CHAPTER 14

BATS IN THE BELGIAN PART OF THE NORTH SEA AND POSSIBLE IMPACTS OF OFFSHORE WIND FARMS

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ABSTRACT

Several species of bats in northern Europe undertake seasonal migrations between their summer roosts and wintering areas. Doing so, they are known to cross open sea in some cases. Taking account of the increase of wind farms in the Belgian part of the North Sea and the entire North Sea, the lack of information on the spatio-temporal distribution of bats in Belgian waters and the results of some studies (onshore) demonstrating wind turbines can cause high mortalities in bats, a taxon in global decline, it is important to quantify the risk of offshore wind farms in the North Sea to threaten bat populations.

To investigate bat distribution, we installed an automated acoustic recorder on the Belgian research vessel 'Belgica' to record bats while the vessel is at sea at night. The acoustic detector on the Belgica was operational during 93 nights in autumn 2014 and spring 2015, hence covering two full bat migration periods. In autumn 2014, 117 call sequences were registered in the BPNS, belonging to four different species. In spring 2015, only four sequences were registered, all during one night. The few recordings were all registered during only three nights. These results are not sufficient to solidly determine spatio-temporal patterns of bats in the BPNS, but allow drawing some preliminary conclusions on their frequency of occurrence and distribution at sea.

In 2015 and 2016, a network of nine Batcorders is collecting data in the Dutch and Belgian part of the North Sea and along the coastline. This detector network will increase our knowledge about the impact of offshore wind farms on bats as it will increase the number of detections of bats at sea and will allow direct comparison between data collected at the different locations, without seasonal or meteorological bias. This will allow addressing the question if bats are attracted to or avoid offshore wind farms. This may then lead to appropriate management or mitigation measures.

14.1. INTRODUCTION

Several species of bats in northern Europe undertake seasonal migrations between their summer roosts and wintering areas. Most species only travel short to moderate distances, up to several hundred kilometres per season. However, some species such as Nathusius' pipistrelle (*Pipistrellus nathusii*), noctule (*Nyctalus noctula*), parti-coloured bat (*Vespertilio murinus*)and Leisler's bat (*Nyctalus leisleri*) are known to migrate long distances of up to 2000 kilometres from Scandinavia and Central Europe to more temperate regions of western Europe, and back (Arthur & Lemaire, 2015; Hutterer *et al.*, 2005, Krapp & Niethammer, 2011; Dietz *et al.*, 2009).

The fact that bats forage at sea or cross the open sea during migration is well known. Bats have been found regularly in the southern North Sea, e.g. on oil rigs (Bekker & Boshamer, 2008; Russ, 2000; Skiba, 2009; Walter 2007; Brabant & Laurent *et al.*, 2016). Bats were also sighted during seabird surveys (INBO, unpublished data). In 2013, a Nathusius' pipistrelle specimen banded in the UK, was found in the Netherlands (Leopold *et al.*, 2014). Lagerveld *et al.* (2014) report regular occurrences of bats in the Dutch offshore wind farms. Virtually all recordings of Lagerveld *et al.* (2014) 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. Most migratory activity of the Nathusius' pipistrelle takes place from mid-August until the end of September (Lagerveld *et al.*, 2014).

Bats collect information about their surroundings by listening to the returning echoes of the sequences of high frequency echolocation calls they produce while flying. These echolocation calls are species-specific and can be used to identify bat species based on parameters from the individual calls (e.g. initial frequency, frequency of maximum energy, end frequency) and call sequence characteristics (e.g. time intervals between consecutive calls).

Ahlèn *et al.* (2009) showed that bats at sea use their echolocation and mostly fly at low altitudes (< 10 m). During migration they are often foraging and they adjust their flight height in response to the altitude of their prey. Moreover, other studies, in Sweden in particular (Ahlen, 2007), indicate that migratory bats regularly feed in the vicinity of offshore wind turbines because of the accumulation of flying insects around the turbines. Non-migratory species have also been reported to use wind farms as feeding sites. Doing so, they face an increased risk of colliding with the turbine blades or of barotrauma caused by rapid air pressure reduction near moving turbine blades (Kunz *et al.*, 2007; Dürr & Bach, 2004; Baerwald *et al.*, 2008).

Contrary to wind farms on land, the number of fatalities in offshore wind farms is very difficult to assess as it is impossible to search and collect carcasses. However, the number of collisions is likely to be lower than onshore (Leopold *et al.*, 2014): (1) at offshore wind farms, nearly all activity is limited to the migration period. At onshore wind farms, bat fatalities also occur outside of the migration period (although in relatively low numbers). (2) Bat activity offshore is generally limited to periods with calm weather suitable for long distance migration. Onshore, bats are recorded during a wider range of weather conditions. (3) Non-migratory bats, such as the common pipistrelle *Pipistrellus pipistrellus*, are virtually absent offshore. Onshore, common pipistrelle is one of the most common species.

Leopold *et al.* (2014) roughly estimate the number of collisions offshore, based on expert opinion, to be somewhere between 0 and 1 fatalities per turbine per year. This is a best educated guess based on the knowledge that fatalities in wind farms in large, open intensively used agricultural areas are typically around 1 fatality per turbine per year (Rydell *et al.*, 2010; Limpens *et al.*, 2013).

Taking account of the increase of wind farms in the Belgian part of the North Sea (BPNS) and the entire North Sea, the lack of information on the spatio-temporal distribution of bats in Belgian waters and the results of some studies (onshore) demonstrating wind turbines can cause high mortalities in bats (Voigt, 2012), a taxon in global decline, it is important to better quantify the risk of offshore wind farms in the North Sea to threaten bat populations.

Therefore this study aims at answering the following questions: (1) what is the distribution and density of the bat species observed at sea? (2) What is the spatial distribution (e.g. on – offshore gradient) and is this distribution species dependent? (3) What are the preferred meteorological conditions for (migrating) bats?

14.2. MATERIALS AND METHODS

To investigate bat distribution, we installed an automated acoustic SM3BAT recorder (wildlife acoustics Inc., Massachusetts, USA) on the Belgian research vessel 'Belgica' to record bats while the vessel is at sea at night. The device records the echolocation calls of bats (between 0 and 126 kHz) from shortly before sunset to shortly after sunrise, hence allowing studying the spatio-temporal distribution patterns of bats in BPNS. The Belgica is at sea more than 200 days a year to perform various research activities. During a normal campaign the vessel remains at sea during five days.

The recorder is triggered by the echolocation calls of bats and bat-like sounds. The recordings are saved as sound files on SD cards. . These recordings are used to identify the species present in the area. The results are presented as number of recorded bat call sequences per species.

To level of high numbers of recordings caused by one individual residing near the recorder, the recordings are also converted to detection positive ten minutes (DP10) meaning that a ten minute period is considered as positive if it contains at least one bat call (e.g. a specimen producing 100 calls in 10 minutes and a specimen only calling once are valued in the same way and render one DP10).

The recordings are processed with the software programs SonoChiro (version v3.3.2; Biotope, France) and Batsound (version v1.3.1; Pettersson Elektronik, Sweden) to extract the echolocation calls of bats and to aid the identification to the species level. The identifications were checked and evaluated following the identification criteria of Barataud (2012) and Arthur & Lemaire (2015).

Every registration has a timestamp which is linked to the time and GPS registration of the ship, allowing determining the exact time and location of observation.

To allow spatial analysis of the bat registrations, we calculated the sampling effort, i.e. how many minutes the Belgica was present in a certain area during the study period when the bat recorder was active. Therefore we divided the BPNS in grid cells of two by two kilometers. For each grid cell we calculated the number of minutes the Belgica was present within that cell while the bat recorder was active. The cells are being colour coded accordingly.

Wind speed and wind direction are being measured per ten minutes interval by the Flemish banks monitoring network. We used the data measured at the port of Zeebrugge (www.meetnetvlaamsebanken.be).

14.3. RESULTS

TEMPORAL DISTRIBUTION

The acoustic detector on the Belgica was operational during 48 nights in autumn 2014 (from 1st of September until 30th of November) and 45 nights in spring – summer 2015 (from March 16th until July 17th), hence covering two full bat migration periods. In autumn 2014, 117 call sequences were registered in the BPNS, belonging to four different species (Table 1 and Figure 1). 116 sequences from autumn 2014 were recorded during one single night (18 to 19 September). In spring 2015, only four sequences were registered, all during one night , i.e. 24 – 25 April (Table 1 and Figure 1).

Table 1. Number of bat call sequences per species in autumn 2014 and spring 2015. *Pipistrellus nathusii (*Pip nat*)*, *Pipistrellus pipistrellus (*Pip pip*)*, *Vespertilio murinus (*Ves mur*)*, *Myotis daubentonii (*Myo dau*)*, non-identified bat species (NI). The row 'DP10' indicates the number of 'detection positive 10 minutes', this is the number of 10 minute intervals wherein at least one call of a certain species was recorded.

Date	Pip nat	Pip pip	Ves mur	Myo dau	NI
18-19/09/2014	21	93	1	0	1
23/09/2014	0	0	0	1	0
24/4/2015	4	0	0	0	0
DP10	17	6	1	1	1

The 93 registered sequences of the common pipistrelle were all made during only 53 minutes (DP10 = 6) when the vessel was fairly close to the coast (ca. 5 km). The DP10 value for the Nathusius' pipistrelle was 17, meaning that the recordings for that species were more spread out over a longer period of time.

Besides the two pipistrelle species, we also registered call sequences of Daubenton's bat *Myotis daubentonii* and parti-coloured bat *Vespertilio murinus*.

The night of 18 to 19 September 2014 was a clear night with low wind speeds (average: 1.6 m/s; figure 1). During the night of 23 to 24 September 2014, wind speed was 5.3 m/s on average. In spring 2015, bat calls were registered during one night only with an average wind speed of 4.0 m/s. The average wind speed during the entire measuring period in autumn 2014 was 5.2 m/s, with a maximum and a minimum wind speed of respectively 20.6 m/s and 0.1 m/s. In spring 2015 the average was 7.0 m/s, with a maximum and minimum of 26.6 and 0.1 m/s.

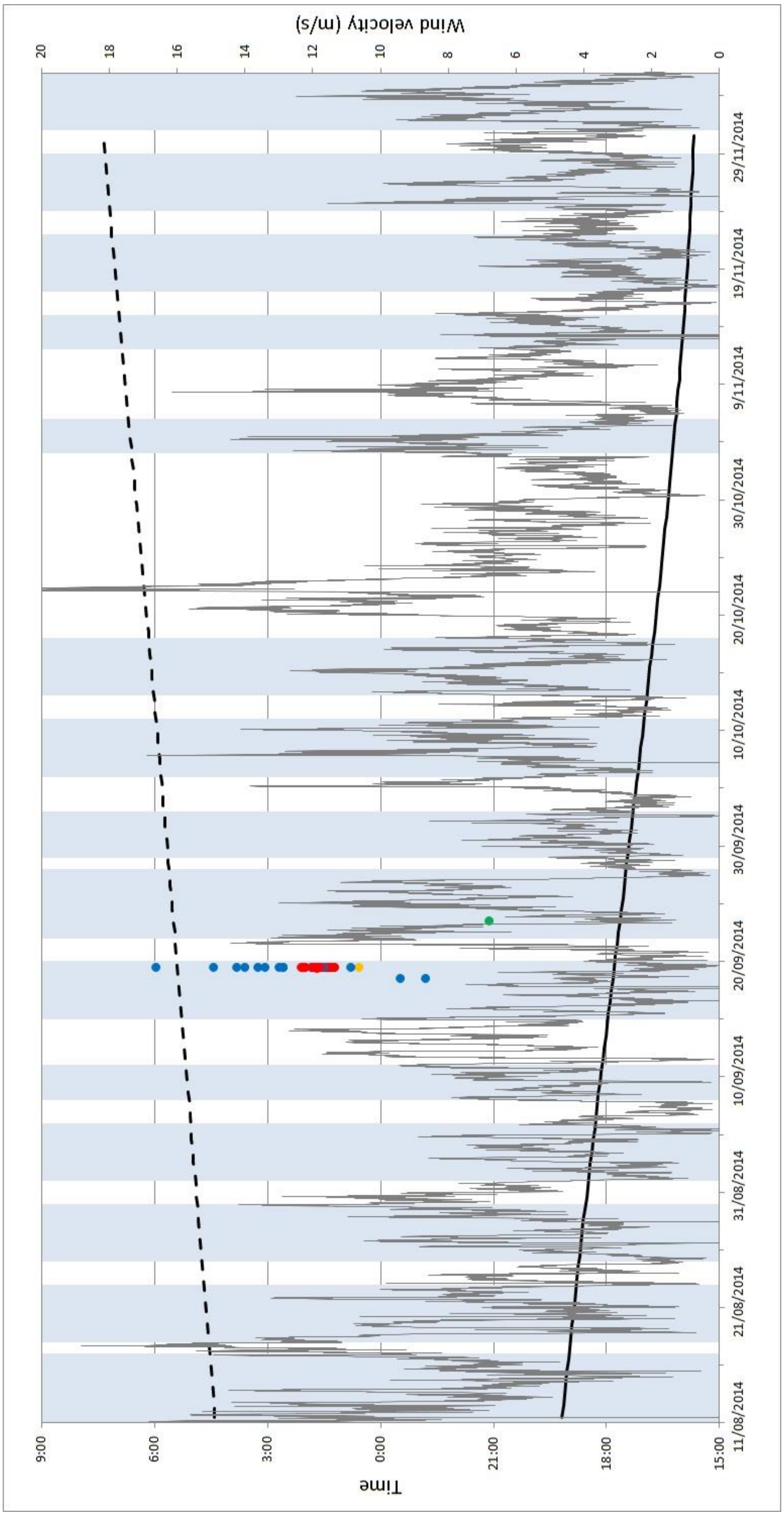

Figure 1: Number of call sequences per species (red: *Pipistrellus pipistrellus*; blue: *Pipistrellus nathusii*, yellow: *Vespertilio murinus*; green: *Myotis daubentonii*) registered by the SM3 songmeter, and wind speed (m/s; grey line) in autumn of 2014. The periods during which the Belgica was at sea are shown in grey. The time of sunset and sunrise is indicated by the black and dotted line, respectively.

SPATIAL DISTRIBUTION

Figure 2 indicates that the sampling effort was much larger in certain areas compared to others. This is especially the case in the coastal waters near the ports of Zeebrugge, Oostende and Nieuwpoort. The area around Zeebrugge is the area where most call sequences were registered. Furthermore, it is clear that the Belgica regularly visited the sand and gravel extraction zone (in the west of the BPNS) and the Thorntonbank (to the west of the area reserved for electricity production). Although the survey intensity was similar to the waters around Zeebrugge, no bats were registered in those areas.

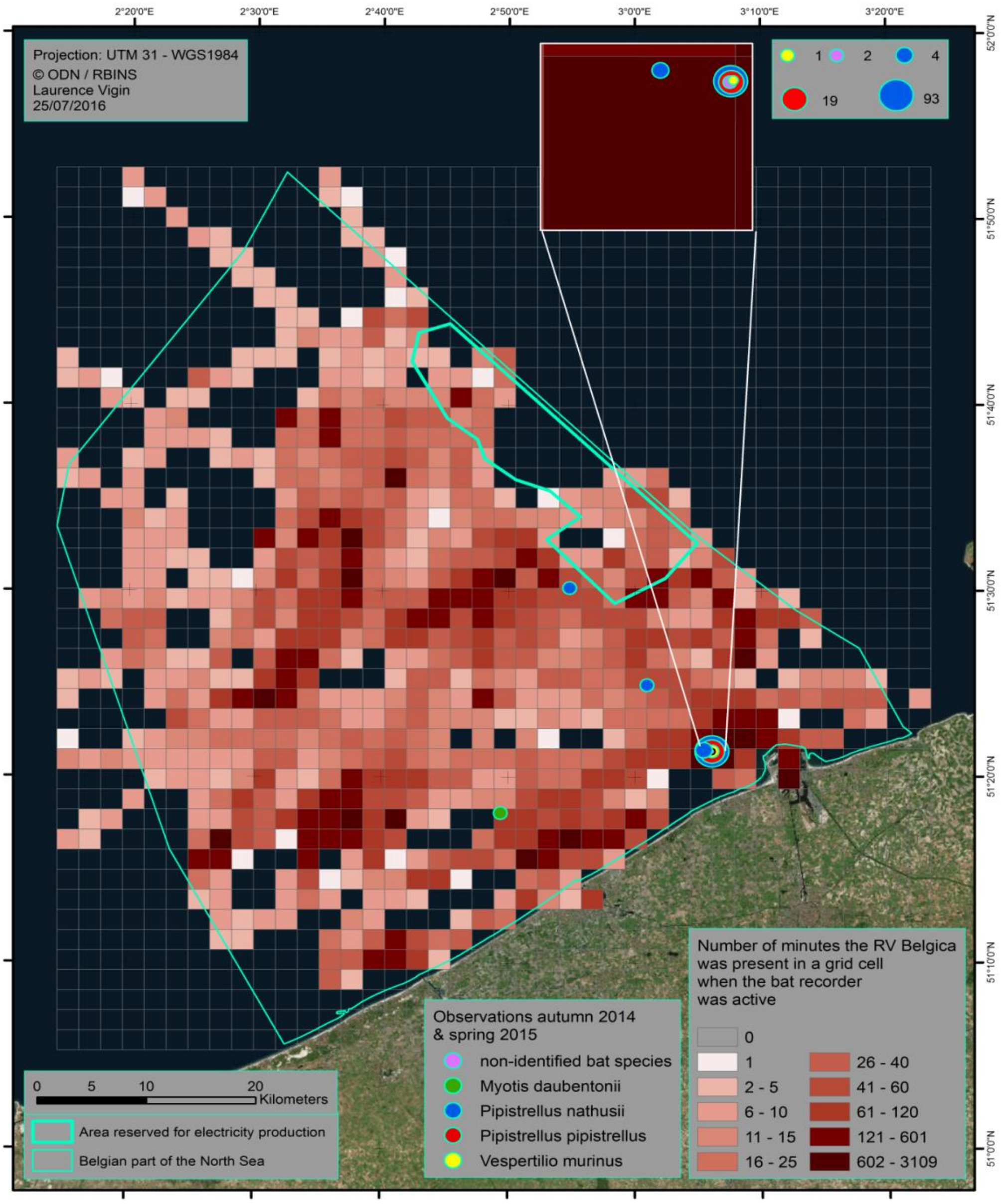

Figure 2. Location of the bat registrations in the Belgian part of the North Sea in autumn 2014 and spring 2015. The color code in the grid cells indicates the number of minutes the Belgica was present in that grid cell (2x2 km) when the bat detector was active in autumn 2014 and spring 2015.

14.4. DISCUSSION

GENERAL

Although the bat recorder was operational during 93 nights in autumn 2014 and spring 2015, we had very few recordings (121 sequences), which were all registered during only three nights. These results are not sufficient to solidly determine spatio-temporal patterns of bats in the BPNS, but allow drawing some preliminary conclusions on their frequency of occurrence and distribution at sea.

The Nathusius' pipistrelle was the most frequent species encountered during our study. We recorded 25 sequences during two nights (DP10 = 17). Nathusius' pipistrelles were recorded at 5, 12 and even 25 km from the coast. These findings of bats at sea correspond to the known fact that this species is a long distance migrant (Arthur & Lemaire, 2015; Hutterer *et al.*, 2005, Krapp & Niethammer, 2011; Dietz *et al.*, 2009) and to the bat registrations in the Dutch offshore wind farms where 98% of all sequences were identified as Nathusius' pipistrelle (Lagerveld *et al.*, 2014). Although the number of registered sequences of the common pipistrelle is 93, this was most likely only one specimen which was attracted by the ship and resided in its vicinity for about one hour when the vessel was fairly close to the coast (ca. 5 km). This is also refelected in the DP10 value for that species, which is only 6.

In certain areas in the BPNS where the sampling effort was high (figure 2), no bats were detected. Possibly, the weather conditions when the Belgica was present in those areas at night were not favorable for bat activity. During the night of 18–19 September 2014, when we recorder the most bat activity, the Belgica stayed at the same location so we do not know if there were bats present in other areas as well at that time. The locations of the bat registrations suggest there are more bats present near- versus offshore, but the data at hand are to scarce to allow to demonstrate this with certainty.

The average wind speed during the nights of the bat recordings was low, 1.6, 4.0 and 5.3 m/s, respectively coinciding with what was found in earlier studies, e.g. Lagerveld *et al.* (2014). Their findings of bats at sea in calm weather conditions resulted in the current mitigating measure for the Borssele offshore wind farm concessions (see chapter 2) in the Dutch part of the North Sea, stipulating that the cut-in wind speed[1] of wind turbines should be set at 5 m/s from August 15 until September 30 (i.e. main bat migration period). According to Eurobats (2014) the use of blade feathering[2], a higher turbine cut-in wind speed and shutting down turbines are the only mitigation measures which so far proved to be effective in reducing wind turbine-induced bat mortality.

[1]The minimum wind speed at which the wind turbine will generate usable power
[2]Adjusting the angle of the rotor blade parallel to the wind, or turning the whole unit out of the wind, to slow or stop blade rotation

EVALUATION OF THE STUDY DESIGN:

The installation of the bat recorder on the vessel resulted in large amounts of noise in the sound files. This noise is generated by the vessel and saturated the batcorder in the low frequencies. Depending on the activity of the vessel (e.g. sailing or anchored) the frequency went up to 30kHz, which is already overlapping with the frequencies of the calls of certain bat species (e.g. Vespertilio murinus). So possibly, the noise generated by the vessel masks out certain bat registrations. In the future we will test different locations on the vessel to install the microphone, to minimize the noise in the data.

FUTURE RESEARCH:

Our preliminary results showed that an increased sampling effort is needed to get a representative view on the spatio-temporal distribution of bats at sea. The same holds true to study the impact of offshore wind farms on bats. To that extent, the recorder will remain installed on the research vessel Belgica from at least mid-March until the end of October. This will increase our general knowledge about the spatio-temporal distribution of bats at sea on the wider scale, i.e. the scale at which the Belgica operates (e.g. potential preferential routes, grouping sites, coastal migrations pathways).

Additionally, we recently started collaborating with the Dutch research institute IMARES and the Flanders Marine Institute (VLIZ). In 2015 and 2016, a network of nine identical IMARES recorders (Batcorder, EcoObs) collects data in the Dutch and Belgian part of the North Sea and along the coastline. This network is complemented with two Batcorders of VLIZ in the framework of the Lifewatch project (www.lifewatch.be). Hence, a total of eleven Batcorders are now operational in front of the Belgian and southern Dutch coastline (figure 3). They are installed on platforms inside wind farms, other platforms and along the coastline. The two recorders which are mounted offshore in the BPNS are on a turbine of C-Power (Lifewatch) and on Belwind's high voltage station (IMARES). The second Lifewatch Batcorder is installed along the Belgian coast, in Oostende. The recorders were configured identically to maximize the comparability of the data. These detectors will be active throughout the entire period when bats are active, i.e. from mid-March until the end of October 2015 and 2016.

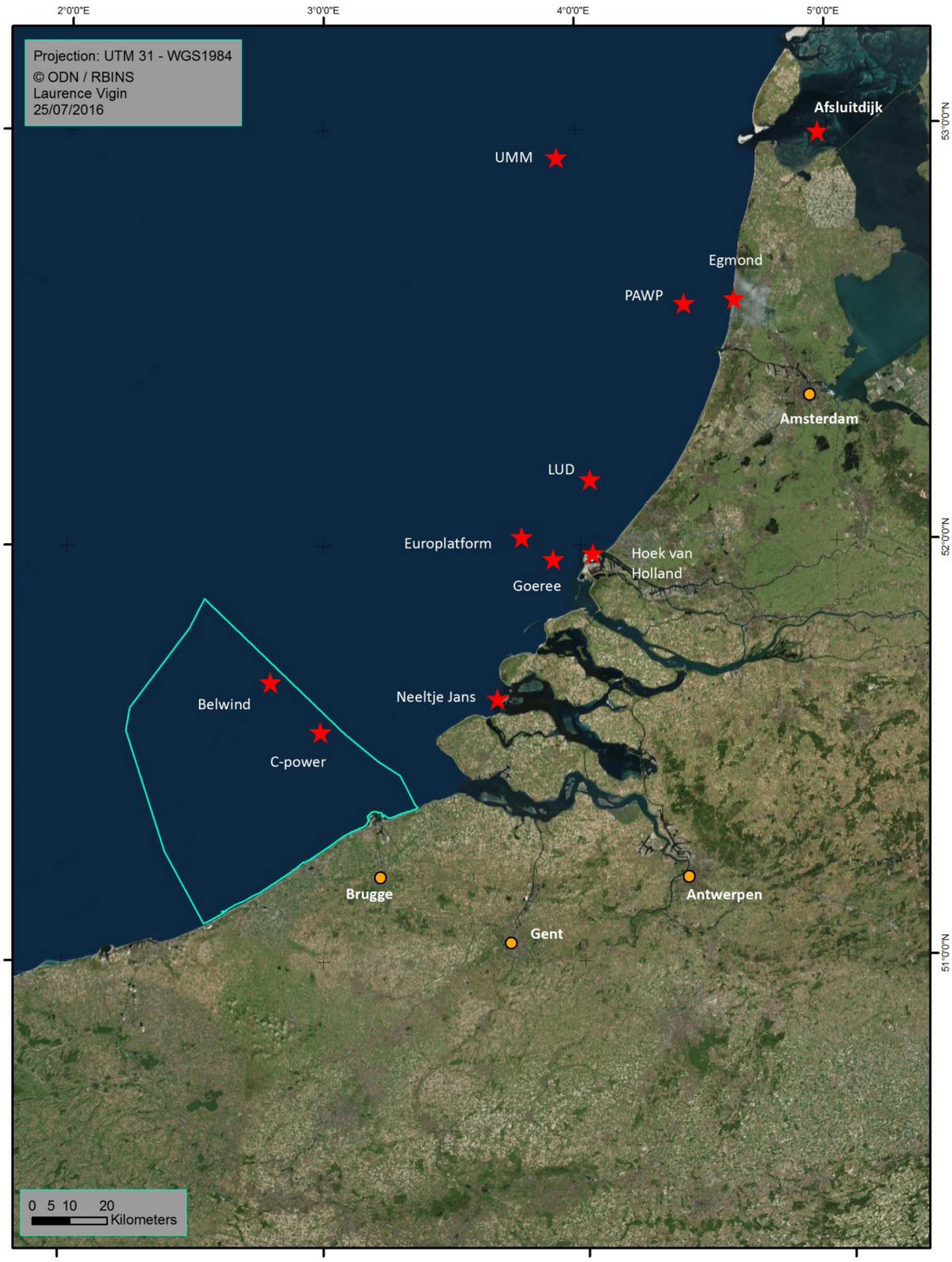

Figure 3. Batcorder network in the Belgian and Dutch part of the North Sea

This research mainly focuses on the presence of bats at sea, how the North – South and onshore – offshore gradients influence the density of bats and how this compares to the presence of bats in offshore wind farms. This detector network will also increase our knowledge about the impact of offshore wind farms on bats as it will increase the number of detections of bats at sea and will allow direct comparison between data collected at the different locations, without seasonal or meteorological bias. This will allow addressing the question if bats are attracted to or avoid offshore wind farms. This may then lead to appropriate management or mitigation measures.

In a later stage of the study (foreseen to start in 2017), we will also look into bat behaviour inside the wind farms. For such behaviour study, two bat recorders will be installed per wind turbine as measurements will have to be made at different altitudes, in order to determine the exact flying height of bats. This will give a better understanding of the activity of individuals, detect particular behaviour (e.g. display, foraging) and the risk associated with that behaviour (collision risk, barotrauma).

The use of other methodologies to investigate bat behaviour inside offshore wind farms and the associated risk (e.g. high resolution IR camera, radiotelemetry) will be investigated and considered in 2016 and 2017.

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