Sector Plan (a systematic conservation plan), however, this product inadequately addresses the impacts of Wind Energy Facilities (WEFs) on bird and bat species. While mitigation may reduce the continuous loss of individual birds through turbine collisions, effective mitigation requires understanding meta-population dynamics to strategically locate WEFs in "sink" areas, avoiding crucial "source" areas, including protected areas, Critical Biodiversity Areas, intact grasslands, Key Biodiversity Areas, and established bird flyways. However, current knowledge of these flyways along the Mpumalanga escarpment, heavily utilised by diverse, often threatened species, is limited. Urgent interventions are required to inform WEF development decisions. Specifically, research on avifaunal flight patterns, particularly nocturnal species, is crucial for developing collision risk maps and identifying high-risk areas.

To address this, the Mpumalanga Bird Flyway Research Project was commissioned to determine the movement (flight paths) and behavioural patterns (flight heights, time of day) of a small sample size of priority bird species vulnerable to collisions with wind turbines. Trapping of key avifauna species of conservation concern was undertaken via various methods to fit tracking devices to individuals. To date, four Greater Flamingos (Phoenicopterus roseus) and two Blue Korhaans (Eupodotis caerulescens) have been captured and fitted with GPS solar bird flight tracker devices, and their movements monitored. This is the first time that tracking devices have been attached to both Greater Flamingo and Blue Korhaan in South Africa.

Preliminary findings reveal that Greater Flamingos fly at lower heights than Lesser Flamingos (Phoeniconaias minor) within the rotor swept zones, and commute mostly at night. This presents significant mitigation challenges for nocturnal collision avoidance at proposed WEFs, highlighting the need for innovative solutions. Conversely, Blue Korhaans exhibit strong territoriality, occupying limited ranges (approximately 100ha), suggesting potential for avoidance strategies through careful micro-siting of turbines.

This study is ongoing, with continued trapping and tagging of additional key species to further elucidate flight paths and behavioral characteristics along the Mpumalanga escarpment. It directly contributes to the development of effective mitigation strategies and informed policy decisions, promoting coexistence between renewable energy development and biodiversity conservation in a changing world.

THURSDAY 11TH SEPTEMBER – 09:00-10:15

MULTI-OBJECTIVE WIND FARM LAYOUT OPTIMIZATION TO REDUCE BARRIER EFFECTS FOR SEABIRDS

Dr Marin Van Regteren[1]*, Dr Rene Bos[1], Dr Abel Gyimesi[2], Mr Jacco Leemans[2], Mr Gerben Ijntema[2]
[1] Eneco, [2] Waardenburg Ecology
*Corresponding author.

North Sea countries set ambitious targets for offshore wind, totalling to 300 GW by 2050. At a target 10-MW/km² wind farm density, more than 10% of the Dutch part of the North Sea could eventually be claimed by offshore wind farms. This puts an increasing strain on wildlife that are already impacted by climate change, disease, overfishing, and habitat loss. Therefore, to honor the international agreements that protect the interests of many key species, developers have to carry out survey work and take mitigating actions. When offshore wind farms interfere with migration or foraging routes of seabirds, one of such measures is to adapt the layout to reduce barrier effects.
We do this by relying on past radar campaigns, such as the one active in Eneco's Luchterduinen wind farm since 2018. From the radar tracks, birds tend to cut through the parts of the wind farm where the turbine density is lower. Moreover, bird traffic was higher at larger distances from the rotors (meso-avoidance) and considerably lower (but not zero) close to the rotors (micro-avoidance). In this work, we simulate this behavior by modelling a wind farm as an obstacle forest and assuming that each unique flight path follows a fixed minimum distance from a turbine. The resulting flight distance can then be found using a shortest path algorithm and repeated for several avoidance distances and multiple species, assuming that fractions of the birds take more or less bold flight paths. This calculation can be quick enough to use as a primary or secondary objective function in a wind farm layout optimization problem.
To demonstrate the method, we consider the Ecowende, HKW wind farm zone (NL) with 52 15-MW wind turbines. To fully explore interesting design directions, we ignore the original permit boundaries and other site constraints but keep the total area footprint. Concerning barrier effects, we look at creating improved connectivity between two Natura 2000 areas: the North Sea coastal zone and Brown Bank. Especially the latter is a foraging area for several key bird species that are thought to be impacted by offshore wind. We reflect on the resulting wind farm layouts, Pareto fronts, and trade-offs from a designer's point of view. Furthermore, we dive into the validation campaign that is planned with Ecowende and how those results can be used to create new nature-inclusive wind farm designs.

THURSDAY 11TH SEPTEMBER – 09:00-10:15

ACOUSTICALLY-TRIGGERED CURTAILMENT – PROTECTING BATS WITH THE SMART SYSTEM

Dr Fran Tattersall[1]*, Mr Paul Howden-Leach[1]
[1] *Automated Bioacoustics Ltd*
*Corresponding author.

Wind energy is a vital part of the renewable energy transition, but it can pose a challenge for bats. Acoustically Triggered Curtailment (ATC) is an emerging mitigation strategy involving feathering a wind turbine's blades when bats are detected to be present.
The SMART (Song Meter with Analysis and Remote Transfer) System from Wildlife Acoustics was one of the first scaled up, commercially available, systems to implement ATC. The SMART System uses advanced acoustic technology to first detect bats at a wind turbine, and then signal the control system to feather the blades until 10 min after the bat was last detected.
Using data from a SMART System installed on a wind turbine in 2024 we aim to test:
1. Can the SMART System identify bat activity and communicate that to the turbine control system to curtail in near-real time? 2. How effective is SMART ATC compared with other curtailment protocols?
Data from July to September, when bat activity was greatest, revealed that ATC significantly reduced turbine downtime compared to wind speed-based Operational Curtailment. Numbers of false positive and false negatives are a useful KPI with which to assess SMART and were sufficiently low for continued operation at the site.
Our results suggest ATC has the potential to reduce bat mortality while increasing energy production at wind farms compared with current curtailment protocols.

THURSDAY 11TH SEPTEMBER – 09:00-10:15

IS BAT ACTIVITY AT NACELLE HEIGHT A GOOD PREDICTOR OF WIND TURBINE MORTALITY?

Dr Elise Sivault[1]*, Dr Andreas Ravache[1], Dr Christian Kerbiriou[1], Mr Brice Normand[2]

[1] Centre d'Ecologie et des Sciences de la Conservation (CESCO), Muséum national d'Histoire naturelle, Centre National de la Recherche Scientifique, Sorbonne Université, Paris ; Station Marine, Concarneau, France, [2] Bureau d'études Ouest Am' SCOPE-SA, 1 rue des Cormiers, 35651 Le Rheu, France

*Corresponding author.

Curtailment strategies are based on the hypothesis that mortality at wind turbines depends on bat activity at nacelle height, with the expectation that higher activity leads to increased mortality. Accordingly, turbines are partially stopped during periods of low wind speeds and mild temperatures—conditions when bats are highly active and energy production is low. However, this presumed relationship between activity at nacelle height and mortality has not been rigorously demonstrated on a large scale, highlighting the need for further investigation. To address this gap, as part of the APOCOPE project, we collected bat activity and mortality data from over 100 onshore wind farms across France, surveyed between 2019 and 2023, enabling both spatial and temporal comparisons. Robust mortality estimates were computed for these wind farms. By modelling activity and mortality relationship at multiple scales, ranging from individual species and species groups to overall bat populations, as well as within and between years, preliminary results show that the relationship between activity and mortality is more complex than previously thought. It varies significantly depending on the species group and the time of year. These findings highlight the need for caution when using bat activity as a predictor of mortality. Developing effective curtailment methods requires nuanced approaches that account for these variations.

THURSDAY 11TH SEPTEMBER – 09:00-10:15

INSECTIVOROUS BAT ACTIVITY REDUCES IN THE PRESENCE OF WIND TURBINES IN INDIA

Mr Sreejith Jayakumar[1]*, Dr Kaleem Ahmed[2], Dr Rohit Chakravarty[1]
[1] Nature Conservation Foundation, [2] Aligarh Muslim University
*Corresponding author.

The expansion of wind energy infrastructure poses significant risks to bats through direct collisions with turbine blades and barotrauma, leading to substantial mortality. India ranks fourth in the world by installed wind energy capacity and is targeting to double its capacity by 2030 to meet sustainability goals. Despite this, no studies have been published from the country assessing the impacts of wind turbines specifically on bat populations. To address this significant knowledge gap, we conducted a two-season study in Chalkewadi Wind Farm in western India, one of the oldest establishments of its kind in India. Specifically, we studied bat mortality and differences in bat activity in areas with and without wind turbines.

We acoustically monitored insectivorous bat activity using a handheld bat detector at ten points in vicinity of wind turbines and ten points away from wind turbines. Each point was sampled eight times in each season. Additionally, we searched for bat carcasses at five turbines within 100m x 100m plots surrounding the turbine during the dry season. In the wet season, due to overgrown vegetation, we searched for carcasses along roads and pads around 20 turbines. Each turbine was searched seven number of times. Our final dataset comprises 4800 minutes of acoustic recordings and 175 number of carcass searches.

Our results from the dry season show reduced bat activity in the vicinity of wind turbines compared to sites away from turbines. We also recorded the presence of the Otomops wroughtoni in the wind turbine area, which is a poorly-known species that is accorded the highest protection as per Indian laws. However, across the two seasons, we only detected one dead bat belonging to the species Scotophilus heathii. We have yet to analyse the data from the wet season. Overall, our findings suggest that bats may be avoiding wind turbines either through learned experience or because the wind farm hosts lower insect abundance. Given that wind turbines in our study area have been operating for over 20 years, the question also arises whether the age of a wind farm influences bat activity and mortality. We hope to test these important hypotheses in future studies and develop proactive win-win solutions for wind energy and bats in India.

THURSDAY 11TH SEPTEMBER – 09:00-10:15

OFFSHORE WIND TURBINE FOUNDATIONS INFLUENCE THE DISTRIBUTION AND BEHAVIOUR OF HADDOCK MELANOGRAMMUS AEGLEFINUS – A CASE STUDY USING COMPLIMENTARY METHODS IN TWO OPERATIONAL WIND FARMS IN SCOTLAND

Dr Anthony Bicknell[1]*, Mr Sam Gierhart[1], Mr Robert Main[2], Dr Matthew Witt[1]
[1] University of Exeter, [2] Marine Directorate, Scottish Government
*Corresponding author.

Offshore introduced structures can influence the distribution and behaviour of fish through the provision of novel habitat, feeding opportunities and/or shelter. The introduction of 1000s of wind turbine foundations clustered in coastal and offshore waters will undoubtably have an impact on some fish populations (positive or negative) with consequences for their predators and prey. As part of the PrePARED (Predators and Prey Around Renewable Energy Developments) project we assessed how two operational wind farms of differing age and foundation type in NE Scotland (North Sea) affected haddock Melanogrammus aeglefinus using baited remote underwater video (BRUV) and acoustic telemetry. The complementary methods enabled the description of how foundations influence the local population distribution, but also how individuals within the population were spatially and temporally utilising the wind farms.
We designed BRUV surveys to test whether foundations affected the abundance and biomass of fish close to them (2 OWFs in 2022), and then to assess how the effect changed with distance from foundations (1 OWF in 2024). Over the same period, 222 haddock were acoustically tagged and tracked using a large array of receivers placed at 84 turbine foundations across the 2 wind farms.
Abundance and biomass of haddock was found to be higher close to foundations compared to reference locations with the effect being greater at the older and more complex foundations. The abundance and biomass were also found to reduce with increasing distance from the foundations in the more established wind farm. Of the 222 haddock tagged, 160 provided detection data for over 14 days. These individuals showed a mix of exploratory and residency behaviour within the wind farms for varying periods across summer and winter months.
Haddock are important for local marine ecosystems and commercially valuable, exploited on both sides of the north Atlantic. Not generally known to be reef/hard substrate associated species, these results indicate they can be attracted to introduced turbine foundations altering the distribution of local populations and individuals can spend extended residency periods at structures, likely driven by food availability. With the ongoing and planned development of wind farms within haddock's range in the north Atlantic, the cumulative effect on population dynamics, ecosystem interactions and impact on fisheries requires further research.

THURSDAY 11TH SEPTEMBER – 09:00-10:15

TEN YEARS OF PORPOISE MONITORING ON THE EAST COAST OF SCOTLAND DURING OFFSHORE WIND FARM DEVELOPMENT

Dr Evelyn Philpott[1]*, Dr Monica Arso Civil[1], Dr Ross Culloch[2], Dr Ewan Edwards[3], Mr Jack Lucas[1], Dr Hannah Millar[4], Dr Joseph Onoufriou[1], Ms Susanna Quer[1], Mr Paul Stainer[1], Dr Kate Brookes[1]
[1] Marine Directorate, SEDD Portfolio, Scottish Government, [2] Current Affiliation: Apem Group, [3] Current Affiliation: Xodus Group Ltd, [4] Current Affiliation: Dept. Energy, Security & Net Zero
*Corresponding author.

The seas around Scotland hold considerable potential for offshore wind energy development. Nine offshore wind farms are currently operational and more are planned under the ScotWind leasing round. Wind farm construction activities and operation increase underwater sound levels, which could have the potential to cause injury and/or disturbance to marine mammals.
Porpoises are the most abundant cetacean in the North Sea and are sensitive to noise from piling operations and vessel activity. The Scottish Government started the East Coast Marine Mammal Acoustic Study (ECOMMAS) in 2013. This project comprised 30 passive acoustic monitoring (PAM) stations located at approximately 5, 10 and 15km from shore along the east coast of Scotland, all equipped with cetacean click detectors (CPODs). Over a million hours of acoustic data from CPODs were collected between 2013 and 2022, during a period in which several wind farms were constructed and some were operational. Porpoise data from CPODs were modelled using a Generalised Additive Model framework accounting for temporal autocorrelation in the data. A suite of static and dynamic environmental variables, as well as presence of dolphins from the CPOD data were used as explanatory variables to model porpoise presence. Wind farm piling schedules were also incorporated into the model to understand if construction and operation of wind farms influenced porpoise distribution at varying ranges. Preliminary results using environmental covariates and presence of dolphins indicate seasonal and diurnal patterns in porpoise presence, long term trends in porpoise distribution, and a lower presence of porpoise in inshore areas where dolphin presence was elevated. There was variability in these patterns between locations and years.
The spatio-temporal scale of this project around the east coast of Scotland peripheral to wind farm sites in different stages of development captures large scale trends in porpoise presence but also fine scale responses to more localised conditions. The results from this study will inform understanding of the broadscale effects of wind farm development on porpoise presence. They will also steer future analyses of acoustic data that are being collected over wider Scottish sea areas (Scottish Passive Acoustic Network – SPAN) to inform future wind farm planning and consenting. Wind farm developers can also access this dataset and incorporate their own site-specific PAM data to inform their environmental impact assessments.

THURSDAY 11TH SEPTEMBER – 10:45-12:00

EVALUATING THE EFFECTIVENESS OF FLIGHT RISK MODELS IN PREDICTING COLLISION RISKS FOR THE ENDANGERED BLACK HARRIER (CIRCUS MAURUS), AN ENDEMIC BREEDING RAPTOR

Mr Robin Colyn[1]*, Dr Marietjie Oosthuizen[2], Dr Rob Simmons[1], Mx Marlei Martins[3], Mr Albert Froneman[2]

[1] FitzPatrick Institute, University of Cape Town, [2] AfriAvian, [3] Birds & Bats Unlimited

*Corresponding author.

Renewable energy facilities play a critical role in sustainable energy transitions but also pose significant risks to wildlife. Wind energy infrastructure, in particular, can lead to habitat fragmentation and direct mortality from bird and bat collisions with turbine blades. Raptors are especially vulnerable due to their long lifespans and low reproductive rates, necessitating effective mitigation strategies.

The Endangered Black Harrier (Circus maurus), a breeding endemic raptor in South Africa, has yielded disproportionally high collision rates with wind energy infrastructure. A recent population viability study suggested that wind energy development could directly increase the species' extinction risk. To assess the feasibility of improving mitigation of this threat, we developed and compared flight risk models using two data sources commonly used in wind energy risk assessments: GPS tracking data and vantage point (observer-recorded) flight lines. Both spatial (topography, habitat, etc.) and temporal (weather, daily, and seasonal activity) flight risk models were developed and tested against post-construction collision mortality data from two operational wind energy facilities.

Our results show that the spatial flight risk models produced high-risk envelopes with 80% overlap in their intersection-over-union (IoU), indicating strong agreement in core risk areas originating from tracking- and vantage point data. Tracking data sometimes provided more robust datasets and encompassed risk better (e.g., Windfarm A), but did not always capture all localized high-use areas, such as communal roosts (e.g., Windfarm B), which were better represented by vantage point data. When compared to actual post-construction collision mortality data, both models encompassed 100% of the recorded fatalities. Of the 11 recorded collisions, all occurred in predicted high-risk areas, suggesting that micro-siting adjustments to turbine placement could have mitigated these fatalities. Additionally, temporal flight risk models successfully predicted >85% of high-risk time periods based on weather conditions that coincided with observed fatalities.

Our findings highlight that flight risk models from both GPS tracking and vantage point data can effectively identify high-risk areas for Black Harriers. However, careful consideration is needed regarding data collection structure, spatial representation, and species-specific movement patterns. We recommend integrating these models into pre-construction planning for windfarms to optimize turbine placement and reduce collision risks. For operational windfarm facilities, our study demonstrates the potential use of proactive curtailment guided by dynamic temporal flight risk models as a mitigation measure to reduce future mortalities.

THURSDAY 11TH SEPTEMBER – 10:45-12:00

A SPATIALLY EXPLICIT PERFORMANCE INDICATOR TO EVALUATE IMPACT OF ONSHORE WIND ENERGY INFRASTRUCTURE ON VARIOUS ECOSYSTEM SERVICES USING DIFFERENT LIFE-CYCLE IMPACT PATHWAYS

Dr Reto Spielhofer[1]*, Dr Thomas Kvalnes[1], Dr Roel May[2]
[1] Norwegian Institute for Nature Research, [2] NINA
*Corresponding author.

Wind energy is a key technology for reducing global CO2 emissions and thus mitigating climate change. However, wind energy projects often face noticeable local opposition due to concerns regarding impacts on biodiversity and other landscape values, local people gain from nature. Research has made significant advances in calculating and mapping different impact pathways, such as habitat alteration, disturbance or barrier effects of onshore wind energy infrastructures on different species. This spatially explicit knowledge is used in in strategic- (SEA) and environmental impact assessments (EIA) of wind energy infrastructure. However, in EIA consequences on local landscape values and ecosystem services is often simplified and approximated using view shed analysis or distance measures to settlements. A lack of trust from local people and stakeholders might be a result and finally lead to local opposition and project resistance. Hereinafter we present a methodology to spatially explicitly map and quantify impacts of onshore wind energy on cultural, regulation and provisioning ecosystem services including local landscape values. First, we curate ecosystem service capacity maps that reflect on local knowledge and important landscape values through a participatory and consensus-based mapping approach. Second, building upon the concept of potential disappeared fraction (PDF) of species as used in life-cycle impact assessments, we propose a potential disappeared fraction of ecosystem service capacity (PDFES). While PDF of species relies on empiric species-area relationship, the presented PDF-ES is based on invariability-area relationship of spatial consistency of ecosystem service capacity. PDFES is calculated for land occupation and disturbance effects, considering different life-cycle impact pathways for different wind turbine types. We test the methodology in a case study area for a drafted wind farm project in mid-west Norway. Preliminary results reveal spatially explicit impact patterns for different ecosystem services and different impact pathways. The calculation of PDF-ES shows that this index can be combined with PDF of species into one single environmental performance indicator (NEP). The NEP provides a spatially explicit and easy-to-use KPI to evaluate the impact of a wind farm, relative to other locations in a study area to support policy makers as well as planners and developers of wind energy infrastructure.

THURSDAY 11TH SEPTEMBER – 10:45-12:00

BLACK SEA BASS (CENTROPRISTIS STRIATA) RESPONSE TO NOVEL HABITAT INTRODUCED DURING OFFSHORE WIND CONSTRUCTION ALONG THE NORTHEASTERN UNITED STATES COAST: EXAMPLES FROM SOUTH FORK WIND

Mr Chris Sarro[1]*, Dr Gregory Decelles[1], Dr David Bethony[2], Mr Brian Gervelis[3]
[1] Orsted, [2] Commercial Fisheries Research Foundation, [3] Inspire Environmental
*Corresponding author.

Black sea bass (Centropristis striata) are a commercially and recreationally important fish species along the U.S east coast from Massachusetts to the Gulf of Mexico and are commonly associated with natural and introduced complex habitats. Introducing wind turbine foundations and associated scour protection could provide favorable habitat through a reef effect. To test for the potential reef effect, a ventless fish pot survey, primarily targeting black sea bass, was included in the South Fork Wind Fisheries Monitoring Plan. South Fork Wind is a 132-megawatt wind farm consisting of 12 turbine and 1 offshore substation located approximately 40 kilometers southeast of Rhode Island, USA. It is the first fully operational utility scale offshore wind project in US federal waters.
This Before-After-Gradient study is investigating the spatial scale and extent of the potential reef effect around individual wind turbine foundations and scour protection. During each month of sampling, fish pots are deployed at a range of distances (0 to 900 m) from a subset of the foundations to estimate the scale and magnitude of fish aggregation. The survey began in June 2021, with monitoring in the wind farm occurring before, during, and after construction. The survey is conducted in collaboration with a local fishing vessel and input from local fishermen was central for the study design. Observations from the fish pot survey are being supplemented with video surveys and fine-scale acoustic telemetry. The ROV-based video monitoring thus far has demonstrated high abundance of black sea bass around foundations and scour protection months after installation. The baseline results demonstrate that fish pots are effective for sampling a range of size and age classes for black sea bass, and other structure associated species. In the presentation, we will discuss the survey design and methodology, provide a summary of the early results from our post-construction monitoring and discuss these preliminary results in a regional context.

THURSDAY 11TH SEPTEMBER – 10:45-12:00

FISH FOR THOUGHT: THE NUTRITIONAL QUALITY OF PREY SPECIES WITHIN A DEVELOPING OFFSHORE WIND LANDSCAPE

Ms Philippa Wright[1]*, Dr Cormac Booth[2], Dr Laura Oller Lopez[1], Dr Sophie Smout[1], Dr Katherine Whyte[3], Dr Gordon Hastie[1]

[1] 1. Sea Mammal Research Unit, Scottish Oceans Institute, University of St Andrews, KY16 8LB Scotland, UK, [2] 2. SMRU Consulting, Scottish Oceans Institute, University of St Andrews, KY16 8LB Scotland, UK, [3] 3. Biomathematics and Statistics Scotland, EH9 3FD Edinburgh, UK

*Corresponding author.

With the rapid expansion of offshore wind farms (OWFs) in coastal waters, there is an urgent need to determine how OWF construction and operation influence predators, their prey, and food web dynamics. For top predators (e.g., marine mammals and seabirds), survival requires a balance between the energy acquired through consuming prey and the energy expended through completing daily activities. Understanding the energetic value of prey for marine predators is a key component to understanding their overall energetic balance and resilience to potential disturbance. Currently, a lack of species-specific prey energetic data limits our ability to predict how OWF-driven changes in fish communities may affect energy availability for predators. This knowledge gap also limits our understanding of how prey quality may drive changes in predator behaviour during OWF development phases. To address this, we are investigating the effects of OWF installation and operation on prey quality, and demonstrating how this data can be applied to investigate changes in the energy content of predator diet over time. The work presented here is part of a larger research project investigating interactions between OWFs and marine ecosystems: the Predators and Prey Around Renewable Energy Developments (PrePARED) project.

From 2022 to 2024, fish and cephalopod samples have been collected around OWFs off the east coast of Scotland. To assess prey quality, bomb calorimetry is being used to measure prey energetic density (kJ/g) by species and size. To date, over 1,000 prey samples have been processed, representing 30 different prey species. Using replicate samples to ensure robust analyses, over 500 new energy estimates have been generated ranging from 3.21 to 12.49 kJ/g across species. These data make a significant contribution toward building an energy density database for prey species across marine habitats utilised by OWF developments. The findings from this study will help to characterise the potential impacts of OWF sites and provide valuable input for bioenergetic models and cumulative impact assessments. Ultimately, these insights will aid in reducing uncertainty in the environmental impact assessment process and enhance our understanding of the effects of OWF developments on predator-prey dynamics.

THURSDAY 11TH SEPTEMBER – 10:45-12:00

PELAGIO: PHYSICS-TO-ECOSYSTEM LEVEL ASSESSMENT OF IMPACTS OF OFFSHORE WIND FARMS

Prof Beth Scott[1], Dr Benjamin Williamson[2]*, Prof Nicola Beaumont[3], Dr Morgane Declerck[1], Dr Michela De Dominicis[4], Dr Alejandro Gallego[5], Dr Jennifer Jardine[4], Dr Aly Mccluskie[6], Mr William Macdonald[5], Dr Rory O'hara Murray[5], Prof Matthew Palmer[3], Dr Julie Salvetat[2], Dr William Schneider[7], Prof Tim Smyth[3], Dr Claire Szostek[3], Dr Neda Trifonova[1], Dr James Waggitt[8], Dr Stephen Watson[3], Dr Juliane Wihsgott[3], Dr Charlotte Williams[4], Dr Arianna Zampollo[1]

[1] University of Aberdeen, [2] Environmental Research Institute, The University of the Highlands and Islands, [3] Plymouth Marine Laboratory, [4] National Oceanography Centre, [5] Marine Directorate, Scottish Government, [6] RSPB Scotland, 2 Lochside View, Edinburgh, Scotland EH12 9DH, [7] Bangor University, [8] University of Bangor

*Corresponding author.

By 2050 it's estimated >400 GW of electricity will be generated by offshore wind in the North Sea alone. How will this increased anthropogenic use of our coastal seas impact already stressed marine ecosystems? And how will that same production of renewable energy offset risks of extreme climate change that, left unchecked, will increase biodiversity declines. An important effect of wind-energy extraction is to reduce the amount of energy that would normally go into local ocean currents via surface stress, altering mixing. Conversely, there are local increases in turbulence around turbine structures. Any change in ocean mixing may change the timing, distribution and diversity of primary production, the base of the food chain for marine ecosystems. This has knock-on-effects on the diversity, health and locations of pelagic fish that are critical prey species of commercial fish, seabirds and marine mammals. The displacement of seabirds and fishing fleets means they have potentially increased competition for fish. However, if OWFs are also de-facto marine protected areas and positively affect primary production, they may provide good habitat for fish population growth. So, what are the full cumulative effects of current OWF developments and the thousands of additional planned structures? Do the physical, biogeochemical and ecosystem changes exacerbate or mitigate those resulting from climate change?

The PELAgIO project is addressing all of these questions through an inter-disciplinary, multi-scale observation and modelling framework that spans physical mixing through to plankton production, on to the response of fish and whole ecosystems. We present how we have collected fine-scale data using the latest multi-instrumented acoustic platforms set near and down-tide as well as down-wind from OWFs, complemented by autonomous underwater robots. Capturing continuous and coincident data, from physics to fish, is providing a clearer understanding of the changes to mixing and wind-deficit impacts. This bottom-up, comprehensive approach has enabled calibration and validation of 3D ocean-biogeochemical modelling systems providing predictions of effects across the whole North Sea. These new data are also helping to understand and quantify how OWF expansion may change prey fish availability to seabirds and mammals, with the identified changes integrated into Bayesian Dynamic Ecosystem models. Both these types of models are also being run under different climate and fisheries scenarios chosen by stakeholders. This presentation will cover the data collection methods, the types of analysis and models needed to incorporate this wide range of physical and multi-trophic information, and provide examples of preliminary outcomes.

THURSDAY 11TH SEPTEMBER – 10:45-12:00

NO EVIDENCE THAT BATS ARE ATTRACTED TO THE WAKES OF WIND TURBINES AT AN IOWA WIND FACILITY

Mr Donald Solick[1]*, Prof Aaron Corcoran[2], Mr Michael D. Whitby[3], Mrs Praanjal Nasery[1], Prof Tyler Bell[4], Prof Noah Myrent[1], Prof Corey Markfort[4], Mr Jesse Leckband[5], Ms Seta Aghababian[6], Mr Christian Newman[7]

[1] Electric Power Research Institute, [2] University of Colorado--Colorado Springs, [3] Bat Conservation International, [4] University of Iowa, [5] MidAmerican Energy, [6] Stantec Consulting Services Inc., [7] EPRI

*Corresponding author.

Bat fatalities at wind turbines are a major ecological problem for a technology that is seeing dramatic growth to combat climate change. However, the reasons for these fatalities are still poorly understood. We tested the hypothesis that bats are attracted to the wakes of turbines and mistake turbines as tall trees. To test this hypothesis, we deployed 3-D thermal videography and acoustic recording equipment at two turbines at a wind farm and at three tall trees in central Iowa, USA. This approach is novel compared to the typical observations of bats at wind turbines, which usually focus on interaction with the wind turbine structure (tower, nacelle, blades). We refer to video detections at wind turbines as "targets," as it was not possible to differentiate bats and birds due to the small detection size of objects in the video. Our analyses suggest that bat and bird activity at wind turbines was highest on nights with northerly winds, and that animals mainly flew with the wind to the southwest, consistent with migratory behavior. Flights past wind turbines were mostly linear, and acoustic detections were mainly of migratory species, whereas flights at trees were mostly nonlinear and acoustic detections were mainly of nonmigratory species. Only 2% of 13,298 targets observed using thermal video cameras at wind turbines occurred in the wake, and flights in the direction of the wind turbine were exceedingly rare. The low number of flying animals recorded within wind turbine wakes suggests that bats and birds may either actively avoid wake regions or that air currents affect bat and bird flight paths such that they do not enter the wake region.

THURSDAY 11TH SEPTEMBER – 10:45-12:00

STRATEGIES FOR EFFICIENT LARGE BIRD FATALITY MONITORING

Mr Eric Hallingstad[1]*, Mr Daniel Riser-Espinoza[1]
[1] *Western EcoSystems Technology, Inc. (WEST)*
*Corresponding author.

The *Good Practice Handbook and Decision Support Tool Post-Construction Bird and Bat Fatality Monitoring for Onshore Wind Energy Fatalities in Emerging Market Countries* (International Finance Corporation 2023; Handbook) promotes a consistent, systematic approach for designing and implementing post-construction fatality monitoring (PCFM) programs across the globe. Information collected during these programs increases our understanding of direct impacts of wind energy facilities on wildlife and enables stakeholders to take effective actions to avoid, minimize, and mitigate for these impacts. As wind energy development continues to expand into emerging markets, many priority species have the potential to be impacted, including species on the International Union for Conservation of Nature Red List. Monitoring that is sufficient to quantify impacts to target species is often costly, and challenging site characteristics—such as topography, dense vegetation, and agricultural activities—can limit survey protocol options for attaining desired detection probabilities. The need for cost-efficient methods to obtain adequate detection probabilities is universal. In this presentation we summarize our recent research quantifying the utility of commonly used search methods (including those described in the Handbook) and alternative search methods (such as incidental detection by operations staff or drone-based searches). We will illustrate the importance of utilizing the best available surrogates in persistence trials when estimating fatality rates of target species. Finally, we will relate our lessons learned in the US to the challenges faced by wind energy facility operators trying to meet PCFM objectives for target species in other parts of the world and identify available tools for developing an efficient PCFM program that provides a quantifiable detection probability. Operators can then demonstrate compliance with environmental requirements of governments or financiers by using optimized search protocols that balance detection probability with monitoring effort and costs.

THURSDAY 11TH SEPTEMBER – 10:45-12:00

BROWN BEAR FEMALES, CUBS AND WIND TURBINES

Dr Slaven Reljic[1]*, Dr Goran Guzvica[2], Mrs Laura Schulte[3], Dr Neda Bogdanovic[4], Prof Dusko Cirovic[4], Prof Lidija Sver[5], Ms Gaja Hana Francky[6], Mr Ratko Popovic[7], Mrs Gordana Iskric[8], Prof Djuro Huber[9]
[1] Oikon Ltd. - Institute for Applied Ecology; Faculty of Veterinary Medicine, University of Zagreb, [2] Oikon Ltd. - Institute for Applied Ecology, [3] Department of Behavioural Ecology, Bielefeld University, Konsequenz 45, 33615 Bielefeld, Germany, [4] Faculty of Biology, University of Belgrade, [5] Faculty of Food Technology and Biotechnology, University of Zagreb, [6] Faculty of Veterinary Medicine, University of Ljubljana, [7] Croatian Forests Ltd., [8] Oikon Ltd. – Institute of Applied Ecology, [9] Faculty of Veterinary Medicine, University of Zagreb
*Corresponding author.

Constructing new infrastructure in a natural environment requires a pre-construction Environmental Impact Assessment which is expected to determine the minimum safe construction exclusion zone. From literature and personal research experience, we know that bears tend to choose remote areas for denning which are usually difficult to access and/or at higher altitudes. In such areas, especially on mountain ridges, there could be good wind-power potential and in Croatia, the construction of wind farms in these areas has been rising in recent years. It is of utmost importance to preserve the denning areas.
We wanted to answer the question of how far from the den a female bear with cubs of the year (COYs) moves in each of the consecutive months following their emergence. Assumption: in the first month(s) after the emergence the COYs are small and the distance from the den and monthly range covered will be lesser, increasing as the COYs grow.
We collected telemetry data of 15 brown bear females with COYs tracked in Croatia and Serbia from 2010 to 2024. We measured and compared their monthly ranges (MCP 100%) and longest distances from the den to the edge of the range. Emergence from the den occurred from the very end of March to the end of April, hence, movements and MCP areas in the first three months of the year were zero or close to zero.
In April, the average of the longest distances from the den in Croatia and Serbia were 1,22 and 1,83 km, while the average MCPs were 0,69 and 1,44 km2, respectively. The values in the following months were: in May 4,01 and 4,04 km, and 4,85 and 9,14 km2. In June 4,70 and 8,40 km, and 12,14 and 33,38 km2. In July 5,03 and 9,46 km and 14,03 and 44,10 km2. In August 4,98 and 9,13 km and 17,26 and 56,45 km2. In September 19,82 and 9,34 km and 249,94 and 84,61 km2. In October 21,67 and 25,63 km and 116,48 and 549,85 km2. In November 8,45 and 22,48 km and 21,20 and 117,05 km2. In December 4,46 and 6,76 km and 13,55 and 44,53 km2. The largest distances and ranges were in the hyperphagia period from September to November. Preliminary, more feeding sites and provided anthropogenic food and higher bear densities in Croatia could explain smaller distances and monthly ranges compared to Serbia.

THURSDAY 11TH SEPTEMBER – 10:45-12:00

PRIORITISING THE ALLOCATION OF FUNDING FOR VULTURE ELECTROCUTION MITIGATION IN SOUTH AFRICA – A CASE STUDY OF THE RENEWABLE ENERGY DEVELOPMENT ZONES

Mr Matt Pretorius[1], Mr Mpalela Oscar Mohale[1], Ms Abulele Adams[2]*, Mr Paul Lochner[3], Dr Dee Fischer[4]

[1] Endangered Wildlife Trust, [2] Council for Scientific and Industrial Research and Centre for Sustainability Transitions, [3] Council for Scientific and Industrial Research, [4] Department of Forestry Fisheries and the Environment

*Corresponding author.

In support of South Africa's Strategic Integrated Projects which were developed to proactively plan and fast-track development of social and economic infrastructure, the Department of Forestry, Fisheries and the Environment commissioned Strategic Environmental Assessments (SEA) which were conducted by the Council for Scientific and Industrial Research in collaboration with several partners. The SEAs aimed to pre-assess environmental sensitivities within specific geographical areas to plan for the site-specific Impact Assessments so that permitting timeframes for renewable energy developments are reduced.

While the location of the REDZs optimises solar and wind resources, they also overlap sensitive avifaunal habitats/distributions including two REDZs in the Eastern Cape province, that are home to the Cape Vulture (*Gyps coprotheres*). While collision impacts with wind turbines are a concern, power lines distributing electricity have a significant impact on vultures.

The aim of the study was to identify and prioritise opportunities for applying mitigation measures intended to reduce Cape Vulture electrocutions in, and within close proximity to, Eastern Cape REDZs. Specifically, to:

- identify distribution pole structure types;
- assesses the existing electrocution mitigation measures;
- prioritise power line for mitigation; and
- estimate costs for mitigation intervention.

An assessment of electrocution risk was conducted by integrating population utilization distribution, historical mortality records, and information obtained from site visits. High-risk power lines were identified based on overlap with high use vulture distribution areas. An analysis of how power line structures contribute to electrocution risks was also conducted. The cost of retrofitting the high-risk likes was determined together with the national transmission entity, and a local supplier of wildlife protection materials.

Preliminary results indicate there are approximately 336 km of line that need to be mitigated with varying structures, T-pole structure represent 2011 of the poles, Delta T pole at 1 700 and H poles representing 74 of these. Only 0.62% of the existing power network has been retrofitted with mitigation measures, highlighting a substantial gap in conservation action. A prioritized mitigation framework was developed to direct resources toward high-risk areas first, ensuring targeted interventions.

The findings provide a scientific basis for mitigation planning, ensuring that funding and interventions are efficiently allocated for strategic retrofitting to reduce impacts on Vultures. The next steps build on this work by EWT to develop an agreed funding framework and mechanism based on collaboration between the project developers, the national transmission company, funding institutions and conservation agencies that prioritises the mitigation of these high-risk lines.

THURSDAY 11TH SEPTEMBER – 10:45-12:00

SEASCAPE-SCALE RESTORATION - SEAGRASS, OYSTERS AND SALTMARSH THREE YEARS ON

Mr Samir Whitaker[1]*, Dr Andy Van Der Schatte Olivier[2]
[1] Ørsted, [2] Yorkshire Wildlife Trust
*Corresponding author.

Overview: Three years ago we initiated an innovative 'seascape' scale restoration programme for the Humber Estuary, by supporting the reestablishment of a series of transitional coastal habitats in their natural succession chain, and the robust assessment of the restoration's biodiversity impacts.
Site 1: Chalk Bank – We have focused on restoration of seagrass and reestablishing connections between fragmented saltmarsh, seagrass, native oysters and sand dune. We have been working on the restoration, improvement and biodiversity enhancement of saltmarsh, seagrass, and the laying of native oysters over a 2 ha area with improvement to 1.5 acres of sand dune.
Site 2: Horseshoe Point – We have focused on the creation of a saltmarsh nursery to aid the restoration, improvement and biodiversity enhancement of saltmarsh at the site. We are also trialing several seagrass restoration approaches, with an intention to introduce native oysters into a sparse cockle bed with historic records of oyster presence.Site 3: Badger's Bog - We aim to carry out a small-scale restoration project to convert arable farmland back to its original saltmarsh habitat and track this change over time.
A suite of biodiversity, water quality and ecosystem service monitoring studies have now largely been completed in order to establish a baseline to qualify and quantify the impact of this combined seascape restoration.
Session Focus: We will share the intent and original plan, key achievements, challenges and our adapted approach to address these challenges. We will also share the details of technical monitoring approach and results of the baseline studies as well as how we intend to show biodiversity uplift moving forward. Finally, we will share results from a recently conducted assessment of the value of the ecosystem services being generated by the project.



POSTERS

P001 – Assessing measurement bias in flight height estimates from animal tracking devices

Dr Evan Adams[1]*, Dr Kim Lato[1], Dr Philipp Boersch-Supan[2], Dr Melinda Conners[3], Dr Daniel Johnston[2], Ms Esther Nosazeogie[4], Dr Lesley Thorne[4], Dr Michael Wethington[1], Dr Kate Williams[1]
[1] Biodiversity Research Institute, [2] British Trust for Ornithology, [3] Western EcoSystems Technology, Inc. (WEST), [4] Stony Brook University
*Corresponding author.

Individual tracking technologies have allowed ecologists to ask novel questions and provide significant insight into how and why animals use habitat. In the context of wind energy development, tracking devices have been used to define migratory routes, estimate the risk of turbine interactions to species, and assess displacement around offshore structures. Advances in animal tracking technologies now enable the collection of altitude (i.e., flight height) measurements for flying species, enhancing our understanding of animal responses to environmental variables and the risks posed by offshore or terrestrial wind development. However, the precision and accuracy of tracking devices are highly variable in the vertical dimension, which can limit their applications to research or monitoring efforts depending on the scale of the inference required.
While horizontal position estimates have been well documented across studies, vertical position accuracy remains under-researched. In this study, we synthesized current information from the literature on accuracy, measurement bias, and precision in altitude estimates across a variety of avian tracking devices. In general, barometric pressure devices consistently exhibit lower bias in altitude estimates than GPS devices, which in turn show lower bias than satellite telemetry devices. However, bias can vary across technical specifications like manufacturer, device model, and individual unit as well as ecological conditions like animal behavior and weather. Here, we will present our synthesis of vertical bias and precision across multiple tracking devices and propose a framework for integrating measurement bias into analyses of flight height. Using a state-space modeling framework we can incorporate multiple estimates of measurement accuracy into a modeling framework that can account for these uncertainties and better estimate true changes in flight height. As these estimates and their uncertainty have significant implications for understanding OWED-related risk, we will provide an example of how these data can be incorporated into a collision risk model.
Studies focused on high-flying species, collision risk assessments, and/or behavioral and biomechanical analyses in relation to atmospheric or oceanic conditions would also benefit from accounting for these biases to reduce uncertainty in their scientific findings. We encourage future research to acknowledge known device biases, document calibration procedures, and conduct field trials to assess altitude measurement accuracy specific to their study when feasible.

P002 – Large-scale validation of smart curtailment using nacelle-mounted acoustic detectors

Ms Seta Aghababian[1]*, Dr Trevor Peterson[1], Ms Caroline Byrne[1]
[1] *Stantec Consulting Services Inc.*
*Corresponding author.

The growth of the wind industry and increasing awareness of turbine-related impacts on bat populations underscore the need for strategic environmental management. Turbine curtailment, which involves preventing turbine rotation under certain conditions, is an effective and widespread practice to reduce the fatality risk among bats. Traditional curtailment often uses a "blanket" approach with a single cut-in speed over an entire season based on regulatory precedent. In contrast, "smart" curtailment incorporates site-specific data to better align with bat activity patterns, reducing risk to bats and minimizing energy loss. We conducted extensive acoustic monitoring at two closely located wind facilities in Iowa, USA, from 2021 to 2023, expanding to 11 additional facilities across the state, totaling 210 wind turbines, during 2022 to 2023. Using one season of nacelle-mounted acoustic data at the first two facilities in 2021, we designed a smart curtailment strategy targeted at high bat activity periods. This strategy aimed to provide similar protection for bats as the existing blanket strategy while minimizing energy loss. The smart curtailment strategy was then implemented at a subset of turbines across the first two facilities in 2022 and five additional facilities in 2023. Despite variations in bat activity levels, the smart strategy reduced acoustic exposure (bat activity exposed to turbine operation) by the same margin as the blanket strategy, with less energy loss. We also simulated turbine operation to evaluate curtailment effectiveness across all facilities, improving our ability to measure inter-facility and inter-year comparisons of curtailment treatments. We observed that the smart strategy would result in energy savings at most sites and similar reductions in acoustic exposure across sites and years. These findings highlight how minimal site-specific information can inform a smart curtailment alternative that is equally protective to bats and yields more energy. Simulated analyses provide extensive evidence that the smart curtailment alternative would likely be similarly effective at other sites and years with comparable underlying seasonal and temporal patterns in bat activity.

P003 – How can food-webs models be relevant to assess the direct and indirect impacts of human activities on marine mammals ?

Ms Emma Araignous[1]*, Dr Pierre Bourdaud[1], Dr Karine Heerah[1], Dr Juliette Delavenne[1], Dr Lydie Couturier[1], Dr Yann Planque[1], Dr Anthony Acou[2], Mr Etienne Almoric[3], Mr Hugo Blanchet[4], Dr Frida Ben Rais Lasram[5], Mr Nicolas Buisson[6], Mr Antoine Chabrolle[7], Mr Dominique Clorennec[8], Ms Magali Collin[9], Ms Lena Despringhere[10], Dr Ronan Fablet[11], Ms Célia Fery[12], Mr Fabrice Gallien[13], Dr Lisa Garnier[14], Dr Laura Iborra[15], Dr François Le Loch[16], Dr Nathalie Niquil[17], Mr Gilles Nolibé[18], Dr Jean-Philippe Pezy[19], Ms Emma Quintard[20], Dr Flore Samaran[21], Dr Thomas Trancart[22], Ms Nastassia Urien[23], Ms Jehanne Prévot[24]

[1] France Energies Marines, [2] PatriNat (OFB-MNHN-CNRS-IRD), Centre d'expertise et de données sur le patrimoine naturel, Dinard, [3] Febus optics, [4] Iberdrola, [5] Unité Mixte de Recherche Laboratoire d'Océanologie et de Géosciences (LOG), [6] Exail, [7] Groupement d'intérêt scientifique sur les oiseaux marins (GISOM), [8] Quiet Oceans, [9] TotalEnergies OneTech SA, [10] Direction générale de l'énergie et du Climat, [11] IMT Atlantique, [12] Skyborn Renewables, [13] Groupe Ornithologique Normand, [14] RTE France, Paris, [15] RWE, [16] IUEM, [17] UMR 8067 BOREA (CNRS, MNHN, UPMC, UCBN, IRD), [18] Cesigma, [19] Normandie Univ, UNICAEN, UNIROUEN, Laboratoire Morphodynamique Continentale et Côtière, CNRS UMR 6143 M2C, 24 rue des Tilleuls, 14000 Caen, France, [20] EDF Renouvelables France, [21] CNRS Lab-STICC, ENSTA Bretagne, [22] Museum National d'Histoire Naturelle, BOREA, Station Marine de Dinard, Dinard, [23] EDF R&D, Paris, [24] France Energies Marines, Brest

*Corresponding author.

The rapid growth of offshore windfarms (OWF) in the English Channel raises concerns about the potential impacts on the marine ecosystems and in particular on marine megafauna. Multiple impacts of OWF are under consideration, including underwater noise, habitat changes and collision risks that have been listed as high priority for marine mammals and seabirds. Usually, the methods used to assess such pressures lack to consider the indirect impacts that can cascade through the food-web. The ecosystem approach provide the ability to integrate direct and indirect impacts of OWF, other activities and climate change. Two main challenges are to be addressed here, the proper integration of marine megafauna in trophic food-webs and certain pressures that particularly affect marine megafauna are yet to be fully considered in this approach.
In the DRACCAR-MMERMAID project, we propose to consider a nested scale ecosystem approach focusing on marine megafauna, to be able to fully consider the direct and indirect effects of OWF at local and regional scales. Here, we present the different methodological challenges that we address to work on a proper representation of the marine megafauna in two food-web models and on the integration in the ecosystem approach of the high priority risks identified for these species.
The local model is particularly designed to assess the specific impacts of the Fecamp OWF. Here, we rely on the instrumentation of the met mast to apprehend the marine megafauna occupation and behavior in the OWF vencinity. This work brings us closer to having a model that could be driven by real-time data. A second, larger model is also used to consider that the Fecamp OWF is implemented in a larger area already hosting multiple humans activities that could act in synergy and have a cumulative effect on marine megafauna. This is specifically the case for the impact of underwater noise and the strong presence of marine traffic in the area. We propose to combine noise propagation models and food-web models to evaluate the potential cumulative effect of noise generated at the different phases of OWF lifecycle along with marine traffic. Our developments emphasize the importance to consider trophic links when assessing the impacts of humans activities on marine megafauna since the pressures on these compartments result from a complex combination of direct and indirect effects affecting the whole food-web.

P004 – Monitoring wind energy projects in Spain: an analysis of environmental consents and impacts on wildlife

Mr Gaspar Arenas Martinez[1]*, Mr Cristóbal Martínez Iniesta[1]
[1] *Ideas Medioambientales*
*Corresponding author.

The analysis of Environmental Impact Assessment Documents (EIAs) is a complex process due to the volume, structural diversity, and case-specific nature of the projects. However, thoroughly understanding the information contained in these documents is essential for properly planning, maintaining, and controlling the avoidance, corrective, compensatory, and complementary measures defined according to administrative guidelines.
The primary objective of this study is to find, extract, analyze, and interpret information on wind energy projects and their impacts on wildlife. We analyzed total of 119 environmental consents for wind energy projects issued between January 2020 and December 2024 by the Ministry for the Ecological Transition and the Demographic Challenge (MITERD). The data was extracted by technical personnel specialized in document analysis, utilizing Artificial Intelligence (AI) tools, including prompting engineering, cloud computing, and a comprehensive technological stack.
The methodological phases include: 1) access and systematic collection of legal gazettes, and regulations from official web portals (BOE); 2) document filtering; 3) data extraction by expert technical staff assisted by advanced AI processes; 4) statistical analysis of all objective parameters, and 5) evaluation of the predictive capacity of the dataset.
The results focused on the analysis of the number of authorized (61.3%) and rejected projects (48.7%) based on the spatial distribution across the territory. The main impacts that resulted in the withdrawal of environmental consent were direct mortality from collisions, barotrauma, connectivity loss between areas used by birdlife, or the presence of nests presence in the vicinity of the facility. A second group included species-specific monitoring, such as those listed in the National catalogue of endangered species, large raptors, and bats. Regarding the group of projects with positive resolutions, specific wildlife monitoring plans were considered; plans for monitoring mortality caused by the structures and their periodicity; and compensatory measures adopted, depending on the administration, capacity, and number of wind turbines.
The conclusions of this study provide a comprehensive view of the evolution of monitoring and wildlife protection measures in wind energy projects, enabling the assessment of trends and identification of critical issues in project development.
The AI tool allowed us to reduce the reviewing times of a large amount of documents. A better understanding of the resolutions improves the establishment, maintenance, and follow-up of the adopted measures, thus supporting the advancement of environmental impact assessment processes.

P005 – Simultaneous offshore and inshore radar recordings bring new insights into bird migration at the Gulf of Lions scale

Dr Camille Assali[1]*, Mr Dorian Chauvin[1], Mr Cyprien Daïdé[1], Mr Nicolas Delelis[1], Mr Vincent Liebault[1], Dr Baptiste Schmid[2], Ms Hélène Schopper[1], Mr Vincent Delcourt[1]
[1] Biotope, [2] Vogelwarte
*Corresponding author.

While bird migratory displacements are informed by inshore visual countings since decades, at-sea distribution of migratory bird in the Western Europe, and especially across the Mediterranean Sea, is poorly known. However, significant development of offshore windfarms is planned in the French waters of the Mediterranean Sea, and especially in the Gulf of Lions, raising crucial needs to acquire improved knowledge about bird migratory patterns at this scale. Combining for the first time concomitant inshore and offshore radar surveys conducted during 3 years within the MIGRALION programme, we got an unprecedented view of bird migratory movements at the Gulf of Lions scale. Data was collected with 3 vertical looking radars, deployed simultaneously on the coast (ornithological radar, 2 units) and offshore (navigation radar, 1 unit). The offshore radar was especially installed onboard a dedicated vessel, conducting more than 1000 km-long transects over the whole Gulf of Lions during 3 days and nights (2 times in spring, 2 times in autumn). Surveys were conducted during 3 years, covering 3 spring migrations and 3 fall migrations. Birds were recorded up to 1500 m agl/asl, informing fluxes (Migration Traffic Rates) and flight heights. Data analysis provided direct comparison between at-sea and inshore movements and gave new insights into bird migration at sea. Cross-analysing different radar sources across the Gulf of Lions allowed us to inform characteristics of migration flows in terms of phenology, spatial and altitudinal distribution of birds. In addition, this comparative study allowed to evaluate the representativity of offshore navigation radar surveys in characterizing at-sea bird migration, while inshore ornithological radar could provide precise quantification of migration on the coast with continuous data recording over the whole 3-years programme. While windfarm development in currently conducted in the area, the observed proportion of the avian migrating community potentially at risk at the Gulf of Lions scale is evaluated, in the light of these new elements on migrating birds at-sea distribution.

P006 – Using novel techniques to calculate flight heights of Manx shearwaters and storm-petrels in the Irish and Celtic Seas with a view to understanding impact pathways from future offshore wind farm (OWF) development

Ms Bryony Baker[1], Dr Orea Anderson[1]*, Ms Sarah Fenn[1], Dr Lise Ruffino[1], Dr Helen Baker[1], Dr Kerstin Kober[1], Dr Sarah Money[1]
[1] *JNCC*
*Corresponding author.

Offshore Wind Farms (OWFs) have the potential to impact seabirds through collision, displacement and barrier effects. Collision risk is estimated using flight behaviour data including flight height and speed, but this is not well understood for all seabirds. ProcBe (Procellariform Behaviour and Demographic rates) seeks to address uncertainty around flight heights of Manx shearwaters and storm-petrels in UK waters. This project uses multiple technologies, including laser range finders (LRFs) and tagging to unlock information around the collision impact pathway for these species. While these species are largely considered to fly at low heights relative to typical collision risk heights, the shear-soaring behaviour of Manx shearwater may change considerably in poorer weather conditions.
ProcBe will acquire data at-sea using LRFs to assess how flight heights may change with weather conditions, potentially increasing collision risk during stormy conditions. The project uses large, stable vessels including ferries and small, charter boats that are able to continue operating in higher sea states and winds than other methods such as traditional boat-based and digital aerial surveys.
We will present the results of the calibration trials (2024/2025), preliminary land-based work on Manx shearwater (2024) and results from our first season of boat-based data collection (2025).
Calibration trials used a range of models of LRF, and a drone mounted with high-resolution GPS to allow the error associated with flight height measurements to be defined and the relative capabilities of LRFs to be ascertained.
Land-based fieldwork at strategic locations was carried out to refine methods and explore the capability of the devices. We collected 216 flight height estimates for Manx shearwater; this will be complemented by data collection in 2025 with new devices and from boat-based platforms, which should increase the number of birds within range of the observer. These data are not currently sufficient to calculate representative flight heights, but they indicate a positive correlation between flight height and wind speed (not significant potentially due to small sample size).
Boat-based data, and flight height distributions, for Manx shearwaters and storm-petrel from 2025 will be presented.
ProcBe will use LRF and tagging data to produce novel best practice guidelines for how to incorporate shearwaters and storm-petrels into impact assessments which will be vital as OW expands both offshore and into areas of high shearwater/storm-petrel density.
This project forms part of the Offshore Wind Evidence and Change programme, led by The Crown Estate in partnership with DESNZ and Defra.

P007 – MARCIS: A tool for assessing the cumulative impact of marine industries and climate on seabirds

Dr Tessa Bargmann[1]*, Dr Lila Buckingham[1], Dr Signe Christensen-Dalsgaard[1], Dr Emma Jane Critchley[1], Prof Francis Daunt[2], Dr Nina Dehnhard[1], Dr Elena Eriksen[3], Dr Per Fauchald[1], Mr Frank Hanssen[1], Dr Kevin Hodges[4], Dr Kate Layton-Matthews[1], Dr Ulf Lindstrøm[3], Dr Elizabeth A. Masden[5], Dr Roel May[1], Dr Anna Nilsson[1], Dr Charlotte Regan[2], Dr Kate R. Searle[2], Dr Arnaud Tarroux[1], Dr Tone Kristin Reiertsen[1]
[1] Norwegian Institute for Nature Research, [2] UK Centre for Ecology & Hydrology, [3] Institute of Marine Research, [4] University of Reading, [5] Environmental Research Institute, The University of the Highlands and Islands
*Corresponding author.

The growth of coastal and marine industries such as energy development, fishery and shipping, has led to increasing pressure on marine biodiversity. Consequently, there is an urgent demand for novel marine spatial planning tools to ensure sustainable use of the marine environment ("blue growth"). Seabirds play an important role as indicators of health in marine ecosystems and are threatened globally, partly due to anthropogenic activities at sea. Norway is home to a significant proportion of the world's seabird populations and therefore has an international responsibility to protect them. Here we present the MARCIS project, a Norwegian Research Council funded project that focuses on marine spatial planning and cumulative impacts of blue growth on seabirds in the Norwegian exclusive economic zone as well as the North Sea.
The goal of the MARCIS project is to develop a spatial decision support tool, based on the Halpern approach, to assess cumulative impacts of human marine industries and climate on seabirds' marine distribution and land birds migrating over sea. To achieve this goal, the project has compiled detailed maps of marine industries and the distribution of seabird populations during their non-breeding season. In addition, we have further developed the Halpern approach, by qyantifying the impacts on seabird populations and migratory birds to be assessed by using state-of the art modelling tools. Seabird populations sensitivity have been assessed analytically to the different marine pressures (offshore wind farms, fishery competition and bycatch, and climate change). The output from the tool and of the project allows users to quantify, and immediately illustrate, the spatial specific cumulative impact of marine industries on seabirds, and use this in their planning processes. The project has been a collaborative project, with partners from industry, management, NGOs and research organisations to ensure the usefulness of an app that will improve marine spatial planning and risk assessment in Norway in particular, thus contributing to sustainable development in the marine environment.

P008 – Blade tip speed and collision risk assessment for three raptor species

Dr Lucie Barluet De Beauchesne[1]*, Mr Henri-Pierre Roche[1]
[1] *Biodiv-Wind*
*Corresponding author.

The expansion of wind energy industry increases concerns about biodiversity and especially endangered bird species subject to collisions with wind turbines. One solution to reduce bird fatalities on wind farms is to install an automatic detector system, such as the *SafeWind* technology. This SafeWind system actively stops the blade tip rotation while birds are detected close to the turbine. This preventive action would allow birds to have more time to safely cross or avoid blades. However, this action causes a loss of profitability for wind farms. It is, thus, important to investigate if an optimum rotation speed can be found to reduce bird mortality at less cost for wind farms. In this study, we aim to show the relation between blade tip speed (BTS) and collisions of three raptor species the Red Kite (*Milvus milvus*), Griffon Vulture (*Gyps fulvus*) and the Eurasian Kestrel (*Falco tinnunculus*). We hypothesized that raptors can better avoid collision when BTS is within their natural flight speed range. Over six years of SafeWind deployment, we have detected 35 Red Kite, 21 Eurasian Kestrel and 36 Griffon Vulture collisions with wind turbines. Whereas the distribution of BTS over one year indicates that 60 to 65% of the time BTS was inside the natural flight speed ranges of these three species (Griffon Vulture: up to 94 km/h; Eurasian Kestrel: up to 72 km/h; Red Kite: up to 76 km/h), only 20% of collisions occurred at this speed range. Interestingly, concerning lethal collisions, we found that there is a species-specific sensibility to BTS. Indeed, 90% of lethal collisions occurred at BTS superior to 60 km/h for the Eurasian Kestrel, superior to 90 km/h for the Red Kite and superior to 120 km/h for the Griffon Vulture. These findings suggest that while reducing blade tip speed does not completely prevent collisions, it significantly contributes to lowering collision risks and bird mortality. Our results highlight a clear species-specific pattern in susceptibility to BTS, with griffon vultures being particularly less vulnerable to low BTSs than the two other species. To optimize both bird protection and energy production, future systems could benefit from dynamically adjusting BTS based on real-time species identification, enabling targeted interventions.

P009 – Comparative analysis of five ultrasound devices to detect, record and identify bats on wind farms

Dr Lucie Barluet De Beauchesne[1]*, Ms Eléonore Lefebvre[1], Mr Henri-Pierre Roche[1]
[1] *Biodiv-Wind*
*Corresponding author.

Industrial wind turbines for electricity production can cause a significative number of bat mortality. Predictive models of bat activity are commonly used to limit collisions risks of bats with wind turbines. These models determine critical periods when turbines should stop to prevent collisions. They generally use ultrasound devices to detect, record and identify bats around wind turbines. While the performance of these devices is crucial for the strength of the predictive models, there is a lack of comparative studies on devices already on the market. Considering the importance of this subject for both bat conservation and the economic impact on wind farm operators (study costs, loss of production), we wanted to reproduce the comparative analysis conducted by T. Disca in 2023. To do this, we used the same equipment, same settings and we reproduced its test protocol, while also incorporating more recent equipment that was not tested by Disca (2023), the *Smart System* from Wildlife Acoustics. From the 20 nights of survey, we recorded a mean of 9376 contacts per device. Our results are very close to those obtained by Disca (2023) and show that the performance differs significantly between the tested devices. However, these disparities do not seem to affect the conclusions of the predictive models. Indeed, all predictive models indicate that a curtailment when the temperature is between 9°C and 16°C would cover 90% of bats activity, which is measured in number of bats recordings. These 90% of bats activity can also be covered by the humidity level (90% of bat recordings between 55% and 85% humidity). These conclusions must be qualified by the fact that bats activity was measured in March, with an overrepresentation of *Miniopterus schreiberi* (60% of the bats recordings). Although technological devices for the acoustic detection of bats have become essential for the study of these species, it is surprising that the comparative study of the performance of these devices has attracted so little interest. This comparative work is necessary for each new device to ensure the data quality and the strength of the predictive model.</p

P010 – Investigation of pelagic fish communities in Offshore Wind Farms during construction and operational phases using bottom moored echosounders

Dr Benoit Berges[1]*, Dr Jeroen Hubert[2], Ms Jozefien Marijke Demuynck[3], Dr Elisabeth Debusschere[4], Dr Carlota Muñiz[4], Prof Hans Slabbekoorn[3]
[1] Wageningen Marine research, [2] Wageningen University, [3] Leiden University, [4] Flanders Marine Institute (VLIZ)
*Corresponding author.

Following European targets for renewable energy, it is expected that the number of Offshore Wind Farms (OWF) in the southern North Sea will increase substantially in the coming years. Moreover, there is already numerous OWF operating along the Dutch and Belgian coast. The monitoring work to date has focused on alterations in the bentic community, while effects on the pelagic community remain relatively unexplored. For both construction and operational phases, there is a lack of insight into the impact on pelagic fish communities. Using bottom-mounted echosounders (active acoustics) and passive acoustic sensors deployed in the vicinity of OWFs, pelagic fish were monitored through extended periods of time at various locations along the Dutch and Belgian coast. Fish biomass was derived using narrowband acoustics at 70 kHz whilst broadband acoustics (160-250 kHz) was used to determine pelagic target types based on acoustic fingerprint similarities. In parallel, passive acoustics was used to investigate the associated presence of predators such as harbour porpoises. As part of this project, four sets of sensors were deployed: 1) during the construction phase of 2 Dutch OWFs and 2) during the operational phases of OWFs along the Dutch and Belgian coast.
First, in relation to OWF construction, the behaviour of pelagic fish in the direct surroundings of pile driving events was investigated. A large amount of data at various distances from a few hundred meters up to almost ten kilometres away from the pile driving site revealed low spatial responsiveness in the local fish community within the water column. We found strong evidence for a lack of spatial evasion (vertical or horizontal) at all distances, while the sound exposure levels of pile driving exceeded the temporary hearing damage thresholds for fish.

Second, the monitoring in operational OWFs aimed at capturing the density, diversity, and behaviour of pelagic fishes within and outside OWFs. For this study, data were collected synchronously in a paired design, for a windfarm location and an ecologically equivalent (in terms of distance to shore/depth) shipwreck location. Echosounder data provided insight into pelagic fish presence and behaviour (swimming direction/depth) and passive acoustic data into harbour porpoise presence and behaviour (echolocation clicks indicating social interaction and foraging). We found that there were less pelagic fish present in OWFs than in the control shipwreck sites.

P011 – Scalable Oyster Reef Restoration in Offshore Wind Farms: Deployment of Droppable Oyster Structures in the North Sea

Ms Karin Bilo[1]*, Ms Nienke Oostenbrink[2]
[1] *Orsted,* [2] *Ocean Health, Van Oord*
*Corresponding author.

In 2024, Ørsted and Ocean Health implemented an innovative approach to European flat oyster (*Ostrea edulis*) restoration by deploying lightweight, droppable oyster structures (DOS) within the Borssele 1&2 offshore wind farm in the North Sea. As offshore wind farms present a unique opportunity for marine habitat restoration, this project aims to enhance biodiversity by reintroducing a keystone species that has largely disappeared from the North Sea. Traditional broodstock structures used for oyster restoration are heavy, require large vessels and cranes for installation, and thus incur high costs. To address these challenges, we developed and piloted two innovative broodstock structures: (1) bio-based oyster cubes constructed from dredged sediment and natural binders, and (2) robust, easily deployable tetrapods designed in collaboration with Delft University of Technology. The two designs, weigh up to 50 kg and can be installed manually from small vessels, significantly reducing logistical complexity and expenses. A total of 70 droppable oyster structures were installed at the scour protection of the Borssele 1&2 wind farm. Adult oysters were attached to these structures with the goal of producing larvae to facilitate natural colonization in adjacent areas, thereby improving local biodiversity and water quality. The innovative design of these structures allows for their integration into routine offshore wind farm maintenance, enabling scalable and cost-effective deployment. To assess the success of this initiative, a comprehensive monitoring program has been established. An initial assessment, conducted one month after installation using a remotely operated vehicle (ROV), confirmed that all structures had settled on the scour protection as intended. The ongoing analysis of ROV footage will provide insights into oyster survival, reef development, and overall habitat impact. This presentation will outline the project's objectives, the characteristics of the droppable oyster structures, the installation methodology, and the preliminary monitoring results. By demonstrating the feasibility of this approach, we aim to showcase a scalable, cost-efficient solution for oyster reef restoration in offshore wind farms, with potential applications across European waters and beyond. **Keywords**: Oyster reef restoration, offshore wind farms, European flat oyster, droppable oyster structures, biodiversity, marine habitat restoration

P012 – Mortality among birds and bats due to small wind turbines is higher than expected

Mr Allix Brenninkmeijer[1], Mr Bob Jonge Poerink[2]*, Dr Jasja Dekker[3], Mrs Saartje Munten[2], Dr Erik Klop[4], Mr Paul Westerbeek[5]
[1] province of Groningen, [2] Ecosensys, [3] Jasja Dekker Dierecologie, [4] Altenburg & Wymenga, [5] provincie of Fryslân
*Corresponding author.

As part of the energy transition, small wind turbines (with a maximum hub height of approximately 15 meters) are increasingly being installed at agricultural enterprises in the Netherlands. However, little research has been conducted on bird and bat collisions with these turbines. Previous studies reported relatively low numbers of collision fatalities among birds and bats. Between 2022 and 2024, we systematically searched for collision victims at small wind turbines in the northern Netherlands, specifically in the province of Groningen. We conducted year-round searches for casualties at a total of 28 small wind turbines, completing more than 4,000 search rounds throughout the monitoring period. Our study revealed a substantial number of fatalities among both birds and bats. The bird species most frequently affected were common farmyard and farm land species, including barn swallow (*Hirundo rustica*), house martin (*Delichon urbicum*), common starling (*Sturnus vulgaris*), common wood pigeon (*Columba palumbus*), mallard (*Anas platyrhynchos*) and common kestrel (*Falco tinnunculus*). Additionally, we recorded a relatively high number of bat casualties, identifying six different bat species as victims. The common pipistrelle (*Pipistrellus pipistrellus*) was the most frequently found bat species. Although the number of casualties per individual wind turbine is relatively low, the cumulative impact of a high density of small wind turbines may result in mortality rates that exceed the ORNIS 1% threshold for additional mortality for certain species. Our findings highlight the necessity for local policymakers to consider the effects of small wind turbines on populations of bird and bat species. To prevent victims among birds and bats, it is essential to place small wind turbines strategically by taking into account landscape features and the flight behavior of birds and bats. Furthermore, developing mitigation measures to reduce collisions among birds and bats is recommended.

P013 – BIRDSAFE: Measuring and modelling nocturnal bird migration through an offshore windfarm

Mr Joep Breuer[1]*, Dr Karen Krijgsveld[2], Mr Martin Poot[2]
[1] TNO, [2] Wageningen University & Research
*Corresponding author.

At the North Sea, offshore wind energy is expanding rapidly, but these developments must consider natural values. A key concern is understanding the impact of wind farms on the millions of migrating songbirds crossing the North Sea each year. Songbird migration occurs primarily during nocturnal hours and remarkably mass migration is often restricted to only those nights when the weather is favourable for a safe and quick crossing.. Especially during the relatively rare nights with side or tailwinds, migration activity can peak and collision rates with offshore turbines may be higher. Minimising risk of mortality to migrating birds can be achieved by curtailing (stopping) wind turbines during peak migration moments and is currently applied in the Netherlands with the so-called “Start/Stop procedure”. Improving the efficiency and effectiveness of this measure lies the focus of BIRDSAFE.With BIRDSAFE we will achieve a better understanding of (nocturnal) migrating bird behaviour towards, close to and through the offshore wind farms. Over 70 nocturnal camera systems distributed over 7 turbines, in the Hollandse Kust Zuid windfarm of Vattenfall, together with 2 powerful bird radar systems, will capture the behaviour of migrating birds in the autumn of 2025 and 2026, from wind farm scale to at an unprecedented level of detail close to the rotor disc. The set up will also give the opportunity to record last instance avoidance behaviour near the rotor and/or actual collisions. This large empirical dataset will allow us to create a better modelling of the actual risk of the OWF development for (migrating) birds. This will also lead to an optimisation of shut-down-on-demand scenarios. Preliminary results will be shown of onshore tests of the camera systems to determine the bird flux and collision rates. Also initial bird flow model results are presented with an parameter set derived from literature. These models will be updated on basis of the newly data to be gathered offshore. Equipment installation will coincide with the conference, and initial measurement results are expected in Q4 2025, with final findings in Q4 2026. BIRDSAFE is a large scale measurement and modelling campaign focused on the nocturnal migration of birds through offshore windfarms. Goal is to acquire detailed knowledge on migration movement through offshore windfarms and to finetune curtailment strategies to further reduce the impact of offshore wind farms on birds. The models will also aid to better plan operation of existing and layout of future wind farms.

P014 – ZWEMT: A comparative study into the flight behavior of birds around turbines with and without a single black blade using technology

Mr Joep Breuer[1]*, Mrs Jonne Kleyheeg-Hartman[2], Dr Erik Klop[3]
[1] TNO, [2] Waardenburg Ecology, [3] Altenburg & Wymenga
*Corresponding author.

An earlier study in Norway [May 2020] indicated that painting one of the turbine blades black can potentially reduce bird fatality rates by over 70%. It is hypothesized that improving the visibility of the turbine by painting one of its blades black, allows birds to take evasive action early on. The Norwegian experiment has been repeated in a windfarm in the Eemshaven (Netherlands), where besides counting bird fatalities, as part of the ZWEMT project also a wide range of other measurement techniques were deployed. The goals of the ZWEMT project were: 1) to gain insight in the behaviour of birds in the proximity of wind turbines with and without a single black blade and 2) to study the timing of and circumstances under which collisions of birds with wind turbines occur . Two pairs of turbines were studied, each with a standard turbine (unpainted blades) and a turbine with one of the blades painted black. A Max® 3D bird radar was installed, which tracked the flight paths and behaviour of birds around the wind turbines. Furthermore, WT-bird® systems [Wiggelinkhuizen 2006] and microphones have been installed in the blades of one turbine with and one turbine without a black blade to register any bird-to-blade impacts. The WT-bird system registers blade vibrations at various positions in the blade and by analysing this data one can determine whether a bird impact occurred and approximately where the impact must have happened. Additionally, thermal and daylight cameras register the birds flight behaviour in proximity of the wind turbines. The experiment ran from September 2023 to October 2024 and the final results are presented during the conference. The measurements with the Max® 3D bird radar revealed no differences in the flight behaviour (flight height, flight speed and straightness of the flight) of birds close to wind turbines with and without a black blade. In addition, the thermal camera data (although on a more limited data set) showed no difference in behaviour between the standard turbine and the turbine with a black blade. The WT-Bird systems registered, due to installation limitations, only a few collisions, which made that the timing of and collisions under which collisions occur could not be determined in this project. Technological aids like radar, cameras and in-blade sensors can give valuable information on the flight behaviour and collision risks around wind turbines if limitations of the technologies are considered.

P015 – Ecological baseline monitoring before the construction of a wind farm in the Dutch North Sea

Dr Joost Brinkkemper[1]*, Mr Pepijn Van Tol[1], Ms Irna Huisjes[1], Mr Joël Cuperus[2], Ms Lisa Hoekema[2], Ms Pauline Roos[3], Ms Hermione Van Zutphen[3]
[1] WaterProof Marine Consultancy & Services BV, [2] Waardenburg Ecology, [3] Ecowende
*Corresponding author.

The area in the Southern North Sea that is dedicated to the development of offshore wind is rapidly increasing. To ensure these developments are sustainable for the North Sea ecology, potential ecological impacts need to be considered, and mitigation measures need to be implemented in the design of wind farms. The Ecowende wind farm includes an extensive ecological monitoring programme, that aims to provide insight into the effectiveness of measures taken to reduce negative and stimulate positive ecological impacts. To monitor long-term trends in ecological parameters, a large-scale network of sensors was deployed in August 2024. This network allows to study an evolving habitat from the baseline situation to the construction and operational phase of the wind farm. The long-term monitoring network consists of 14 measurement platforms deployed on the seabed, in and outside the area of the future wind farm. All measurement platforms contain cetacean click detectors, to monitor cetacean presence and activity, and fish telemetry receivers to detect tagged fish. These instruments are co-located at 8 locations with broadband hydrophones to monitor ambient sound, at 4 locations with echosounders to monitor pelagic fish, and at 2 locations with ADCPs (Acoustic Doppler Current Profilers) and multi-parameter probes to measure currents, waves and water quality parameters. From August 2024 – August 2025 data has been gathered on a continuous basis to collect baseline measurements. These baseline measurements allow us to study the presence of species, gain a better understanding of their habitat use, and collect data on the characteristics of their current habitat. The results of the baseline measurements are presented, followed by an outlook into future research. The ecological monitoring network that is part of the Ecowende wind farm provides a unique opportunity to collect data on the ecology of the Southern North Sea. The baseline data presented are essential to critically evaluate the impact of the construction and operation of the wind farm and the effectiveness of the implemented ecological measures.

P016 – Population viability assessment of the Cape vulture considering the emerging wind energy infrastructure development in South Africa

Dr Francis Brooke[1], Dr Carmen Bessa-Gomes[2], Dr Olivier Duriez[3], Dr Francois Sarrazin[4], Dr Jean-Baptiste Mihoub[4], Dr Morgan Pfeiffer[5], Prof Colleen Downs[6], Prof Jan Venter[1]*

[1] Department of Conservation Management, Madiba Drive, George Campus, Nelson Mandela University, South Africa, [2] Ecologie Systématique Evolution, Université Paris-Sud, CNRS, AgroParisTech, Université Paris Saclay, Orsay, France, [3] Centre of Evolutionary and Functional Ecology, Univ Montpellier, CNRS, EPHE, IRD, 1919 Route de Mende, 34293 Montpellier cedex 5, France, [4] Centre d'Écologie et des Sciences de la Conservation (CESCO), Muséum National d'Histoire Naturelle, Centre National de la Recherche Scientifique, Sorbonne Université, CP 135, 43 rue Buffon, 75005, Paris, France, [5] U.S Department of Agriculture, Animal and Plant Health Inspection Service, Wildlife Services, National Wildlife Research Centre, Ohio Field Station, 6100 Columbus Avenue, Sandusky, OH 44870, USA, [6] Centre for Functional Biodiversity, School of Life Sciences, University of KwaZulu-Natal, Private Bag X01, Scottsville, Pietermaritzburg 3209, KwaZulu-Natal, South Africa

*Corresponding author.

Vultures are the most threatened avian guild worldwide as they are susceptible to anthropogenic pressures. African vultures have declined dramatically in the past few years due to consumption of poisoned carcasses, fatal interactions with electrical infrastructure, the illegal trade of body parts and, recently, wind energy infrastructure. The southern African endemic Cape Vulture (Gyps coprotheres) is considered at risk to wind turbine collisions given its overlap with proposed and developed wind farms and its international ranked conservation status as "Endangered". Therefore, using a population viability modelling approach, our study examined how the present threats impact the Cape Vulture population and how the population will respond to potentially increased mortality rates from wind farm development at "worst-case scenarios". Model simulations indicated that wind energy development will cause a decline in stochastic population growth in a portion of the population that overlaps with wind farms, and should large numbers of adult birds be killed in a "worst-case scenario", the global population will begin to decline. Present population figures for breeding colonies are not available for the portion of Cape Vultures likely to be impacted by wind farms and obtaining clear population figures must be prioritised to ensure future effective management decisions. Measures to limit the impacts of wind turbines on Cape Vultures are imperative whilst South Africa is still in the early stages of renewable energy development. Appropriate locational planning for future proposed wind farms need to take priority, whilst mitigation measures at operational wind farms should be explored to ensure the species long term survival.

P017 – All hands on deck: A collaborative approach to compensation, reducing the bycatch of northern gannet in Portugal

Mr Thomas Broom[1]*, Mr Fraser Carter[1]
[1] *NIRAS*
*Corresponding author.

Bycatch is one of the biggest threats to seabirds worldwide, with recent estimates suggesting around 200,000 seabirds are bycaught in European waters each year. The northern gannet is one of the most significantly affected species, experiencing threats from bycatch along its migratory flyway through north and western Europe, as well as the potential cumulative impacts of European offshore wind farms. In Portuguese waters, gannets are repeatedly the most bycaught seabird species, with estimates of annual bycatch reaching as high as ~14,000 birds bycaught in a single harbour. Migratory connectivity links these bycatch hotspots with protected areas at risk of impacts from offshore wind developments, providing an opportunity for bycatch mitigation measures to contribute to compensation efforts to offset offshore wind impacts further up the flyway. Here, we present a case study of collaborative compensation, in which two proposed offshore wind developments in Scotland are collaborating on a compensation measure aiming to reduce gannet bycatch in Portugal. Working closely with the NGOs and researchers leading the efforts to combat seabird bycatch, the measure aims to work with fishers in Portugal to implement evidenced bycatch reduction techniques to reduce the numbers of gannet caught in bycatch, many of which originate from colonies in Scotland and the surrounding UK National Site Network. The potential scale of implementation of the measure in Portugal has made it well-suited to collaboration, with the two projects enabling wider implementation that benefits both the projects and the birds. This presentation will describe the collaborative process by which the measure has been, and continues to be, planned, secured and evidenced. We will share the key lessons learned and the challenges that have been overcome throughout the process. We will also discuss the approaches taken in evidencing connectivity between Portuguese bycatch and Scottish Special Protection Areas, and therefore quantifying the delivery of compensation for the impacted sites. Offsetting the impacts of offshore wind on seabirds is becoming increasingly important as countries aim to increase offshore electricity generation and collaborative, strategic level measures can offer efficient and effective solutions.

P018 – Protection and Reinforcement of Farmland Bird Populations in Western France

Mr Mickaël Caceres[1]*, Mrs Marine David[1]
[1] *EDF Renouvelables France*
*Corresponding author.

In the context of conserving farmland birds in the West of France, including the Little Bustard (Tetrax tetrax) and associated species such as the Montagu's Harrier (Circus pygargus), the Hen Harrier (Circus cyaneus), the Stone-curlew (Burhinus oedicnemus), and the Eurasian Curlew (Numenius arquata), conservation actions have been implemented. These measures aim to enhance biodiversity specific to agricultural plains, particularly in favor of the *Tetrax* tetrax, considered an umbrella species due to its important ecological role. Notably, the population in the Poitou-Charentes region in France is classified as Endangered (EN) on the French IUCN Red List of Threatened Species. The goal is to maintain and increase local populations by consolidating existing ones and promoting the reconstitution of a viable and sustainable population. A partnership with agricultural operators was established in 2015 with the aim of creating and maintaining a natural cover favorable to plain-dwelling birds. This collaboration commits the operators to adapt their vegetation management methods on 22 hectares of agricultural parcels. These measures are designed to protect the nesting of the Tetrax tetrax and associated species to improve reproductive success. Nests are located and protected each year, and GPS tracking is conducted on the males of the *Numenius* arquata. The management of existing environments, such as fallows and meadows, is optimized to favor nesting and feeding of targeted species. To evaluate measures effectiveness, follow-up surveys are carried out each year by a local association, through a protocol called "flash counting". This protocol provides an indicator of the number of settled males and the areas that birds frequent during the breeding period, thus allowing for long-term adaptation of conservation measures. Furthermore, systematic observations are conducted. They include the recording of time of observation, number, sex, and behavior of identified individuals as well as geographical data analyzed using GIS. The follow-up surveys conducted have improved the state of knowledge on local avifauna. They demonstrate that parcels targeted by the supportive measures are functional and able to host a stable *Tetrax* tetrax population. Associated species such as *Numenius* arquata and *Burhinus* oedicnemus use these same parcels for nesting and feeding. Nest protection also allows for the conservation of *Circus* pygargus and *Circus* cynaeus populations. The reproductive success of plain birds improves yearly thanks to the involvement of agricultural operators in protection actions. This type of sustainable and concrete measure is beneficial to endangered populations, without causing additional impacts on operational wind farms.

P019 – Feedback on 15 years of monitoring bird and bat mortality at a Mediterranean wind farm

Mr Mickaël Caceres[1]*, Mrs Marine David[1], Mr Pierre Gitenet[1]
[1] *EDF Renouvelables France*
*Corresponding author.

p>A study initiated in 2010 has been monitoring avian and chiropteran mortality at a 31-turbine wind farm located in a natural area near the Montpellier metropolis (Hérault, 34), south of France. The wind farm was constructed in three phases (2006, 2009, and 2014), with turbines rated at 2MW and an average height ranging from 95 to 120 meters. The primary objective of this study was to characterize the impact of the wind farm on local flying fauna. It quickly revealed a significant impact on local raptors, particularly the lesser kestrel (*Falco naumanni*), a small falcon that is both protected and vulnerable on the IUCN Red List of Threatened nesting birds in France, necessitating continuous enhanced monitoring over the past 15 years. Initially, a voluntary protocol was tested in 2010 and subsequently reinforced in 2011. Since 2012, the protocol has seen minimal changes, with bi-weekly inspections per turbine over an 8.5-month period (March 1st to November 15th), maintaining a regular interval of 2 to 4 days between inspections. Since 2010, three operators—LPO Hérault, Synergis Environnement, and Biotope—have alternated monitoring management, with one operator providing consistent oversight for twelve consecutive years, from 2010 to 2021. Carcass persistence tests, observer efficiency assessments, and a surface correction factor have been applied to results in the aim to estimate real mortality rates. Following recorded collisions with certain species, curtailment measures (for both avifauna and chiroptera) and collision risk reduction strategies (bird detection systems) have been implemented since 2013 and are ongoing. The results indicate a relatively low impact on migratory bird fauna, a significant proportion of raptors and galliformes in the recorded collisions, and overall, a wide diversity of affected species. The impact on chiroptera has been moderate and typically concentrated within the post-reproductive activity period. These monitoring efforts also demonstrate the effectiveness of implemented risk reduction solutions and the evolution of their efficacy in time. This long-term monitoring, with an unprecedented level of survey effort (over 1000 inspections across 15 years), provides unique insights into the mortality of flying fauna at a wind farm in the south of France and highlights effective solutions to reduce collision risk.

P020 – Further technical improvements in vantage points localization: improving observation quality, economic efficiency and SNH (2017) compliance

Mr Bruno Ćaleta[1]*, Ms Dora Čuljak[1], Ms Ivana Latković[1], Mr Josip Nikolić[1], Ms Ksenija Hocenski[1], Mr Branimir Radun[1]
[1] *Oikon Ltd. – Institute of Applied Ecology*
*Corresponding author.

Collision risk assessment for birds is a crucial aspect of wind farm planning and biodiversity conservation. The Vantage Point (VP) method is widely used for monitoring bird behavior for high-risk species. However, traditional VP selection relies on expert judgment, introducing subjectivity and biases. Additionally, low-resolution Digital Terrain Models (DTMs) used in GIS-based VP location selection fail to represent above-ground obstructions like forests and buildings, leading to suboptimal observer placement. Thus, we introduce a new data-driven methodology that optimizes VP selection using high-resolution LiDAR-derived spatial data and the Reverse Viewshed algorithm. The goal of this research was to compare the LiDAR-based method against traditional expert-driven VP selection across four proposed wind farm sites in Croatia, quantify improvements in visibility coverage, and assess reductions in the number of VPs required for monitoring. LiDAR data were processed to generate key geospatial datasets: DTM, Digital Surface Model (DSM), Canopy Height Model (CHM), and a land cover map. A Reverse Viewshed algorithm was implemented using the Visibility Analysis plugin in QGIS, utilizing proposed wind turbine locations as observer points to determine the visibility of the collision risk volume. Observer height was set to the lowest rotor clearance, while target height was fixed at 1.6 meters to represent human eye level. This resulted with high-resolution visibility heatmaps that were used to pinpoint visibility hotspots to optimize VP localization. Results show that the LiDAR-based VP selection method reduced required VPs by up to 50% compared to expert-selected locations and improved visibility coverage by 42–62%, particularly in areas with complex terrain and dense vegetation. This reduction could lower monitoring costs by up to 41%. The most significant gains were in areas with high tree cover (>80% canopy density), where traditional DTM-based analyses underestimated obstructions, leading to ineffective VP placements. The LiDAR-based methodology accounted for vertical occlusions, enabling optimal observer positioning even in forested landscapes. This study demonstrates that LiDAR-based VP selection outperforms traditional methods, offering a precise, cost-effective, and scalable approach for collision risk monitoring. Proposed methodology minimizes surveyor bias, reduces fieldwork costs, and provides a scalable framework for wind farm impact assessments. Limitations include LiDAR data availability, computational demands of high-resolution visibility modeling, and the necessity of field validation for terrain accessibility at VP locations. The methodology aligns with Scottish Natural Heritage (SNH) guidelines and has global applicability. Future research should explore automating VP selection and integrating real-time bird tracking data to refine monitoring protocols.

P021 – AVI-Artificial Intelligence Recognition – AGRI - Towards dynamic wind turbines shutdown during farm work assisted by drones: a step towards better bird safety

Mr Philippe Cannesson[1]*, Mr Antoine Coulombel[2], Mr Salim Mekni[1], Mr Arezki Meziane[1], Mr Guillaume Marchais[3], Mr François Taraud[4], Dr Arnaud Lewandowski[5]
[1] Ecosphère, [2] Prodrones, [3] edp, [4] WPD, [5] LISIC - Université du Littoral Côte d'Opale
*Corresponding author.

Agricultural activities within wind farms lead to increased avian activity on site. This increase in activity also raises the risk of collisions between birds of prey and wind turbines. The measures currently suggested to reduce this risk can be burdensome for farmers and/or developers. In this context, Ecosphère has partnered with Prodrones, edp, WPD, and the LISIC laboratory to launch the AviAir-Agri project. This innovative research project aims to use drones to monitor agricultural activities across multiple wind farms and reduce the risk of bird of prey collisions with wind turbines. The goal is to identify agricultural activities that may attract birds, such as alfalfa mowing or plowing, and then recommend that wind farm developers temporarily shut down the affected turbines. One of the main advantages of using drones is their ability to perform multiple passes per day, providing real-time data on crop conditions and agricultural activities while minimizing the impact on the environment and farmers. In the event of detecting a high-risk activity, developers can react quickly, for example, by shutting down the turbines, to avoid bird collisions. This process can be adapted to any type of crop, its rotation from year to year, and the landscape context of the wind farm. The AviAir-Agri project follows a three-step methodology. The first step involves mapping ongoing or past agricultural activities using drones between two imagery captures. This first step is fully automated with the use of an autonomous drone. The second step is to assess the collision risk based on the type of farm work and bird activity detected and its proximity to sensitive zones (300 meters around the blades) using photographs taken by the drone. Finally, the third and last step is to send our temporary shutdown recommendations (the number of turbines affected and the recommended shutdown duration) to wind developers. Eventually, each of these steps will be automated. Tests conducted on pilot sites have shown positive results, with a notable reduction in bird mortality. AviAir-Agri thus represents a step forward towards sustainable wind energy development, integrating innovative technologies to address the challenges of coexistence between agriculture, biodiversity, and renewable energy.

P022 "5* – would nest there again" - Mr and Mrs Kittiwake: Delivering kittiwake artificial nesting structures as compensation at scale. A Hornsea Project Three and Four Case Study

Mr Fraser Carter[1]*, Mr Robin Ward[1]
[1] *NIRAS*
*Corresponding author

With the increasing pace and scale of offshore wind deployment in the North Sea, the likelihood of cumulative developments having an adverse effect on protected habitats or species is growing. Given the current climate emergency and finite possibilities for locating wind farms, it is likely that future projects will increasingly rely on a derogation case under the Habitats Regulations, including the delivery of ecological compensation measures, in order to secure the necessary consents. Here we present a case study of Ørsted's Hornsea Projects Three and Four as the first offshore wind farms for which derogation measures were specified in its consent requirements. The UK Government could not rule out via their Habitats Regulation Assessment an adverse effect on integrity in relation to in-combination collision impacts on black-legged kittiwake (*Rissa tridactyla*), a red listed species and a qualifying feature of the Flamborough and Filey Coast Special Protection Area (part of the UK National Site Network). The objective of this work was to find a suitable measure which would deliver sufficient compensation for the Hornsea projects to offset their potential impact on the designated feature. Nearshore and onshore Artificial Nesting Structures (ANS) were proposed to provide nesting space for a colony of kittiwake to establish in suitable areas. The aim of the strategic collaboration between Hornsea projects allows for compensatory measures that meet the needs of both projects, and aligns with net zero and biodiversity goals. The approach taken in the UK may serve as useful precedent for other countries with offshore wind ambitions. The process lasted over four years, requiring extensive consultation with stakeholders including Statutory Nature Conservation Bodies, Government bodies, planning authorities, research organisations and engineering innovation. The final compensation plan for Hornsea Project Three was accepted by the UK government in 2023, permitting construction to begin. Hornsea Project Four aims to receive the same level of acceptance before the CWW conference. Now built, the ANSs will be monitored to ensure they are successful and compensate for the impact of the offshore wind farms. They will also provide an exciting opportunity for a detailed insight into kittiwake ecology because of the unique structural design. From concept to construction, this presentation will showcase the greater than expected and extensive process undertaken collaboratively between both projects to deliver artificial nesting structures across four locations in the UK. Lessons learnt will be shared to help inform the future pipeline of similar compensation measures.

P023 – Vertical interactions between sessile and mobile species of biofouling on the Fécamp platform

Mrs Mathilde Charbonnelle[1]*, Mrs Manon Leroux[1], Dr Aurore Raoux[1], Dr Lucille Furgerot[1], Mr Ferdinand Sclicklin[1], Dr Jean-Philippe Pezy[1]
[1] *Normandie Univ, UNICAEN, UNIROUEN, Laboratoire Morphodynamique Continentale et Côtière, CNRS UMR 6143 M2C, 24 rue des Tilleuls, 14000 Caen, France*
*Corresponding author.

The imperative to mitigate climate change and reduce greenhouse gas emissions has accelerated the development of Marine Renewable Energies (MRE), particularly wind energy, which has recently experienced substantial growth. At the same time, these infrastructures contribute to the increasing presence of artificial structures in marine environments, which enables rapid colonisation by benthic species. This phenomenon, known as the reef effect, constitutes a major impact of MREs on marine biodiversity. The wind turbines of the Fécamp offshore wind farm are gravity-based foundations placed on the seabed. These foundations serve as strategic attachment sites for benthic species, potentially leading to a reef effect. Within this framework, the DRACCAR project, the first French offshore research platform dedicated to wind energy, was established in the English Channel, one of the most anthropized seas in the world. This project aims to investigate the interactions between offshore wind energy and the various components of the ecosystem while developing a multi-level marine environmental observation network. In our study, samplings are conducted at the base of the instrumentation mast, a structure similar to the foundations of the wind farm turbines, composed of metal in the intertidal zone and concrete in the subtidal zone. Five replicates of 0.1 m² each of fauna are collected on the foundation along a depth gradient (-4 m, -14 m, and -25 m) at two seasons (autumn 2024 and winter 2025) and according to current exposure. This study enables the quantification of biofouling on the foundations and characterizes artificial hard substrate communities within an offshore wind farm based on depth and physical forcing factors. For autumn sampling, more than 120 taxa were identified with an abundance ranging from 744 to 3731 ind./0.1m². This project will contribute to a better knowledge of the role of each species in the establishment of the community by examining the influence of biogenic species on hard substrates on the presence of vagile benthic species. The perspectives of this study are to characterize potential reef and reserve effects of wind farms and to observe the interactions of these structures within an ecosystem-based management approach.

P024 – A "meta"-systematic map of onshore wind turbines impacts on biodiversity and mitigation solutions

Mr Mathis Chavignon[1]*, Dr Romain Sordello[1], Dr Yorick Reyjol[1]
[1] PatriNat (OFB-MNHN), Centre d'expertise et de données sur le patrimoine naturel
*Corresponding author.

The earth is currently undergoing a global energy crisis. In response, most countries have started developing sustainable solutions, such as geothermal, biomass, solar, and wind energy. The development of these renewable energies has been significant in recent years. However, renewable energy has been demonstrated to have detrimental impacts on the environment and ecosystems (flora and fauna) such as various types of pollution as well as environmental modifications. In particular, as onshore windfarms have been developed for several years, a vast body of scientific literature is already available. This literature revealed several harmful effects of wind turbines on biodiversity, such as collisions with birds and bats, noise pollution, etc. Research has also investigated solutions to mitigate these impacts. As a result, a significant amount of "secondary" research (i.e reviews, evidence syntheses, meta-analyses) has been produced during the last 30 years. In this context, we aim at creating a systematic map of secondary research in the field of biodiversity and onshore wind turbines. A systematic map is an evidence synthesis method that aims at providing an accurate description of the evidence base and metadata, and allow a high level of comprehensiveness and are valuable to inform both researchers and practitioners regarding the state of knowledge on a given topic. The goal is to obtain both a quantitative and qualitative review landscape, to provide a comprehensive overview and to identify clusters and gaps in articles reviewing impacts, mitigations or offsetting measures of onshore wind power on biodiversity. To do so, we followed the method promoted by the CEE for conducting systematic maps in ecology, and will present here the first steps and results of this approach.

P025 – Innovative data integration for mapping avian sensitivity to offshore wind

Dr Bethany Clark[1]*, Ms Catha Auchincloss[1], Dr Larissa Biasotto[2], Ms Bruna Arbo-Meneses[1], Dr Simon Sanghera[1], Mr Antonio Vulcano[3], Dr Claudio Celada[4], Dr Giorgia Gaibani[4], Dr Marco Gustin[4], Dr Golo Maurer[5], Dr Grainne Maguire[5], Dr Glenn Ehmke[5], Dr Yuna Kim[5], Mr Tris Allinson[1]
[1] BirdLife International, [2] BirdLife, [3] Stichting BirdLife Europe, [4] Lega Italiana Protezione Uccelli (LIPU), [5] BirdLife Australia
*Corresponding author.

p>Offshore wind turbines play a key role in accelerating the growth of renewable energy, but also negatively impact wildlife. Species are not equally at risk, and sensitive species are not evenly distributed. Sensitivity mapping can guide energy development to avoid the areas of greatest importance to sensitive species in accordance with the mitigation hierarchy. Birds are particularly sensitive to collision with wind turbines or displacement from preferred areas, and seabirds are among the most threatened groups of birds. BirdLife International, in collaboration with national partners (Lega Italiana Protezione Uccelli, LIPU and BirdLife Australia), has produced detailed avian sensitivity maps for offshore wind development in several countries. Here, we present examples for Italy and Australia due to their rich data on many seabird populations and movements, but also data gaps that required new approaches to integrating different data types. We calculated sensitivity scores for all of the regularly occurring seabird species in each country separately for collision and displacement. We then combined these scores with metrics relating to conservation status and annual adult survival, to capture potential population implications. Mapping the distributions of birds at sea is challenging because offshore observations are rare and key foraging areas for seabirds are diffuse, mobile and highly seasonal. To address this, we developed methods for integrating information on seabird numbers and nest locations with GPS tracking data to model at-sea distributions for breeding seabirds. We used range maps to include non-breeding seabirds when tracking data was limited and integrated other important conservation areas and static habitats. We also show how tracking data for migrating terrestrial birds can be incorporated into offshore sensitivity maps. The results are high-resolution gridded maps of relative avian sensitivity to offshore wind at a country level. These maps provide valuable resources for decision-makers, such as governments, developers, funders and NGOS, to limit wildlife impacts by incorporating biodiversity into planning and site choice. Our robust approach builds on a range of existing methods and can be adapted to other areas. Overall, we recommend sensitivity mapping in advance of selecting locations for large-scale wind energy projects.

P026 – Investigating interactions between fish and offshore wind farms using acoustic telemetry

Dr Lydie Couturier[1]*, Dr Pierre Labourgade[1], Mr Hugo Hervé[1], Dr Bastien Taormina[2], Dr Mathieu Woillez[3], Dr Jérôme Bourjea[4], Mr Eric Stephan[5], Dr Jan Reubens[6], Dr Thomas Trancart[7], Dr Philippe Lenfant[8], Prof Eric Feunteun[7], Dr Marine Gonse[3], Dr Martial Laurans[3], Dr Anthony Acou[9], Dr Olivier Blanpain[1], Dr Laurence Besseau[10], Ms Magali Collin[11], Ms Clémentine Duval[12], Mr Benoit Figarede[13], Dr Lisa Garnier[14], Dr Karine Heerah[1], Mr Guy Herrouin[15], Dr Armelle Jung[16], Dr Emilien Lasne[17], Mr Gilles Lecaillon[18], Dr Geraldine Nogaro[19], Mr Nicolas Peignet[20], Dr Jean-Philippe Pezy[21], Ms Emilie Praca[22], Mr Paul Resseguier[23], Dr Amédée Roy[1], Mr Thomas Sérazin[24], Ms Claire Weller[25], Ms Jehanne Prévot[1]

[1] France Energies Marines, Brest, [2] France Energies Marines, [3] DECOD (Ecosystem Dynamics and Sustainability), IFREMER, INRAE, Institut Agro, Brest Brest, [4] Ifremer, MARBEC, [5] Association pour l'étude et la conservation des sélaciens, Brest, [6] Flanders Marine Institute (VLIZ), [7] Museum National d'Histoire Naturelle, BOREA, Station Marine de Dinard, Dinard, [8] Université de Perpignan, [9] PatriNat (OFB-MNHN-CNRS-IRD), Centre d'expertise et de données sur le patrimoine naturel, Dinard, [10] Sorbonne Université, Observatoire Océanologique de Banyuls , Banyuls, [11] Total Energies, Pau, [12] Comité Régional des Pêches Maritimes et Elevages Marins de Normandie, Port-en-Bessin, [13] EDF Renouvelables, Nantes, [14] RTE France, Paris, [15] Pôle Mer Méditerranée, Montpellier, [16] Des Requins et des Hommes, Brest, [17] DECOD (Ecosystem Dynamics and Sustainability), INRAE, IFREMER, Institut Agro, Rennes, [18] ECOCEAN, Montpellier, [19] EDF R&D, Paris, [20] GIS EMYN & Ocean Winds, Nantes, [21] Normandie Univ, UNICAEN, UNIROUEN, Laboratoire Morphodynamique Continentale et Côtière, CNRS UMR 6143 M2C, 24 rue des Tilleuls, 14000 Caen, France, [22] GIS Eolien en Mer, Dieppe, [23] Ailes Marines, Iberdrola, St Brieuc, [24] Comité Régional des Pêches et des Elevages Marins d'Occitanie, Sète, [25] RWE Offshore Wind GmbH

**Corresponding author.*

In France, the increasing demand for decarbonized energy production has led to a rapid expansion of offshore wind farm (OWF) deployment, with over 15 projects currently in progress. The introduction of these anthropogenic structures in the marine environment is likely to influence space use and habitat connectivity of fish. OWFs can act as artificial reefs for certain fish communities with species exhibiting high residency and/or site fidelity patterns for these new habitats. On the other hand, pressures generated by OWF, such as noise emissions, may repel certain species and modify movement and migration behaviour. Considering the ecological functions and socio-economic importance of fish communities, these effects need to be assessed through comprehensive and long-term monitoring. The collaborative FISHOWF project (2021-2024) used acoustic telemetry to identify how mobile fish species use and connect different habitats across OWF development areas in the Channel, Atlantic and Mediterranean Sea. This project relied on dedicated receiver arrays deployed within 4 OWF, combined with the region-wide acoustic telemetry networks FISHINTEL (Channel), CONNECT-MED & RESMED (Mediterranean) to monitor over 400 fish/crustaceans (including sea bass, pollack, lobster, sharks and rays). Protocols using acoustic telemetry at different spatial scales were tested, including a fine-scale positioning approach to track movement behaviour near an OWF structure. Key results include the identification of important existing habitats for several species in OWF under construction, temporary residency and site fidelity of two elasmobranch species within an operational OWF, and detections within OWF areas of several migratory species travelling across the Channel. Here we will present 1) how OWF may influence fish habitat use and connectivity, 2) how fish movements within and across OWF were monitored through the FISHOWF project, 3) what new information FISHOWF have brought on space use and habitat connectivity for mobile species and, 4) the follow-up project FISHOWF+ (2024-2027) which is maintaining and expanding this acoustic telemetry monitoring to 6 OWF (fixed-bottom and floating OWF) to address specific research questions. The project FISHOWF demonstrated the relevance of using acoustic telemetry at multiple spatial scales to identify and evaluate specific effects of OWF and their grid connection on fish. Results contribute to improve ecological knowledge on monitored species and to better assess habitat modifications induced by OWF from the seafloor to the surface, and the ecological role of these artificial structures (e.g. refuge, essential habitat, ecological trap).

P027 – Balancing the roll-out of renewable energy and conservation in South Africa: Spatial planning in a biodiversity hotspot

Dr Oliver Cowan[1]*
[1] *Endangered Wildlife Trust*
*Corresponding author.

South Africa as a country has made national and international commitments both in terms of increased conservation of its rich biodiversity, and the de-carbonization of its economy - predominantly achieved through the increased roll-out of renewable energy facilities. Generally speaking, these competing land uses are incompatible and systematic spatial planning is required to optimally inform their placements across the landscape. We have created a tool that uses best science to support decision making towards South Africa reaching its targets in both sectors. Working closely with partners, we are using numerous spatial information products related to renewable energy resource maps, grid infrastructure and capacity, threatened species distributions, key biodiversity areas, protected area expansion plans, and protected agricultural land maps to inform the spatial plan, which we aim to ultimately make available as on online interactive tool. A key output of the tool, and one that is highly relevant to the renewable energy industry, will is a map of low biodiversity sensitivity most suitable for renewable energy facility siting, which will take into account natural resource availability as well as grid capacity and infrastructure accessibility. Although currently limited in scope to South Africa, we hope to create a blueprint that will allow neighboring countries in sub-Saharan Africa to conduct similar studies to ensure that the necessary increase in renewable energy facilities does not come at the cost of the regions biodiversity.

P028 – Multi-stakeholder Landscape Scale Forest to Bog Restoration at an Onshore Wind Farm in Wales – Collaboration, Communication, Cooperation

Mr Robin Cox[1]*
[1] *Vattenfall*
*Corresponding author.

At Vattenfall's Pen y Cymoedd wind farm in South Wales, a pioneering landscape-scale Habitat Management Plan (HMP) is being implemented to restore peatland habitats from commercial Sitka spruce plantation. This initiative exemplifies the potential for synergy between renewable energy development and ecological restoration, and highlights the importance of stakeholder collaboration and the additionalities that can be realised as a result. We hope it can serve as a useful case study to inspire similar approaches elsewhere. The 76 turbine site, operational since 2017, is the largest onshore wind farm in England and Wales. Given the scale of the project there is sufficient budget (£3m index linked to 2010) available to realise a truly landscape scale forest to bog restoration project. The HMP area is 1500 ha and the focus is restoring fully hydrologically functioning peatland for the benefit of biodiversity but also for carbon sequestration. Restoration methods being used include ditch blocking (former drainage ditches installed during tree planting), stump flipping and cross tracking all of which aim to maintain the water level at or near the surface for the majority of the year. Revegetation is relatively rapid, progressing from bare peat to a full covering of grass and rush dominated vegetation within 2-3 years. This now requires management through grazing with hardy breed cattle and no-fence collar technology to ensure biodiverse vegetation communities develop. To date we've restored approaching 300ha and by the end of 2025 expect to have spent the first £1m. This is just one part of the story however. Key to the continued success of this project is collaboration, communication and cooperation with multiple stakeholders: The Ecological Steering Group – collaborative decision making of multiple stakeholders to implement the HMP.

- Swansea University – we have funded forest to bog research, enabling leveraging of additional funding.
- The Lost Peatlands of South Wales project, a national lottery funded project combining peatland restoration with multiple other social workstreams – match funding enabled.
- Local communities – communication to further understanding of multiple benefits of onshore wind.

The importance of wind industry money acting as seed funding to open up multiple, often considerably larger sources of funding for mutual benefit should not be underestimated. Through innovative techniques, stakeholder collaboration, and a commitment to long-term monitoring, we are paving the way for a more sustainable and biodiverse future.

P029 – New insights of bird migration in Iceland from radar technology

Mr Cyprien Daïdé[1]*, Mr Vincent Delcourt[1], Mr Alexandre Hamon[1], Mr Vincent Liebault[1], Dr Camille Assali[1], Mr Alexandre Thouzeau[1]
[1] *Biotope*
*Corresponding author.

Iceland is a world leader in renewable energies that is now seeking to strengthen its energy capacity by diversifying its energy mix and developing wind power projects. In this context, QAIR Iceland has conducted several studies for onshore wind farm projects in the country. As birds are one of the most significant issues from wind farm development and as Iceland inhabits significant European populations of breeding and migrating birds, Icelandic government requested bird radar studies to assess the impacts of the projects regarding this fauna group. To answer these questions, Biotope has conducted long-term bird-radar studies on 6 different sites distributed all around the island, with continuous recording from March to November since 2021 and until now. Monitoring was done with high-power marine radars dedicated to birds studies, used in both horizontal mode for trajectories study, and vertical mode for quantification of fluxes and flight heights. Data analysis gives information over the months and on a large spatial scale about: Bird migration fluxes with the standard unit Migration Traffic Rate (MTR), per hour, day and monthBirds tracks densities

- Day and night activity proportions
- Directions and heights of flight
- Flight speeds

These results provide new insights about birds movements around the island, and particularly about migration and nocturnal movements. Months of maximum activity were recording in April, May, September and October, with important night migration movements. Flight heights vary among sites and the period of year, as well as flight directions. In addition to this new knowledge, several interesting and surprising phenomena were highlighted, such as unexpected flight directions during migration periods (in direction of north during autumn for example) and recordings of Pink-footed Geese moult migratory flow to Greenland. We propose to present the key results of these 6 radar studies in Iceland, regarding the new insights about birds movements and the implications for interactions between birds and wind energy.

P030 – Net Positive Biodiversity Impact for offshore wind – A case study based on Orsted's eight step framework

Dr Gregory Decelles[1]*, Ms Ditte Bilde[1], Dr Anthony Dvarskas[1], Mr Samir Whitaker[2], Mr Tommy Kristoffersen[2], Ms Chih-An Lee[2], Ms Sally Holyrod[1], Ms Emma Hospes[1]
[1] *Orsted,* [2] *Ørsted*
*Corresponding author.

In 2021 Ørsted set an ambition for all new renewable energy projects we commission from 2030 onwards to deliver a net positive biodiversity impact (NPI). As currently defined by Ørsted, NPI is achieved when significant, adverse direct impacts on priority biodiversity features are outweighed by the measurable outcomes from actions taken in accordance with the mitigation hierarchy to achieve sustainable biodiversity gains. Ørsted launched its biodiversity measurement framework in 2024. The framework provides Ørsted with the tools needed to calculate our project level biodiversity impacts by applying a standardized eight-step approach to assess and quantify threats to important species and habitats. The framework is intended to help Ørsted focus resources where they are most needed and take an ecosystems approach to project design. The biodiversity measurement framework was released for stakeholder input last year. Stakeholders frequently indicated that a detailed example of how the framework would be applied to a renewable energy project was needed to fully evaluate the merits of our proposed approach. Towards that end, we have developed an NPI case study for a hypothetical commercial-scale offshore wind farm. This presentation will provide an overview of how the NPI framework will be applied to future projects and will demonstrate the decisions taken and methodologies applied across the eight steps of the framework. The process is informed by our experience, observations, and pilot studies to date. The presentation will also illustrate how we intend to solicit stakeholder input throughout the process to ensure that our NPI actions target the appropriate species and habitats.

P031 – A novel real-time visualization framework for understanding large-scale avian migration dynamics using the French weather radar network

Dr Thibault Désert[1]*, Dr Amédée Roy[2], Dr Baptiste Schmid[3], Dr Raphael Nusssbaumer[3], Mr Vincent Delcourt[4], Dr Camille Assali[4]
[1] *Météo-France,* [2] *France Energies Marines, Brest,* [3] *Vogelwarte,* [4] *Biotope*
*Corresponding author.

Avian migration is a complex spatiotemporal process governed by multiple biotic and abiotic factors. The most intense migratory movements predominantly occur nocturnally, with peak activity following sunset. These fluxes exhibit substantial variability from night to night, influenced by meteorological conditions (both current and antecedent), seasonal timing, and topographic or atmospheric constraints that can modulate movement patterns. Avian migration is also associated with various risks, including collisions with vertical structures, such as wind turbines. With expected increases in the utilization of airspace, there is a need to better monitor large-scale avian migration and to provide relevant real-time visualization tools.
This study presents a novel real-time visualization framework for nocturnal bird migration across France. This dynamic cartographic tool enables high-resolution monitoring of spatiotemporal variations in migratory fluxes at both intra- and inter-night scales. The framework is implemented within the operational system of Météo-France and leverages automated processing of meteorological radar data in conjunction with numerical weather models. While primarily designed for atmospheric observation, weather radars inherently detect biological targets such as birds and insects. The raw radar signal represents an aggregated measurement over volumetric sampling units of approximately 1 km³. As a result, advanced signal processing techniques are required to discriminate and extract avian-specific signatures, ensuring accurate estimation of migration intensities. This process involves electromagnetic signal analysis to correct inherent biases and refine the precision of derived migration parameters.
The primary objective of the study is to harness the capabilities of weather radar networks for enhancing the spatial and temporal resolution of bird migration monitoring. To assess the robustness and accuracy of this methodology, we perform a comparative analysis between migration estimates derived from weather radar data and reference measurements obtained from ornithological radars at multiple sites. These ornithological radars, capable of detecting individual birds, serve as ground-truth benchmarks for calibrating and validating meteorological radar-based migration estimates.
This integrative approach contributes to an enhanced understanding of large-scale avian migration dynamics and provides a critical framework for assessing the ecological impacts of anthropogenic infrastructures, such as wind farms, on migratory bird populations.

P033 – A step-forward in digital aerial marine megafauna surveys thanks to high resolution images and AI for offshore wind

Mr Gwenael Duclos[1]*, Dr Emeline Pettex[2], Mr Leaonard Heinry[2], Ms Ioana Le Guillou[2], Dr Charlene Gemard[3], Ms Estelle Donadio[1], Dr Pierre Allain[1], Mr Bruno Roux[4], Mr Thomas Stockart[4]
[1] WIPSEA/Envol Environnement, [2] COHABYS/LA ROCHELLE UNIVERSITE, [3] CEFE/WIPSEA, [4] L'AVION JAUNE
*Corresponding author.

ELADOM is a project led French Biodiversity Office and funded by French Offshore Wind Observatory. ELADOM consisted in acquisition of knowledge on marine megafauna and human activities along the South Brittany coast from September 2021 to April 2024. 4.464 km of observation effort was realized through eight flights covering 2 295 km². Data were collected via visual observations and 90,000 high-resolution image acquisition. Abundance analyses were performed by distance sampling and density maps were produced by ordinary kriging of local density. A total of 5,557 seabird observations were recorded, representing approximately 18,418 individuals, divided into 22 taxa. Numbers were particularly high in winter and spring, wintering and pre-nuptial migration periods. The most abundant groups included Alcids, gannets, shearwaters and gulls. As for marine mammals, 535 observations were made, corresponding to approximately 3,139 individuals belonging to 9 species, including the Common Dolphin, the Harbour Porpoise, the Bottlenose Dolphin and the Risso's Dolphin. The majority of observations took place in summer and autumn, with the Common Dolphin being the vast majority in the study area. The use of aerial photographs was very effective to assist visual shearwater observations. 952 shearwaters were observed of which only 54 shearwaters were identified to the species level (13.6%). Thanks to the aerial photos, the verifiers noted 356 additional flying shearwaters and identified 401 flying shearwaters at species level out of a total of 752 flying shearwaters (53.3%). The contribution of artificial intelligence (AI) was very important for the census of shearwaters and cetaceans. Thanks to AI, 361 shearwaters were added to the study. This represents an added value of 23.4%, of which 65,6% were identified to the species level. Regarding marine mammals, 214 sightings (+68%) of 789 individuals were detected by AI (+31%), including 3 seals and rare species like a Kogia, a Minke whale and several Pilot whales. These results underline the need for continued conservation efforts in this biodiverse region and the contribution of high-resolution images and AI to efficient marine megafauna surveys also very useful for offshore wind planning and mitigation. The consortium has ongoing efforts on improvement of bespoke AI performances and decarbonization of aerial surveys thanks to high range aerial drones at Yeu-Noirmoutier Ocean Winds offshore wind farm.

P034 – Impacts on nocturnal flyers from wind energy development in Southwest Norway

Prof Katrine Eldegard[1]*, Dr Reed April Mckay[1], Ms Maris Pärn[1], Ms Mara Zebele[1], Prof Fiona Mathews[2], Dr Andrea Vallejo Vargas[1], Prof Richard Bischof[1], Mr Bjarne Oddane[3], Dr Pierre Dupont[1], Prof Geir A. Sonerud[1], Prof Hans Ole Ørka[1], Dr Ronny Steen[1]
[1] Norwegian University of Life Sciences, [2] University of Sussex, [3] Ecofact AS
*Corresponding author.

The risks to resident and migratory nocturnal flyers must be addressed before wind energy can be considered truly sustainable. The highest concentration of Norway's onshore wind turbines is found in Southwestern Norway. This is also where the country's densest population of eagle owls (*Bubo bubo*) resides. The eagle owl population has been declining for decades, and the species is classified as Endangered (EN) on the Norwegian Red List. Our understanding of how wind turbines impact eagle owls, both in Norway and beyond, remains surprisingly limited. Compared to eagle owls, the impacts of wind turbines on bat species have been studied more extensively. However, in Norway, the potential risks to bats have long been overlooked by the wind energy sector, regulatory authorities, environmental agencies, and researchers alike. To fill important knowledge gaps about impacts of wind turbines on eagle owls, and on resident and migratory bats in Norway, we have initiated two related research projects. (1) The project 'Impacts of wind turbines on nocturnal flying wildlife' aims to understand and predict the risks posed by onshore wind turbines to eagle owls and bats in a landscape that differs significantly, both topographically and climatically, from most wind farm locations in Europe. To assess the effects of wind turbines on GPS-tagged eagle owls, we use a Before-After-Control-Impact study design. We also study how eagle owls and their prey interact in and around wind farms. To study bat activity patterns and movements, we use acoustic monitoring, bat box surveys, radio tagging and radiotracking, using the Motus wildlife tracking network. (2) The project 'Migratory bat activity in coastal Southwest Norway' focusses on spatiotemporal variation in bat acoustic activity along the Norwegian coast of the North Sea. In both projects, we are particularly interested in the Nathusius' pipistrelle (*Pipistrellus nathisii*), as it is known to undertake long-distance migrations along the coasts and waters of the North Sea. Therefore, it is at risk of multiple encounters with both onshore and offshore wind farms. Our current knowledge of Nathusius' pipistrelle in Norway is based mostly on anecdotal observations. This study aims to uncover their migration routes through Norway, including whether they cross the North Sea to other countries in the region, and whether some individuals remain in Norway. We are currently analysing the data and will present preliminary results from 2024-2025 on eagle owls and bats, along with our plans for further field data collection and analysis.

P035 – From Impact Mitigation to Net Positive Outcomes: A Framework for Baseline Biodiversity Studies in Wind Energy

Ms Inês Evaristo[1]*, Dr André Jorge[1], Mr Paulo Cardoso[1], Dr Miguel Mascarenhas[1]
[1] *BE - Bioinsight & Ecoa*
*Corresponding author.

As wind energy expands to meet EU and national renewable energy targets, the challenge is no longer just to mitigate impacts but to integrate nature-positive strategies into project planning. Environmental Impact Assessments (EIA) typically focus on minimizing negative effects, but proactive biodiversity frameworks can shift projects from simple compliance to net positive outcomes. In Portugal, EIA regulations do not explicitly require field-based biodiversity surveys, often relying on species presence/absence data that provide little insight into habitat use. This case study demonstrates how an early, structured baseline framework, combined with targeted conservation actions, enhances regulatory decision-making while benefiting biodiversity.The Almodôvar Wind Farm in Portugal serves as a model, where the developer voluntarily conducted extensive biodiversity monitoring before regulatory requirements were imposed. The study followed a Before-After-Control-Impact (BACI) approach, capturing seasonal and spatial variations. With 437 hours of fieldwork, surveys targeted diurnal and nocturnal birds, raptors, soaring birds, and bats, mapping species activity and flight behavior to support evidence-based turbine placement and mitigation. Results identified 86 bird species, including 12 of conservation concern, and 21 bat species, five of which are threatened. While collision risk was assessed as low, the project moved beyond impact avoidance to active biodiversity conservation. Building on this robust baseline, the project incorporated oriented conservation actions to enhance conditions for key species, shifting from a mitigation mindset to a net positive strategy. The Spanish Imperial Eagle (*Aquila adalberti*), a flagship and umbrella species in the Mediterranean Basin, guided broader ecosystem interventions. Three main conservation measures were integrated: (1) improving nesting conditions through breeding site enhancement, (2) boosting prey availability by managing wild rabbit (*Oryctolagus cuniculus*) populations, and (3) retrofitting power lines to prevent electrocution and minimize collision risks. These measures demonstrate that wind farms can actively contribute to biodiversity while aligning with best practices in nature-inclusive wind energy planning. This case highlights the regulatory and financial advantages of integrating net positive biodiversity strategies within EIAs. Moving beyond conventional assessments, early, structured baseline studies combined with conservation-driven actions can reduce project uncertainty, improve permitting efficiency, attract sustainability-focused investors, and contribute to EU and national biodiversity goals. The Almodôvar WF provides a model for how industry, regulators, and financial institutions can work together to align renewable energy development in the Mediterranean Basin with ecological resilience and species recovery.

P036 – Monitoring the impact of wind turbines on birds with a full 3D radar in a difficult environment

Mr Joris Everaert[1]*, Mr Thierry Onkelinx[1], Dr Raïsa Carmen[1], Mr Jo Loos[1], Mr Hilbran Verstraete[1], Mr Marc Van De Walle[1]
[1] *Research Institute for Nature and Forest (INBO)*
*Corresponding author.

The Port of Antwerp is a large industrial area alongside the Scheldt River in Flanders (Belgium). Several nature reserves are also located in and around the port. During the application process for planned wind turbines, knowledge gaps were identified regarding bird flight patterns and the potential effects of the turbines on birds. As a result, in 2021, a long-term monitoring project was launched, using a 3D bird radar. The project is being conducted by the Research Institute for Nature and Forest (INBO) in collaboration with VLEEMO, the company responsible for the wind farm development. The radar provides full 3D tracking of bird movements in the surrounding area, with coverage extending several kilometers. Bird tracks are stored in a database, and automatically classified into categories based on size (small, medium or large individual birds, or flocks of birds). The radar operates continuously, 24/7, generating millions of bird tracks. Processing the large dataset of radar tracks presents several challenges. Industrial structures such as buildings, silos, piled containers, moving cranes, and rotating blades from wind turbines - along with natural features like groups of trees - can interfere with the radar, leading to clutter, false bird tracks, or reduced detection capacity. To address this, from 2021 to 2024, ornithologists performed field validations at several vantage points in the area using binoculars, spotting scopes, thermal imaging binoculars, and field tablets with real-time radar bird track information. Several validated bats were also detected by the radar. The validation results were incorporated into a post-processing framework designed to filter the data and improve the reliability of bird track information. Standardized relevant bird tracks were then analyzed using 3D cubes (30 meter sides) in a voxel grid of 21x21x21 cubes (630 meter, horizontally centered on the wind turbine) for both wind turbine and control locations. Preliminary results indicated a significant avoidance of bird flights at rotor height around the wind turbines. With further optimization of the post-processing data filtering and analysis, we have now taken the next step in facilitating comparative analyses of bird movement over time and space, thus improving the knowledge for future impact assessments. Some challenges remain that must be addressed to further enhance radar detection and automatic bird classification in the future. We are also able to make recommendations on how to overcome the challenges of radar research into the effects of wind turbines on birds, particularly in cluttered environments.

P037 – Wings unharmed: Global approaches to mitigating wildlife collisions

Dr Shilo K. Felton[1]*, Mx La' Portia Perkins[1], Dr Eric Schauber[1]
[1] *Renewable Energy Wildlife Institute*
*Corresponding author.

The rapid expansion of renewable energy through land-based and offshore wind energy has required the parallel development of collision risk minimization technologies to reduce the operational impacts of these wind energy innovations on resident and migrant bird and bat species. While a plethora of hardware, software (including AI), and tools have been developed, they vary in effectiveness, real-time application, and costs for operation. Additionally, while adopting cost-effective technologies could reduce effects on wildlife, there is still a lack of consensus on how to define effectiveness, acceptance in the broader community, and a standardized validation process towards the use of these solutions more broadly. The Renewable Energy Wildlife Institute has been entrenched in collaborations with technology developers from the United States and abroad to conduct technology validation studies, produce peer-reviewed literature, and since 2016 has maintained a searchable catalog of existing risk minimization technologies. We reviewed the 58 technologies detailed within REWI's technology catalog and found 22 risk minimization technologies, all of which focused on one of two strategies for collision risk reduction: deterrence or curtailment. Of these 22 collision risk minimization technologies, 19 meet the United States Department of Energy Technology Readiness Level (TRL) of 8 or 9 Technologies, indicating that the systems have been field tested and operated in real-world conditions. Only 13 have been tested for efficacy through at least one peer reviewed study. Given these disparities, it is important that additional funding and collaboration is supported globally to conduct and report on replicate rigorous validation studies for commercially available collision risk minimization technologies. In providing more knowledge on the efficacy of these technologies we underscore the value of collaborations required to lead to the rapid and widespread adoption of successful technologies to protect critical bird and bat species.

P038 – Sound attraction of wind turbines on bats: a case study

Mr Ignacio Fernández[1]*, Dr Fulgencio Lisón[2], Mr Bernardino Camousseigt[3], Mr Ignacio Von Unger[1]
[1] Myotis Chile, [2] Universidad de Concepción, [3] Enel
*Corresponding author.

Bats suffer high mortality rates due to collisions with wind turbines, yet the reasons behind their attraction to these structures remain unclear. While previous studies suggest that light, landscape features, and insect presence may play a role, the potential influence of turbine-generated sounds has received little attention. This study assessed whether ultrasonic emissions from wind turbines affect bat behavior. Field recordings of operational wind turbine nacelles were collected at a wind farm in central Chile. The recordings were filtered to isolate frequencies overlapping with bat echolocation calls and then broadcast using BatLure devices at two sites with similar bat species compositions. Over one month, bat activity was monitored with ultrasonic detectors in both experimental and control plots. The study included species frequently involved in turbine collisions, such as *Tadarida brasiliensis* and *Lasiurus* spp. Results showed no significant differences in bat activity between experimental and control sites, nor between active and inactive playback periods. This suggests that turbine-emitted sounds neither attract nor deter bats. While acoustic emissions appear unrelated to collision risk, other factors—such as insect aggregation near turbines, flight altitude, and wind conditions—may play a more significant role. Understanding the mechanisms behind bat interactions with wind farms is essential for improving mitigation measures. Future research should explore additional environmental variables and assess whether continuous exposure to turbine sounds at operational heights influences bat behavior differently.

P039 – An innovative approach for studying nocturnal small migrants at sea: airborne acoustic detection using helium balloons

Dr Benjamin Folliot[1]*, Mr Marc Leménager[1], Dr Yann Patry[1], Dr Philippe Bornens[1], Dr Thomas Pommier[1]
[1] *Setec invivo*
*Corresponding author.

Nocturnal small migrants, particularly passerines and bats, remain poorly documented during their movements over the sea due to the lack of suitable methodologies for collecting data at high altitudes and offshore. Unlike seabirds or large migratory species, these more discreet animals are difficult to detect using traditional survey methods. Understanding their migration routes, flight altitudes, and potential interactions with offshore infrastructure is crucial for risk assessment and conservation planning. This study aims to address these knowledge gaps by testing an innovative airborne acoustic detection method adapted to offshore environments. So far, most available data on migratory bats, such as Nathusius' pipistrelle (Pipistrellus nathusii) and Leisler's bat (Nyctalus leisleri), have been obtained from recording devices installed after offshore infrastructures have been built, limiting the ability to analyze migration flows during the pre-construction phase. Nocturnal passerines, despite being well-documented in terrestrial environments, remain largely undocumented at sea, making it difficult to assess their flight paths and potential vulnerability to offshore wind farms. These knowledge gaps highlight the need for new methods to monitor these species in offshore environments. To address this challenge, an innovative approach has been tested as part of environmental studies conducted on the future offshore wind farm site off Oléron: acoustic sensors deployed at a target altitude of 100 m using a helium balloon. This technology enables the recording of passerine vocalizations and bat echolocation calls at an altitude more representative of their migration trajectories, while minimizing acoustic interference from vessels. Species identification is then classically performed through frequency analysis of vocalizations and comparisons with reference databases (e.g., NOCMIG program for passerines, European ultrasonic bat databases). During a one-year acquisition campaign in 2024, monthly recordings were conducted from March to November. The collected signals were compared to recordings made from a vessel, with its aerial parts instrumented. Results show a significant improvement in recording quality at higher altitudes, with reduced background noise and enhanced species detection. Initial acoustic analyses reveal peak migratory activity occurring in the middle of the night, with seasonal and meteorological variations influencing passage rates. This study highlights the potential of helium balloons as an alternative to traditional monitoring techniques, providing a non-intrusive, maritime-adapted approach that is better aligned with the phenology of migratory species. Its large-scale application could allow for improved characterization of migration corridors at sea and refined collision risk assessments for offshore wind farms.

P040 – Navigating data analysis in offshore windfarm impact assessments: prescribed vs. flexible approaches

Dr Jack Forster[1]*, Mr Naphon Olley[1], Dr Yves Le Bras[2], Dr Johanna Osterberg[3], Dr Kelly Macleod[1]
[1] *HiDef Aerial Surveying Ltd,* [2] *Biotope,* [3] *BioConsult SH*
*Corresponding author.

The degree of guidance on data collection, analysis, and assessment at offshore wind farms (OWFs) varies considerably across Europe. In the UK, pre- and post-construction ornithological monitoring typically relies on digital aerial surveys, with data analysis mandated through a prescribed modelling package, MRSea. While MRSea was developed specifically to assess seabird displacement, its application to real-world datasets presents several challenges, including constraints in handling complex ecological interactions. In contrast, other European nations adopt more flexible approaches. In Germany, impact assessments benefit from bespoke statistical models tailored to specific datasets, often incorporating Bayesian methods to refine uncertainty estimates. Meanwhile, France has extensive monitoring programs but lacks clear guidance on impact pathways or standardised analytical approaches. We present the similarities and differences in biostatistical methods used across the UK, Germany and France, drawing on simulated examples of different methods applied to the same data. We compare the benefits of prescribed versus flexible modelling approaches and discuss which methods are most effective under different circumstances. By evaluating lessons learned, we aim to contribute to the development of best practices that ensure robust, ecologically meaningful assessments while meeting regulatory and conservation objectives.

P041 – Improving bird detection of wind turbine rotatory motion: Experimental insights of black and white patterns painted on wind turbines

Ms Lucie Foucart[1], Dr Olivier Duriez[1], Dr Aurélien Besnard[2], Ms Claire Million-Ranquin[1], Dr Simon Potier[3], Dr Constance Blary[1]*

[1] CEFE, Univ Montpellier, CNRS, EPHE, IRD, Montpellier, France, [2] CEFE, Univ Montpellier, CNRS, EPHE PSL University, IRD, Montpellier, France, [3] Les Ailes de l'Urga, 72 rue de la vieille route, 27320 Marcilly-la-campagne, France

*Corresponding author.

The development of wind energy is a cornerstone of Europe's renewable energy transition but poses challenges to biodiversity, particularly through bird collisions with turbine blades and towers. Automated detection systems are often implemented to mitigate these impacts, but they are costly and of limited documented effectiveness. An alternative passive solution under investigation is modifying the visual appearance of turbines to improve their detectability by birds. Previous studies in Norway found that painting one blade of turbines black reduced mortality for a single bird species, likely by mitigating motion blur that may be caused by high rotation speeds. However, additional factors, such as low rotation speeds and birds' limited sensitivity to achromatic contrasts, may also influence turbine detectability. Black-and-white patterns on both blades and towers could enhance visibility and further reduce collisions. We performed an experimental study to identify the most effective patterns for improving birds' detection of rotating turbine blades. We conducted a laboratory experiment using miniature wind turbines and operant conditioning with captive birds to evaluate the effects of three patterns—one black blade, striped blades, and checked blades—on blade rotation detection by birds. The study involved three species: black kites (*Milvus migrans*), griffon vultures (*Gyps fulvus*), and domestic homing pigeons (*Columba livia*). Results showed that detection of blade rotation was influenced by the patterns, rotation speed, and contrast with the background, with significant inter- and intra-species variability. Birds' ability to differentiate between a stationary and a rotating wind turbine is reduced at lower rotation speeds and with lower achromatic contrast between the turbine and its background. Most birds were unable to differentiate stationary turbines from turbines rotating at low speeds (< 5 rotations per minute). Striped and checked patterns improved rotation detection at low speeds for black kites, while checked pattern and a single black blade reduced rotation detection for pigeons and vultures. Striped patterns emerged as the most promising for improving rotation detection across multiple species. These findings highlight the need for species-specific approaches and suggest that striped patterns may enhance turbine visibility for a broader range of bird species. *In natura* test are essential to confirm these laboratory results and assess their practical implications for mitigating bird collisions.

P042 – Bat mortality at wind farms in Poland – a summary of over 10 years of monitoring and factors determining bat collisions with wind turbines

Ms Lucie Foucart[1], Dr Olivier Duriez[1], Dr Aurélien Besnard[2], Ms Claire Million-Ranquin[1], Dr Simon Potier[3], Dr Constance Blary[1]*

[1] CEFE, Univ Montpellier, CNRS, EPHE, IRD, Montpellier, France, [2] CEFE, Univ Montpellier, CNRS, EPHE PSL University, IRD, Montpellier, France, [3] Les Ailes de l'Urga, 72 rue de la vieille route, 27320 Marcilly-la-campagne, France

*Corresponding author.

Wind energy development in Poland has been progressing intensively for around 15 years. However, the nationwide impact of wind energy on bats remains largely unknown. We attempted to estimate bat mortality parameters at Polish wind farms based on post-construction monitoring reports from 2012 to 2024, made available by national environmental protection authorities. We gathered data on over 1,650 fatalities, representing at least eleven species, from around 100 wind farms located exclusively in open agricultural areas. The most frequently killed species were the noctule *Nyctalus noctula* (ca. 30% of fatalities) and Nathusius' pipistrelle *Pipistrellus nathusii* (ca. 24% of fatalities). The common pipistrelle *Pipistrellus pipistrellus* accounted for around 13%, while species such as the parti-colored bat *Vespertilio murinus*, the serotine *Eptesicus serotinus*, and the soprano pipistrelle Pipistrellus pygmaeus each made up a few percent. Approximately 15% of pipistrelle casualties were not identified to the species level. Only isolated cases of other species such as the northern bat *Eptesicus nilssonii*, Leisler's bat *Nyctalus leisleri*, the Daubenton's bat *Myotis daubentoniid*, Brandt's bat *Myotis brandtii*, and Natterer's bat *Myotis nattereri* were recorded. The average mortality rate ranged from 1 to 11 individuals per turbine per year. The highest number of fatalities occurred in August and September, aligning with the period of seasonal autumn migrations and confirming the dominance of long-distance migratory species among victims. Most collisions were recorded in areas with a high number of forest complexes, where the wind farms were located within approximately 1300 meters of a forest and between a few hundred to about 1500 meters from watercourses or water bodies. The further the distance, the fewer collisions were observed, indicating increased mortality in mosaic landscapes with a high proportion of forest patches and a greater presence of rivers and water bodies. Spatial analysis of collisions across the country revealed interspecific differences, likely linked to variations in bats' ecological traits. Bats were killed at every wind farm analyzed, which confirms the difficulty of clearly identifying exclusion zones for wind farm locations due to the protection of these animals, and highlights the need to seek the best methods for minimizing the negative impact of wind farms, regardless of their geographical and landscape-habitat placement. Our analysis is the first nationwide attempt to assess bat mortality at Polish wind farms and to identify the determining factors, which could help develop an effective tool for planning wind farm locations with minimal collision risk for bats.

P043 – Long-Range Bird Species Identification Using Directional Microphones and CNNs

Mr Tiago Garcia[1]*, Dr Luís Pina[1], Dr Roel May[2], Mr Magnus Robb[1], Mr Ricardo Oliveira[1]
[1] STRIX, [2] NINA
*Corresponding author.

This study explores the integration of directional microphones with convolutional neural networks (CNNs) for long-range bird species identification. By employing directional microphones, we aimed to capture high-resolution audio from specific directions, potentially improving the clarity of bird calls over extended distances. Our approach involved processing these recordings with CNNs trained on a diverse dataset of bird calls. Field tests were conducted to evaluate the system's performance in outdoor conditions. The results demonstrated that the system is capable of systematically identifying bird species up to 150 m, reaching 280 m for species vocalizing at frequencies greater than 1000 Hz and clearly distinct from background noise. The furthest successful detection was obtained at 510 m. While the method showed promise in enhancing the identification process compared to traditional techniques, there were notable limitations in the clarity of the audio recordings. These findings indicate that while integrating directional microphones and CNNs for long-range bird species identification shows promise, further refinement and testing on both onshore and offshore wind farms are necessary to fully realize the benefits of this approach. For effective integration with radar-based bird monitoring in wind farms, future efforts should prioritize advanced noise reduction techniques to enhance detection accuracy and reliability over long distances.

P044 – GPS Tracking Highly Mobile Bat Species enables Large-Scale Assessment of Cumulative Interactions with Wind Energy Development: Feedback from two years of Monitoring Greater Noctule Bat (Nyctalus Lasiopterus) in the Massif Central (France)

Ms Thérèse Gauthier[1]*, Mr Yannick Beucher[1], Mr Xavier Nardou[1]
[1] *EXEN*
*Corresponding author.

The Greater Noctule Bat is a little-known species in France, with few breeding colonies recorded. As one of the most mobile and open-sky european bat species, it must be highly sensible to fatality risks at wind turbines and especially to cumulative effects along its long distances flights. However, significant gaps remain in understanding its behavior and flight strategies (e.g., hunting, migration, social interactions). Conventional acoustic monitoring methods do not adequately identify the level of a population exposure that may frequent multiple wind farms in its wide home-range. In the Massif Central, a Greater Noctule breeding colony was discovered in 2012 and monitored for 10 years, in parallel with the development of several wind farms at few kilometers far. In 2021, as part of a new wind farm project close to the colony, a GPS tracking study was launched focused on the large-scale spatial use patterns of Greater Noctules. 33 males and females (non-pregnant) were equipped with GPS beacons (PinPoint 50 GPS/VHF Lotek) and tracked during 3 seasonal campaigns (parturition, post-parturition, and autumn mating/transits) over two years (2021, 2023), under varying climatic conditions. Results highlight several movement patterns, depending on the individual and climatic conditions. During lactation, females mainly fly in a core activity area located within 10 km of the colony, rather away from the nearest wind energy development zone. However, exploration flights are occasionally recorded at remarkable distances (100 to 170 km in 5-6 hours) and altitudes (up to 2,500 m over the landscape), even during intense thunderstorms. After juvenile dispersal (september), both males and females increase mobility, using a same activity zone located up to 45 km from roosts site (more than 100 km flights per night). A few isolated individuals, however, again show remarkable exploratory flights in opposite directions, covering much greater distances. This alternation between predictive flights strategies in a same area and long-distance exploratory flights at high altitudes challenges the hypothesis of wind risks focused on colonies proximity. At certain times of the year, wind farms located 40 km from the colony might present equal or greater risk than the nearest wind energy development zone. While the use of GPS appears as a valuable way for understanding flights ecology and factors influencing the most mobile species, it should also be more valued for refining the assessment of risk conditions at wind turbines, and for developing appropriate mitigation measures concerning a succession of wind farms.

P045 – Evaluation of mitigation measures in agricultural areas: effectiveness and prospects for biodiversity

Mr Antoine Goderniaux[1]*, Mr Arnaud Collard[1]
[1] *Faune & Biotopes*
*Corresponding author.

The installation of wind turbines can have negative impacts on biodiversity, particularly through habitat degradation and collisions affecting birds and bats. As part of the No Net Loss project, we evaluated the effectiveness of the mitigation measure known as COA1/COA2 (food and grass cover). This is the most widely used measure in Wallonia to minimise the residual impacts of wind farms in agricultural landscapes. The main objective of the project is to identify the factors influencing their success, to propose improvements but also to compare several field monitoring methods.
The field part focused on the period from April to June during which protocols on avifauna (transect, listening point and continuous recordings), on bats (continuous recordings by batbox) and on micromammals (gallery counting) were carried out. 48 sites (24 compensation measures and 24 control sites) were prospected. The sites were evaluated by considering the environment in which they were located: ecological connections, culture environment or diversified environment (environment composed of several types of land use other than crop).
Although the COA1/COA2 mitigation measures promote bird abundance in diverse environments (all species combined), they are not effective in spring to attract the bird species targeted by these measures. The COA1/COA2 promote the activity of several groups of bats in diverse environments. Finally, the COA1/COA2 compensation measures have more micromammal galleries (used as a proxy for the food supply for raptors) than the winter cereal crop plots. Regarding the comparison of protocols, we observe that listening points and transects allow good detection of species, especially the most discreet ones, and thus remain effective methodologies. The “birdbox” acoustic recorders are very good complements because they capture a good representation of the species in the environment given their deployment over time but cannot detect discreet species.
The results highlight the importance of verifying the effectiveness of the compensation measures installed, to ensure compliance with the NoNetloss of Biodiversity principle. The specifications of the COA1/COA2 measure could be adapted to better meet the needs of each target species. It is important to complete and consolidate this study with a similar analysis in winter.

P046 – The red-throated diver energetics project: findings and the future

Dr Jonathan Green[1]*, Dr James Duckworth[1], Dr Sue O'brien[2], Dr Lise Ruffino[3], Ms Danni Thompson[3], Dr Ruth Dunn[4], Mr Ib Krag Petersen[5], Dr Aevar Petersen[6], Mr Guðmundur Benediktsson[6], Mr Logan Johnson[6], Dr Petteri Lehikoinen[7], Mr Roni Väisänen[8], Mr Jim Williams[6], Mr Stuart Williams[6], Prof Francis Daunt[9]
[1] University of Liverpool, [2] MacArthur Gren, [3] JNCC, [4] Centre d'Ecologie Funtionelle et Evolutive, CNRS, [5] Aarhus University, [6] Independent Researcher, [7] Finnish Museum of Natural History, Finland, [8] Avescapes Oy, [9] UK Centre for Ecology & Hydrology
*Corresponding author.

In 2017, a group of experts discussed the consequences of displacement by offshore windfarms (OWF) for red-throated divers (*Gavia stellata*), a species sensitive to displacement, but with significant knowledge gaps. They concluded that key to understanding displacement effects, including consequent competition due to habitat loss, were data on time and energy budgets throughout the annual cycle. This would allow times and places of energetic stress and vulnerability to be identified. This then could improve decision making in spatial planning and better understand the likelihood of detrimental impacts from consenting OWF developments. Following the workshop a collaboration between government, industry and academia evolved to increase understanding in this area. Biologging devices recording location and behaviour were deployed in 2018 & 2019 on divers breeding in Iceland, Finland and Scotland and retrieved alongside feather samples in subsequent years. Data analysis has revealed remarkable insights into the behaviour of this species and facilitated the development of novel tools and approaches in avian ecology. Divers wintering in Northwest Europe show considerable spatial and temporal variation in migratory strategy and behaviour. Overwinter movement strategy ranges from residence to migration. Diving behaviour is concentrated in discrete bouts consistent with shallow benthic diving. However, while diving periods are intense and occur almost exclusively during daylight, they spend less daylight time engaged in diving than comparable species (guillemots, razorbills). Energy expenditure estimated from time-budgets indicates the Icelandic population that remains resident in cool waters throughout the winter faces the greatest energetic challenge. The Icelandic divers accommodate increased energy demands through increasing time spent foraging. Other populations of divers subject to energetic stress may be able to compensate by increasing foraging behaviour, if sufficient daylight is available in their more southerly wintering locations. Modelling displacement of divers in the southern North Sea confirmed our suggestion that divers may have capacity to maintain body condition in the face of increased competition due to displacement and increased energy costs of additional movement. While our project did not close all the outstanding knowledge gaps, it has made a substantial contribution to knowledge of this species of high concern that is commonly displaced by OWFs. This presentation will give further details of our findings as well as indicate possible next steps and ideas for future work to further complete the picture for these enigmatic birds. Importantly, we will showcase the benefits of multi-organisational and international cooperation to answer difficult questions.

P047 – Assessing the Accuracy of Bird Tracking Systems for Wind Energy Applications: A Collaborative Research Project

Dr Jonas Haakansson[1]*, Dr Caroline Brighton[2], Dr James Clarke[2], Ms Raaisa Raaisa[1], Ms Mamoona Birkhez Shami[1], Mr Andreas Günther[1], Dr Philipp Boersch-Supan[2]
[1] Spoor, [2] British Trust for Ornithology
*Corresponding author.

While wind energy is a crucial tool in the fight against climate change, it can have unintended and detrimental effects on wildlife, particularly flying animals. This ecological issue also directly impacts the wind energy sector's ability to generate power and meet the needs of the market and society. To mitigate these risks, accurate bird tracking systems are essential. To that end, the Oslo-based company Spoor develops camera-based solutions that use computer vision and artificial intelligence to monitor bird activity in the vicinity of wind turbines. In order to quantify the performance of the Spoor monitoring method, and to test the utility of the method in producing ecological insights, Spoor, Vattenfall, and the British Trust for Ornithology (BTO) engaged in a collaborative research effort. Specifically, the work was aimed at comparing and contrasting the range and accuracy of mono-vision (single camera) versus stereo-vision (two cameras) when determining the positions of birds and to assess the utility of each method in assessing bird flux and avoidance behavior. We investigated this with four distinct approaches. This was done 1) in a controlled environment where a drone was tracked, as well as 2) in an offshore environment where birds were tracked using mono-vision, stereo-vision, and by an on-site ornithologist equipped with a laser rangefinder. In addition, 3) since mono-vision methods of calculating the distance between the camera and an object depend on knowing the real-world size of the object, a literature review was performed to quantify the intra-specific variation in seabird and raptor body size, and how this variation informs uncertainties in mono-vision-based range estimation. Lastly, 4) distance sampling methodologies were employed to construct a statistical model that estimates the three-dimensional distribution of birds within the Spoor camera system's sampled volume. In this presentation we will detail the results of this collaboration in terms of accuracy metrics and ecological insights, how these have guided improvements of the Spoor bird monitoring solution, and how the collaboration highlights the potential for mutualistic partnerships between industry and research institutions.

P048 – Smart curtailment for bats: testing efficacy with multiple data streams at three wind energy facilities

Dr Amanda Hale[1]*, Mr Michael True[1], Dr Paul Rabie[1], Dr Kevin Heist[1], Mr Rhett Good[1], Mr Brogan Morton[2], Mr Jon Ritter[2]
[1] *Western EcoSystems Technology, Inc. (WEST),* [2] *Wildlife Imaging Systems*
*Corresponding author.

Around the globe, wind turbine-related bat mortality is a conservation challenge for wildlife managers and the wind energy industry. These mortalities are an important issue because bats have low reproductive potential and require high adult survivorship to avoid population declines. Given the increasing demand for wind energy to help meet decarbonization goals, coupled with increasing evidence that bats are attracted to wind turbines, developing cost-effective and practical impact minimization strategies is imperative. "Smart curtailment" strategies incorporate site-specific information to identify high-risk periods for bats, with the potential to provide more conservation value for less power loss compared to traditional blanket curtailment methods. Optimized Smart Curtailment (OSC), developed by WEST, reduces bat fatalities while maximizing power production by curtailing wind turbines when a Bayesian decision tree model indicates higher risk conditions for bats and lower energy production potential. In this talk, we will present results from the first year of a validation study conducted at three operational wind energy facilities in the US. Data sources include bat activity collected with acoustic detectors and thermal video cameras; post-construction fatality monitoring; and wind speed, temperature, and power production data. Preliminary analyses show that turbines operating under OSC were curtailed fewer hours with equivalent conservation benefits to bats as turbines operating under blanket curtailment. We will also highlight key considerations when implementing smart curtailment and discuss the evolving regulatory context and acceptance surrounding this strategy.

P049 – Effects of offshore wind development on thermal updraft dynamics

Mr Frank Hanssen[1]*, Dr Line Cordes[2], Dr Roel May[2], Dr Erin Bachynski-Polić[3]
[1] Norwegian Institute for Nature Research, [2] NINA, [3] Norwegian University for Technology and Science (NTNU)
*Corresponding author.

Research motivations and objectives
Development of offshore wind power farms (OWF) poses a collision risk to seabirds, especially in overlap with breeding, migratory, or wintering habitats. It is unknown how (changes in) oceanographic conditions affect offshore habitat utilization of seabirds like gulls that use thermal soaring to conserve energy. Wake effects of OWFs may affect flight behaviour in offshore thermal updraft areas, and it is essential to develop tools that helps to predict and understand the dynamics of thermal updrafts and their alteration by OWF wake effects. While several onshore studies (including NINAs work on raptors in Norway and Spain) demonstrate how updraft modeling helps to identify landscape areas with higher collision risk, no similar tools exist for sea areas. Limited information exists on how seabirds utilize offshore thermal updrafts, and none is available on how temperature-wakes affect thermal updrafts offshore. This presentation aims to outline the state-of-the-art, knowledge gaps, and efforts to address these gaps through development of operational tools. Such tools will help to direct siting allocations in future OWF projects, and close knowledge gaps, mitigate collision risk, and improve decision-support in screening of suitable areas for OWF development. Methodology Within a cloud-computing environment, we use climate and atmospheric models to develop spatial metrics on the positive sea to air temperature difference (ΔT) and the convective velocity scale (w*) to approximate seabirds offshore thermal uplift potential. To quantify the OWFs-induced spatial-temporal wakes, and their impacts on wind and offshore thermal updrafts, we will use Large Eddy Simulations (LES) and Dynamic Wake Meandering (DWM) models. To investigate how seabirds interact with the spatio-temporal thermal updraft changes we will correlate bird tracking data with ΔT and w*. Summary of results NINA currently develops an innovative web application for large-scale, spatio-temporal estimation of offshore thermal updrafts. In the BIRDWAKE project (2025–2028), NINA and NTNU will implement new algorithms to estimate how offshore thermal updrafts are affected by wake effects. Conclusion New research is needed to address the dynamics of offshore thermal updrafts and how their alteration by OWF wake effects impact seabirds. We offer a tool for calculation and visualization of updraft seascapes alongside modeled wakes, and an innovative approach to assess how wake-induced wind speed deficits and altered thermal updrafts affect flight costs in seabird species with varying morphologies and adaptations. This provides spatially explicit insights into species-, season-, and colony-specific impacts, aiding OWF siting, spatial planning, and turbine design.

P050 – Elasmobranchs, Offshore Wind and Electromagnetic fields

Mrs Annemiek Hermans[1]*, Dr Auriel Sumner-Hempel[1], Prof Tinka Murk[1], Dr Erwin Winter[2], Mr Daniël Van Berkel[1], Mrs Xantia Van Den Brink - Rienstra[1], Ms Renate Olie[3], Dr Reindert Nijland[1], Dr Diede Maas[1], Mr Tom Spanings[1], Mr Lydia Mesquita Vieira De Barros Neta[1], Dr Edwin Foekema[2]
[1] *Wageningen University,* [2] *Wageningen Marine research,* [3] *The Rich North Sea*
*Corresponding author.

The development of offshore wind farms (OWFs) in coastal seas presents both challenges and opportunities for threatened elasmobranch populations. However, the extent to which OWFs influence elasmobranch presence and habitat use remains unclear. As the number of OWFs grows, the demand for marine space from fisheries, conservation, and energy sectors increasingly overlaps, emphasizing the need for informed marine spatial planning and management. One key question is whether elasmobranchs utilize OWFs as habitats and, if so, why they are present there. Our study confirmed the occurrence of five elasmobranch species (two sharks, three skates) within four OWFs, with an overall detection probability of 8.5%. A quarterly sampling campaign over two years highlighted the seasonality of *Mustelus asterias* on subsea power cables, aligning with known migratory patterns. These findings demonstrate that OWFs are used by elasmobranchs, but the reasons for their presence are not yet fully understood. Since OWFs exclude bottom trawling fisheries, the habitat may provide refuge, and provide foraging and reproduction opportunities, but the introduction of multi-use activities could counteract these benefits. Further research is needed to inform policymakers on the (multi-use) function of OWFs, particularly in light of new EU legislative acts, including the nature restoration act. One potential important factor governing elasmobranch presence and behaviour in OWFs is the subsea power cables, which emit electromagnetic fields (EMFs) into the marine environment. These EMFs could influence the behaviour and development of elasmobranchs, particularly during the vulnerable embryonic stage of oviparous elasmobranch when they lay eggs on the seafloor within an EMF. Laboratory experiments showed that embryos of the thornback ray (Raja clavata) exposed to alternating current EMFs (1.8 to 4.6 μT) were significantly more active, displaying 33% more tail undulations and 150% increased body movements compared to non-exposed individuals. This heightened activity could lead to increased predation risk, although no adverse effects on health, survival, or development time were observed post-hatching. If elasmobranchs are laying eggs within OWFs, the overlap with subsea cables could expose embryos to anthropogenic EMFs throughout embryogenesis, potentially affecting survival and behaviour. This underscores the need to understand the implications of EMF exposure on sensitive life stages. Future research should explore these interactions further to support evidence-based management and conservation strategies for elasmobranchs in the context of expanding offshore renewable energy.

P051 – Innovative Benthic Habitat Monitoring for Offshore Wind Energy with Underwater Drones and AI-Powered Solutions

Dr Laura Huguenin[1]*, Mr Yannick Penneçot[1], Mr Quentin Chenevier[1], Mr Frédéric Mittaine[1]
[1] *Cosma*
*Corresponding author.

The offshore wind energy sector is growing rapidly, yet environmental impacts on marine ecosystems, particularly benthic habitats, remain a significant challenge. Traditional methods for marine habitat mapping are often time-consuming, costly, and lack the precision needed to fully assess biodiversity or subsea infrastructure. This research introduces a novel approach for large-scale seabed mapping and marine biodiversity assessment using a swarm of autonomous underwater drones and AI-powered data processing. This technology promises to improve the speed, accuracy, and cost-effectiveness of offshore site surveys, particularly for wind energy projects, by reducing survey time from months to days while enhancing environmental monitoring capabilities. Cosma, a cutting-edge subsea technology startup, has developed a solution that integrates autonomous underwater drones and an AI-powered platform for collecting, analyzing, and displaying high-resolution seabed data. Using synchronized drones, the technology performs large-scale, continuous seabed mapping at depths ranging from 2 to 200 meters. The solution generates 2D and 3D image reconstructions, benthic habitat mapping, and marine species detection, utilizing AI algorithms to identify species and assess their condition, tailored to the specific needs of the study. In 2024 and 2025, Cosma conducted several surveys in France and internationally, across the Mediterranean and Atlantic, demonstrating the effectiveness of its technology in mapping various species and habitats of interest, such as Posidonia and Cymodocea seagrass meadows, kelp forests, and other benthic biocenoses. These surveys addressed challenges in areas like harbor access zones, potential future marine protected area, and prospective offshore wind farm site. Preliminary results from the implementation of Cosma's technology show its ability to map and monitor benthic ecosystems with high precision over large areas, up to 10 hectares. The technology has successfully identified and mapped key marine habitats, detected some species, and provided detailed visual and semantic data on marine ecosystems. It has been successfully applied in environmental impact assessment projects for coastal civil engineering and subsea cable localization. Cosma's innovative solution represents a significant advancement in marine biodiversity monitoring and offshore site surveying. By offering large-scale, high-precision mapping and reducing survey time and risks, this technology can greatly enhance environmental impact assessments for offshore wind energy projects and opens new possibilities for risk management and operational planning. With the potential to contribute to long-term monitoring of marine resources, Cosma's technology is a critical tool for ensuring sustainable offshore energy development while protecting marine ecosystems.

P052 – PREDICT: Predicting reasons for change in prey (fish) availability to top predators and implications for offshore windfarm development

Dr Georgina Hunt[1]*, Prof Beth Scott[1], Dr Deon Roos[1], Dr Peter Miller[2], Dr Benjamin Williamson[3]
[1] University of Aberdeen, [2] Plymouth Marine Laboratory, [3] Environmental Research Institute, The University of the Highlands and Islands
*Corresponding author.

Within the planning of future large-scale offshore wind developments, there is a growing need to understand where top-predator distributions will have increased probability of interaction and overlap with windfarms. Marine top predators (seabirds and marine mammals) are heavily dependent on the availability and distribution of their prey, primarily a few mid-trophic pelagic fish species. In shelf seas such as the North Sea, these distributions, in turn, may be driven by biweekly, seasonal and annual changes in the timing and locations of where new primary production is created. Fine-scale oceanographic features have been identified as important locations with very high and predictable primary production (i.e., conditions that can create predictable foraging opportunities), including mesoscale fronts with high gradients of chlorophyll-a, density and temperature. It remains unclear how temperate mid-trophic pelagic fish species utilise these foraging habitats throughout their life history and annual migrations. In collaboration between the University of Aberdeen, Ørsted, and the Environmental Research Institute at the University of the Highlands and Islands, the PREDICT project researched this knowledge gap by investigating the movements of key pelagic fish species (Atlantic herring *Clupea harengus*, Atlantic mackerel *Scomber scombrus*, European sprat *Sprattus sprattus*) and examined associations with frontal characteristics across their life history at the North Sea scale. Using a Generalised Additive Modelling (GAM) approach, we used fisheries-independent data from the International Council for the Exploration of the Sea (ICES) International Bottom Trawl Surveys (IBTS) and sea surface thermal (SST) frontal metrics gradient strength density (FGD) and persistent (FP) derived from high-resolution Earth Observation (EO) data, to quantify associations between frontal characteristics and key pelagic fish species. Our results revealed highly consistent within-species and age-specific associations with FGD and FP within the North Sea. However, the spatial abundance of different age classes of herring, sprat, and mackerel were all influenced differently by FGD and FP values. These results suggest that the different fish species and age-classes use distinct frontal habitats during their summer feeding distributions. By understanding the predictability of pelagic fish distributions in relation to oceanographic fronts, we can better anticipate potential overlap between essential fish habitats, top predator foraging locations and offshore wind farm developments. This can support the development of co-use management strategies that balance the growth of offshore renewable energy with the conservation of marine ecosystems in an increasingly crowded seascape.

P053 – Quantifying sensitivity: a spatial risk-ranking framework to map relative species risk to seabirds from offshore wind energy developments in Danish marine waters

Dr Saana Isojunno[1]*, Dr Lindesay Scott-Hayward[1], Dr Claus Lunde Pedersen[2], Dr Heidi Thomsen[2], Dr Jordan Chetcuti[2], Dr Morten Frederiksen[2], Dr Thomas Bregnballe[2], Mr Jacob Sterup[2], Mr Rasmus Due Nielsen[2], Prof Anthony Fox[2], Prof Monique Mackenzie[1], Mr Ib Krag Petersen[2]
[1] CREEM, University of St Andrews, [2] Aarhus University
*Corresponding author.

Sensitivity mapping supports spatial planning by identifying areas where species are expected to be most or least at risk from future offshore wind energy developments. Typically, sensitivity maps rank areas by their importance to species of most conservation concern and susceptible to hazards, such as displacement and collision. However, how species "sensitivity" is defined, measured, and represented as a relativistic metric in space varies widely. We developed a spatially explicit risk-ranking framework building upon previous sensitivity mapping approaches, but with the following key advances: 1) sensitivity is quantified with respect to species-specific assessment (management) targets and existing area-based protections, 2) all input parameters are quantitative and can be directly informed by empirical data, 3) relative species risks are calculated in ways reflecting the causal pathways of impact, and 4) uncertainty is propagated through the algorithm by re-sampling input parameters. The proposed approach also enables minimizing risks to any species of concern, i.e., at any given location, high risk for one species is not compensated by a low risk to another. This precautionary approach is particularly important for assessing risks to charismatic megafauna, such as seabirds and marine mammals, whereby impacts on just one rare species can be significant risk to developments being able to go ahead. We tested the proposed spatial risk-ranking framework on 17 seabird species in Danish marine waters, in relation to three potential sources of risk (hazards) from future offshore wind energy development: habitat alteration, displacement, and collision. Spatial variation in species occurrence, and thus potential exposure to the hazards, was informed by species density distribution estimates from aerial line transect survey data, collected over 25-year period. Most survey data were collected in winter and spring, sufficient for winter visitors, but which leaves a substantial gap for describing breeding species distributions. These will be addressed by incorporating usage estimates from GPS tracking data. We also plan to incorporate migratory corridors which are important to improve the assessment of collision risk. Despite considering the present implementation a preliminary result with important methodological caveats, the proposed framework provides a solid foundation for refining the algorithm and incorporating additional empirical evidence to reduce assessment uncertainty in the future. We will demonstrate the applicability of the framework to other species (e.g. marine mammals) and discuss avenues for future development and potential approaches to validation.

P054 – Variations in estimation of birds' flight height – example from on-shore wind farm project in Croatia

Dr Nela Jantol[1]*, Ms Dora Čuljak[1], Ms Ksenija Hocenski[1], Mrs Gordana Iskric[1], Mr Josip Nikolić[1], Ms Ivana Latković[1], Mr Marko Augustinović[1]
[1] *Oikon Ltd. – Institute of Applied Ecology*
*Corresponding author.

Estimation of bird flight height is an essential step in collision risk modeling since the observations in the critical zone of the wind turbine are an input for the calculations. Our objective was to test researchers' estimations of the bird flight height using an unmanned aerial vehicle (UAV) on a site with a planned on-shore wind farm. The tested UAV heights included 20 to 120 m where each ornithologist was independently asked to make the estimation during a vantage point survey. Challenges in this methodology include permissions for the maximum flight of the UAV which is 120m, while special permits should be obtained for the higher flight altitudes. In general, both researches overestimated flight height by 37 ± 12 m, averaging in 50% overestimation of flight heights. Additionally, a more experienced researcher was somewhat better at estimating flight heights compared to the less experienced one. Flight height zone 80-100 m had the largest overestimation (+47 m), while the 20-40 zone had an overestimation of +20 m. Both overestimations in flight zones could affect the input data for the collision risk model (CRM). Preliminary results show that for larger wind turbines, with a rotor radius of around 82m, potential bird transits and collisions assuming avoidance rate are overestimated by 30%. This happens because the part of the flights recorded in the critical zone (60-140m) in reality happened in the lower zone. For smaller wind turbines with a rotor radius of around 66m, there were no significant differences between CRM results for estimated and real flight heights, leading to a conclusion that the majority of raptor's daily flight activities happened in the critical zone (36-100m). Results show a need for flight height calibration and validation throughout the research period.

P055 – Improvements in the method of collecting the data required for the PCFM: Searcher efficiency and carcass persistence

Mr Dorian Tepić[1]*, Ms Dora Čuljak[1], Ms Ivana Latković[1], Mr Josip Nikolić[1], Mr Lovro Turkalj[1], Ms Ksenija Hocenski[1], Mr Marko Augustinović[1]
[1] *Oikon Ltd. – Institute of Applied Ecology*
*Corresponding author.

Post-construction fatality monitoring (PCFM) is the only method for estimating the actual collision impacts of onshore wind energy facilities on wildlife, particularly birds and bats. Since it is difficult to quantify the post-construction impacts of wind farms (WFs) using terrestrial environmental factors, PCFM provides the only quantitative data on the actual impact on birds. To assess the quantitative risk of bird casualties, PCFM involves conducting plateau searches for bird and bat fatalities, as well as carrying out bias correction trials (unsearched and unsearchable area, searcher efficiency trials, and carcass persistence trials). Carcass persistence trials are field experiments used to measure how long bird carcasses remain on the ground before being removed by scavengers or becoming undetectable due to environmental factors. According to the Handbook (IFC, 2023), carcass persistence trials require that placed carcasses need to be inspected on the 1st, 2nd, 3rd, 4th, 7th, 14th, 21st, and 30th day (or even longer in the case of birds of prey). Since the frequency of plateau searches for an area is adjusted based on the carcass disappearance rate, it is crucial to obtain the most accurate data possible. Using this method, the accuracy of carcass disappearance is at least 24 hours (+/- 1 hour, depending on the size of the research area). To enhance accuracy, the Mortality Stopwatch, a low-power device combined with a web platform was developed to provide the most precise timing of carcass removal. In addition to this new device, camera traps were installed as an additional parameter to validate its functionality. As the goal of this development was to measure removal time in minutes and seconds, four trials have been conducted so far. While showing potential, the devices require further refinement, as current testing revealed that devices were operational in only 20 out of 36 tests, with a 90 % accuracy rate in correctly detecting carcass removal.Additionally, with further development and improved reliability, these devices could enhance economic efficiency, potentially leading to significant financial savings in future applications.

P056 – Development of a web-based bat curtailment analysis tool

Mr Terry Jennings[1]*, Mr Christian Newman[2], Mr Donald Solick[2], Dr Jonathan Rogers[3]
[1] Electric Power Research Institute, [2] EPRI, [3] Persimia, LLC
*Corresponding author.

The worldwide growth in installed wind energy capacity has led to increased concerns about wind-wildlife interactions, particularly regarding bat mortality at wind energy facilities. There is an industrywide need for analysis tools that would allow wind farm developers and owner-operators to understand bat fatality risk at wind farms in the development phase and to design operational minimization strategies for existing wind farms. EPRI and Persimia LLC have jointly developed an interactive website that utilizes a meta-analysis of bat fatality risk models and geolocated meteorological data to evaluate bat fatality risk as a function of various meteorological conditions. The webtool automatically accesses the National Renewable Energy Laboratory (NREL) Wind Integration National Dataset (WIND) Toolkit API (Draxl et al. 2015) for modeled meteorological data for the years 2007–2014 for the project site, runs the strategies for each year, and estimates the average AEP loss and average fatality risk reduction for each strategy. Strategies can be easily compared to assess the trade-offs between production losses and predicted fatalities at current or future wind project sites. The tool is designed to run quickly and be completely self-contained, with all necessary data being obtained from open-literature sources and publicly available datasets via web interfaces such as NREL's WIND Toolkit. Future iterations of this tool will allow users to upload project and species-specific fatality data, acoustic data, meteorological data, or other useful datasets to improve the fidelity of the predictions. Potentially, this type of tool may expand to address other forms of environmental impact analysis as well as to assess tradeoffs associated with other operations and maintenance decisions.

P057 – A review of seabird flight height measurement methods and their use in offshore wind farm impact assessment

Dr Daniel Johnston[1]*, Dr Alastair Feather[1], Dr Niall Burton[1], Dr Andrew Harwood[2], Mr Eddie Cole[2], Dr Alex Banks[2], Dr Philipp Boersch-Supan[1]
[1] British Trust for Ornithology, [2] Natural England
*Corresponding author.

Seabirds are vulnerable to offshore renewable energy developments, with direct mortality from turbine collisions being a major concern. Collision risk assessments rely heavily on modelling approaches to predict collision rates using empirical data on species' flight height distributions and other biological traits. Knowledge gaps remain in both the natural variation and measurement uncertainty of these input parameters, adding to the uncertainty in predicted collision rates. Many methods has been used to collect flight height data, including visual surveys, digital aerial surveys, animal-borne tracking devices, radar, camera systems and airborne LiDAR. Each of these methods is associated with particular uncertainties and logistical constraints. As part of the OWEC ReSCUE (Reducing Seabird Collisions Using Evidence) project, we reviewed methods used to determine seabird flight heights and highlight their strengths and weaknesses with a particular focus on separating the sampling and measurement processes underlying each method. Most methods are prone to both random and systematic measurement and/or sampling errors, impacting collision risk estimates. Measurement errors are generally better understood than sampling errors, with flight height measurement errors in the range of 1-10 meters in favourable conditions for most technologies, however some technologies produce measurements with errors exceeding 100m. Sampling characteristics are less well understood for most technologies. In particular, spatial coverage in three dimensions remains poorly characterized for most technologies, as does detection efficiency within the sampled volume. Developing and adopting procedures for determining sampled volumes and detection probabilities therein is a priority. Statistical techniques have enhanced uncertainty quantification at the analysis stage, but even advanced statistical corrections cannot overcome large measurement errors and/or heavily biased sampling. Rigorous calibration of sensors and empirical validation of monitored quantities should therefore be included in best practice guidelines for monitoring technology deployments. Overall we found that no single technology can provide fully representative species-specific flight height distributions under all relevant environmental conditions, highlighting the importance of integrating complementary technologies while accounting for their respective measurement and sampling characteristics.

P058 – A natural HighTech: the great scallop as a sensor of potential effects of submarine cables

Dr Aurelie Jolivet[1]*, Dr Lisa Garnier[2], Dr Laurent Chauvaud[3], Dr Delphine Mathias[4], Dr Sylvain Chauvaud[1]
*[1] TBM environnement, [2] RTE France, Paris, [3] UMR 6539 LEMAR - IUEM, [4] Société d'Observation Multi-Modale de l'Environnemen*t
*Corresponding author.

Transmission cables from offshore wind farms in coastal areas are expected to grow rapidly in the coming years and increase potential environmental impacts. Very little research has been conducted on the role of increased turbidity, noise and electro-magnetic fields linked to the installation of transmission cables on the seabed. Our project called OASICE evaluates the disturbances produced during and after seabed installations with a natural sensor: Pecten maximus, the great scallop. Bivalve shells are constructed through daily accretion of small striae of calcium carbonate (CaCO3) mineral along the outer valve edges. The widths of these striae, which are visible at the shell surface, are apparently sensitive to variations in the environment of the individual scallop. We are studying if this record of growth, the associated changes in elemental composition of the carbonate mineral in the stripes and the shell's behavior measured using accelerometers can be used to estimate an impact. The cable laying work for the France-England interconnection (IFA2) as well as the connection cable for the Calvados park were monitored during this project as well as their operating phase. During the work phase, the noise generated by the different phases of the project was characterized and corresponded to a maximum increase of 45 dB at 20 m and 25 dB at 80 m. A slowdown in the growth of the shells was observed and is essentially linked to the turbidity generated in the environment. This disturbance is short-lived with a rapid recovery of the individuals. Finally, the behavior of the shells is also disrupted by the turbidity generated with a change in its activity rate and their movements. However, recovery is also rapid. During the operating phase, no effect is observed on the individuals monitored by the power supply of the interconnection which can generate magnetic fields. The project must continue during the operating phase of the Calvados park as well as open up to the effects of the vibrations generated by these activities as well as the installation of rockfill modifying the habitat of the shells.

P059 – Assessing the Impact of Wind Energy Projects on Migratory Soaring Birds in the Gulf of Suez: Sensitivity Mapping of Spring and Autumn Migration Patterns

Mr Ali Khazma[1]*, Ms Aya Ayad[1], Mr Mohamed Sherwali[1], Mr Ahmed Khalil[1], Mr Mahmoud El Mongy[2], Mr El Sayed Ibrahim[2], Dr Ahmed Abdullah[2]
[1] RCREEE, [2] Safe Soar
*Corresponding author

The Gulf of Suez in Egypt, serves as a critical migration corridor for soaring birds migrating between their breeding grounds in Europe and Asia and their wintering areas in Africa. This region holds significant importance for migratory soaring bird (MSB) populations crossing the Gulf during their spring and autumn migrations. However, the rapid development of wind energy projects in the area presents a potential risk to these migratory birds, primarily through collisions with turbine blades and associated power lines. Considering this, understanding the passage rates of MSBs across the GoS is crucial for determining the impacts of wind energy developments on MSBs migration. The primary objective of this study is to analyze the average passage rates of MSBs along the western bank of the GoS by creating two sensitivity maps—one for the spring migration and the other for the autumn migration. Data from strategic studies and monitoring vantage points across all wind energy projects in the region, collected between 2016 and 2024, will be utilized to assess the temporal distribution and density of MSBs passage. The methodology involves the aggregation of data from existing monitoring points, which have been part of the collective Bird Monitoring Program (BMP) established in the area. These data will be analyzed to calculate the average passage rates for each migration period, followed by the development of sensitivity maps that highlight areas with the highest passage density. These maps will serve as key tools in identifying the impact of wind energy projects development on MSB migration patterns. Preliminary results suggest that the GoS is a hotspot for MSB migration, with significant passage rates observed during both the spring and autumn periods. These findings are in line with existing knowledge of the region's importance as a migration corridor. The sensitivity maps are expected to provide critical insights into the temporal and spatial distribution of MSBs throughout the years. In conclusion, this posture aims to provide valuable insights into the impact of wind energy projects on MSBs in the GoS by analyzing passage rates and developing sensitivity maps for spring and autumn migration periods. The findings will ensure the conservation of MSB populations by gaining a better understanding the interactions between MSBs and wind energy facilities.

P060 – Investigating the Use of LiDAR for Avian Flight Monitoring at Small Wind Turbines

Dr Wataru Kitamura[1]*, Mr Masashi Barada[1]
[1] *Tokyo City University*
*Corresponding author.

To assess and mitigate bird collision risks with wind turbines, a detailed understanding of avian flight behavior around turbine structures is essential. In particular, obtaining precise data on the utilization of the three-dimensional (3D) airspace within the rotor-swept zone would greatly contribute to addressing this issue. Therefore, this study explores the use of LiDAR (Light Detection and Ranging) as a method for capturing 3D flight trajectories. LiDAR is a remote sensing technology that measures distances to objects by emitting laser pulses and analyzing the reflected signals. Recent advancements in processing speed have enabled high-density laser emission at rates of hundreds of thousands of points per second, allowing for rapid 3D scanning of multiple points on target objects. Traditionally, LiDAR has been used for acquiring 3D structural data, but recent studies suggest its potential for tracking the flight trajectories of birds in motion. This study aims to acquire 3D flight trajectories of birds using LiDAR and explore its application in environmental impact assessments for wind farm development, while also identifying potential challenges. The primary target species were gulls and crows flying around small wind turbines. In Nemuro City, Japan, we conducted LiDAR-based measurements alongside visual observations to compare the accuracy of both methods. Results showed discrepancies of several meters between LiDAR-derived and visually recorded flight trajectories. Even at the scale of small wind turbines, such discrepancies in visual observations were not negligible when estimating collision probabilities, highlighting the advantages of using LiDAR for more precise assessments. However, several challenges remain. First, when multiple birds simultaneously enter the LiDAR detection range, distinguishing individual birds becomes difficult, posing a fundamental issue given the flocking behavior of many species. Second, while LiDAR can capture flight trajectories, it cannot identify species from point cloud data. Therefore, when species identification is required, visual observations are still necessary, preventing full automation of the monitoring process. Nonetheless, future advancements may enable species classification based on flight trajectory characteristics, potentially allowing LiDAR to independently collect detailed, long-term flight data without additional visual confirmation.

P061 – Using insects to describe habitat quality

Mr Tommy Kristoffersen[1]*, Ms Chih-An Lee[1], Mr Samir Whitaker[1], Mrs Tina Tamm Bendixen[1], Ms Line Kræmer[2], Mr Richard Blundell[2]
[1] *Ørsted,* [2] *FaunaPhotonics*
*Corresponding author.

Biodiversity is incredibly diverse, both in terms of the number of species and their interactions with each other and the environment. It is therefore extremely difficult to find a unit of measurement that summarizes biodiversity in its entirety and the use of proxies and metrics becomes necessary. Finding reliable metrics is essential for understanding impacts and uplifts to biodiversity. Insects are the largest and most diverse group of organisms on earth and constitute about 75% of all described animal species and insects could be a suitable proxy for ecosystem health because of their roles in e.g. pollination, nutrient cycling and as food source. Moreover, insects react quickly to changes in their environment, unlike other fauna and flora. FaunaPhotonics has developed a sensor-based technology eVolito that continuously measures electrical signals in the environment, caused by the wingbeat vibrations of insects. Data is uploaded and analyzed in the cloud using machine learning and AI software. Data including five biodiversity metrics are displayed on a customer portal. Biodiversity metrics include insect abundance, activity, diversity and estimated biomass and overall biodiversity uplift. Ørsted has deployed FaunaPhotonics solution in several different locations to test its suitability as a proxy for natural habitat condition and to assess the robustness of the sensors under different environmental and climatic conditions. Test locations and objectives range from an urban office landscape and cable corridor to a fishpond and mudflats, which are important for migratory birds. Results from the cable corridor, after approx. 6 months of monitoring, show that the sensors are working continuously without any interruption concerning their ability to detect insect fauna and upload data to the cloud. The treatment sites, consisting of different seed mixes of clover, rye grass and flowers, have, for the most part, demonstrated higher species diversity with all results trailing off as colder temperatures prevail, compared to the control site (arable cropland). Clover and rye grass generally showed the highest peaks for abundance and activity. Biomass trends were interesting, as numbers tailed off in the treatment sites, whereas there was an increase in the control sites. This was not reflected in changes in diversity for the control sites over this period. This could be due to increased activity e.g. field preparation or fertilizer application. New applications for 2025 includes monitoring during periods with little or no available light, enabling detection of important insect groups like moths.

P062 – Habituation of common guillemot and razorbill to two offshore wind farms in the Netherlands

Mrs Nienke Kwant-Heida[1]*, Ms Elisa L. Bravo Rebolledo[1], Dr Rob S. A. Van Bemmelen[1], Mr Henrik Skov[2], Dr Mardik F. Leopold[3], Dr Ruben C. Fijn[1], Mr Mark P. Collier[1]
[1] Waardenburg Ecology, [2] DHI, [3] Wageningen Marine research
*Corresponding author.

Offshore wind farms (OWFs) have various ecological impacts on birds in marine ecosystems, with displacement and associated habitat loss being among the most significant concerns. With the increasing number of OWFs in the North Sea, habitat loss may lead to population declines in sensitive species. Several studies have found evidence for displacement of seabirds from newly constructed OWFs, with some species exhibiting near-complete displacement. For some species however, there is emerging evidence that habituation might occur, where birds gradually return to OWF areas over time. Notable examples of these species include common guillemot (*Uria aalge*) and razorbill (*Alca torda*). Here, we studied the habituation of seabirds to two OWFs in the Dutch North Sea, which have been operational for approximately 17 years. Early post-construction seabird distribution data were collected through ship-based transect surveys. The current research seeks to build on that dataset with new surveys employing the same transects and methodology, allowing comparisons of the relative bird densities outside and inside the OWF. The primary focus is on wintering razorbills and common guillemots. Data collection for the first of two winter seasons has been completed. A first comparative analysis between historical and novel data was done to find preliminary results on habituation. For common guillemot, we found less avoidance than previously to one of the OWFs, but more avoidance to the other. Razorbill also showed less avoidance to this first windfarm, but only when comparing inside to one of the neighbouring sides of the windfarm. No differences were found to the other windfarm. These preliminary results do not consistently show habituation, but it does provide an indication that habituation might be occurring. Hopefully adding the second winter of surveys, planned in 2025/26, will give a better understanding of the long-term habituation of seabirds to OWFs.

P063 – Aircraft Detection Lighting System (ADLS) as a win-win mitigation measure for bat response to wind turbines

Mrs Gaëlle Larnoy[1], Dr Fabien Verniest[2]*, Dr Christian Kerbiriou[2], Dr Isabelle Le Viol[2], Mrs Pauline Lefebvre[1], Mr Nicolas Valet[1], Dr Kévin Barré[2], Dr Camille Leroux[1]
[1] *Auddicé biodiversité,* [2] *Centre d'Ecologie et des Sciences de la Conservation (CESCO), Muséum national d'Histoire naturelle, Centre National de la Recherche Scientifique, Sorbonne Université, Paris ; Station Marine, Concarneau, France*
*Corresponding author.

Although wind turbines (WT) impacts on bats have been largely documented, very few mitigation measures have been proved to be efficient, and none of them benefits both biodiversity and wind energy production. The main current measures to mitigate collision risks and habitat loss are curtailment and WT implementation away from bat habitats. While relatively efficient, the first one can affect energy production and the second one is rarely strictly enough applied to achieve good results in mitigation. Complementary measures based on the determination of attraction and repulsion factors are thus needed. These factors remain poorly understood, in particular for large spatial scales (i.e. from a few hundred meters to a few kilometers). It has been suggested that red obstruction warning lighting (OWL) at WT- designed to prevent collisions with aircraft - could be perceived by bats from a long distance and thus explain bat response to WT at a large spatial scale. To the best of our knowledge, the only published studies to date investigated the effect of WT lighting at the turbine scale and in North America only. We assessed whether OWL at WT can explain bat response to wind turbines. We quantified bat acoustic activity using a triplet sampling design by recording simultaneously at i) control sites (i.e. no WT), ii) sites located near WT lit all night, and iii) sites located near WT lit on average only 5% of the night (turbines equipped with Aircraft Detection Lighting System – ADLS WT). Thirteen triplets were sampled at woody edges located between 150 and 300 m from WT, and nine triplets were sampled in open habitats just next to WT. Each triplet was sampled during two nights in June 2021 in the Uckermark district (Germany). Our results show that activity of all bat guilds and at both habitat was significantly (4/6) or almost significantly (2/6) higher near WT lit all night compared to ADLS WT and that bat activity levels near ADLS WT were similar to those at control sites (except for LRE activity at wooded edges). Our findings suggest that implementing ADLS at wind turbines could help mitigating their impacts on bats from all guilds (SRE, MRE and LRE) by reducing bat attraction.

P064 – Unraveling ecosystem-level indicators for the impact assessment of offshore wind projects on benthic environments

Dr Ivan Laurino[1]*, Mr Bruno Olian[1], Ms Anna Alves[1], Dr Márcia Denadai[1], Dr Luis Sánchez[1], Dr Alexander Turra[1]
[1] *University of Sao Paulo*
*Corresponding author.

Research motivations and objectives Offshore wind energy (OWE) is increasing and arriving quickly in developing countries. A current challenge for these new projects is determining what biodiversity parameters should be considered for the baseline assessment aiming to select meaningful indicators for monitoring. Thus, we aimed to assess the main known impacts of OWE projects on benthic invertebrates, identifying what ecological parameters regarding this group could be used as indicators of ecosystem-level changes. Methodology We reviewed 73 scientific articles regarding the impacts of OWE in benthic environments. Then, we developed conceptual ecosystem models to assess the main cause-effect relationships and their specific ecological indicators related to benthic invertebrates. Preliminary results We found that the main negative impact of OWE on benthic invertebrates is the loss of soft-bottom species, especially due to the introduction of new hard artificial habitats and the loss of sediments. Positive impacts include the benthic organic enrichment due to the biodeposition from the biofouling community on the turbines (with a net biodiversity gain on surrounding sediments), and the reef effect (aggregation of mobile invertebrates for feeding and sheltering). The local abundance of invertebrates was the most used indicator to detect these changes. However, some evidence showed that benthic enrichment can lead to an increase of opportunistic invertebrates followed by net biodiversity losses, while the reef effect can attract hard-bottom mobile invertebrates but displace soft-bottom species. Therefore, impact assessment should be performed by weighted abundance of invertebrates based on living habit traits, such as preferred habitat, feeding strategy, and life span. This trait-based approach can weight abundance indicators by functional groups with distinct sensitivities to OWE impacts. For instance, the increased abundance of opportunistic r-strategists and the decreased abundance of long-lived k-strategists signal net biodiversity losses on surrounding sediments, while the opposite signals net gains. Additionally, attraction behaviors resulting in a local increased abundance only for hard-bottom invertebrates indicate a group-specific aggregation effect, with possible net losses for soft-bottom invertebrates. Community diversity and total benthic biomass are also important indicators to corroborate these ecosystemic effects. Conclusions We conclude that benthic invertebrates can provide precise and useful ecosystem-level indicators of OWE impacts, mainly when treated in a functional approach and analyzed from an integrated perspective. Such indicators must be measured during pre-construction surveys (baseline) and monitored during the installation and operation of OWE projects. Therefore, our results are especially timely for projects that are just starting planning for construction.

P065 – A large-scale analysis of post-implementation fatalities monitoring surveys in France

Dr Yves Le Bras[1], Mr Nicolas Carenton[1]*, Mrs Ludivine Doyen[1]
[1] *Biotope*
*Corresponding author.

The growth of wind energy is raising concerns about its impact on wildlife, particularly birds and bats, which are at risk from collisions, barotrauma and habitat destruction. It's important to understand these impacts in order to balance the development of wind energy with the conservation of biodiversity. Since 2018, France has implemented a new standardised national monitoring protocol to assess turbine-related mortality through systematic searches for carcasses and mortality estimation models. Large-scale analyses help to standardise methods, improve mortality estimates and provide insights into spatial and temporal variability between different wind farms. A meta-analysis was conducted of 158 mortality monitoring surveys conducted between 2019 and 2023 on 104 wind farms (with 584 turbines), involving 22,815 turbine-specific searches in France. Mortality estimates were adjusted for three main factors: (i) search area extant and sampling coverage, incorporating land cover data and carcass distribution patterns; (ii) searcher efficiency, modelled using mixed effects logistic regression with fixed effects and nested random effects; and (iii) carcass persistence, estimated using an exponential survival model, following the methodology of Huso (2010). To produce mortality estimates, we implemented the Huso mortality estimator within a Bayesian framework, with the posterior median as summary statistic. Results describe detection bias as a function of lancover and vegetation height, carcass peristance duration as function of date and number of replicated PIFM surveys and distribution of carass as a function of distance to the turbines. The estimated median annual mortality per turbine was 5.5 birds (SD = 3.57) and 5.25 bats (SD = 6.04) for a search radius of 50 meters. Mortality rates showed large spatial and temporal variability, highlighting the influence of site characteristics and seasonal dynamics. These results highlight the need for standardized monitoring and methodological refinement to accurately assess the impact of wind farms on wildlife. The results highlight the need for ongoing refinement of methodologies and continued data integration to improve mitigation strategies. Future research could aim to identify landscape-level factors and turbine features that influence mortality risk, and integration of acoustic activity monitoring data. [If a PCM workshop takes place, we would like to be associated with it]

P066 – Long-term monitoring of foundation biofouling in the Saint-Brieuc offshore wind farm: first insights from ROV surveys

Mr Aodren Le Gal[1]*, Ms Lisa Wauters[1], Dr Paulo Bonifácio[1], Dr Yann Patry[1], Dr Philippe Bornens[1], Dr Thomas Pommier[1]
[1] *setec énergie environnement – setecinvivo, 358 ZA La Grande Halte, 29940 La Forêt-Fouesnant*
*Corresponding author.

Habitat modification and artificial reef effect of submerged structures are central to understanding the impacts on biodiversity of marine renewable energy. To address this question, we tracked the biofouling of the foundations of the Saint-Brieuc offshore wind farm using Remotely Operated Vehicles (ROVs) and underwater photogrammetry, enabling a three-dimensional reconstruction of the structures along their entire vertical extent. This non-invasive approach allows for the collection of raw, bankable data and ensures a fully reproducible acquisition process without operator bias. Annual observations of six tripod wind turbine foundations and the associated quadripod electrical substation, allowed the analysis of the dynamics of biological colonization according to depth and substrate type. Due to the rather long period of the farm settlement we compared the colonization status between recent (<1 year) and older (~2 years) foundations. Quantitative analysis of the collected images relies on a stratified random point projection protocol, applied to 0.10 m² quadrats extracted from photogrammetric reconstructions, covering different depth levels for each foundation pillar. Benthic community classification was conducted using diversity indices (Shannon, Pielou) and multivariate analyses (Hierarchical Clustering - CAH, Multidimensional Scaling - MDS). Preliminary results highlight a rapid and structured colonization of the foundations, with a strong presence of barnacles (*Perforatus perforatus*), encrusting bryozoans, hydroids, and serpulid polychaetes. Deeper areas exhibit higher biodiversity, while upper sections, exposed to stronger hydrodynamics and light, are dominated by algae and opportunistic species. The integration of 3D hydro-photogrammetry enables a detailed analysis of the spatial structuring of biofilms and sessile organisms, offering an unprecedented insight into colonization patterns at the foundation scale. This long-term monitoring represents one of the first detailed studies on offshore wind turbine biofouling in France. It provides new insights into the role of these structures in reshaping coastal ecosystems and underscores the need for prolonged ecological monitoring to better assess the impact of offshore wind infrastructure on marine biodiversity.

P067 – spmapper: A spatial planning tool to indicate the foraging value of marine areas to breeding seabirds

Dr Oliver Leedham[1]*, Dr Kate R. Searle[1], Ms Claudia Caporusso[1], Dr Deena Mobbs[1], Prof Francis Daunt[1], Dr Adam Butler[2]
[1] UK Centre for Ecology & Hydrology, [2] Bioinformatics and Statistics Scotland
*Corresponding author.

As we increasingly develop the marine space for renewable energy generation, seabirds are threatened by changes to their foraging environment. Seabirds may face difficulty in meeting their prey intake needs if they are displaced from offshore windfarms into areas of lower quality foraging habitat. It is critically important to the resilience of seabird populations that breeding adults acquire sufficient prey to meet their own energetic requirements, and for the provisioning of their chicks. Because of this, the siting of offshore windfarms and other marine infrastructure is key to their potential impacts on breeding seabirds. To assist with the complex task of choosing areas for offshore wind energy developments to minimise impacts on seabirds, we present a freely accessible spatial planning tool *spmapper* (*R* Package) that estimates the foraging value of spatial areas to breeding seabirds. To do so, we combine information concerning seabird behaviour, energetics, demography and population sizes to estimate—with uncertainty—the quantities of fish prey taken by seabird populations breeding in Britain and Ireland. We combine these prey mass estimates with predictions of marine space use from GPS tracking to map the spatial distribution of prey consumption. With *spmapper*, users can input spatial areas of their choice and retrieve the absolute and proportional quantity of prey taken in these areas by the breeding populations of each of 3 seabird species (common guillemot, razorbill, and black-legged kittiwake). By indicating the quantity of seabird prey intake that is *at-risk* under scenarios of displacement, these results can be used in spatial planning by allowing comparison of candidate areas and their relative importance to foraging breeding seabirds. *spmapper* also allows assessment of the ability of current marine protected areas to safeguard seabird foraging. We will present and demonstrate *spmapper* as a spatial planning tool for stakeholders, with an emphasis on de-risking offshore wind energy siting for breeding seabirds.

P068 – Day and night variation in bird movement levels throughout the year in a Dutch offshore wind farm

Mr Jacco Leemans[1]*, Dr Abel Gyimesi[1]
[1] *Waardenburg Ecology*
*Corresponding author.

Birds face the risk of colliding with wind turbines. In impact assessments of offshore wind farms, the number of collision victims is generally estimated with collision rate models (CRMs). When using such models, it is important to consider the variation in the estimated collision numbers. This variation is a result of both the measurement uncertainty in the parameter values, as well as the natural variation in the parameters values. The latter may include for example spatial and temporal variation, or variation between individuals of a species. Traditionally, our perception of these parameters is largely determined by data collected with visual observations during daylight. As such, variation in bird activity between day and night may not have been sufficiently captured in CRMs. The emergence of bird tracking technology, which allows continuous data collection, already significantly improved our estimations. Another technology that provides round-the-clock data are radars, which have the advantage that they can record variation in bird movement levels on a much larger scale than trackers. In this study, we present data collected by a bird radar in offshore wind farm Borssele in the southern North Sea to show the temporal variation in bird movement levels during day and night and throughout the year. These variations may have substantial effects on the outcomes of CRMs. Hence, we stress the importance that these variations are properly addressed in studies aiming to determine or improve CRM parameter estimates.

P069 – Effects of large-scale onshore wind projects on land birds of Patagonia and Tierra del Fuego should require large scale studies

Dr Domingos Leitão[1]*, Dr Pedro G. Nicolau[1], Mr Nuno Cidraes-Vieira[1], Dr Pedro Cardia[1], Ms Sara Gomes[1], Mr Pedro Neves[1], Mr Cristofer De La Rivera[2], Mr David Gomes[1], Mr Pedro Garcias[1], Mr Ricardo Oliveira[1], Mr Julio Duran[2], Mr Miguel Repas-Goncalves[1]
[1] *STRIX,* [2] *TecNativa*
*Corresponding author.

Particularly large wind farms are being planned in Southern Chile and Southern Argentina associated with green hydrogen production plans assumed by both countries. It is feared that this drastic change in the landscape of Patagonia and Tierra del Fuego will have serious impacts on the region's biodiversity, particularly on migratory and resident birds.Current work focus is on studying collision risk of birds with wind turbines. Several large-scale studies use radar-assisted methodologies to model the collision risk for local birds throughout the annual cycle. Our results, based on these models, indicate, very high collision estimates for certain species, as expected. These high collision estimates are mainly due to the large scale of the projected wind farms, rather than the collision rates per wind turbine. Our studies in Patagonia show that collision rates per turbine are lower than the rates recorded in other regions of the globe in similar habitats. The collision risk, despite being high, can be strongly reduced. These insights will allow the development of Active Turbine Management Plans that consider the most sensitive species locations, biodiversity hotspots and periods of the year. The recent studies were focused on collision risk, which is perceived as the most problematic direct impact. However, there is a general lack of studies and concern regarding other direct impacts, like barrier effect and the effect of exclusion and habitat loss. These are impacts that can have a negative effect on bird species whose most important areas of occurrence overlap with large-scale wind projects. The most vulnerable species are those that have their breeding strongholds in the Patagonian steppe, like Upland Goose (*Chloephaga picta*) and Tawny-throated Dotterel (*Oreopholus ruficollis*). These species might suffer a double impact resulting from the barrier effect on their routes in the region and the exclusion of important breeding areas. Comprehensive studies of the barrier and exclusion effects resulting from wind large-scale projects are essential to mitigate these cumulative risks and ensure the conservation of these groups of species. The studies should be carried out on a regional scale and partnerships should be created between promoters, universities, consultancies and government entities in both countries to model these effects and their impact on bird populations. It is a huge challenge, but one that is perfectly within the reach of the entities involved and proportional to the scale of the developments planned to the southern tip of South America.

P070 – 6 years and 8 kinds of monitoring on two offshore buoys: what are their benefits for the offshore wind structures monitoring?

Dr Philippe Lenfant[1]*, Mrs Anais Gudefin[2], Mr Gilles Lecaillon[2], Mr Pierre Boissery[3]
[1] Université de Perpignan, [2] ECOCEAN, Montpellier, [3] Agence de l'eau Rhone Méditerranée Corse
*Corresponding author.

Between 2019 and 2024, a buoy and a biodiversity study platform, BoB and OCG DATA respectively, were deployed off Leucate in southern France, as part of preliminary work on floating wind turbines. Over these six years, a large number of ichthyic and invertebrate fauna surveys have been carried out, in several seasons and using different methodologies, such as UVC visual monitoring, environmental DNA, acoustic telemetry, sampling, passive acoustics, camera and sonar monitoring. These methods, usually deployed in coastal environments, required certain adjustments to be able to be used on these offshore structures, and all presented their own advantages and limitations in terms of the results obtained. eDNA is the most effective method for identifying a large number of species, especially in offshore ecosystems, even it does not provide information on the abundance, size or life stage of individuals. Some species detected visually were not identified by eDNA, raising questions about the detectability of species certainly link to their low density or their low activity. Acoustic telemetry provides valuable data on species behavior and connectivity, but requires the tagging of a large number of individuals and a suitable receiver network. UVC tracking enables precise assessment of fish abundance and size, but is limited in time and space. Camera monitoring has shown convincing results in enriching the list of species observed without having to visit the site, but it requires a specific infrastructure to operate efficiently, which needs to be anticipated upstream. Sampling with standardized observation units is the most accurate for determining abundance and size, and provides easy access to invertebrates. For fish, however, the observation units used are limited to small species and to crypto-benthic behavior. Passive acoustics, while useful for detecting fish sounds, may be hampered by structure-borne noise, as structure size increases. Lastly, sonar tracking presented interpretation difficulties due to wave around the platform. The solution will be obtained in calibration specific of storm and no storm state. In short, each method has its strengths and constraints, underlining the need for an integrated approach to fish monitoring in offshore environments A part of those methods will be deployed in the pilot park « Les Eoliennes Flottantes du Golfe du Lion », in the next years.

P071 – Towards a more predictive understanding of Floating Offshore Wind (FLOW) consequences on key ecosystem drivers

Dr Lilian Lieber[1]*, Dr Peter Miller[2], Prof Alex Nimmo-Smith[3]
[1] Marine Biological Associaiton, [2] Plymouth Marine Laboratory, [3] University of Plymouth
*Corresponding author.

The rapid expansion of floating offshore wind (FLOW) into deeper, seasonally stratified shelf seas necessitates a more predictive understanding of ecological consequences. In the Celtic Sea, FLOW infrastructure has the potential to alter ocean mixing and key ecosystem drivers such as phytoplankton and zooplankton dynamics, particularly when placed near biologically important ocean fronts, such as seasonally persistent tidal mixing fronts. However, the influence of FLOW on these critical habitats remains poorly understood, calling for innovative approaches to monitor depth-resolved ecosystem responses at appropriate spatial and temporal scales. As part of the FRONTLINE project within NERC's EcoFlow program, we integrate autonomous underwater vehicle (AUV) observations with satellite remote sensing to understand FLOW consequences on ocean processes, lower trophic interactions and knock-on effects on biodiversity, from plankton to predators. A central innovation in this approach is the deployment of a bespoke holographic camera (holocam) aboard NERC's Autosub Long-Range 1500 (ALR1500). The holocam enables unprecedented, high-resolution imaging of phyto- and zooplankton, providing essential data on biodiversity and lower trophic interactions. This is complemented by an Underwater Vision Profiler (UVP6) and active acoustics (EK80 echosounder) to enhance zooplankton characterisation throughout the water column. The ALR1500 missions are designed to operate in the tidal flows of the Celtic Sea, making it uniquely suited for extended multi-week deployments. Equipped with a comprehensive suite of other instruments, including Acoustic Doppler current profilers, a turbulence profiler and nutrient and oxygen sensors, the AUV will capture fine-scale interactions between FLOW infrastructure and oceanographic processes. These in situ measurements will be combined with near real-time satellite-derived ocean front maps to assess ecosystem-wide responses. Anticipated results will provide insights into how FLOW-induced wake effects influence vertical stratification, plankton dynamics, and predator-prey dynamics in frontal zones. This novel, multi-scale observational framework will advance our ability to predict and mitigate potential biodiversity impacts of FLOW development. This work is part of a broader scientific consortium, also integrating AUV-enabled passive acoustics, digital aerial surveys, and long-term seabird tracking. By employing state-of-the-art biologging sensors, we leverage seabirds as 'animal oceanographers' to complement in situ AUV observations and provide a bird's-eye perspective on turbine perception. Additionally, fine-scale fisheries data and stakeholder engagement will help assess the implications of FLOW displacement scenarios for fisheries management and policy. These insights will support the evaluation of frontal habitats as potential protected areas for compensatory measures, ensuring conservation strategies align with the sustainable expansion of offshore wind energy.

P072 – Development of Ornithology Regional Compensation Measures – Marine Litter Removal

Ms Alice Lowry[1]*, Ms Polly Brown[1], Ms Jaz Harker[1], Ms Fiona Nimmo[2], Dr Murray Grant[3]
[1] HiDef Aerial Surveying Ltd, [2] NiMa Consultants Ltd, [3] Royal HaskoningDHV
*Corresponding author.

Offshore wind farms in the Northeast and East ScotWind regions are predicted to have significant impacts on breeding seabird Special Protection Areas (SPAs) along Scotland's east coast. Several of these projects may conclude potential for Adverse Effect on Integrity of SPAs, making them subject to higher level ornithological constraints with some likely to be required to develop a package of compensatory measures. In this work, we define compensatory measures as providing equivalent benefit to a site network that has been deemed to be lost, ensuring that overall coherence of the network of European sites, as a whole, is protected. Compensation packages to date have largely been developed in isolation on a project-specific basis, limiting scalability and effectiveness. As the requirement for compensation grows, a shift towards regional-scale approach is needed, particularly for ScotWind developments. On behalf of a developer consortium, Phase 1 of this work engaged stakeholders to assess potential regional-scale compensation measures suitable for multiple ScotWind projects. Nine measures were identified as having the most potential to provide, or contribute to, regional-scale compensation. Phase 2 aims to expand on this and quantify the scale and efficacy of these measures primarily for ornithological impacts. In this work, we focus on marine litter removal specifically as one of the measures evaluated in detail during Phase 2. We refine details of litter removal as a regional compensatory measure for target seabird species affected by ScotWind projects, the extent to which removal of marine litter can address this, and costs involved in its implementation. Through literature review and data synthesis, this work discusses sources and movement of marine litter in the North Sea, assesses seabird susceptibility to ingestion and entanglement, and estimates the number of birds affected annually. Additionally, the feasibility, costs, and expected ecological benefits of enhanced clean-up efforts are evaluated. Findings indicate that while litter removal can reduce plastic ingestion and entanglement risks, direct seabird population benefits are difficult to quantify due to uncertainties in species-specific exposure and mortality attribution. However, clean-up efforts are expected to significantly reduce marine litter loads, improving seabird habitat quality and broader ecosystem health. We highlight key knowledge gaps and suggest pathways to enhance the viability of marine litter removal as a compensatory measure. By advancing understanding of the ecological returns of marine litter removal, this work informs ongoing discussions on effective offshore wind compensation strategies, ensuring sustainable outcomes for both biodiversity and renewable energy development.

P073 – OWESOME - Offshore Wind Environmental Survey Optimization for Monitoring impacts on Ecosystems

Prof David Lusseau[1]*, Mr Christian Riisager-Simonsen[2], Dr Fletcher Thompson[1], Prof Einar Eg Nielsen[1], Prof Patrizio Mariani[1], Dr Martin Lindegren[1], Dr Jon Svendsen[1], Ms Magali Collin[3], Dr Camille Le Guen[3]
[1] Technical University of Denmark, [2] DTU Aqua, [3] TotalEnergies OneTech SA
*Corresponding author.

[aim and objective] The European ambitions on climate and energy security require a rapid development of offshore wind energy production. At the same time, European ambitions outlined in the Regulation on Nature Restoration require that such energy production development must be done in a manner that does no significant harm to biodiversity and when possible, significantly contribute to its restoration. We currently have a piecemeal view of the net biodiversity impact of offshore wind construction, operation and decommissioning. Most impact assessment work carried out to date has focussed on regulatory requirements which treats the concept of biodiversity in silos: i) species that we deem important in their own sake assessed independently, ii) species contributing significantly to ecosystem services assessed for their continued contributions, and iii) habitats underpinning important ecosystems assessed for their continued contributions. We know that those features of biodiversity interact and that those interactions result in complex changes in essential biodiversity indicators, yet we lack an integrative view of the net total contributions of placing a windfarm at sea to biodiversity as a whole concept. Importantly, much of our knowledge is driven by experience with bottom-mounted platforms. Yet, much of future developments will rely on floating platforms, placed further offshore, in deeper regions. [methods] TotalEnergies has been consented to construct a demonstration floating wind platform West of the Culzean gas field in the northern North Sea, 200km East of Aberdeen. This platform is being equipped during its construction with environmental and ecological sensors that will allow it to have a high flow of multidimensional biological and ecological data at high sampling frequency. OWESOME will engineer observation to data analytical pipelines across ecosystem trophic levels to deliver biological and ecological data at a high throughput rate. [results] Here we present the technical approach used to develop the data flow and the approach we will use to develop novel methods to integrate multi-sensor biological and ecological data to estimate essential biodiversity indicators and estimate their change through time during the operational years of a platform. The data generated at Culzean will be made available to researchers both to better understand the North Sea biodiversity dynamics, but also as benchmark to test analytical methods. We present the roadmap and mechanism for data release. [conclusion] OWESOME will yield a blueprint for monitoring biodiversity within and around floating wind farms aiming to bring clarity about sensor choice and parameters most useful to monitor.

P074 – Beyond Mitigation: A Nature-Positive Framework for Wind Energy EIAs

Dr Miguel Mascarenhas[1]*, Dr Luís Rosa[1], Dr André Jorge[1], Dr Karina Amaral[1], Dr Sandra Rodrigues[1], Dr Madalena Matias[1], Mr Paulo Cardoso[1], Dr Cláudia Montenegro[2]
[1] BE - Bioinsight & Ecoa, [2] Galp
*Corresponding author.

As wind energy expands to meet EU and national renewable targets, the challenge is not just mitigating impacts but integrating nature-positive strategies into project planning. EIA traditionally focus on minimizing negative effects, but advancing methodologies can transform projects from compliance to net positive biodiversity outcomes. This shift is crucial where EIA regulations do not mandate positive outcomes. The Alcoutim Wind Farm pioneers a structured avifauna assessment in sensitive areas, establishing a methodological framework that provides a reference for regulators, developers, and financial institutions seeking to align renewable energy expansion with biodiversity conservation while actively contributing to ecosystem restoration and long-term ecological resilience. For the first time in Portugal, an EIA combined advanced techniques into a structured framework. The baseline dataset integrated monitoring data from other projects, and citizen science platforms with a 1,267-hour field effort, including 264 hours dedicated to Collision Risk Modelling (CRM). Species Distribution Modelling (SDM) using a Bayesian approach refined predictions of species presence and space use. These models, combined with thermal uplift mapping and species flight behaviour data, estimated exclusion volumes and identified areas where wind farm infrastructure could cause displacement effects. A Shutdown on Demand (SDOD) through an automated system was considered a standard mitigation. Field surveys confirmed 91% of 136 recorded species, including 20 of conservation concern. CRM estimated annual collision rates between 0.12 and 1.79 before mitigation, while exclusion volumes ranged from 0.7% to 6%, reinforcing the importance of high-resolution assessments in project siting. These findings shaped impact assessments and mitigation strategies, ensuring SDOD implementation to achieve zero mortality for target species. The EIA extended beyond mitigation by incorporating a proactive Biodiversity Action Plan (BAP) with measures targeting the Spanish Imperial Eagle, Bonelli's Eagle, and Iberian Lynx, including pastureland management through extensive grazing, restoration of aquatic vegetation, stream protection, diversifying shrublands, and habitat enhancement for key prey species, particularly wild rabbits. Alcoutim's case study is a proof of concept of how structured, positive-driven EIAs could guide regulatory decisions and enhance project sustainability. For regulators, this framework sets a benchmark for best practices, defining the depth of analysis required in sensitive areas. For developers and investors, it de-risks projects, demonstrating that proactively exceeding regulatory requirements strengthens environmental responsibility and accelerates permitting. As the EU and national 2030 energy transition goals drive wind energy expansion, this case underscores the importance of structured, high-resolution impact frameworks that move beyond mitigation toward biodiversity gains, ensuring regulatory certainty.

P075 – Fostering Social-Ecological Acceptance of Wind Energy in Europe

Dr Roel May[1]*, Dr Roopali Bhatnagar[2], Dr Reto Spielhofer[1], Dr Thomas Kvalnes[1], Mr Frank Hanssen[1], Mr Prodromos Gkalimanis[3], Mr Michail Ntovas[4], Mr Sergio Arregui Remon[5], Mrs Silvia Masci[6]
[1] Norwegian Institute for Nature Research, [2] Copenhagen Business School, [3] Q-PLAN International Advisors, [4] White Research, [5] Fundación CIRCE, [6] EGP
*Corresponding author.

The WENDY project, funded through the EU Horizon Europe Programme, aims to trigger a change in the social perception of onshore and offshore wind energy projects. To unravel the triggers for social acceptance of wind farms, an integrated approach encompassing social, environmental, and technical perspectives is adopted. Decision-support tools were developed and validated to facilitate spatially explicit planning, impact assessment, and the selection of suitable interventions. The online WENDY toolbox consists of a set of tools that allow developers to plan for environmentally friendly wind farms. This includes a tool to map biodiversity hotspots for terrestrial birds and bats, and seabirds and marine mammals for onshore and offshore wind farms, respectively. A participatory spatial Delphi tool allows mapping of locally valid ecosystem services. Both tools are used to quantify the potential life cycle impact of wind farm development. This information is then integrated into a spatial multi-criteria decision analysis tool to balance trade-offs between socio-ecological values and renewable energy production potential, identifying sites with minimal social-ecological impacts per kWh produced. This is expected to enhance transparency and inclusiveness during the early planning phase. A social acceptance interventions tool serves as a decision-making aid, presenting recommendations across the world, to enhance social acceptance at different phases of a wind energy project. While impacts can thus be avoided, residual impacts at a chosen site can be further mitigated through the handbook on environmental design solutions. Tracking of social-technical-ecological performance along all project phases can be done with an online multivariate key performance indicator application to support sustainability reporting. These tools are currently being validated in four use cases in Spain, Italy, Greece and Norway. The project's Knowledge Exchange Platform further fosters long-term cooperation among key stakeholders, promoting the uptake of the WENDY tools and knowledge.

P076 – Bird protection on renewable generation grid connections, mitigation technology and global experience

Mr Brian Mcgowan[1]*
[1] *Scientias-Energy*
*Corresponding author.

Research motivations and objectives: The energy transition requires construction of new overhead energy infrastructure in remote and wildlife rich area in order to connect renewable generation to urban consumption, increasing the interactions between wildlife and energised lines. These increased interactions require planning to avoid outages, fire ignition risk and mortality associated with avian collision and electrocution. The goal of this research was to help utility engineers understand the avian collision challenge, and optimise the use and deployment of bird flight diverter technology with a view to maximising the efficiency of diverters in service. It will detail outage and fire ignition risks associated with bird collisions. Methodology: This P0will summarise avian collision risks based on a synopsis of over 60 recent studies evaluating avian collisions published since 2005, and interviews with utility engineers and ecologists with recent expertise in the field. The P0will also summarise and critique 15 modern bird flight diverter solutions freely available in the market. It will define the most important variables that impact collision risks overhead line design, environment, avian biology and avian behaviour. This results will demonstrate mortality reductions in the range 54-95%. The review of bird flight diverters will assess improvements in design characteristics; size, color and contrast, modern engineered surfaces(fluorescing, UV reflecting and phosphorescent), artificial light and durability. It will detail the most common flight diverter failure modes reported from utility users. Summary of finding:

- There is no current technology that can reduce avian power line collisions by 100% in all scenarios. Environmental durability and wind resilience of bird flight diverters designs remains a pervasive challenge and very few papers systematically report on durability.

- New bird flight diverters and improvements in current designs have yielded improvements in both mitigation performance and durability in the past 5-7 years.

Conclusion: The poster concludes with the following recommendations:

- A process to follow to determine where and how to use bird flight diverters with a view to maximising their effectivity.

- That all future bird flight diverter mitigation studies, record data on diverter durability and failure modes.

- The definition of an optimal diverter.

P077 – Displacement effects of offshore windfarms on marine bird populations – an assessment framework

Ms Eleni Melis[1]*, Dr F H Floor Helena Soudijn[1], Dr Vincent Hin[1], Mrs Chun Chen[1], Dr Susanne Van Donk[1], Mr Daniel Benden[1], Mr Martin Poot[1]
[1] *Wageningen Marine research*
*Corresponding author

The rapid expansion of offshore wind in the southern North Sea raises concerns for marine birds. Species like the common guillemot (*Uria aalge*) and northern gannet (*Morus bassanus*) face potential displacement and loss of important foraging habitat. To assess the displacement impacts of existing and planned offshore wind farms (OWFs) in the Dutch waters, we developed a comprehensive model framework integrating habitat suitability models, overlap analyses, and population models. We combine this with tests of acceptable levels of impact at population level and implement uncertainty propagation over the entire framework. Our results suggest an increased annual mortality due to displacement by OWFs. Results of the population models further indicate a negative effect on annual population growth rate in scenarios with OWFs compared to no OWFs. With the planned Dutch OWF expansion up to 2031, acceptable levels of impact are violated for the common guillemot. This is likely due to the large impact distance observed for this species. Outcomes depend on key assumptions regarding marine bird food availability, spatial distributions, displacement distances, and displacement mortalities. This model framework considers uncertainty in all data inputs by propagating the uncertainty through all model components. Its outcomes support decision-making in energy development policy by estimating displacement effects at the population level.

P078 – Practical application of the space use collision risk model (RKR model) in approval procedures

Dr Moritz Mercker[1]*, Mr Rainhard Raab[2], Mr Jan Blew[3], Dr Thilo Liesenjohann[3], Dr Jannis Liedtke[3]
[1] Bionum GmbH, [2] TB Raab GmbH, Quadenstraße 13, 2232 Deutsch-Wagram, Austria, [3] BioConsult SH
*Corresponding author.

The LIFE EUROKITE project aims to reduce human-caused mortality of the red kite (Milvus milvus). Infrastructure projects, particularly the expansion of renewable energy sources like wind turbines, can increase anthropogenic mortality rates. Given the rapid development of wind energy infrastructure, accurate collision risk assessments at wind turbines are essential for efficient project planning and timely implementation. To balance species protection with the demand for environmentally friendly energy generation, precise and legally compliant calculation models are necessary. The “Space use collision risk model” (RKR model) serves this purpose. This standardized, probabilistic method integrates species-specific aspects of habitat use and collision risks with wind turbines, taking into account meso- and micro-avoidance rates. In the first step, the RKR model forecasts the three-dimensional project-specific habitat use of the red kite based on habitat potential, considering factors such as forests, pastures, settlements and many others. It reveals that field edges, settlement borders, and grasslands strongly attract red kites, while forests act as barriers for birds searching for food.In the second step, predictions of flight activity (in seconds) per breeding site are combined with wind turbine-specific data to estimate the average time spent in the risk area, defined as the airspace covered by rotor blades, collision risk is given as number of collisions per individual and season. Beside the space use, this analysis incorporates species-specific flight speed, body dimensions, and empirically determined avoidance behaviour, evaluated using hight-frequency GPS telemetry data. The RKR model provides a comprehensive tool for integrating species protection into infrastructure development and plan approval procedures. Utilizing modern remote sensing technologies (e.g., Copernicus) and telemetry data from tagged birds, it delivers standardized, reproducible, and precise results regarding habitat use and collision risks for breeding birds near wind turbines. The model accounts for all relevant factors based on current research, making it the most reliable method for assessing collision risks of individual birds. The development process involved extensive collaboration among stakeholders from various sectors, leading to consensus on its suitability for future assessments of collision and thus mortality risks. The current RKR model for the red kite is considered finalized. Plans to incorporate additional species such as the white-tailed eagle and white stork and others. A discussion about mortality thresholds will ensue to be able to assess wind energy projects in the framework of the German Federal Nature Conservation Act.

P079 – Combining Linear Inverse Modelling and Ecological Network Analysis to Assess Offshore Wind Farm effects with uncertainty evaluation

Ms Laurie Michaud[1]*, Dr Aurore Raoux[1], Dr Jean-Philippe Pezy[1], Ms Emma Araignous[2], Dr Pierre Bourdaud[2], Dr Nathalie Niquil[1]
[1] Normandie Univ, UNICAEN, UNIROUEN, Laboratoire Morphodynamique Continentale et Côtière, CNRS UMR 6143 M2C, 24 rue des Tilleuls, 14000 Caen, France, [2] France Energies Marines
*Corresponding author.

Keywords: reef effect; food webs; cumulative impacts; climate changeThe development of offshore wind farms (OWFs) introduces new anthropogenic pressures on marine ecosystems, necessitating robust ecosystem-based approaches to assess their effects. In this context, we combine food-web models—specifically Linear Inverse Modelling (LIM) and Ecological Network Analysis (ENA) indices, to quantify ecosystem responses to OWFs, including cumulative impacts, climate change effects, and interactions with other human activities. This approach not only improves the estimation of network indices by incorporating uncertainty analysis but also enables statistical comparisons between different ecosystem states, particularly regarding the artificial reef effect. Additionally, our work contributes to the selection of relevant food web indicators for the Marine Strategy Framework Directive. While ecosystem-based approaches in fisheries typically rely on simulations in the absence of OWFs, the recent commissioning of OWFs in France now allows for empirical validation of these models. Our study focuses on the eastern English Channel, where a measuring mast within the Fécamp wind farm provides a unique opportunity to assess the ecological effects of artificial reef effect in OWFs. We build three food- web models, each representing at stations located at increasing distances from the mast. These food webs, built using local biomass and isotopic data, enable us to investigate how the reef effect influences ecosystem structure and functioning along a spatial gradient. By integrating LIM and ENA, this study enhances our understanding of OWF-induced changes in marine ecosystems and evaluates the relevance of structural and functional indices in detecting spatial patterns and functional shifts. Ultimately, our findings will inform ecosystem-based management strategies and contribute to a more comprehensive assessment of Marine Renewable Energy ecological footprint.

P080 – Between Wind and Wings: Bird and Bat Collisions at Polish Wind Farms

Ms Aleksandra Mikołajczyk[1]*, Mr Jan Brożek[1], Mrs Katarzyna Kamionka-Kanclerska[1], Ms Milena Stefaniak[1], Mrs Paulina Brzeska-Roszczyk[1]
[1] *Ambiens Sp. z o.o.*
*Corresponding author.

One of the key elements when assessing the environmental impact of wind farms is the mortality of birds and bats. However, large quantities of data from a similar region are necessary for such assessments to be precise, and Poland lacks a comprehensive nationwide database that would consolidate the results of mortality monitorings. To address this matter, data on wind farms mortality were obtained from local authorities. They included results from post-construction monitorings for 115 wind projects comprising 966 turbines, conducted between 2009 and 2024 in accordance with national guidelines. The dataset was then analyzed using statistical methods, focusing on identifying mortality patterns by species, season, and proximity to turbines, offering insights into collision risks and their influencing factors. Data on 1936 casualties were obtained: 1036 birds (54%) and 900 bats (46%). Among birds, the most frequent casualties were the goldcrest *Regulus regulus* (22%) and lark *Alauda arvensis* (16%), while among bats, individuals of the genera *Pipistrellus* spp. (59%) and *Nyctalus* spp. (27%). Seasonal trends showed that most bird collisions occurred in October (21%), April (20%), September (12%), and March (11%), with a peak in late October. Bat fatalities peaked in August (42%), particularly in the third decade of the month. Collision distances varied between groups. Among birds, 100% of victims were found within 100 m from the tower, and 94% within 70 m. Among bats, 97% of victims were found within 100 m from the tower, and 84% up to 70 m away. The results highlight high-risk periods: spring migration (March-April) and autumn migration (September-October) for birds, and breakup of the breeding colonies (August) for bats. These findings will be used to refine methods of mortality studies in Poland, particularly by increasing survey frequency during periods with the highest probability of collisions, and to improve the effectiveness of searching for victims. The results will also contribute to better assessment of collision risk based on birds and bats activity and plan methods to minimize negative impacts.

P081 – VULNEO: Assessment of the Sensitivity and Vulnerability of Avifauna to Onshore Wind Turbine Infrastructures in Mainland France

Dr Alexandre Millon[1]*, Dr David Vallecillo[2], Mrs Lucile Morcelet[2], Dr Agathe Leriche[2], Dr Nicolas Hette-Tronquart[3], Dr Olivier Duriez[4], Dr Aurélien Besnard[5]
[1] Mediterranean Institute of Biodiversity and Marine and Continental Ecology, [2] Aix Marseille Univ, IMBE, IRD, CNRS, Avignon Univ, [3] Office Français de la Biodiversité, [4] Centre of Evolutionary and Functional Ecology, Univ Montpellier, CNRS, EPHE, IRD, 1919 Route de Mende, 34293 Montpellier cedex 5, France, [5] CEFE, Univ Montpellier, CNRS, EPHE PSL University, IRD, Montpellier, France
*Corresponding author.

The deployment of new wind farms to fulfill the European Green Deal objectives will inevitably increase the number of collisions with flying fauna. The aim of the VULNEO project is to produce reliable indicators of the sensitivity and vulnerability of avifauna in order to inform the selection of sites for onshore wind farms with the lowest environmental impact. To do this, we carried out a collision sensitivity assessment for 142 species of bird found in mainland France. This sensitivity index combines the general risk of extinction with a collision risk based on birds' flight behaviour, including the time spent at the height of the area swept by the rotor. This estimate is based on GPS telemetry data for around half of the species considered, and has been extrapolated for the others on the basis of correlations between flight behaviour and morphology. We propose a map of overall sensitivity scores on the scale of a 10×10 km grid over the whole of France, incorporating all the species known to be present in each cell, during the breeding, migration and/or wintering periods. This community-wide approach is intended to complement the environmental impact assessments, which typically include a few species considered to be at high risk. VULNEO also provides an assessment of the potential for wind energy production on a national scale, incorporating wind data, regulatory criteria and the areas suitable for the development of onshore wind power, defined by the regional authorities. Combining this information with the map of the overall sensitivity of the avian community indicates that the objectives of energy production at the 2035 horizon could be achieved with new wind farms concentrated in grid cells hosting an avian community showing a low sensitivity to the risk of collision. By combining the risk exposure (i.e. the number of wind turbines in operation in each grid cell) and the overall sensitivity of the avian community at the scale of these grid cells, VULNEO also provides an assessment of the current relative vulnerability for each of the 142 species. Finally, VULNEO combines all the information produced and collected on the avian community and the potential wind energy production within a spatial prioritisation algorithm (Zonation 5 v2.0). This method offers an opportunity for planning onshore wind development on a national scale, in order to meet wind energy production targets while minimising the impact of this development on the bird community.

P082 – Application of the "supplier" protocol (MAPE research program): limits and prospect of improvement

Ms Marie Minmeister[1], Dr Lucie Barluet De Beauchesne[1]*, Mr Simon Carsin[1], Mr Florian Poulain[1], Mr Henri-Pierre Roche[1]
[1] *Biodiv-Wind*
*Corresponding author.

Automatic detector systems (ADS) play an important role in the reduction of collision risk for avifauna with wind turbines. Today, there is an important diversity of marketed ADS using different technologies and it can be difficult to compare the performance of each device. In order to standardize the evaluation of marketed ADS, the National Centre for Scientific Research (CNRS) developed two protocols published in May 2023: one for system suppliers and the other for wind farm operators. *Biodiv-Wind*, a company that developed the *SafeWind* system, aims to test the feasibility of the "supplier" protocol and conduct a critical analysis, in order to suggest potential improvements. The tests were performed at two different geographical sites (56 km apart) and at one of these sites, measurements were taken at 12 distinct locations. Following the CNRS protocol, field surveys were carried out by two ornithologists, using a laser rangefinder, to identify species and distances of birds present around the ADS. Using an R script supplied by the CNRS, these data are compared to detections made at the same time by the ADS to evaluate its performance. Before we attempt to use the R script, it requires several adjustments and some elements of the script question the reliability of the results. For example, a detection is successful if, within a time interval of 40 seconds, a laser rangefinder measurement corresponds to an ADSs detection. However, it doesn't account for criteria such as bird azimuth or species. Therefore, a Red Kite located 400 m from the ADS, in the opposite direction of the ADS camera's viewing angle, can be considered successfully detected because, at the same time, a passerine was flying 20 m in front of the camera. Preliminary results show that, even with identical settings, there is a variability of the performance evaluation both between and within sites. This may be due to several factors, such as topography, ADSs installation height or the height at which birds fly. In conclusion, this research program therefore provides an essential analytical framework for ensuring consistency in the evaluation of ADSs. However, its application highlights limits and raises questions, opening prospects for improvement, such as determining a standardized location for performing the tests.

P083 – Advancing Offshore Wind Farm Assessments: An Automated Solution for By-Sea Distance Calculations

Ms Danielle Moore[1]*, Mr Aleksander Uszczyk[1], Dr Christopher Brodie[1], Dr Murray Grant[1]
[1] *Haskoning*
*Corresponding author.

The global expansion of offshore wind energy demands increasingly precise environmental impact assessments to ensure sustainable coexistence with marine wildlife. A critical yet challenging aspect of these assessments is accurately measuring by-sea distances between offshore wind farms and seabird colonies—essential data for determining connectivity and the apportioning of breeding season impacts to key colonies (particularly those which designated as Special Protection Areas), as required by UK Statutory Nature Conservation Bodies. Current manual measurement methods are both time-intensive and susceptible to human error, particularly as projects scale to hundreds of required measurements, often taking days to complete for a single project and reducing the time available for critical analysis on potential impacts on these bird species. We developed an innovative QGIS-based automation tool that revolutionizes this process through the integration of custom Python algorithms and digital elevation modelling. The tool calculates optimal seabird flight paths using least-cost pathway analysis, accurately simulating how seabirds are expected to navigate around coastlines rather than crossing landmasses. Built on open-source platforms to ensure accessibility, our solution features a user-friendly interface that simplifies complex spatial calculations into a streamlined workflow suitable for non-technical users. The tool generates both visual path representations for rapid quality assurance and detailed distance measurements in attribute tables for regulatory documentation. Extensive validation testing across diverse scenarios, including seabird species with both small and large foraging ranges at various UK offshore wind farm locations, demonstrated substantial improvements in both accuracy and efficiency. When compared with verified measurements for an example offshore wind farm, our automated calculations achieved 94.2% accuracy while reducing processing time from over a day of manual work to one hour. This significant reduction in processing time, combined with the elimination of human error in path selection, represents a step-change in assessment capability for the offshore wind sector. The current implementation focuses on applications for offshore ornithology, however there are planned expansions to include adaptations for marine mammals and fish movement patterns. This tool represents a significant advancement in standardising and streamlining offshore wind farm impact assessments, enabling stakeholders to focus on critical decision-making rather than time-consuming measurements. As the offshore wind sector continues its rapid growth, our innovation demonstrates how technological solutions can maintain rigorous environmental standards while accelerating renewable energy deployment, directly addressing the pressing need for efficient, accurate environmental assessment tools in this expanding industry.

P084 – Development of an offshore bird and bat activity and mortality detection system using thermal cameras

Mr Brogan Morton[1]*, Mr Jon Ritter[1]
[1] *Wildlife Imaging Systems*
*Corresponding author.

Wildlife Imaging Systems has announced a project with Vattenfall and Wageningen Environmental Research to study the use of thermal cameras in the offshore environment. The intent of the project is to study the efficacy of using thermal cameras around an offshore wind turbine to monitor wildlife micro-activity, micro-avoidance and collisions with the turbine blades in the rotor swept zone, as well as direct mortality occurring in the offshore environment.The project is taking place at the Hollandse Kust Zuid (HKZ) Offshore Wind Farm in the North Sea off the coast of the Netherlands. This pilot study is deploying sixteen thermal cameras. Twelve of sixteen will be used to measure direct mortality caused by the wind turbine. They will be mounted on the railing of the transition platform and their field of view will be directed radially outward away from the turbine tower, with the focal length of the camera chosen to see a 10 cm object up to 115 m away, covering the whole area below the rotor swept zone for all wildlife of interest. They will cover the full 360° around the base of the tower and operate for 24 hours a day. The goal of these cameras is to detect a falling object after a direct fatality. The additional four cameras will be looking up toward the nacelle, monitoring the rotor swept zone. The four cameras will be positioned such that they will each be monitoring a side of the turbine, resulting in 360° coverage of the rotor swept zone. All camera data will be processed using state-of-the-art machine vision and AI to automatically detect, track, and classify each detection. The tracks will then be used to analyze the behavior of wildlife near the turbine and will be able to document any micro-avoidance seen and any specific behavior that may lead to a fatality. The study began in November 2024 and is planned to cover the spring and autumn migration season of 2025. In our P0we will present the technical aspects of the systems, lessons learned from equipment deployment and the initial data processed.

P085 – Field Testing of a 3D Wildlife Tracking System

Mr Brogan Morton[1]*, Mr Jon Ritter[1]
[1] *Wildlife Imaging Systems*
*Corresponding author.

New onshore wind development has brought wind plants into greater conflict with wildlife, especially bats. The global offshore wind industry is also contending with these wildlife conflict issues as well, with a focus on migratory and marine birds. While the timing and relative wildlife activity can be gleaned from acoustic and 2D thermal data, three-dimensional monitoring and tracking methods must be used to better quantify wildlife interactions with wind turbines. For onshore turbines, understanding how bats use the vertical aero-environment around turbines and if there are specific risky behaviors associated with mortality is critical. For offshore turbines, informing the collision risk model input parameters as well as validating models to predict avian distributions, calculate mortality, and estimate individual and population level impacts is also needed. The technology innovation we have developed is a cost-effective 3D wildlife tracking system based on stereo security cameras and advanced processing software. Using security cameras improves the reliability of the system by eliminating the need for a field-computer to acquire synchronized video from both cameras. Switching to these cameras is enabled by the advanced software that time synchronizes the data in software as well as automates the in-situ camera-to-camera (extrinsic) calibration that is required. We designed and fabricated a prototype 3D camera hardware kit and deployed two prototypes to turbines at an operational wind facility in the U.S. Midwest during the bat season in 2024. In our poster, we will discuss the benefits of 3D wildlife tracking for both the onshore and offshore turbines, and we will present the results of the field testing conducted. This will include examples of 3D bat tracks, the flight height distribution of the bats around the turbine and how the flight height varies with wind speed.

P086 – Spatially-explicit central-place foraging model for wind farm mitigation hierarchy and cos-efficiency of deterrence systems

Dr Sylvain Moulherat[1]*, Mr Matthieu Moulherat[1], Dr Denis Maréchal[1], Dr Mélodie Kunegel-Lion[1], Dr Catherine De Roincé[1]
[1] *TerrOïko*
*Corresponding author.

As part of the environmental measures applied to onshore wind turbines, more and more wind farms are being equipped with systems for recognizing or detecting avian fauna in order to trigger mechanisms for slowing down or stopping the blades, as well as repelling systems to reduce collision risks. However, during the conception phases, estimating the efficiency of such systems and the costs related to their functioning remains challenging.
To estimate the collision risk and the frequency of avian protection system triggering, a dedicated modelling module has been developed in SimOïko. SimOïko is a spatially explicit agent-based model initially developed to perform population viability analysis. The model is a combination of modules dedicated to:

1. Population modelling
2. Movement modelling
3. Transmission of genes

Based on the movement module, a central-place foraging model has been implemented and previously used to estimate the pollination service produced by wild bees. In this work, the movement model has been adapted to operate in the context of wind farm conception.
In this respect, the module assumes that:

- Birds are foraging in their nest vicinity, and the foraging intensity increases where resources are more likely to be found.
- Once replete, birds return to their nest in a straight line.
- Birds' activity patterns depend on the season and their age class.
- Repelling systems are not 100% efficient.

Based on these assumptions, the model returns:

- The expected foraging territories of birds.
- The occurrence of bird presence in the risky sphere where collision risk is maximum and wind turbines are expected to stop if equipped with automatic stopping systems.

Supported by showcases of the model implementation, this work illustrates multiple uses of the model during the wind farm conception phase to address the mitigation hierarchy implementation and anticipate the productivity loss due to the flanging system. It also illustrates the model's application conditions and, consequently, its implementation limits (data requirements, replicability, transferability, etc.).
Finally, this presentation will develop further perspectives to improve the model's accuracy and predictive abilities (3D explicit modelling, aerology integration) and its combination with the population module to integrate the local effect of wind farms on bird foraging abilities and the remaining collision risk at the population scale.

P087 – Pilot studies of different camera systems for bird monitoring in a floating offshore wind farm

Mrs Kari Mette Murvoll[1]*, Dr Arne Myhrvold[1], Mr Aksel Alstad Mogstad[1], Mr Felix Kelberlau[2], Mr Helge Reikerås[3], Mr Andreas Günther[3], Mr Andrew Watts[3]
[1] Equinor, [2] Fugro Norway, [3] Spoor
*Corresponding author.

Globally, many bird populations are in decline, and offshore wind farms (OWFs) might further increase the stress on these populations. Consequently, there is a need to improve knowledge on OWF bird collision risk and to understand the potential displacement and subsequent effects for the relevant bird populations. In the world's largest *floating* offshore wind farm (FOWF), Hywind Tampen (88 MW), the operator Equinor and research collaborators have piloted the use of cameras on a metocean buoy for the purpose of bird monitoring. In addition, standard surveillance cameras installed for safety reasons on the turbines have been used for monitoring of bird activities. Hence, these studies examine the potential use of transportable buoys and existing infrastructure at OWFs to collect data on bird activity and attendance. A validated buoy-based bird monitoring concept will be beneficial in areas where construction has not yet started, e.g. in baseline studies. Opportunities for multi-use of existing infrastructure constitute a resource-efficient approach for bird monitoring. The buoy pilot was conducted from June 2023 until October 2023 whereas the monitoring using the standard surveillance cameras at Hywind Tampen took place from June 2023 until February 2024. Both systems gathered extensive data with the video recordings from both systems analysed by means of computer vision and machine learning technology. This provided insights on birds in the wind farm area, including number of birds, species, estimated flight height and direction, seasonal activity, and influence of weather conditions. Although the systems collected data simultaneously, they monitored mutually exclusive parts of the area due to the different vantage points of the sensors: The cameras on the buoy were placed close to the sea surface while the turbine cameras were installed approximately 20 meters above sea level. The data on bird presence and behavior obtained from these studies constitute new knowledge on birds in the vicinity of this remote FOWF, and the concepts piloted for bird monitoring proved promising.

P088 – Extensive eDNA campaign for mapping of fish biodiversity in a floating offshore wind farm

Mrs Kari Mette Murvoll[1]*, Mrs Anita Skarstad[1], Mr Lars Petter Myhre[1], Mr Jon Thomassen Hestetun[2], Mrs Sigrid Mugu[2], Prof Thomas Gunnar Dahlgren[2]
[1] Equinor, [2] Norce Research
*Corresponding author.

As floating offshore wind farms (FOWFs) represent a novel development solution, there are still uncertainties regarding potential impacts. Thus, environmental studies are needed to improve the current knowledge base. In Hywind Tampen – being the world's largest FOWF (88 MW) – a robust eDNA study was performed during May 2023 to map fish biodiversity in the area and assess potential differences between the wind farm area and reference sites. The study also aimed to investigate the possible influence of eDNA transport from the strong dominating currents from north to south in the area to assess whether samples accurately represented local organism communities. This was done by taking samples from the same locations upstream, within and downstream of the FOWF three times in the course of one week – at T0, T1 (+ 24 hours) and T2 (+7 days). In addition, this study also had the opportunity to compare eDNA results with capture studies from the same area, i.e. gillnet and ROV transect studies. The results showed that demersal species were identified in greater diversity and numbers in bottom water samples, and pelagic schooling species were identified in large numbers (sequences read) in samples from 20 meters below sea surface. Only minor differences in fish biodiversity were found between FOWF and reference stations. This could be due to the short time since the construction of Hywind Tampen. Further, there was no significant effect of current transport on the community composition detected by the eDNA method, suggesting that at the Hywind Tampen site such transport is not substantial enough to interfere with data interpretation, despite the strong dominating currents. The study represents a promising result in using eDNA technology for mapping and monitoring of fish biodiversity in FOWF areas (i.e. baseline studies and follow-up activities). Comparisons between eDNA results and net & ROV studies for the same area gave high degree of overlap, which also is a good validation of the eDNA technology in open dynamic marine waters.

P089 – Sustainable Autonomous Vessels for Offshore Wind Monitoring: Evaluating Impact and Coexistence in a pelagic environment

Dr Virginie Ramasco[1]*, Dr Pierre Priou[1], Mr Morten Thorstensen[1], Dr Lionel Camus[1], Mr Salve Dahle[1], Mr Lars Petter Myhre[2], Mrs Kari Mette Murvoll[2]
[1] Akvaplan-niva, [2] Equinor
*Corresponding author.

The growing demand for sustainable energy has driven the expansion of offshore wind farms into deeper waters and the development of floating technologies. While many studies have modelled the effects of floating wind parks, few have directly measured the operational impacts in these deeper offshore environments, but effects are assumed to be mainly for the pelagic environment, rather than the seafloor,. Given the dynamic nature of pelagic ecosystems and their inherent seasonal and interannual variability, long-term monitoring is essential to distinguish between potential impacts from wind farms and natural fluctuations. Autonomous platforms, such as gliders, offer a sustainable and cost-effective method for collecting long-term data offshore. Through multiple studies, we evaluated the potential and limitations of such platforms for monitoring the pelagic environment around operational floating offshore wind farms in the North Sea: Hywind Scotland and Hywind Tampen. Wind-driven surface gliders, equipped with oceanographic sensors and acoustic echosounders, were deployed to assess biomass distribution and fish aggregation (reef effect), as well as planktonic biomass variations. The study also explored the feasibility of using these platforms for evaluating the potential coexistence of kelp farming at Hywind Tampen, comparing in-situ data with model estimates. While no significant impacts from the wind farms were detected, the data successfully captured the natural variability in the area, consistent with open-source model predictions. The autonomous platforms proved effective for long-term monitoring, operating for over a month, and provided high-quality acoustic data without the need for large vessel deployments. However, challenges included weather and current effects on steering capabilities, which limited track precision, as well as the need for additional data to improve species identification from acoustic signals. Future work will focus on integrating predictive models to guide sampling efforts, adding sensors for enhanced ecosystem characterization (e.g., nutrients, eDNA), and deploying diving platforms to study deeper water layers. This approach will further support the sustainable monitoring of offshore wind farms and their environmental coexistence with other marine industries.

P090 – Monitoring of biofouling colonization on coupons with or without antifouling coating in a controlled marine environment

Dr Geraldine Nogaro[1]*, Mrs Carole Veckerle[2], Dr Raphaël Lami[2]
[1] EDF R&D, Laboratoire National d'Hydraulique et Environnement, Chatou, France, [2] Sorbonne Université, Observatoire Océanologique de Banyuls, Laboratoire de Biodiversité et Biotechnologies Microbiennes (LBBM) UMR 8176
*Corresponding author.

Offshore wind farms (OWF) are particularly prone to the development of biofouling (i.e., accumulation of living organisms such as algae, plants, microorganisms, animals). In particular, the operation of floating OWF can be impacted by biofouling causing, for instance, additional mass on floaters and dynamic cables, premature corrosion, and potentially affecting system floatability over time. A better understanding of the colonization process of biofouling (species, thickness, growth rate, etc.) is essential to develop innovative mitigation strategies of biofouling. The aim of this study was to monitor the biofouling colonization on coupons using non-biocidal antifouling coatings in a controlled marine environment. The experiment was carried out in a laboratory located in the Mediterranean Sea (Banyuls sur Mer, France) and consisted of immersing 36 coupons (10x10 cm each) of two different substrates (polycarbonate and stainless steel) covered with different antifouling coatings (e.g., 4 innovative treatments, 1 commercial treatment, and 1 control treatment) in natural seawater aquariums during 7 months from February to September 2024. The biocolonization of the coupons was monitored every month using different parameters: photograph of each coupon to determine the different species and the percentage of biofouling colonization, mass measurements of coupons before immersion and each month during the experiment to estimate the quantity of biofouling developed on each coupon, and at the end of the experiment, measurements of the surface concentration of chlorophyll a on each coupon by spectrophotometry.Our final results showed a significant antifouling effect of all tested antifouling treatments compared to the controls for both substrates (polycarbonate and stainless-steel). Two of the four innovative antifouling treatments had the highest antifouling efficacy after 7-month incubation compared to the other treatments. The colonization kinetics over time revealed an interesting antifouling effect of the commercial antifouling coating on pioneer microbial colonization, which was no longer observed after a few months' incubation in the aquarium. This laboratory experiment showed interesting results on the efficacy of innovative and commercial antifouling coatings in controlled marine environment. Perspectives of this work would be to study of the potential detachment of biofilms attached to antifouling coated coupons. Non biocidal coatings have a mode of efficacy that relies on easy mechanical detachment of the biofouling under the effect of hydrodynamic stress, which would be interesting to further investigate in open water conditions. The results presented in this study have strong implications for the development of future commercial floating OWF that can be impacted by biofouling.

P091 – Gannet Get Away: Tracking the Wandering Youth of Northern Gannets

Mr Naphon Olley[1]*, Mr William Peden[1]
[1] *HiDef Aerial Surveying Ltd*
*Corresponding author.

Understanding the movements and habitat use of immature seabirds is crucial for effective conservation and management, yet relatively little is known about the behaviour of immature northern gannets (*Morus bassanus*). Unlike adults, which are tied to breeding colonies during the reproductive season, immature gannets do not breed and may display different spatial distributions and habitat preferences (Pettex, et al., 2019). However, the extent of their dispersal, their reliance on specific areas, and the factors influencing their movements remain largely unknown. This study aims to address these knowledge gaps by analysing the distribution of immature gannets in offshore environments using digital aerial survey data. Data were collected by HiDef via high-resolution video footage from aircraft flown along transects across multiple offshore regions in UK and Irish waters. Surveys conducted between 2018 and 2024 recorded around 8,800 immatures and juveniles, and approximately 105,000 adults. This method provides standardised observations over large spatial scales, allowing for the identification of individual birds and differentiation between age classes based on plumage characteristics. The use of digital aerial surveys minimises observer bias and provides a robust dataset suitable for assessing seabird distributions in relation to environmental and anthropogenic factors. Our analysis focuses on the spatial distribution of immature gannets, assessing their proximity to known breeding colonies and investigating whether certain regions serve as important foraging or staging areas. By analysing our multi-year survey data, we assess whether immatures stay near established colonies, disperse widely with adults on foraging trips, or exhibit loyalty to specific offshore locations. Additional analyses will explore environmental drivers, such as sea surface temperature, water depth, and prey availability, that may influence their distribution. The integration of these factors will provide a more comprehensive understanding of immature gannet behaviour during the breeding season. The findings of this study have important implications for seabird conservation and marine spatial planning. As offshore wind energy development expands, understanding how immature gannets use offshore habitats is critical for assessing potential risks, such as collision mortality or displacement from key foraging areas. Additionally, improved knowledge of immature gannet distribution can inform broader conservation strategies, helping to identify important marine areas for protection. By addressing this knowledge gap, our research enhances understanding of the early life stages of northern gannets, supporting evidence-based conservation efforts. The results offer new insights into how immature seabirds interact with their environment, ultimately improving our ability to mitigate human impacts on marine ecosystems.

P092 – A robust data-collection pipeline for training AI-enabled avian wildlife detection systems

Mr Vassilis Orfanos[1], Mr Ioannis Misios[1], Dr George Dimas[1], Mr Konstantinos Zalachoris[1]*, Mr Lampros Argyris[1]
[1] *nvisionist S.A.*
*Corresponding author.

Rapid Artificial Intelligence (AI) advancements offer new opportunities for avian wildlife protection and biodiversity conservation in wind energy projects. Reliable AI-based detection systems demand high-quality and diverse data; therefore, we propose a pipeline that integrates automated data collection, systematic sampling, and self-supervised annotation to optimize training dataset generation for AI models. This approach enhances avoidance, minimization, and mitigation measures, promoting sustainable coexistence between renewable energy expansion and wildlife conservation. The proposed data collection pipeline utilizes 4K camera rigs mounted on wind turbines across different geographical locations capturing avian wildlife detection data. To ensure temporal and environmental diversity, images are collected from various cameras on random days. The collected data undergoes self-supervised weather annotation using a Convolutional Neural Network-based approach (Hao et al., 2022) for systematic dataset distribution assessment. Initially, a pretrained AI detection model labels birds, aircraft, insects, and other objects, followed by manual refinement to enhance accuracy while reducing annotation costs and time. A conditioned distribution assessment per class and weather condition ensures balanced representation, mitigating biases that could impact model generalization. During training, dataset construction involves uniform sampling from these conditioned distributions to expose the AI model to diverse scenarios. Model evaluation, however, is conducted on non-uniformly sampled datasets that better reflect real-world imbalances. This approach enhances robustness, improving the model's applicability in avian wildlife detection scenarios.
To evaluate the proposed pipeline, a YOLO-based (Redmon et al., 2016) model architecture was trained on two different datasets, a) one constructed using a random sampling method from the whole set of data, and b) one constructed using the proposed data collection pipeline. Both model instances were evaluated on a dataset created to reflect real-world imbalances. Preliminary results indicate that the dataset constructed using the proposed pipeline offers an 8% performance improvement on avian wildlife detection in terms of precision and recall. The preliminary results indicate that the proposed pipeline leads to the development of more robust AI detection models with application in avian wildlife monitoring and protection. The pipeline also offers an iterative dataset expansion cycle, where newly collected and annotated samples continuously refine and augment the dataset, leading to progressively improved model performance. This adaptive approach ensures that the AI system remains robust across varying environmental contexts, ultimately enhancing its effectiveness in real-world avian wildlife monitoring applications.

P093 – NiD4OCEAN: Nature-inclusive Designs For Reconciling Offshore Renewables With Ocean Protection

Mr Juan Pardo[1]*, Dr Akvaplan-Niva (Apn)[2], Dr Spanish National Research Council (Csic)[3], Dr Oscar Bos[4], Dr Luca Van Duren[5], Dr Technical University Of Denmark (Dtu)[6], Dr Klaipeda University (Ku)[7], Ms Sophie De Reus[8], Dr Science Crunchers (Scc)[9], Ms Renewables Grid Initiative (Rgi)[10], Dr Dnv Dnv[11], Dr Arne Myhrvold[12], Dr Teresa Enriquez[13]
[1] NIVA, [2] Akvaplan-niva, [3] Spanish National Research Council, [4] Wageningen Marine research, [5] Deltares, [6] DTU Aqua, [7] Klaipeda University, [8] North Sea Foundation, [9] Science Crunchers, [10] Renewables Grid Initiative, [11] DNV, [12] Equinor, [13] ScottishPower Renewable
*Corresponding author.

By integrating nature inclusive designs (NiDs), offshore renewable infrastructure can contribute to restoring degraded marine ecosystems. The EU-funded project NiD4OCEAN (2024-2027) advances the emerging field of NiDs and nature-based solutions in general for offshore renewables. The project will provide effective, novel and context-dependent solutions to industry, managers, and policymakers. This will accelerate the implementation of NiDs to support the achievement of international and EU targets for biodiversity restoration and the blue economy. The project focuses on three distinct European ecoregions (North Sea, Baltic Sea, and north-western Mediterranean), each with different technologies (bottom fixed or floating offshore wind), environmental characteristics, and sectorial conflicts. NiDs have already been tested in the field for bottom-fixed offshore wind but their development for floating turbines is still in its early stages and presents unique challenges and opportunities. University students and SMEs are invited to our Innovation Challenges to come up with novel NiDs and nature-based solutions for floating solar structures (addressing issues such as design, material choice, noise, and laying cables). We will further develop context-dependent metrics and impact assessment frameworks to evaluate the benefits and risks of NiDs for policy-relevant species and habitats. Moreover, we will identify data and monitoring requirements for evaluating the performance of NiDs as well as recommendations towards standards. An evidence-based decision-support tool will be co-created with industry and managers to provide clarity on the selection process of NiDs in offshore wind farms. Finally, we will deliver a co-created policy toolkit for the requirements of offshore wind development to comply with biodiversity protection and restoration targets. The NiD4OCEAN consortium (involving scientists, industry, SMEs, NGOs, and a standardization body) and the wider NiD4OCEAN network, will be key to an ambitious communication and dissemination strategy designed to reach all relevant stakeholders. NiD4OCEAN strives to raise awareness among stakeholders on the need to prioritize joint solutions for biodiversity protection and restoration, and decarbonization.

P094 – Overview of the VisAviS project - Visualizing avian migration across Norway supporting sustainable coastal and offshore wind energy development

Dr Diego Pavón-Jordán[1]*, Dr Line Cordes[1], Dr Emma Jane Critchley[1], Mr Frank Hanssen[1], Mr Øyvind Nyheim[1], Dr Reto Spielhofer[1], Dr Bård Stokke[1], Dr Roel May[1]
[1] *Norwegian Institute for Nature Research*
*Corresponding author.

Renewable energy is critical in becoming a low-emission society and the expansion of wind-power plants, especially offshore, are envisaged to play a significant role. Wind energy projects are increasingly considered to be in conflict with biodiversity, recreational activities, indigenous culture and traditions, and influences quality of life and social interactions in local communities. Proposed wind energy projects are therefore often fiercely opposed and frequently rejected at the planning stage. One of the major concerns for risks of environmental impact, amongst other, are associated with bird migration. In Norway, bird migration is assumed to follow the elongated Norwegian leading coastlines. Yet, migration flyways are exceedingly little studied in Norway, and passage routes have never been properly identified and quantified on a scale appropriate for e.g. localization of energy developments. The VisAviS project, led by researchers at the Norwegian Institute for Nature Research (NINA) and funded by the Research Council of Norway, started in spring 2023 with the overall objective of mapping avian migratory flyways in Norway (mainland and adjacent offshore areas) to support (strategic) environmental impact assessments, coastal and offshore wind-power plant siting with minimal environmental costs. VisAviS uses state-of-the-art radar technology to map migratory routes across Norway and adjacent sea areas and provides a dynamic visualization tool to spatially assess migration in near-real time so that measures to mitigate negative impacts of coastal and offshore wind energy development can be implemented. Specifically, VisAviS will generate direly needed spatially explicit knowledge on bird migration patterns and innovative visualizations to support strategic environmental assessments as a basis for policy design. The project's outcomes overcome environmental conflicts, by fostering environmentally friendly siting of wind energy through stakeholder engagement for a more sustainable utilization of Norway's extensive wind energy resources. VisAviS' outcomes will significantly contribute, and reduce the costs, of achieving the EU policy goals for the transition to a sustainable society, support Blue Growth in general as well as meeting the post-Aichi Targets, the Paris Agreement, and the UN SDGs. In this poster, we presents the research plan and results obtained so far in project.

P095 – Investigating bat activity at floating wind turbine with passive acoustic monitoring

Dr Anaïs Pessato[1]*, Ms Marine Reynaud[2], Mr Thomas Soulard[2], Mr Olivier Martinet[3], Ms Nathalie Tertre[4], Mr Antoine Chabrolle[1], Dr Christian Kerbiriou[1]
[1] Muséum national d'Histoire naturelle, Centre d'Ecologie et des Sciences de la Conservation, [2] Fondation OPEN-C, [3] BW IDEOL, [4] EDF Renouvelables France
*Corresponding author.

As renewable energy, offshore wind farms (OWF) play a fundamental role in mitigating climate change by reducing gas emissions. However, their rapid development at sea may have consequences, not only for marine organisms, but also for land animals such as birds and bats foraging and migrating in those areas. To date, little is known about the impact of OWF on the flying fauna, partly because of the lack of knowledge on the spatial and temporal occurrence of them at sea, notably in the Atlantic Ocean, an important sector for the French development of OWFs. The PIAFF&CO project aims to fill this gap by collecting data on birds and bats through several innovative monitoring methods. Here, we address specifically bats, using state-of-the-art passive acoustic monitoring for nocturnal species, as it can be used in challenging environments, where visual observation is more difficult, such as offshore. From 2021 to 2023, we recorded bat echolocation calls from sunset to sunrise using song meters SM4 (wildlife acoustics) installed on the platform and at nacelle height on a floating wind turbine Floatgen (© BW IDEOL) in the Bay of Biscay. We used an automated identification software, Tadarida, to detect and identify the species from the recordings. Our preliminary results show that at least five species of bats are present at sea at the platform level (n=1096 contacts of bats during 351 nights sampled), including migratory and sedentary bat species. The majority of bat activity was detected during migration periods -autumn and spring- and under similar weather conditions as inland (i.e. low wind speed, warm temperature) and at sea in the North of Europe. In addition, two migrating species were detected both at platform and nacelle heights, suggesting that long-distance migrating bats can fly above 35m above the sea, and therefore through the rotor swept area. Our results improve our knowledge on bat nocturnal migration and presence at sea in the Bay of Biscay, and have great implications for developing tools to predict temporal occurrence of flying fauna offshore. Furthermore, through a national French project (MIGRATLANE) we will be able to compare these activities at sea with activities on the coast. Lastly, given the difficulty of tracking bats at sea, our study provides new ecological data that will contribute to a better understanding of offshore wind farm impacts.

P096 – Mapping the vulnerability of seabirds and marine mammals to offshore wind farms in French waters: a tool for spatial planning

Dr Emeline Pettex[1]*, Ms Mènel El Abdellaoui[1], Dr Charlotte Lambert[2]
[1] COHABYS/LA ROCHELLE UNIVERSITE, [2] Littoral Environnement et Sociétés (LIENSs)
*Corresponding author.

Given France's ambitious target of 45 GW of installed offshore wind capacity by 2050, rigorous planning is essential to reconcile energy production and biodiversity conservation. Spatially detailed vulnerability assessments are essential to identify sites that minimise impacts on biodiversity, including seabird and marine mammal populations. To support marine spatial planning, we developed seasonal maps of the vulnerability of marine megafauna (seabirds and marine mammals) to offshore wind energy, covering French Atlantic and Mediterranean waters. Habitat modelling was performed using Generalised Additive Models, incorporating monthly averages of physiographic and biological covariates corresponding to the data collection period. This meta-analysis is based on 12 years of standardised aerial and boat-based at-sea surveys covering over 315,000 km in the Atlantic and 110,000 km in the Mediterranean. The study is based on 44 datasets containing more than 200,000 recorded sightings of seabirds and marine mammals. The distribution maps were then combined with species-specific vulnerability indicators and conservation status to produce maps of seabird vulnerability to offshore wind farms (OWFs). Risk factors included collision and habitat displacement for birds, and underwater noise, entanglement and habitat displacement for marine mammals. These maps were an important resource for the French government to inform the national public debate on 2024. They have also been used by government agencies to identify the areas least at risk from offshore wind and prioritise them for future wind farm development. The study also highlighted the need to improve data collection, in particular through greater standardisation of practices. Several of the available datasets showed gaps in the observation effort (environmental conditions and spatialisation), increasing the uncertainty of the predictions. To date, this work represents the best available knowledge in France for spatialising the vulnerability of marine megafauna to offshore wind turbines. However, it will be essential to update it regularly as knowledge of the responses of seabirds and mammals to offshore wind farms increases. Finally, we highlight the importance of continuously integrating ecological knowledge into energy transition strategies in order to reduce conflicts over marine use and ensure the rational development of renewable energy.

P097 – Predicting the cumulative effects of offshore wind farms on seabird demography and consequent population viability

Dr Christopher Pollock[1]*, Dr Deena Mobbs[1], Dr Adam Butler[2], Dr Oliver Leedham[1], Prof Francis Daunt[1], Dr Kate *R. Searle*[1]

[1] UK Centre for Ecology & Hydrology, [2] Bioinformatics and Statistics Scotland

*Corresponding author.

Offshore wind farm (OWF) developments represent a key component of global strategies to reduce impacts of anthropogenic climate change. However, such developments are often located on habitat used by protected seabird species, potentially altering movement patterns, and causing displacement. Predicting the potential impacts of seabird displacement from proposed OWFs is complex, and the resulting uncertainty in assessments can lead to challenging consenting decisions. Further complications are introduced when considering cumulative effects of multiple OWFs. We used a process-based Individual-Based Model (IBM, SeabORD) to predict the impacts of displacement and barrier effects of OWFs on common guillemots (*Uria aalge*) and black-legged kittiwakes (*Rissa tridactyla*). By simulating the time-energy budgets of individuals during the chick-rearing period, we quantified adult mass loss, overwinter survival, and breeding success in both the presence and absence of a suite of hypothetical OWFs generated to displace up to 25% of a population's individuals. By predicting the demographic consequences of simultaneous developments on a population of interest, we obtained the metrics to conduct Population Viability Analysis (PVA) for scenarios with an increasing number of OWFs. Our final results indicate that the demographic consequences scale with the foraging area occupied by OWFs. At large levels of potential exposure, subsequent population trajectories were significantly altered, which is largely attributed to reduced breeding success. In this application of SeabORD we showcase the model's ability to capture potential nonlinear dynamics of cumulative wind farm exposure by explicitly modelling many of the underpinning processes, e.g., behavioural decisions driven by time-energy budgets, involved in translating wind farm interaction into population-level effects. We then show how the outputs can be readily applied in a PVA. To encourage uptake with practitioners we will highlight how our model can be accessed via open-source code (GitHub) with accompanying help files for improved confidence in what can be a daunting area of Environmental Impact Assessments, owing to its inherent complexity. This talk is proposed to be part of the "Seabirds and fish distributions and behaviour: understanding predator-prey interactions to build evidence for cumulative impact assessment" special session.

P098 – Investigating the main mortality reasons of the European Red Kite population by high-resolution GPS telemetry tracking

Dr Rainer Raab[1]*, Mr Connor T. Partner[2], Ms Carina Nebel[3], Mr Moritz Mercker[4], Mr Maximilian Raab[5], Mr Rainhard Raab[1], Ms Hannah Böing[1], Mr Manuel Wojta[1], Mr Jochen Steindl[1], Mr Eike Julius[1], Ms Clara Freytag[1], Mr Adrian Aebischer[6], Mr Patrick Scherler[7], Mr Martin Kolbe[8], Dr Alexandre Millon[9], Mr Javier De La Puente[10], Mr Javier Viñuela[11], Mr Piotr Zduniak[12], Mr Duncan Orr-Ewing[13], Mr Oliver Krone[14], Mr Torsten Langgemach[15], Ms Susanne Åkesson[16], Mr Brady Mattsson[17], Mr Jendrik Windt[18], Mr Christian H. Schulze[19], Ms Petra Sumasgutner[20], Mr Sven Aberle[21], Mr Manuel Alcantara De La Fuente[22], Mr Ernesto Alvarez[23], Mr Juan Arizaga[24], Ms Carole Attie[25], Mr Melvin Bach[26], Ms Ana Bermejo[10], Ms Elena Bravo-Chaparro[27], Mr Guido Ceccolini[28], Mr Nayden Chakarov[29], Mr Peter Derpmann-Hagenström[30], Mr Marek Dostál[31], Ms Julia Ellersdorfer[32], Mr Gerd Fabian[33], Ms María Fernández-García[27], Mr Wolfgang Fiedler[34], Ms Cassandra Fröhlich[35], Mr Manuel Galán[23], Mr Clément Ganier[36], Mr Andreas Gärtner[1], Ms Liza Glesener[37], Mr Alfonso Godino[38], Mr Martin U. Grüebler[7], Mr Iván Gutiérrez[39], Ms Zuzana Guziová[40], Mr Matthias Haase[35], Mr László Haraszthy[41], Mr Rafael Hernández Martín[23], Mr Christof Herrmann[42], Ms Stefanie Holm[43], Ms Irene Hoppe[35], Mr Juan José Iglesias-Lebrija[23], Ms Caka Karlsson[44], Ms Katharina Klein[45], Mr Urs Kormann[7], Mr Ivan Literák[31], Mr José Vicente López-Bao[27], Mr Nicolas Lorenzini[46], Ms Manuela Löwold[47], Mr Christopher Lüning[48], Mr Gzegorz Maciorowski[49], Mr Boris Maderič[40], Mr Jesper Johannes Madsen[50], Ms Karel Makoň[51], Ms Kerstin Mammen[52], Mr Ubbo Mammen[52], Mr Torsten Marczak[53], Ms Patricia Mateo-Tomás[27], Mr Hynek Matušík[54], Mr Bernd-Ulrich Meyburg[55], Mr Aymeric Mionnet[56], Ms Sara Morollón[57], Mr Jakub Mráz[58], Mr Antoni Muñoz[59], Mr Winfried Nachtigall[60], Mr Bernd Nicolai[8], Ms Marta Olalde Fernández[61], Mr Meinolf Ottensmann[62], Ms María Jesús Palacios González[63], Mr Jean-Yves Paquet[64], Mr Vladimír Pečeňák[40], Ms Eva Pejchalová[1], Mr José Pereira[39], Mr Lubomír Peške[65], Mr Thomas Pfeiffer[66], Mr Robert Pudwill[67], Mr Dušan Rak[68], Mr Tim Maximilian Rapp[69], Mr Per Rasmussen[70], Mr Alexander Resetaritz[71], Mr Luís Ribeiro[39], Mr Stef Van Rijn[72], Mr Romain Riols[73], Mr Sascha Ritter[35], Mr Arturo Rodríguez[74], Mr Jorge Rodríguez-Pérez[27], Mr Hans Rytter[75], Mr João Pedro Valente E Santos[39], Dr Tonio Schaub[76], Ms Luisa Scholze[1], Ms Laura Schulte[77], Ms Aurélie De Seynes[78], Mr Jan Škrábal[79], Mr Péter Spakovszky[1], Mr Martin Sprötge[80], Mr Eike Steinborn[8], Ms Verena Strauss[81], Mr Jan Svetlík[1], Mr Samuel Talhoet[82], Mr Kasper Thorup[50], Mr Anders P. Tøttrup[50], Mr Miklós Vaczi[83], Mr Stefan Vadura[84], Mr Verdier Verdier[36], Mr Zdeněk Vermouzek[85], Mr Diego Villanúa[86], Mr Robin Walz[43], Mr Jörg Westphal[87], Ms Bettina Wilkening[88]

[1] TB Raab GmbH, Quadenstraße 13, 2232 Deutsch-Wagram, Austria, [2] School of Geography, University of Nottingham, University Park Campus, Nottingham, NG7 2RD, United Kingdom and School of Applied Sciences, University of Brighton, Moulsecoomb Campus, Brighton, BN2 4GJ, United Kingdom, [3] Department of Biology, University of Turku, Yliopistonmäki (Vesilinnantie 5), Natura, 20014 Turku, Finland and Turku Collegium for Science, Medicine and Technology, University of Turku, Yliopistonmäki, 20014 Turku, Finland, [4] Bionum GmbH - Büro für Biostatistik und Ökologische Statistik, Finkenwerder Norderdeich 15 A, 21129 Hamburg Finkenwerder, Germany, [5] TB Raab GmbH, Quadenstraße 13, 2232 Deutsch-Wagram, Austria and Institute of Materials Chemistry, TU Wien, Getreidemarkt 9, 1060 Vienna, Austria, [6] Imp. du Castel 20, CH-1700 Freiburg, Switzerland, [7] Swiss Ornithological Institute (SOI), Seerose 1, 6204 Sempach, Switzerland, [8] Rotmilanzentrum am Heineanum, Am Kloster 1, 38820 Halberstadt, Germany, [9] Aix Marseille Univ, CNRS, IRD, Avignon Univ, Institut Méditerranéen de Biodiversité et d'Écologie, 13545 Aix-en-Provence, France, [10] Independent researcher, C/ Quiterio López 4, 28280 El Escorial, Madrid, Spain, [11] Instituto de Investigación en Recursos Cinegéticos (IREC-CSIC-UCLM-JCCM), Ronda de Toledo 12, 13071 Ciudad Real, Spain, [12] Department of Avian Biology and Ecology, Faculty of Biology, Adam Mickiewicz University, Poznań ul. Uniwersytetu Poznańskiego 6. 61 - 614 Poznań, Poland, [13] RSPB Scotland, 2 Lochside View, Edinburgh, Scotland EH12 9DH, [14] Leibniz Institute for Zoo and Wildlife Research (IZW), Dept. Wildlife Diseases, Alfred-Kowalke-Straße 17, 10315 Berlin, Germany, [15] Brandenburg State Agency for Environment, Bird Conservation Centre, Buckower Dorfstraße 34, 14715 Buckow / Nennhausen, Germany, [16] Department of Biology, Lund University, Ecology Building, Sölvegatan 37, 223 62 Lund, Sweden, [17] Institute of Wildlife Biology and Game Management, Department of Ecosystem Management, Climate and Biodiversity, BOKU University, Vienna, Gregor-Mendel-Straße 33, 1180 Vienna, Austria, [18] Institute of Wildlife Biology and Game Management, Department of Integrative Biology and

Biodiversity Research, BOKU University, Vienna, Gregor-Mendel-Straße 33, 1180 Vienna, Austria, [19] Division of Tropical Ecology and Animal Biodiversity, Department of Botany and Biodiversity Research, University of Vienna, Rennweg 14 1030 Wien, Austria, [20] Konrad Lorenz Research Center, Core Facility for Behavior and Cognition, University of Vienna, Fischerau 13, 4645 Grünau im Almtal, Austria, [21] Austrian Power Grid AG, Wagramer Straße 19 (IZD-Tower), 1220 Vienna, Austria, [22] Gobierno de Aragon, Edificio San Pedro Nolasco, Plaza San Pedro Nolasco 7, 50071 Zaragoza, Spain, [23] GREFA, Monte del Pilar S/N, 28220 Majadahonda, Madrid, Spain, [24] Department of Ornithology, Aranzadi Sciences Society, Zorroagagaina 11, 20014 Donostia, San Sebastián, Spain, [25] Conservatoire d'espaces naturels de Corse (CEN Corse), Avenue de Borgo 871, 20290 Borgo, France, [26] WIND-projekt Ingenieur- und Projektentwicklungsgesellschaft mbH, Am Strom 1 – 4, 18119 Rostock OT Seebad Warnemünde, Germany, [27] Biodiversity Research Institute (CSIC-University of Oviedo-Principality of Asturias), c/ Gonzalo Gutiérrez Quirós s/n, 33600 Mieres, Spain, [28] CERM Endangered Raptors Centre Association, Via S. Cristina, 6, 58055 Rocchette di Fazio (GR), Italy, [29] Department of Animal Behaviour, Bielefeld University, Konsequenz 45, Bielefeld, Germany and Joint Institute for Individualisation in a Changing Environment (JICE), University of Münster and Bielefeld University, [30] Am Quälberg 9, 38518 Gifhorn, Germany, [31] Department of Biology and Wildlife Diseases, Faculty of Veterinary Hygiene and Ecology, University of Veterinary Sciences Brno, Palackého tř. 1946/1, 61242 Brno, Czech Republic, [32] Qualitas Energy Service GmbH, Unter den Linden 21, 10117 Berlin, Germany, [33] Eichenallee 11, 29525 Uelzen, Germany, [34] Max Planck Institute of Animal Behavior, Am Obstberg 1, 78315 Radolfzell am Bodensee, Germany, [35] Landschaftspflegeverband Grüne Umwelt e. V., Schwaneberg, Am Anger 4a, 39171 Sülzetal, Germany, [36] LPO France, Fonderies Royales, 8 rue du Dr Pujos, CS 90263, 17305 Rochefort Cedex, France, [37] Naturschutzsyndikat SICONA, 12 rue de Capellen, 8393 Olm, Luxembourg, [38] AMUS (Acción por el Mundo Salvaje), Apartado de correos 6, 06220 Villafranca De Los Barros, Spain, [39] Palombar – Conservação da Natureza e do Património Rural, Antiga Escola Primária, 5230-232 Uva Vimioso (Bragança), Portugal, [40] Ochrana dravcov na Slovensku, Raptor Protection of Slovakia (RPS), Trhová 54, 841 01 Bratislava 42, Slovakia, [41] Pro Vértes, Természetvédelmi Közalapítvány, 8083 Csákvár, Kenderesi u - Geszner-house, Hungary, [42] Agency for Environment, Nature Conservation, and Geology Mecklenburg-Vorpommern, Bird Ringing Scheme Hiddensee, Goldberger Str. 12b, 18273 Güstrow, Germany, [43] Amprion GmbH, Robert-Schuman-Str. 7, 44139 Dortmund, Germany, [44] Department of Biology, Lund University,Ekologihuset, Sölvegatan 37, 223 62 Lund, Sweden, [45] natur&ëmwelt a.s.b.l., 5 Rte de Luxembourg, 1899 Kockelscheuer, Luxembourg, [46] LPO AURA-Loire, 11 Rue René Cassin, 42100 Saint-Étienne, France, [47] MEGEG DE, Dalherdaer Str. 4A, 36043 Fulda, Germany, [48] LEA LandesEnergieAgentur Hessen GmbH, Mainzer Str. 118, 65189 Wiesbaden, Germany, [49] Poznań University of Life Sciences, Department of Game Management and Forest Protection, Wojska Polskiego 71d, 60–625 Poznań, Poland, [50] Natural History Museum of Denmark, University of Copenhagen, Øster Voldgade 5-7, 1350 Copenhagen K, Denmark, [51] DES OP, Záchranná stanice živočichů Plzeň, Zábělská 1512/75, 312 00 Plzeň, Czech Republic, [52] ÖKOTOP - Büro für angewandte Landschaftsökologie, Willy-Brandt-Straße 44/1, 06110 Halle (Saale), Germany and Förderverein für Ökologie und Monitoring von Greifvogel- und Eulenarten e. V., [53] Vor dem Rostocker Tor 53, 18246 Bützow, Germany, [54] Březolupy 324, 68713 Březolupy, Czech Republic, [55] Chairman of the Federal Working Group Birds of Prey Protection of BirdLife Germany, P.O. Box 33 04 51, 14199 Berlin, Germany, [56] LPO Champagne-Ardenne, Ferme des Grands Parts, D 13, 51290 Outines, France, [57] SEO/BirdLife, C/Melquiades Biencinto 34, 28053 Madrid, Spain, [58] Nádražní 434 , 37816 Lomnice nad Lužnicí, Czech Republic, [59] Grup Balear d'Ornitologia i Defensa de la Naturalesa (GOB-Mallorca), C/Manuel Sanchis Guarner 10, 07004 Palma (Illes Balears), Spain, [60] Förderverein Sächsische Vogelschutzwarte Neschwitz e.V., Park 4, 02699 Neschwitz, Germany, [61] Arabako Foru Aldundia - Diputación Foral de Álava, Plaza de la Provincia 4, 2º, CP ES 01001 Vitoria-Gasteiz, Spain, [62] Department of Animal Behaviour, Bielefeld University, Konsequenz 45, 33615 Bielefeld, Germany and Biological Station Gütersloh/ Bielefeld, [63] Directora de Programas de Conservación, Dirección General de Sostenibilidad de la Junta de Extremadura, Avda. Valhondo, s/n, Edif. III Milenio, M2, 4ª planta, 06800 Mérida, Spain, [64] Département Études Natagora, Traverses des Muses 1, 5000 Namur, Belgium, [65] Moskevská 61, Praha 10, 10100, Czech Republic, [66] Rosenweg 1, 99425 Weimar, Germany, [67] Nachtigallenallee 506, 38524 Sassenburg, Germany, [68] ANITRA System s.r.o., Na Královce 31/4, 101 00 Praha 10 Vršovice, Czech Republic, [69] Department of Animal Behaviour, Bielefeld University, Konsequenz 45, 33615 Bielefeld, Germany, [70] Smedebakken 23, 5792 Årslev, Denmark, [71] ÖKOTOP - Büro für angewandte Landschaftsökologie,

Willy-Brandt-Straße 44/1, 06110 Halle (Saale), Germany, [72] Deltamilieu Projecten, Edisonweg 53/D, 4382NV Vlissingen, the Netherlands, [73] LPO AURA Auvergne, 2 Rue du Clos Perret, 63100 Clermont-Ferrand, France, [74] Asociación Hontza, C/ Zadorra 21, 01200 Salvatierra-Agurain (Araba) , Spain, [75] Nyborgvej 20, 5853 Ørbæk, Denmark, [76] Mediterranean Institute of Biodiversity and Marine and Continental Ecology, [77] Department of Behavioural Ecology, Bielefeld University, Konsequenz 45, 33615 Bielefeld, Germany, [78] LPO France Direction Territoriale Aquitaine, Avenue de la Gare, Centre Jara, 64220 Saint-Jean-pied-de-port, France, [79] TB Raab GmbH, Quadenstraße 13, 2232 Deutsch-Wagram, Austria and Department of Biology and Wildlife Diseases, Faculty of Veterinary Hygiene and Ecology, University of Veterinary Sciences Brno, Czech Republic, [80] Planungsgruppe Grün GmbH, Rembertistraße 30, 28203 Bremen, Germany, [81] TB Raab GmbH, Quadenstraße 13, 2232 Deutsch-Wagram, Austria and Research Institute of Wildlife Ecology, Department for Interdisciplinary Life Sciences, Vetmeduni Vienna, Savoyenstraße 1, 1160 Vienna, Austria, [82] LPO Occitanie, Rue du Couvent 10, Cruéjouls, 12310 Palmas-d'Aveyron Aveyron, France, [83] Fertő-Hanság Nemzeti Park Igazgatóság, Rév-Kócsagvár 4, 9435 Sarród, Hungary, [84] EVN AG, EVN Platz, 2344 Maria Enzersdorf, Austria, [85] Czech Society for Ornithology, Na Bělidle 34, 150 00 Praha-Smíchov, Czech Republic, [86] Navarra Environmental Management (GAN-NIK), Padre Adoáin 219 bajo, 31015 Pamplona, Spain, [87] District of Lippe, Lower Nature Conservation Authority, Felix-Fechenbach-Straße 5, 32756 Detmold, Germany, [88] ENERTRAG SE, Gut Dauerthal, 17291 Dauerthal, Germany
*Corresponding author.

The LIFE EUROKITE project aims to reduce the anthropogenic causes of mortality of the Red Kite. To effectively protect European species such as the Red Kite, a detailed understanding of anthropogenic and non-anthropogenic influences, especially the causes of mortality, is required. Within the inter-European LIFE EUROKITE project, we study the anthropogenic causes of mortality by applying high-resolution GPS telemetry tracking that allows fast and exact locating of dead birds. Information to determine these causes is however complex, which calls for a standardized approach. We introduce the LIFE EUROKITE Assessment Protocol (LEAP), a framework for determining timing, locations and causes of mortality in GPS-tagged birds. LEAP is a multifaceted approach that integrates: (1) GPS tracking data, (2) evidence from the mortality location (site investigation), and (3) necropsy results to derive the mortality cause and a corresponding certainty score. By 12/02/2025 data of 3,185 tagged red kites from 16 European countries is currently available in the LIFE EUROKITE data base through data exchange with (cooperation-) partners of the project. GPS tracking of 2,346 red kites throughout their continental European range allowed detection of 979 mortality events between 2013 – 2022. For 624 adult and subadult birds with a conclusive mortality cause, anthropogenic-related mortality accounted for 69.1%. Among these causes, the most prevalent were poisoning, road collisions, collisions with or electrocution on power lines, illegal shooting/trapping, rail collisions, and collisions with wind turbines. Predation was the most common natural cause. We detected clear between-country differences in the probabilities of mortality causes, strengthening the need for effective conservation strategies throughout the species' range. Most importantly, these findings highlight the importance of coordinated monitoring among countries and jurisdictions to inform targeted policies and regulations aimed at protecting wildlife populations from ongoing threats associated with human activities. Additionally, we show the results of the investigation of confirmed collisions of Red Kites with wind turbines across Europe from 2017 to 2024. The analysis focused on exploring collision risk in relation to environmental and turbine-specific factors, by comparing circumstances during collisions and non-collision movement (of the studied individuals) in 500 m vicinity from wind turbines. These results emphasize that free space under rotor and rotor diameter play an important role in determining collision likelihood.

P099 – Do we need a more efficient turbine curtailment method for bats? - A comparison of acoustically recorded bat activity and actual turbine shutdowns

Mr Fabian Reichard[1], Mr Jannes Kreutzfeldt[1]*
[1] *PNE AG*
*Corresponding author.

Research motivations and objectives
The curtailment of onshore wind turbines (WT) to protect bats is a crucial step for species conservation. However, it often results in significant losses in electricity generation. Optimizing WT operations with demand-oriented curtailment strategies could reduce the land and resources needed. This approach is vital for meeting renewable energy expansion targets.The aim of this study is to analyze how often bats are actually present in the rotor area during shutdown periods. Furthermore, a first curtailment strategy based on real-time call activity to reduce energy losses will be evaluated. The data is based on several wind turbines located in Germany, each equipped with acoustic detectors in the nacelle, with annual energy losses up to 10% due to bat curtailments. Methodology The current weather-based method will shut down the WT as a precaution if certain temperature, wind speed and precipitation conditions are met, regardless of actual bat activity. As a result, the operation of WT is also stopped on nights with little or no bat activity. Using call and WT SCADA data, it is possible to determine whether bat calls were recorded during periods in which the turbine should have been stopped in accordance with the curtailment requirements. Based on these results, an initial real-time curtailment was tested, assuming a 60-minute stop following the first detected bat call. Summary of results The investigations revealed that during the curtailment period from March to October, bat calls were detected on only 33 to 46% of all nights. A closer look at hourly data highlights this even further: of approximately 1,390 real shutdown hours at a single turbine, around 1,260 hours showed no bat activity at all. This means that the shutdowns were probably unnecessary on approx. 90% of the nights. In some cases, the 60-minute real-time curtailment method was able to reduce the WT energy losses by four times or at least to under 2% of the annual energy production. Conclusion Our results show that the current curtailment strategy is not effectively tailored to actual bat activity, leading to unnecessary shutdowns and significant energy losses. While acoustic monitoring only covers a limited portion of the rotor and is therefore not fully comprehensive for a simplified 60-minute real-time curtailment method, the significant discrepancy between shutdown times and detected bat calls highlights a clear potential for optimization. In our view, this potential justifies further research into a new curtailment method.

P100 – Flight altitudes of migrating birds crossing future offshore wind energy facilities in the Mediterranean Sea

Dr Jocelyn Champagnon[1]*, Dr Paul Dufour[2], Mr Stéphan Tillo[1], Prof Frédéric Jiguet[3], Dr Olivier Duriez[4]
[1] Tour du Valat, research institute for the conservation of Mediterranean wetlands, [2] Tour du Valat, CEFE/CNRS, Swiss ornithological institute, [3] Muséum National d'Histoire Naturelle, [4] Centre of Evolutionary and Functional Ecology, Univ Montpellier, CNRS, EPHE, IRD, 1919 Route de Mende, 34293 Montpellier cedex 5, France
*Corresponding author.

For decades it has been unclear how migratory birds cross major ecological barriers such as seas. This lack of knowledge is problematic in the context of the large scale development of offshore wind projects planned for the coming decades, as it prevents proper assessment of the potential impact of these projects on migratory birds through the risk of collision. Thanks to the advancement and miniaturisation of tracking technologies, we studied the flight strategies used by terrestrial migratory birds of almost all sizes to cross the Mediterranean sea, at the crossroad between Europe and Africa. In the MigraLion project (2021-2025), we deployed 486 GPS and 327 multi-sensor (light, pressure, temperature, activity) loggers (hereafter named GLS) on 46 migratory species breeding along the Mediterranean coast of southern Europe. We used this data to study how migratory birds cope with crossing the Mediterranean during their migration, with a particular focus on altitude flight and potential interactions with future offshore wind farms. New GLS technology revealed previous unknown flight altitudes and their variations over the Mediterranean Sea for passerines, with contrasted altitude flight among species. For instance, 9 flights of Northern wheater *Oenanthe oenanthe* revealed that this species fly low above sea level. Other species like Western Yellow Wagtail *Moticilla flava* fly at a mean altitude of 1000 m above sea level but with large variations among individuals. In some cases, we observed a steep drop in altitude after a night flight. These prolonged flights at sea level are likely to be used for sampling and finding a suitable stopover site, but may increase the likelihood of collisions with future offshore wind turbines. The flight strategies of larger species revealed by GPS were also highly contrasted. Large waterbirds such as Greater Flamingo *Phoenicopterus roseus* or Eurasian spoonbill *Platalea leucorodia* generally flew below 200 m while waders like dotterel *Charadrius morinellus* or rollers *Coracias garrulus* flew over 500m. Some species such as lesser kestrels *Falco naumanni* adopt flexible flight height between 100 and 1000 m. No major migratory corridor could be identified. While still preliminary, these results highlight the large variation in flight strategies of landbirds crossing the Mediterranean in spring and autumn. A single and simple measure such as curtailment at specific periods cannot protect all species. A spatial planning of future offshore wind energy facilities at places where birds are most likely to fly above the rotors is necessary.

P101 – MIGRALION: a large research programme that provides key knowledge about avifauna migration and presence at sea in the Gulf of Lion (Mediterranean Sea, France) in the context of offshore wind energy development

Dr Yann Planque[1]*, Dr Cécile Bon[1], Ms Constance Audiffren[2], Dr Camille Assali[3], Dr Aurélien Besnard[4], Dr Coline Canonne[5], Mr Victor Cat[6], Dr Jocelyn Champagnon[7], Mr Théo Chateaugiron[7], Dr Nicolas Courbin[6], Mr Cyprien Daïdé[3], Mr Christophe Defranceschi[6], Mr Nicolas Delelis[3], Dr Sophie De Grissac[8], Mr Vincent Delcourt[3], Mr Léo Denoual[9], Mr Thomas Dragonnet[7], Dr Paul Dufour[10], Dr Olivier Duriez[6], Ms Marie Fretin[7], Ms Virginie Gailly[7], Dr David Grémillet[6], Ms Coralie Hermeloup[7], Mr Guy Herrouin[11], Mr Bastien Jeannin[7], Prof Frédéric Jiguet[12], Dr Valentin Lauret[5], Dr Florian Lecorps[3], Ms Jehanne Prévot[1], Dr Maud Quéroué[6], Ms Fanny Rey[7], Dr Sébastien Roques[6], Ms Jade Saez[11], Dr Baptiste Schmid[13], Mr Louis Schroll[6], Mr Stéphan Tillo[7]
[1] France Energies Marines, [2] Office Français de la Biodiversité (OFB), [3] Biotope, [4] CEFE, Univ Montpellier, CNRS, EPHE PSL University, IRD, Montpellier, France, [5] France Energies Marines & CEFE/CNRS, [6] Centre d'Ecologie Fonctionnelle et Evolutive (CEFE - CNRS), [7] Tour du Valat, research institute for the conservation of Mediterranean wetlands, [8] Muséum national d'Histoire naturelle (MNHN-CESCO), [9] Littoral Environnement et Sociétés (LIENSs), La Rochelle University - CNRS, [10] Tour du Valat & CEFE/CNRS, [11] Pôle Mer Méditerranée, Montpellier, [12] Muséum National d'Histoire Naturelle (MNHN), [13] Vogelwarte
*Corresponding author.

A large development of offshore wind projects is planned in the coming decades in France to achieve the objectives of low-carbon energy production, raising issues to consider and anticipate their impacts on the environment. The scientific community have identified important gaps of knowledge on bird migration and presence at sea in the Gulf of Lion (Mediterranean sea, France), while it is a major crossing point for avifauna migration in Europe. In this context, the MIGRALION research programme, launched by the French Biodiversity Agency (OFB; French government), was realised during the last four years (2021-2025) to fill these knowledge gaps on avifauna. Based on an extensive research collaboration, the MIGRALION programme acquired multi-source data from several complementary technologies deployed at the coast and at sea, and provides now unprecedent large-scale knowledge on: functional areas of seabirds, migratory bird fluxes and patterns, phenology of migratory events, preferential routes, as well as movements, behaviours and flight altitudes, at coast and at sea. Such information are crucial for species management and conservation, in a context of cumulative impacts on populations. They will ultimately guide policies and practices to help to better integrate avifauna issues in the development of human activities at sea, including the offshore wind energies, and to better mitigate the potential impacts of these activities on avifauna. We propose here to present the key results obtained during the MIGRALION programme, that ends in the Summer 2025, at the 8th Conference on Wind energy and Wildlife impacts, in Montpellier France, as they are of major interest for research and conservation issues about the potential impacts of offshore wind energy on avifauna. We propose to create and present a series of five cohesive scientific posters, focusing on:

- A general presentation of the MIGRALION programme (WP1 and WP2): context, prior knowledge, objectives, project structure (workpackages), partnerships, main results, how the results will be useful to the community, prospects;
- MIGRALION programme (WP3): main results obtained from bio-telemetry surveys performed on 3 marine bird species and 36 terrestrial migrating birds;
- MIGRALION programme (WP4): visual bird observational surveys from vessels completed by onboard radars and passive acoustic;

- MIGRALION programme (WP5): ornithological radar surveys from the coast;
- MIGRALION programme (WP6): cross-processing and innovative integrative modelling analyses of these multi-source data.

All of these five posters will be presented in a cohesive format, and are led by the co-authors of this abstract.

P101 – MIGRALION: Gulf of Lion Avifauna Migration Research

- **P101.1 – General presentation of MIGRALION**:

Authors: Dr Yann Planque (France Energies Marines), Ms Constance Audiffren, Dr Camille Assali, Dr Aurélien Besnard, Dr Cécile Bon, Dr Coline Canonne, Mr Victor Cat, Dr Jocelyn Champagnon, Mr Théo Chateaugiron, Dr Nicolas Courbin, Mr Cyprien Daïdé, Mr Christophe Defranceschi, Mr Nicolas Delelis, Dr Sophie De Grissac, Mr Vincent Delcourt, Mr Léo Denoual, Mr Thomas Dragonnet, Dr Paul Dufour, Dr Olivier Duriez, Ms Marie Fretin, Ms Virginie Gailly, Dr David Grémillet, Ms Coralie Hermeloup, Mr Guy Herrouin, Mr Bastien Jeannin, Prof Frédéric Jiguet, Dr Valentin Lauret, Dr Florian Lecorps, Mr Vincent Liébault, Ms Jehanne Prévot, Dr Maud Quéroué, Ms Fanny Rey, Dr Sébastien Roques, Ms Jade Saez, Dr Baptiste Schmid, Mr Louis Schroll, Mr Stéphan Tillo

- **P101.2 – Telemetry tracking**

Authors: Dr Jocelyn Champagnon (Tour du Valat), Dr Nicolas Courbin, Dr Paul Dufour, Mr Stéphan Tillo, Mr Léo Denoual, Dr David Grémillet, Prof Frédéric Jiguet, Dr Olivier Duriez

- **P101.3 – At-sea surveys by boat**

Authors: Dr Camille Assali (Biotope), Mr Vincent Delcourt, Mr Nicolas Delelis, Mr Vincent Liébault

- **P101.4 – Coastal bird radar**

Authors: Mr Vincent Delcourt (Biotope), Ms Hélène Schopper, Dr Baptiste Schmi, Mr Cyprien Daïdé

- **P101.5 – Combined analysis of data**

Authors: Dr Coline Canonne (France Energies Marines & CEFE-CNRS), Dr Maud Quéroué, Dr Sébastien Roques, Dr Valentin Lauret, Mr Louis Schroll, Mr Victor Cat, Dr Nicolas Courbin, Dr Yann Planque, Dr Jocelyn Champagnon, Dr Olivier Duriez, Dr Aurélien Besnard

P102 – Passive acoustic monitoring of underwater soundscape and marine mammals' occurrence at the operational Saint-Nazaire offshore wind farm

Dr Gaëtan Richard[1]*, Mr Elie Retailleau[1], Mr Romain Foucher[1], Dr Delphine Mathias[1], Mrs Nathalie Tertre[2]
[1] *Société d'Observation Multi-Modale de l'Environnement,* [2] *EDF Power Solutions, Nantes*
*Corresponding author.

The Saint-Nazaire offshore wind farm began operations in November 2022, becoming the first offshore wind farm on France's mainland coastline. The French Environment Code requires environmental monitoring to assess the project's effects on the environment, including underwater noise and marine mammals. Within this context, the present study describes the underwater soundscape of an operational wind farm by assessing wind turbines' acoustic footprint in the context of all other underwater noise components. Particular attention was given to biophony, specifically the acoustic detection of marine mammals. Acoustic recorders were deployed in the vicinity of the wind farm, with one placed 20 km away as a control station during the summer of 2023 and the winter of 2024. The acoustic signature of the operational wind farm was characterized through noise level estimation and spectral analysis at different distances. Cyclicity analyses were applied to sound levels in frequency bands specific to benthic fauna to describe potential biological activity. Additionally, we monitored acoustic detection of dolphins and porpoises (two species of interest in the area). These detections were obtained by processing the signals through PAMGUARD, followed by automatic classification. The acoustic behaviour of dolphins was assessed by analysing each presence event for the proportion of time spent producing whistles and "buzzes." The latter refers to a sound resulting from an increase in echolocation click rates, used by dolphins to resolve their target when approaching prey. Buzzes are generally considered a reliable proxy for feeding attempts. Preliminary results indicated that the wind turbines' acoustic signature is characterised between 10 and 250 Hz, and that its average footprint (i.e. sound above ambient noise within this frequency band) extended approximately 3 to 4.5 km. However, considering species audiograms, dolphins and porpoises cannot hear the wind turbines' sounds, whereas baleen whales and phocids could. Nevertheless, levels remain low enough to induce any response of behaviour (and so any risk of threshold shift) for these species. Furthermore, sound levels in the frequency bands associated with benthic activity were higher at night than during the day, with energy peaks occurring at dawn and dusk. Regarding dolphins and porpoises, the study revealed seasonal and spatial variations in their acoustic presence around the wind farm. For dolphins, the results indicated acoustic events with buzz production, suggesting potential feeding activity. These observations align with known species densities estimated from aerial survey data and with acoustic detections from previous environmental studies.

P103 – Quantifying Spatial and Temporal Impacts of Saint-Brieuc OWF Construction on Marine Birds: A Gradient-Based Modeling Approach

Mr Julien Ringelstein[1]*, Dr Yves Le Bras[1]
[1] *Biotope*
*Corresponding author.

This study examines how the construction of the Saint-Brieuc offshore wind farm affects marine bird populations, aiming to separate natural fluctuations in bird abundance from human-caused disturbances. Data were collected by Biotope on behalf of Ailes Marines through digital aerial surveys across 47 flights during a baseline period and three years of construction, creating a large and consistent dataset, compatible with "Before-After Gradient" (BAG) impact assessment standards. The BAG approach takes advantage of regularly spaced samples along a disturbance gradient extending from the source to beyond the likely impact area. It avoids the challenge associated to finding suitable control sites which are required in traditional Before-After Control-Impact (BACI) studies. This approach allows for a more continuous and spatially detailed understanding of environmental impacts and generally provides higher statistical power (Methratta, 2020). Adopting the BAG approach, we analyzed data for 16 bird species groups within a Bayesian framework, employing R-INLA (Lindgren & Rue, 2015), inlabru (Bachl et al., 2019), and stochastic partial differential equations (Lindgren, Rue & Lindström, 2011) to model spatial and temporal variations, with specific adjustments for interannual, seasonal, and survey-based fluctuations. We also included a time-decay component to assess how long disturbances persisted and accounted for potential biases from an avian influenza outbreak that affected certain species during construction. The bird density pattern along radial distance to the windfarms indicated small to no impact for most species. However, to account for the varying degree of matching between spatio-temporal distributions of birds and those of the construction activities, we constructed a "counterfactual" metric comparing bird abundance during construction with a hypothetical scenario without construction. Our results allow us to refine our understanding of the interactions between certain bird species and construction, such as the effects of attraction or repulsion. These insights contribute valuable knowledge for the ecological impact assessment of offshore wind developments, with implications for spatial planning and conservation management.

P104 – Using environmental DNA to assess fish and invertebrate communities around offshore windfarms

Dr James Robbins[1]*, Dr Edward Wort[2], Dr Nathan Geraldi[2], Dr Michelle Elliott[1]
[1] Natural Power, [2] NatureMetrics
*Corresponding author.

Offshore wind is an ideal proving ground for using environmental DNA (eDNA) as a cost effective and robust marine biodiversity assessment and monitoring tool. As governments strive for Net Zero, developers aim to deliver Marine Net Gain (MNG) and Net Inclusive Design (NID). These ambitions exist alongside significant time pressure to deliver gigawatts of green energy to national grids, hence require innovation throughout the supply chain. This study at Blyth offshore windfarm investigates the commercial use of eDNA around offshore renewable energy developments to provide ecological data required to establish baseline environments, monitor change, inform targeted mitigation measures and inform NID. Conventional trawls, grabs, and eDNA-based sampling methods were conducted in parallel, allowing for comparative analysis. Many taxa including, fish, marine mammals, seabirds and invertebrate species were identified in eDNA samples, providing data on multiple taxonomic groups in the same sample. All samples were analysed for species presence, relative abundance, diversity indices, and multivariate statistics were used to compare community composition between seasons and stations, to compare directly between methods. This study focuses on fish to present eDNA based methods as a valid alternative to conventional survey methods. eDNA consistently detected a greater number of fish species than trawl data (54 species detected by eDNA, compared to 26 species in trawls). The most abundant species identified were consistent between trawl and eDNA data. Diversity metrics were broadly similar between sampling methods. Seasonal and spatial patterns in species occurrence and community composition were similar, and broadly consistent with historic trends in seasonality. The eDNA sampling methodology allowed areas adjacent to turbines to be surveyed, not normally feasible using conventional methods. DNA of key species was detected at higher relative levels within the turbine area, supporting the hypothesis that the artificial habitat created by turbines provides shelter and food for fish. Data for invertebrates around the turbines has also been obtained, although analysis of these data are in preliminary stages. In summary, eDNA based monitoring appears to be a promising alternative or complementary technique for offshore wind biodiversity assessments. It is a non-invasive tool that can be collected by non-specialists, and from a wide range of vessel types. This increase in high quality biodiversity data can drive more informed management decisions such as NID and provide evidence of MNG at both a project and a regional level. eDNA has the potential to form a key part of the toolkit to measure success.

P105 – A new approach to Seaweed Aquaculture as a Biodiversity Solution for Offshore Wind Expansion

Prof Laura Robinson[1]*, Dr Hong Chin Ng[1], Mr Wave Crookes[1], Dr James Wood[2]
[1] SeaGrown, [2] Northern Shores Marine Consultancy
*Corresponding author.

The expansion of offshore wind energy is essential for meeting net-zero targets but poses significant challenges for marine biodiversity. In the North Sea, the increasing demand for space has led to a "spatial squeeze," intensifying competition among industries and heightening concerns over biodiversity loss. To balance renewable energy development with marine conservation, we need solutions that promote co-existence and actively enhance biodiversity. Seaweed aquaculture presents an opportunity to mitigate these challenges by delivering ecosystem services such as oxygenating seawater, removing excess nutrients, and providing habitat for marine life. Additionally, seaweed cultivation requires no freshwater, fertilizer, or land, offering a sustainable alternative to terrestrial biomass production while also supporting coastal economies through diversification for inshore fisheries. However, scaling seaweed aquaculture to maximize these benefits requires overcoming key challenges, including quantifying its ecological contributions, identifying potential unintended consequences, and integrating it into the complex operational needs of offshore wind. We have investigated these challenges using a novel modular system, Kelpedo. Designed to address existing limitations of seaweed farming, Kelpedo is flexible, is designed to be navigationally safe, can be maintained by fishing vessels to allow for co-existence, and can easily be removed during decommissioning. Kelpedo enhances habitat complexity and promotes biodiversity while fitting within the growing demands of offshore development. Observations over a year demonstrate its effectiveness. Notably, we have observed a 2.24-fold increase in seabird presence, with Kelpedo creating a recognized Kittiwake hotspot. Our biodiversity surveys identified more than 50 species, including invertebrates and macroalgae, with a marked rise in key prey species such as blue mussels—suggesting the potential for Kelpedo to host Ark Populations. These findings highlight the role of seaweed aquaculture as a nature-based solution for mitigating biodiversity loss in offshore wind farms. By integrating Kelpedo within offshore energy infrastructure, we can support conservation targets, enhance marine food webs, and provide a sustainable framework for co-existence between wind energy and marine ecosystems. Our work provides critical evidence to inform spatial planning and investment decisions that align with future conservation, economic, and social drivers.

P106 – Intelligent curtailment: how AI can solve the bat-wind energy dilemma

Mr Roger Rodriguez[1]*, Dr Virginia Iorio-Merlo[2], Dr James Robbins[2], Dr Gillian Vallejo[2]
[1] EchoSense LLC, [2] Natural Power
*Corresponding author.

As the demand for renewable energy grows, balancing the need for efficient wind energy production with bat conservation is becoming increasingly important. Artificial intelligence (AI) has been applied in ecology to understand complex patterns in wildlife occurrence, behavior, and biodiversity, as well as being explored to improve efficient operation of wind energy systems. Thus, AI can potentially transform smart curtailment systems, addressing the challenge of reducing bat fatalities while optimizing wind energy generation. To avoid detrimental impacts to bat populations, regulatory authorities have mandated measures, such as curtailment, to minimize bat fatalities. Conventional curtailment, which decreases turbine operation based on wind speed alone, has proven effective in reducing bat fatalities but comes at a significant cost in lost energy production. In contrast, smart curtailment technologies that use real-time data on both bat activity and weather conditions have shown promise in reducing bat fatalities with increased energy output. AI is rapidly proving to be a robust solution to many complex, contemporary problems including human-environment interactions. Thus, through the integration of AI, smart curtailment systems can be further refined, such as enabling bat risk prediction with real-time response to improve both conservation outcomes and energy efficiency. We propose a new paradigm referred to as 'intelligent curtailment,' that encompasses how these AI-driven technologies will shape the future of sustainable wind energy projects by addressing the bat-wind energy dilemma. In this presentation, we will discuss preliminary efforts and lay out a framework in how AI algorithms can be integrated with real-time smart curtailment technology.

P107 – A new approach to strategic planning of offshore wind – Example of Sunnanvind

Mr Jonas Sahlin[1]*, Mr Ralf Häggblom[2]
[1] WSP Sweden, [2] Gouvernment of Åland
*Corresponding author.

This talk will show a new approach to strategic planning of offshore wind that constitutes an innovative way to assure a sustainable development and resilient community. The approach also represents a solution to avoid the obstacles that have hampered offshore wind power developments in Nordic countries where long lead times, permitting uncertainties and profitability concerns have slowed down the investments.
The Government of Åland is currently producing a comprehensive municipal Master Plan that will form the basis for an allocation of one of the potentially largest offshore wind projects to date, named Sunnanvind. Using an innovative iterative process between planning and strategic environmental assessment (SEA), conditions for a sustainable development of the area are established in an early planning stage. These conditions include mitigation measures, no-go areas and development schedules in order to assure preservation of sensitive habitats and nearby protected areas such as Natura 2000 areas. Åland is an autonomous region of Finland located in the Baltic Sea between Finland and Sweden. Comprising 6,700 islands, the archipelago is home to 30,000 Ålanders who, despite their remote location, have a bold ambition for a carbon neutral future. The work with Sunnanvind began in August 2023 with a public hearing. Åland Government has since conducted comprehensive field- and desktop surveys in order to collect valuable input data for the SEA. This work has resulted in mitigation measures and an updated outline of the Plan's geographic footprint. This adopted methodology provides an opportunity to streamline the permitting process for potential developers by providing a guidance document upon which they can base their own impact assessments once the auction has been conducted. This in turn will significantly reduce the potential risks and uncertainties for developers considering participating in the auction, while social acceptability and a sustainable development is assured from an early planning phase. The Sunnanvind project is striving to find the sweet spot between environmental, economic and social issues connected to offshore wind power. With work progressing at pace, the Master Plan and the SEA will be presented to the Åland population in spring 2025 and a first auction could be held by the end of 2025, with a fully built wind park operational by the early 2030s, delivering clean energy for the next 50 years.

P108 – Assessing Bat Activity and Mortality Risks at Wind Farms in Turkey: Insights from Long-Term Monitoring

Ms Maha Salameh[1]*, Ms Melisa Bal[2], Mr Kerem Boyla[3]
[1] Phd student, [2] Project Manager, [3] KAB Ecology founder
*Corresponding author.

The rapid expansion of wind energy is crucial for reducing dependence on fossil fuels, yet its impact on wildlife, particularly bats, has become a growing concern. Wind turbines contribute to bat mortality through collisions and barotrauma, posing risks to local populations and ecosystem balance. Understanding bat activity patterns and their interaction with wind energy infrastructure is essential for developing effective conservation strategies. However, assessing risk levels remains challenging in many regions due to limited ecological studies and incomplete datasets. In Turkey, where wind energy development is accelerating, research on bat populations and their responses to wind farms is still in its early stages. KAB Ecology, a leading environmental consultancy, has conducted long-term studies across multiple wind farms, mainly in the Marmara and Aegean regions, to address this knowledge gap. Using acoustic monitoring, we recorded bat activity levels and applied the Bat Activity Index (BAI)—which quantifies bat calls per hour—to assess collision risks. Our analysis revealed seasonal variations in bat activity, with fluctuations influencing the likelihood of turbine-related fatalities. We categorized bat activity levels as low (<10 calls), medium/low (10–15 calls), medium/high (15–20 calls), and high (>20 calls) and found that activity in the project areas was predominantly medium to high, indicating an increased risk of mortality. Our findings, which are preliminary but provide valuable insights, suggest that implementing science-based mitigation measures, such as adjusting turbine cut-in speeds during peak bat activity, could significantly reduce mortality rates while maintaining energy efficiency. This research underscores the urgent need for standardized monitoring frameworks and ecological assessments to support evidence-based conservation strategies. As Turkey's wind energy sector continues to expand, integrating biodiversity considerations into planning and operation will be essential for balancing renewable energy development with bat conservation efforts.

P109 – Offshore Renewables Joint Industry Programme - results from key research projects

Mr Ivan Savitsky[1]*
[1] *Carbon Trust*
*Corresponding author.

The Offshore Renewable Joint Industry Programme (ORJIP) for Offshore Wind studies the impact of offshore wind farms in the marine environment, to reduce consenting risk for offshore wind farm developments and support increased capacity growth. ORJIP for Offshore Wind is a collaborative initiative that aims to fund research to improve our understanding of the effects of offshore wind on the marine environment and biodiversity. The programme pools resources from the private sector and public sector bodies to fund projects that provide empirical data to support consenting authorities in evaluating the environmental risk of offshore wind. Projects are prioritised and informed by the ORJIP Advisory Network that includes key stakeholders such as statutory nature conservation bodies, academics, non-governmental organisations and others. The conference presentation will focus on sharing results from ORJIP Stage II extension, which will all be completed by the time of CWW: - Modelling of kittiwake metapopulation dynamics – developing approaches to incorporate connectivity between colonies to inform accurate offshore wind assessments; - Closing the loop – feasibility study to determine a feedback approach for post-consent monitoring to reduce consenting risk in future assessments; - Assessing the extent and significance of uncertainty in offshore wind assessments – with recommendations for dealing with uncertainty appropriately; - Improving understanding of distributional change for relevant seabird species – with objectives to provide evidence-backed parameters for future assessments; - Benthic habitat changes post-construction of offshore wind: a strategic investigation – multi-site analysis of pre- and post-construction benthic data to understand offshore wind impacts; - Displacement in the non-breeding season – development of an individual-based model to be used in future assessments; - Prevalence of seabird species and collision events in offshore wind farms – harmonising data from seabird collision monitoring studies to draw new conclusions;- Apportioning seabirds seen-at-sea –an improved apportioning tool for offshore wind projects; - Quantification of mortality rates associated with displacement in the assessment process – provide more ecologically and geographically informed estimates of displacement-related mortality rates by species; - Range-dependent nature of impulsive noise (focusing on impacts on marine mammals); and- Integration of tracking and at-sea survey data (to further develop apportioning techniques for seabirds). In addition to sharing these project results, we may share updates on upcoming projects under the ORJIP OSW programme.

P110 – Wind4Birds: An interactive tool for optimising the dimensions of wind turbines and their distance to nest sites to mitigate bird collision risk

Dr Tonio Schaub[1]*, Dr Raymond Klaassen[2], Mrs Caroline De Zutter[3], Dr Alexandre Millon[1]
[1] *Aix-Marseille University,* [2] *University of Groningen,* [3] *ENGIE Lab CRIGEN*
*Corresponding author.

Wind energy development leads to an increased mortality of birds due to collisions with wind turbines, unless effective mitigation measures are put in place. Recent GPS-tracking studies have highlighted that the layout of wind farms may have important effects on the collision risk of different raptor species (Schaub et al. 2024, Schaub 2024). These results implied that by carefully selecting the dimensions of wind turbines (ground clearance, rotor diameter) and their locations with respect to the nest locations of birds, collision risk can be reduced considerably – potentially without compromising the energy production. To facilitate the informed selection of the wind farm layout, we are currently developing an interactive online tool based on the aforementioned studies entitled *Wind4Birds*. This freely accessible tool will allow project developers, environmental authorities and other stakeholders to compare the expected collision risk for a given target species among different scenarios. For each scenario, a collision risk index is calculated based on the widely applied Band Collision Risk Model. Regarding bird behaviour, the main input data for the calculations are 1) the birds' flight height distribution and 2) the relationship between the time spent in a given area and the distance from nest. For these aspects, the tool provides default matrices on six raptor species (Montagu's Harrier, Hen Harrier, Marsh Harrier, Common Buzzard, Red Kite and Short-toed Eagle) derived from an extensive GPS-tracking dataset (288 individuals from six European countries). The matrices comprise bootstrap replicates which are used to derive confidence intervals. Besides the six default species, users will have the possibility to apply *Wind4Birds* to other bird species by uploading their own data. The input parameters required from the users are ground clearance, rotor diameter, the number and the locations of wind turbines for each scenario, as well as the locations of (suspected) nest sites of the target species. Concerning technical turbine parameters such as power capacity and rotation speed, users may rely on default values based on the given rotor diameter. Besides the total collision risk, *Wind4Birds*allows to compare the collision risk per power capacity and optionally the collision risk per energy production among scenarios. We expect *Wind4Birds*to provide valuable insights for mitigating bird collision risk during the planning phase of new wind farms and repowering projects. The first version of the tool is expected to be operational in summer 2025.

P111 – Improving cumulative effects assessments for seabirds: benefits and challenges from developing a new cumulative effects framework for estimating impacts from offshore wind farms in the UK

Dr Kate R. Searle[1]*, Dr Adam Butler[2], Dr Deena Mobbs[1], Prof Francis Daunt[1]
[1] UK Centre for Ecology & Hydrology, [2] Bioinformatics and Statistics Scotland
*Corresponding author.

Research motivations and objectives Offshore wind farms (OWFs) may affect seabirds through collisions, displacement from habitat, and barriers to movement. A range of disparate research projects have developed methods for estimating these different effects and their population level impacts, often in isolation, or in a single season. However, there is a need to develop a framework for transparently and consistently assessing impacts of OWFs on seabirds across all seasons, over multiple years and at multiple population scales. Methodology We developed a framework for robust assessment of cumulative effects using a consistent and transparent approach for collation and analysis of best available data in the UK. This framework incorporates three key elements: a data library, holding the key knowledge, parameters and data that feed into assessment tools; a modelling platform used to run assessment tools; and a user interface that allows users to generate predicted impacts at a population level for cumulative assessments, with a clear audit trail to provide transparency and reproducibility. Summary of results We outline the benefits and challenges of developing and operationalising a comprehensive assessment tool for estimating cumulative impacts from OWFs on seabirds throughout their annual cycle. Benefits include improved consistency, transparency and stakeholder trust. Challenges involved a lack of strategic oversight for data availability and acquisition, and for reaching consensus on guidance across national boundaries. Conclusion The resulting Cumulative Effects Framework (CEF) delivers a step change in the consistency, transparency and auditability of estimating OWF impacts on seabirds in the UK context. It provides a new platform for strategic research on improving assessment methodologies, especially via end-to-end estimation of uncertainty.

P112 – Maximum Likelihood Estimators are ineffective for acoustic detection of rare bat species

Mr Donald Solick[1]*, Mr Bradley Hopp[1], Mr John Chenger[2], Mr Christian Newman[1]
[1] EPRI, [2] Bat Conservation & Managemnet
*Corresponding author.

Acoustic monitoring of bat echolocation calls is an important tool for determining presence of threatened and endangered bat species prior to construction of a wind energy facility. The U.S. Fish and Wildlife Service considers a species to be present if automated bat echolocation classification software ('autoclassifiers') calculates a significant Maximum Likelihood Estimate (MLE) from a night of recorded files. MLE calculation is influenced by the accuracy of an autoclassifier and by the relative abundance of other species recorded during a night, which suggests accurately determining acoustic presence might be challenging for rare species. We used known reference calls for nine northeastern US species to simulate survey nights that varied in absolute counts of target species and relative abundance of other recorded species to estimate the number of correctly classified files required by Kaleidoscope Pro and SonoBat software to establish acoustic presence for each species. We found that, in general, Kaleidoscope Pro required fewer files than SonoBat to establish presence for most species, and that the number of files required by both programs increased dramatically at lower relative abundance of the target species and when accuracy of the program was taken into account. For example, both programs likely require >25 high-quality calls of Indiana bats (a federally endangered species) or up to 75 low-quality calls to establish statistical acoustic presence of this species when it comprises 10% of the recordings, illustrating the challenge of acoustically detecting rare, acoustically ambiguous species at wind energy facilities.

P113 – A novel approach to bioacoustic monitoring of birds offshore

Mr James Spencer[1]*
[1] *Current Affiliation: Apem Ltd*
*Corresponding author.

This presentation introduces a novel bioacoustic approach for monitoring low-volume and unpredictably occurring bird species in offshore wind farm environments. Designed to address limitations in traditional data collection methods, such as Digital Aerial Surveys and boat-based observations, this approach focuses on species that migrate at night or in response to weather conditions that preclude conventional survey approaches. We outline the development of this methodology, integrating established Nocturnal Flight Call (nocmig) protocols from the UK with insights from tracking and radar studies on bird migration. The key challenge of species identification was addressed through leveraging global bird call reference libraries created by amateur ornithologists, by experienced field ornithologists and allying these with occurrence patterns at coastal migration hotspots. To ensure a robust yet cost-effective solution, sub-sampling was employed, which whilst high effort, ensured high quality data. The method was applied at multiple locations along the U.S. eastern seaboard, from Virginia to New Jersey, yielding significant findings, including seasonal occurrences of wintering and migratory seabirds and waterfowl, the first at-sea bioacoustic records of a seabird species singing away from its colony, and evidence of regular offshore habitat use by a range of species and groups on migration. The presentation also explores the identification process, limitations of the approach, and how advancements in Artificial Intelligence (AI) and machine learning may enhance future detection capabilities while introducing potential challenges. We conclude by discussing the practical applications of bioacoustic data in the context of offshore wind farm baseline development, particularly in areas with high volumes of migrant species not well characterised by traditional survey methods. This approach may offer a valuable tool for improving ecological understanding and informing responsible offshore wind development.

P114 – A technology-driven framework for reducing vessel strike risk to marine mammals: using a risk assessment planning tool and a thermal camera system for real-time detection

Ms Tara Stevens[1]*, Ms Mary Jo Barkaszi[1]
[1] *CSA Ocean Sciences*
*Corresponding author.

Vessel traffic poses a significant collision risk to marine mammals that can result in severe injury or mortality. This risk remains a persistent challenge for the recovery of endangered species like the North Atlantic right whale (E*ubalaena glacialis*). Offshore wind (OSW) energy development increases vessel activity during construction and operational periods in areas overlapping with marine mammal habitats. While mitigation measures are in place for OSW vessels and no documented strikes have been attributed to these activities, reducing vessel strike risk remains a priority for industry and regulatory agencies. Understanding the spatial and temporal risk of vessel strike aids in assessment, planning, regulation, and management. To enhance risk assessment and management, a model was developed to estimate the probability of vessel-whale encounters based on user-defined criteria. This model enables scenario development and comparative testing within an intuitive, spatially registered framework. Integrating this tool with emerging technologies offers a comprehensive strategy for minimizing and mitigating vessel strike risk. When integrated with machine learning, thermal cameras enhance real-time monitoring to detect and distinguish marine mammals from other objects. These systems can provide early warnings through automated alerts, enabling vessel operators to take proactive measures, such as slowing down or altering course, to prevent collisions. Unlike human observers, thermal cameras offer continuous surveillance, making them a reliable tool for minimizing vessel strikes, particularly in offshore wind energy areas with high marine mammal activity. A thermal camera system was prototyped and tested for vessel strike risk reduction. The system is designed to detect whale blows and other relevant objects (e.g., boats, buoys) in real time, enhancing situational awareness. The integration of advanced detection technologies with risk assessment models represents a multifaceted approach to protecting marine mammals while supporting the responsible growth of offshore wind energy.

P115 – Do adult birds keep a greater distance from turbines? White-tailed eagles case study

Ms Aleksandra Szurlej Kielańska[1]*, Dr Dariusz Górecki[2], Dr Lucyna Pilacka[3], Dr Jakub Glapan[4]
[1] Tactus, [2] TACTUS,, [3] Pracownia Przyrodnicza Pilacka, [4] Avian
*Corresponding author.

The dynamic development of wind energy requires the simultaneous implementation of effective systems minimizing the risk of collisions between birds and wind turbines. Data on collision avoidance behavior of big raptors with wind turbines is limited. Especially when it comes to the use of detection-reaction systems that enable taking actions like stopping the turbine.
We have analysed data from one wind farm located in north Poland, form breading season in 2023. We used data recorded by the system during operation: distance, altitue, size class of the birds, information about turbine curtailment, flight path, wideos and photos. We used data on the white-tailed eagle *Haaliaetus albicilla* marked by ornitohologist from video and photos recorded by the systems. All eagles were ageing. The toal numer of birds recorded by the system used in analyses was 318. In this numer there was 108 juvenile birda, 145 adult birds and 73 birds not recognized to the age. Only 3,1% of birds were detected in DCRS, but many birds were recorded in PCRS when using airspace near the turbine. All statisstical analyses were performer in R program. We found some rules of using the space buy juvenile and adult birds, and relations between distance and high of flight of juvenile and adult white tailed eagles. There is statistically significant differences in the minimum distance from the turbine between age groups. Young birds approach the turbine more than adult birds. The mean minimum distance from the turbine for adult birds was: 466 m, and 285 m for juvenile birds. Moreover there is a strong, statistically significant positive relationship between the minimum flight height and the minimum distance from the turbine. Birds flying at higher minimum altitudes maintain a greater minimum distance from the turbine and birds flying lower fly closer to the turbine, which may increase the risk of collision. Flight altitude looks like to be a key factor in how close birds approach the turbine. An increase in the minimum flight height by 1 meter is associated with an increase in the minimum distance from the turbine by an average of 1.3 meters. Further tests and analyzes are needed regarding the use of sound and light signals in different locations and for wind projects with different parameters of turbines.

P116 – Scientific partnership for the protection of wild pollinators within and around renewable energy projects

Mr Benoît Terrien[1]*, Ms Olivia Izquierdo[2], Ms Fanny Prigent[3], Ms Chloé Santin[1], Mr David Genoud[4]
[1] wpd onshore, [2] Noé association, [3] wpd solar, [4] Entomologist Expert
*Corresponding author.

The partnership between Noé and wpd aims to reconcile renewable energy development with biodiversity conservation by implementing and evaluating agro-environmental measures that benefit pollinators and other wildlife. This initiative aligns with Noé's mission to safeguard biodiversity through restoration, awareness, and systemic action, and wpd's commitment to Corporate Social Responsibility (CSR).
The partnership adopts a scientific methodology to assess the positive ecological effect of measures like "flowering fallows" near wind and within solar farms, leveraging a Before-After-Control-Impact (BACI) design. Data collection spans multiple years across diverse sites, focusing on metrics such as pollinator abundance and diversity. Early findings demonstrate the positive potential of tailored habitat restoration in enhancing pollinator populations while highlighting the need for site-specific adaptations. A key outcome objective is the development of replicable guidelines and potential certification schemes, facilitating broader adoption within the renewable energy sector. By integrating local ecosystems' needs with renewable energy projects, this partnership seeks to foster a sustainable coexistence between human energy demands and biodiversity conservation.
The partnership has provided early insights into the ecological benefits of habitat restoration near and within renewable energy sites. Initial studies across wind and solar farms focused on pollinator abundance and diversity, showing promising results for agro-environmental measures like "pollinator-friendly fallows".
At the Auzay wind farm, pollinator populations doubled from 2023 to 2024, with over 60 species recorded, demonstrating the value of these measures in resource-poor agricultural areas. The Clussais site revealed significant overall diversity with 74 species, reflecting the potential of the landscape context but also its limits with favorable but dispersed micro-habitats. The richness of certain control plots with fewer resources reflects the effort/resource ratio in the bee movement strategy. In contrast, the Chouy site highlighted challenges in stabilizing pollinator populations in degraded environments, emphasizing the need for adaptive management strategies.
The solar sites selected are sites with low levels of biodiversity (crops or quarries). These sites are currently in the initial inventory phase. The aim of introducing flower meadows on these sites is to achieve a gain in biodiversity.
Continuity of studies proved essential for capturing ecosystem dynamics, revealing that multi-year monitoring is necessary to accurately assess the impact of interventions. The BACI methodology employed provided robust data to guide improvements.
These findings validate the partnership's approach, demonstrating the potential for tailored ecological measures to reconcile renewable energy development with biodiversity conservation. They lay the groundwork for broader implementation and further scientific research.

P117 – SDOD devices: methodology to study the interaction between black storks and wind farms

Mr Marc Thauront[1]*, Ms Céline Kandel[1], Mr Emilien Weissenbacher[1]
[1] *Ecosphère*
*Corresponding author.

The Shut Down On Demand (SDOD) devices are primarily used to protect birds against collision with wind turbines. In addition, certain devices can collect large datasets that can be used to study the behaviour of a species surrounding the wind farm. One example of such a device is IdentiFlight, which was installed on two lines of four turbines in Haute-Marne (northeastern France, Boralex wind farm). In 2023 and 2024, more than 45,000 sightings of Black stork were recorded with timestamps and 3D positions in the sky. This species breeds in the surrounding large forest (± 5 km) but may change precise nesting location annually.
An Access database was created using this dataset and complementary information such as the sight decade, flight height category or distance to mast category. All the sightings have a corresponding photograph of the birds, facilitating the filtering of false positive datapoints (since Black storks may sometimes be mistaken for cranes or white storks).
Preliminary results indicate a high density of data points within the 500 m around the masts, a clear avoidance of the first 100 m, and a majority of high to extremely high flights. The presence of local forests may influence the distribution of the data. A few flights were recorded at dawn, while peak activity occurred at noon, and near to no flights were noticed in the evening.
The relationship between the Black stork and wind farms remains controversial, with differing point of views among stakeholders in Germany, Belgium, and France. A small number of birds have been equipped with GPS transmitters, although none are in the vicinity of wind farms. The SDOD devices may help complete this information gap by providing data from areas adjacent to wind farms.

P118 – Migration flight behaviour of Eurasian curlew and Eurasian oystercatcher in the North Sea reveals implications for interactions with offshore wind farms

Dr Chris Thaxter[1]*, Dr Philipp Schwemmer[2], Ms Ros Green[1], Dr Pierrick Bocher[3], Dr Gary Clewley[1], Dr Heinz Düttmann[4], Dr Jaanus Elts[5], Prof Thomas Fartmann[6], Prof Jérôme Fort[3], Prof Stefan Garthe[2], Prof Frédéric Jiguet[7], Dr Steffen Kämpfer[6], Dr Helmut Kruckenberg[8], Dr Riho Marja[9], Dr Markus Piha[10], Dr Rob Robinson[11], Dr Pierre Rousseau[12], Dr Sam Franks[11]
[1] British Trust for Ornithology, [2] Research and Technology Centre (FTZ), University of Kiel, [3] Littoral Environnement et Sociétés (LIENSs), La Rochelle University - CNRS, [4] Heinz Düttmann, [5] BirdLife Estonia, [6] Department of Biodiversity and Landscape Ecology, Osnabrück University, [7] Muséum National d'Histoire Naturelle, [8] Institute for Wetlands and Waterbird Research, [9] Birdlife Estonia / 'Lendület' Landscape and Conservation Ecology, Institute of Ecology and Botany, Centre for Ecological Research, [10] Natural Resources Institute Finland / Finnish Museum of Natural History, University of Helsinki, [11] British Trust for Ornithology / Wash Wader Research Group, [12] National Nature Reserve of Moëze-Oléron
*Corresponding author.

Research motivations and objectives: With the current installed global offshore wind power capacity of 64.3 GW expected to rise to 447 GW capacity by 2032, there is an ongoing need to assess of impacts of increased turbine numbers on migratory bird species. Fine-scale data of individual bird movements, particularly for migration, are essential to inform effective marine planning, but suitable data are often lacking.
Methodology: We tracked two species of near-threatened waterbird, Eurasian curlew (170 birds) and Eurasian oystercatcher (eight birds), on migration across the North Sea using GPS telemetry between 2014 and 2022, to assess spatio-temporal interactions with offshore wind farms. Using a general linear modelling Bayesian framework, we assessed key determinants of collision risk (flight height and ground speed) accounting for known biases in GPS altitude data through a measurement error model.
Summary of results: Migration was focused in the southern North Sea with peak intensity during the night. There was an indication that oystercatchers take a more northerly migration route than curlew, suggesting species-specific flyways. Our final results showed that overall mean flight height of curlew was 268 ± 491 m whereas oystercatcher flew slightly lower at 227 ± 661 m. Flight height was lowest for curlew heading west in autumn, driven by lower altitudes at night and by male curlew. Ground speeds were similar between species (curlew, 16.3 ± 5.3 m/s, oystercatcher, 16.4 ± 4.8 m/s). A slight decrease in curlew flight height was observed over wind speeds of 10 m/s, and positive relationship of altitude with tailwind. Consequently for curlew, the proportion of time at collision risk height was greatest for spring daytime migration (0.69, 0.64-0.82 Credible Intervals) over a range of typical rotor sweep zones for the region (22-252 m), and was progressively lower at greater wind speeds. This, coupled with a positive relationship of ground speed with tailwind speed, suggests potential for significant variation in collision risk over changing wind conditions. We recorded no effects of temperature or measures of visibility (precipitation and relative humidity).
Conclusion: This study has identified sensitive areas in the North Sea flyway and both intrinsic and extrinsic effects on collision risk that will (1) help inform spatial planning through positioning of new wind farms, (2) pave the way for developing mitigation measures for existing offshore wind farms such as adjusting cut-in speeds and (3) facilitate further collision risk modelling for further predictive assessment.

P119 – The Offshore Coalition for Energy and Nature – Mediterranean basin

Ms Manon Thiel[1]*
[1] *Renewables Grid Initiative*
*Corresponding author.

Mediterranean countries are moving at different paces in the development of offshore wind and grid infrastructure. While some Member States are advancing rapidly with ambitious targets, auctions, and projects, others are still navigating early planning stages, facing challenges such as limited maritime spatial planning, the lack of regulatory frameworks, and technological barriers. The Mediterranean Sea and adjacent Atlantic waters, in particular, is a biodiversity hotspot, home to numerous vulnerable marine species and ecosystems that require careful protection. Additionally, the region's unique socio-economic dynamics, including the reliance of local communities on fishing, tourism, and other maritime activities, make it imperative to ensure that offshore wind development is carried out in a way that considers and respects these interests.

To address these challenges and opportunities, the Renewables Grid Initiative established in 2023 the Offshore Coalition for Energy and Nature – Mediterranean basin (Med OCEaN), bringing together NGOs, wind industry representatives, and TSOs to promote a balanced approach to offshore wind and grid deployment in the Mediterranean and Atlantic regions alongside environmental protection.

Med OCEaN now includes 17 organisations working together to align climate and biodiversity goals. They collaborate to address, for instance, critical knowledge gaps on the environmental impacts of floating offshore wind energy and its supporting grid infrastructure, emphasising the need for scientific input to inform decision-making. By facilitating knowledge exchange between researchers, industry, and policymakers, Med OCEaN ensures that scientific insights translate effectively into policies. The coalition fosters dialogue, builds trust among stakeholders, and promote good practice solutions to ensure that offshore wind and grid expansion are both environmentally and socially sustainable.

Med OCEaN's collaborative efforts extend beyond its Membership, actively engaging with local communities, scientists, and policymakers at the national and European levels to ensure their perspectives and expertise shape the development process, safeguarding both biodiversity and livelihoods of the region. As a key partner for researchers, Med OCEaN provides opportunities for collaboration and knowledge co-creation, inviting the scientific community to engage in joint efforts to enhance understanding and develop best practices.

Through initiatives such as producing best practice recommendations, exploring ecological criteria for offshore wind auctions, and facilitating multi-stakeholder engagement, Med OCEaN are driving forward an integrated, nature-friendly vision for offshore wind development in the Mediterranean basin and adjacent Atlantic waters.

P120 – Functional diversity analysis: a robust method for monitoring benthic communities. A case study of the future offshore wind farm "Centre Manche 1 & 2" off the Bay of Seine

Mr Robin Van Paemelen[1]*, Prof Eric Thiebaut[2], Dr Jean-Philippe Pezy[1]
[1] Normandie Univ, UNICAEN, UNIROUEN, Laboratoire Morphodynamique Continentale et Côtière, CNRS UMR 6143 M2C, 24 rue des Tilleuls, 14000 Caen, France, [2] Sorbonne Université, CNRS, Station Biologique de Roscoff, UMR7144, Place Georges Teissier, 29680 Roscoff, France ; Sorbonne Université, CNRS, OSU STAMAR, 4 Place Jussieu, 75252 Paris cedex 05, France
*Corresponding author.

The development of marine renewable energies has grown significantly in recent years and must coexist with ecosystems already exposed to multiple disturbances. This is particularly true for the English Channel (EC), one of the most anthropized marine ecosystems in the world, subject to both numerous anthropogenic activities (*e.g.,* aggregate extraction, dredging, and trawling) and natural disturbances (*e.g.,* strong hydrodynamics, extreme events). These pressures, occurring within the context of climate change, are driving profound shifts in ecosystem structure and functioning, altering their resistance and resilience. Measuring the impact of human activities on marine ecosystems to develop effective management measures remains a critical challenge for ecologists.
Traditionally, the assessment of human impacts on ecosystems relies on species taxonomy. While informative, this approach does not fully capture the complexity of ecosystem functioning. In contrast, a functional diversity approach complements structural descriptions by focusing on the ecological roles of species. Biological Trait Analysis (BTA) is a powerful method to describe ecological functions by integrating species' morpho-anatomical, behavioral, and life-cycle characteristics. By quantifying functional diversity and the traits of benthic communities, this approach enables an evaluation of ecosystem resilience and resistance to change through functional redundancy. This study aims to demonstrate how functional diversity analysis can enhance structural descriptions of benthic communities, particularly in the context of environmental impact assessments of human activities on benthic communities' health, on the example of different coarse sediment habitats within the EC, where the future 'Centre Manche 1 & 2' offshore windfarms will be developed. To measure functional diversity, a focused set of traits was selected to minimize redundancy while providing a detailed understanding of the functioning of benthic systems. Specifically, only 'response' traits, which describe how organisms react to disturbances or environmental changes were considered to better assess the impacts of ongoing changes on habitat functioning. At local scale, changes in species diversity (*i.e.*, Species richness, Shannon index, and Pielou's evenness) will be compared to changes in functional diversity (*i.e.*, Functional richness, Functional divergence and Functional evenness). Likewise, at a larger scale, the spatio-temporal changes in community structure will be assessed according to both species and trait composition. Measures of functional diversity and redundancy will also provide insights into the resilience of these communities.

P121 – Ecowende: developing a wind farm in harmony with nature - lessons learned and look-ahead

Dr Marin Van Regteren[1]*, Ms Hermione Van Zutphen[1], Ms Pauline Roos[1], Dr Joost Brinkkemper[2], Ms Debby Barbe[3], Ms Sytske Van Den Akker[3]
[1] Ecowende, [2] WaterProof, [3] Waardenburg Ecology
*Corresponding author.

Hollandse Kust West (HKW) lot VI, situated 50km of the coast of the Netherlands in the North Sea, will be the first offshore wind farm with a focus on ecology – from design, construction and operation to research and knowledge sharing. As such, we find ourselves at the start of future wind farms a flourishing ecosystem with minimised impact on marine mammals, birds and bats, and a vibrant marine life. When the welcome speeches are being held for CWW 2025, Ecowende are setting sail for the first offshore construction works of the wind farm, with the rock dumping for the scour protection. During this presentation, we will share our lessons learned from the first two years of the project. From detailed design of our ecology commitments to integration of ecological measures into the technical delivery, to the preparations and execution of the baseline surveys, the project team went through a steep learning curve:

- bridge between disciplines: creating mutual understanding of ecological and technical principles between parties
- grasp the complexity of the ecological programme: developing feasible implementation plans for the ecological commitments
- integration of ecological measures in the wind farm: balancing learnings from ongoing research into the wind farm development
- keep the authorities abreast of our developments and learnings and therefore changes in the implementation of the programme

In parallel, a holistic approach to data collection and quality control was put in place to allow the research objectives being met. The wind farm will be operational end 2026: over the next 18 months, the wind farm monopiles and tower will be installed and commissioned, in combination with the mitigation measures and ecological sensors.

P122 – The real and unreal correlation between wind turbines and wildfires – Lessons from Greece

Mr Andreas Vlamakis[1]*, Mrs Ioanna Eleftheriou[2], Mrs Sevie Dima[3]
[1] Andreas Vlamakis, [2] Environmentalist, ENTEKA SA, [3] Physicist, ENTEKA SA
*Corresponding author.

The climate crisis has taken a toll on the Mediterranean ecosystems. The increased frequency and severity of wildfires is one characteristic example. In Greece the case is not different. Indicatively, in the summer of 2023 Greece suffered the most severe wildfire in Europe, almost 100.000 ha were burnt in one incident in northeastern Greece. The last decade increased irrational voices put the blame on the wind turbines for the increasing number of wildfires, with numerous cases of fake news spread on social media and press. The objectives of the present study are twofold: A) to investigate the above argument. For this reason, a GIS analysis was elaborated using:

- Data for all wind farms installed in Greece by the end of 2024 (locations, power, year of installation etc.)
- Copernicus data (polygons) with all the wildfires occurred in Greece from 1.1.2008
- Forestrial maps for all regional units of the country with specific polygons for burnt areas (even before 2008) which are characterized as “reforestable” areas according to the Greek legislation.

The analysis brings robust evidence that there is no correlation between the installation of a wind station and wildfire in a specific area. The total number of wind stations installed in reforested areas – whether they were installed before the fire or at some point after it – occupies less than 0.06% of these areas. B) to investigate what are the changes the installation of a wind station brings to the environment and if they play a positive or negative role if a wildfire occurs in the broader area. For this task, a GIS analysis is elaborated to explore issues such as the type of areas the wind stations are installed (distributed according to corine land cover), land footprint of such facilities, road works opened to give access to wind turbine locations and the fire protection they can have. Lastly, the importance of the obligation, as derived by the corresponding legislation, to reforestate area of equal size or to execute reforestations works is discussed.

P123 – Wind turbines displace bats from drinking sites

Prof Christian Voigt[1]*, Dr Carolin Scholz[1]
[1] *Leibniz Institute for Zoo and Wildlife Research*
*Corresponding author.

Bats depend on water for drinking and foraging, but the increasing number of wind turbines may pose a problem for bats, as operating wind turbines are known to displace bats over long distances. We asked whether turbines displace bats from critical habitats, namely small ponds where bats drink and forage. We recorded the acoustic activity and foraging activity of three functional guilds of bats, i.e. open space, edge space and narrow space foraging bats, using automated detectors at 59 ponds located at varying distances (~50 to 5000 m) from wind turbines. We observed that edge space foraging bats were most abundant at focal ponds compared to narrow and open space foraging bats. The overall acoustic activity of open and narrow space foraging bats decreased with decreasing distance to wind turbines, whereas the activity of edge space foraging bats was unaffected by wind turbines. The foraging activity of bats at focal ponds decreased for open space foraging bats in proximity to wind turbines. For narrow space foraging bats, we observed a trend towards reduced foraging activity at ponds close to wind turbines, whereas we did not observe any effect of wind turbines on the foraging activity of edge space foraging bats. The siting of wind turbines close to drinking sites may degrade the resource landscape for bats, which could lead to population declines. Avoiding the proximity of turbines to important bat habitats is essential to protect biodiversity on farmland.

P124 – Assessing the impact of offshore wind energy on marine migratory species: a systematic review of evidence and knowledge gaps

Ms Rowana Walton[1]*, Ms Stacey Baggaley[1], Ms Grace Chandler[1], Ms Giulia Costa-Domingo[2], Dr Adele Dixon[1], Dr Sebastian Dunnett[1], Ms Aime Rankin[1]
[1] *UNEP-WCMC,* [2] *IUCN Centre for Mediterranean Cooperation*
*Corresponding author.

Offshore wind energy development is expanding rapidly worldwide, yet its impacts on marine migratory species remain poorly understood (Piggott et al., 2021). The movement and migratory routes of these highly mobile species can be impacted by this infrastructure (Bishop et al., 2017), yet reviews to date have focussed on the impacts to migratory seabirds (Piggott et al. 2021). This systematic review evaluates existing research on the impacts of offshore wind farms on marine migratory species, excluding seabirds. Of the 597 publications identified, a total of 68 publications and grey literature reports were analyzed, extracting data on focal species, geographical location, lifecycle stage, impact type, impact pressure and response. Our results revealed a geographical bias, with most studies in the North Sea and Baltic Sea. The harbour porpoise (n=34; *Phocoena phocoena*) was the most commonly studied species, with the harbour seal (n=9; *Phoca vitulina*), grey seal (n=6; Halichoerus grypus) and cod (n=6; *Gadus morhua*) following. There were more negative (52%) than positive responses documented, with avoidance behaviours (n=24) the most commonly recorded negative response. Pile driving during construction was the most frequently studied pressure, with documented negative responses such as avoidance behavior and hearing loss. Conversely, a small number of studies (29%) reported positive responses, such as new habitat provision and increased species abundance. Significant knowledge gaps were identified with many migratory species including crustacea, cephalopods, cartilaginous fish, and marine turtles, largely unstudied. Most studies focussed on the construction and operation phases of offshore wind developments, with little research on pre-construction and decommissioning impacts. Regions where there is expected growth in the offshore wind sector, such as China and North America, were also underrepresented in the literature. Additionally, only one study looked at the impacts of floating offshore wind farms, a technology expected to play a major role in future energy generation. As offshore wind developments expand into new areas, it is crucial to address these knowledge gaps. Future research should focus on underrepresented species and regions, as well as the long-term and cumulative effects of offshore wind energy. Effective mitigation strategies, improved regulatory frameworks, and enhanced collaboration across sectors will be key to ensuring that offshore wind contributes positively to both climate change mitigation and biodiversity conservation.

P125 – Validating collision risk modelling for Whooper Swan at offshore wind farms: overcoming practical difficulties in detecting avoidance

Mr Robin Ward[1]*, Dr Larry Griffin[2], Mr Richard Green[3], Mr Mike Armitage[4]
[1] NIRAS, [2] Wildfowl and Wetlands Trust, [3] Ørsted, [4] ScottishPower Renewables
*Corresponding author.

Deployment of a multiple sensor monitoring system at an offshore wind farm, would have a low probability of recording tracks attributable with certainty to migrating Whooper Swan. This presentation will describe the results from the latest advancement in miniaturisation of GPS technology to overcome the practical difficulties that have until now existed in validating collision risk modelling for Whooper Swan at offshore wind farms, post-construction. GPS/GSM collars were deployed to twenty female Whooper Swans that transit the Irish Sea surrounding the west coast Cumbrian Offshore Wind Farms. All collars functioned as per their technical specifications when each bird was transiting on migration on one or more occasions. At this time, 97% of GPS fixes were spaced at 1 second intervals. No GPS/GSM collared birds flew into the footprint of any of the west coast Cumbrian Offshore Wind Farms during the study, the final results of which this presentation will present. The nearest any of the 20 birds came to an offshore wind farm off the Cumbrian west coast was 140 m. No macro-avoidance response was shown by birds that could be attributed to the west coast Cumbrian Offshore Wind Farms when passing over sea at a distance of 6 km or greater from the nearest turbines during autumn and spring migrations, with two possible exceptions. The two exceptions were birds that showed what was suggestive of pre-emptive changes in trajectory at a distance of between 13 - 15 km from the west coast Cumbrian Offshore Wind Farms when approaching over sea. When considering all 20 birds, 15 of 23 tracks within 6 km of the wind farms were interpreted as showing behaviour indicative of macro-avoidance. The study successfully demonstrated a macro-avoidance of operational offshore wind farms by Whooper Swan transiting the Irish sea, and thus confirming a low risk of collision with operational turbines.

P126 – Spatiotemporal patterns in sex ratios of bat fatalities at wind energy facilities in the United States

Dr Sara Weaver[1]*, Dr Amanda Hale[2], Dr David Nelson[3], Dr Sarah Fritts[4], Dr Todd Katzner[5], Mr Austin Chipps[6], Dr Jennifer Korstian[7], Ms Sarah Licari[2], Dr Juliet Nagel[2], Dr Dean Williams[8]
[1] Bowman Consulting, [2] Western EcoSystems Technology, Inc. (WEST), [3] Appalachian Laboratory, University of Maryland Center for Environmental Science, [4] Texas State University, [5] U.S. Geological Survey, Forest and Rangeland Ecosystem Science Center, [6] Department of Biology, Louisiana State University, [7] TetraTech, [8] Texas Christian University
*Corresponding author.

A challenge facing bat conservation and wind energy development is how to maximize renewable energy production while minimizing impacts to bat populations. Reproductive-aged females are particularly important to dynamics and stability of bat populations due to their life history characteristics, but morphological sex identification methods have resulted in inaccurate reporting of sex ratios of fatalities at wind energy facilities. Our goal was to assess overall species-specific sex ratios of fatalities, and how those ratios varied by time and location. We used molecular techniques to determine the sex of 4,445 carcasses of Brazilian free-tailed (*Tadarida brasiliensis*), evening (*Nycticeius humeralis*), hoary (*Lasiurus cinereus*), eastern red (*Lasiurus borealis*), northern yellow (*Lasiurus intermedius*), silver-haired (*Lasionycteris noctivagans*), and southern yellow (*Lasiurus ega*) bats found during turbine searches at 20 wind energy facilities in ten states in the United States between 2009 and 2022. Species composition and number of years of data varied by site. Overall, there were more fatalities of females than males for silver-haired and southern yellow bats, but not the other species. Brazilian free-tailed bat sex ratios were female skewed in late summer, whereas female skew occurred during portions of spring and summer/fall for eastern red bats, hoary, and silver-haired bats, and in spring and late fall for evening bats. In addition, spatial patterns in sex ratios existed for eastern red and hoary bats. The observed spatial and temporal patterns of fatalities can help target fatality reductions strategies to locations and times of year that maximize the conservation benefit of those actions.

P127 – New camera technology indicates low collision risk of nocturnal bird migration at wind turbines

Dr Jorg Welcker[1]*, Dr Jannis Liedtke[1]
[1] *BioConsult SH*
*Corresponding author.

Nocturnally migrating birds are often thought to be vulnerable to collisions with wind turbines, particularly in offshore areas. It is hypothesized that collision risk increases with increasing migration activity, peaking during nights with highest flux rates. Thus, currently discussed mitigation measures aiming at reducing collision risk of nocturnal migrants target nights with high migration intensity. In a pilot study at a nearshore wind farm in northern Germany we applied novel AI-based camera technology to test this hypothesis. During the course of three bird migration periods, we determined avoidance rates and collision risk of nocturnal migrants by comparing the number of bird transits through the rotor zone recorded by the camera system with the overall flight activity within the wind farm assessed by specialized bird radar. These data were then correlated with the actual number of collisions determined by extensive fatality searches. Preliminary results indicate that nocturnally migrating birds exhibit very high avoidance rates of >0.99. The occurrence of rotor passages was largely independent of overall migration intensity at rotor height. However, bird flight activity in the rotor area was substantially increased when rotation speed of turbines was low. In addition, collision victims found during the main bird migration seasons did not contain species known to constitute the bulk of nocturnal migration at the study site. The results of our study suggest that birds migrating at night are able to perceive rotating wind turbines in time to circumvent collisions effectively. Particularly during nights with high migration activity, which usually occur during favourable weather conditions, avoidance behaviour seems high resulting in low collision risk. Consequently, mitigation measures implementing turbine curtailment based on flux rates may prove ineffective.

P128 – Refining the Estimation of Avian Movement Patterns to Improve Offshore Collision Risk Predictions

Dr Michael Wethington[1]*, Dr Evan Adams[1], Mr Andrew Gilbert[1], Dr Holly Goyert[1], Mx Julia Gulka[1], Dr Julia Stepanuk[1], Dr Kate Williams[1]
[1] *Biodiversity Research Institute*
*Corresponding author.

In the context of offshore wind energy development, collision risk models are a key tool for estimating how frequently birds may encounter turbines. In the United States, a publicly accessible model called the Stochastic Collision Risk Assessment for Movement (SCRAM) was introduced in 2022 to evaluate collision risk for three species protected under the U.S. Endangered Species Act: the Red Knot (*Calidris canutus*), Piping Plover (*Charadrius melodus*), and Roseate Tern (*Sterna dougallii*). Traditional approaches to collision risk modeling rely heavily on observational surveys, which are largely unsuitable for capturing offshore movements of these focal species. SCRAM addresses this challenge by integrating automated telemetry data to track occupancy and passage rates across the U.S. Atlantic Outer Continental Shelf, thereby helping researchers and managers better understand potential risks. Recent updates to SCRAM incorporate new tracking technologies and refine the model's framework, improving computational efficiency and reducing uncertainty in collision risk estimates. Satellite-based data broaden coverage for Red Knots, while an updated flight height model, based on GPS altitudes, shows that tagged birds often fly at lower elevations than previously assumed. SCRAM also now uses revised avoidance rates and population estimates from recent research and U.S. Fish and Wildlife Service figures, providing more accurate inputs for collision assessments. Looking ahead, a multi-state movement model is under development to capture different behavioral modes, and further improvements to flight height estimates will draw on new datasets and international collaborations. These planned enhancements will continue to sharpen risk projections and inform decision making for offshore wind energy development.

P129 – Developing and evaluating a smart curtailment strategy for bats integrated with a wind turbine manufacturer platform

Mr Michael D. Whitby[1], Ms Isabel Gottlieb[2]*, Dr Carl Donovan[3], Dr Leslie New[4], Dr Taber Allison[2]
[1] Bat Conservation International, [2] Renewable Energy Wildlife Institute, [3] DMP Stats, [4] Ursinus College
*Corresponding author.

Cumulative impacts of bat fatalities at wind energy facilities are a major conservation concern in North America. A leading strategy to minimize bat fatalities is to curtail turbines when bats are at the highest risk of collision: often during the fall migration season (approximately July through October), at night, and in low wind speeds (e.g., below 5.0 m/s; commonly referred to as "blanket curtailment"). We developed a bat fatality risk model using empirical bat fatality, bat activity, temporal, and environmental data, which then informed curtailment rules for the Vestas Bat Protection System (VBPS): a novel "smart" curtailment strategy with the goal of reducing bat fatalities without further increasing the loss of power production compared to blanket curtailment. The model selected varied its parameters by month, including the curtailment window (portion of the night), cut-in speed, and wind direction. We evaluated the performance of the VBPS smart curtailment in comparison to blanket curtailment and control turbines by comparing observed bat fatality rates and power production data between treatments using generalized linear and additive mixed models. Implementation of the model was partially automated (time and wind speed), and partially manually (wind direction) due to delays in the finalization of capabilities of the curtailment software, which led to the refinement of the model to VBPS-surrogate rules which were implemented based on nightly forecasted wind directions. Both curtailment treatments resulted in fewer bat fatalities and less power production compared to control turbines, but there was not a significant difference in performance between VBPS-surrogate and blanket curtailment treatments. The VBPS-surrogate treatment resulted in a 36.3% reduction in bat fatalities compared to control turbines, and a 7.1% reduction in power production during the curtailment periods (i.e. nighttime hours during the study period), or an estimated 0.75% reduction in Annual Energy Production. VBPS-implemented smart curtailment shows promise as a conservation tool; future studies should evaluate VBPS using fully automated curtailment based on wind direction and should include precipitation as an added covariate to potentially improve VBPS's value as a conservation tool.

P130 – The benefits of national Strategic Environmental and Social Assessment to support wind energy development

Mr Peter Wright[1]*
[1] *ERM Ltd*
*Corresponding author.

Research Motivations and Objectives This paper explores the value of Strategic Environmental and Social Assessments (SESAs) as a tool for companies and governments to strengthen sustainable wind energy development and resolve conflicts with biodiversity. Based on previous experience of conducting SESAs, desk-based research and interviews with practitioners, this paper weighs the relative merits of the exercise. It then asserts that while SESAs can be resource-intensive and require complex stakeholder coordination, they are extremely useful for companies, lenders, and governments to navigate environmental, social, political and regulatory spaces for renewable energy development. By engaging in a robust research process that includes understanding environmentally sensitivities, SESAs consolidate information into a centralised platform in a manner that integrates various national, regional, and local perspectives. The paper concludes by offering recommendations to maximise the value that SESAs can provide in resolving conflicts between biodiversity and sustainable wind power development. Methodology This research was informed by a comprehensive review of publicly available SESAs for renewable energy projects globally. It also incorporated insights from ERM's subject matter experts (and previous deliverers of SESAs) and included interviews with relevant stakeholders to evaluate the impact and potential challenges associated with conducting a SESA. Results This paper identifies several limitations to the practical value of SESAs, including: Resource intensity: SESAs require significant time, expertise, and financial resources to conduct. Political dependence: The effectiveness of SESAs relies heavily on government support and commitment. Complex stakeholder coordination: Successful implementation of SESAs demand an alignment and coordination among diverse stakeholders, which can be challenging. Risk of reductive analysis: by reducing complex dynamics to a single output, SESAs may become one-dimensional, making them less influential in overall decision making. Despite their limitations, SESAs remain an effective tool for identifying nation-wide risks and opportunities within the renewable energy sector. Conclusions For companies, SESAs serve as an effective instrument in securing early stakeholder buy-in. As a publicly available document, SESAs play a key role in fostering alignment by delivering a comprehensive overview of optimal operational areas and outlining necessary mitigation measures. This strategic approach lays a strong foundation for collaboration between the private sector and government entities, ensuring that environmental and social impacts are managed responsibly from the outset and supporting the long-term success of wind energy projects. Additionally, SESAs provide a foundation for developing and appraising investment projects, offer insights for future investors on project conditions, and identify potential challenges in wind energy development.

P131 – Gridlock – Biodiversity Challenges of Grid Expansion to Meet Wind Generation Targets. Case Studies in Developed and Developing Countries

Mr Peter Wright[1]*
[1] *ERM*
*Corresponding author.

Research Motivations and Objectives: The UN Climate Change Conference in Baku, COP29's included a call to reach USD 700 billion in grid infrastructure investments by 2030 and add or upgrade over 25 million kilometres of transmission and distribution lines by 2030 to meet the Paris Agreement goals on renewable energy development. This scale of grid development has the potential to significantly impact biodiversity, particularly on birds and disproportionately on particular groups of birds which are susceptible to collision or electrocution from overhead power lines. This paper sets out the challenges of large-scale grid development with two contrasting case studies, in Scotland and in Uzbekistan to highlight different approaches to considering wind power -related grid development. Methodology: The paper compares two approaches to grid development. The first approach in Scotland is of centrally planned grid expansion which multiple wind developments will connect to. The approach to development involves a collaborative consultative staged approach developed by a grid operator to identify sequentially more refined, corridors, routes and then alignments based on environmental and social constraints mapping and regular stakeholder consultation. The second approach is from Uzbekistan where individual large wind power projects are developed alongside their own export infrastructure. This approach to project design is less transparent and consultative and appears to present greater potential impacts to biodiversity. Results: The results draw on the direct experience of the authors in reviewing and authoring different approaches to grid infrastructure development. The review suggests that a staged, consultative approach provides more opportunity for key sensitivities to be identified and more sustainable alternatives to be proposed. By 'showing your working' authorities can demonstrate the mitigation hierarchy has been followed and conflicts between development and biodiversity have been addressed. However, such an approach is resource intensive, and there is a cost for government and stakeholders (NGOs, scientists) to contribute in terms of time and expertise that may not be available in developing countries. Conclusions: Best practice suggests that a staged, informed and collaborative approach to developing the required grid expansion to support large scale wind power generation is required to avoid significant biodiversity impacts. As there is an up-front cost to this work, it may be a challenge for developing countries to implement such an approach. However the potential impacts to biodiversity from badly planned grid infrastructure should be recognized and additional support be provided to governments and industry to help implement best practice approaches.

P133 – Twenty years monitoring of birds in a territory before and after construction of wind turbines

Prof Pavel Zehtindjiev[1]*, Mr Nikolay Yordanov[1]
[1] *Institute of Biodiversity and Ecosystem Research Bulgarian Academy of Sciences*
*Corresponding author.

The territory, subject of twenty years consistent monitoring is located in the region with the highest wind potential and respectively represents the main wind power production of Bulgaria. This area also is of significant bird importance. We present monitoring results in breeding, migratory and wintering periods before and after construction of 114 wind turbines. The data after 42268 systematic carcass searches under operational wind turbines revealed seasonal variations in number of collisions and species of birds found. The searches efficiency and scavenging rate experiments as well as all methodological details of the long term monitoring are published already in number of reports available on websites https://www.aesgeoenergy.com/Studies.html and https://kaliakrabirdmonitoring.eu/ . These results are valuable for the international research community and need larger dissemination for objective evaluation of the wind farm bird interaction. There are fluctuations of the numbers of breeding bird species through the wind farm, but they do not differ from the control territory outside the farm with no evidence of adverse effect on the breeding bird community. The numbers of species passing through the territory in autumn varied by year with no trend for a decrease after construction of the wind turbines. The absolute number of observed birds fluctuated by year with no trend for a decrease after construction of wind farms. The altitude of flight varied by years with no overall trend for an increase after construction of wind farms. There is no evidence for change in migratory direction (macro-avoidance or displacement). At a gross scale, birds did not demonstrate macro-avoidance of the turbines that could be considered as a change of migratory direction and, thereby, a change of migratory route. 65 bird species have been recognized as collision victims. 55 species have less than 1 collision per year in 14 years. Collision rate vary significantly by year, season and habitats. Collision rate vary by year between 0,1 and 0,7 with an average of 0,46 birds/per turbine. Larks, starlings, gulls, buntings, shrikes, common buzzards and common swifts have over 1 collision per year. Most collisions are registered in periods of migration in contrast to low collision rate in breeding and wintering periods. The most sensitive habitat for collisions is natural grasslands with 41% of total collisions followed by vineyards and non-irrigated agricultural fields with 36% and 23% respectively. Long term monitoring results presented allowed objective evaluation in respect to natural fluctuations in bird numbers and added mortality.

P134 – The Spatial Effect of Wind Energy: Assessing Overlaps with Norwegian Nature, Wildlife, and Recreation Areas

Dr Beate Zein[1]*, Dr Brett Sandercock[1]
[1] *Norwegian Institute for Nature Research*
*Corresponding author.

A rapid expansion of renewable energy requires larger amounts of land area annually. While a green transition is important to reduce greenhouse gas emissions, developing renewables can create challenges as they compete for space with natural areas. A large-scale analysis can compare different renewable energy types and projects and can identify which natural areas are mostly affected, which is particularly important when it comes to areas with high ecological and social values. In this study, we quantified the spatial overlap of planned and operational windfarms in Norway with important key ecological areas and recreation areas. For this we calculated footprint areas based on turbine locations and land use. Additionally, we performed analysis for solar and hydropower developments and compared the renewable energy types. Our findings show that wind energy developments in Norway have a large overlap with undisturbed nature areas, increasing habitat fragmentation of the Norwegian landscape. Additionally, onshore wind projects overlap with hotspot areas for endangered insects, arachnids, fungi, lichens and mosses and red listed species. We also detected a large overlap of windfarms with Sami reindeer areas and important outdoor recreation areas. Hydropower is generating by far the largest amounts of renewable energy in Norway, yet it impacts Sami reindeer areas and undisturbed nature areas less than wind power developments. However, hydropower plants affect twice as much hotspot areas for endangered insects, arachnids, fungi, lichens and mosses. Solar power plants are very recent in Norway and contribute the least amount of renewable energy in Norway to date. However, they have the largest overlap with hotspot areas, which is as much as the overlap areas of wind and hydro power developments combined. Large scale spatial analysis can benefit strategic decision-making and optimise the spatial planning for different types of renewable energy developments.

P135 – The U.S. Wildlife and Offshore Wind Project: Integrating empirical observations with risk assessment frameworks

Prof Douglas Nowacek[1]*, Dr Evan Adams[2], Dr Marianna Fuentes[3], Dr Frants Jensen[4], Prof Pat Halpin[1], Dr Joseph Haxel[5], Dr Josh Kohut[6], Dr T Aran Mooney[7], Prof Susan Parks[8], Dr Jessica Redfern[9], Dr Aaron Rice[10], Dr Howard Rosenbaum[11], Dr Brandon Southall[12], Prof Len Thomas[13], Dr Lesley Thorne[14], Dr Kate Williams[2]
[1] Duke University, [2] Biodiversity Research Institute, [3] Florida State University, [4] Aarhus University, [5] Pacific Northwest National Laboratory, [6] Rutgers University School of Environmental and Biological Sciences, [7] Woods Hole Oceanographic Institution, [8] Syracuse University, [9] New England Aquarium, [10] Cornell Lab of Ornithology, [11] Wildlife Conservation Society, [12] Southall Environmental Associates Inc, [13] CREEM, University of St Andrews, [14] Stony Brook University
*Corresponding author.

Offshore wind (OSW) is an emerging industry in the United States, with several recently constructed windfarms already delivering energy and other forthcoming projects along the east and west coasts. Amid this rapid development, there has been significant investment in research to document baselines and potential impacts for wildlife in wind energy lease areas (WEAs). Multiple data gaps still exist on multiple scales, and such data are essential to allow decision-making while minimizing risk. Working with developers, state and local governments, and non-governmental groups, the Wildlife and Offshore Wind project (WOW) is constructing risk assessment frameworks and conducting field studies at the site-specific scale with an eye to regional scale application in the US. Informed by similar studies in Europe, UK, and Asia, we seek to address data gaps and contribute to our research and risk assessment framework development. Our research focus is on baleen whales (right, fin, humpback, and minke), sea birds (great black-baked gulls, northern gannets, red-throated loons), and several bat species; we are using a combination of methods including: aerial surveys, tagging (cetaceans and birds), biopsy and blow sampling, and extensive acoustic sampling. There exists precious little data on the impacts of pile driving on baleen whales, and with the need to understand potential effects, particularly on North Atlantic right whales, we are conducting, in coordination with developers, 'opportunistic behavioral response studies (BRS)' in and around construction activities, taking advantage of the actual activity to test animal responses. We are tagging whales and birds in areas where we know construction will be occurring and measuring their responses, or lack thereof. Robust statistical methods have been developed to use these types of data to test for animal responses, and we are making use of this analytical repertoire. Additionally, we are developing risk assessment frameworks from the basic, less data demanding occurrence-exposure-response-consequence models through to the data hungry population consequence of disturbance models. This information is essential for informing regulatory and management decisions, including science-based assessments of potential impacts from OSW. Initial results indicate that both fin and minke whales show distinct diel trends in diving behavior, with deeper dives during the daytime compared to night, and the gannets and gulls are making use of the entire area, well beyond though also including in/around the WEAs.

CWW 2025 IS ORGANIZED WITH THE SUPPORT OF:

RÉPUBLIQUE FRANÇAISE
Liberté
Égalité
Fraternité

OFB
OFFICE FRANÇAIS DE LA BIODIVERSITÉ

ADEME
AGENCE DE LA TRANSITION ÉCOLOGIQUE

La Région Occitanie
Pyrénées - Méditerranée

Montpellier Méditerranée Métropole

