Bats in Dutch offshore wind farms in autumn 2012

Sander Lagerveld[1], Bob Jonge Poerink[2], Raymond Haselager[2] & Hans Verdaat[1]

[1]IMARES Wageningen UR, P.O. Box 57, NL-1780 AB Den Helder, the Netherlands,
email: sander.lagerveld@wur.nl
[2]The Fieldwork Company, Stockholmstraat 2B, NL-9723 BC Groningen, the Netherlands

Abstract: In the autumn of 2012, we conducted a pilot study with ultrasonic recorders to assess the occurrence of bats over the North Sea. At Offshore Wind Farm Egmond aan Zee (OWEZ) a recorder was installed at the meteorological mast and at Princess Amalia Wind Farm (PAWP) a recorder was attached to the entrance platform of an offshore wind turbine. There were 189 recordings of bat echolocation calls at OWEZ and 25 at PAWP. Virtually all recordings concerned Nathusius' pipistrelle (*Pipistrellus nathusii*); noctule (*Nyctalus noctula*) was noted a few times. Bats were only recorded during nights with low or moderate wind speeds, no precipitation and a high ambient pressure. It seems unlikely that the observations referred to individuals which were blown off course by storms, and there are no indications that roosts were present in the vicinity of the recorders. The occurrence pattern of Nathusius' pipistrelle indicates that the observations were of migrating individuals. The observations of noctule possibly concerned migrants as well, but they could also be residents from the mainland which may use the wind parks as foraging area.

Keywords: bats, North Sea, sea, wind farm, migration, acoustic monitoring, wind speed, conservation, *Pipistrellus nathusii*, *Nyctalus noctula*.

Introduction

Several species of bat in northern Europe show seasonal migrations between their summer roosts and winter quarters. Most of them travel short or moderate distances, but some species like Nathusius' pipistrelle (*Pipistrellus nathusii*), soprano pipistrelle (*Pipistrellus pygmaeus*), noctule (*Nyctalus noctula*), Leisler's bat (*Nyctalus leisleri*) and parti-coloured bat (*Vespertilio murinus*) are long distance migrants, travelling from northern and eastern Europe to more temperate areas and vice versa (Hutterer et. al. 2005, Krapp & Niethammer, 2011). Some bats migrate individually while others migrate in groups, sometimes even large groups (Dietz et al. 2009). Generally bat migration occurs at night, but some species like noctule have been seen migrating in the morning or just before dusk (Randler 2001, Mostert 2012).

Not much is known about the migration routes of bats. At least some specific flyways are used, such as river valleys (Furmankiewicz & Kucharska 2009) and coasts (Dietz et al. 2009, Masing 2011, Šuba et. al. 2012). At the North Sea coast, bat migration was studied on the German islands of Mellum, Neuwerk and Wanderooge (Bach et al 2009, Frey et al 2012) and on the Dutch island of Rottumeroog (Jonge Poerink & Haselager 2013). Bats do not migrate exclusively over land. A study of the Swedish coast of the Baltic Sea showed that migration commonly occurs over sea (Ahlén et al. 2007, 2009). Interestingly, this study also revealed that the local populations from the mainland used the coastal sea as foraging area. In particular offshore wind turbines were favoured as foraging area because of the accumulation of insects around the turbines.

For quite some time there have been indications of bat movements over the North Sea. Observers of bird migration at the Dutch coast record bats flying in from sea with some regularity (N. van der Ham in litt., M. de Lange in litt., R. van der Vliet in litt., S. Lagerveld, personal observation). Most sightings occur from late April to May and throughout September and October. Bats have also been observed during surveys at the North Sea in September (S. Lagerveld and H. Verdaat, personal observations) and have been found on oil platforms and ships (Boshamer & Bekker 2008, Russ et al. 2001, Skiba 2007, Walter et al. 2007, Petersen et al. 2014). In 2013 a Nathusius' pipistrelle was found in the Netherlands, which was banded three years earlier in the UK (T. Dolstra, personal communication). At the North Sea, bat activity was studied on Helgoland (Hüppop 2009) and on FINO 1, a research platform 45 km north of Borkum (Hüppop & Hill 2013). Both studies confirmed the occurrence of bats over the North Sea. In order to assess the occurrence of bats in offshore wind farms at the North Sea, we conducted a pilot study with ultrasonic recorders at two Dutch offshore wind farms. In addition, we gathered meteorological data. We used the occurrence patterns and meteorological data to establish why bats occur at sea. Another aim of this study was to assess the performance of the ultrasonic recorders under offshore conditions.

Material & methods

Study area

This study was conducted in the autumn of 2012 in two Dutch offshore wind farms (figure 1):

- 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 approximately 15 km off the Dutch coast. Monitoring was done from 29 August to 20 October 2012.
- Princess Amalia Windpark (PAWP); consists of 60 Vestas V80-2 MW wind turbines and a transformer platform. The wind farm covers an area of approximately 17 km^2 and is located 23 km off the Dutch coast. Monitoring was done from 4 to 23 September 2012.

Recording equipment and data analyses

Monitoring was performed with a Batcorder 2.0 (EcoObs GmbH); an automated ultrasonic recorder which can record sounds in the range of 16-150 kHz. The recorders were ruggedised for offshore conditions (Jonge Poerink et. al. 2013). Both recorders were operating between 19:00 p.m. and 08:30 a.m. The recorders did not record continuously but only after being triggered by a bat call, or bat call-like ultrasonic sound. Bats can be recorded at a maximum distance of 15 - 50 meters from the recorder, depending on their specific sonar characteristics, the environmental conditions and the recorder settings.

At OWEZ a recorder was installed at the meteorological mast (figure 2); at PAWP a recorder was attached to the entrance platform of a wind turbine. Details of the locations are given in table 1.

All sound files were recorded in real-time onto a SD memory card. The sound files containing bat calls were separated from the noise files by BcAdmin 2.0 (EcoObs GmbH). Individual bat call recordings were analysed and identified using the automated identification software Batident 1.0 (EcoObs GmbH). In addition, all identifications were checked and evaluated using the criteria provided by Skiba (2009) and Barataud (2012).

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.

Results

The ultrasonic recordings in OWEZ & PAWP

At OWEZ 189 bat call sequences containing 1477 individual echolocation calls were recorded in the period of 29 August until 20 October 2012. Within this period, bats were recorded during nine nights. Relatively high bat activity was observed during the nights of 3, 8, 22 September and 8 October (figure 3). Two species of bats were identified at OWEZ: Nathusius' pipistrelle and noctule. Nathusius' pipistrelle represented 98% of all call sequences and noctule represented 2%. Noctules were only recorded early September.

At PAWP 25 bat call sequences containing 110 individual echolocation calls were recorded from 4 to 23 September 2012. Within this period, bats were recorded during three nights. High bat activity was recorded during the nights of 8 and 22 September, which corresponds with high activity at OWEZ (figure 3). All observations at PAWP referred to Nathusius' pipistrelle.

At OWEZ 8% of the call sequences contained different echolocation calls that were emitted at the same time, proving that more than one individual was present. In one call sequence even three calls were recorded almost simultaneously, indicating the presence of three individuals. At PAWP there were no call sequences that indicated the presence of more than one individual. We recorded no social calls or feeding buzzes at either location.

In addition to the bat echolocation calls, the detectors recorded ultrasonic noise as well. At the OWEZ meteorological mast on average 50 noise files were recorded per 24 hours, whereas at the PAWP wind turbine on average 1500 noise files were recorded per 24 hours.

Bat activity and weather conditions
All observed bat activity occurred in nights with an average wind speed per night of less than 7 m/s with the exception of the night of 15 September when an average wind speed of 10 m/s was measured (figure 3). Furthermore, all observed bat activity occurred during nights with no precipitation and with an average atmospheric pressure >1010 hPa (figure 4).

Nocturnal pattern of bat activity
The time of the observed bat activity for Nathusius' pipistrelle was related to the time of sunset to assess the pattern of occurrence throughout the night (figure 4). Bat activity did not start immediately after dark: the peak activity occurred between 3-4 hours after sunset in both wind farms.

Performance of the recorder

The recorders have been functioning properly during the monitoring period. After the monitoring period the casings and microphones were inspected and found unaffected by salt spray, humidity or mechanical forces.

Discussion

Occurrence of bats in the offshore wind farms

It is hard to give an estimate of the actual number of bats based on the number of call sequences. An individual migrating bat may trigger the recorder only once, resulting in one recorded call sequence. Migrating bats however frequently travel in groups (Ahlén et al. 2009, Dietz et al. 2009, Mostert 2012) and a group of bats may also trigger the recorder only once. At OWEZ several recordings included more than one individual at the same time.

Ahlén et al. (2007, 2009) observed that migrating bats often interrupt their flight to

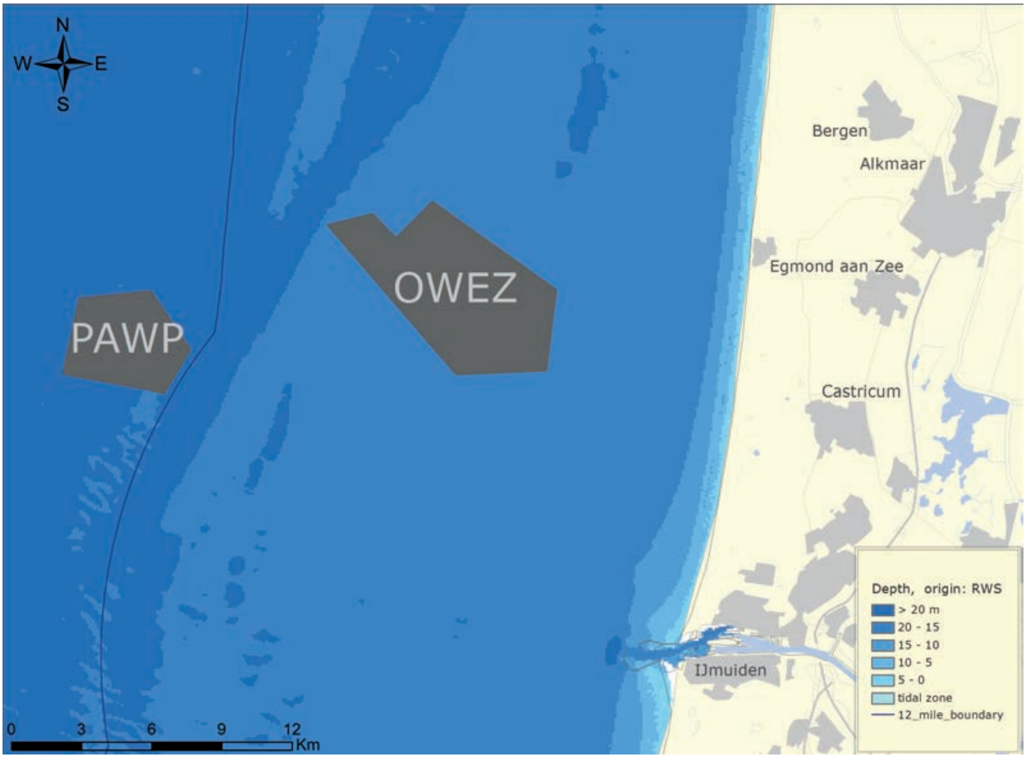

Figure 1. geographical locations of OWEZ and PAWP.

Figure 2. Ultrasonic recorder at the OWEZ meteorological mast. *Photo: Hans Verdaat*.

Table 1. Positions of the ultrasonic recorder.

Wind Farm	Geographical Position recorder	Distance to shore (km)	Height above sea level (m)	Direction of 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

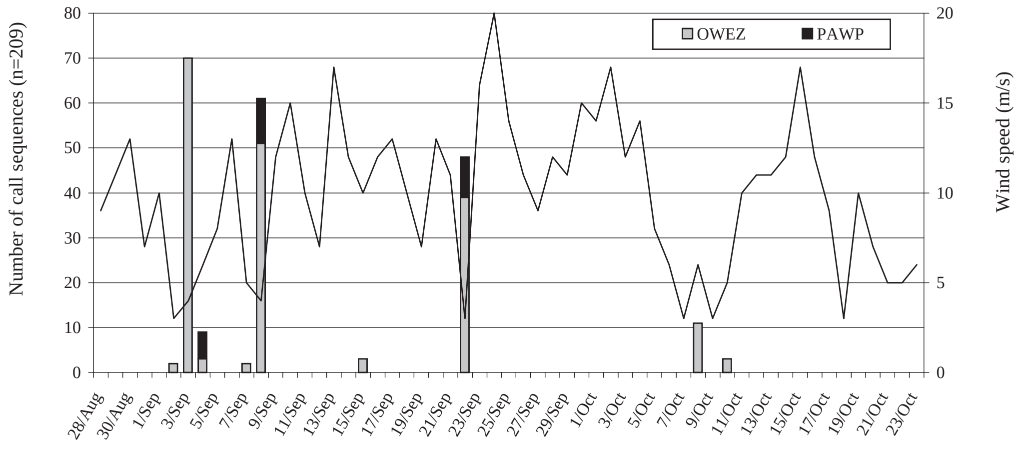

Figure 3. Number of call sequences of Nathusius' pipistrelle at OWEZ and PAWP and the average wind speed at OWEZ per night.

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. Consequently, it is not possible to give an estimate of 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.

Ahlén et al. (2007) observed that bats always use their echolocation during flight over the Baltic Sea at night. Whether they do so during the day is apparently not known. It is possible that they don't use their sonar (or that they use it to a lesser extent) during daylight hours at sea since at least some species of bat use visual cues for navigation over larger distances (Eklöf 2003). Consequently, they can be missed by the ultrasonic recorders.

Offshore wind turbines and other offshore structures attract bats (Ahlén et al. 2007, 2009). The observed abundance near the detectors therefore is likely to be higher than the abundance over open sea.

The mounting height of the recorders was approximately 15 m above sea level. Bat calls are detected between 15 and 50 m from the recorder, which means that we recorded bats from sea level up to a height of 30 to 65 metres above sea level. It also means that higher-flying bats are likely to be missed. However, most bats that were observed at the Baltic Sea flew below 10 m altitude, including the normally high-flying species like noctule (Ahlén et al 2009). Bats observed during surveys at the North Sea (n=3) flew at altitudes between 5 and 20 m (S. Lagerveld and H. Verdaat, personal observations).

In OWEZ the number of recorded bat call sequences was much higher than in PAWP, also during the overlapping monitoring period. This can be due to a higher abundance of bats at OWEZ but there may be other explanations for the observed pattern:

- OWEZ is located 15 km off the coast, PAWP is located 23 km off the coast. The shorter

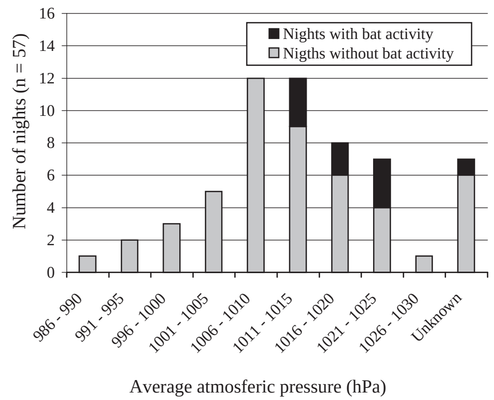

Figure 4. The number of nights with bat activity and the average atmospheric pressure at OWEZ.

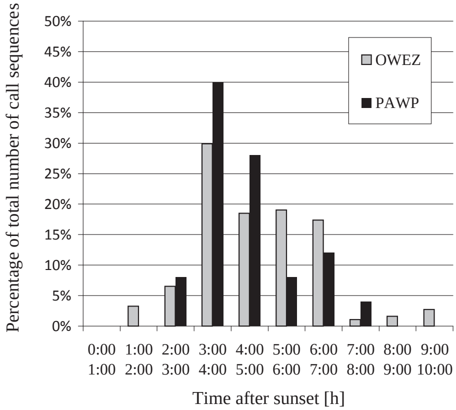

Figure 5. Percentage of call sequences of Nathusius' pipistrelle per hour after sunset at OWEZ and PAWP.

distance to the coast of OWEZ can affect the number of bats in the wind farm. Also the location of the wind farms in relation to specific flyways can affect the abundance of bats in the wind farms;
- The higher number of recorded bat call sequences at OWEZ can be due to different behaviour (e.g. more activity due to a higher insect abundance);
- During our study the offshore wind turbine at PAWP produced 30 times more ultrasonic noise recordings than the OWEZ meteorological mast. Ultrasonic noise can mask bat calls and can lead to an underestimation of the bat activity;
- OWEZ covers an area of 27 km^2 and consists of 36 wind turbines and a meteorological mast. PAWP consists of 60 wind turbines including a transformer platform and covers 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.

Behaviour of bats in the offshore wind farms

Ahlén et al. (2007, 2009) mentioned that service engineers found roosting individuals of various bat species in the nacelles of offshore wind turbines near the Swedish coast. Those bats stayed there for several days and social calls were frequently observed. During our study there have been no indications that roosts were present in the vicinity of the recorders. Both noctule and Nathusius' pipistrelle leave their roost at dusk (Russ 2012, Dietz et al. 2009) and the observed bat activity started at least one hour after dusk and peaked between 3-4 hours after darkness had set in. In addition, we did not record any social calls, which can be indicative for the presence of roosts.

Noctule and Nathusius' pipistrelle pass through the Netherlands during migration, but are also fairly common residents at the Dutch mainland near the coast (Limpens et al 1997). The temporal pattern of occurrence during this pilot study suggests that the observed Nathusius' pipistrelles were migrating: their time of occurrence matches the species' migration season and both offshore wind farms are located well beyond their foraging range, which extends up to 6.5 km from their roosts (Dietz et al. 2009). The observations of noctules also coincide with their migration season, but we cannot exclude the possibility that foraging individuals of local populations from the mainland were involved. Distances up to 26 km between their roosts and foraging areas have been reported (Altringham 2003) and therefore both offshore wind farms are located within their foraging range from the mainland.

This pilot study shows a strong link between bat activity in the two wind farms: when bats were observed in PAWP, they were always present in OWEZ as well. Bats were observed at wind speeds up to 10 m/s, but most activity occurred at wind speeds below 5 m/s. This result exactly matches the pattern observed in southern Sweden by Ahlén et al. (2007, 2009). In addition, bats were only observed during nights with high ambient pressures and no precipitation, shortly after periods of unfavourable weather conditions. This also corresponds with the findings of Ahlén et al. (2007, 2009) and Cryan & Brown (2007) who observed that migrating bats wait for favourable conditions to cross over sea.

Conclusions

It is possible to perform acoustic monitoring of bat activity at sea when ruggedised ultrasonic recorders are used.

This study indicates regular occurrence of bats in the Dutch offshore wind farms. Bats were only recorded during nights with low or moderate wind speeds, no precipitation and a high ambient pressure and it seems therefore unlikely that these observations refer to individuals who were blown off course by storms.

Virtually all recordings concerned Nathusius' pipistrelle. Noctules were recorded a few times. Both species are long-distance migrants but also occur as residents at the mainland near the coast. The observed occurrence pattern during this study indicates that Nathusius' pipistrelle occurred as a migrant in the offshore wind farms. The noctules were possibly migrating as well, but we cannot exclude the possibility that local populations from the mainland use the offshore wind farms as a foraging area.

Due to the restricted monitoring period and geographical scale of this pilot project it is not possible to draw overall conclusions of the occurrence of bats at the North Sea. Our observations, however, combined with offshore sightings and findings of stranded individuals on oilrigs and ships, do indicate that bats regularly occur over the North Sea.

Acknowledgements: We like to thank Henk Kouwenhoven and Bart Hoefakkers (Shell-NUON), Jan Dam (Ecofys), Edwin Jansen, Mienke Hollander and Gerke Hoekstra (ENECO), Gertjan Spaans and Arno Verduin (Vestas), Andrew Ford (Total Wind) for facilitating this study. We are indebted to Teddy Dolstra, Nick van der Ham, Michel de Lange and Rinse van der Vliet who shared valuable information about their field observations, Elze Dijkman for producing figure 1 and Charlotte Deerenberg, Steve Geelhoed, Mardik Leopold and Meike Scheidat for their comments on earlier drafts of this paper. Furthermore, we thank two anonymous reviewers and the editor for their constructive review.

Literature

Ahlén, I., H.J. Baagøe & L. Bach 2009. Behavior of Scandinavian bats during migration and foraging at sea. Journal of Mammalogy 90: 1318–1323.

Ahlén, I., L.Bach, H.J. Baagøe & J. Pettersson 2007. Bats and offshore wind turbines studied in southern Scandinavia. Report 5571. Swedish Environmental Protection Agency, Stockholm, Sweden.

Altringham J. 2003. British Bats. Harper Collins, London, UK.

Bach, L., P. Bach, A. Helge, K. Maatz, V. Schwarz, M. Teuscher & J. Zöller 2009. Fledermauszug auf Wangerooge – erste Ergebnisse aus dem Jahr 2008. Natur und Umweltschutz (Zeitschrift Mellumrat) 8: 10-12.

Barataud, M. 2012. Ecologie acoustique de Chiropteres d'Europe. Biotope – Muséum national d'Histoire naturelle, Paris, France.

Boshamer, J.P.C. & J.P. Bekker 2008. Nathusius' pipistrelles (*Pipistrellus nathusii*) and other species of bats on offshore platforms in the Dutch sector of the North Sea. Lutra 51: 17-36.

Cryan, P.M. & A.C. Brown. 2007. Migration of bats past a remote island offers clues toward the problem of bat fatalities at wind turbines. Biological Conservation 139: 1-11.

Dietz, C., O. Helversen & D. Nill 2009. Bats of Britain, Europe and Northwest Africa. A. & C. Black, London, UK.

Eklöf, J. 2003. Vision in echolocating bats. PhD thesis. Zoology department. Göteborg university, Sweden.

Frey, K., L. Bach, P. Bach & H. Brunken 2012. Fledermauszug entlang der südlichen Nordseeküste. Naturschutz und Biologische Vielfalt 128: 185-204.

Furmankiewicz, J. & M. Kucharska 2009. Migration of bats along a large river valley in southwestern Poland. Journal of Mammalogy 90: 1310-1317.

Hüppop, O. 2009. Bat migration at Helgoland, a remote island in the North Sea: wind assisted or wind drifted? Poster presentation. Proceedings of the 1st International Symposium on Bat Migration: 55. Leibniz Institute for Zoo and Wildlife Research (IZF), Berlin, Germany.

Hüppop, O. & R. Hill 2013. The occurrence of migrating bats at an anthropogenic offshore structure in the south-eastern North Sea. Poster presentation. Proceedings of the 3rd International Bat Meeting: Bats in the Anthropocene: 150. Leibniz Institute for Zoo and Wildlife Research (IZF), Berlin, Germany.

Hutterer R., T. Ivanova, C. Meyer-Cords & L. Rodrigues 2005. Bat migrations in Europe: a review of banding data and literature. Naturschutz und Biologische Vielfalt 28: 1–176.

Jonge Poerink, B. & R. Haselager 2013. Rapportage monitoring migratie vleermuizen Rottumeroog voor- en najaar 2012. Report number 20130102. The Fieldwork Company, Groningen, the Netherlands.

Jonge Poerink, B., S. Lagerveld & H. Verdaat 2013. Pilot study Bat activity in the Dutch offshore wind farms OWEZ and PAWP. Report number C026/13, IMARES / report number 20120402, the Fieldworrk Company,Groningen, the Netherlands.

Krapp, F. & J. Niethammer 2011. Die Fledermäuse Europas. AULA Verlag, Wiebelsheim, Germany.

Limpens H., K. Mostert & W. Bongers 1997. Atlas van de Nederlandse Vleermuizen. KNNV Uitgeverij, Utrecht, the Netherlands.

Masing, M.V. 2011. How many bats migrate along Estonian coasts during late summer? In: XII European Bat Research Symposium, Vilnius, Lithuania, 22–26 August 2011: 37. Lithuanian Society for Bat Conservation, Vilnius, Lithuania.

Mostert, K. 2012. Vleermuizen in Den Haag en omgeving 2009-2011. Stichting Zoogdierenwerkgroep Zuid-Holland, Den Haag, the Netherlands.

Petersen, A., J.-K. Jensen, P. Jenkins, D. Bloch & F. Ingimarsson 2014. A review of the occurrence of bats (Chiroptera) on islands in the North East Atlantic and on North Sea installations. Acta Chiropterologica 16: 169-195.

Randler, C. 2001. Ziehen Abendsegler (*Nyctalus noctula*) bei Tag? Nyctalus 7: 643-645.

Russ, J. 2012. British Bat Calls. Pelagic Publishing, Exeter, UK.

Russ, J.M., A.M. Hutson, W.I. Montgomery, P.A. Racey & J.R. Speakman 2001. The status of Nathusius' pipistrelle (*Pipistrellus nathusii* Keyserling & Blasius, 1839) in the British Isles. Journal of Zoology 254: 91-100.

Skiba, R. 2007. Die Fledermäuse im Bereich der Deutsche Nordsee und Berücksichtigung der Gefährdungen durch Windenergieanlagen. Nyctalus 12: 199-220.

Skiba, R. 2009. Europäische Fledermäuse. 2nd edition. Neue Brehm-Bücherei 648. Westarp Wissenschaften, Hohenwarsleben, Germany.

Šuba J., G. Petersons & J. Rydell 2012. Fly-and-forage strategy in the bat *Pipistrellus nathusii* during autumn migration. Acta Chiropterologica 14: 379–385.

Walter, G., H. Mathes & M. Joost 2007. Fledermauszug über Nord- und Ostsee – Ergebnisse aus Offshore-Untersuchungen und deren Einordnung in das bisher bekannte Bild zum Zuggeschehen. Nyctalus 12: 221-233.

Samenvatting

Vleermuizen in Nederlandse offshore windparken in het najaar van 2012

In de herfst van 2012 is een pilotstudie uitgevoerd met ultrasone recorders naar het voorkomen van vleermuizen op de Noordzee. Eén recorder werd geïnstalleerd op de meteorologische mast in Offshore Windpark Egmond aan Zee (OWEZ) en een andere recorder op een offshore windturbine in het Prinses Amalia Windpark (PAWP). In OWEZ en PAWP werden respectievelijk 189 en 25 opnamen van vleermuis-echolocatiegeluiden gemaakt. Bijna alle opnames waren van ruige dwergvleermuizen (*Pipistrellus nathusii*); rosse vleermuizen (*Nyctalus noctula*) werden slechts enkele keren opgenomen. Vleermuizen werden vrijwel uitsluitend waargenomen tijdens nachten met een zwakke of matige wind, geen neerslag en een hoge omgevingsdruk. Het lijkt onwaarschijnlijk dat de dieren uit koers zijn geblazen door hoge windsnelheden en er zijn geen aanwijzingen dat er verblijfplaatsen waren nabij de recorders. Het patroon van voorkomen van de ruige dwergvleermuis duidt er op dat het hier om migrerende dieren gaat. De waargenomen rosse vleermuizen betreffen mogelijk ook migrerende dieren, maar het kan niet uitgesloten worden dat het (ook) om foeragerende dieren gaat van lokale populaties in het kustgebied.

Received: 31 October 2014
Accepted: 7 January 2015