Deep Wind Offshore

Report

Experiences on avian mapping with Spoor at Utsira

Document code: 3003-dwo-z-ra-0001
Access level: Open

Project: Utsira Nord
Project number: 3003
Project manager: Kjetil Jakobsen

Abstract:
The Spoor installation at Utsira has given interesting data on avian life on Utsira and is a start on mapping bird life and design requirements for an offshore wind farm at Utsira Nord. The technology camera generally works very well. Spoor's technology is still under development and Spoor expects to continuously make improvements. In particular, Spoor has a strong focus on the development of species recognition, adding more species and improving the hit rate for existing species.

Rev.	Date	Description	Author	QA	Approval
1,0	27.01.2023	First edition	HeK	ErO	KjJ

Deep Wind Offshore

Contents

Notice

This report is released for the purpose of information sharing on Deep Wind Offshore's ongoing R&D-activities related to avian life and offshore wind on Utsira Nord. It shall not be considered as an environmental impact assessment (EIA) or a part of an EIA for Utsira Nord. Work related to the EIA is ongoing and estimated completed in 2024 / 2025.

Deep Wind Offshore recognises the contribution from Spoor, Solvind and Utsira municipality for making this report.

1 Background

1.1 Utsira Nord

A 1500 MW offshore wind development zone has been identified 7-8 km west of the island of Utsira. The proposed area will be divided into three smaller sections and developed by different consortiums in time for a COD in 2029.

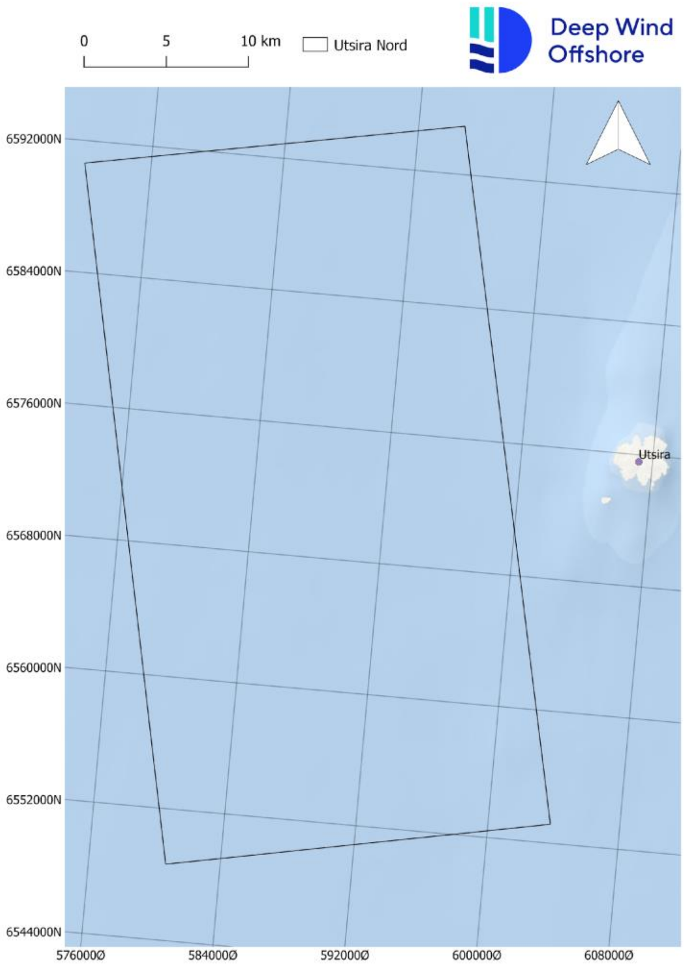


Figure 1: Utsira North offshore wind development area

1.2 Birdlife on Utsira

Utsira is a hotspot for avian life. Migrating birds pass through Utsira on their migration routes and there is a nature reserve for seabirds close to Utsira, on Spannholmene.

Development of offshore wind on Utsira North needs to consider the presence of avian life, and what consideration must be made when constructing, operating, and decommissioning the offshore wind farms. There is in the first phase therefore a need to map avian life on Utsira to establish a baseline and as a basis for planning mitigation measures for the offshore wind farm.

A short screening was done to identify some of the key species in the surrounding area, shown in table 1 below. Up to date information of species expected to be found near a specific location can be found at Nibio Kilden.[1]

Table 1: Red listed species and their presence close to Utsira Nord. Species listed by colour as Critically Endangered (CR), Endangered (EN), Vulnerable (VU), Near Threatened (NT) and Least Concern (LC) according to Artsdatabanken[2].

Protected areas and nature reserves	Important species (Norwegian in first parentheses)	Shortest distance to Utsira Nord
Spannholmane, Utsira	European shag (toppskarv), atlantic puffin (lunde), black guillemot (teist), alke, common murre (lomvi) and other gulls	6 km
Ferkingstadøyene	European herring gull (gråmåke), great black-backed gull (svartbak), lesser black-backed gull (sildemåke), european shag, common eider (ærfugl), black-legged kittiwake (krykkje), atlantic puffin, black guillemot, northern fulmar (havhest).	17 km
Urter, Karmøy	Black-legged kittiwake, black guillemot, greylag goose, northern fulmar, european shag, common eider, lesser black-backed gull, mew gull (fiskemåke), european herring gull, great black-backed gull.	18 km
Jegningen	Common tern (makrellterne), arctic tern (rødnebbterne)	21 km
Jarstein	Lesser black-backed gull, european herring gull, common eider, black guillemot, great black-backed gull, european shag	21 km
Ryvingen, Klovningen og Nordre Longaskjær	Arctic tern, gulls (especially great black-backed gull)	23 km
Indrevær, Haugesund	Great black-backed gull, greylag goose	29 km
Gitterøy, Haugesund	Great black-backed gull	29 km
Heglane	Great black-backed gull, european herring gull, greylag goose	35 km
Eime	Lesser black-backed gull, great black-backed gull, common eider, greylag goose	39 km

1.3 Spoor

Spoor is an innovative start-up delivering a system for bird monitoring. Spoor's software uses cutting-edge computer vision and AI to detect, track, and classify birds in wind farms to help developers and operators gain insights and guide mitigation measures. Installing a camera running

[1] https://kilden.nibio.no
[2] https://artsdatabanken.no/lister/rodlisteforarter/2021

Spoor's algorithm in the cloud gives continuous monitoring on the selected site. Some specifics regarding the solution are:

- **Long-range bird detection and tracking.** Spoor software can detect and track birds up to 2km away using video. Multiple birds and flocks can be tracked real time.
- **3D tracking.** Spoor's proprietary model estimates a bird's 3D flight path. This data provides insights on bird flight patterns, pre and post construction.
- **Species-specific data.** Target species are identified automatically using patent pending "Spoor artificial ornithologist." System can be trained to recognise different species on request.
- **Collision detection and micro avoidance.** Based on a bird's flight path, Spoor can detect possible collisions and other flight activity near turbines, a first for offshore solutions.
- **Ease of deployment** using off-the-shelf video cameras Spoor's system offers flexible camera and mounting options. Camera placement is based on the unique data-acquisition needs of each project.

Not included in this project:

- **Night vision capable**. The system can track and detect birds' nocturnal activity using thermal-spectrum cameras. This enables round-the-clock monitoring.
- **Dynamic curtailment (under development).** Using both the 3D flight path and automated species identification Spoor will be able to offer dynamic curtailment on a turbine level with minimal impact on production.

DWO has chosen to utilise Spoor for initial surveys of birdlife at Utsira, both to map avian life and to assess if Spoor could be a useful mitigation measure for an offshore wind farm at Utsira Nord and in other offshore wind projects.

2 Method

It was decided to install the camera at the Utsira lighthouse due to high visibility towards the Utsira North field, and access to electricity. A monitoring plan was delivered by Spoor, showing among other things the monitored area covered by the camera.

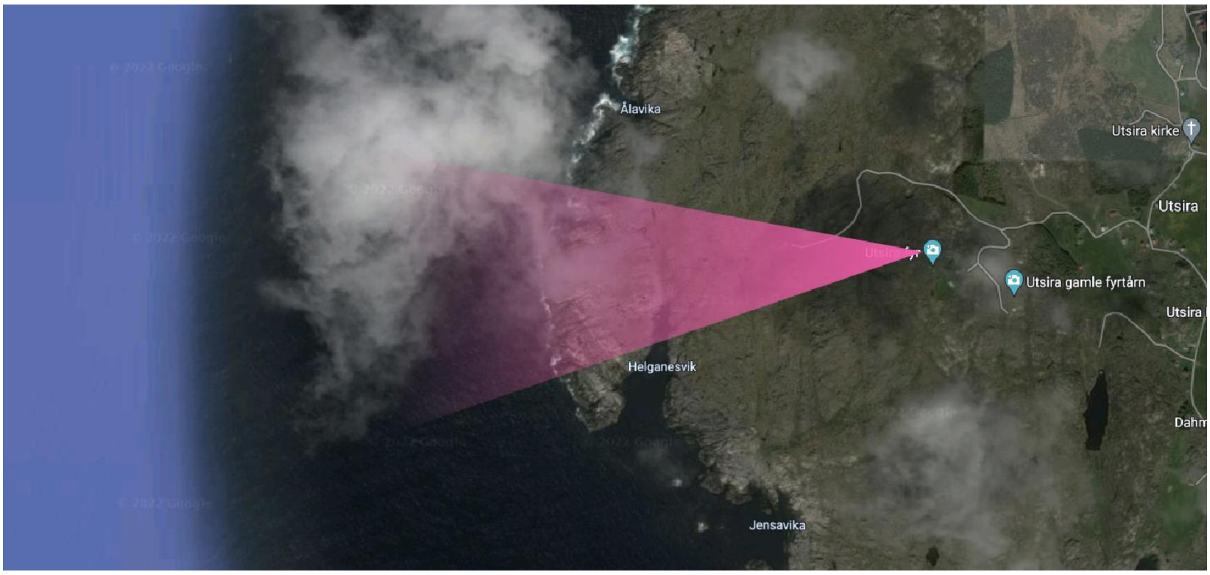


Figure 2: Camera direction and visibility towards the Utsira North field.

Kystverket, who owns the lighthouse, was consulted to examine requirements for installation and possibility to use electrical supply of the lighthouse. As the lighthouse was protected, an application was delivered to Rogaland County administration to be allowed to set up the camera and installation coordinated with them. The original application was for a limited time from April to December 2022. An application for extension was approved in October, and the camera will be operational until the end of 2023.

An Axis Q1798-LE 4K camera was installed by Viste & Sømme on the Utsira lighthouse 28th of April 2022. The camera receives power from the lighthouse and communicates over a 4G router. Figure 2 shows the placement of the camera. No permanent changes to the lighthouse were made, according to Kystverket's requirements.

Around a month later, a Spoor camera was installed by Solvind on the north of Utsira next to their two wind turbines. Deep Wind Offshore has access to this camera and Solvind has access to Deep Wind Offshore's camera. There is also an older installation at the MetCentre closer to Karmøy.

During the summer of 2022 there have been two blackouts at the lighthouse, one of which was caused by lightning activity. This blackout reset the zoom of the camera, slightly changing the setup during the measurement campaign which among other things could affect the measured height of the birds.

A change during measurement has also been made for Solvind's camera. The yaw direction of the camera was changed manually in July 2022.

For this report, data from April 28th to 1st of September 2022 has been analysed.

Figure 3: Installation on the Utsira lighthouse.

3 Results

The number of birds detected per day is shown below. A total of 22,985 birds have been detected in this measurement period. The two blackouts are visible. Due to a reset of the zoom level of the camera after the first black, the detection volume after the first blackout is altered resulting in overall fewer detections. Note the colour scale showing the number of hours the camera has been recording per day. Days with low visibility can have low number of measured birds, but with an indication that the data is unreliable (e.g. one day around 20th of May).

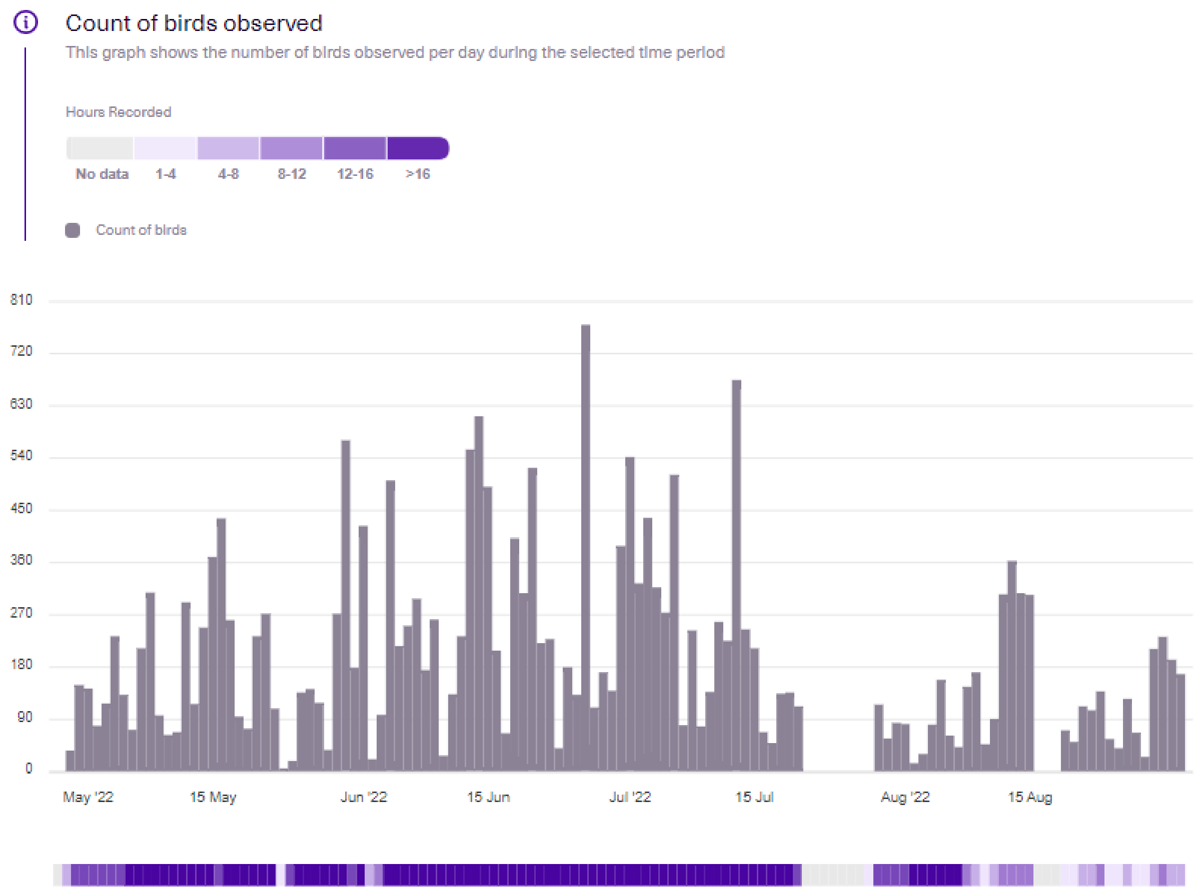


Figure 4: Observed birds during the time period 28.4-1.9.22

To determine the recall (the count of actual birds that are detected compared to a ground truth method) Spoor's ornithologist visited Utsira to collect ground truth data for the purpose of comparing the count of birds as made by the ornithologist against the count reported by camera. The experiment showed that 89% of the birds observed by the ornithologist was also detected using Spoor's AI software.

Some notes regarding the observation of birds:

- This camera only detects birds during daylight hours as a night vision camera was not selected for this installation. The amount of data collected per day will therefore be better in the summer season than during the winter season.

- More birds are registered as flying along the north-south direction rather than east-west. This is likely due to flight patterns following the coastline that goes north-south at this location but may also be because these birds are more often in the camera's field of view

3.1 Statistics for the observed birds

The figure 5 below shows detected birds per time of day. During the time when there is enough light to observe birds, most birds are active during the period 06-13 hours.

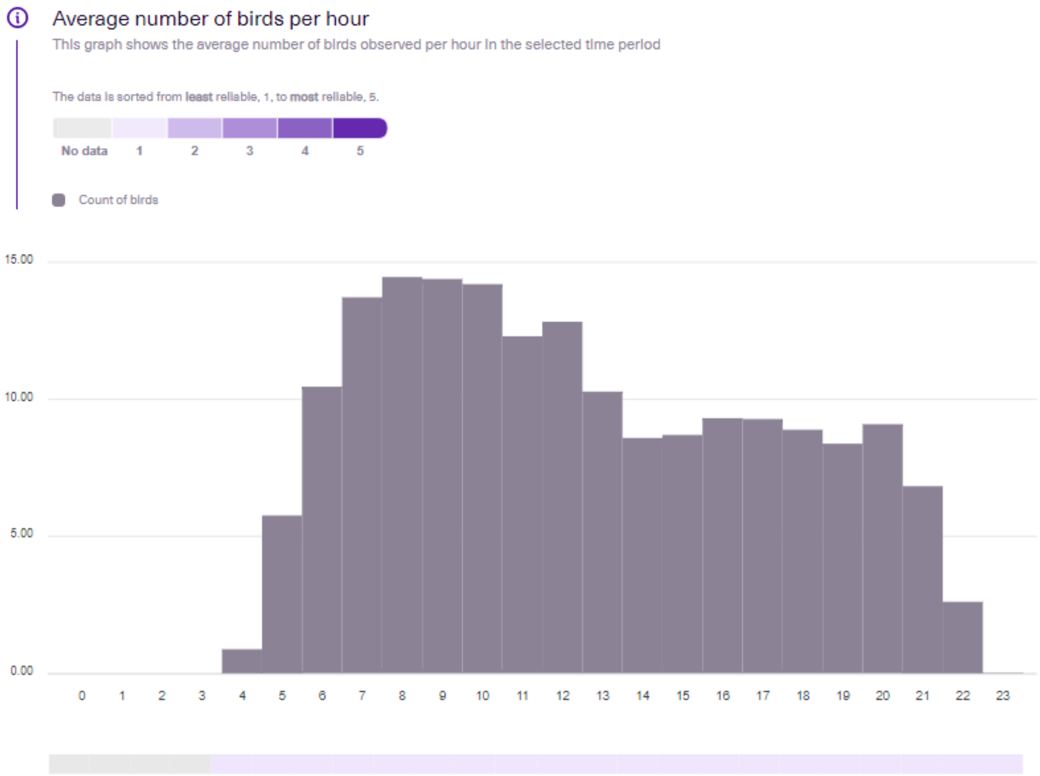


Figure 5: Observed birds during the time of day. Note wrong colour on reliability index, all columns are marked as 4 when the mouse is hovered above them, but as one in the bar below the graph.

As mentioned the majority of birds are registered as flying south, which is shown to the left in figure 6. This can be contrasted by the flight direction of birds at the Solvind location, which is primarily east and west, as shown to the right.

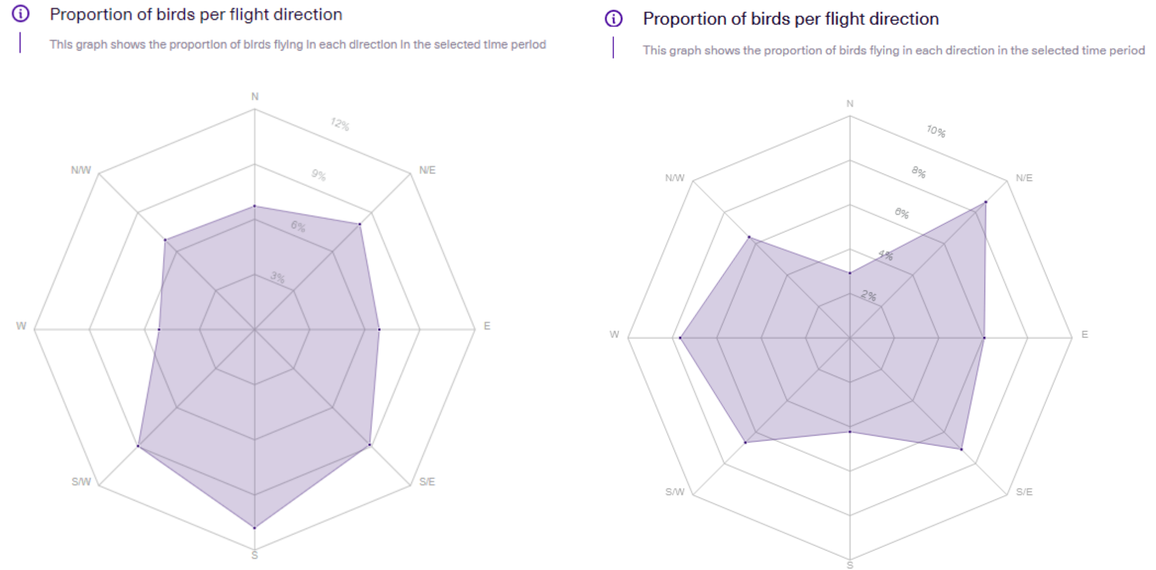


Figure 6: Observed flight direction of the birds for the lighthouse (left) and Solvinds location (right).

The observed flight height is shown in figure 7 for the two locations. Height is given in meters above sea level, and the lighthouse camera is installed approximately 75 m above sea level while Solvinds camera is closer to sea level. Note that the base for comparing height measurement for the camera on the lighthouse has likely been affected by the zoom change that happened after the blackout.

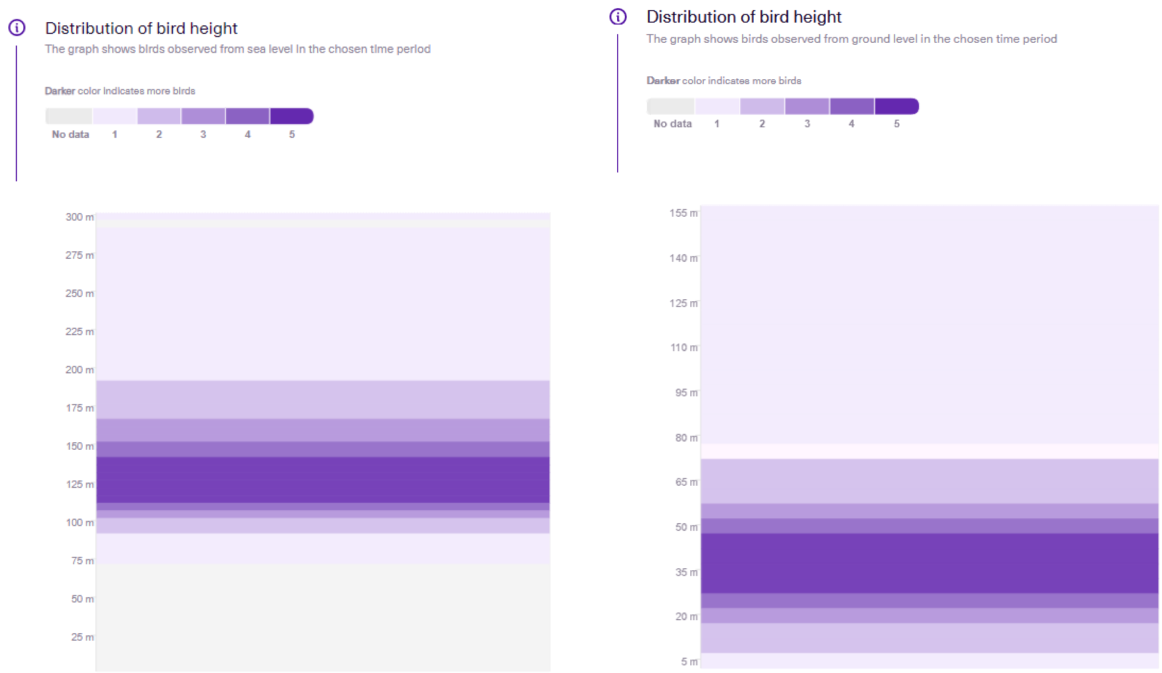


Figure 7: Observed flight direction of the birds for the lighthouse (left) and Solvinds location (right).

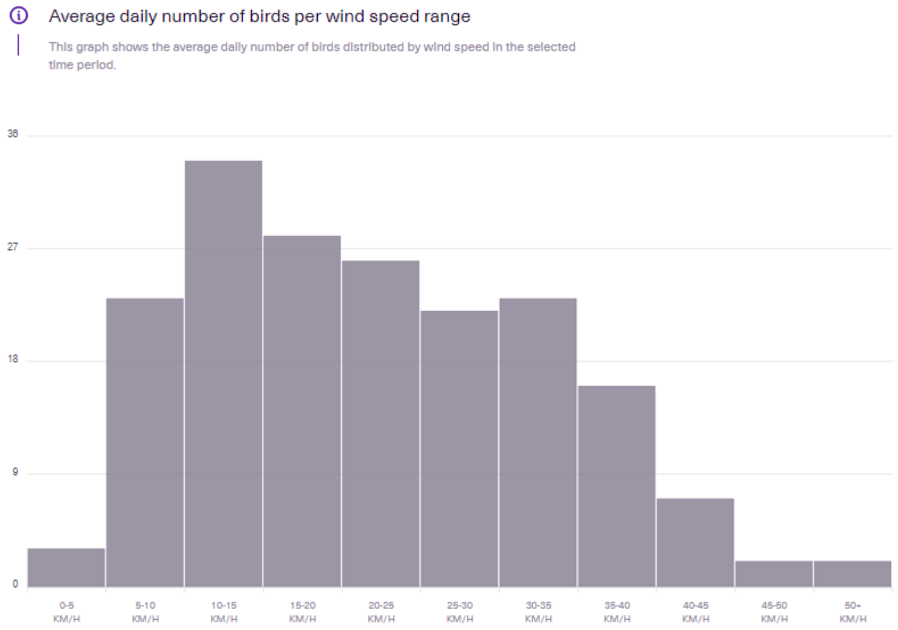


Figure 8: Observed birds by different wind speeds.

Figure 8 shows the number of observed birds per wind speed. It is assumed that few birds are detected during low wind speeds primarily because the wind speed not often is below 5 km/h.

Figure 9 shows the number of observed birds during different wind directions. The number of observed birds is highest during western winds. Sea birds in Norway / Europe prefer fishing offshore during these wind conditions, which fit well with the observed data.

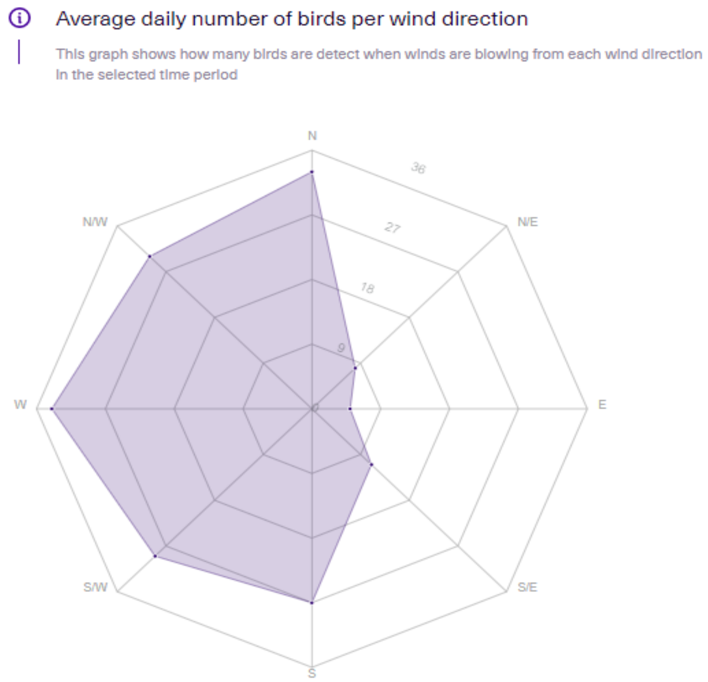


Figure 9: Observed birds by wind direction.

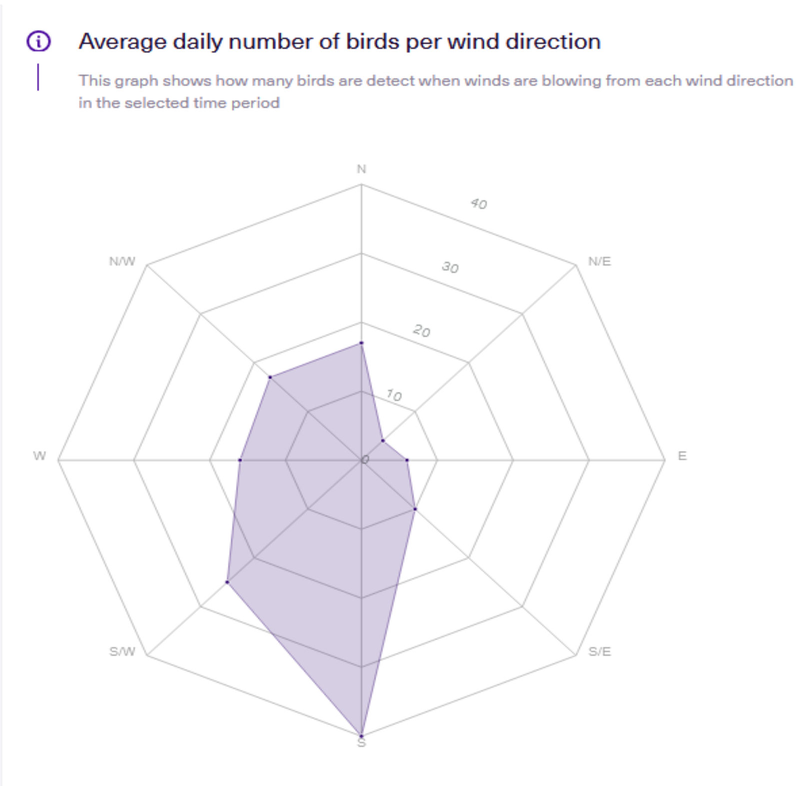


Figure 10: Observed birds by wind direction at Solvinds installation.

Comparing the measurement results from Solvind's location, there are more observed birds when the wind is blowing from the south. The reason for this observation is unknown. It should be noted that the dependence of wind direction is lower in June and July, which shows high activity during all wind speeds.

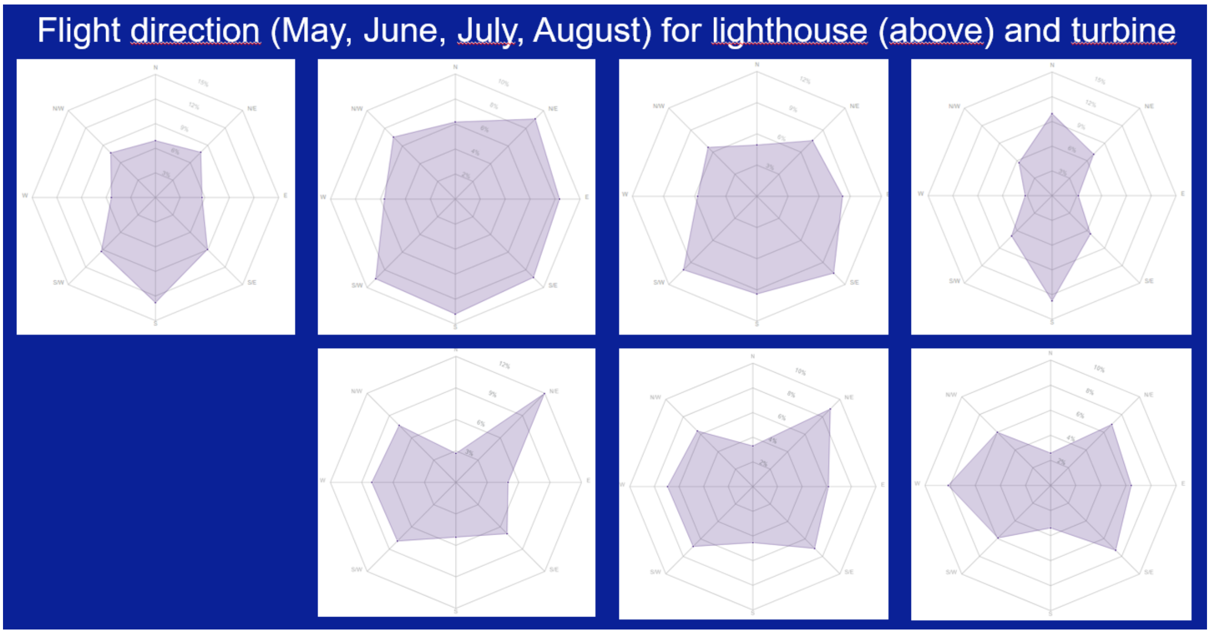


Figure 11: Variation of wind speed during the measurement period.

3.2 Species recognition

Spoor's AI for species recognition is still under development. As some manual input is required to guarantee the species recognition, two analyses have been made:

1. A general analysis for the full time period
2. A detailed analysis over two weeks, requiring manual analysis of the data

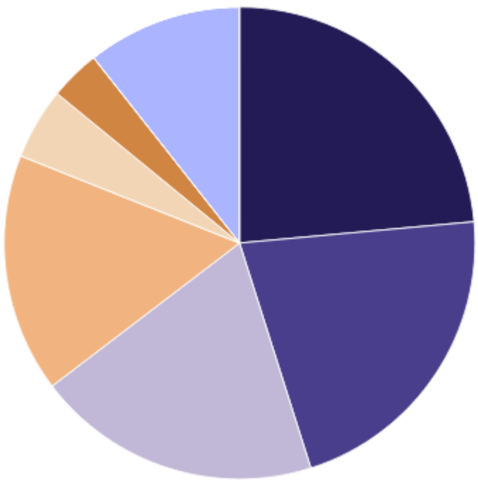
The results of the first analysis are shown in figure 12 for Solvind's location and figure 13 for the lighthouse. As mentioned, the highest number of observed birds at the lighthouse are gulls, whereas for Solvind's location, it is small passerine birds. Among other things, it can be observed that there are eagles, hawks and falcons at Utsira.

Species data

This pie chart shows the breakdown of different species detected in the selected time period

17183 Birds detected

348 Birds identified



PERCENTAGE	SPECIES	COUNT
23.56	Small passerine bird	82
21.55	Great black-backed gull	75
19.54	Gull	68
16.38	Hooded crow	57
4.89	European starling	17
3.45	Lesser black-backed gull	12
10.64	Other ^	37
3.45	Common raven	12
2.01	Common linnet	7
1.44	European herring gull	5
1.15	Bird	4
0.57	Northern wheatear	2
0.57	Common kestrel	2
0.29	Eurasian sparrowhawk	1
0.29	Twite	1
0.29	European greenfinch	1
0.29	Thrush	1
0.29	Greylag goose	1

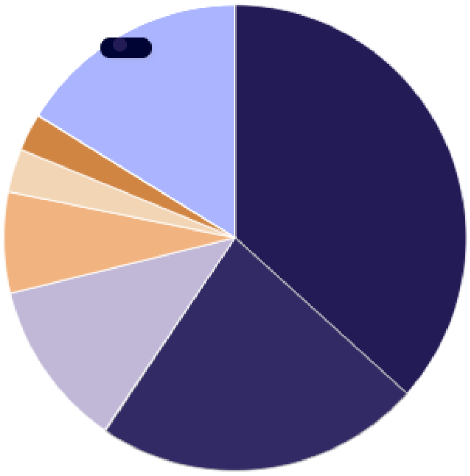
Figure 12: Observed birds by species, Solvind's location (whole analysis period).

Species data

This pie chart shows the breakdown of different species detected in the selected time period

22985 Birds detected

499 Birds identified



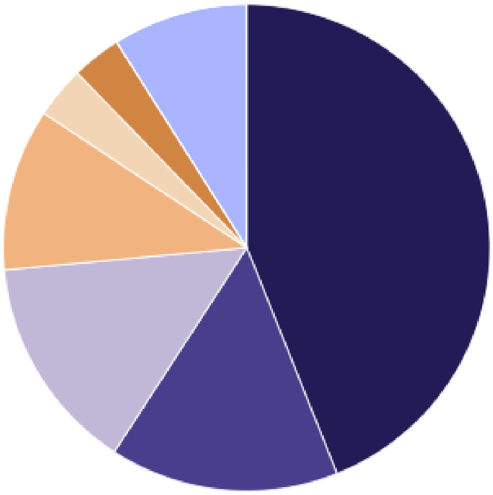
PERCENTAGE	SPECIES	COUNT
36.67	Great black-backed gull	183
22.85	Small passerine bird	114
11.62	European starling	58
7.01	Gull	35
3.01	European herring gull	15
2.61	Common raven	13
16.21	Other ^	81
2.61	Hooded crow	13
2.2	Common kestrel	11
2	Bird	10
1.4	Barn swallow	7
1.2	Wader	6
1	Lesser black-backed gull	5
0.8	Peregrine falcon	4
0.8	Common swift	4
0.6	Common wood-pigeon	3
0.6	European Golden Plover	3
0.4	White-tailed eagle	2
0.4	Grey heron	2
0.4	Greylag goose	2
0.2	Eurasian sparrowhawk	1
0.2	Goose	1
0.2	European greenfinch	1
0.2	Eurasian skylark	1
0.2	European golden plover	1
0.2	Thrush	1
0.2	Eurasian curlew	1
0.2	Swallow	1
0.2	Northern wheatear	1

Figure 13: Observed birds by species at the lighthouse (whole analysis period).

The results of the more detailed analyses are shown in figure 14 for Solvind's location and figure 15 for the lighthouse. Of a total of 2338 birds, 2096 was identified, equalling a species recognition rate of 90 %. In the more detailed data a higher number of detected birds are small passerine birds at the lighthouse, and a higher rate of the birds detected at Solvind's location are gulls.

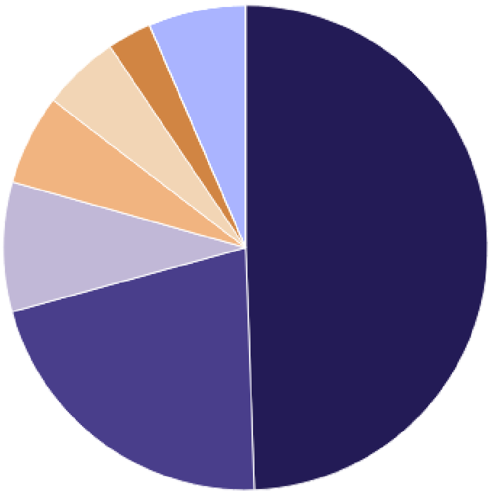
The following observed species (both locations and analysis periods) are red listed:

- EN: Eurasian Curlew (Storspove). Observed once at the lighthouse.
- VU: European Herring Gull (Gråmåke). Common at the lighthouse, at both locations.
- VU: Mew gull (Fiskemåke). Observed once at the lighthouse.
- VU: European greenfinch (Grønnfink). Observed once at both locations.
- NT: Common swift (Tårnseiler). Common at Solvind's location, once at the lighthouse.
- NT: Eurasian skylark (Sanglerke). Observed once at the lighthouse.
- NT: European golden plover (Heilo). Observed at the lighthouse.
- NT: European Starling (Stær). Common at both locations.
- NT: Eurasian oystercatcher (Tjeld). Observed once at Solvind's location.



	PERCENTAGE	SPECIES	COUNT
	43.95	Small passerine bird	269
	15.2	Bird	93
	14.38	European starling	88
	10.78	Gull	66
	3.43	Great black-backed gull	21
	3.27	Common swift	20
	8.98	Other ^	55
	2.78	Barn swallow	17
	2.12	Lesser black-backed gull	13
	0.82	Thrush	5
	0.82	Greylag goose	5
	0.65	European herring gull	4
	0.33	Grey heron	2
	0.33	Northern wheatear	2
	0.33	Hooded crow	2
	0.16	Meadow pipit	1
	0.16	Common linnet	1
	0.16	Eurasian oystercatcher	1
	0.16	Northern gannet	1
	0.16	Eurasian woodcock	1

Figure 14: Observed birds by species, Solvind's location (detailed analysis 18.7-31.7).



	PERCENTAGE	SPECIES	COUNT
	49.42	Gull	853
	21.32	Small passerine bird	368
	8.63	Bird	149
	6.03	Lesser black-backed gull	104
	5.16	European starling	89
	2.95	Hooded crow	51
	6.5	Other ^	112
	2.03	European herring gull	35
	1.68	Great black-backed gull	29
	0.81	Greylag goose	14
	0.46	Meadow pipit	8
	0.41	Common linnet	7
	0.35	Common raven	6
	0.29	Barn swallow	5
	0.17	Northern wheatear	3
	0.06	Mew gull	1
	0.06	Grey heron	1
	0.06	Thrush	1
	0.06	Common swift	1
	0.06	White wagtail	1

Figure 15: Observed birds by species at the lighthouse (detailed analysis 18.7-31.7).

Spoor has analysed in detail the required distance to detect a certain bird as defined by order, family and species. Some birds are due to certain characteristics easy to identify even from a large distance, but others have identifiers that requires closer inspection. Some species can easily be detected from a distance (e.g. gulls, common swifts and European starlings), but differentiating certain species of gulls from each other requires higher resolution / closer proximity. The characteristics for when birds may be identified or not are useful for further work and are summed up in figure 16 and 17 below.

It should be noted that the cameras used in this report were 4K (10MP) Axis cameras with 12-48mm adjustable Canon lens. The sensor resolution and zoom factors are determining factors for the range obtainable for detection and species ID. With higher resolution cameras and increased focal length greater ranges are obtainable (at the cost of a more narrow field of view). The focal length used with both cameras on Utsira were 25mm.

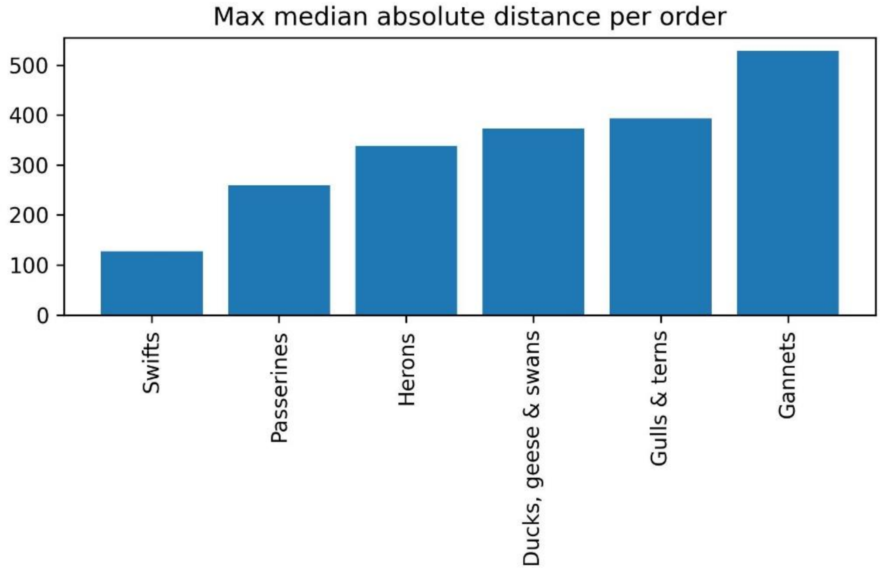


Figure 16: Maximum distance for species recognition per order for the detected birds. Distance depends on camera model.

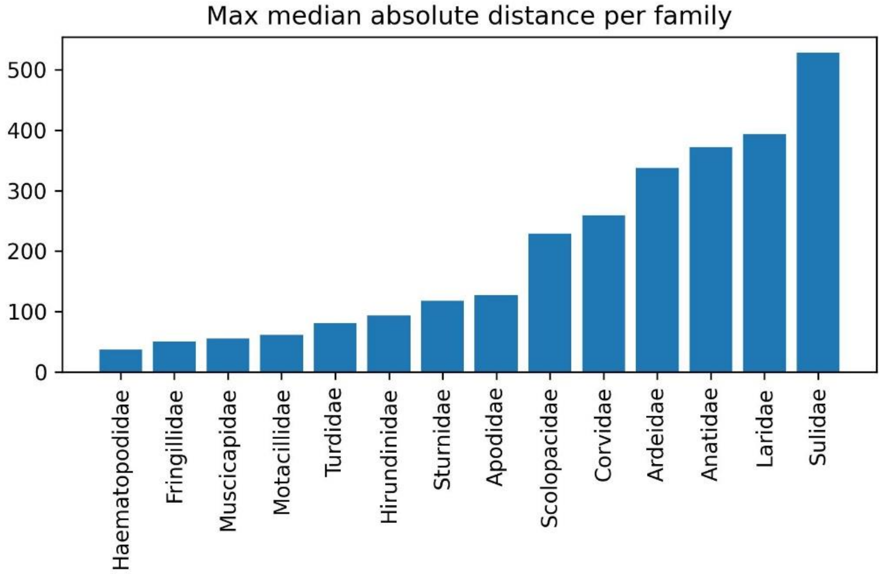


Figure 17: Maximum distance for species recognition per family for the detected birds. Distance depends on camera model.

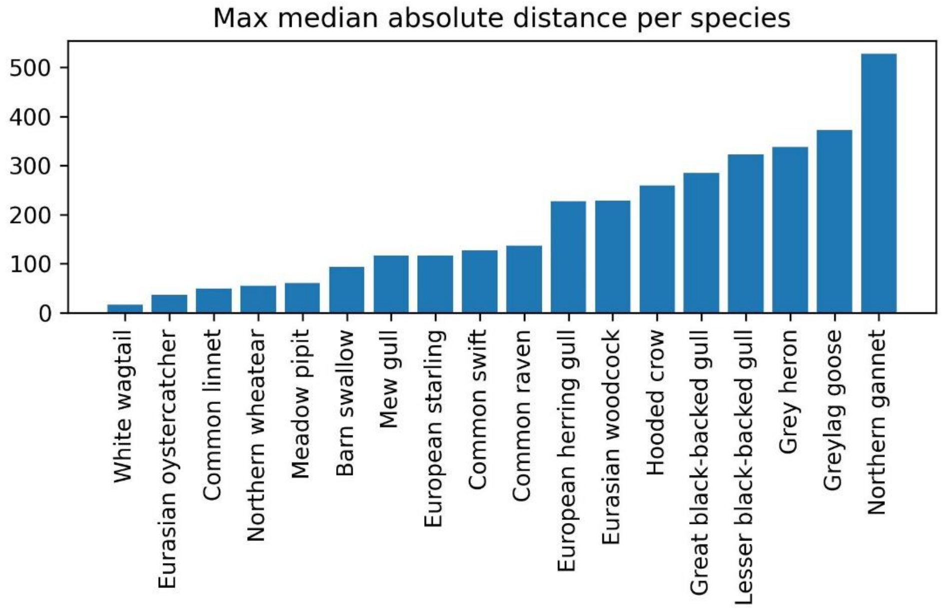


Figure 18: Maximum distance for species recognition per species for the detected birds. Distance depends on camera model.

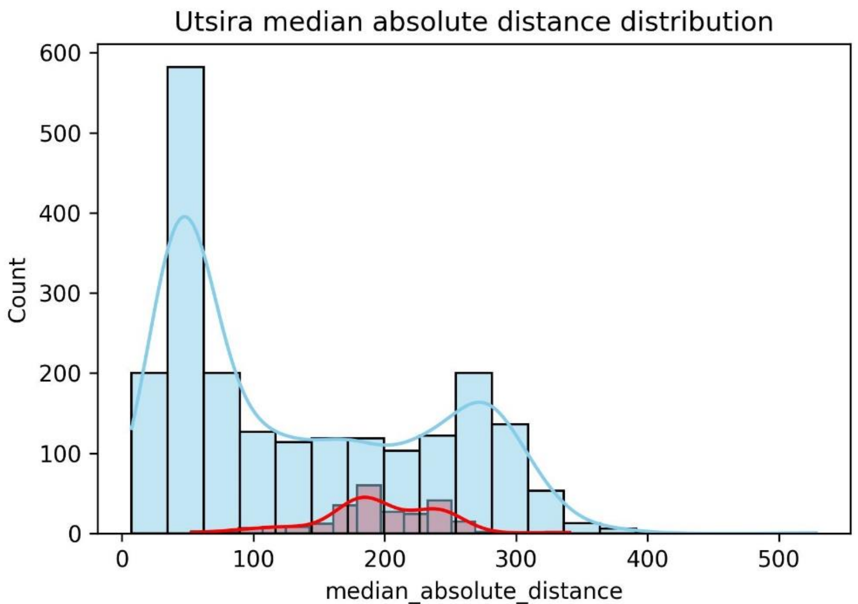


Figure 19: Distance at which birds were either identified (blue) or un-identifiable (red). Distance depends on camera model.

3.3 Examples of detected birds

Some individual birds are also shown in figure 18-22.

Figure 20: Peregrine falcon

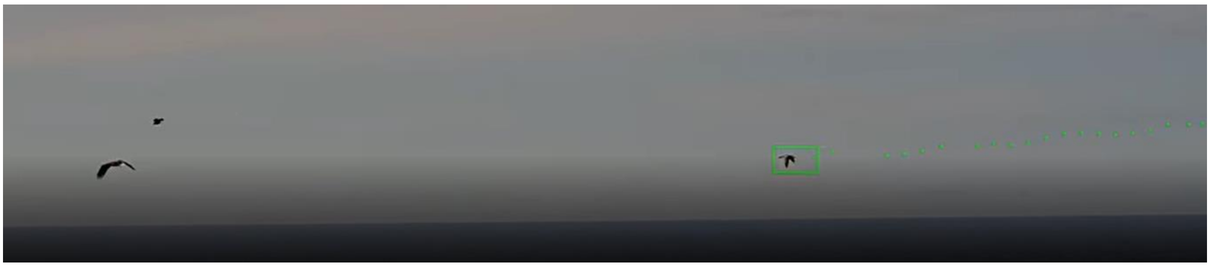


Figure 21: Greylag geese (chasing a white-tailed eagle)

Figure 22: Eurasian skylark

Figure 23: *European Herring Gull*

Figure 24: Hooded crow

4 Evaluation of suitability of Spoor to map avian life

Spoor is still developing their product, and it is to be expected that the technology will continually evolve as it is used to monitor more sites under different conditions. Based on the experiences from Utsira and Spoors work to verify these data, Deep Wind Offshore has the following evaluation on what we view as the most important aspects of the software:

1. Species ID
Species ID is potentially important for the protection of at-risk bird species on wind farms, so the more of these birds which the Spoor system identifies, the more valuable their software will be in certain cases. The system can identify a high percentage of the observed birds but requires some manual input to achieve a high rate of identification. Deep Wind Offshore assumes the AI will improve as more installations are put online and the AI has more data to work with. For scenarios where some manual identification is acceptable, the system already works well.

2. Accuracy
There are not yet published numbers on accuracy on:

- How large percentage of birds are captured by camera
- The accuracy of height and distance (spatial mapping)

To address the first bullet point, Spoor has done manual verification for the installation on Utsira, putting the number of birds detected by the camera at 89 %, which is quite satisfactory.

For the second bullet point: Flight height is a useful parameter when designing wind farms and therefore it’s important to measure this as accurately as possible. Designing the lowest point of the wind turbine blades can be done to accommodate higher flight patterns for sea birds to prevent bird strikes. The accuracy of the data on this campaign is uncertain both due to the specific setup, but also as there is not published data on spatial accuracy. This would have been improved by using a second camera to record “in stereo” but was not selected for this installation.

There are also some general technical limitations of using camera-based observations. The covered area is limited both in distance and field of view, so choosing the correct placement of the equipment is important. This is both an opportunity and a risk. Unless thermal cameras are used, observations are only possible during daylight, which can be limited during the migratory periods in early spring and late autumn. It should be noted that both manual observations by biologists (significantly limited observation window) and bird radars (no species recognition, no recording of collisions) have their own drawbacks.

When the installation is dependent on a grid connection, interruptions may cause loss of data for long periods. There is also an additional challenge of settings resetting. This can be solved by using an UPS.

In general, Deep Wind Offshore’s experience is that Spoor is a promising product that already is useful and could be even more useful when developed further.

5 Conclusion and further work

The Spoor installation at Utsira has given some interesting data on avian life on Utsira and is a start on mapping bird life and design requirements for an offshore wind farm at Utsira Nord. There are still significant activities that need to be carried out to build a complete picture.

In 2023 the project VisAviS led by NINA will start. The project will look at migrating birds in a context of offshore wind. Deep Wind Offshore participates in the project. During the project a bird radar will be installed at Utsira, and it will be interesting to compare measurements from Spoor to the bird radar.