



Energy Islands – Floating LiDAR Measurements

Bat monitor data evaluation report for Lot 2, November 2021 – April 2023

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| Client | ENERGINET |
| Client Address | ENERGINET Eltransmission A/S, Tonne Kjærvej 65, DK-7000 Fredericia, Denmark |
| Client Contact | Guillaume Mougin, Kim Parsberg Jakobsen and Gry Schachtschabel |

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Abbreviations

| Abbreviation | Definition |
|--------------------|---------------------------------------------------|
| CTD | Conductivity, temperature, depth |
| DD | day of month 2 digits |
| DGPS | Dual GPS |
| GNSS | Global Navigation Satellite System |
| GPS | Global positioning system |
| HAT | Highest Astronomical Tide |
| LAT | Lowest Astronomical Tide |
| LiDAR (or lidar) | Light Detection and Ranging |
| MM | month 2 digits |
| MSL | Mean Sea Level |
| MWL | Mean Water Level |
| NaN (Not a Number) | Label indicating data as invalid/missing |
| PEP | Project Execution Plan |
| PPE | Personal Protective Equipment |
| QHSSE | Quality, Health, Safety, Security and Environment |
| QA/QC | Quality Assurance / Quality Control |
| SI | Système International |
| SWLB | Seawatch Wind Lidar Buoy |
| SWMini | Seawatch Mini Wave Buoy |
| UTC | Universal Time Coordinated |
| WMO | World Meteorological Organization |
| WS | Seawatch Wavescan buoy |
| YYYY | year 4 digits |
| EPTNIL | <i>Eptesicus nilssonii</i> |
| MYODAU | <i>Myotis daubentonii</i> |
| MYONAT | <i>Myotis nattereri</i> |
| NYCLEI | <i>Nyctalus leisleri</i> |
| PIP NAT | <i>Nathusius's pipistrelle</i> |
| PIPKUH | <i>Pipistrellus kuhlii</i> |
| PIPPIP | <i>Pipistrellus pipistrellus</i> |
| PIPPYG | <i>Pipistrellus pygmaeus</i> |
| RHIFER | <i>Rhinolophus ferrumequinum</i> |
| RHIHIP | <i>Rhinolophus hipposideros</i> |
| TADTEN | <i>Tadarida teniotis</i> |
| VESMUR | <i>Vespertilio murinus</i> |

Conventions

| Convention | Description |
|------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Time | All times are UTC |
| Directions | <p>Directions are given in degrees (°) increasing clockwise from north. For wind and waves the direction is defined as incoming: 0° means wind/waves from the north, 90° from the east etc. For current velocity, the vector or flow direction is used: 0° means current flowing toward the north, 90° toward the east etc.</p> <p>The directions are subject to the source of heading, which is either compass - relative to magnetic north, or GNSS - relative to true north. Magnetic compass is used for wind directions from Gill, waves and currents, while GNSS is the main heading source for lidar wind directions. Compass data is available (stored in the data logger) as backup heading source for lidar wind directions.</p> <p>At Lot 2 the deviation between magnetic and true north is approximately 2.4°(E). This deviation applies to wave direction orientation and external compass heading data.</p> <p>¹ https://www.ngdc.noaa.gov/geomag/calculators/magcalc.shtml#declination</p> |

Executive Summary

Fugro Norway (OCEANOR) AS entered into an agreement with ENERGINET, Denmark for the project "Floating LiDAR Measurements Energy Island Offshore Wind Farm - Lot 1-4" for initially 12 months. Lots 1, 2 and 4 were extended for an additional 12 months each. The purpose of the assignment is to provide met ocean data obtained through real time measurements at the two (2) energy islands: Energioe Nordsoen and Energioe Bornholm. The results of the atmospheric and oceanographic measurements should be used for verification of the wind energy potential, as basis for derivation of metocean design parameters and as a supplement to the environmental baseline description.

For Lot 2 the following instruments were deployed: a LiDAR buoy (SWLB) together with a bottom mounted Thelma water level sensor, a Seabird SBE CTD string, and a bottom mounted upward-looking Nortek Signature500 current profiler. The buoy was equipped with a Wildlife Acoustics Song Meter bat monitoring system. The collected bat data was stored on the instrument, collected at every service and stored associated with the SWLB ID.

This report covers an initial analysis of the collected bat data at Lot 2 in the North Sea and includes general information on the measurement campaign, as well as a summary of the measurement configuration and automatic data analysis of the bat data between November 2021 and April 2023. For each set of sound recordings per buoy, deployment and SD card, the Auto-ID option was enabled with the classifier library set to "Germany" (Bats_of_Europe_5.4.0).

Bat calls were detected in both winter months and spring and summer months.

The recordings in the winter months (November through February) and during stormy conditions appear to be influenced by wind and wave noise, noise from any of the other systems on the buoys, or bird sounds and the detections are likely false positives. During periods of high sea states, especially in the winter months, both high motion of the buoy and high winds and waves can act as several sources of noise which the automatic algorithm falsely interprets as matches.

The detections in March through May 2022 are more likely to be actual bat call identifications. During this time, sea state and wind conditions were calm and less wind and wave noise is expected in the sound recordings. .

A check of sound files form 18 Aug 2022 revealed a repeating signal pattern of a group of 4 pulses prominent at 40 kHz. This could be an animal sound but it is more likely a machine-generated pattern either from equipment on the buoy or a passing vessel. The detection peak in August 2022 does most likely not include bat calls.

However, these results should be verified by doing a thorough analysis of the respective sound recordings.

1. Introduction

1.1 Energie Nordsoen project area

The Energie Nordsoen project area (**Figure 1-1**) is located approximately 90 km west of Thyborøn, Denmark. The water depth in the 1,100 km² large project area varies between 25 m LAT and 50 m LAT (Admiralty Chart).

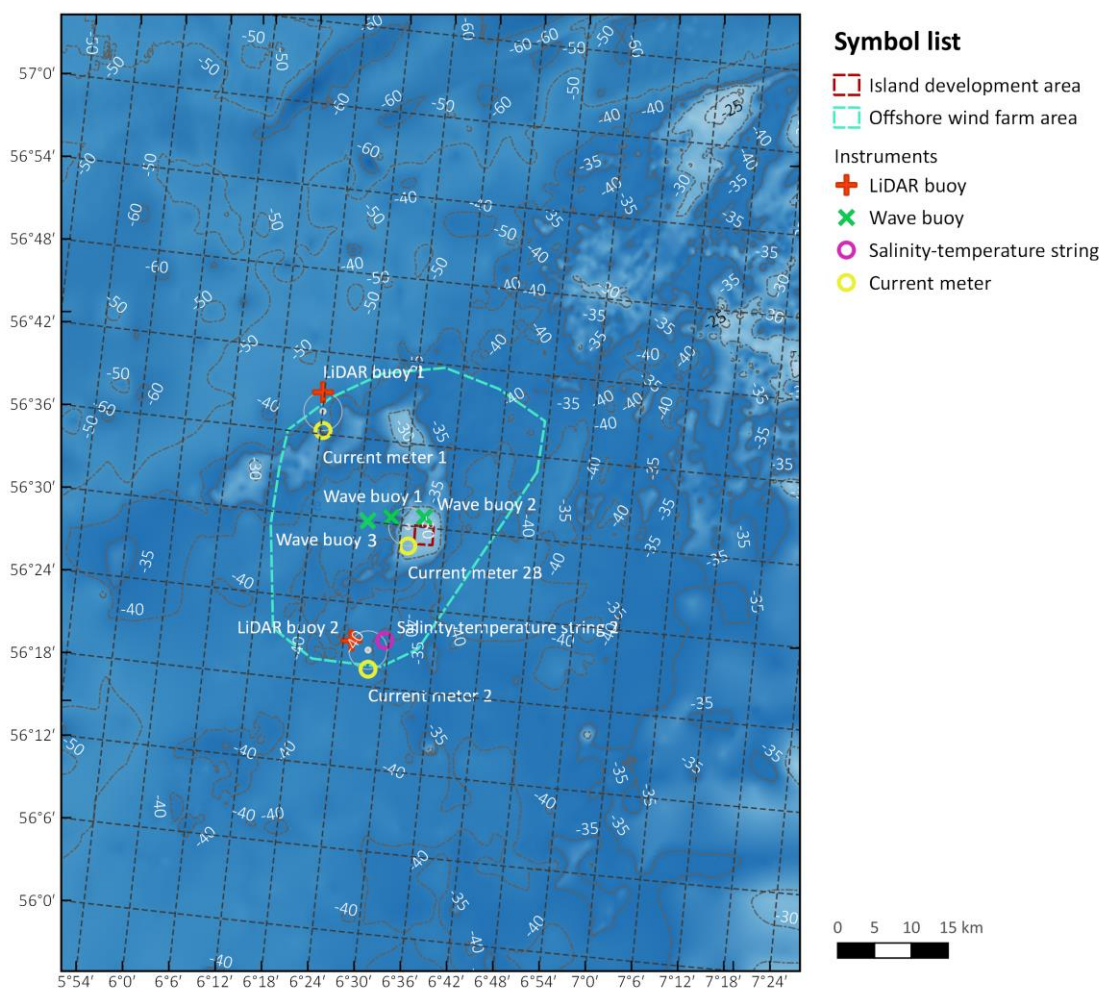


Figure 1-1 Instrument locations in the Energie Nordsoen project area

The aim of the measurement campaign is to provide a set of continuous meteorological and oceanographic (metocean) data with excellent quality and high availability. The measurement campaign lasted 12 months and was extended for an additional 12 months. The results of the atmospheric and oceanographic measurements are to be used for verification of wind energy potential, as basis for derivation of metocean design parameters and as a supplement to the environmental baseline description.

1.2 Lot 2

During the campaign, 2 LiDAR buoys were used at Lot 2: WS181 and WS170. WS181 was deployed on the main Lot 2 mooring. WS170 was deployed in parallel to WS181 from July 2022 until November 2022 at the Lot 2 B mooring. Both LiDAR buoys were equipped with an ultrasonic Wildlife Acoustics Song Meter SM 4BAT FS recorder.

The positions of the bottom mooring weights are listed in [Table 1-1](#). The buoys are free to float around the mooring point within a radius of about 110 m.

LiDAR buoy WS181 was deployed at Lot 2 on 15 November 2021 at 15:30 UTC together with a Seabird SBE CTD string, a bottom mounted Thelma water level sensor and a bottom mounted upward-looking Nortek Signature500 current profiler. On 13 July 2022 at 05:20 UTC, SWLB WS170 was deployed near WS181 in alternate location Lot 2 B after attempts to recover WS181 for service were abandoned due to adverse weather conditions. From 13 July 2022 10:00 UTC, WS170 is considered the main Lot 2 buoy. On 26 October 2022, WS181 was recovered for service at 07:20 UTC. On 30 November 2022, WS181 was deployed on the original Lot 2 mooring at 08:40 UTC and WS170 was recovered for service from alternate location B at 10:00 UTC. From 30 November 2022, 10:50 UTC, WS181 is considered the main Lot 2 buoy. WS181 was recovered for maintenance on 22 April 2023 at 07:10 UTC. There was no lidar buoy at Lot 2 from 22 April 2023 until 13 June 2023. On 13 June 2023 at 09:00 UTC, WS181 was re-deployed on the Lot 2 mooring. At 22:50 UTC on 27 June 2023, WS181 started drifting out of position and opposing the dominant wave and current directions. The speed and pattern of motion suggests that the buoy was dragged by a 3rd party vessel. On 01 July 2023, WS181 was recovered by the vessel that had deployed it on 13 June 2023. After inspection by a Fugro service engineer, the same vessel re-deployed WS181 on 05 July 2023 at 09:40 UTC with a new mooring at the main Lot 2 location. The campaign ended on 15 November 2023 but was extended further until 24 February 2024. WS181 was finally recovered on 26 April 2024.

[Table 1-2](#) shows a log of the deployments at Lot 2. This table should be consulted when using the bat data, as only data collected during times when the buoys were offshore should be considered.

For this report, sound recordings until April 2023 were analysed.

Table 1-1 Buoy locations and water depth

| Buoy | Location | Latitude [°N] | Longitude [°E] | Water Depth [m MWL] |
|---------------------|-------------------|------------------|-------------------|------------------------|
| LiDAR Buoy 2 (SWLB) | North Sea/Lot 2 | 56.3444 | 6.4574 | 39.8 |
| LiDAR Buoy 3 (SWLB) | North Sea/Lot 2 B | 56.343 | 6.4555 | 40.0 |

Table 1-2 Deployments at Lot 2

| Deployment | Station | Buoy S. no. | LiDAR # | Start time (UTC) | End time (UTC) | Status |
|------------|---------|-------------|---------|---------------------|---------------------|-------------------------|
| D01-SWLB | Lot 2 | WS181 | ZX759 | 2021-11-15 15:30 | 2022-10-26 07:20 | Recovered for service |
| D02-SWLB | Lot 2 B | WS170 | ZX585 | 2022-07-13 05:20 | 2022-11-30 10:00 | Recovered for service |
| D03-SWLB | Lot 2 | WS181 | ZX759 | 2022-11-30 10:50 | 2023-04-22 07:10 | Recovered for service |
| D04-SWLB | Lot 2 | WS181 | ZX759 | 2023-06-13 09:00 | 2023-07-27 22:50 | Drifted out of position |
| D05-SWLB | Lot 2 | WS181 | ZX759 | 2023-07-05 09:40 | 2024-02-24 23:50 | End of campaign |

2. Measurement configuration, data analysis, and post-processing

2.1 Measurement configurations

The general measurement setup, sensors, configurations, and measurement scheme of the whole campaign are described in the measurement plan [1].

Bat activity was recorded using a weatherproof, single channel, full-spectrum, ultrasonic Wildlife Acoustics Song Meter SM 4BAT FS recorder. Firmware algorithms attempt to detect and count individual echolocation pulses from bats and sequences of bat pulses based on configured parameters. A “bat pass” refers to a series of pulses recorded as a bat passes by the microphone. A bat pass begins with the first detected pulse and ends when either no pulses have been detected after the maximum time between pulses has occurred, or when the maximum trigger duration has been reached.

The SM 4BAT FS recorder was placed inside the central cylinder of the buoy where it was protected from any water intrusion. The SMM-U2 microphone was placed on the secondary mast in ca. 4 m height and connected with the recorder via a cable. On both WS170 and WS181, the power supply system was air-cooled using air-intake pipes. **Figure 2-1** shows the mounting arrangement for WS170 and WS181.

Table 2-1 summarizes the measurement configuration of the SM 4BAT FS recorders. The recorders were set to record all.

A Gill Windsonic M acoustic wind sensor was mounted at 4 m height on the main mast on each buoy. The buoy also recorded sea state data with a Wavesense 3 directional wave sensor. The wind and wave measurements were averaged every 10 minutes and reported monthly. **Table 2-2** summarizes the measurement configuration of the Wavesense 3 directional wave sensor and Gill Windsonic M acoustic wind sensor.

At the end of each deployment, the SD cards were recovered from the bat recorders and replaced with new cards. The sound recordings were downloaded and stored under the Lot number and buoy designation.

Table 2-3 summarizes the high-level folder structure. Each subdirectory includes a “Data” directory which contains the .w4v recordings.

Please note that all recordings have been provided, also those taken while the buoy was still on land, and **Table 1-2** should be consulted to ensure that only data when the buoys were offshore is considered.

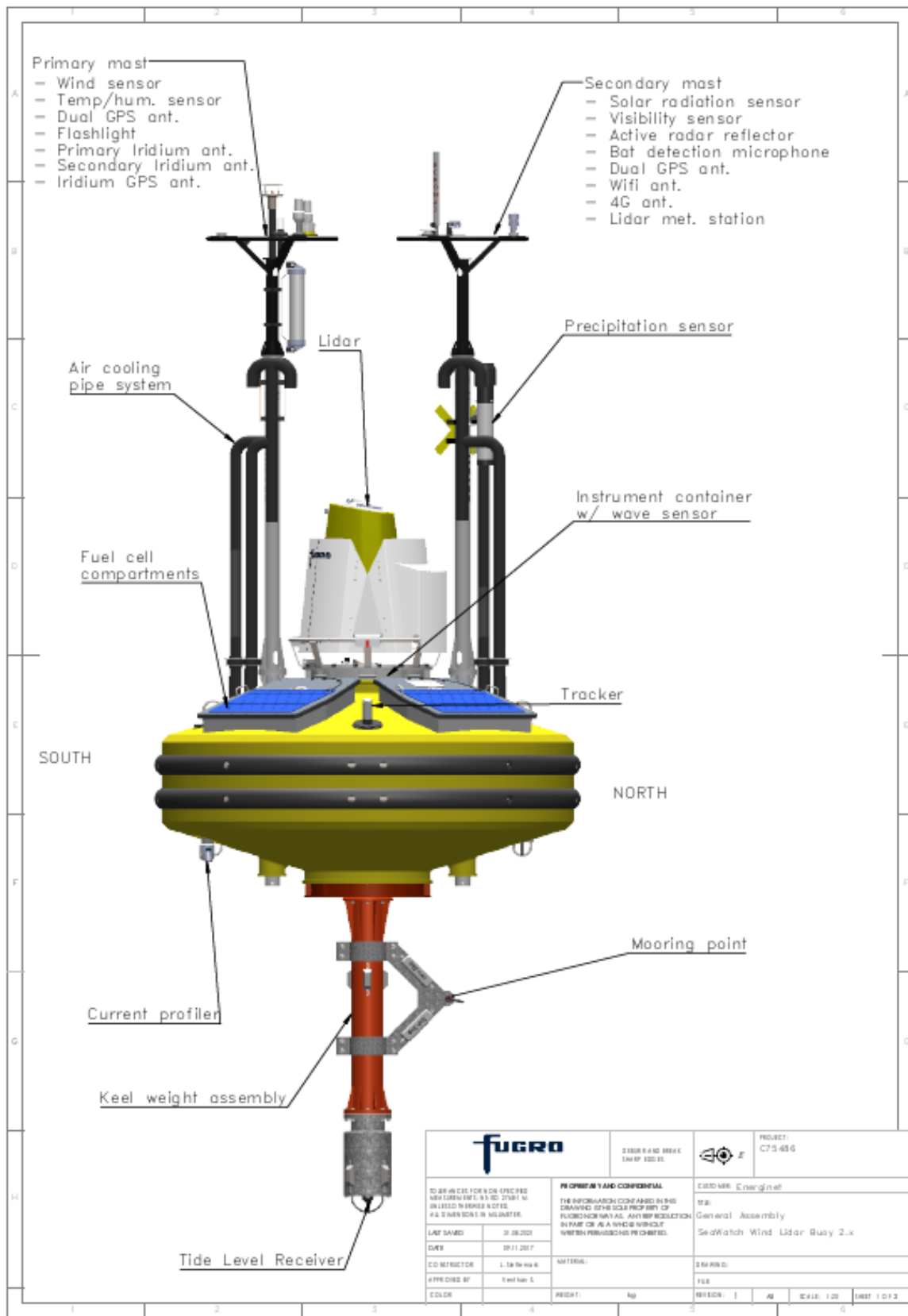


Figure 2-1 SWLB Mounting arrangement (air cooling)

Table 2-1 Configuration of the SM 4BAT FS recorder

| Parameter | Unit | Setting |
|------------------------|---------|---------|
| SD cards (slots 1 & 2) | GB | 512 |
| Mic 0 | - | SMM-U2 |
| Trig Ratio | % | 10 |
| Gain | dB | 12 |
| 16kHz high filter | - | off |
| Sample rate | kHz | 256 |
| Min duration | mxs | 1.5 |
| Max duration | - | None |
| Min trig frequency | kHz | 16 |
| Trigger level | dB | 6 |
| Trigger window | s | 3.0 |
| Max length | (mm:ss) | 00:15 |
| Compression | - | W4V-8 |
| Record | - | always |

Table 2-2 Configuration of the wave and wind sensors

| Instrument Type | Sensor Height [m] | Parameter Measured | Sample Height ¹ [m] | Sampling Interval [s] | Averaging Period [s] | Burst Interval [s] ² | Measurement Resolution |
|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------|-----------------------------------|--------------------------------|-----------------------|------------------------------|---------------------------------|--------------------------|
| Wavesense 3 | 0 | Heave, pitch, roll, heading | 0 | 0.5 | Time series duration: 1024 s | 1024 | 0.1m, 0.2°, 0.2° 0.5° |
| | | Sea state parameters ³ | 0 | 600 | 1024 | 1024 | 0.1m, 0.2°, 0.1s |
| Gill Windsonic M | 4.1 | Wind speed and direction | 4.1 | 1 | 600 | 600 | 0.01m/s 1° |
| <p>Notes</p> <p>¹ = Height relative to actual sea surface.</p> <p>² = A burst of measurements is the raw data time series used to calculate the average parameters. The burst interval is the time from the beginning of one burst to the beginning of the next burst, and equal to the interval between writing of raw data to disk and transmissions.</p> | | | | | | | |

Table 2-3 Data files - Sound recordings

| Lot and buoy | Deployment subdirectory |
|---------------------------------------------------------------------------------------------------------------------------------------|-------------------------------|
| Lot2_WS181 | D1_Lot2_D01_Nov2021_Oct2022 |
| Lot1_WS170 | D1_Lot1_D01_Nov2021_May2022** |
| Lot2_WS181 | D2_Lot2_D03_Nov2022_Apr2023 |
| ** Please note that this subfolder was mis-labeled. The files in this folder cover the period Lot2 D02 July 2022 until November 2022. | |

2.2 Post processing

The general data flow, post-processing and quality control applied to the buoy data before they are delivered to the client is described in the measurement plan [1].

This chapter outlines the analysis of the bat recordings using the Wildlife Acoustics Kaleidoscope Pro software with the automatic identification algorithm enabled.

According to the Kaleidoscope Pro Manual [2], Auto-ID for Bats is an automated batch process analysis where the input files are separated into segments according to any split to max duration setting. Then full-spectrum files are converted to zero-crossing format. By default, full-spectrum to zero-crossing format conversion is enhanced with advanced signal processing. Files are then analysed for the presence of bat calls. Initial analysis is based on the signal parameter settings summarized in **Table 2-4**. Files which do not meet the described signal parameters are designated as Noise files. Input file segments which meet the signal parameter settings are passed to the Auto-ID function [2].

Table 2-4 Signal parameters

| Parameter | Unit | Setting |
|-----------------------------------|------|---------|
| Minimum frequency | kHz | 8 |
| Maximum frequency | kHz | 120 |
| Minimum pulse length | ms | 2 |
| Maximum pulse length | ms | 500 |
| Maximum inter-syllable gap | ms | 500 |
| Minimum number of pulses | int | 2 |
| CF noise filter maximum frequency | kHz | 0 |
| CF noise filter maximum bandwidth | kHz | 0 |

For each set of sound recordings per buoy, deployment and SD card, the Auto-ID option was enabled with the classifier library set to "Germany" (Bats_of_Europe_5.4.0). The classifier library contains multiple individual Species Classifiers which are used to comparing recordings of bat calls to a known Species Classifier.

Statistical analysis is then performed on the detected bat calls. Statistical information includes the number of detected calls and average call characteristics. Identified bat calls are compared to enabled Species Classifiers within a classifier library. If a detected call in the file matches any reference call in the enabled Species Classifiers, the individual call is identified with a species type. If a detected call does not match calls in any enabled Species Classifier, the call is labeled No ID. Sequences of identified pulses are analyzed to create a file-level AUTO-ID designation. If multiple species are detected within a single file, Alternate IDs are created [2].

Table 2-5 summarizes the content of the output files of the AUTO-ID analysis mode.

Table 2-5 Output files of the Auto-ID process

| Output file | Description |
|---------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| settings.ini | This file is a snapshot of every setting in Kaleidoscope Pro at the time of the Auto-ID for Bats batch process. The settings.ini file is additionally useful because it provides a record of any custom Button Labels in the Viewer |
| idsummary.csv | This file provides a summary of which species were detected in the analysis. The total number of files labeled with an Auto-ID tag are listed for each species. Likelihood of presence probability is provided for each Species Classifier which was enabled in the batch process. |
| id.csv | This file contains the analysis results for each file or file segment in the input batch. The id.csv file contains extensive statistical information regarding the content of the input files. The main output parameters are: <ul style="list-style-type: none"> - AUTO-ID - This field shows the file-level automatic species identification. - PULSES - This is the number of total pulses detected in the file or file segment. The number of pulses is based on usable detections. - MATCHING - The number of detected pulses which match the AUTO-ID. - MATCH RATIO - The ratio of MATCHING over PULSES. |
| meta.csv | The meta.csv file contains a record of the input files used in the batch process. |
| db-batch.wdb | This file contains a record of the cluster analysis batch process in the form a file which can be uploaded to a database. |
| log.txt | Log file |

For each deployment, the id.csv files were used to create time series of pulses and match ratio were plotted.

The AUTO-ID results were summarized in tabular form.

For comparison, significant wave height (hm0), mean wave direction (mdir), and wind speed and direction from the Gill Windsonic M acoustic wind sensor at 4 m height are also presented in [Section 0](#).

Only very few spot checks (< 10) of the sound recordings versus the AUTO-ID results were done to gain an indication whether the detections are trustworthy or are dominated by false positives. [Section 4](#) summarizes caveats to be considered when using the results of the automatic analysis.

3. Presentation of the Auto-ID results

During deployment 1, the recordings cover the period from November 2021 until May 2022. The dataset for D01 is split into two batches (A and B). A and B were analysed separately. Only few calls were detected between November 2021 and 23 January 2022. There are a high number of detections between 23 and 25 January 2022. In batch B, calls were detected in February, March, and April 2022. **Table 3-1** summarizes the number of Auto ID detections for batch A and **Table 3-2** for batch B. **Figure 3-1** shows timeseries of pulses, matches and match ratio for batch A during the period from November 2021 until January 2022. **Figure 3-2** shows timeseries of pulses, matches and match ratio for batch B during the period from February until May 2022.

Table 3-1 Lot 2 D01 WS181 A Auto ID summary Nov 2021 – Jan 2022

| Auto ID | Species | Number of separate detections | Timeframe detected |
|---------|--------------------------------|-------------------------------|--------------------|
| PIPPYG | <i>Pipistrellus pygmaeus</i> | 1 | Dec 2021 |
| PIP NAT | <i>Nathusius's pipistrelle</i> | 5 | Dec 2021 |
| PIPKUH | <i>Pipistrellus kuhlii</i> | 4 | Jan 2022 |
| NYCLEI | <i>Nyctalus leisleri</i> | 4 | Jan 2022 |
| PIP NAT | <i>Nathusius's pipistrelle</i> | 50 | Jan 2022 |

Table 3-2 Lot 2 D01 WS181 B Auto ID summary Feb 2022 – May 2022

| Auto ID | Species | Number of separate detections | Timeframe detected |
|---------|----------------------------------|-------------------------------|--------------------|
| EPTNIL | <i>Eptesicus nilssonii</i> | 1 | Mar 2022 |
| VESMUR | <i>Vespertilio murinus</i> | 1 | Mar 2022 |
| MYODAU | <i>Myotis daubentonii</i> | 2 | May 2022 |
| RHIFER | <i>Rhinolophus ferrumequinum</i> | 2 | Mar 2022 |
| PIPPYG | <i>Pipistrellus pygmaeus</i> | 4 | Feb 2022 |
| PIPKUH | <i>Pipistrellus kuhlii</i> | 8 | Feb 2022 |
| RHIHIP | <i>Rhinolophus hipposideros</i> | 8 | Feb, Mar, Apr 2022 |
| NYCLEI | <i>Nyctalus leisleri</i> | 48 | Feb, Mar, Apr 2022 |
| PIP NAT | <i>Nathusius's pipistrelle</i> | 225 | Feb, Mar, Apr 2022 |

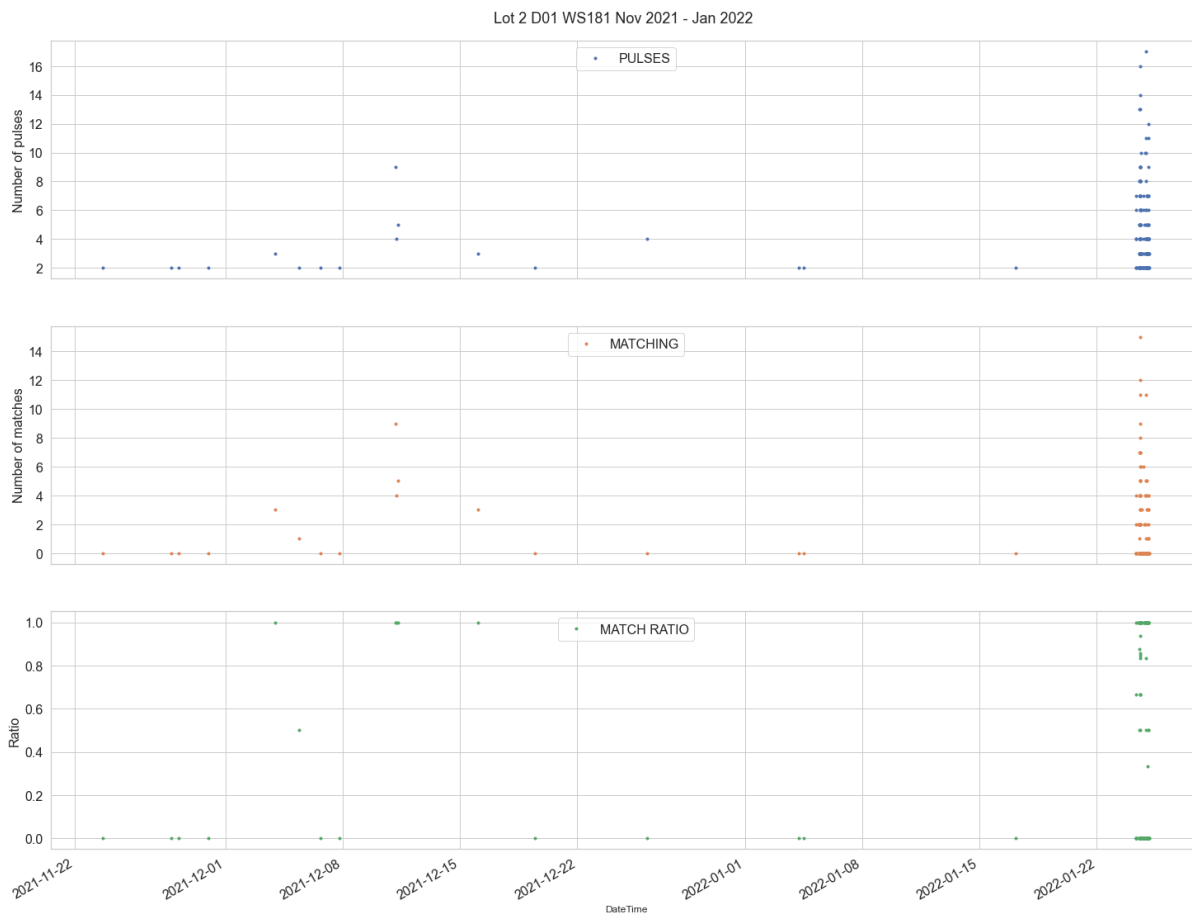


Figure 3-1 Pulses, matches and match ratio during the period from November 2021 until Jan 2022 (batch A)

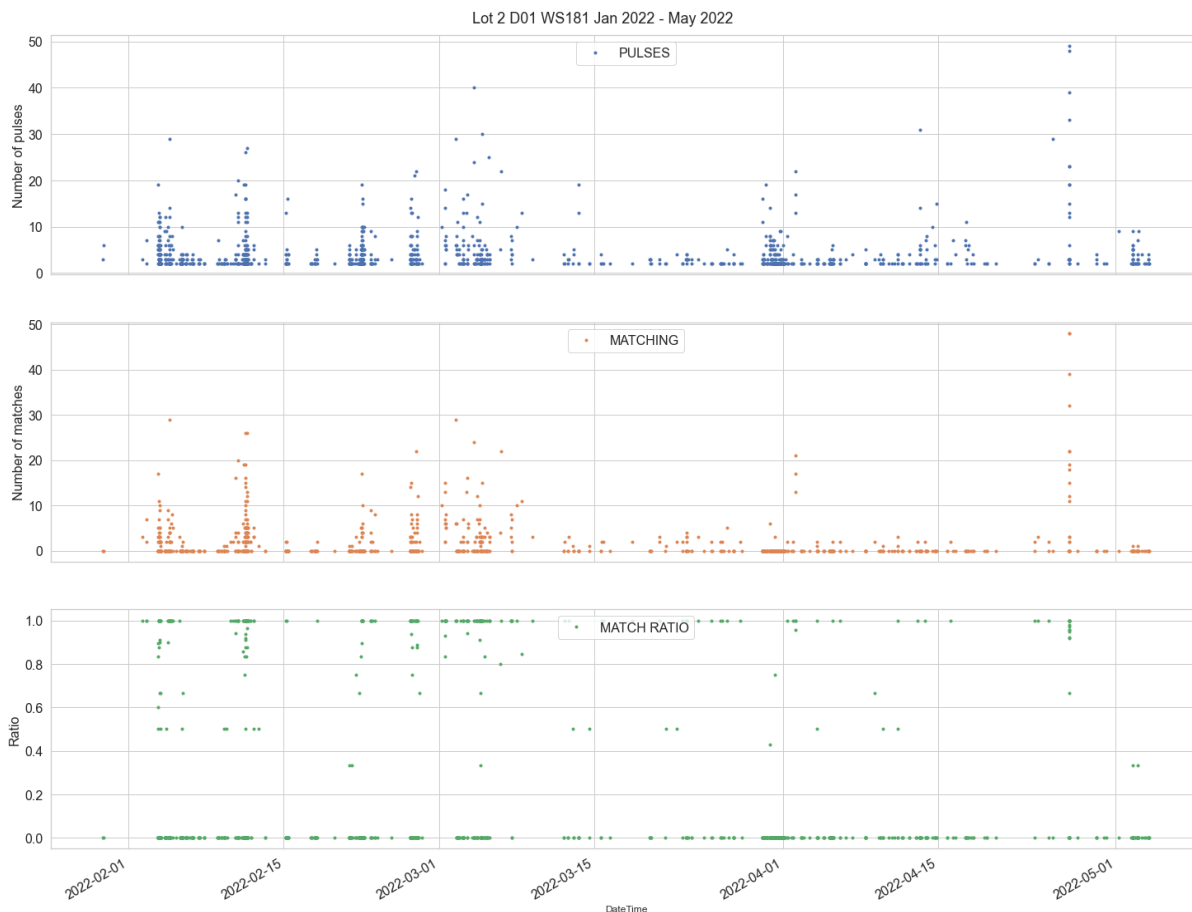


Figure 3-2 Pulses, matches and match ratio during the period from February 2022 until May 2022 (batch B)

During deployment 2 (July – October 2022), the sound recordings were made at location 2 B. Most matches were found in July 2022. There is a single peak on 18 August 2022. **Table 3-3** summarizes the number of Auto ID detections for deployment 2. **Figure 3-3** shows timeseries of pulses, matches and match ratio during the period from July until October 2022.

Table 3-3 Lot 2 D02 WS170 Auto ID summary July 2022 – October 2022

| Auto ID | Species | Number of separate detections | Timeframe detected |
|---------|--------------------------------|-------------------------------|-----------------------|
| PIP NAT | <i>Nathusius's pipistrelle</i> | 188 | Jul 2022, 18 Aug 2022 |
| PIP KUH | <i>Pipistrellus kuhlii</i> | 528 | Jul 2022, 18 Aug 2022 |

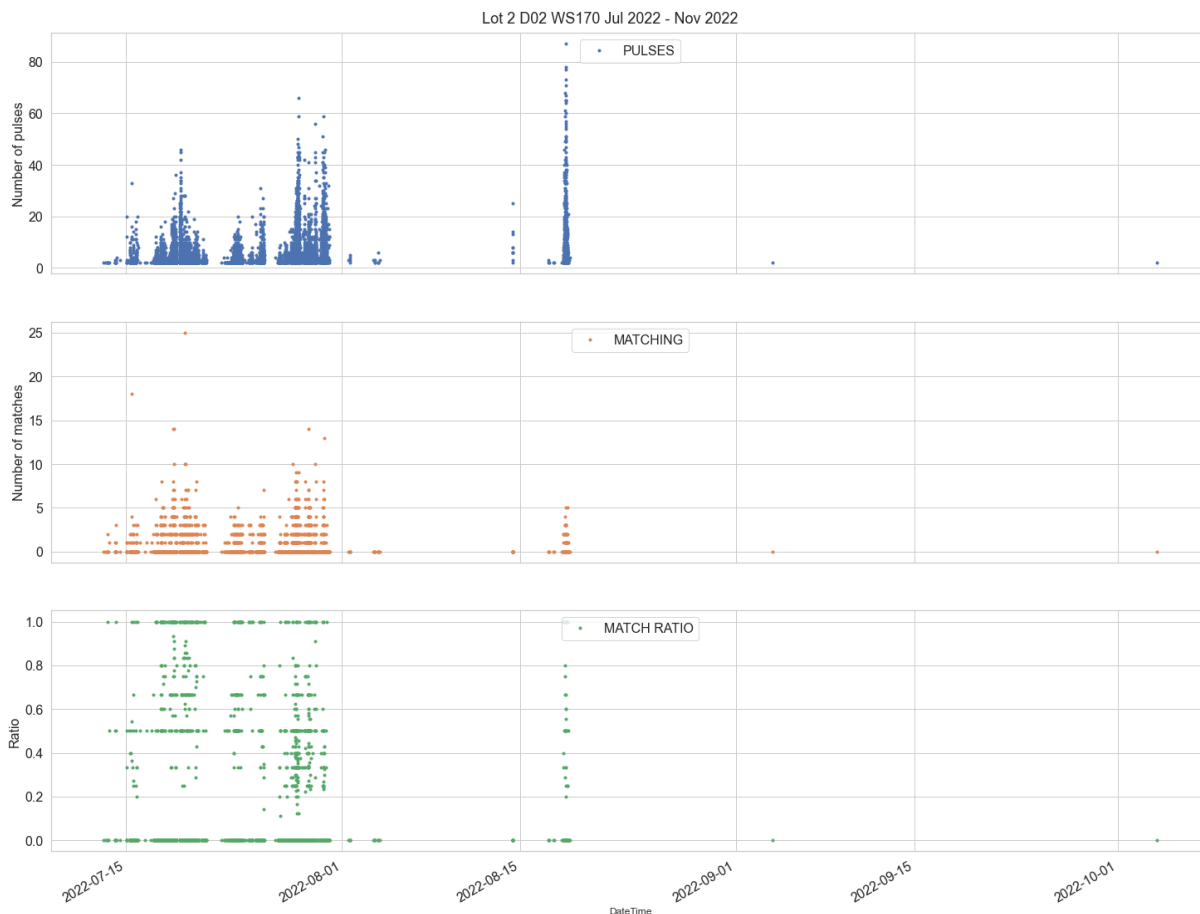


Figure 3-3 Pulses, matches and match ratio during deployment D02, WS170, from July 2022 until October 2022

During deployment 3 (November 2022 – April 2023), the sound recordings were made at location 2. Most matches were found in December 2022 and February 2023. **Table 3-4** summarizes the number of Auto ID detections for deployment 3. **Figure 3-4** shows timeseries of pulses, matches and match ratio during the period from November 2022 until April 2023.

Table 3-4 Lot 2 D03 WS181 Auto ID summary November 2022 – April 2023

| Auto ID | Species | Number of separate detections | Timeframe detected |
|---------|--------------------------------|-------------------------------|--------------------|
| PIPKUH | <i>Pipistrellus kuhlii</i> | 1 | Dec 2022 |
| PIP NAT | <i>Nathusius's pipistrelle</i> | 30 | Dec 2022, Feb 2023 |
| NYCLEI | <i>Nyctalus leisleri</i> | 46 | Dec 2022, Feb 2023 |

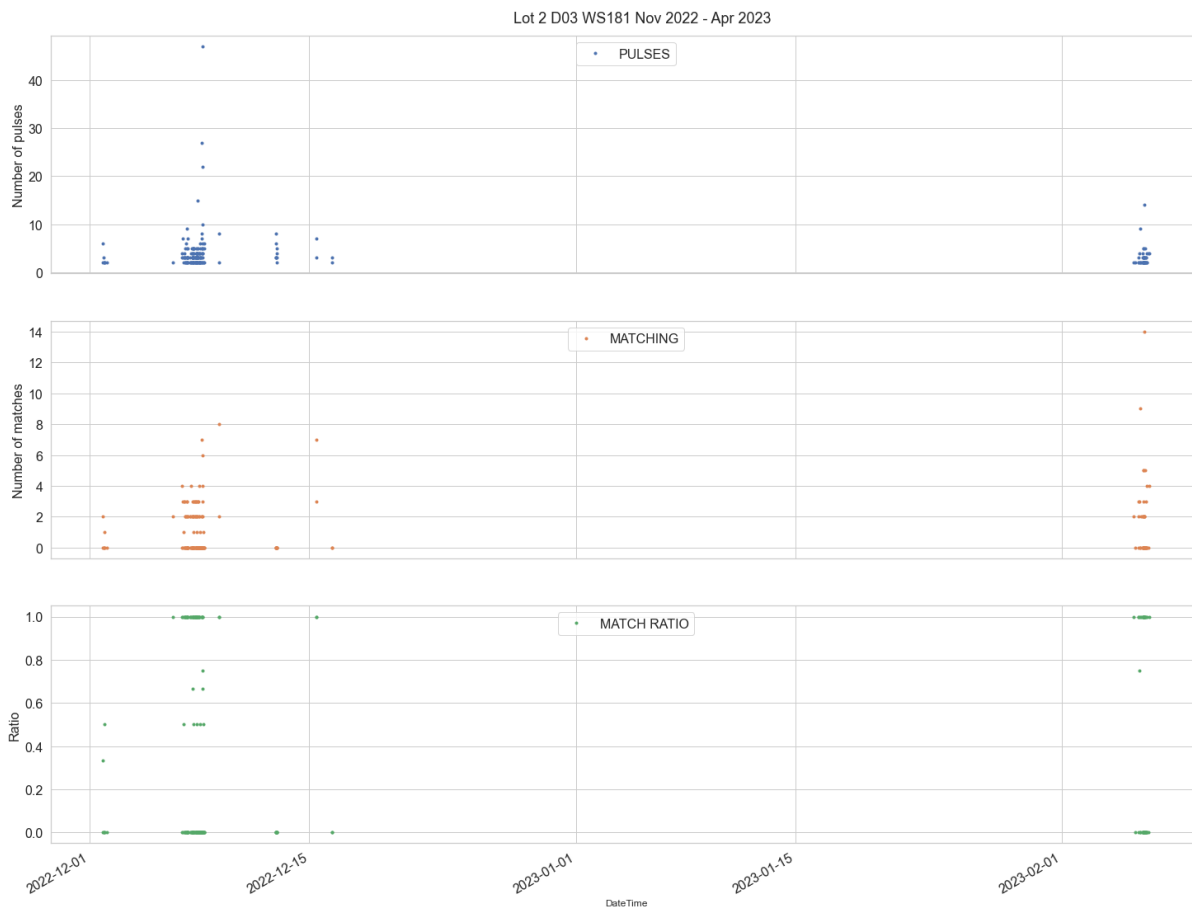


Figure 3-4 Pulses, matches and match ratio during deployment D04, WS181, from November 2022 until March 2023.

4. Discussion

4.1 Comparison with sea state

During deployment 1, the recordings cover the period from November 2021 until May 2022. Only few calls were detected between November 2021 and 23 January 2022. There are a high number of detections between 23 and 25 January 2022. Calls were also detected in February, March, and April 2022.

During November 2021 – January 2022, the buoys experienced winter storm conditions (**Figure 4-1**). Wind speeds measured at 4 m mast height exceeded 15 m/s and wave heights reached 5 m. Motion of both the buoy and the masts was high. Since the microphone was mounted on top of the secondary mast, it must be considered that the recordings are influenced by noise from wind and waves during this time. In addition, the recordings could also be dominated by bird sounds.

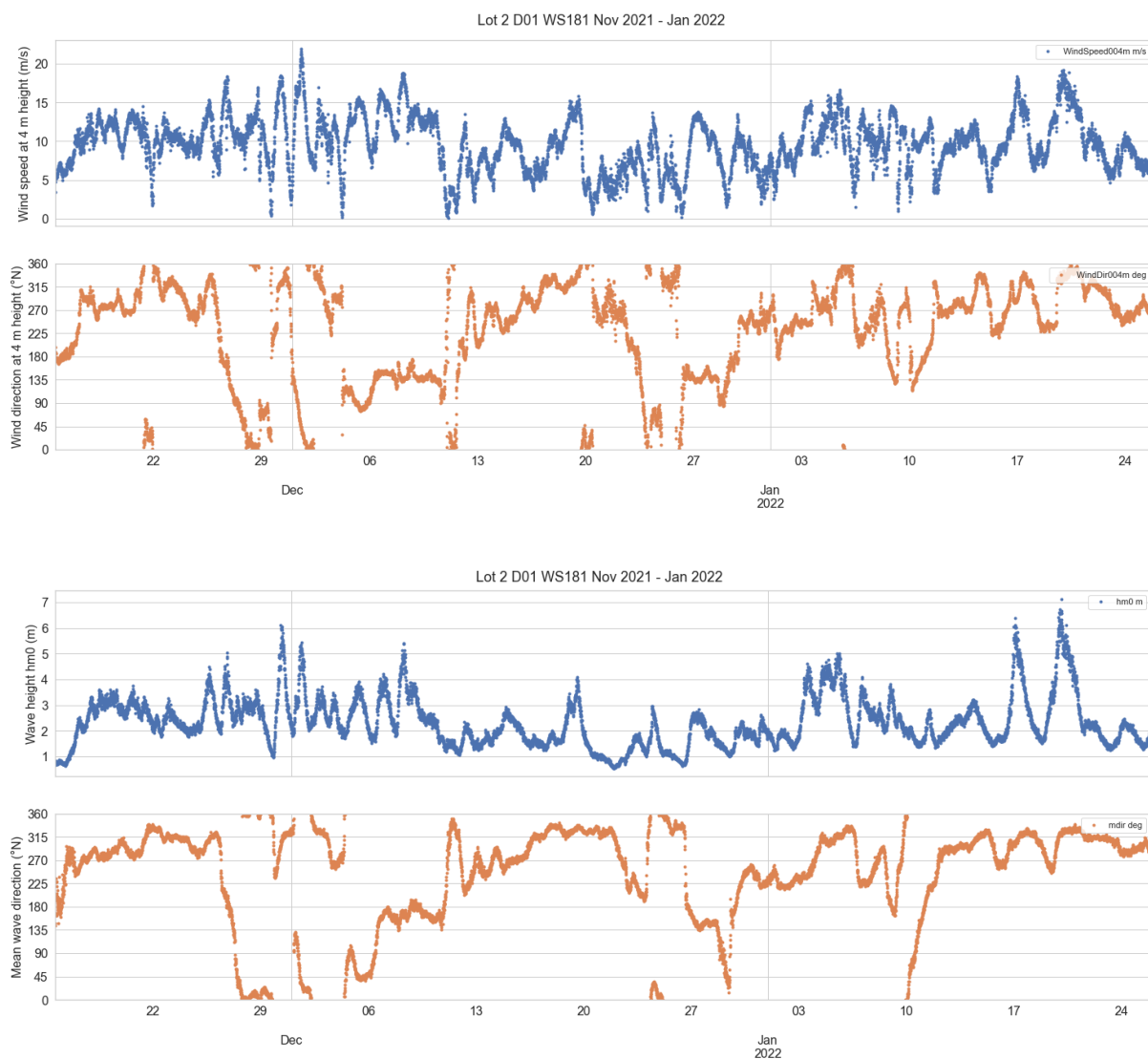


Figure 4-1 Wind speed and direction at 4 m height (top) and significant wave height and wave direction (bottom) from November 2021 until January 2022.

In February, March, and April 2022, winds were still strong but wave heights were generally lower and thus buoy motion was lower than during the winter. The detections, with the main ID assigned as PIPNAT, could possibly be bat calls.

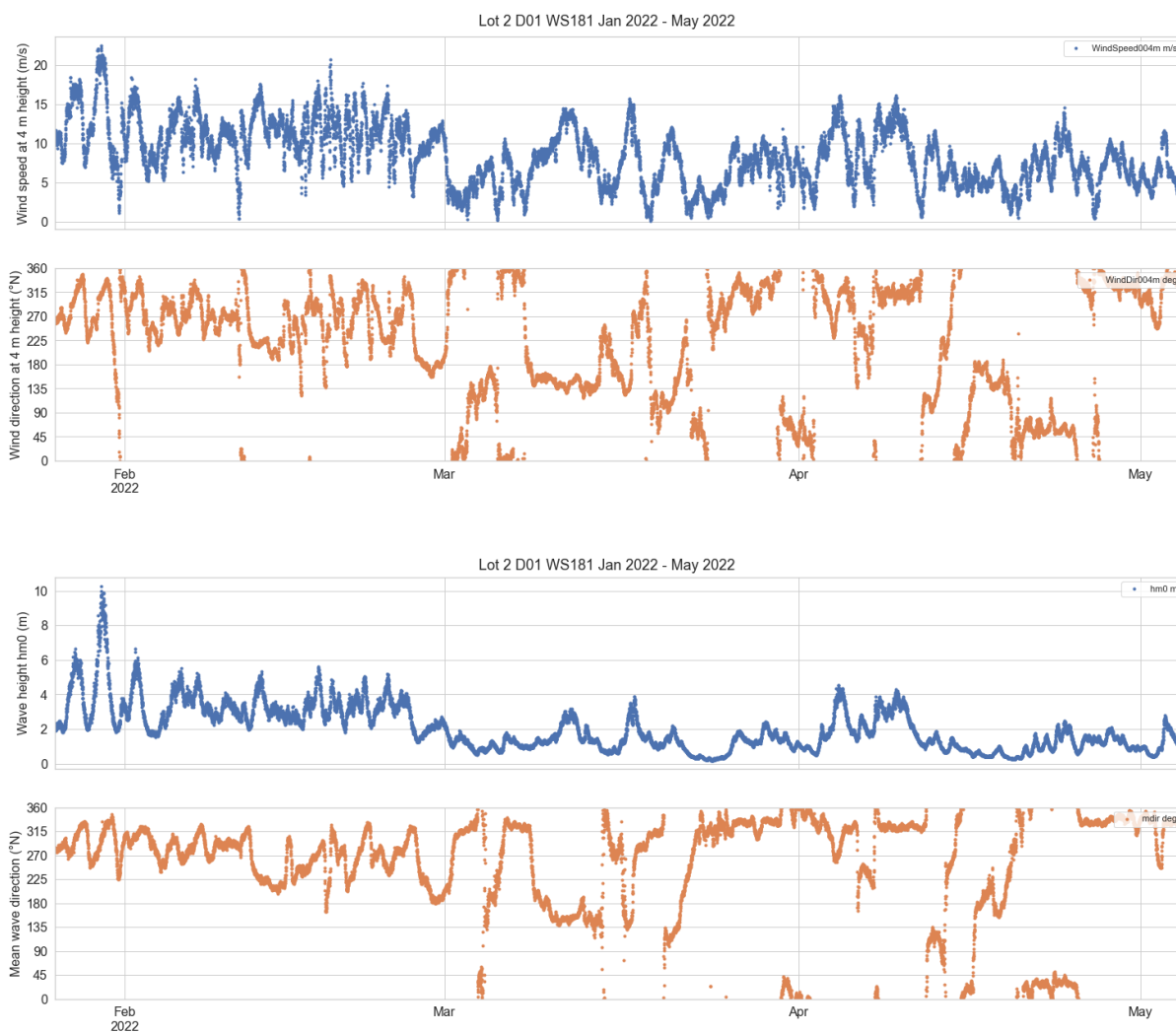


Figure 4-2 Wind speed and direction at 4 m height (top) and significant wave height and wave direction (bottom) from February 2022 until May 2022.

During deployment 2 (July – October 2022), most matches, with the main ID assigned as PIPKUH were found in July 2022. There is a single peak on 18 August 2022.

During this time, sea state and wind conditions were generally calm (Figure 4-3) except around 18 August 2022. During calm periods less wind and wave noise is expected and the detections could possibly be bat calls. However, the stormy conditions on 18 August 2022, could have introduced noise.

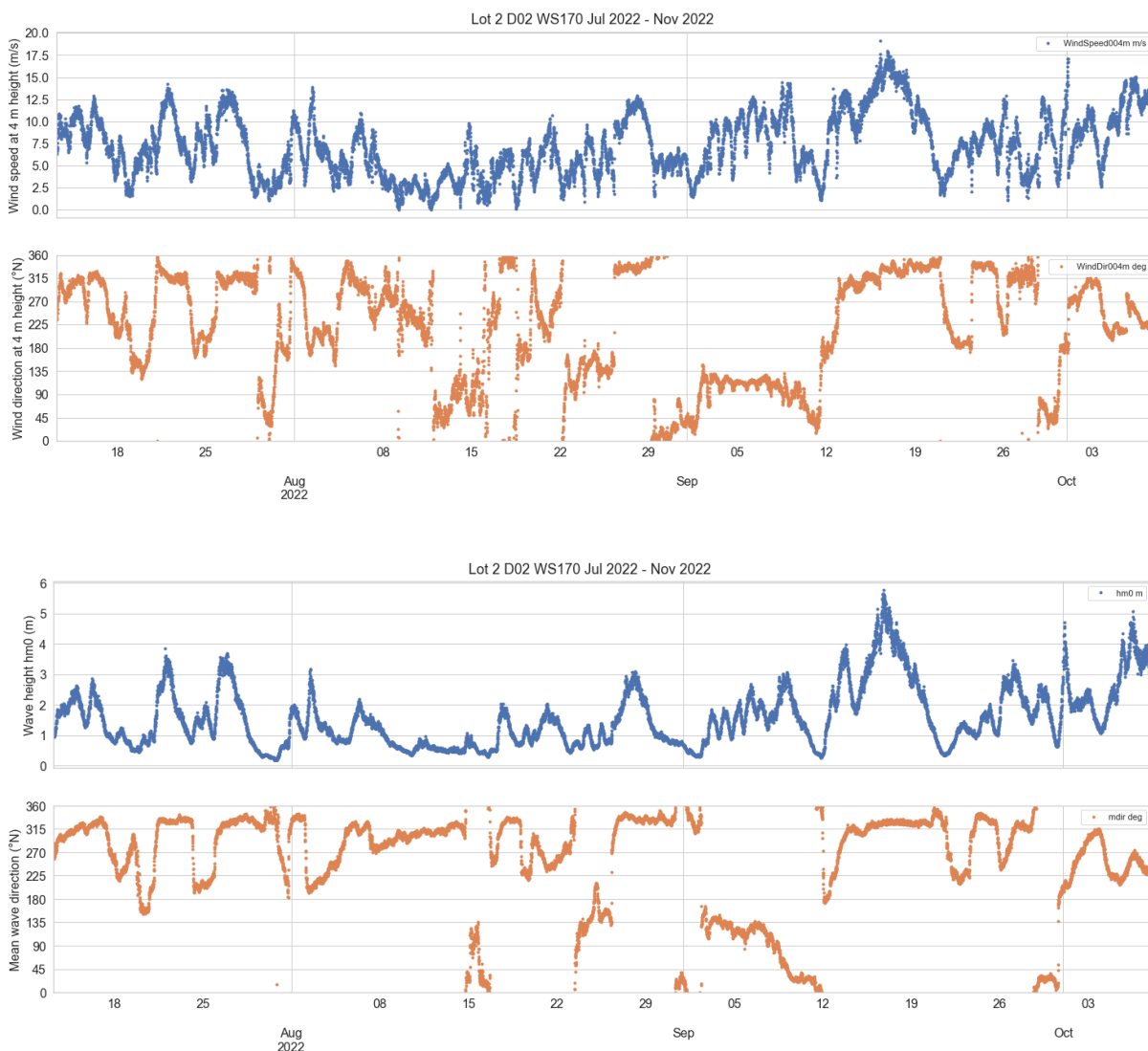


Figure 4-3 Wind speed and direction at 4 m height (top) and significant wave height and wave direction from July 2022 until October 2022.

During deployment 3 (November 2022 – April 2023), most matches were found in December 2022 and February 2023. This was a period of higher winds and higher sea states and thus higher buoy motion. It must be considered that the recordings are influenced by noise from wind and waves during this time.

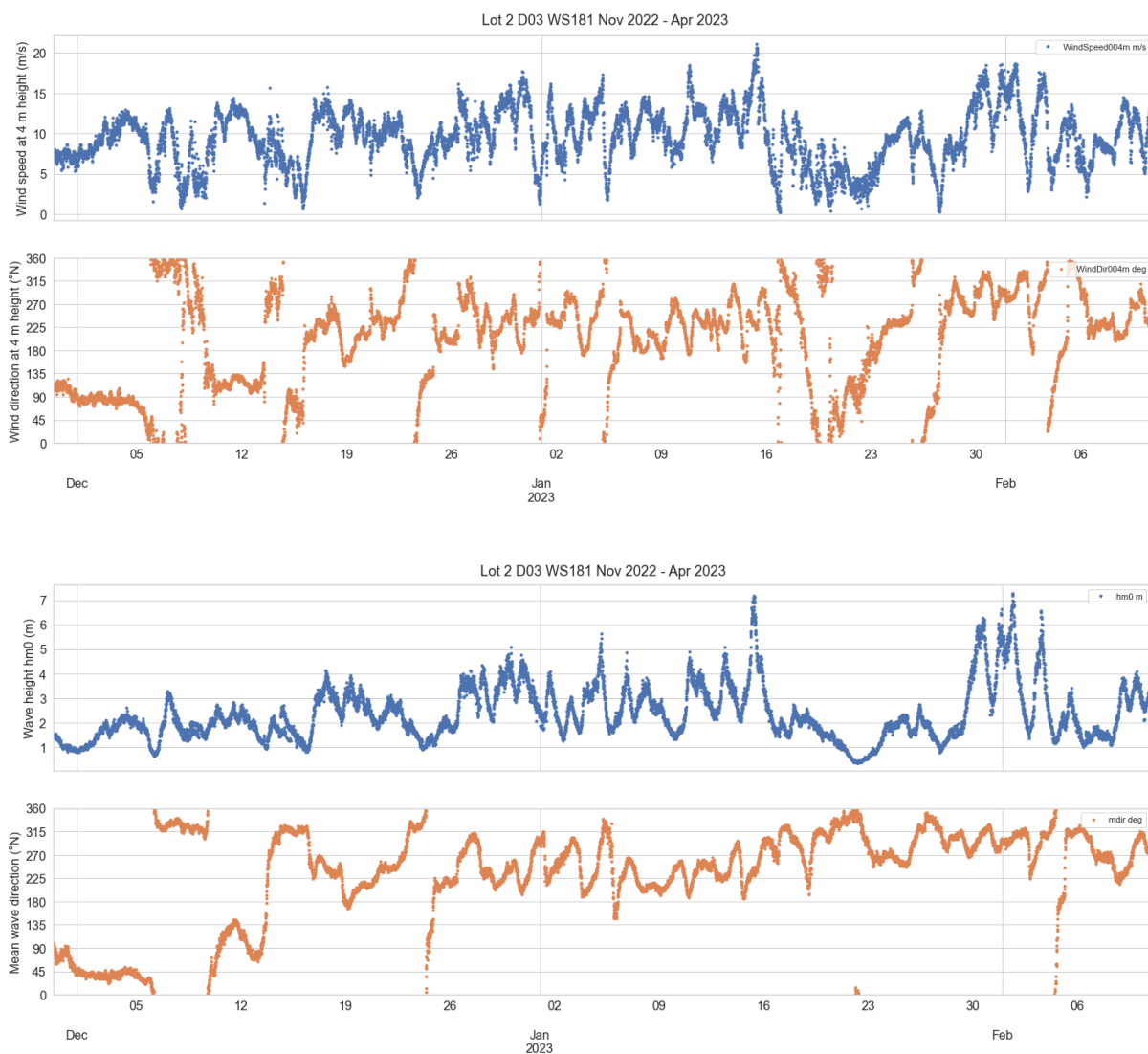


Figure 4-4 Wind speed and direction at 4 m height (top) and significant wave height and wave direction from November 2022 until April 2023.

Only very few spot checks (< 10) of the sound recordings versus the AUTO-ID results were done. A check of a recording from December 2021 indicates a continuous repeating signal pattern which seems connected to machine-generated sound. In addition, there are faint larger patterns, which could be related to wind, waves or birds.

A spot check of a recording in spring 2022 revealed a sound pattern that was likely correctly identified.

A check of 3 sound files from 18 Aug 2022 revealed a repeating signal pattern of a group of 4 pulses prominent at 40 kHz. This could be an animal sound but it is more likely a machine-generated pattern either from equipment on the buoy or a passing vessel. The detection peak in August 2022 does most likely not include bat calls.

4.2 Limitations in the applied methodology

There are a number of caveats that should be considered when using this dataset.

1. Placement of the microphone and recorder:
 - a. The microphone was mounted on top the secondary mast at 4 m height. The masts are somewhat flexible and can move with the wind. The buoy itself moves with the waves and the masts move with the buoy. During periods of high sea states, especially in the winter months but also at other times, both high motion of the buoy and high winds and waves can act as several sources of noise.
 - b. There is a possibility that additional noise from the air-intake pipes on WS170 could distort the recordings.
 - c. There is a possibility that noise from the buoy's power supply system or sounds from other sensors could distort the recorded signals or introduce repetitive sound patterns.
 - d. The recorder was mounted inside the buoy's cylinder where it was kept waterproof. However, this location is difficult to access. The instrument was thus left on to record at all times which used up disk space and battery power.
2. Measurement configuration:
 - a. The instrument was configured to detect all sounds at all times with the default cut-offs activated. The scheduling option was not activated and thus the recordings were not targeted to exclude background noise and winter storms.
 - b. The instrument was configured with the default frequency cut-offs.
3. Automatic processing and species identification:
 - a. The signal processing was run with the default parameters and frequency cut-offs.
 - b. There is a possibility that the recordings could include bird sounds that distort the shape of the bat calls and could lead to misidentifications.
 - c. Bats use echolocation for navigation and hunting, they adapt their calls in real time to respond to their situation. Individual species of bats can display extremely variable repertoires of call types [2] which may not all be captured in the species classifier library.
 - d. Classifiers are generally built using recordings of individual bats in free flight, in low clutter environments. Background noise (e.g. wind, waves, buoy's power supply system) can obscure the call shape and influence the automatic ID accuracy [2].
 - e. A thorough analysis of all single sound recordings was not done.

5. Conclusion

Background noise, clutter or echo can obscure the bat calls. Thus, it should be expected that there will be false positive and false negative identifications [2].

The recordings in the winter months (November through February) and during stormy conditions appear to be influenced by wind and wave noise, noise from any of the other systems on the buoys, or bird sounds and are likely false positives. During periods of high sea states, especially in the winter months, both high motion of the buoy and high winds and waves can act as several sources of noise which the automatic algorithm falsely interprets as matches.

The detections in March through May 2022 are more likely to be actual bat call identifications. During this time, sea state and wind conditions were calm and less wind and wave noise is expected in the sound recordings. .

A check of sound files from 18 Aug 2022 revealed a repeating signal pattern of a group of 4 pulses prominent at 40 kHz. This could be an animal sound but it is more likely a machine-generated pattern either from equipment on the buoy or a passing vessel. The detection peak in August 2022 does most likely not include bat calls.

However, these results should be verified by doing a thorough analysis of the respective sound recordings.

6. References

- [1] Fugro, "SWLB measurements at Energy Islands Project Measurement Plan, All Lots," Fugro, 2022.
- [2] Wildlife Acoustics, Inc., "Kaleidoscope Use Guide," 12/16/2022.