Bat activity at offshore wind farms LUD and PAWP in 2016

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Contents

1 Introduction

1.1 Context

For quite some time, there have been indications of bat movements at the North Sea. Observers of bird migration at the Dutch coast regularly report bats flying in from sea (Lagerveld *et al.* 2014a). Bats have also been observed during ship-based bird surveys in the North Sea and found on oil and gas platforms, ships, remote islands (Walter *et al.* 2007, Boshamer and Bekker 2008), and several ringed Nathusius' Pipistrelles have shown that they are able to cross the North Sea successfully (http://www.bats.org.uk/pages/national_nathusius_pipistrelle_project.html).

Numerous studies have shown that onshore wind turbines can cause high fatality rates amongst bats (for a recent review see Arnett *et al.* 2016). Therefore it cannot be ruled out that offshore wind turbines can also have a negative impact on bat populations, if these animals routinely fly over the North Sea, thus taking the risk of collision with offshore wind turbines, or become a victim of barotrauma (due to rapid air pressure fluctuations near the blades).

To gain a better understanding of bat activity at the North sea, several research studies have been carried out in recent years. In 2012-2014 offshore bat activity in the North Sea was monitored with passive acoustic ultrasonic recorders at three different locations (Jonge Poerink *et al.* 2013, Lagerveld *et al.* 2014b, Lagerveld *et al.* 2015). During these studies bats were regularly recorded, in particular during the migration season in spring and autumn. The observed species-specific patterns of their occurrence indicate that most offshore bat activity originates from individuals on migration.

In view of the planned rollout of new offshore wind farms (the so-called SER farms) and given the fact that bats across Europe are strictly protected by law, 'Rijkswaterstaat' (RWS) commissioned a bat monitoring programme in 2015 (hereafter referred to as 'RWS-project') in order to reduce uncertainties about possible impacts of offshore wind on bat populations. Until now, there is no clear understanding of why bats turn up at wind turbines at sea, which, however, is a prerequisite for developing effective mitigation strategies designed to anticipate possible population-level effects.

1.2 Assignment

The present study, executed as part of the Monitoring and Evaluation Programme (MEP) for the Eneco offshore wind farm Luchterduinen, contributes to the 'RWS-project'. Both projects, the 'Eneco-project' and 'RWS-project', are linked to each other to make maximum use of available resources and facilities. The scope of the Eneco-project includes the passive acoustic monitoring of bat activity at two offshore locations: offshore wind farm Eneco Luchterduinen (LUD) and Princess Amalia Wind Park (PAWP), and the analysis of the bat data obtained in relation to freely available data on the weather conditions.

Early 2016, the first progress report was delivered (Lagerveld *et al*. 2016), which presents the results of the monitoring effort at offshore wind farms LUD and PAWP in 2015. The present report provides the results of the second monitoring year (2016). The 'weather-analysis', though belonging to the Eneco-commission, will be presented in the context of the more comprehensive RWS report, which, as planned, will be available in March 2017.

2 Material and Methods

2.1 Study area

Both in 2015 and 2016, bat activity was monitored at two locations; offshore wind farm Luchterduinen (LUD) and Prinses Amalia Wind Park (PAWP); see Figure 2.1.

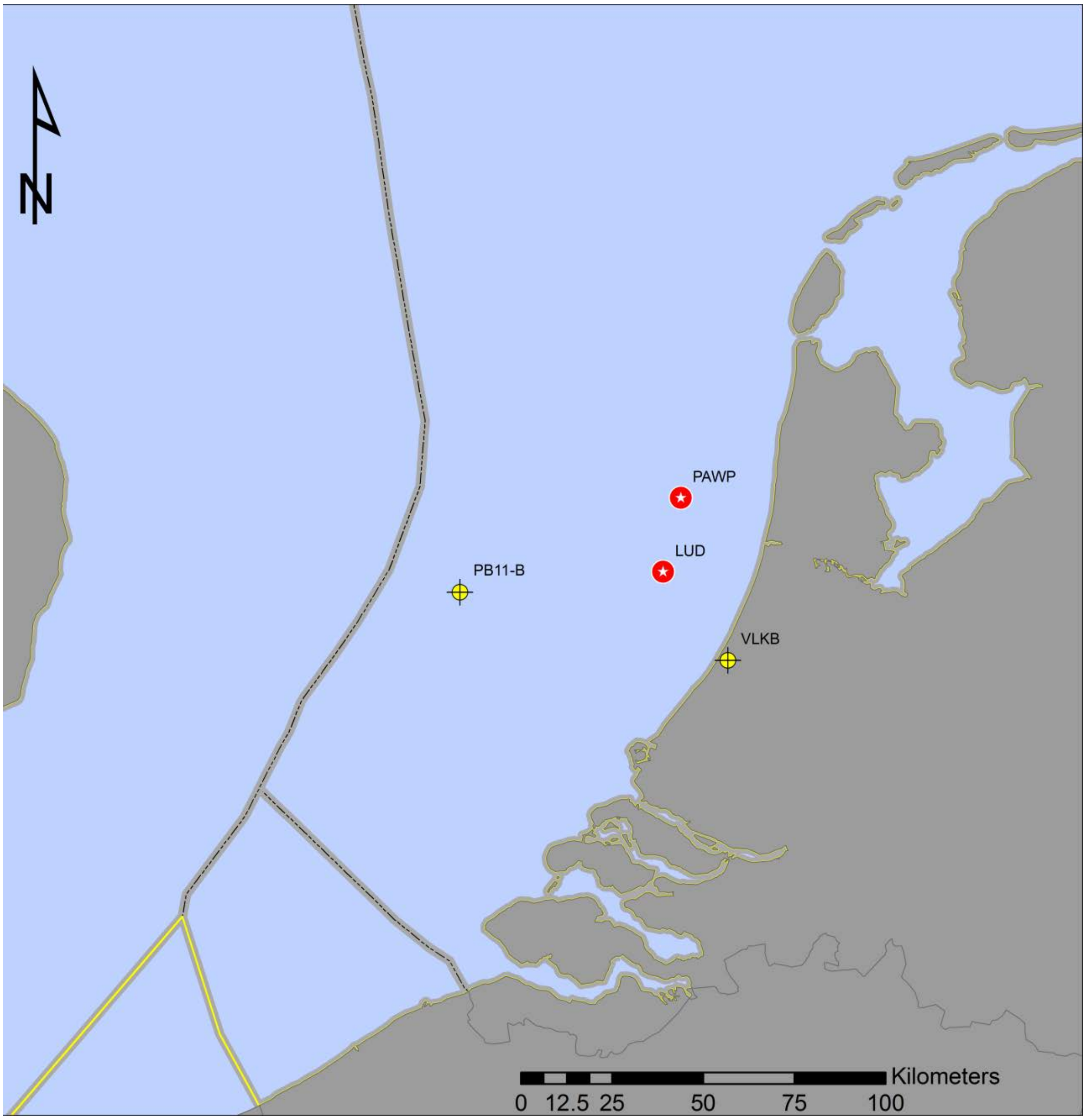


Figure 2.1 *The 2015/2016 monitoring locations LUD and PAWP, and the weather stations P11-B and Airport Valkenburg (VLKB; no longer available in 2016).*

- LUD consists of 43 Vestas V112-3MW wind turbines and an Offshore High Voltage Station (OHVS). The wind farm covers an area of 16 km^2 and is located approximately 23 km off the Dutch mainland (Figure 2.1). The recorder was installed at the rail of the OHVS (Figure 2.2). The monitoring periods in 2015 and 2016 were from 2 March 2015 until 9 October 2015 and from 3 April 2016 until 17 October 2016 respectively.

Figure 2.2 *The recorder at the OHVS of LUD (Photo: Nienke Ladage).*

- PAWP consists of 60 Vestas V80-2 MW wind turbines and an OHVS. The wind farm covers an area of 17 km^2 and is located approximately 23 km off the Dutch coast (Figure 2.1). The recorder was installed at the OHVS (Figure 2.3). The monitoring periods at this station in 2015 and 2016 were from 23 March 2015 until 20 October 2015 and from 16 March 2016 until 24 October 2016 respectively.

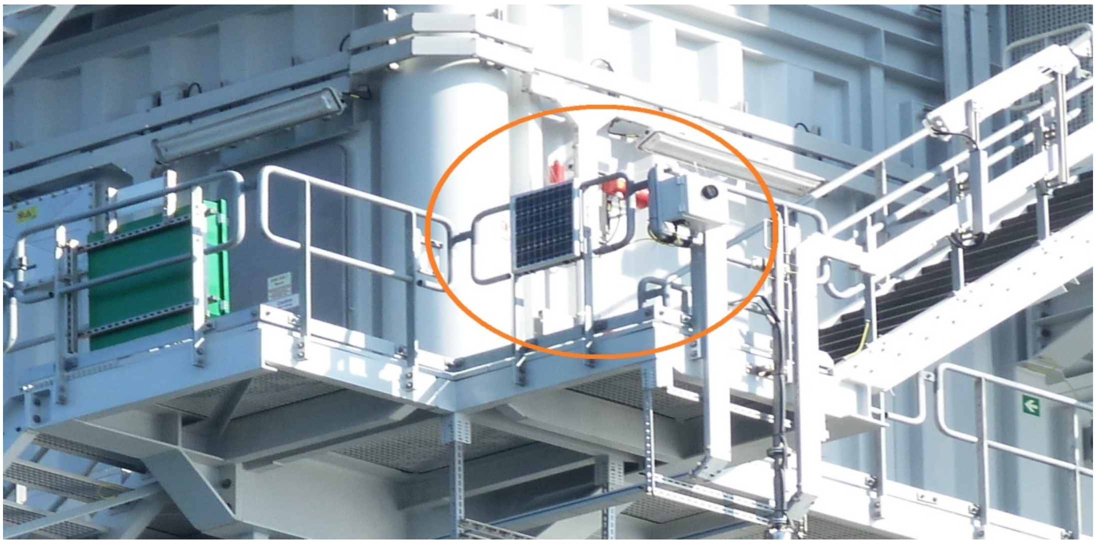


Figure 2.3*. The recorder at the OHVS of PAWP (Photo: Renzo Schildmeijer).*

Details on the locations of the recorders are given in Table 2.1.

Table 2.1 *Monitoring locations.*

Monitoring location	Geographical location (WGS 84)	Distance to shore [km]	Approximate height above sea level [m]	Direction of microphone
LUD – OHVS	N 52.40, E 4.17	23	20	East
PAWP – OHVS	N 52.59, E 4.24	23	15	East

2.2 Equipment

Bat activity was monitored with a Batcorder 3.0 at PAWP and a Batcorder 3.1 at LUD; an automated ultrasonic recorder capable of recording sounds in the range of 16-150 kHz (EcoObs GmbH). The recorders do not record continuously but only after being triggered by a batcall, or batcall-like ultrasonic sound. Sounds are recorded at a maximum distance of 15 - 50 m from the recorder, depending on their specific sonar characteristics, the actual environmental conditions, and the recorder settings (Barataud 2015).

The threshold amplitude was set to -36 dB in order to gain microphone sensitivity (default setting is -24 dB). For all other parameters the default settings of the recorder were used: post-trigger 400 ms, threshold frequency 16 kHz and recording quality 20.

Every morning when the recorder automatically switches off, it sends a status message via SMS, consisting of:

- Identifier of the bat detector
- Free memory on the SDHC-card
- Total number of recordings
- Number of recordings previous night
- Microphone-signal-level: TSL [%]
- Warning messages, such as *low battery*, *memory card (almost) full*, *read or write error memory card*.

In order to maximise the monitoring effort the recorder was switched off for only 15 minutes per day.

The recorder is replaced during the monitoring season when the capacity of memory card has reached its limits, low TSL levels or other technical issues. Table 2.2 shows the different monitoring periods per recorder, including the time on and time off (Coordinated Universal Time: UTC).

Table 2.2 *Monitoring period in 2016 per recorder and recorder on/off setting.*

Location	Serial number recorder	Start date / time	End date / time	Time off	Time on
LUD	381	03.04.2016 / 12:00	17.10.2016 / 12:00	6:30	6:45
PAWP	559	16.03.2016 / 12:00	24.10.2016 / 12:00	6:30	6:45

2.3 Sound analysis

Echo-locating bats emit ultrasonic pulses to gain information about their environment. Ultrasonic sound however is also produced by offshore structures. All sound files were recorded real-time onto a Secure Digital (SD) memory card and subsequently processed by BcAdmin 3.4 (EcoObs GmbH) in order to separate the sound files containing bat calls from noise files. Then, individual bat call recordings were analysed and identified using the automated identification software Batident 1.5 (EcoObs GmbH). All identifications were checked manually and evaluated using the criteria provided by Skiba (2009) and Barataud (2015).

2.4 Data analysis

For the analysis of the data we used the date and time (UTC) of each call sequence. Since bats are nocturnal it makes more sense to analyse its occurrence per night instead of per calendar day. Therefore we shifted the date limits with 12 hours for the analysis of the data; e.g. 14 April runs from 14 April 12:00 (UTC) until 15 April 12:00 (UTC).

We use the number of 10 min intervals in which bats have been present as indicator of bat activity (for each species), just as in the previous monitoring season (Lagerveld *et al.* 2016).

In 2016 the weather station VLKB (former Airport Valkenburg) was no longer available. We therefore only used weather data from the KNMI offshore station P11-B (N 52.37 E 3.35), 80 km west of Zandvoort aan Zee. Of the weather data, in this study, only the wind speed was used, which was averaged per night (from sunset to sunrise). The weather station P11-B itself has an elevation of 24 m above sea level. All wind data measured at a KNMI station are mathematically converted for a height of 10 m above surface level. [1]

[1] https://www.knmi.nl/kennis-en-datacentrum/uitleg/windmetingen; https://www.knmi.nl/kennis-en-datacentrum/uitleg/automatische-weerstations

3 Results

3.1 Performance of the equipment

Figure 3.1 shows the TSL value, an indicator of the microphone performance, of the recorders at PAWP and LUD in 2016. Overall the TSL values were high, and there were no prolonged periods with low TSL values. Therefore both microphones were not replaced during the monitoring year.

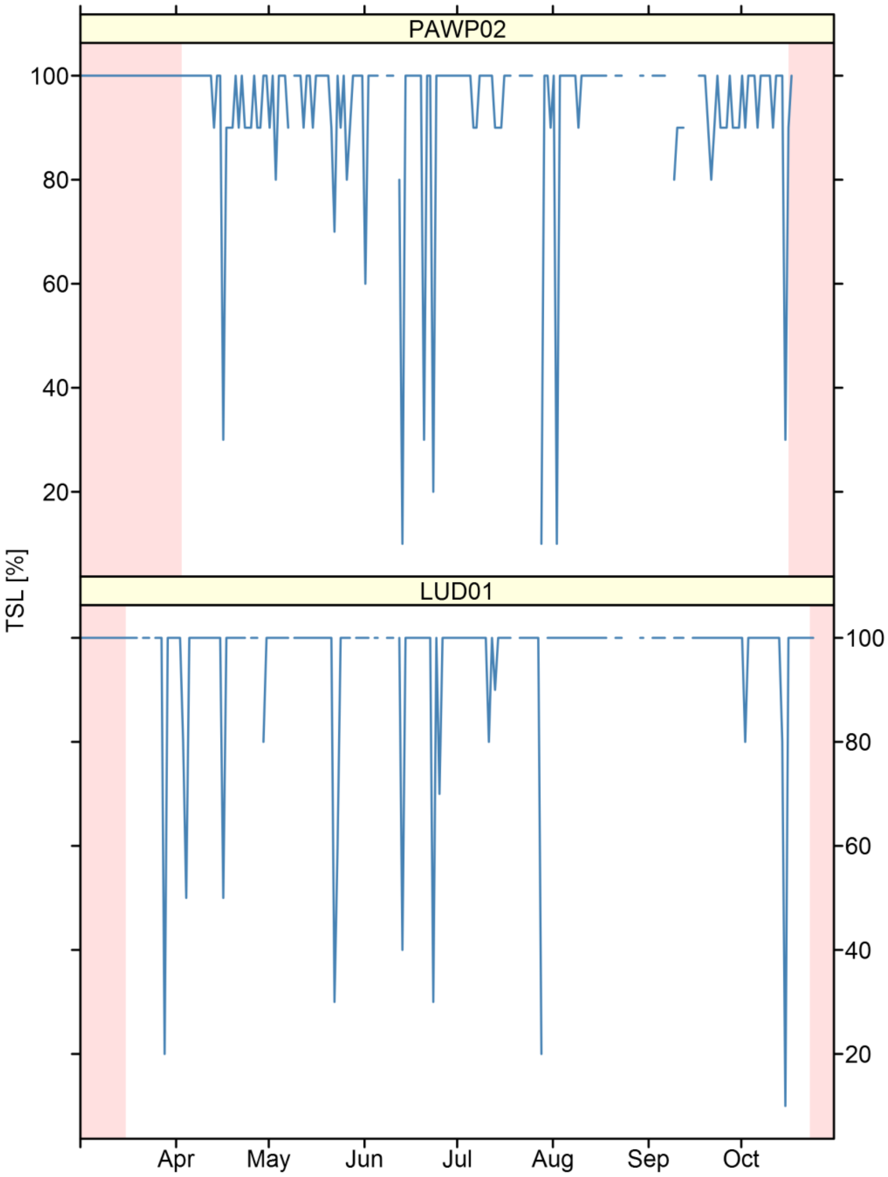


Figure 3.1 *TSL value of the microphone at the monitoring locations PAWP (above) and LUD (below) in 2016. X-axis label indicates beginning of the month.*

As mentioned before, bat detectors do not exclusively record bat sounds but also bat-like sounds. In general, ultrasonic sounds can also be produced by vibrations in (offshore) structures or passing rotor blades, and this so-called ‘noise’ is recorded as well. Table 3.1 shows the total number of noise files per location and the average number per day.

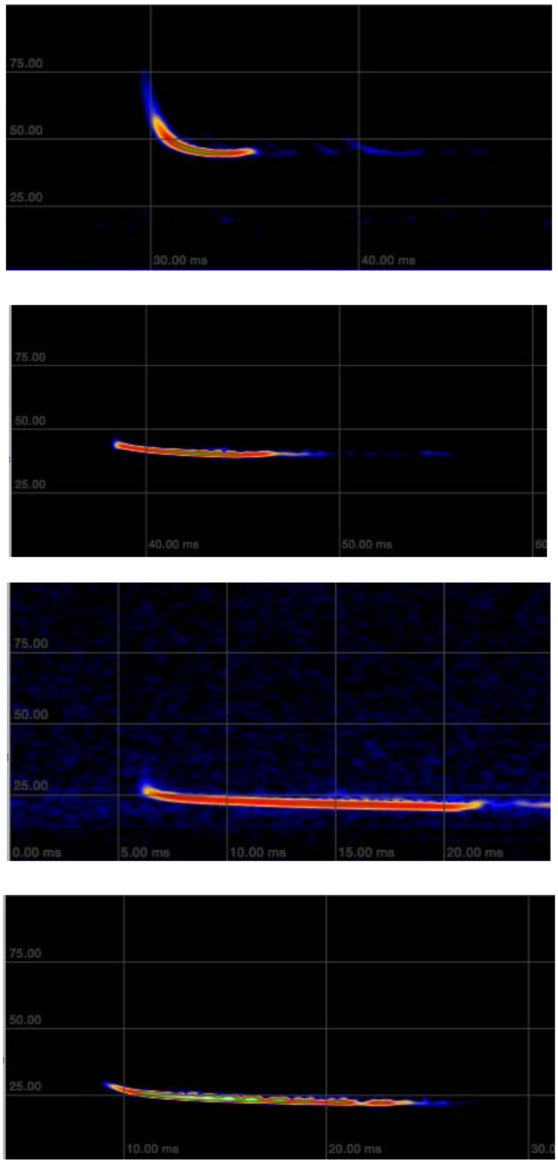
Table 3.1 *Recorded noise files per monitoring location in 2016.*

Monitoring location	Number of noise files	Number of monitoring days	Average number of noise files per day
LUD	1123	197	6
PAWP	3730	222	17

3.2 Bat activity

3.2.1 Species composition

In 2016 we recorded three species: Common Pipistrelle (*Pipistrellus pipistrellus)*, Nathusius' Pipistrelle (*Pipistrellus nathusii*) and Common Noctule (*Nyctalus noctula*). In addition we recorded the species group 'Nycaloid', which includes the genera *Nyctalus*, *Vespertilio*, and *Eptesicus*. Examples of spectrograms are shown in Figure 3.2.



Common Pipistrelle

30 July 2016

PAWP

Nathusius' Pipistrelle

10 September 2016

LUD

Common Noctule

13 September 2016

PAWP

Nyctaloid

24 August 2016

LUD

Figure 3.2 *Examples of spectrograms of Common Pipistrelle, Nathusius' Pipistrelle, Common Noctule and 'Nyctaloid' echolocation calls. The X-axis shows the time in ms and the Y-axis the frequency in kHz. The colours are indicative for the amplitude of the signal.*

3.2.2 Temporal occurrence

Figure 3.3 shows the observed acoustic bat activity at PAWP from March to October 2016.

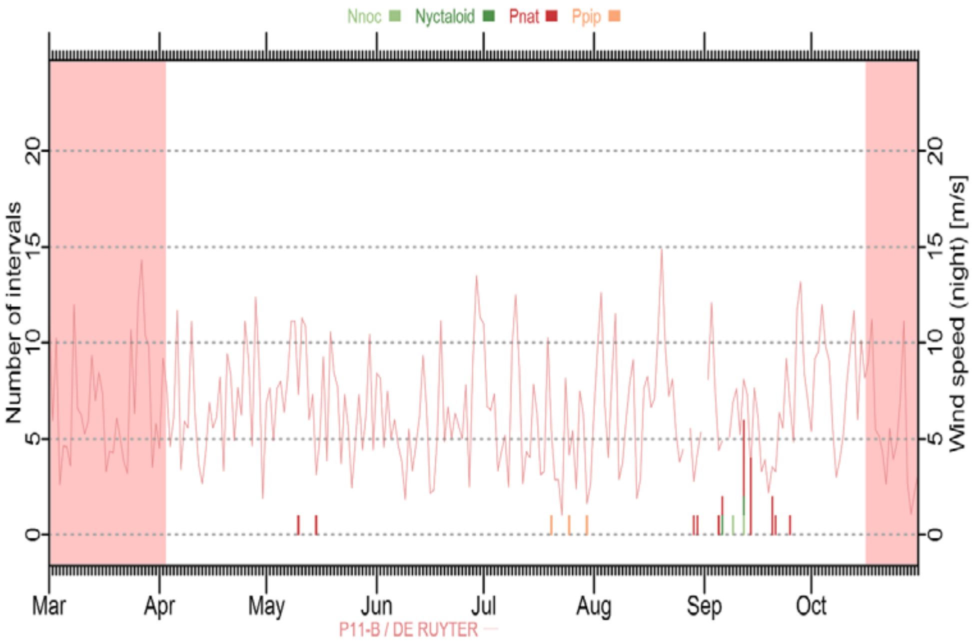


Figure 3.3 *The number of 10-minute intervals per species per night at PAWP (March–October 2016), including the average wind speed per night (from sunset to sunrise) at offshore weather station P11-B. The actual monitoring period is indicated by a white background. X-axis label indicates beginning of the month.*

In Figure 3.4 the observed bat activity at LUD is shown from March to October 2016.

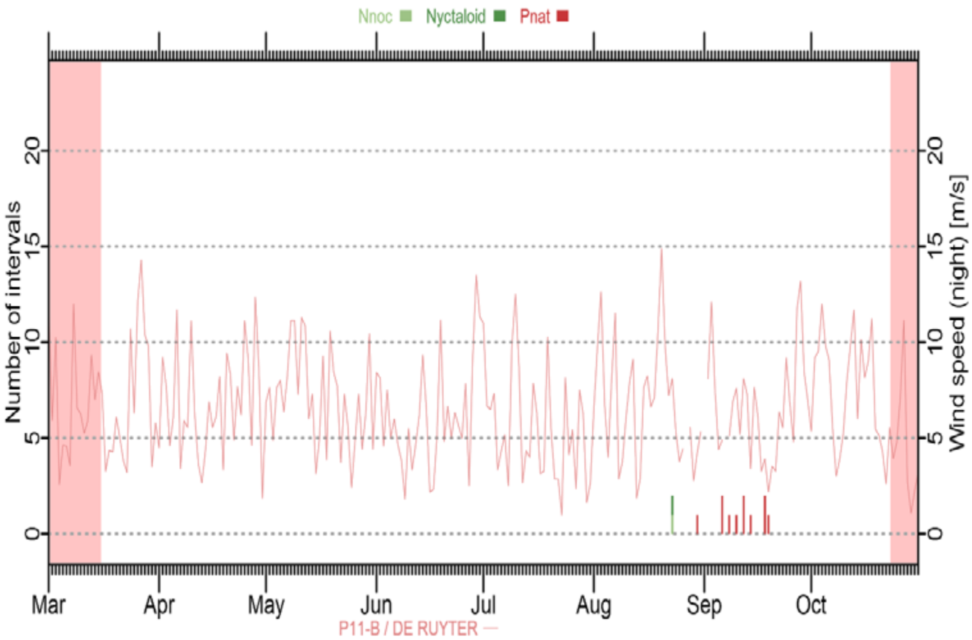


Figure 3.4 *The number of 10-minute intervals per species per night at LUD (March–October 2016), including the average wind speed per night (from sunset to sunrise) at offshore weather station P11-B. The actual monitoring period is indicated by a white background. X-axis label indicates beginning of the month.*

Table 3.2 shows the numbers of 10-minute intervals with detections, specified per species and monitoring location (as indicated by colour in Figures 3.3 and 3.4), for 2016 and 2015.

Table 3.2 *Numbers of 10-minute intervals with detections, per species and monitoring location, in 2016; in brackets: the 2015-numbers.*

Monitoring location	Number of 10-minute intervals				
	Nnoc	Nyctaloid	Pnat	Ppip	Total
LUD	1 (0)	1 (3)	11 (5)	0 (0)	14 (8)
PAWP	2 (0)	2 (0)	18 (8)	3 (0)	25 (8)

Figures 3.5 and 3.6 show the temporal occurrence during the night. In general, when bats are recorded at a station immediately after sunset, this indicates that they have already been there, i.e. have probably arrived during the previous night or during the day. When registered close to sunrise, it is likely that they will spend the day roosting at the station.

At PAWP Nathusius' Pipistrelle was recorded both early after sunset and early in the morning, in spring as well as in autumn. In autumn, almost all detections occurred in the hours between sunset and midnight. Nyctaloids, including Common Noctule, were only recorded in September and only before midnight. Common Pipistrelle was detected three times, at the end of July. (The observation on 30 July occurred between 12:32 – 12:36 UTC and therefore is not visible in Figure 3.5).

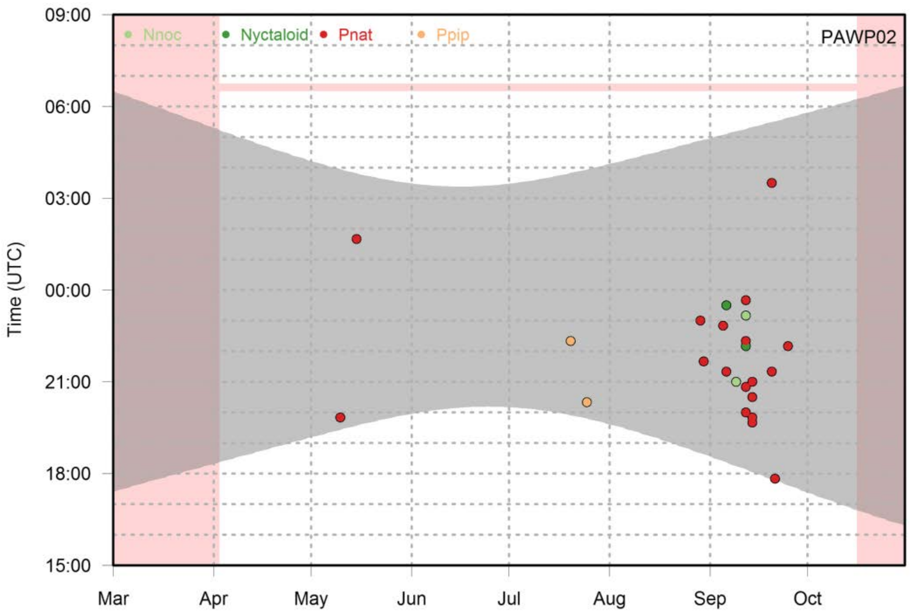


Figure 3.5 *Timing of occurrence (10-minute intervals) in 2016 during the night (grey) at PAWP. The actual monitoring period is indicated by a white background. X-axis label indicates beginning of the month.*

At LUD there were no bats recorded in the spring and summer. Records of Nyctaloids and Nathusius' Pipistrelle occurred in autumn. While all activity of Nyctaloids occurred between 3-6 hours after sunset, Nathusius' Pipistrelles also occurred in the early morning hours close to sunrise. No activity was registered between 22:00 and 4:00.

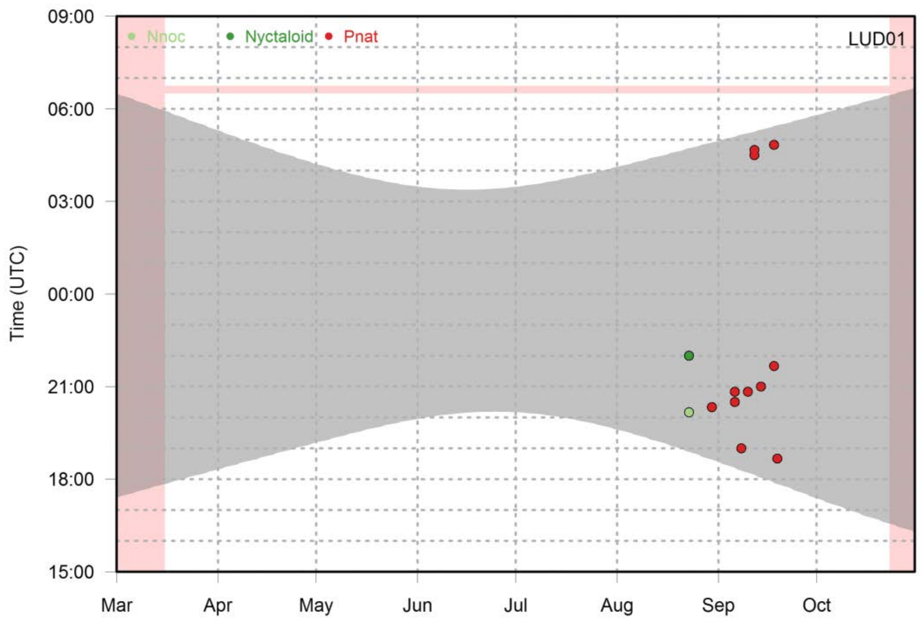


Figure 3.6 *Timing of occurrence (10-minute intervals) in 2016 during the night (grey) at LUD. The actual monitoring period is indicated by a white background. X-axis label indicates beginning of the month.*

3.2.3 Spatial occurrence of Nathusius' Pipistrelle and wind speed

Nathusius' Pipistrelle was the most commonly recorded species (in 76% of all 10-minute intervals with detections, n = 29). Figure 3.7 shows its occurrence in 2016 during the season at PAWP and LUD. In autumn, the offshore occurrence of bats at both locations exhibits a strong similarity.

The occurrence of Nathusius' Pipistrelle seems to be associated with the wind speed. During this study most offshore bat activity occurs during nights with an average (sea-based) wind speed of less than 5 m/s, although on two occasions during this study it has been recorded at wind speeds of up to 8 m/s.

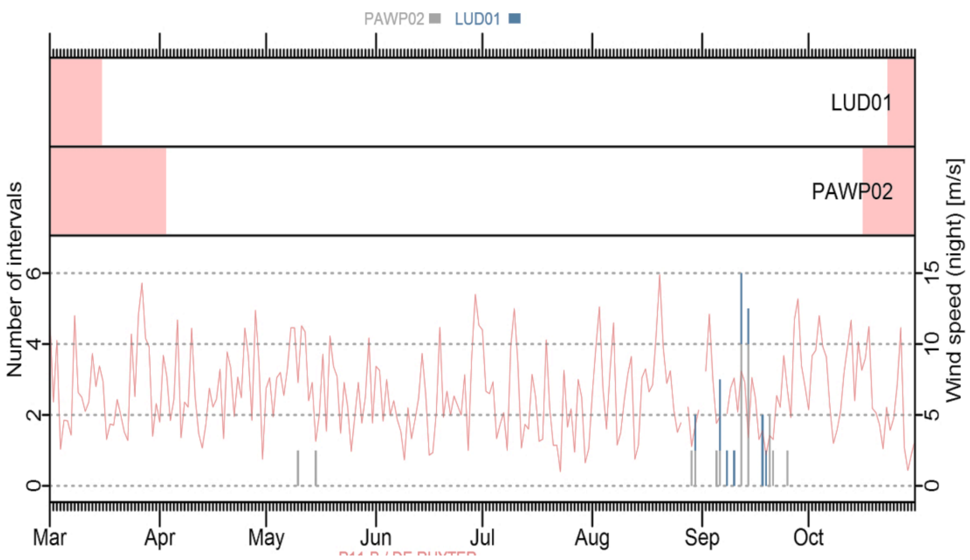


Figure 3.7 *The number of 10-minute intervals per night of Nathusius' Pipistrelle at PAWP and LUD, including the average wind speed per night (from sunset to sunrise) at offshore weather station P11-B. The actual monitoring periods at LUD and PAWP are indicated at the top of the graph (pink = no monitoring). X-axis label indicates beginning of the month.*

4 Discussion

4.1 Performance of the equipment

Over time, the microphone of a bat detector may lose its sensitivity, in particular when it is exposed to humidity or frost. (At both the LUD and PAWP station, the microphones were directed eastward to avoid as much as possible the salty spray carried by the prevailing westerly winds.) In order to monitor its performance, every time when a Batcorder (EcoObs Gmbh) is switched off, the microphone sensitivity level (TSL) is determined by comparing a test signal with a calibrated reference value. The TSL, however, should not be considered as an absolute performance indicator. Values that are considerable lower than 100%, frequently occur as well as strong fluctuations (e.g. caused by fog or rain). TSL values below 30%, and occasionally below 10%, can be considered normal. The few short periods with a low TSL shown in Figure 3.1 are likely to be caused by unfavourable weather conditions, e.g. rain or fog. Only if the TSL drops to values between 0-10% during several days, the microphone requires replacement (EcoObs GmbH).

Besides bat calls, we also recorded ultrasonic noise (which is normal when monitoring bat activity with passive acoustic detectors) that might mask bat calls. The average number of noise files per day at PAWP was 17, which is much lower than in 2015 (39) and equal to 2014 (Lagerveld *et al.* 2015 and 2016). At LUD on average 6 noise files were recorded per day, whereas in 2015 on average 39 noise files were recorded per day (Lagerveld *et al.* 2016). Numerous causes can be responsible for that: wind, rattling wires, maintenance work at the station etc. In this study, periods with TSL levels between 0-10% did not occur for more than one day and the numbers of recorded noise files were relatively low. Therefore we can assume that the equipment performed adequately during the 2016 monitoring season.

4.2 Bat activity

With the current knowledge and techniques it is impossible to estimate the actual number of bats based on sound recordings. Ahlén *et al.* (2007, 2009) observed that migrating bats often interrupt their flight to forage around offshore wind turbines because of the accumulation of flying insects. When foraging, an individual bat may stay in the vicinity of the recorder for a prolonged period of time, resulting in a sequence of several 10-minute intervals. Because it can also happen that more than one bat is present at the same time (Lagerveld *et al.* 2014b), it is not possible to give an estimate of how many individual bats have been present in the vicinity of the recorders.

A recorder is detecting bat echolocation calls with a maximum distance of 15 – 50 m from the microphone (Barataud 2015). The actual area surveyed is relatively small and it seems likely that the overall bat activity at sea must have been much higher. On the other hand, it seems also likely that the observed bat activity near the recorders is higher than at the open sea, because of the potentially perceived feeding opportunities near offshore structures (Ahlén *et al.* 2007, 2009). At present, it is not known how the presence of bats near offshore structures can be extrapolated to larger areas.
In previous monitoring studies, bat activity at sea (and at the coast) was strongly linked with the wind speed. Most bat activity was observed during nights with wind speeds of less than 5 m/s and occasionally of up to 8 m/s. This matches the observed pattern of this study and reconfirms that our observations do not refer to individuals blown off-shore by strong winds.

In 2016, the observed bat activity at PAWP and LUD was higher than in 2015. At PAWP Common Pipistrelle, which was never observed here before, was recorded three times late July. In the same week at LUD a Nathusius' Pipistrelle was found roosting at a wind turbine (Figure 4.1).

Figure 4.1 *Nathusius' Pipistrelle on 26 July 2016 at LUD (photos: Joost Rotteveel).*

The number of 10-minute intervals in which Nathusius' Pipistrelle was recorded at PAWP was 50 in 2014, 6 in 2015 and 18 in 2016. The number of recorded 10-minute intervals at LUD was 5 and 11 in respectively 2015 and 2016. Nyctaloids, including Common Noctule, were recorded 4 time intervals at PAWP (none in 2015 and 2 in 2014) and 2 time intervals at LUD (also 2 time intervals in 2015).

The occurrence of bats at the offshore monitoring locations LUD and PAWP occurred mainly in autumn from late August until late September, a few occurred in spring and summer. This is consistent with the monitoring results of 2012 – 2015 (Jonge Poerink *et al.* 2013, Lagerveld *et al.* 2014a, 2014b, 2015, 2016).

5 Conclusions

Our observations in 2015 and 2016 at PAWP and LUD, reconfirm the assumption that bats regularly fly over the North Sea.

Nathusius' Pipistrelle is the most common recorded species at sea. 'Nyctaloids' (including Noctule) have been observed with some regularity. Common Pipistrelle has been recorded occasionally.

The observed species-specific patterns of occurrence indicate that most offshore bat activity originates from individuals on migration.

Bats occur at sea particularly from late August until late September during nights with calm weather (wind speeds usually well below 5 m/s, occasionally up to 8 m/s). Therefore it is unlikely that the observed bat activity was caused by individuals that were blown off-course by strong winds.

On one occasion we recorded a bat during daylight hours (around noon) indicating that bats also use their sonar during the day. (It may have been an individual arriving during daylight hours or a nearby roosting individual that has been disturbed.)

6 Quality Assurance

Wageningen Marine Research utilises an ISO 9001:2008 certified quality management system (certificate number: 187378-2015-AQ-NLD-RvA). This certificate is valid until 15 September 2018. The organisation has been certified since 27 February 2001. The certification was issued by DNV Certification B.V.

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Justification

Report C001/17
Project Number: 431 51000 08

The scientific quality of this report has been peer reviewed by a colleague scientist and a member of the Management Team of Wageningen Marine Research

Approved: Steve C.V. Geelhoed
Researcher

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