

Monitoring bat activity in offshore wind farms OWEZ and PAWP in 2013

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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.* in prep.). Bats have also been observed during surveys at the North Sea and have been found on oil 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 firm 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 amongst bats.

We therefore conducted a pilot study in 2012 to monitor offshore bat activity with passive acoustic ultrasonic recorders (Jonge Poerink *et al.* 2013). During this study 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. Monitoring was done 29 August until 20 October 2012 at OWEZ and during 4 - 23 September 2012 at PAWP.

Bats were regularly recorded in both wind farms during this study. Virtually all call sequences (98%) could be attributed to Nathusius' pipistrelle and the remaining 2% to Noctule *Nyctalus noctula*.

In the follow-up project reported here, more data on the occurrence of bats at sea off the Dutch mainland coast were collected. Using the same methodology as in 2012, bat activity was monitored in both wind farms in 2013, from spring to autumn.

2 Materials and Methods

2.1 Study area

As in the 2012 pilot, this study was conducted in the two Dutch offshore wind farms:

- 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 km² and is located 10-18 km off the Dutch mainland.
- 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 km² and is located 23-26 km off the Dutch coast.

At OWEZ a recorder was installed at the meteorological mast at the western fringe of the wind farm and at PAWP a recorder was attached to the entrance platform of the easternmost wind turbine. Details on the locations of the recorders are shown in table 1.

Table 1 Positions of the ultrasonic recorder

Wind Farm	Geographical Position recorder	Distance to shore [km]	Height above sea level [m]	Direction microphone
OWEZ	N 52° 36' 22.9" E 004° 23' 22.7"	15	15	East
PAWP	N 52° 34' 89.4" E 004° 15' 60.3"	23	15	East

Figure 1 shows the geographical locations of both wind farms, as well as the approximate position of the recorder.



Figure 1. Geographical locations of OWEZ and PAWP and the positions of the recorders (red dots).

2.2 Monitoring period and timing

The monitoring period ran from 4 April until 15 October 2013 at OWEZ, and from 6 until 16 June and from 5 August until 2 October 2013 at PAWP. Both recorders were set to record only between 19:00 and 08:30 hours.

2.3 Equipment

Bat activity was monitored with a Batcorder 2.0 (Ecoobs GmbH); an automated ultrasonic recorder that can 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).

Initially, the threshold frequency for both recorders was set to 16 kHz and the threshold amplitude to -36 dB. Because of the vast amount of noise files which was recorded at PAWP, the threshold frequency of the PAWP recorder was adjusted to 30 kHz and the threshold amplitude to -30 dB from 5 August onwards.

2.3 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 realtime 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).

2.4 Weather data

Wind speed and wind direction were logged per 10 minute intervals by the weather station at the WTG08 wind turbine at OWEZ at a height of 70 m above sea level. The ambient pressure and precipitation data were measured at the OWEZ meteorological mast. The weather data were averaged per night for the analysis of the data. Sudden weather changes did not occur during nights with bat activity.

3 Results

3.1 Performance of the equipment

At OWEZ the recorder performed well from 4 April until 4 October 2013. During the last 11 days of the monitoring period the test signal of the batcorder indicated a low sensitivity level of the microphone. Therefore, bats might be missed during this period at OWEZ. At PAWP more than 65.000 noise files were recorded during the first monitoring period causing a full SD card after 11 days (6-16 June). The SD card was replaced on 5 August and the settings of the recorder were adjusted (threshold amplitude and frequency) in order to prevent recording of a vast amount of noise files again (paragraph 2.3). This time the capacity limit of the SD card was reached after 58 days of monitoring on 2 October. Therefore, bats may be missed or recorded less frequently, in particular bat species with low frequency calls (e.g. Noctule, Particoloured Bat) might be missed or recorded less frequently at PAWP during this period.

3.2 Bat activity

A total of 158 bat call sequences was recorded at OWEZ and 45 at PAWP. Nathusius' pipistrelle was the most commonly recorded species; 94% of the recordings could be attributed to this species. Probable Noctules were recorded at OWEZ during one night (3% of the recordings) and probable Particoloured bats *Vespertilio murinus* were recorded during three nights at PAWP (2% of the recordings). Common pipistrelle *Pipistrellus pipistrellus* was recorded once at OWEZ (1% of the recordings). Examples of spectrograms of the recorded species are shown in figures 2-5.

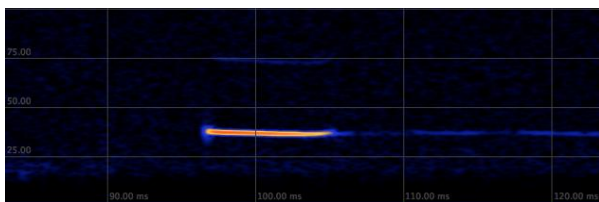


Figure 2: Spectrogram of Nathusius' pipistrelle 26 August 2013 OWEZ

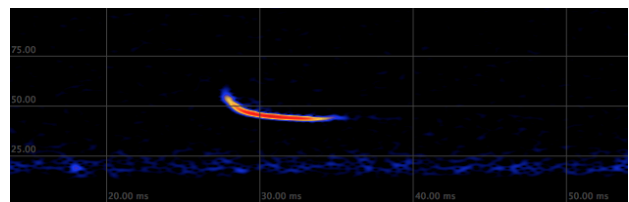


Figure 3: Spectrogram of Common pipistrelle 25 August 2013 PAWP

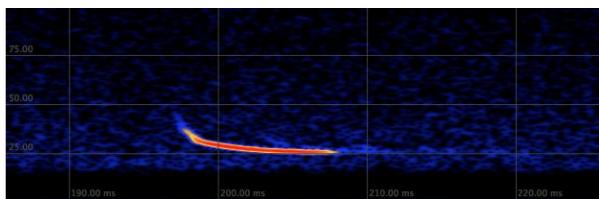


Figure 4: Spectrogram of a probable Particoloured Bat 6 September 2013 PAWP

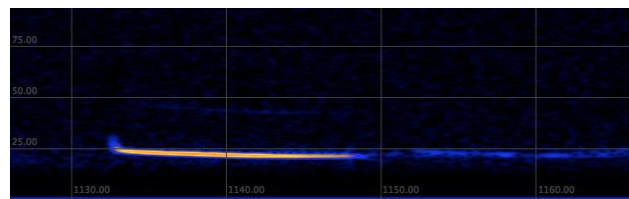


Figure 5: Spectrogram of a probable Noctule 23 August 2013 OWEZ

Bats were not recorded at PAWP during the first monitoring period (6 until 16 June) when the settings of the batcorder were not yet adjusted. There were occasional observations of Nathusius' pipistrelle in spring at OWEZ during the nights of 16 April and 6 May (3% of all call sequences). Bats were not recorded during June and July. Figure 1 shows the observed pattern of occurrence in spring at the OWEZ metrological mast.

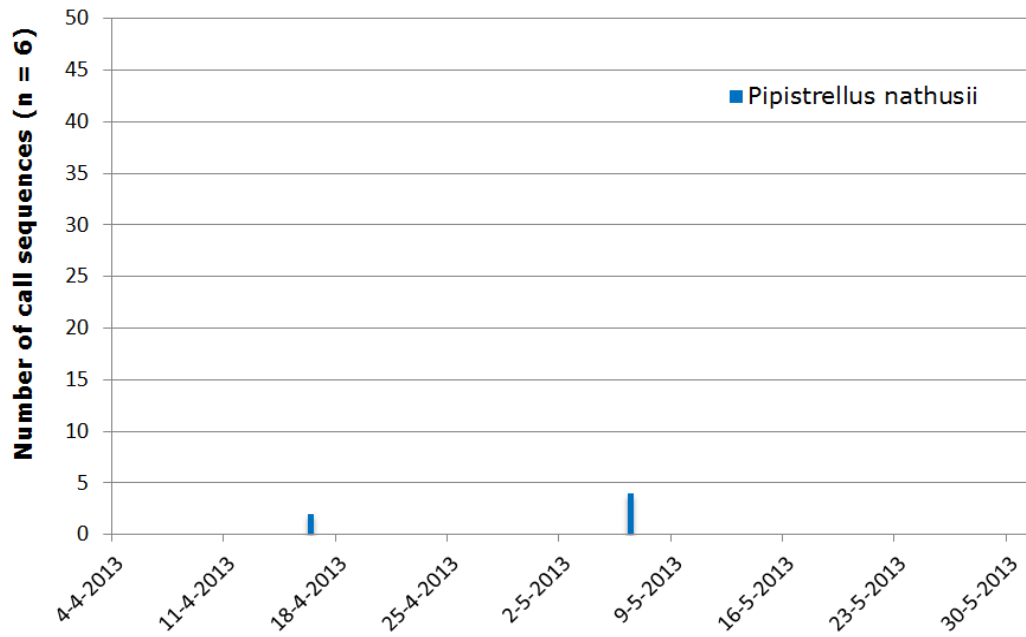


Figure 6. Number of call sequences per night at OWEZ spring 2013.

The vast majority of bats was recorded in autumn between 23 August and 28 September (97% of the call sequences). Most bat activity (70% of the call sequences) occurred during five nights; 25 and 28 August and 3, 23 and 24 September. Figures 2 and 3 show the recorded call sequences per night in autumn 2013 at OWEZ and PAWP respectively.

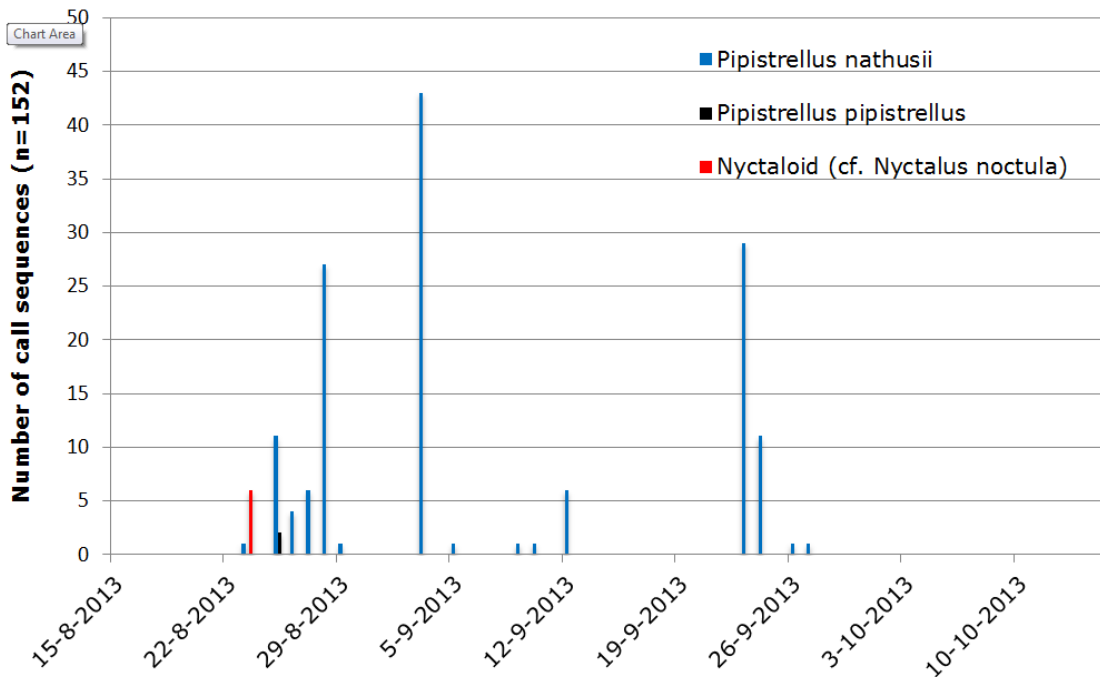


Figure 7. Number of call sequences per night at OWEZ autumn 2013

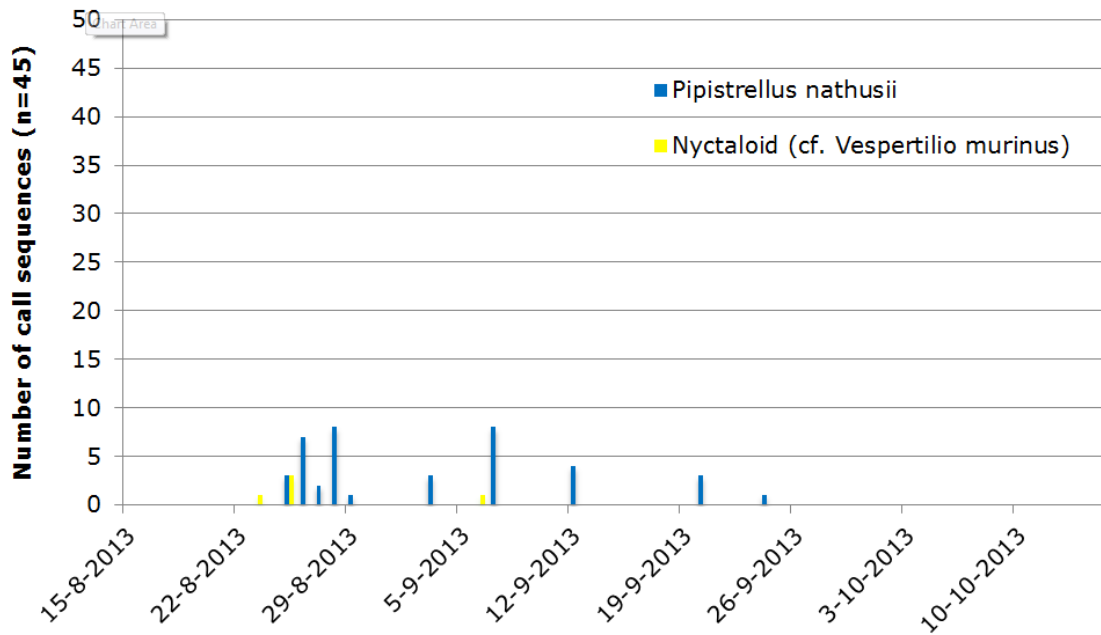


Figure 8. Number of call sequences per night at PAWP autumn 2013.

Bats were recorded during 18 nights in autumn of which they were noted during 9 nights at both wind farms. During 6 nights bats were recorded exclusively at OWEZ and during 3 nights exclusively at PAWP. The overall recorded bat activity in autumn was approximately three times higher in OWEZ than in PAWP.

Figures 9 and 10 show the observed bat activity in respectively spring and autumn in relation to the wind speed at OWEZ and PAWP. During spring, bat activity was noted during one night with a relatively low wind speed and one night with gale-force winds from the southwest. In autumn bat activity was strongly associated to low or moderate wind speeds, no precipitation and a high ambient pressure.

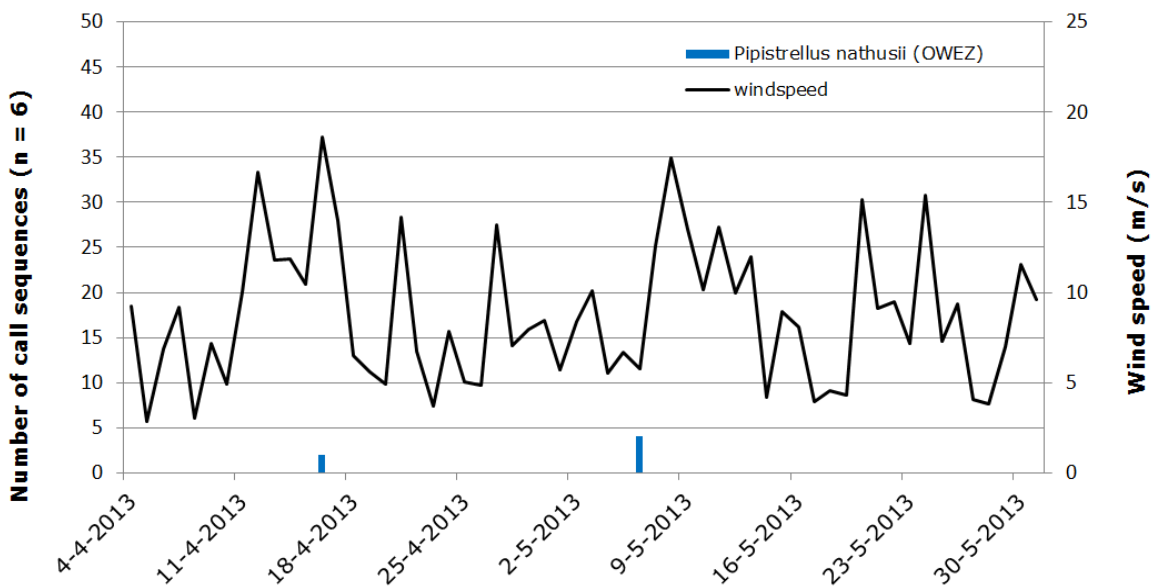


Figure 9. Bat activity in spring in relation to the average wind speed per night. Note that no monitoring was executed at PAWP in April and May.

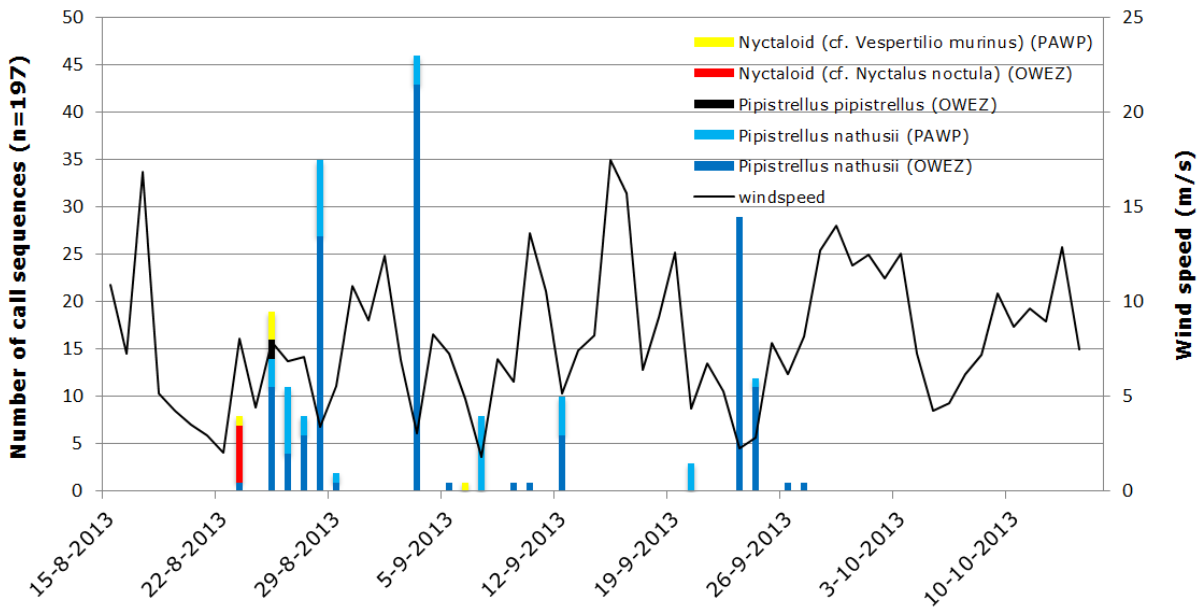


Figure 10. Bat activity in autumn in relation to the average wind speed per night.

Figure 11 shows the number of nights with and without bat activity at both monitoring locations per wind speed class from 23 August – 27 September. In this period bat activity was observed during 75% of the nights with wind speeds up to 5 m/s and during 47% of the nights with wind speeds between 6 and 10 m/s. Bats were observed during one night (14%) with wind speeds over 11 m/s.

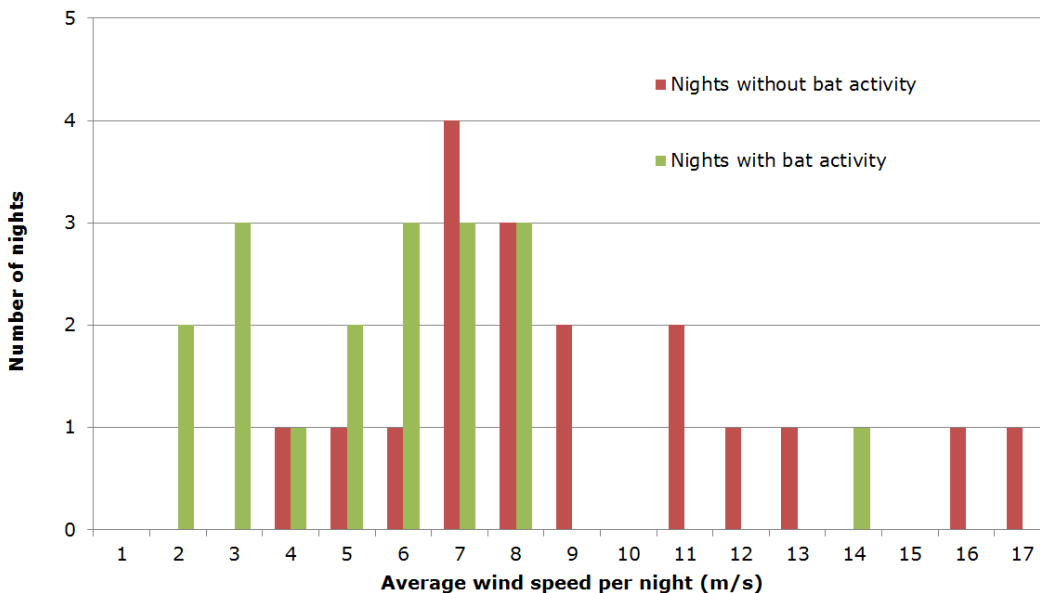


Figure 11. Number of nights with and without bat activity per wind speed class from 23 August until 27 September at either monitoring location.

Figure 12 shows the nocturnal activity of Nathusius' pipistrelle in relation to the time of sunset at both monitoring locations. Bat activity did not start immediately after sunset. The observations at PAWP within one hour after sunset referred actually to individuals which were recorded 57 and 58 minutes after sunset. The bat activity peaked between 3 and 4 hours after sunset at both locations. The observed bat activity between 10-11 hours after sunset referred to one or more individuals which were recorded two minutes after dawn in the morning of 26 August.

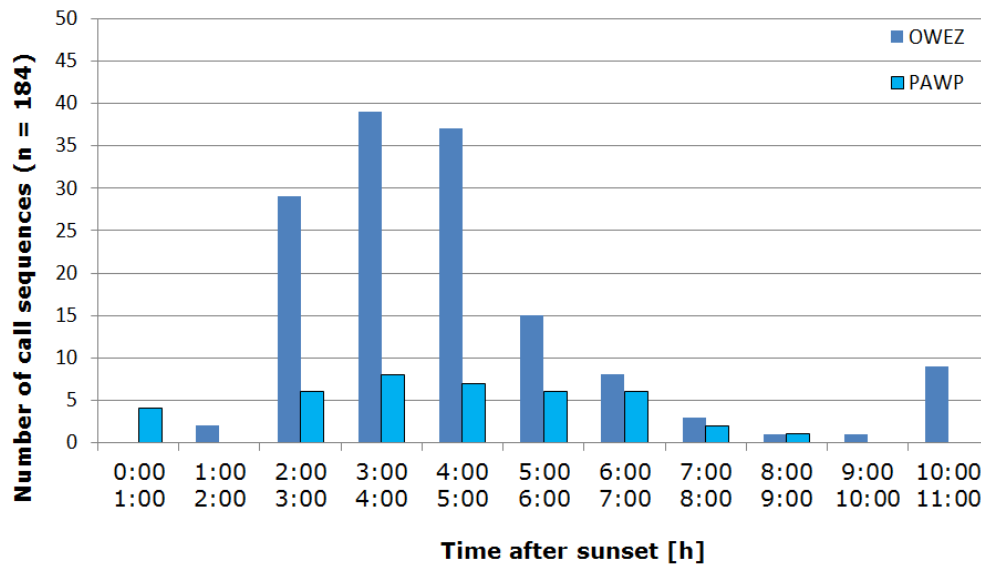


Figure 12. Bat activity of Nathusius' pipistrelle during the night at OWEZ and PAWP in autumn.

3.3 Noise files

Table 2 shows the number of noise files which were recorded at the monitoring locations in spring and summer, as well as the average wind speed per night. During this period the settings of the two recorders were identical.

Table 2 Number of noise files at night (from dusk to dawn) in spring and summer

Wind Farm	Monitoring period	Number of noise files	Average number of noise files per night	Average wind speed at night [m/s]
OWEZ	4 April – 31 July 2013	912	11	8.2
PAWP	6 – 15 June 2013	29964	2996	10.0

The number of noise files differed significantly amongst the different locations. At PAWP the average number of noise files per night during was almost 275 times higher compared to the number of noise files which was recorded at the OWEZ meteorological mast. After adjusting the settings of the recorder at PAWP the number of noise files decreased considerably, but was still much higher than OWEZ as can be seen in table 3.

Table 3 Number of noise files at night (from dusk to dawn) in autumn

Wind Farm	Monitoring period	Number of noise files	Average number of noise files per night	Average wind speed at night [m/s]
OWEZ	1 August – 15 October 2013	1800	30	7.9
PAWP	5 August – 2 October 2013	45205	822	7.8

4 Discussion

Observed species

Nathusius' pipistrelle was the most commonly recorded species in 2012 and 2013; respectively 98% and 94% of all recordings could be attributed to this species. Nathusius' pipistrelle is known to cover large distances –up to 1905 km- during migration (Hutterer *et al.* 2005). Other long-distance migrants which have been observed are Noctule and (probably) Particoloured bat. Interestingly, in 2013 there was also one observation of Common pipistrelle, a species which is assumed to be a sedentary, travelling up to a maximum of 20 km between the summer and winter roost (Dietz *et al.* 2007).

Bat activity

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 (Jonge Poerink *et al.* 2013). 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 refer to migrants.

In both 2012 and 2013 at both monitoring locations bat activity never started immediately after sunset. The first bats were recorded approximately one hour after sunset and peaked between 3 and 4 hours after sunset. Therefore, there are no indications that roosts were present in the vicinity of the recorders, as most bats leave their roosts shortly after sunset (Dietz *et al.* 2007).

Bat activity was associated with the weather conditions. Almost all bats were observed during nights with low or moderate wind speeds (up to 8 m/s, or 4 Bft). It seems therefore unlikely that these observations refer to individuals that were blown off-course by storms.

Methodology and representatively of the survey

The number of sampling locations in this study was limited as only one recorder was installed in each wind farm. Therefore, no information was obtained about the spatial distribution of bats within the wind farms.

A recorder is detecting bat echolocation calls with a maximum distance of 15 – 50 meters from the microphone, the area surveyed therefore is very small in relation to the size of the wind farms. It seems likely that the overall bat activity in the wind farms has been much higher. It seems also possible that the observed 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).

Offshore structures can produce ultrasonic sounds and it seems possible that bat calls can be masked by this ultrasonic noise. During our studies the recorder at the offshore wind turbine at PAWP logged much more ultrasonic noise than the recorder at the OWEZ meteorological mast, possibly causing an underestimation of the bat activity at PAWP.

In autumn 2013 the settings of the PAWP recorder were adjusted to prevent recording vast amount of noise files. The adjustment of the threshold frequency from 16 kHz to 30 kHz could have resulted in an underestimation of species with 'low-frequency' calls (e.g. Noctule and Particoloured bat). Modifying the threshold amplitude from -36 dB to -30 dB might have resulted in recording less bat activity overall. Note however, that the settings of both recorders in 2012 were identical.

Number of bats

It is hard to estimate the actual number of bats within the detection range of the recorders based on the number of call sequences. 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 fly multiple times in the vicinity of the recorder resulting in several recorded call sequences. An individual migrating bat may trigger the recorder only once, resulting in one recorded call sequence, (or even remain silent and pass undetected). Migrating bats however frequently travel in groups (Dietz *et al.* 2007) and a group of bats may also trigger the recorder also only once. Consequently, it is not possible to give an estimate how many individual bats have been present in the vicinity of the recorders. The number of call sequences is therefore used as an indication of the bat activity.

In both 2012 and 2013 the number of recorded bat call sequences at OWEZ was higher than at PAWP (not only overall, but also during the overlapping monitoring periods). This can be due to a higher abundance of bats at OWEZ or the methodological restrictions of the survey mentioned before, but there may be other explanations for the observed pattern:

- OWEZ covers an area of 27 km² and consists of 36 wind turbines and a meteorological mast. PAWP has nearly twice the number of turbines, in a much smaller area of 17 km². The higher density of structures at PAWP might result in lower bat density per object compared to OWEZ.
- The insect abundance at the OWEZ meteorological mast might be higher than the abundance at the wind turbine at PAWP. More prey availability may result in more bat activity but not necessarily in more bats.

5 Conclusions

The monitoring projects in 2012 and 2013 indicate regular offshore occurrence of bats in autumn, in particular from late August until early October. Bat activity was recorded occasionally in April and May 2013 and was not observed during June and July 2013.

Nathusius' pipistrelle was the most commonly observed species in both years. Noctule and (probable) Particoloured bats were recorded occasionally and Common pipistrelle was recorded only once. The species which have been observed are all known to be long-distance migrants with the exception of Common pipistrelle which is considered a sedentary species.

The observed pattern of occurrence in combination with the species composition indicate that the observed bats were migrants. Bats were seen mainly in autumn and in two consecutive years. It seems not likely that the observed bat activity was caused by individuals that were blown off-course by storms. Furthermore, there were no indications that roosts were present near the recorders, i.e. in the wind farms. The wind farms were apparently not used as foraging area by local (coastal) populations, at least not during summer.

Our observations, 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 in prep.) indicate that bats regularly fly over the North Sea.

6 Recommendations

Monitoring bat activity at offshore structures without moving parts seems to be preferable to wind turbines, in order to prevent potential masking of bat calls by ultrasonic noise and rapid attainment of the storage capacity of the memory card.

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

To date, the presence of bats at sea has not been taken into account during the site selection and operational management of offshore wind farms in the Netherlands. Clearly, however, bats regularly occur over the North Sea and therefore these protected species cannot be ignored when assessing ecological effects of offshore wind energy at the North Sea.

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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 1st of April 2017 and was first issued on 27 March 1997. Accreditation was granted by the Council for Accreditation.

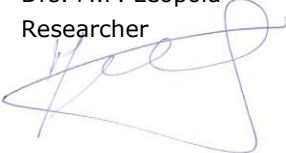
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Justification

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

Approved: Drs. M.F. Leopold
Researcher


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Date: 9 December 2014

Approved: Drs. J Asjes
Head of Ecosystems Department

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Date: 9 December 2014