Monitoring bat activity at the Dutch EEZ in 2014

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Noctule *Nyctalus noctula* migrating at the coast near The Hague 4 October 2010 ©Gerjon Gelling

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Contents

1 Introduction

For quite some time there have been indications of bat movements over the North Sea. Observers of bird migration at the Dutch coast regularly report bats flying in from sea (Lagerveld *et al*. 2014b). Bats have also been observed during surveys at the North Sea and have been found on oil & gas platforms, ships and remote islands (Walter 2007, Boshamer & Bekker, 2008). In 2013 a Nathusius' pipistrelle *Pipistrellus nathusii* was found in the Netherlands, which was banded three years earlier in the United Kingdom (UK; pers. comm. Teddy Dolstra), providing the first evidence that bats are able to cross the North Sea.

To what extent and how bats use the North Sea is a relevant question, considering that the number of offshore wind farms in the North Sea is increasing and that several (onshore) studies have shown that wind turbines can cause high fatality rates among bats.

We therefore conducted studies in 2012 and 2013 to monitor offshore bat activity with passive acoustic ultrasonic recorders (Jonge Poerink *et al*. 2013, Lagerveld *et al.* 2014a). During these studies one recorder was installed at the meteorological mast at the Offshore Wind Farm Egmond aan Zee (OWEZ) and a second recorder was attached to the entrance platform of wind turbine number 22 at Princess Amalia Wind Farm (PAWP), respectively 15 and 23 km from the shore.

In 2012 monitoring has been conducted exclusively in autumn; from 29 August until 20 October at OWEZ and from 4 until 23 September at PAWP. The monitoring period in 2013 ran from 4 April until 15 October at OWEZ and at PAWP from 6 until 16 June and from 5 August until 2 October. Bats were recorded regularly at both locations in both years during the autumn migration period. In 2013 there were occasional recordings in spring and no bats were recorded during June and July. The observed pattern of occurrence (observations in the migration season and apparently absent in June and July) in combination with the recorded species indicate that our observations referred to migrants.

In the follow-up project reported here, more data on the offshore occurrence of bats was collected in 2014. Using the same methodology as in 2012 and 2013, bat activity was monitored from spring to autumn in both wind farms (OWEZ & PAWP) and two additional locations: the IJmuiden meteorological mast (85 km west of Callantsoog) and at the coast near Egmond aan Zee.

2 Materials and Methods

2.1 Study area

The 2014 study was conducted at four different locations:

- Offshore Wind Farm Egmond aan Zee (OWEZ); consists of 36 Vestas V90-3MW wind turbines and a meteorological mast. The wind farm covers an area of 27 km^2 and is located 10-18 km off the Dutch mainland. The recorder was installed at the meteorological mast at the western fringe of the wind farm.
- Prinses Amalia Wind farm (PAWP); consists of 60 Vestas V80-2 MW wind turbines and a transformer platform. The wind farm covers an area of 17 km^2 and is located 23-26 km off the Dutch coast. The recorder was installed at the transformer platform (Note that the recorder was attached to the entrance platform of the easternmost wind turbine in 2012 and 2013).
- IJmuiden Meteorological mast (IJMM); a (single) meteorological mast, located approximately 84 km west of Callantsoog. The recorder was installed at the first platform (Figure 1).
- RWS mast at the beach 2 km south of Egmond aan Zee (EAZ). The recorder was installed at the roof of the working platform (figure 2).

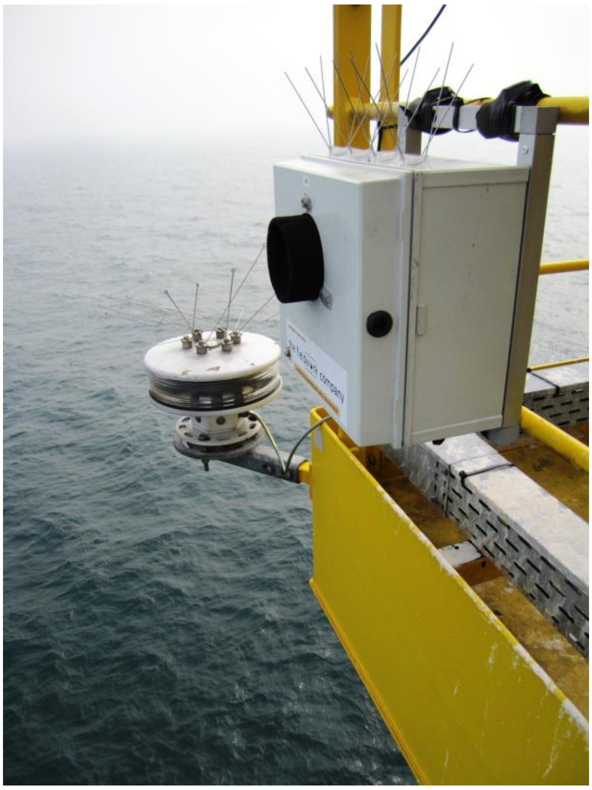


Figure 1: The recorder at the IJmuiden Meteorological mast (IJMM)

Figure 2: The recorder at the RWS mast (EAZ)

Details on the locations of the recorders are shown in table 1.

Table 1 Monitoring locations

Monitoring location	Geographical location	Distance to shore [km]	Approximate height above sea level [m]	Direction microphone
OWEZ - Meteorological mast	N 52.61, E 4.39	15	15	East
PAWP - Transformer platform	N 52.59, E 4.24	23	15	East
IJMM - Meteorological mast	N 52.85, E 3.44	80	19	East
EAZ - RWS mast	N 52.59, E 4.61	0	9	East

Figure 3 shows the geographical locations of the monitoring locations.

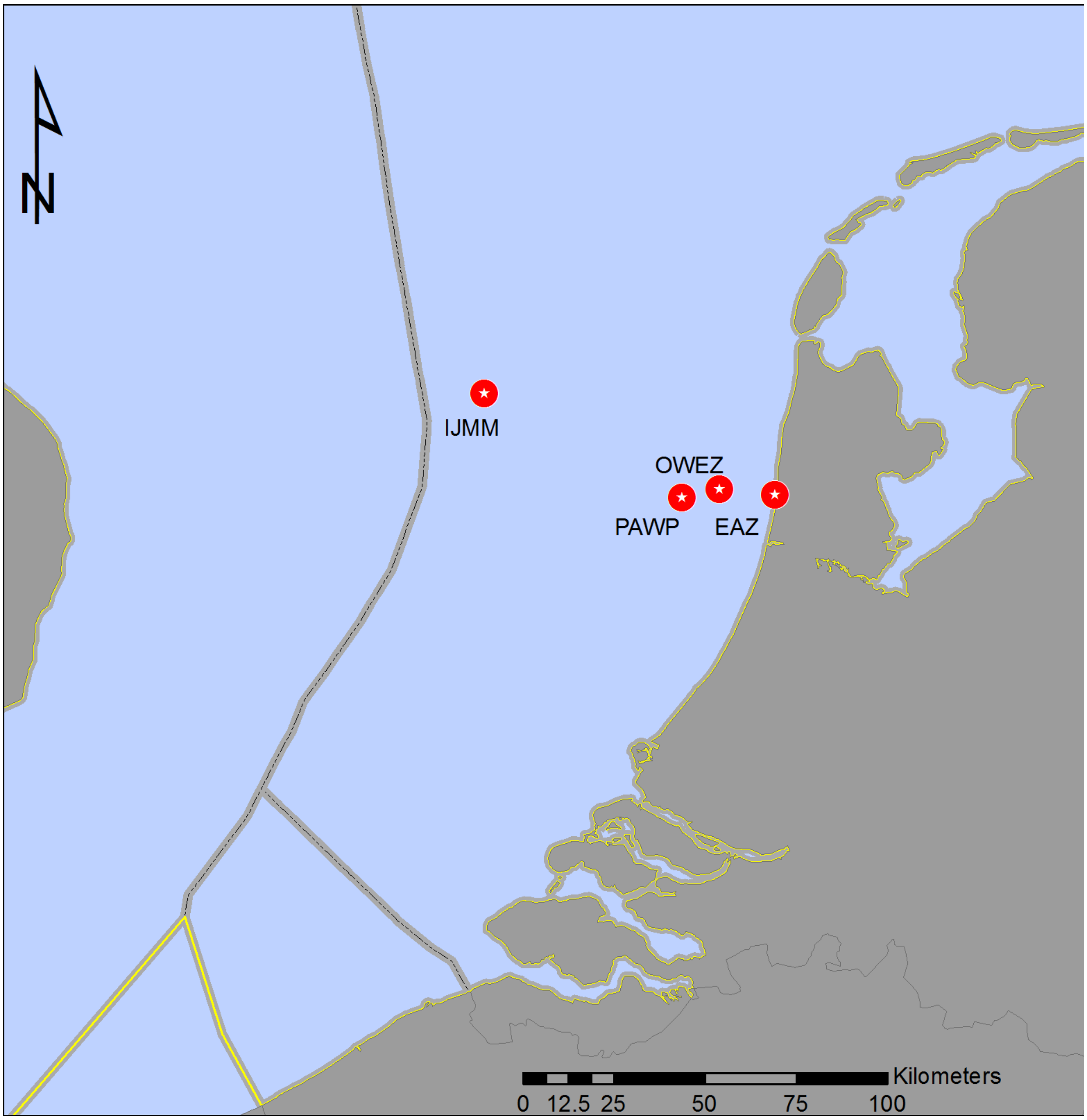


Figure 3: Monitoring locations in 2014.

2.2 Monitoring period and timing

We aimed to monitor during the entire active period of bats (roughly from late March until Mid-October). Due to logistical constraints monitoring started a month later at PAWP and ended some two weeks earlier at IJMM. The monitoring periods per location were:

- OWEZ: 7 March - 14 October,
- PAWP: 29 April - 15 October,
- IJMM: 31 March - 30 September,
- EAZ: 19 March – 15 October

2.3 Equipment

Bat activity was monitored with a Batcorder 3.0 (EcoObs GmbH); an automated ultrasonic recorder that is able to record sounds in the range of 16-150 kHz. The recorders do not record continuously but only after being triggered by a batcall, or batcall-like ultrasonic sound. Bats are recorded at a maximum distance of 15 - 50 meters from the recorder, depending on their specific sonar characteristics, the environmental conditions and the settings of the recorder (Barataud 2012, pers. obs. Bob Jonge Poerink). The casings of the recorders were enhanced to make them suitable for offshore conditions (Jonge Poerink *et al.* 2013). The batcorder at PAWP was electromagnetically isolated to prevent interference from the transformer station.

The threshold frequency of the recorders was set to 16 kHz and the threshold amplitude to -36 dB. Furthermore we used the default settings of the recorder (post-trigger 400 ms and recording quality 20).

When the recorder is switched off in the morning it sends a status SMS when it is within reach of a GSM network. This message contains:

- 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, like *low battery*, *memory card (almost) full*, *read or write error memory card*.

2.4 Sound analysis

Echolocating bats emit ultrasonic pulses to gain information about their environment. Ultrasonic noise however, is also produced by offshore structures. All sound files were recorded real-time onto a SD memory card. The recorded sound files containing bat calls were separated from the noise files by BcAdmin 2.0 (EcoObs GmbH) and individual bat call recordings were analysed and identified using the automated identification software Batident 1.0 (EcoObs GmbH).) . All identifications were checked manually and evaluated using the criteria provided by Skiba (2009) and Barataud (2012).

2.5 Data analysis

For the analysis of the data we used the date and Coordinated Universal Time (UTC) of each call sequence. Since bats are nocturnal it makes more sense to analyse its occurrence per night instead of a 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).

In previous monitoring reports (Jonge Poerink et al. 2013, Lagerveld et al. 2014a) we used the number of call sequences as an indicator of the bat activity. Differences in behaviour however (e.g. foraging versus passing by) may result in huge differences in the number of recorded call sequences, which do not reflect the relative abundance. An alternative indicator of bat activity which limits (but does not solve) this issue is the presence in a certain time frame, or the ratio between the presence and absence. In this study we use the number of 10 min intervals in which bats have been present as indicator of bat activity (for each species).

We obtained weather data from the KNMI stations PB-11B offshore (N 52.37 E 3.35), 80 km west of Zandvoort aan Zee, and at Valkenburg Airport (N 52.18 E 4.42), 3 km inland from Katwijk aan Zee. In this study only the wind speed was used, which was averaged per night (from sunset to sunrise).

3 Results

3.1 Performance of the equipment

During the monitoring season the microphone of a bat detector may lose sensitivity, in particular when it is exposed to humidity or frost. Every time 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 considerable less than 100% frequently occur, as well as strong fluctuations (e.g. caused by fog or rain). TSL values between 30-70% and occasionally between 10 and 90% can be considered normal, but when the TSL drops to values between 0-10% during several days the microphone needs replacement (EcoObs GmbH).

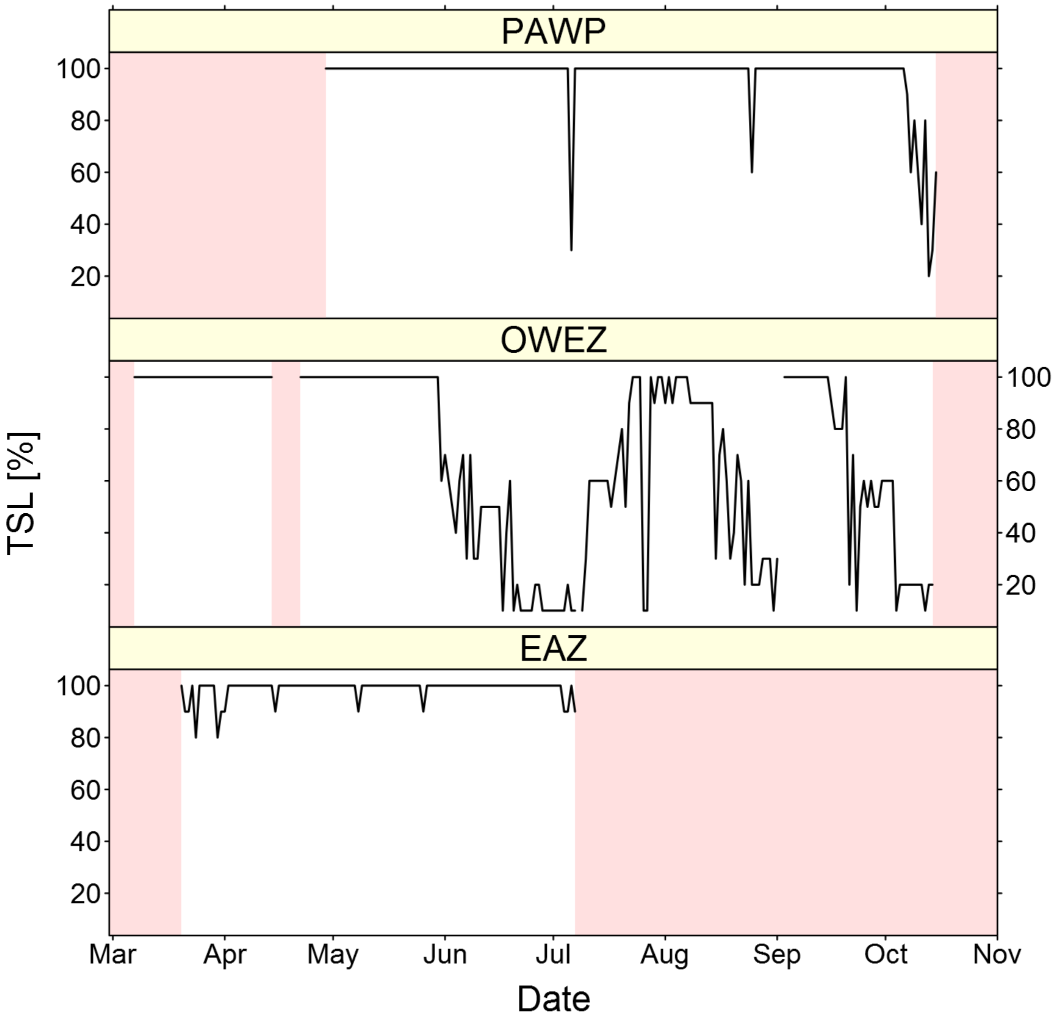


Figure 4: TSL value of the microphone at each monitoring location throughout the season.

Figure 4 shows the performance of the recorders at PAWP, OWEZ and EAZ. The performance of the recorder at IJMM could not be monitored due to the absence of a GSM network. At PAWP the recorder performed properly during the entire monitoring season. At OWEZ the monitoring period was interrupted from 15 until 22 April due to a SD-card error. The TSL value of the microphone from 20 June ranged between 10 and 20% and therefore the microphone (including the recorder) was replaced on 8 July. The

TSL level of the new microphone dropped to fairly low levels from 25 August onwards and this microphone (+recorder) was replaced on 2 September. The performance of the third microphone started to drop to low levels from 4 October onwards until the end of the monitoring period. At EAZ the recorder stopped recording for unknown reasons from 8 July onwards, despite sending a status message every day. Because an error message was never received this technical issue was noted when the recorder was retrieved from the monitoring location at the end of the season. The microphone of the recorder performed properly from 19 March until 7 July.

Bat detectors do not exclusively record bat sounds. 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 2 shows the total number of noise files per location and the average number per day.

Table 2 shows the number of noise files per monitoring location throughout the season.

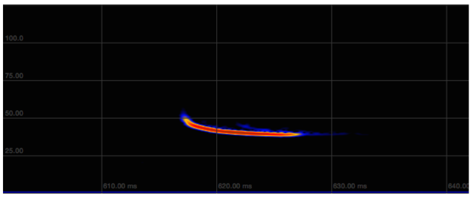
Wind Farm	Number of noise files	Number of monitoring days	Average number of noise files per day
OWEZ	2245	221	10
PAWP	2930	171	17
RWE	1398	111	13
EAZ	371	183	2

3.2 Bat activity

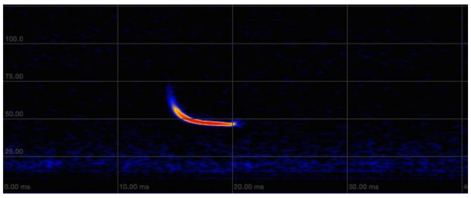
3.2.1 Species composition

Five species of bats were recorded during the 2014 monitoring season. Nathusius'pipistrelle (*Pipistrellus natusii*), Common pipistrelle (*Pipistrellus pipistrellus*), Noctule (*Nyctalus noctula*), Daubenton's bat (*Myotis daubentonii*) and Pond bat (*Myotis dasycneme*). Some recordings could not be identified to species level and were classified as species groups; 'Pipistrelloid' (unidentified Pipistrelles) and 'Nyctaloids' (includes Nyctalus, Vespertilio, Eptesicus).

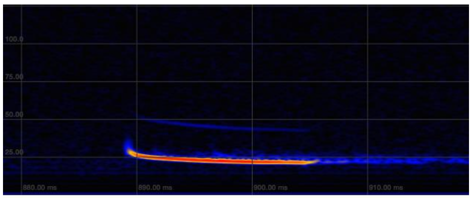
Examples of spectrograms of the recorded species are shown in figure 5.



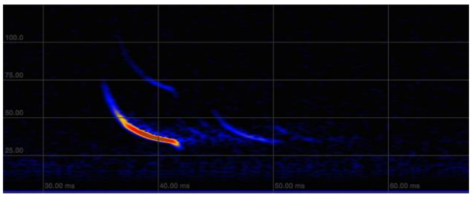
Nathusius'pipistrelle
4-9-2014
IJMM



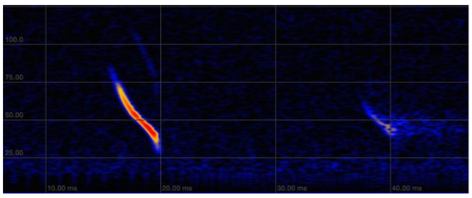
Common pipistrelle
17-7-2014
OWEZ



Noctule
4-9-2014
PAWP



Pond Bat
1-5-2014
EAZ



Daubenton's Bat
26-3-2014
EAZ

Figure 5: Examples of spectograms of the recorded species. A spectogram shows the frequency contour of a signals (call) in time. Most bat species in NW Europe can be identified by their call characteristics.

3.2.2 Temporal occurrence

In this study we use the number of 10 min intervals in which bats have been present as an indicator of bat activity (for each species). For completeness we have also included the figures with the number of recorded call sequences in Appendix A.

<u>EAZ</u>

Figures 6 and 7 show the observed bat activity at EAZ from March to June and from July to October. The first bats were recorded late March and from the second half of April onwards bats were recorded regularly. Unfortunately, due to a technical failure of the recorder no data were obtained after 7 July. At EAZ Nathusius' pipistrelle was the most frequently recorded species (41%), followed by Common pipistrelle (30%), Noctule (15%), 'Nyctaloid' (11%), 'Pipistrelloid' (1%), Pond Bat (1%) and Daubenton's bat (1%).

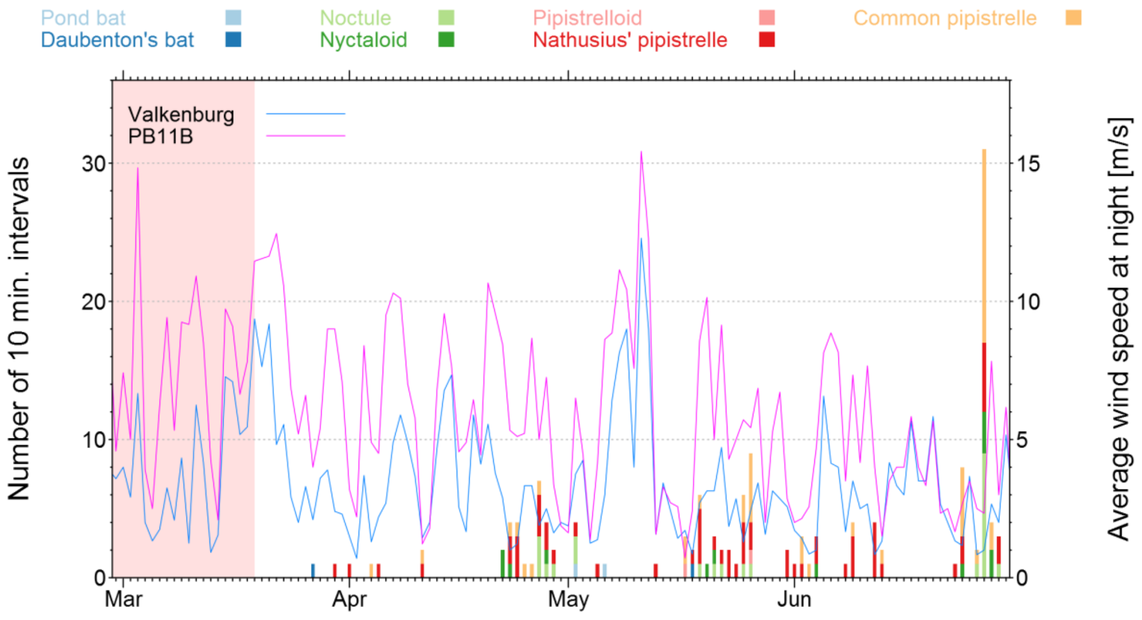


Figure 6: The number of 10-min intervals per species per night at EAZ (March – June), including the average wind speed per night (from sunset to sunrise) at Valkenburg Airport and offshore weather station PB11B.Note that the actual monitoring period is indicated by a white background.

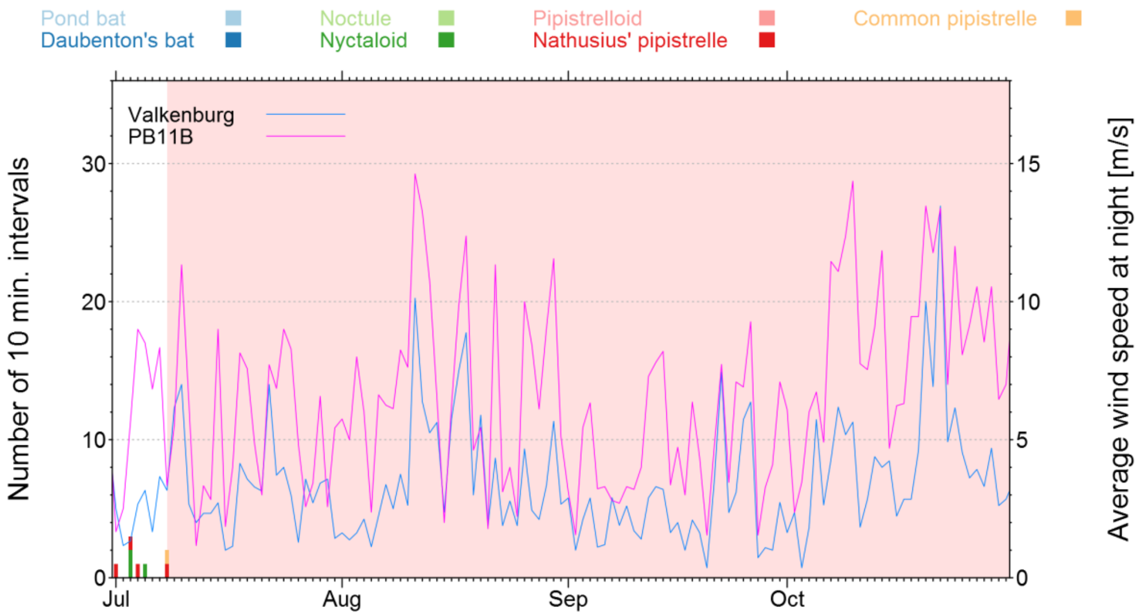


Figure 7: The number of 10-min intervals per species per night at EAZ (July – October), including the average wind speed per night (from sunset to sunrise) at Valkenburg Airport and offshore weather station PB11B. Note that the actual monitoring period is indicated by a white background.

<u>OWEZ</u>

In figure 8 and 9 the observed bat activity at OWEZ is shown from March to June and from July to October respectively. Bats were recorded occasionally late March/April (10% of the 10-min intervals)and in the second half of July (5% of the 10-min intervals). Almost all bat activity occurred in autumn (85% of the 10-min intervals) with an obvious peak in the first week of September. At OWEZ Nathusius' pipistrelle was the most frequently recorded species (86%), followed by 'Nyctaloid' (8%), Common pipistrelle (4%) and Noctule (1%).

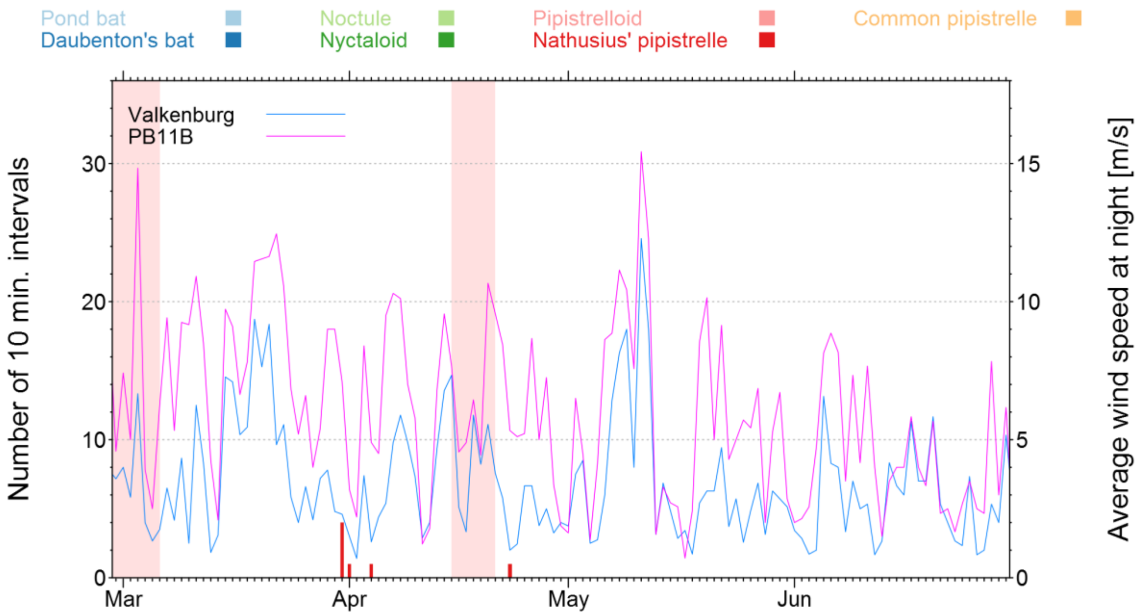


Figure 8: The number of 10-min intervals per species per night at OWEZ (March – June), including the average wind speed per night (from sunset to sunrise) at Valkenburg Airport and offshore weather station PB11B. Note that the actual monitoring period is indicated by a white background.

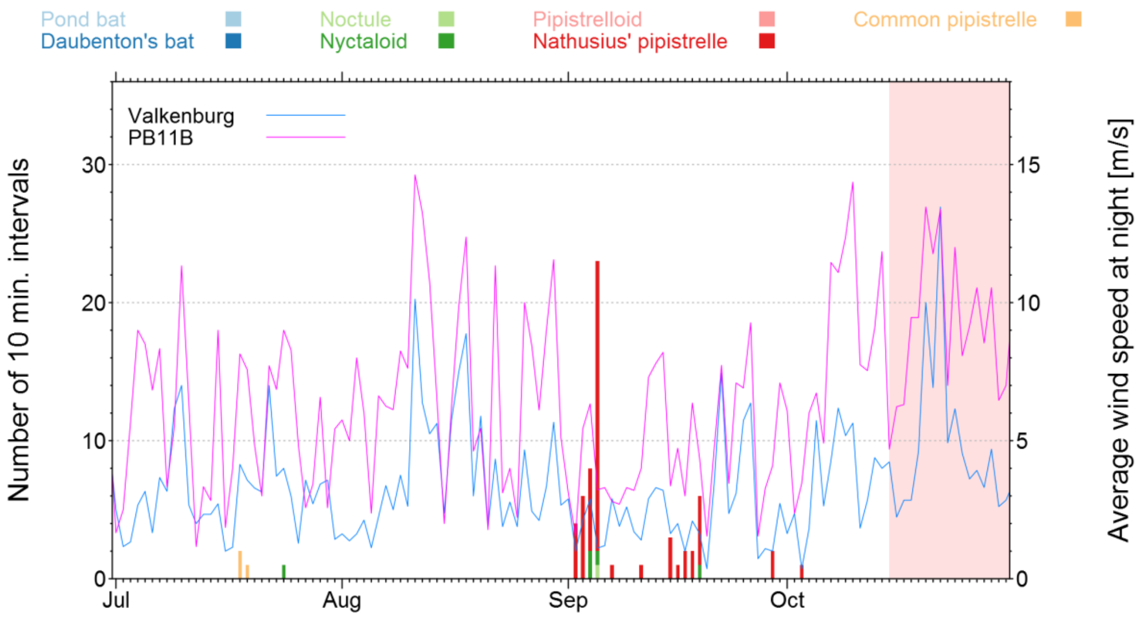


Figure 9: The number of 10-min intervals per species per night at OWEZ (July – October), including the average wind speed per night (from sunset to sunrise) at Valkenburg Airport and offshore weather station PB11B. Note that the actual monitoring period is indicated by a white background.

<u>PAWP</u>

In figure 10 and 11 the observed bat activity at PAWP is shown from March to June and from July to October respectively. The only observation in spring was on 17 May, but note that monitoring at this location started very late (29 April). Also at PAWP almost all bat activity occurred throughout September with an obvious peak in the first week. At PAWP Nathusius' pipistrelle was the most frequently recorded species (94%), followed by 'Nyctaloid' (4%) and Noctule (2%).

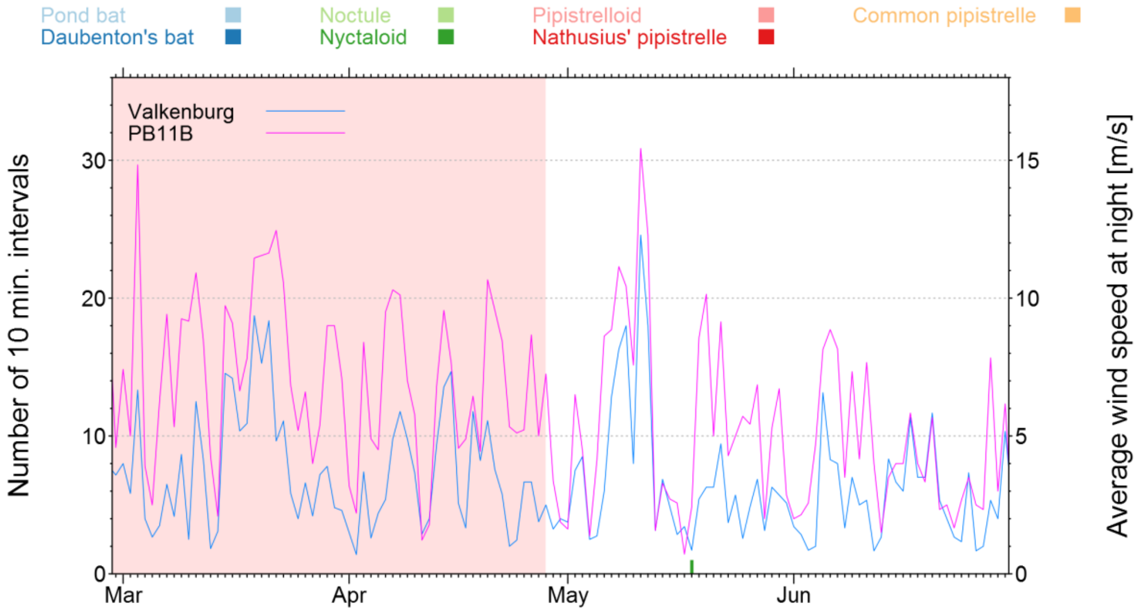


Figure 10: The number of 10-min intervals per species per night at PAWP (March – June), including the average wind speed per night (from sunset to sunrise) at Valkenburg Airport and offshore weather station PB11B. Note that the actual monitoring period is indicated by a white background.

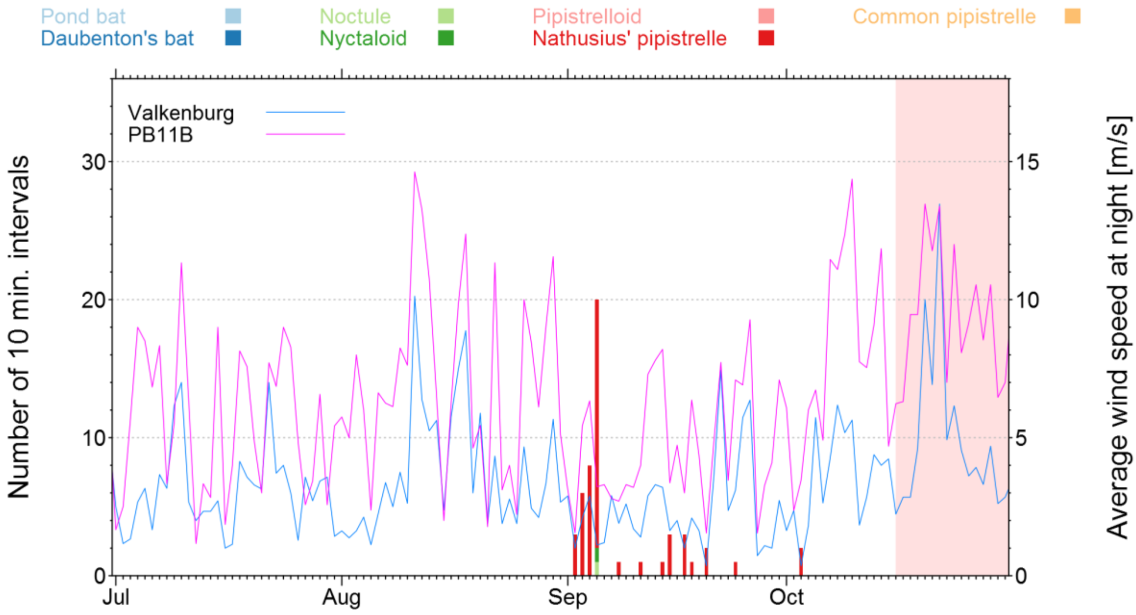


Figure 11: The number of 10-min intervals per species per night at PAWP (July – October), including the average wind speed per night (from sunset to sunrise) at Valkenburg Airport and offshore weather station PB11B. Note that the actual monitoring period is indicated by a white background.

IJMM

Figure 12 and 13 show the observed bat activity at IJMM from March to June and from July to October respectively. Bats were regularly observed throughout April (33 % of the 10-min intervals) and September (67% of the 10-min intervals). Most activity occurred in the first week of September, just like OWEZ and PAWP. The only species recorded at IJMM was Nathusius' pipistrelle.

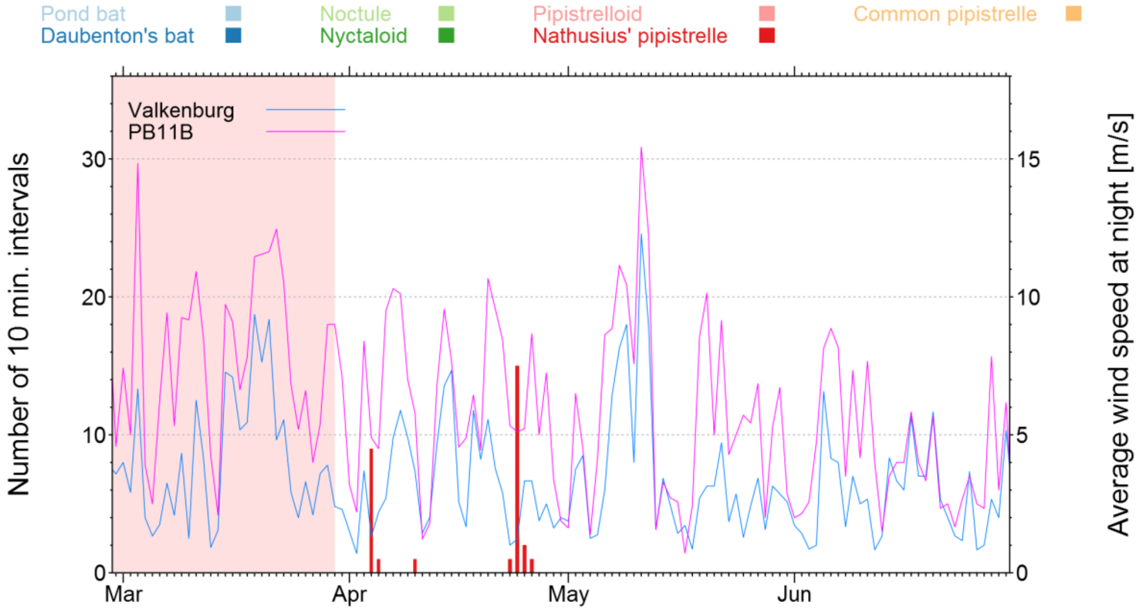


Figure 12: The number of 10-min intervals per species per night at IJMM (March – June), including the average wind speed per night (from sunset to sunrise) at Valkenburg Airport and offshore weather station PB11B. Note that the actual monitoring period is indicated by a white background.

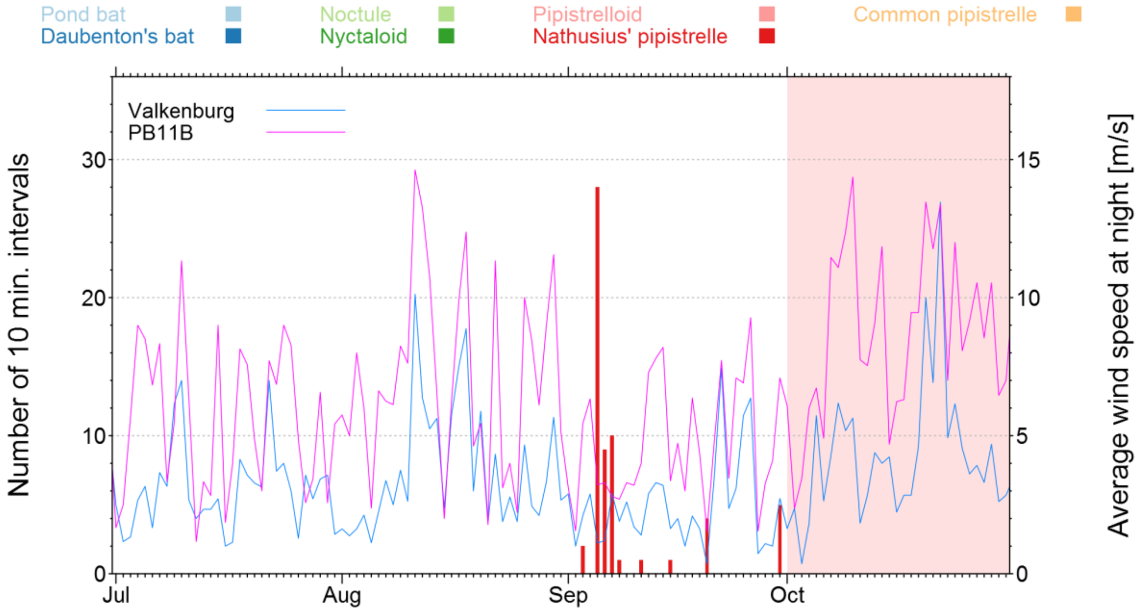


Figure 13: The number of 10-min intervals per species per night at IJMM (July – October), including the average wind speed per night (from sunset to sunrise) at Valkenburg Airport and offshore weather station PB11B. Note that the actual monitoring period is indicated by a white background.

Figures 14-17 shows the temporal occurrence throughout the night at the monitoring locations. At EAZ in spring and early summer bat activity never started earlier than 30 minutes after sunset and peaked between 1-3 hours after dark. Bats are infrequently observed in the second part of the night.

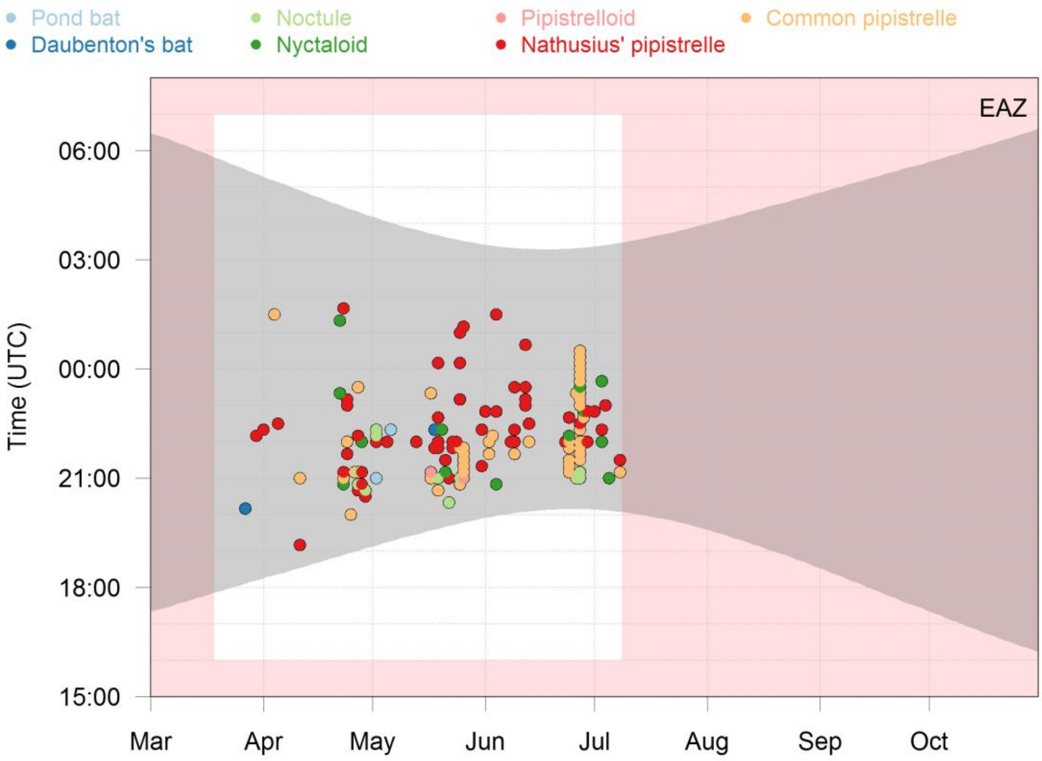


Figure 14: Timing of occurrence (10-min intervals) during the night at EAZ. Note that the actual monitoring period is indicated by a white background. Night time between sunset and sunrise is represented by grey.

At OWEZ the first records of Nathusius' pipistrelle in spring occur either just before sunrise or just after sunset. Furthermore, there are two more records some 8 hours after dark later in the season. A Common pipistrelle is recorded in the night of 17 July (early morning of 18 July) just before sunrise, and another is recorded the next day at midnight. Another mid-summer record concerned a 'Nyctaloid' in the night of 23 July. Almost all bat activity in autumn refers to Nathusius' pipistrelle which peaks between 2-5 hours after sunset. Interestingly, there were two records during daylight hours. One on 4 September some 2 hours before sunset and one in the night of 17 September 30 minutes after sunrise.

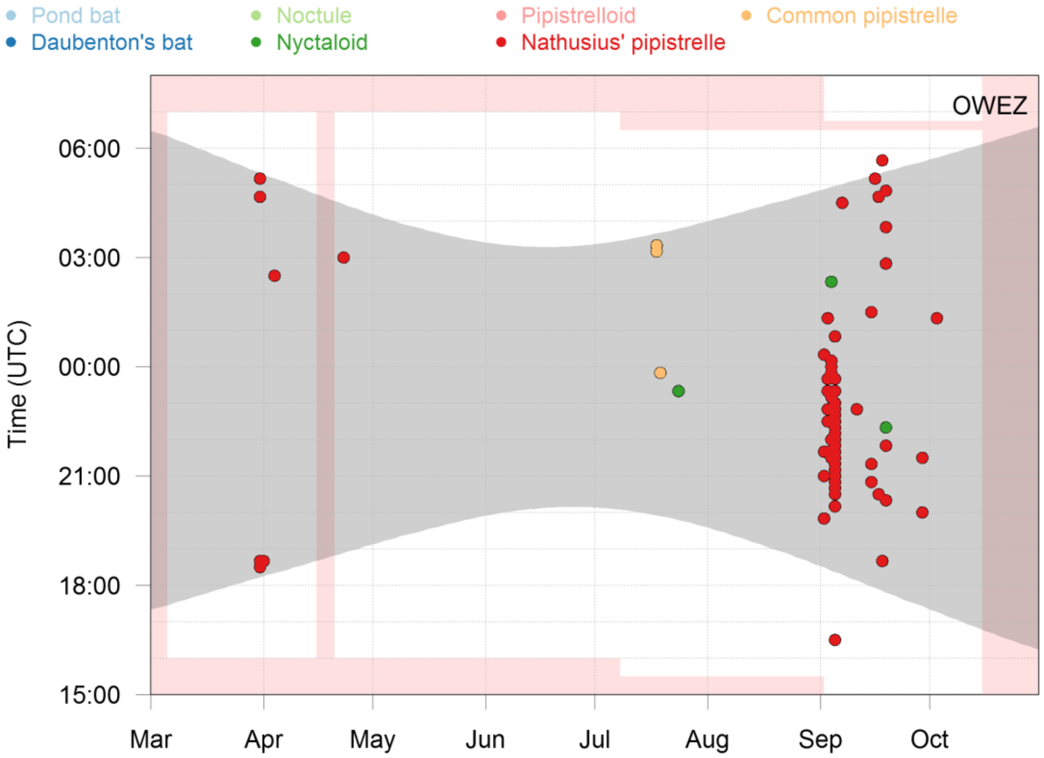


Figure 15: Timing of occurrence (10-min intervals) during the night at OWEZ. Note that the actual monitoring period is indicated by a white background. Night time between sunset and sunrise is represented by grey.

At PAWP, in spring there is one record of a 'Nyctaloid' early in the night of 17 May (note however the late start of the monitoring season at PAWP). Almost all bat activity in autumn is caused by Nathusius' pipistrelle and peaks between 2-5 hours after sunset, just like at OWEZ.

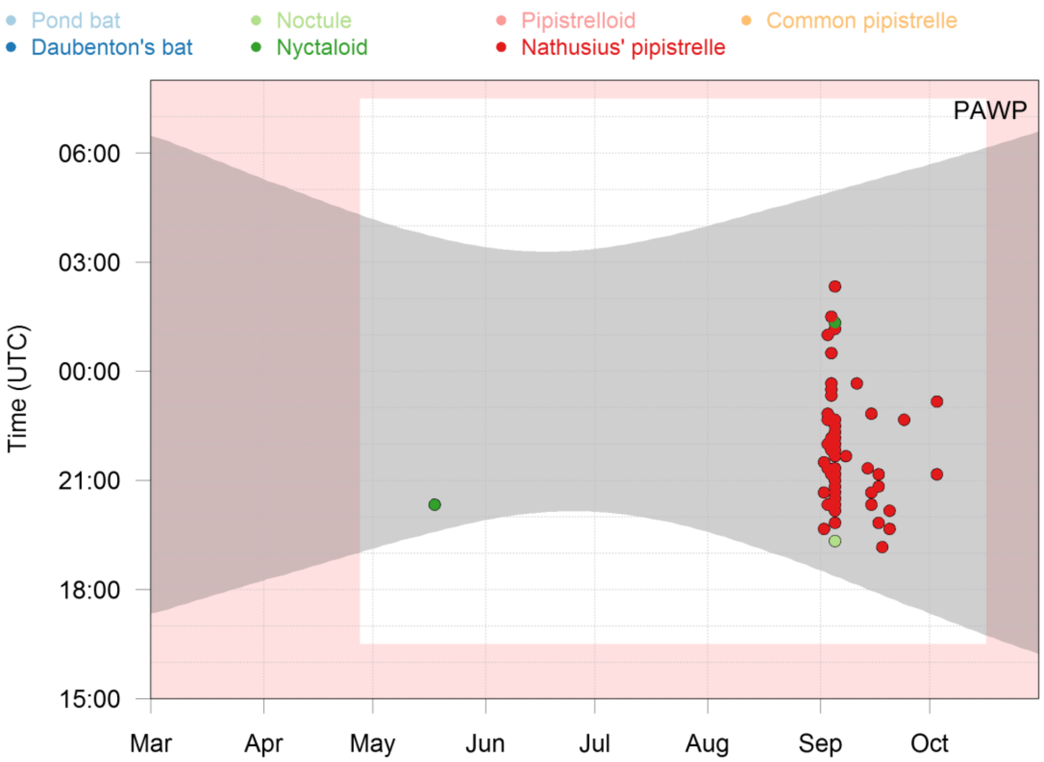


Figure 16: Timing of occurrence (10-min intervals) during the night at PAWP. Note that the actual monitoring period is indicated by a white background. Night time between sunset and sunrise is represented by grey.

Only Nathusius' pipistrelle was observed at IJMM. Most activity in spring occurred late at night, at least 6 hours after sunset. In the night of 23 April bat activity continued just before sunrise and started again just after sunset on 24 April. The next evening another individual was recorded, also shortly after sunset. In autumn, more or less the same pattern was observed. Most bat activity occurs late in the night (the majority more than 5 hours after sunset) or shortly after sunset.

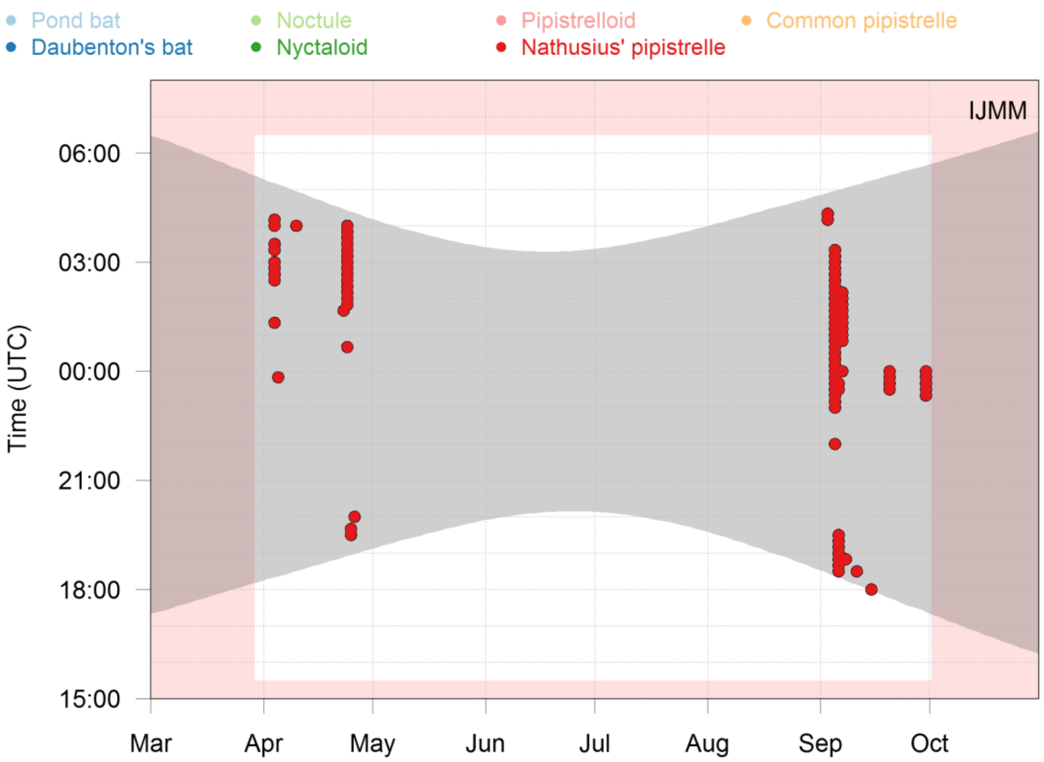


Figure 17: Timing of occurrence (10-min intervals) during the night at IJMM. Note that the actual monitoring period is indicated by a white background. Night time between sunset and sunrise is represented by grey.

3.2.3 Spatial occurrence of Nathusius' pipistrelle and wind speed

Nathusius' pipistrelle was the most commonly recorded species (72% of the 10-min intervals). Figures 18 and 19 shows its occurrence during the season at the various monitoring locations. Throughout April Nathusius' pipistrelle occurs during several nights at more than one monitoring location. From late April until early July it occurs regularly at the coast at EAZ, but is not recorded at sea. In September offshore bat activity is strongly linked amongst the monitoring locations.

The occurrence of Nathusius' pipistrelle is associated with the wind speed. All records at the coast (EAZ) took place during nights with an average (land-based: Airport Valkenburg) windspeed well below 5 m/s. Most offshore bat activity also occurs during night with an average (sea-based: PB11-B) windspeed under 5 m/s, although on some occasions they have been recorded with wind speeds up to 7 m/s.

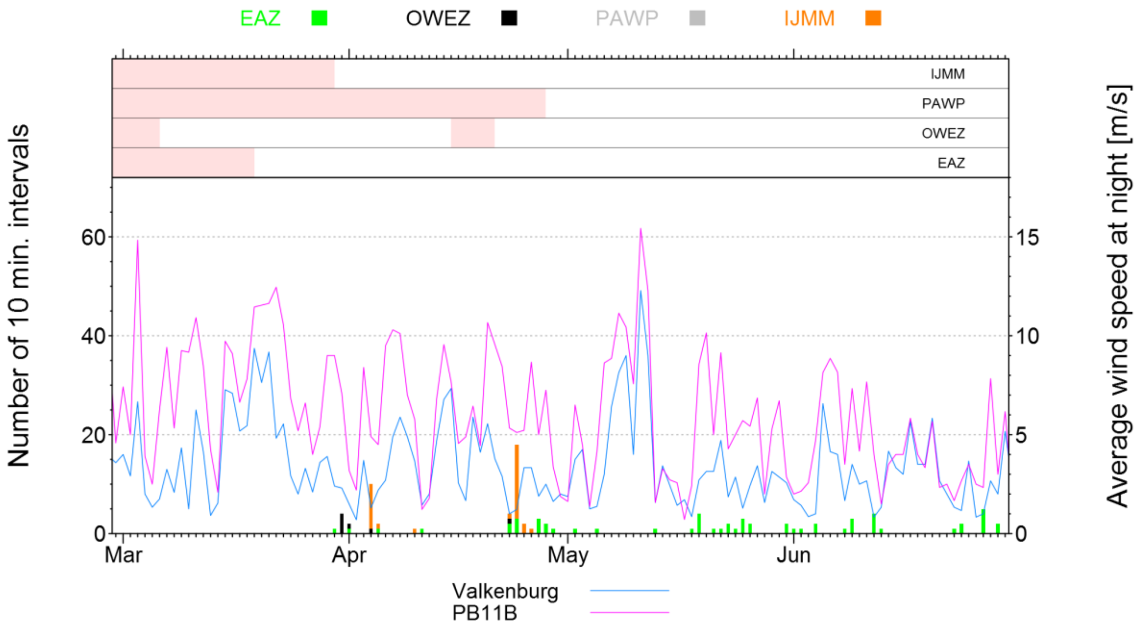


Figure 18: The number of 10-min intervals per night of Nathusius' pipistrelle at EAZ, OWEZ, PAWP and IJMM (March – June), including the average wind speed per night (from sunset to sunrise) at Valkenburg Airport and offshore weather station PB11B. Note that the actual monitoring periods of the various locations are indicated by a white background in the top panel.

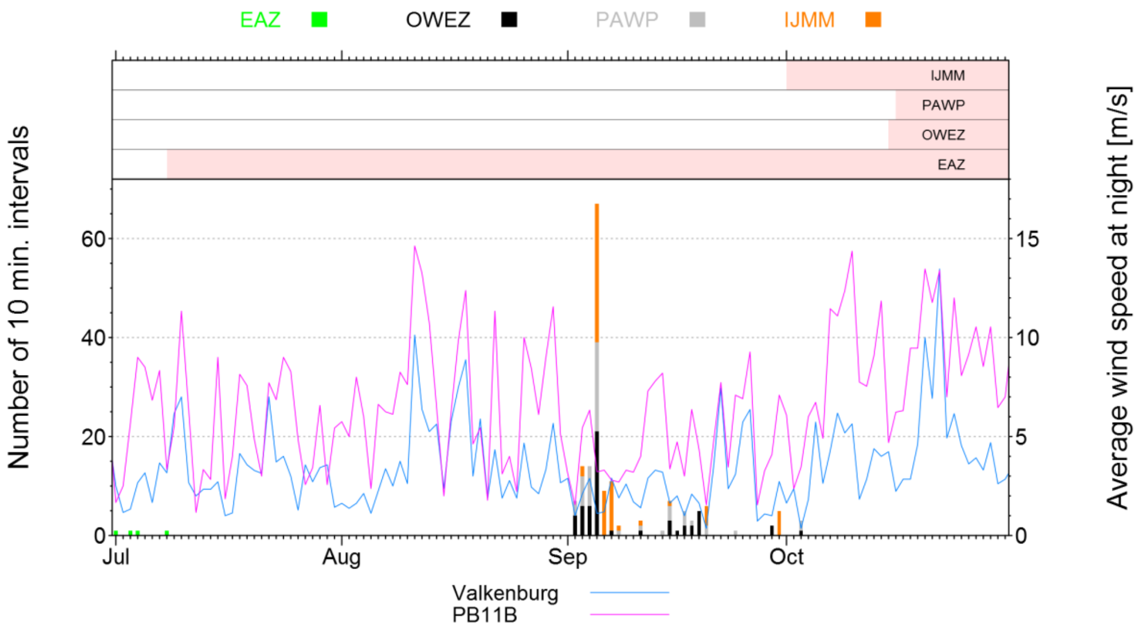


Figure 19: The number of 10-min intervals per night of Nathusius' pipistrelle at EAZ, OWEZ, PAWP and IJMM (July – October), including the average wind speed per night (from sunset to sunrise) at Valkenburg Airport and offshore weather station PB11B. Note that the actual monitoring periods of the various locations are indicated by a white background in the top panel.

4 Discussion

4.1 Performance of the equipment

During the 2014 season we experienced some setbacks in the performance of the equipment. At EAZ the equipment stopped recording for unknown reasons after 7 July and consequently no monitoring data were collected during the remaining summer months and autumn. The recorder at EAZ did perform properly from 19 March until 7 July. At OWEZ the monitoring period was interrupted from 15 until 22 April due to a SD-card error. Furthermore the equipment was replaced three times because of low TSL values of the microphone. Each time the equipment was extensively covered with Cormorant droppings and we think that this was the cause of the subsequent decrease of TSL values. Periods in which we might have under-recorded bat activity at OWEZ were from 20 June until 8 July, 25 August until 2 September and from 4 October until the end of the monitoring period. The recorder at PAWP performed well during the entire monitoring period. At IJMM there is no GSM-network and therefore we do not know the TSL values during the monitoring season.

During the 2014 monitoring season we did record ultrasonic noise (which is normal when monitoring bat activity with passive acoustic detectors), which might mask bat calls. The average number of noise files per monitoring day at OWEZ was similar to that in 2013 (10 versus 11 on average per day). In 2014 the recorder at PAWP was installed at the transformer platform instead of an offshore wind turbine in previous years, and this resulted in a significant reduction of noise files; 17 in 2014 versus 1156 on average per day in 2013 (Lagerveld *et al.* 2014a). At IJMM on average 13 noise files were recorded per day which is comparable with the number at OWEZ and PAWP. The number at EAZ was much lower (2 on average per day) possibly because of the absence of noise sources like ships horns or rattling chains.

4.2 Bat activity

It is hard to estimate the actual number of bats based on the recorded bat activity. 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 a prolonged period in the vicinity of the recorder resulting in a presence of several 10 min-intervals. However, it also happens that more than one bat is present at the same time (Lagerveld *et al.* 2014b). Consequently, it is not possible to give an estimate how many individual bats have been present in the vicinity of the recorders.

Also during the 2014 monitoring season 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 less than 5 m/s and occasionally up to 7 m/s. This matches the observed pattern of occurrence in 2012 and 2013 and reconfirms that our observations do not refer to individuals blown off-shore by strong winds.

4.2.1 Nathusius' pipistrelle

During the 2014 monitoring season Nathusius' pipistrelle was also the most common species at all monitoring locations (72% of the data). At EAZ it was 'relatively less common', representing 41% of the data at this location. At OWEZ and PAWP it was 'relatively abundant' (respectively 86% and 94% of the data) and at IJMM this was the only recorded species. In 2012 and 2013 Nathusius' pipistrelle was also the most frequently recorded species at OWEZ and PAWP.

At EAZ there was no clear seasonal pattern (note however that we didn't obtain data from 9 July onwards). The first animals were recorded late March and it remained regular throughout the monitoring period until 7 July. It seems likely that the observations at EAZ, at least in summer, concerned local populations. Not all Nathusius' pipistrelle migrate long distances, especially the males may spend the summer in or close to the wintering areas (Vierhaus 2004).

The occurrence at the offshore monitoring locations was highly seasonal; it was only recorded from late March throughout April in spring and from early September until early October in Autumn. There was a strong association of bat activity among the offshore monitoring locations. In spring, Nathusius' pipistrelle has been recorded late at night at IJMM (at least 6 hours after sunset, 85 km from the mainland) and at OWEZ (at least 8 hours after sunset). Furthermore, there were observations shortly after sunset at both locations, indicating that these animals roosted there (or in the vicinity) and arrived the previous night or during daytime. In Autumn the peak activity at OWEZ and PAWP occurred 2-5 hours after sunset, just as in 2012 and 2013. Bat activity at IJMM peaked much later, between 5-9 hours after sunset.

The observed pattern of occurrence in spring and autumn in 2014 indicates that the animals were migrating, and this matches our observations in 2012 and 2013. In addition, the nocturnal pattern suggests an east(erly) / west(erly) flight direction of Nathusius' pipistrelle in autumn and the opposite direction in spring. As the flight speed of Nathusius' pipistrelle is approximately 23 km/h (Baagøe 1987) OWEZ and PAWP can be reached in about one hour from the mainland in autumn and IJMM in about 4 hours. In spring IJMM can possibly be reached within 6 hours from the UK and OWEZ/PAWP in about 8 hours.

4.2.2 Common pipistrelle

Common pipistrelle, a non-migratory species (Dietz *et al.* 2007), was frequently observed at EAZ. It seems likely that these observations refer to individuals from local populations at the coast. It was also recorded at OWEZ during two nights in July. In 2013 it was also recorded here once late August. Apparently this species occasionally wanders off at sea.

4.2.3 'Nyctaloid', including Noctule

'Nyctaloids' (includes Nyctalus, Vespertilio, Eptesicus species), including Noctule represent 13% of the data. They were relatively common at EAZ from the second half of April onwards with a peak in June. Late spring one was recorded at PAWP in the night of 17 May and there was a mid-summer record at 23 July at OWEZ. In September it was recorded twice at OWEZ as well as PAWP.
The majority (7% of the data) could be identified as Noctule, a long-distance migrant but also a fairly common resident in forests along the Dutch coast. It is possible that (some) of the unidentified 'Nyctaloids' concerned other species like Parti-coloured Bat (*Vespertilio murinus*). This (migratory) species was possibly recorded during the 2013 monitoring season at PAWP.

4.2.4 Pond Bat

Pond Bat is a short or medium distance migrant (up to 300 km). In the Netherlands important hibernacula are located in Limburg (the southeast) and in preserved WW II bunkers in the dunes along the Dutch coast (Limpens & Lina 1999). Spring migration of females may starts already in February and continues until late April. Males migrate later in the season, from March until Mid-May. Autumn migration of females occurs from July until September, and in males from August until late October (Anne Jifke Haarsma in litt.).

Pond Bat was recorded on two occasions early May at the beach at EAZ. These records may refer to migrants as there were no subsequent records during the summer months.

4.2.5 Daubenton's bat

Daubenton's bat is generally a non-migratory species, or travels only short distances between its summer roosts to its winter quarters. It occurs in the forests near the coast at EAZ and also winters in preserved WW II bunkers in the dunes.

Daubenton's bat was recorded twice at the beach near EAZ, one record in March and one in May.

4.3 Representativeness of the study and the methodology

A recorder is detecting bat echolocation calls with a maximum distance of 15 – 50 meters from the microphone. The actual area surveyed therefore is very small. The overall bat activity along the Dutch coast and its EEZ must obviously have been much higher. On the other hand, it seems also possible 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), which might result in attraction to the wind turbines from a wider area around the turbines.

During the 2014 study there were two records during daylight hours; one some 2 hours before sunset and one 30 minutes after sunrise. We might have missed other bats during daylight hours because most of the day the recorders are switched off.

Another factor which might affect the recorded bat activity is the sensitivity of the microphone (TSL). During the 2014 study the TSL values at one location (OWEZ) dropped during several periods to very low levels and bat activity might be under-recorded during these periods.

In 2013 we recorded high numbers of noise files at PAWP which may have masked bat calls. We therefore moved the monitoring location from the easterly wind turbine to the transformer station in 2014. This resulted in a very significant reduction of the number of noise files, with average number per day comparable with OWEZ and IJMM.

5 Conclusions

Our observations in 2012, 2013 and 2014, combined with findings of stranded individuals on oil rigs and ships (Boshamer & Bekker 2008) and sightings during coastal migration counts and surveys at sea (Lagerveld *et al*. 2014b) indicate that bats regularly fly over the North Sea. In particular from late March until mid-May and from late August until early October during nights with calm weather (wind speeds usually well below 5 m/s, occasionally up to 10 m/s). Therefore, the observed bat activity was not caused by individuals that were blown off-shore by strong winds.

Nathusius' pipistrelle was the most commonly recorded species at sea during consecutive monitoring years. 'Nyctaloids' (including Noctule and probably Particoloured Bat) have also been observed with some regularity and Common pipistrelle has been recorded three times.

The observed pattern of occurrence at sea in combination with the species composition indicate that the observed bats were migrants. More specifically, the nocturnal pattern of Nathusius' pipistrelle suggests an east(erly) / west(erly) flight direction in autumn and the opposite direction in spring.

In 2014 we recorded bat activity shortly after sunset at OWEZ and IJMM on several days, indicating that bats roosted there and arrived the previous night or during daytime.

We recorded bats during daylight hours at two occasions and therefore bats (at least on sometimes) use their sonar also during the day.

In 2014 we also monitored at EAZ and at this coastal location there was no clear seasonal pattern (note however that we didn't obtain data from 9 July onwards). The first animals were recorded late March and it remained regular throughout the monitoring period. It seems likely that the observations at EAZ, at least in summer, concerned local populations. At EAZ we also recorded Pond and Daubenton's Bat (in addition to Noctule, Nathusius' and Common pipistrelle).

6 Recommendations

In order to obtain data concerning the actual number of bats, as well as their behaviour near offshore structures we recommend using thermal image cameras as well, in addition to the monitoring with ultrasonic recorders. In order to determine collision risk both number of bats and their behaviour around these structures need to be determined.

Placing more recorders per offshore structure might be used to assess flight height and to determine potential differences in bat activity on different sides of the offshore structure. More recorders per wind farm may be used to assess patterns of occurrence within the wind farm.

The recorders have been switched off during most of the daylight hours in order to save energy. In 2014 however we recorded bats during daylight hours and therefore it is recommended to keep the recorders running as long as technically possible. Moreover since flying during daylight might not always be avoided when migrating over sea, as opposed to migrating over land. In addition, it then has also to be established whether they use their sonar in a similar way during daylight as during dark. This might be done by combining either thermal-imaging or normal cameras with recorder observations.

The potential presence of bats in autumn will be considered during the operation of the currently developed wind farms at Borssele. In these wind farms the turbines will be switched off during nights with wind speeds less than 5 m/s in the period 15 August – 30 September. The monitoring results in this report however indicate that bats also occur regularly at sea in spring and therefore it seems appropriate to consider them also in this period.

Bats are not taken into account during the operation of Luchterduinen (LUD), OWEZ and PAWP. It seems logical to apply the same mitigation measures on any offshore wind farm.

7 Acknowledgements

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8 Quality Assurance

IMARES utilises an ISO 9001:2008 certified quality management system (certificate number: 124296-2012-AQ-NLD-RvA). This certificate is valid until 15 December 2015. The organisation has been certified since 27 February 2001. The certification was issued by DNV Certification B.V. Furthermore, the chemical laboratory of the Fish Division has NEN-EN-ISO/IEC 17025:2005 accreditation for test laboratories with number L097. This accreditation is valid until 1th of April 2017 and was first issued on 27 March 1997. Accreditation was granted by the Council for Accreditation.

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Justification

Report number: C165/14
Project number: 4306125301

The scientific quality of this report has been peer reviewed by the a colleague scientist and the head of the department of IMARES.

Approved: Dr. ir. H.V. Winter
Researcher

Signature:

Date: 16 September 2015

Approved: Drs. F.C. Groenendijk
Head of the Maritime Department

Signature:

Date: 16 September 2015

Appendix A

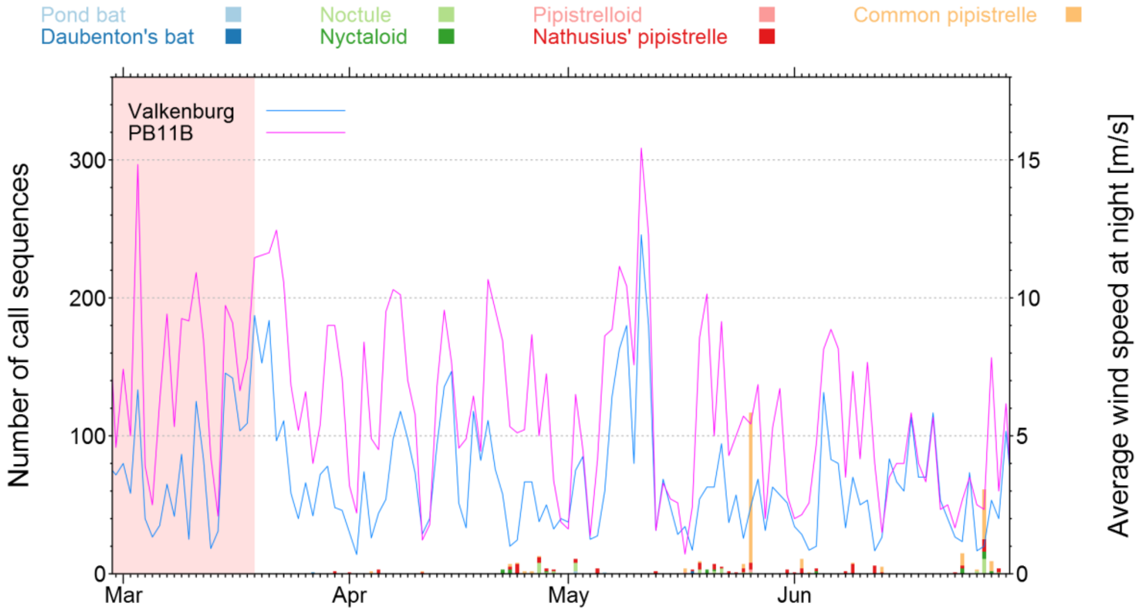

Figure A1: The number of recorded call sequences per species per night at EAZ (March – June), including the average wind speed per night (from sunset to sunrise) at Valkenburg Airport and offshore weather station PB11B. Note that the actual monitoring period is indicated by a white background.

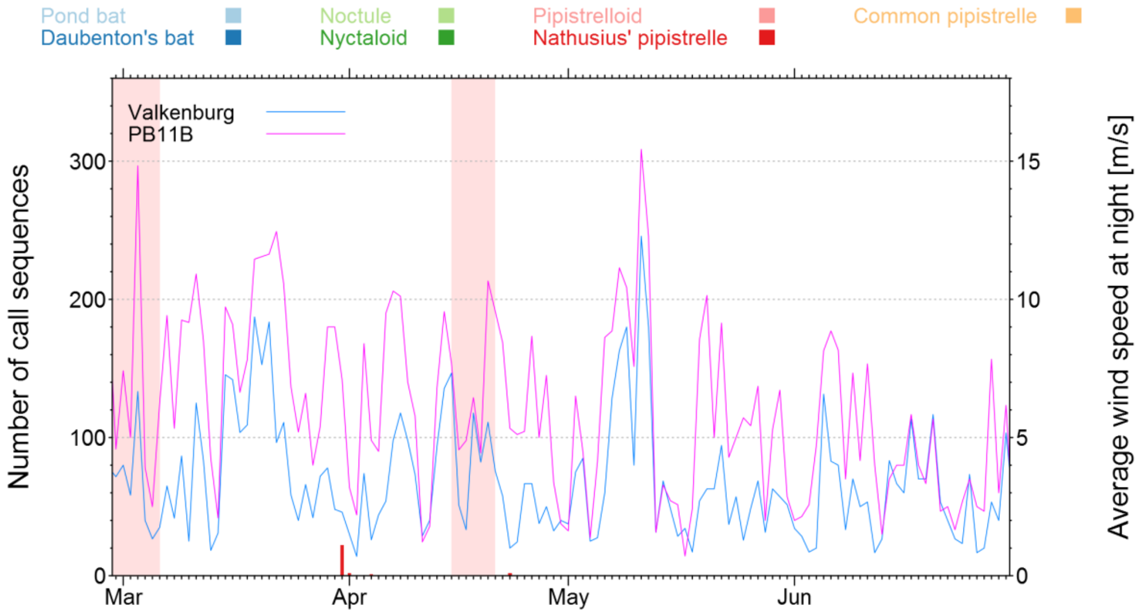

Figure A2: The number of recorded call sequences per species per night at OWEZ (March – June), including the average wind speed per night (from sunset to sunrise) at Valkenburg Airport and offshore weather station PB11B. Note that the actual monitoring period is indicated by a white background.

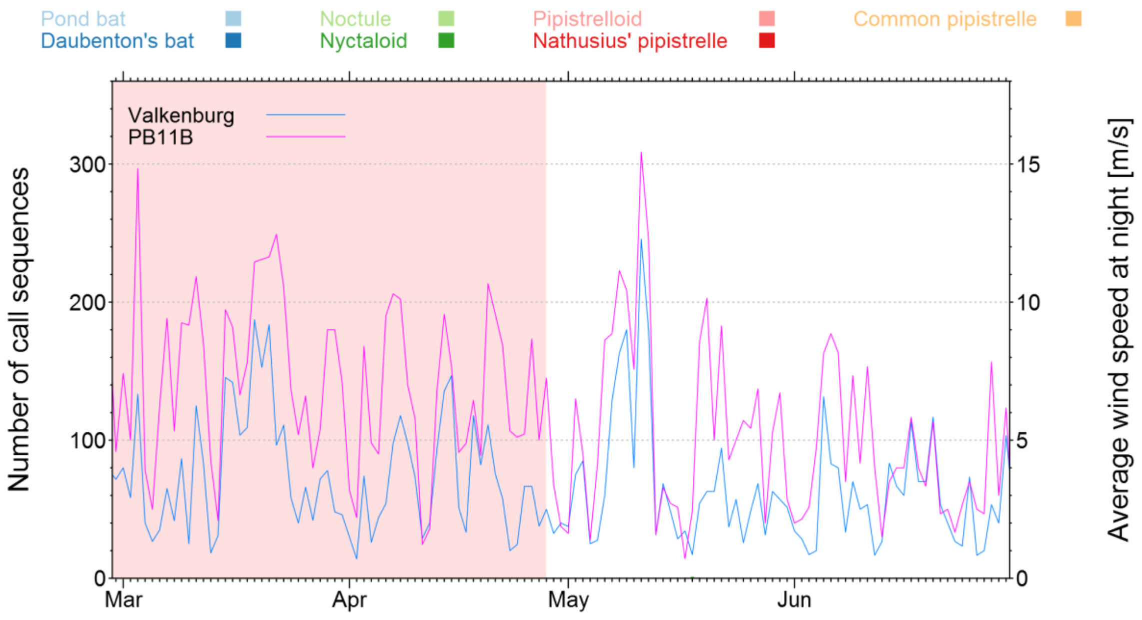

Figure A3: The number of recorded call sequences per species per night at PAWP (March – June), including the average wind speed per night (from sunset to sunrise) at Valkenburg Airport and offshore weather station PB11B. Note that the actual monitoring period is indicated by a white background.

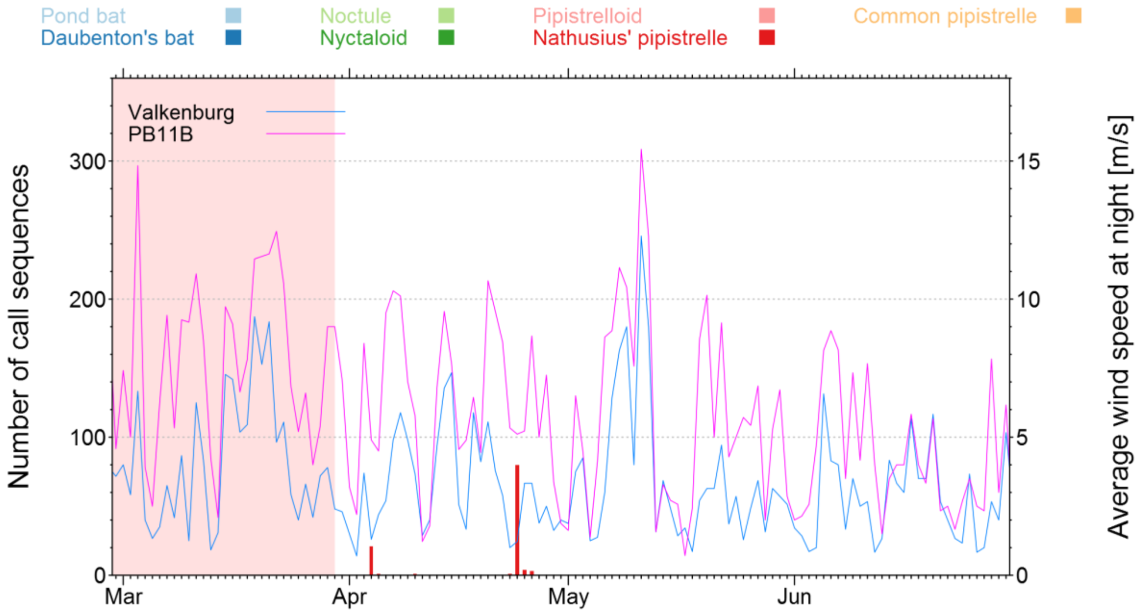

Figure A4: The number of recorded call sequences per species per night at IJMM (March – June), including the average wind speed per night (from sunset to sunrise) at Valkenburg Airport and offshore weather station PB11B. Note that the actual monitoring period is indicated by a white background.

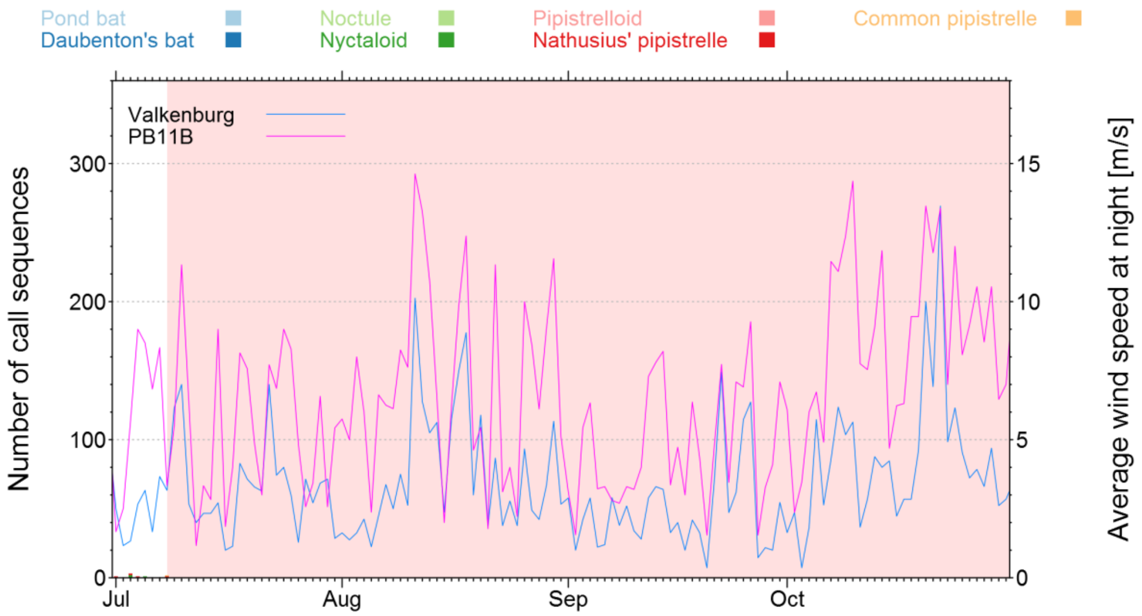

Figure A5: The number of recorded call sequences per species per night at EAZ (July – October), including the average wind speed per night (from sunset to sunrise) at Valkenburg Airport and offshore weather station PB11B. Note that the actual monitoring period is indicated by a white background.

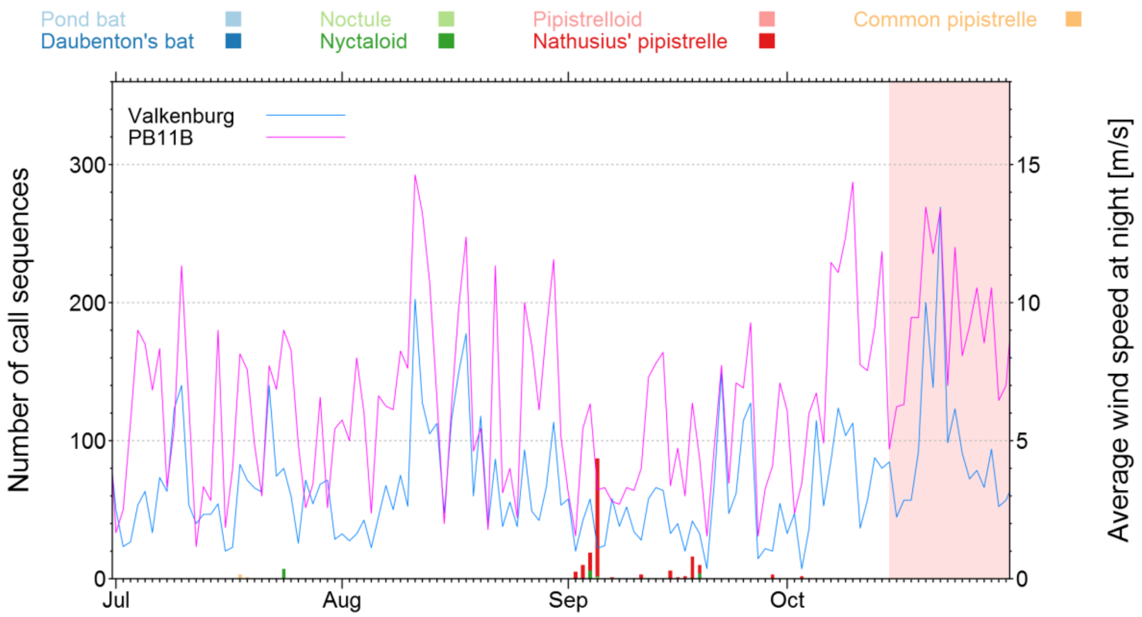

Figure A6: The number of recorded call sequences per species per night at OWEZ (July – October), including the average wind speed per night (from sunset to sunrise) at Valkenburg Airport and offshore weather station PB11B. Note that the actual monitoring period is indicated by a white background.

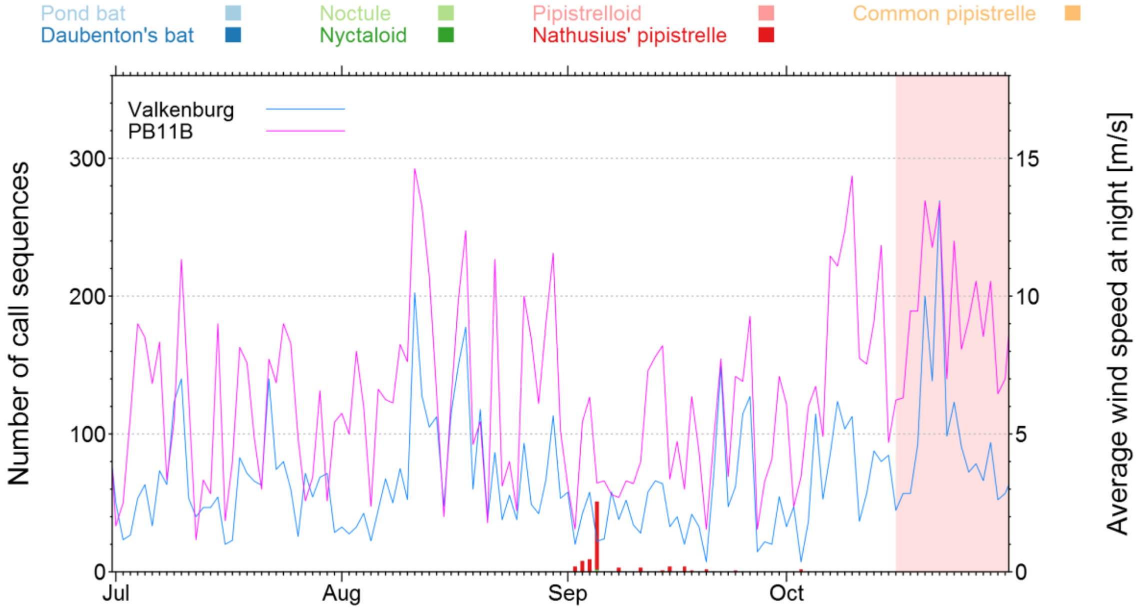

Figure A7: The number of recorded call sequences per species per night at PAWP (July – October), including the average wind speed per night (from sunset to sunrise) at Valkenburg Airport and offshore weather station PB11B. Note that the actual monitoring period is indicated by a white background.

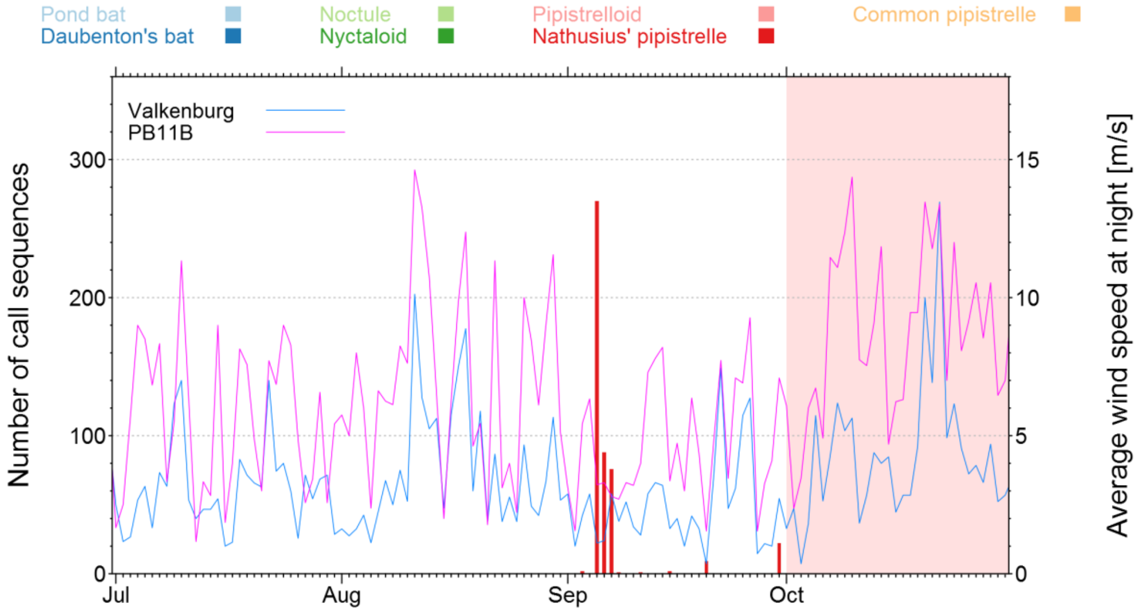

Figure A8: The number of recorded call sequences per species per night at IJMM (July – October), including the average wind speed per night (from sunset to sunrise) at Valkenburg Airport and offshore weather station PB11B. Note that the actual monitoring period is indicated by a white background.