Offshore Wind orjip working to accelerate offshore consenting

Quantifying multi-scaled avoidance of five seabird species to offshore wind farms

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Presentation given by Robin Ward, NIRAS Consulting Ltd (rwa@niras.com)

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Introduction

- The consenting process of offshore wind projects requires the identification, prediction and evaluation of the environmental effects of those proposed projects. In this context, the risk of birds colliding with turbine blades during operation is potentially one of the most significant environmental impacts predicted.
- In order to quantify bird collision risk, collision risk models (CRM) are used and parametrised with technical specifications of the turbines, bird densities, morphology and flight behaviour of existing bird populations present on site.
- The CRM e.g. the Band model (Band 2012), provides an estimate of the potential number of bird collisions likely to occur at a proposed wind farm assuming that birds take no action to avoid colliding with the wind turbines.
- In order to obtain realistic risk estimates, the collision risk modelling is subsequently corrected to take account of behavioural responses of birds to the presence of wind farms (i.e. avoidance).
- However, there is considerable uncertainty over the scale of such impacts due to the relatively few offshore monitoring studies so far undertaken, that have gathered empirical evidence.

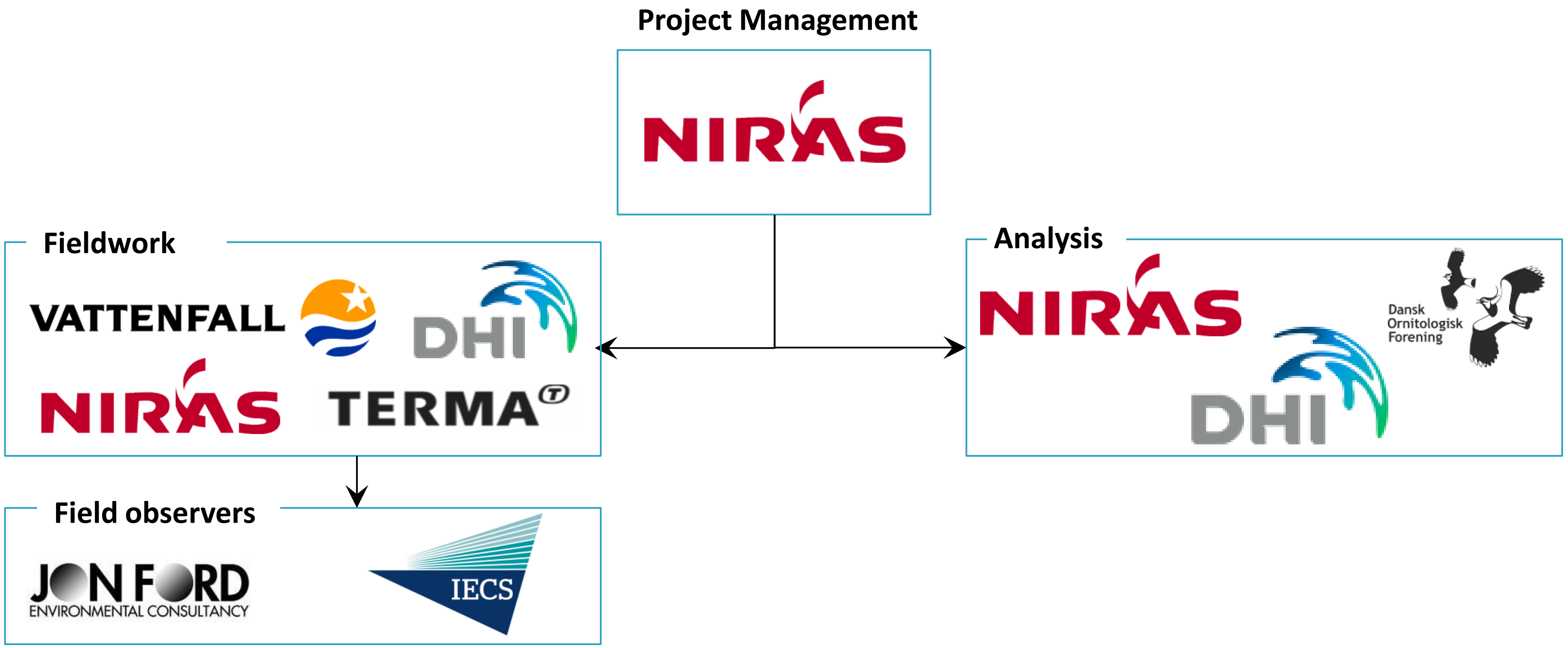
Study aims

The ORJIP BCA study was designed to improve the evidence base for bird avoidance behaviour and collisions around offshore wind farms through the monitoring of seabird behaviour; and to support consenting applications for offshore wind development.

The three main aims of the project were:

- **Aim 1** – Development of a bird monitoring system, that allows detecting and tracking bird movements at the species level in and around an operational offshore wind farm.
- **Aim 2** – Deployment of a multiple sensor monitoring system to measure the level of bird behaviour at an offshore wind farm and provide robust evidence on the rates of avoidance and collision for several target species identified as being at risk from collision with offshore wind turbines.
- **Aim 3** – development of an appropriate methodology for quantifying empirical avoidance rates.

The Team


Project Management
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Analysis
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Field observers
JON FORD
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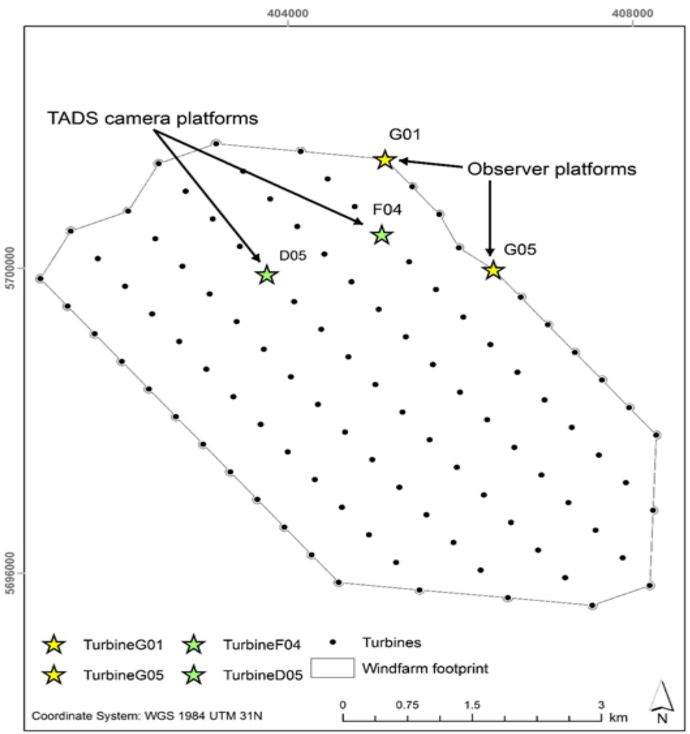
IECS

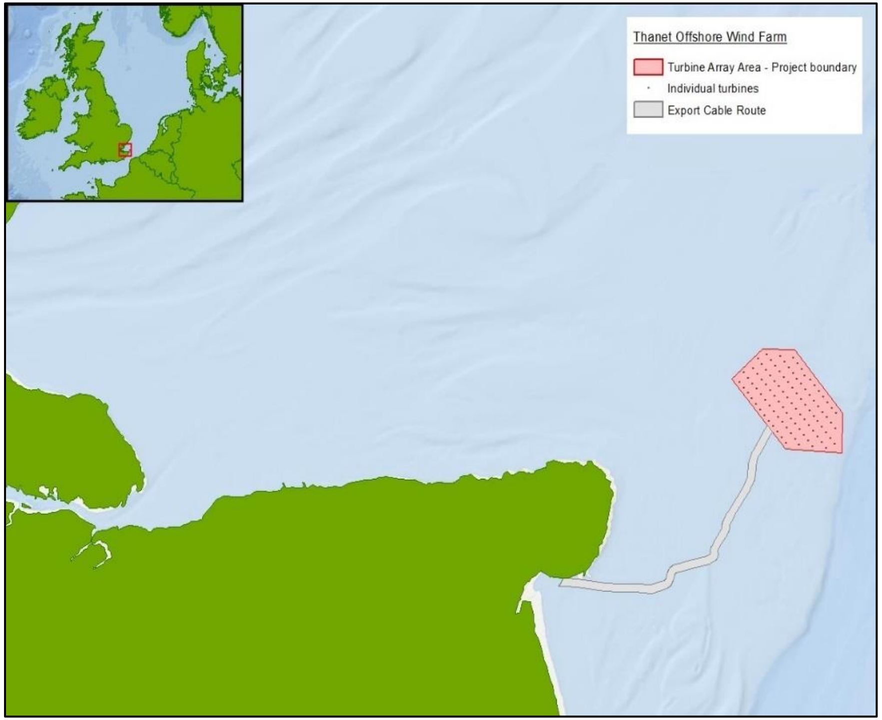
Bird avoidance behaviour

The study's monitoring system was designed to collect reliable data on bird avoidance behaviour at the three different spatial scales into which bird avoidance behaviour can be broken down:

- **Macro avoidance** - Bird behavioural responses to the presence of the wind farm occurring beyond its perimeter, resulting in a redistribution of birds inside and outside the wind farm. In this study, empirical macro avoidance is quantified up to 3 km outside the wind farm.
- **Meso avoidance -** Bird behavioural response within the wind farm footprint to individual turbines (considering a 10 m buffer around the rotor-swept zone) and resulting in a redistribution of the birds within the wind farm footprint.
- **Micro avoidance -** Bird behavioural response to single blade(s) within 10 m of the rotor-swept zone, considered as the bird's 'last-second action' taken to avoid collision.

Combination of observer-aided and automated tracking





Five Priority Species

Northern Gannet

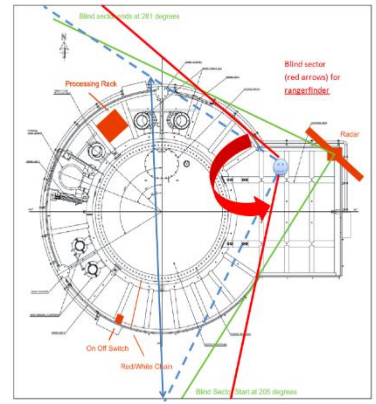
Herring Gull

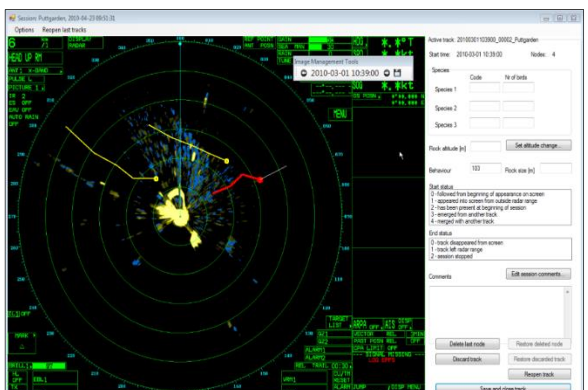
Black-legged kittiwake

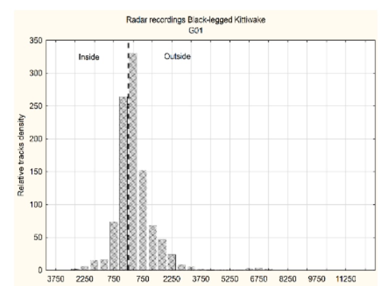
Lesser Black-backed Gull

Great Black-backed Gull

Observer-aided radar tracking



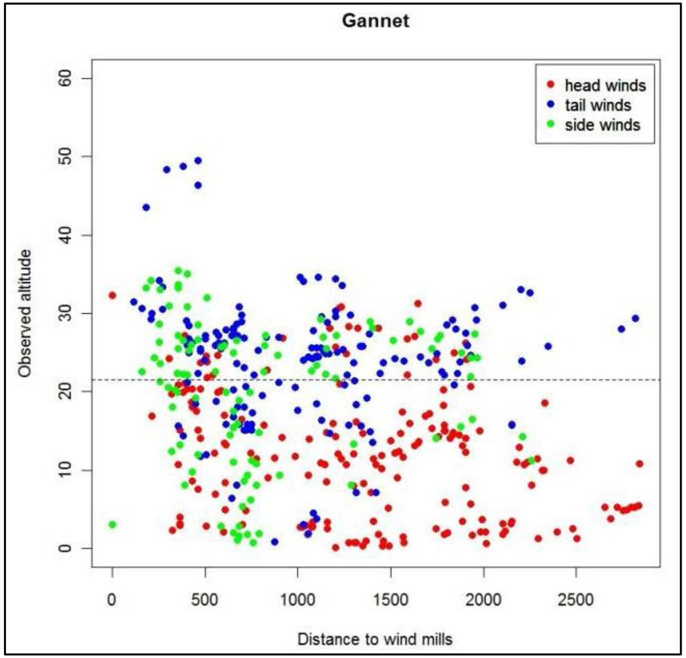




Observer-aided rangefinder tracking

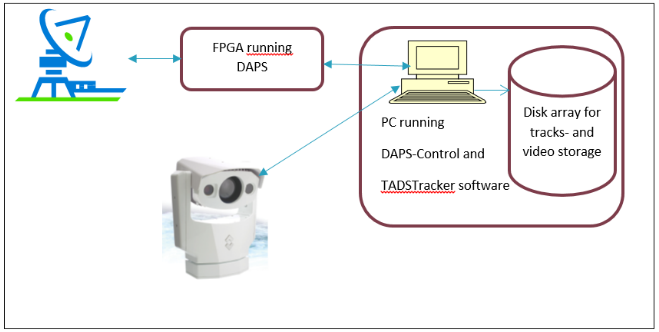
Observer-aided tracking: technical and practical limitations

Weather-induced variability in bird flight behaviour



Source: Skov & Heinänen 2015; Predicting the weather-dependent collision risk for Birds at Wind Farms.
Wind & Wildlife Proc. Springer Science

Development of radar-camera integration

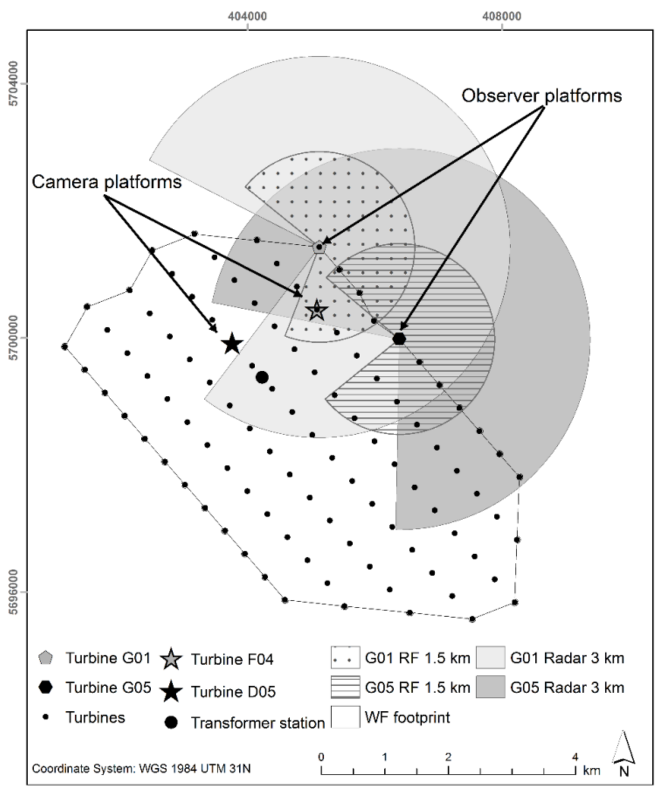


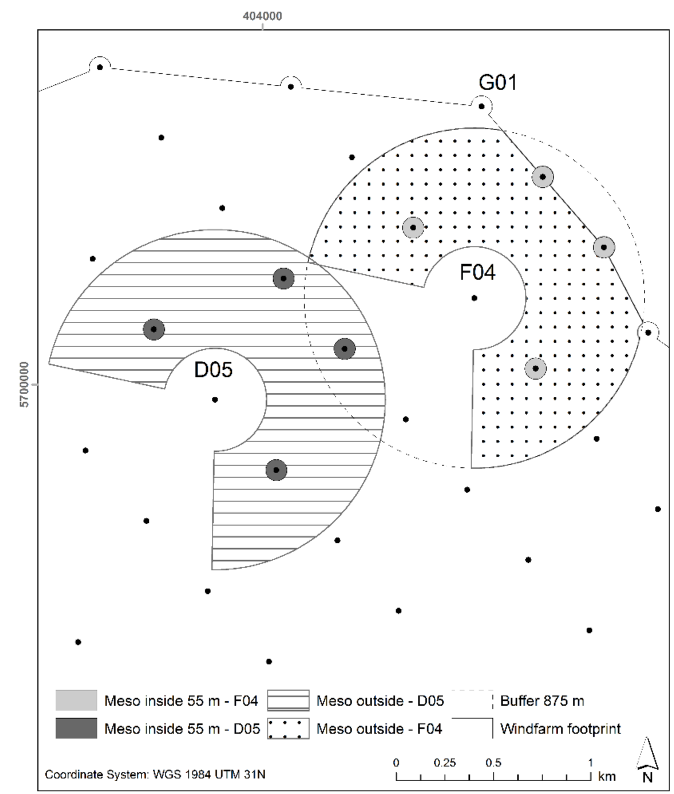
MUSE (MUlti-SEnsor animal detection system):

High-speed signal processing

Embedded programming

Detection ranges





Sample sizes macro avoidance

Number of radar and rangefinder tracks

Species	Sample size
Northern Gannet	1,261
Black-legged Kittiwake	367
Great Black-backed Gull	533
Lesser Black-backed Gull	328
Herring Gull	460
Large gulls	1,323

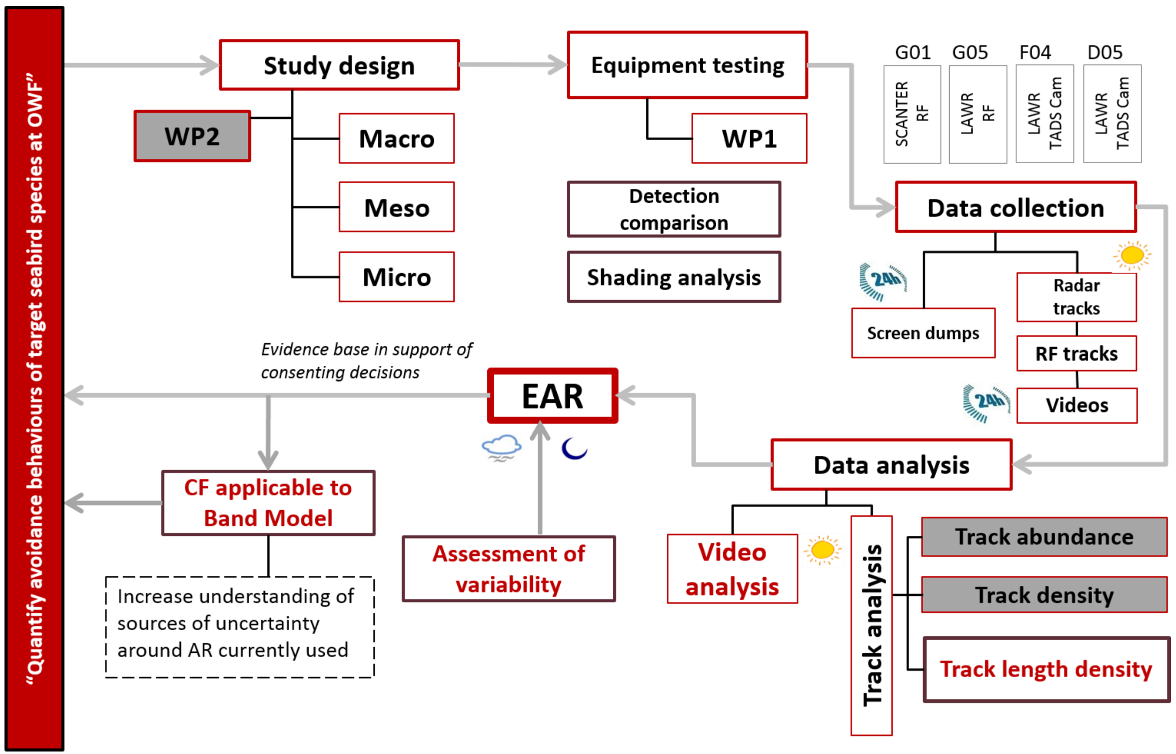
Sample sizes meso avoidance

Species	Meso avoidance		
	Flies between turbines rows	Flies below rotor	Flies above rotor
Northern Gannet	1,473	12	0
Black-legged Kittiwake	203	2	0
Great Black-backed Gull	292	2	0
Lesser Black-backed Gull	51	0	0
Lesser/Great Black-backed Gull	1,060	10	3
Herring Gull	270	2	0
Large gulls	4,143	33	7
Small gull	419	0	0
Gull unid.	3,254	6	2
Seabird unid.	1,178	3	0

Sample sizes micro avoidance

Species	Adjusting			Not adjusting	Collision	Total
	Turns before crossing	Stops before crossing	Crosses with adjustment			
Northern Gannet	4	0	28	1	0	33
Black-legged Kittiwake	0	1	4	0	1	6
Great Black-backed Gull	1	0	12	2	0	15
Lesser Black-backed Gull	0	0	1	0	0	1
Lesser/Great Black-backed Gull	6	0	15	1	1	23
Herring Gull	1	0	2	0	0	3
Large gull unid.	9	4	60	0	2	75
Small gull	1	1	3	1	0	6
Gull unid.	9	6	84	2	2	102
Seabird spp.	1	0	29	2	0	32
Other species of seabirds	0	0	2	0	0	4
All species of seabirds	32	12	240	9	6	299

ORJIP analytical framework



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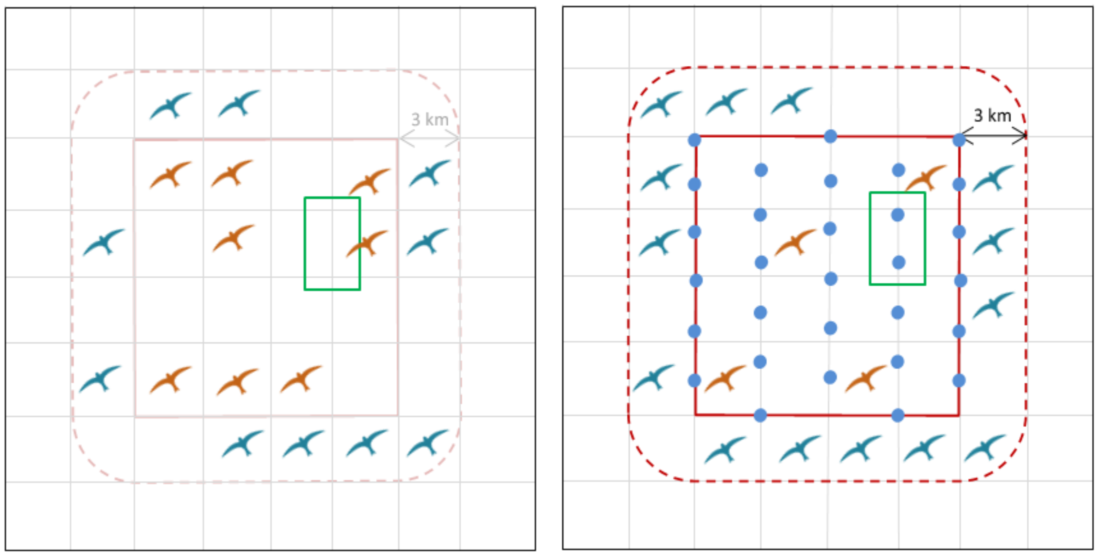
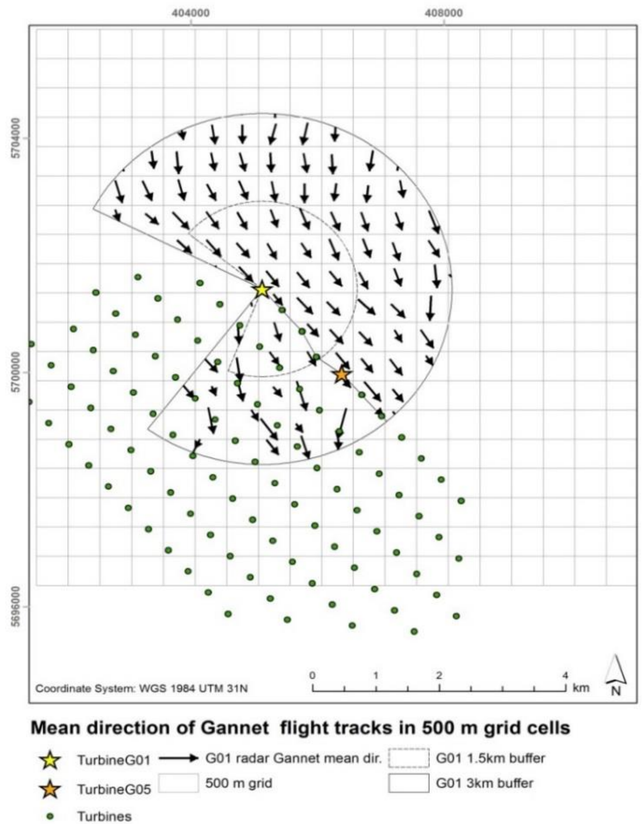
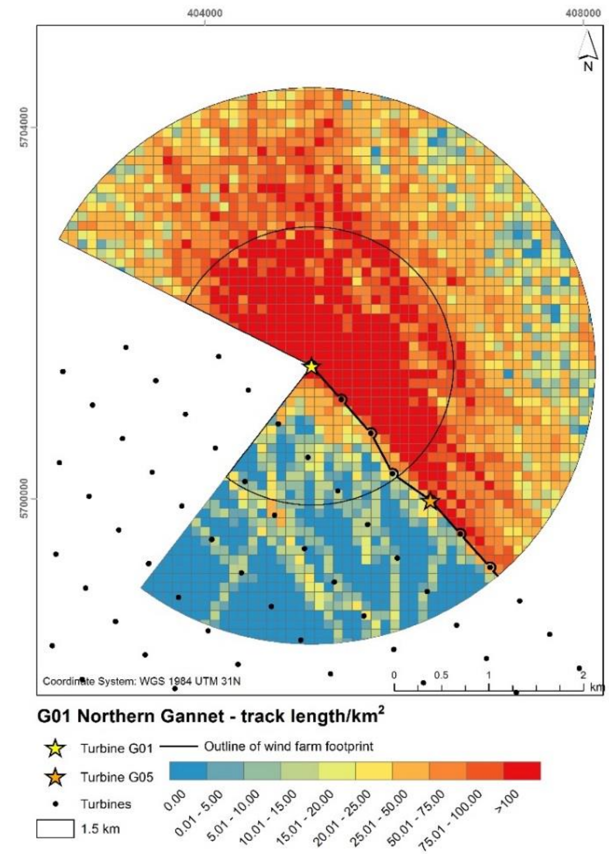
Empirical macro avoidance



Overall Macro EAR = 1 - N_{in} / N_{ref}

Empirical macro avoidance

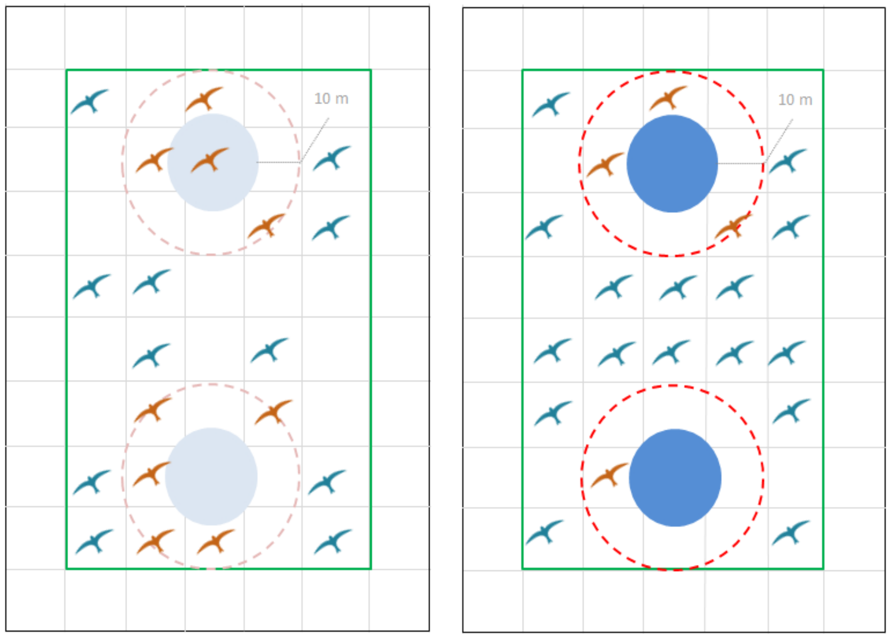




Empirical macro avoidance

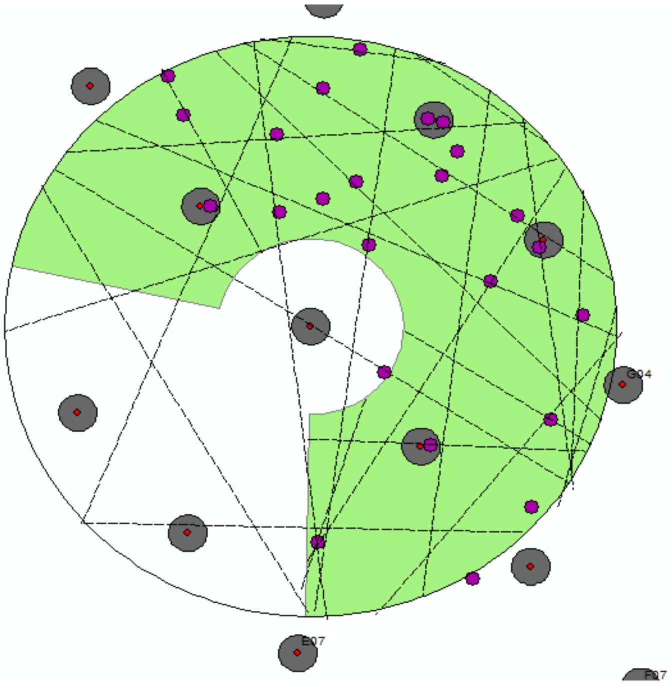
	Northern Gannet	Black-legged Kittiwake	Herring Gull	Great Black-backed Gull	Lesser Black-backed Gull	All large gulls
Overall Macro EAR	0.797	0.566	0.422	0.464	0.619	0.481
SD	0.153	0.169	0.191	0.198	0.199	0.196

Empirical meso avoidance



$$\text{Overall Meso EAR} = 1 - N_{in} / N_{ref}$$

Calculation of mean track lengths in wind farm

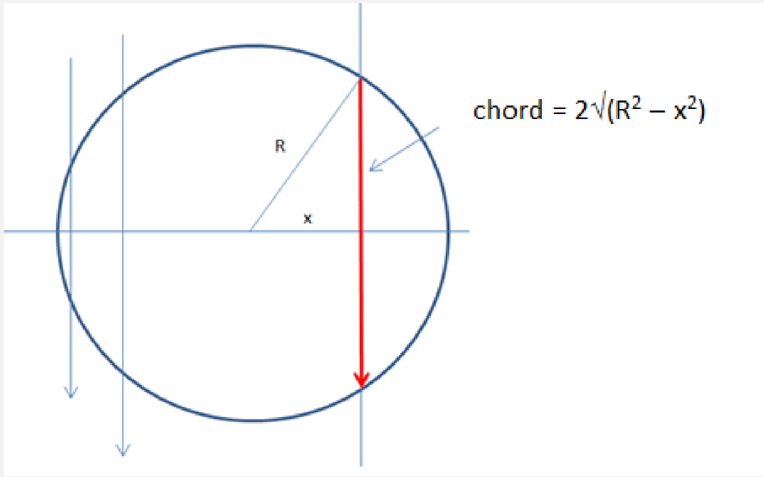


Box 2 – Calculation of mean track length within the rotor swept zone

Total track length = No of data points in swept area x $\pi R/2$

Area = πR^2

Track length per unit area = no of data points in swept area x $\pi R/2$ / πR^2



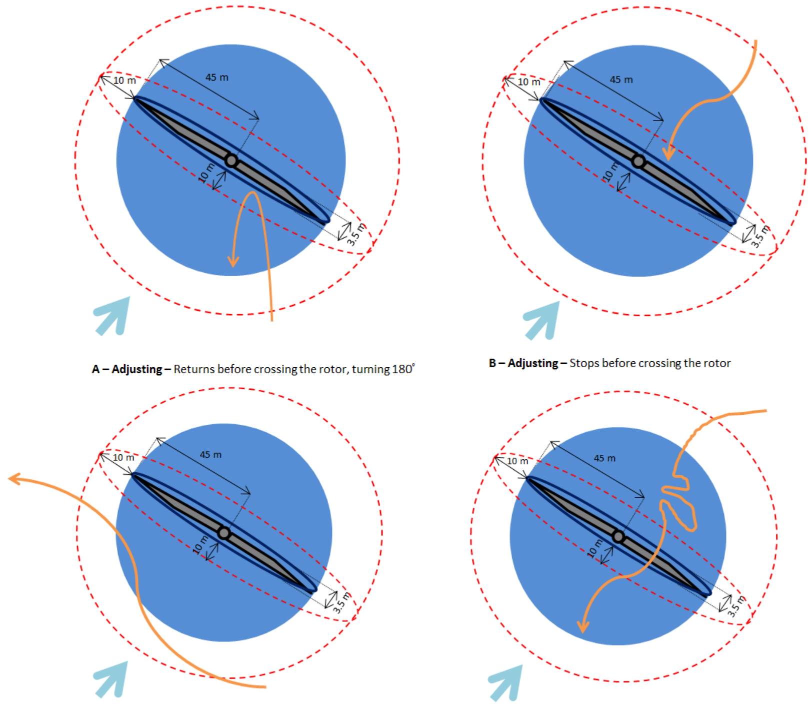
$$\text{Mean chord} = \int_{-R}^{R} 2\sqrt{(R2 - x2)}\,dx \;/\; 2R$$

$$= \pi R/2$$

Empirical meso avoidance

MESO	Northern Gannet	Black-legged Kittiwake	Herring Gull	Great Black-backed Gull	Lesser Black-backed Gull	All large gulls
EAR	0.9205	0.9160	0.9134	0.9614	0.8937	0.8423
SD	0.174	0.177	0.173	0.174	0.175	0.177

Empirical micro avoidance



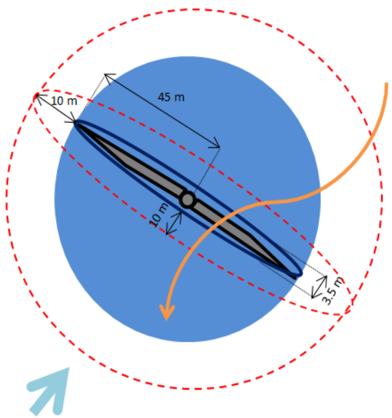
A – Adjusting – Returns before crossing the rotor, turning 180˚

B – Adjusting – Stops before crossing the rotor

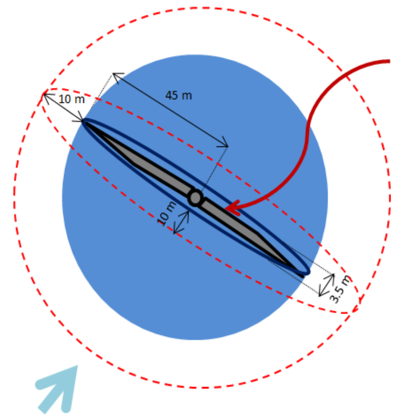
C – Adjusting – Flies along the rotor blades

D – Adjusting – Crosses the rotor with adjustments. Bird changes its path in front of rotor to cross between 2 blades. Also applicable in situations in which the rotor is not spinning

Empirical micro avoidance



E – Not Adjusting – Crosses the rotor without adjustments but survives



F – Collides

Overall micro EAR =

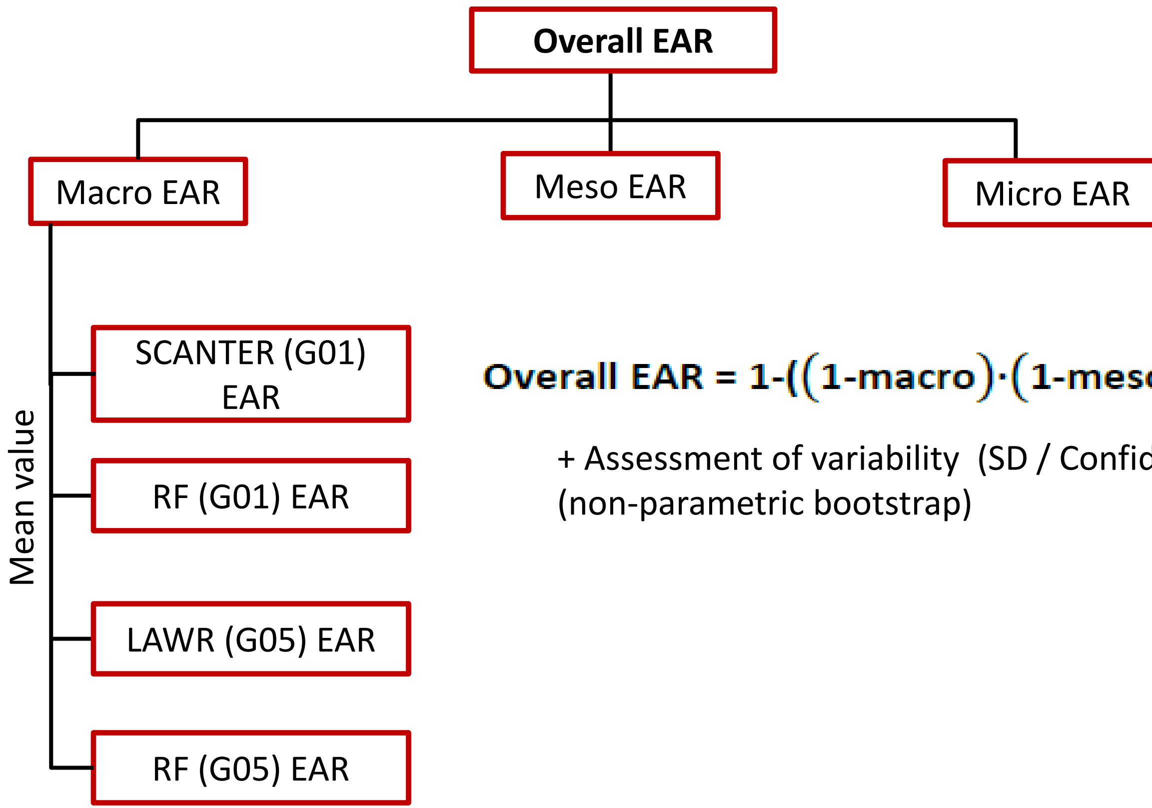
$$\frac{\textbf{N birds adjusting flight}}{\textbf{(N birds adjusting+N birds not adjusting+N birds colliding)}}$$

Empirical micro avoidance

MICRO	Large gulls	All seabirds
EAR	0.9565	0.9500
SD	0.115	0.115

Estimation of overall empirical avoidance

"Quantify avoidance behaviours of target seabird species at OWF"



Overall EAR = 1-((1-macro)·(1-meso)·(1-micro))

+ Assessment of variability (SD / Confidence Intervals) (non-parametric bootstrap)

Overall empirical avoidance

Species	Current avoidance rates Basic model	Current avoidance rates Extended model	Study EARs	SD
Northern Gannet	0.989 (± 0.002)	Not available	0.999	0.003
Lesser Black-backed Gull	0.995 (± 0.001)	0.989 (± 0.002)	0.998	0.006
Herring Gull	0.995 (± 0.001)	0.990 (± 0.002)	0.999	0.005
Great Black-backed Gull	0.995 (± 0.001)	0.989 (± 0.002)	0.996	0.011
Black-legged Kittiwake	0.989 (± 0.002)	Not available	0.998	0.006

Species-specific mean flight speeds

Species	Flight speed commonly used (no. of tracks)	Flight speed estimated by this study (SD)
Northern Gannet	14.9* (32)	13.33 (4.24) [n=683]
Black-legged Kittiwake	13.1** (2)	8.71 (3.16) [n= 287]
Lesser Black-backed Gull	13.1** (11)	9.80 (3.63)*** [n=790]
Great Black-backed Gull	13.7** (4)	
Herring Gull	12.8** (18)	

* Pennycuick (1997)

**Alerstram *et al.* (2007)

***Estimated with data for all large gulls combined

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Summary

The ORJIP study provided **important and enhanced information for Band and other CRM**:

- Empirical avoidance rates at 3 spatial scales for five species of seabirds
- Species-specific data on seabird flight speeds enable better estimation of fluxes
- Species-specific data on seabird flight heights enable better estimation of % at rotor height
- Data on nocturnal night activity of seabirds

The study collected the **most extensive dataset of observations of seabird behaviour** in and around an operational offshore wind farm currently available.

The study developed a **new sensor technology for automated monitoring** of bird behaviour at offshore wind farms

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Thank you for your attention

Bird Collision Avoidance Study
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