Final Progress Report of a 12-month Preconstruction Bat Monitoring Study

- For the proposed Aletta 1 Wind Energy Facility, Northern Cape

Compiled by: Daleen Burger

Reviewed by: Werner Marais and Monika Moir

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PREPARED FOR:

PO BOX 2921, RIVONIA. 2128

PHONE: +27 11 798 0600

EMAIL: INFO@SIVEST.CO.ZA

WWW.SIVEST.CO.ZA

By

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Heldervue
Somerset West
Cape Town
7130
☎+27 78 190 3316

✉werner@animalia-consult.co.za

www.animalia-consult.co.za

Ref: R-1609-68

Appointment of Specialist

Specialist Company:	Animalia Zoological & Ecological Consultation (Pty) Ltd
Fieldwork conducted by:	Carel Malouf
Report done by:	Daleen Burger
Overseen/reviewed by:	Werner Marais and Monika Moir
Appointed by:	SiVEST Environmental Division
For:	12 Month pre-construction bat activity monitoring

Independence:

Animalia Zoological & Ecological Consultation (Pty) has no connection with the developer. Animalia Zoological & Ecological Consultation (Pty) is not a subsidiary, legally or financially of the developer; remuneration for services by the developer in relation to this proposal is not linked to approval by decision-making authorities responsible for permitting this proposal and the consultancy has no interest in secondary or downstream developments as a result of the authorization of this project.

Applicable Legislation:

Legislation dealing with biodiversity applies to bats and includes the following:

NATIONAL ENVIRONMENTAL MANAGEMENT: BIODIVERSITY ACT, 2004 (ACT 10 OF 2004; Especially sections 2, 56 & 97)

The act calls for the management and conservation of all biological diversity within South Africa. Bats constitute an important component of South African biodiversity and therefore all species receive additional attention to those listed as Threatened or Protected.

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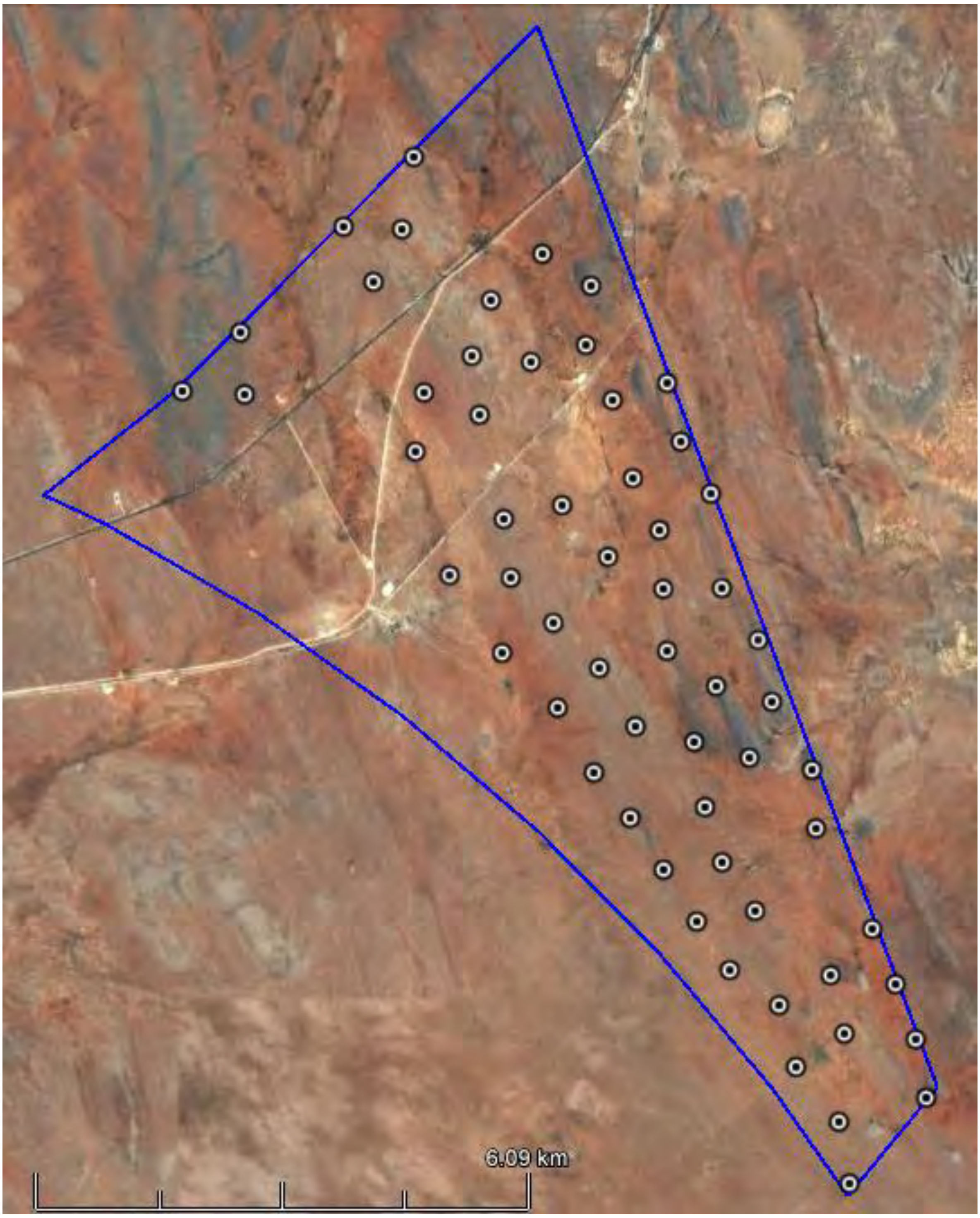


Figure 1: Map overview of the proposed Aletta 1 WEF**.**

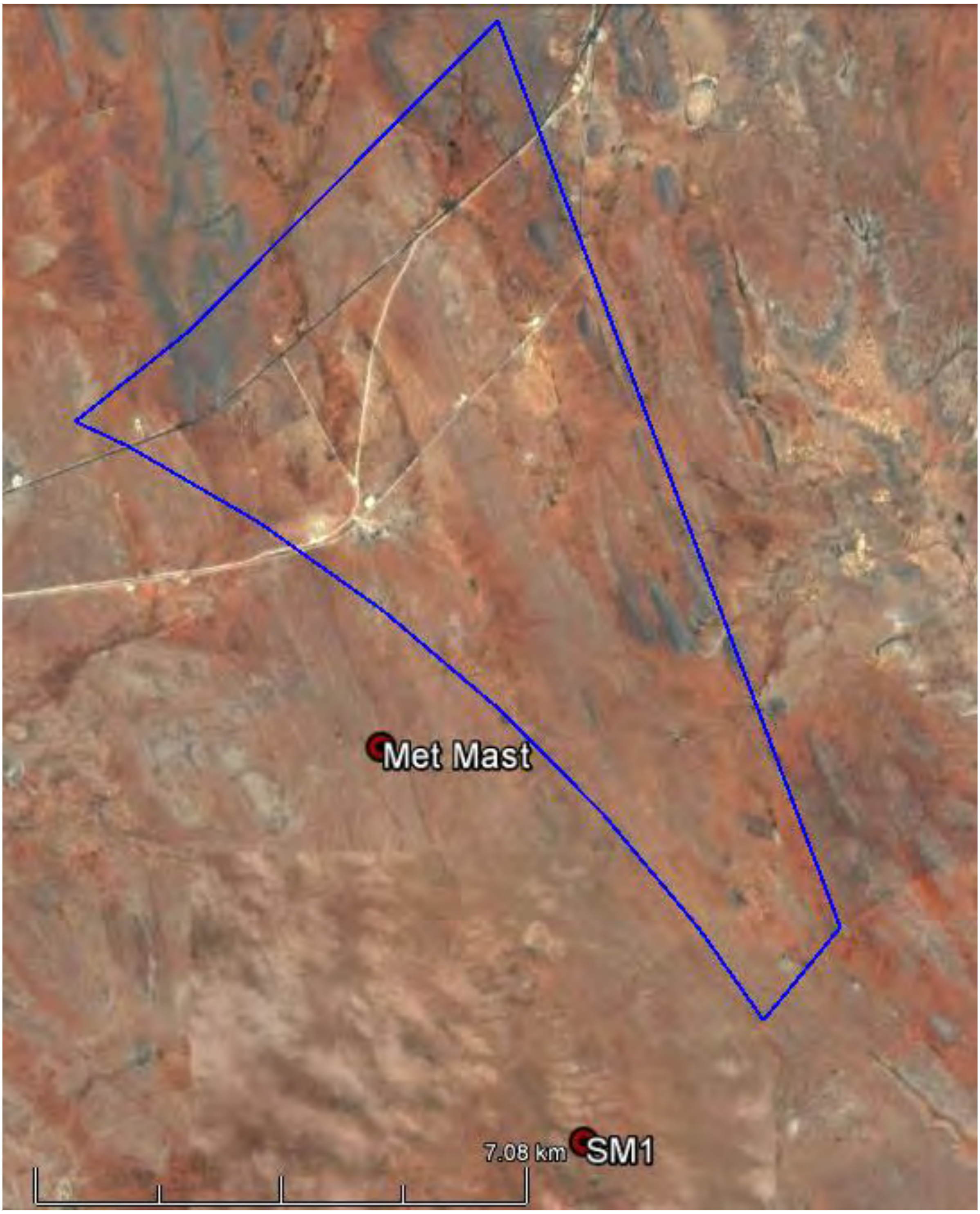


Figure 2: Overview of the passive monitoring systems on the Aletta 1 WEF.

1 OBJECTIVES AND TERMS OF REFERENCE FOR PRECONSTRUCTION STUDY

- Study bat species assemblage and abundance on the site.
- Study temporal distribution of bat activity across the night as well as the four seasons of the year in order to detect peaks and troughs in activity.
- Determine whether weather variables (wind, temperature, humidity and barometric pressure) influence bat activity.
- Determine the weather range in which bats are mostly active.
- Develop long-term baseline data for use during operational monitoring.
- Identify if any turbines occur in sensitive areas and need to be shifted into less sensitive areas or removed from the layout.
- Identify which turbines need to have special attention with regards to bat monitoring during the operational phase.
- Detail the types of mitigation measures that are possible if bat mortality rates are found to be unacceptable, including the potential times/ circumstances which may result in high mortality rates.

2 INTRODUCTION

This is the fifth and final progress report for a twelve-month preconstruction bat monitoring study at the proposed Aletta 1 Wind Energy Facility near Copperton in the Northern Cape.

Three factors need to be present for most South African bats to be prevalent in an area: availability of roosting space, food (insects/arthropods or fruit), and accessible open water sources. However, the dependence of a bat on each of these factors depends on the species, its behaviour and ecology. Nevertheless, bat activity, abundance and diversity are likely to be higher in areas supporting all three above mentioned factors.

The site is evaluated by comparing the amount of surface rock (possible roosting space), topography (influencing surface rock in most cases), vegetation (possible roosting spaces and foraging sites), climate (can influence insect numbers and availability of fruit), and presence of surface water (influences insects and acts as a source of drinking water) to identify bat species that may be impacted by wind turbines. These comparisons are done chiefly by studying the geographic literature of each site, available satellite imagery and observations during site visits. Species probability of occurrence based on the above mentioned factors are estimated for the site and the surrounding larger area (see Section 4.2).

General bat diversity, abundance and activity are determined by the use of a bat detector. A bat detector is a device capable of detecting and recording the ultrasonic echolocation calls of bats which may then be analysed with the use of computer software. A real time expansion type bat detector records bat echolocation in its true ultrasonic state which is then effectively slowed down 10 times during data analysis. Thus the bat calls become audible to the human ear, but still retains all of the harmonics and characteristics of the call from which bat species with characteristic echolocation calls can be identified. Although this type of bat detection equipment is advanced technology, it is not necessarily possible to identify all bat species by just their echolocation calls. Recordings may be affected by the weather conditions (i.e. humidity) and openness of the terrain (bats may adjust call frequencies). The range of detecting a bat is also dependent on the volume of the bat call. Nevertheless, it is a very accurate method of recording bat activity.

2.1 The Bats of South Africa

Bats form part of the Order Chiroptera and are the second largest group of mammals after rodents. They are the only mammals to have developed true powered flight and have undergone various skeletal changes to accommodate this. The forelimbs are elongated, whereas the hind limbs are compact and light, thereby reducing the total body weight. This unique wing profile allows for the manipulation wing camber and shape, exploiting functions such as agility and manoeuvrability. This adaption surpasses the static design of the bird wings in function and enables bats to utilize a wide variety of food sources, including, but not limited to, a large diversity of insects (Neuweiler 2000). Species based facial features may differ considerably as a result of differing life styles, particularly in relation to varying feeding and echolocation navigation strategies. Most South African bats are insectivorous and are capable of consuming vast quantities of insects on a nightly basis (Taylor 2000, Tuttle and Hensley 2001) however, they have also been found to feed on amphibians, fruit, nectar and other invertebrates. As a result, insectivorous bats are the predominant predators of nocturnal flying insects in South Africa and contribute greatly to the suppression of these numbers. Their prey also includes agricultural pests such as moths and vectors for diseases such as mosquitoes (Rautenbach 1982, Taylor 2000).

Urban development and agricultural practices have contributed to the deterioration of bat populations on a global scale. Public participation and funding of bat conservation are often hindered by negative public perceptions and unawareness of the ecological importance of bats. Some species choose to roost in domestic residences, causing disturbance and thereby decreasing any esteem that bats may have established. Other species may occur in large communities in buildings, posing as a potential health hazard to residents in addition to their nuisance value. Unfortunately, the negative association with bats obscures their importance as an essential component of ecological systems and their value as natural pest control agents, which actually serves as an advantage to humans.

Many bat species roost in large communities and congregate in small areas. Therefore, any major disturbances within and around the roosting areas may adversely impact individuals of different communities, within the same population, concurrently (Hester and Grenier 2005). Secondly, nativity rates of bats are much lower than those of most other small mammals. This is because, for the most part, only one or two pups are born per female per annum and according to O'Shea *et al*. (2003), bats may live for up to 30 years, thereby limiting the amount of pups born due to this increased life expectancy. Under natural circumstances, a population's numbers may accumulate over long periods of time. This is due to the longevity and the relatively low predation of bats when compared to other small mammals. Therefore, bat populations are not able to adequately recover after mass mortalities and major roost disturbances.

2.2 Bats and Wind Turbines

Although most bats are highly capable of advanced navigation through the use of echolocation and excellent sight, they are still at risk of physical impact with the blades of wind turbines. The corpses of bats have been found in close proximity to wind turbines and, in a case study conducted by Johnson *et al*. (2003), were found to be directly related to collisions. The incident of bat fatalities for migrating species has been found to be directly related to turbine height, increasing exponentially with altitude, as this disrupts the migratory flight paths (Howe *et al*. 2002, Barclay *et al*. 2007). Although the number of fatalities of migrating species increased with turbine height, this correlation was not found for increased rotor sweep (Howe *et al*. 2002, Barclay *et al*. 2007). In the USA it was hypothesized that migrating bats may navigate without the use of echolocation, rather using vision as their main sense for long distance orientation (Johnson *et al*. 2003, Barclay *et al*. 2007). Despite the high incidence of deaths caused by direct impact with the blades, most bat mortalities have been found to be caused by barotrauma (Baerwald *et al*. 2008). This is a condition where low air pressure found around the moving blades of wind turbines, causes the lungs of a bat to collapse, resulting in fatal internal haemorrhaging (Kunz *et al*. 2007). Baerwald *et al*. (2008) found that 90% of bat fatalities around wind turbines involved internal haemorrhaging consistent with barotrauma. A study conducted by Arnett (2005) recorded a total of 398 and 262 bat fatalities in two surveys at the Mountaineer Wind Energy Centre in Tucker County, West Virginia and at the Meyersdale Wind Energy Centre in Somerset County, Pennsylvania, respectively. These surveys took place during a 6-week study period from 31 July 2004 to 13 September 2004. In some studies, such as that taken in Kewaunee County (Howe *et al.* 2002), bat fatalities were found exceed bird fatalities by up to three-fold.

Although bats are predominately found roosting and foraging in areas near trees, rocky outcrops, human dwellings and water, in conditions where valleys are foggy, warmer air is drawn to hilltops through thermal inversion which may result in increased concentrations of insects and consequently bats at hilltops, where wind turbines are often placed (Kunz *et al*. 2007). Some studies (Horn *et al*. 2008) suggest that bats may be attracted to the large turbine structure as roosting spaces or that swarms of insects may get trapped in low pressure air pockets around the turbine, also encouraging the presence of bats. The presence of lights on wind turbines have also been identified as possible causes for increased bat fatalities for non-cave roosting species. This is thought to be due to increased insect densities that are attracted to the lights and subsequently encourage foraging activity of bats (Johnson *et al*. 2003). Clearings around wind turbines, in previously forested areas, may also improve conditions for insects, thereby attracting bats to the area and the swishing sound of the turbine blades has been proposed as possible sources for disorienting bats (Kunz *et al*. 2007). Electromagnetic fields generated by the turbine may also affect bats which are sensitive to magnetic fields (Kunz *et al*. 2007). It could also be hypothesized, from personal observations that the echolocation capabilities of bats are designed to locate smaller insect prey or avoid stationary objects, and may not be primarily focused on the detection of unnatural objects moving sideways across the flight path.

A pilot wind turbine in the Coega Industrial Development Zone, Port Elizabeth, Eastern Cape, South Africa was surveyed for bird and bat carcasses. Over a period of one year, three surveys per week (total 154 inspections) were performed to search for bat and bird casualties. 17 bat fatalities and one live but injured bat was collected. Two bat species were involved, Cape serotine (*Neoromicia capensis*) and Egyptian free-tailed bat (*Tadarida aegyptiaca*). Of the 18 casualties, 15 were recorded mid-December to mid-March. One bird, a little swift (*Apus affinis*), was hit by a rotor blade. This is the first study to document bat and bird mortalities over the period of a year at a wind turbine in sub-Saharan Africa (Doty and Martin, 2013).

A pilot study was conducted at the Darling Wind Farm in the Western Cape to determine if bats are being killed by wind turbines at the facility. One bat carcass was found and identified as an adult female *Neoromicia capensis*. A necropsy showed that both lungs had pulmonary haemorrhaging and had collapsed. Histological examination revealed extensive haemorrhaging in the lungs consistent with barotrauma (Aronson et al., 2013).

Both of these South African studies point to South African bats being just as vulnerable to mortality from turbines as international studies have previously indicated. And thus the two main species of concern are *Neoromicia capensis* and *Tadarida aegyptiaca*.

Whatever the reason for bat fatalities in relation to wind turbines, it is clear that this is an ecological problem which requires attention. During a study by Arnett *et al*. (2009), 10 turbines monitored over a period of 3 months showed 124 bat fatalities in South-central Pennsylvania (America), which can cumulatively have a catastrophic long term effect on bat populations if this rate of fatality continues. Most bat species only reproduce once a year, bearing one young per female, therefore their numbers are slow to recover from mass mortalities. It is very difficult to assess the true number of bat deaths in relation to wind turbines, due to carcasses being removed from sites through predation, the rate of which differs from site to site as a result of habitat type, species of predator and their numbers

(Howe *et al*. 2002, Johnson *et al*. 2003). Mitigation measures are being researched and experimented with globally, but are still only effective on a small scale. An exception is the implementation of curtailment processes, where the turbine cut-in speed is raised to a higher wind speed. This relies on the principle that the prey of bats will not be found in areas of strong winds and more energy is required for the bats to fly under these conditions. It is thought, that by the implementation of such a measure, that bats in the area are not likely to experience as great an impact as when the turbine blades move slowly in low wind speeds. However, this measure is currently not effective enough to translate the impact of wind turbines on bats to a category of low concern.

3 METHODOLOGY

Bat activity was monitored using active and passive bat monitoring techniques. Active monitoring was done through site visits with transects made throughout the site with a vehicle mounted bat detector. Passive detection was carried out through the mounting of passive bat monitoring systems placed on two monitoring masts on site, one 10m mast and one 80m meteorological mast.

The monitoring systems consisted of SM2BAT+ time expansion type bat detectors that were powered by 12V 18Ah sealed lead acid batteries and 20W solar panels that provided recharging power to the batteries. Each system also had an 8-amp low voltage protection regulator and SM2PWR step down transformer. Four SD memory cards, class 10 speed, with a capacity of 32GB each were utilized within each SM2BAT+ detector; this was to ensure substantial memory space with high quality recordings even under conditions of multiple false wind triggers.

One weatherproof ultrasound microphone was mounted at heights of 9.5 meters on the 10m short mast, while two microphones were mounted at 10m and 80m heights on the met mast.

Each detector was set to operate in continuous trigger mode from dusk each evening until dawn (times were correlated with latitude and longitude). Trigger mode is the setting for a bat detector in which any frequency which exceeds 16 KHz and 18 dB will trigger the detector to record for the duration of the sound and 500 ms after the sound has ceased, this latter period is known as a trigger window. All signals are recorded in WAC0 lossless compression format.

Figure 3: Met mast monitoring system set up

Figure 4: Short mast monitoring system set up

The table below summarizes the above mentioned equipment set up:

3.1 Site Visit Information

<table>
<tr><td colspan="2" rowspan="5">Site visit dates</td><td>First Visit</td><td>20 – 25 July 2015</td></tr>
<tr><td>Second Visit</td><td>19 – 24 October 2015</td></tr>
<tr><td>Third Visit</td><td>8 – 12 February 2016</td></tr>
<tr><td>Fourth Visit</td><td>10 – 15 April 2016</td></tr>
<tr><td>Fifth Visit</td><td>8 – 11 July 2016</td></tr>
<tr><td rowspan="3">Met mast passive bat detection systems</td><td>Amount on site</td><td colspan="2">1</td></tr>
<tr><td>Microphone heights</td><td colspan="2">10m; 80m</td></tr>
<tr><td>Coordinates</td><td colspan="2">29° 58.469'S 22° 31.423'E</td></tr>
<tr><td rowspan="3">Short mast passive bat detection systems</td><td>Amount on site</td><td colspan="2">1</td></tr>
<tr><td>Microphone height</td><td colspan="2">9.5m</td></tr>
<tr><td>Coordinates</td><td colspan="2">30° 1.535'S 22° 33.241'E</td></tr>
<tr><td colspan="4">Replacements/ Repairs/ Comments</td></tr>
<tr><td colspan="2">First Site Visit</td><td colspan="2">The microphones were mounted such that they pointed approximately 30 degrees downward to avoid excessive water damage. Measures were taken for protection against birds, without compromising effectiveness significantly. Crows have been found to peck at microphones and subsequently destroying them. The bat detectors were installed within their weatherproof containers and all peripherals attached.</td></tr>
<tr><td colspan="2">Second Site Visit</td><td colspan="2">Both monitoring systems were operating normally.</td></tr>
<tr><td colspan="2">Third Site Visit</td><td colspan="2">The met mast was operating without errors. The bat detector of the short mast required replacement of internal clock batteries. As a consequence, the bat detector froze and stopped recording on 30 December 2015.</td></tr>
<tr><td colspan="2">Fourth Site Visit</td><td colspan="2">The short mast had fallen over due to an anchor failure. The system was erected and was functioning again on conclusion of the site visit. The met mast was still operating correctly.</td></tr>
<tr><td colspan="2">Fifth Site Visit</td><td colspan="2">Both systems were operational.</td></tr>
<tr><td colspan="2">Type of passive bat detector</td><td colspan="2">SM2BAT+, Real Time Expansion (RTE) type (Figure 5).</td></tr>
</table>

Recording schedule	Each detector was set to operate in continuous trigger mode from dusk each evening until dawn (times were automatically adjusted with latitude, longitude and season).
Trigger threshold	>16KHz, 18dB
Trigger window (time of recording after trigger ceased)	500 ms
Microphone gain setting	36dB
Compression	WAC0
Single memory card size (each systems uses 4 cards)	32GB
Battery size	18Ah; 12V
Solar panel output	20 Watts
Solar charge regulator	6 - 8 Amp with low voltage/deep discharge protection
Transects	Transects were carried out with a SM2BAT+ detector
Other methods	Terrain was investigated during the day.

Figure 5: Example of SM2BAT+ detector and supporting hardware

The data was analysed by classifying (as near to species level as possible) and counting positive bat passes detected by the passive systems. A bat pass is defined as a sequence of ≥1 echolocation calls where the duration of each pulse is ≥2ms (one echolocation call can consist of numerous pulses). A new bat pass is identified by a >500ms period between pulses. These bat passes were summed into 10 minute intervals which were used to calculate nocturnal distribution patterns over time. Bat activity was grouped into 10 minute periods. Only nocturnal, dusk and dawn values of environmental parameters from the wind data were used, as this is the only time insectivorous bats are active. Times of sunset and sunrise were adjusted with the time of year.

The bat activity was correlated with the environmental parameters of wind speed and air temperature, to identify optimal foraging conditions and subsequent periods of high bat activity.

3.2 Assumptions and Limitations

Distribution maps of South African bat species still require further refinement such that the bat species proposed to occur on the site (that were not detected) are assumed accurate. If a species has a distribution marginal to the site, it was assumed to occur in the area. The literature based table of species probability of occurrence may include a higher number of bat species than actually present.

The migratory paths of bats are largely unknown, thus limiting the ability to determine if the wind farm will have a large scale effect on migratory species. This limitation however will be overcome with this long-term sensitivity assessment.

The satellite imagery partly used to develop the sensitivity map may be slightly imprecise due to land changes occurring since the imagery was taken.

Species identification with the use of bat detection and echolocation is less accurate when compared to morphological identification, nevertheless it is a very certain and accurate indication of bat activity and their presence with no harmful effects on bats being surveyed.

It is not possible to determine actual individual bat numbers from acoustic bat activity data, whether gathered with transects or the passive monitoring systems. However, bat passes per night are internationally used and recognized as a comparative unit for indicating levels of bat activity in an area.

Spatial distribution of bats over the study area cannot be accurately determined by means of transects, although the passive systems can provide comparative data for different areas of the site. Transects may still possibly uncover high activity in areas where it is not necessarily expected and thereby increase insight into the site.

Exact foraging distances from bat roosts or exact commuting pathways cannot be determined by the current methodology. Radio telemetry tracking of tagged bats is required to provide such information if needed.

Costly radar technology is required to provide more quantitative data on actual bat numbers as well as spatial distribution of multiple bats.

3.3 Assessment of Impacts

The EIA Methodology assists in evaluating the overall effect of a proposed activity on the environment. The determination of the effect of an environmental impact on an environmental parameter is determined through a systematic analysis of the various components of the impact. This is undertaken using information that is available to the environmental practitioner through the process of the environmental impact assessment. The impact evaluation of predicted impacts was undertaken through an assessment of the significance of the impacts.

3.3.1 Determination of Significance of Impacts

Significance is determined through a synthesis of impact characteristics which include context and intensity of an impact. Context refers to the geographical scale i.e. site, local, national or global whereas Intensity is defined by the severity of the impact e.g. the magnitude of deviation from background conditions, the size of the area affected, the duration of the impact and the overall probability of occurrence. Significance is calculated as shown in **Table 1**.

Significance is an indication of the importance of the impact in terms of both physical extent and time scale, and therefore indicates the level of mitigation required. The total number of points scored for each impact indicates the level of significance of the impact.

3.3.2 Impact Rating System

Impact assessment must take account of the nature, scale and duration of effects on the environment whether such effects are positive (beneficial) or negative (detrimental). Each issue / impact is also assessed according to the project stages:

- planning
- construction
- operation
- decommissioning

Where necessary, the proposal for mitigation or optimisation of an impact should be detailed. A brief discussion of the impact and the rationale behind the assessment of its significance has also been included.

3.3.2.1 Rating System Used to Classify Impacts

The rating system is applied to the potential impact on the receiving environment and includes an objective evaluation of the mitigation of the impact. Impacts have been consolidated into one rating. In assessing the significance of each issue the following criteria (including an allocated point system) is used:

Table 1: Description of terms

NATURE		
Include a brief description of the impact of environmental parameter being assessed in the context of the project. This criterion includes a brief written statement of the environmental aspect being impacted upon by a particular action or activity.		
GEOGRAPHICAL EXTENT		
This is defined as the area over which the impact will be expressed. Typically, the severity and significance of an impact have different scales and as such bracketing ranges are often required. This is often useful during the detailed assessment of a project in terms of further defining the determined.		
1	Site	The impact will only affect the site
2	Local/district	Will affect the local area or district
3	Province/region	Will affect the entire province or region
4	International and National	Will affect the entire country
PROBABILITY		
This describes the chance of occurrence of an impact		
1	Unlikely	The chance of the impact occurring is extremely low (Less than a 25% chance of occurrence).
2	Possible	The impact may occur (Between a 25% to 50% chance of occurrence).
3	Probable	The impact will likely occur (Between a 50% to 75% chance of occurrence).
4	Definite	Impact will certainly occur (Greater than a 75% chance of occurrence).
REVERSIBILITY		
This describes the degree to which an impact on an environmental parameter can be successfully reversed upon completion of the proposed activity.		
1	Completely reversible	The impact is reversible with implementation of minor mitigation measures
2	Partly reversible	The impact is partly reversible but more intense mitigation measures are required.

3	Barely reversible	The impact is unlikely to be reversed even with intense mitigation measures.
4	Irreversible	The impact is irreversible and no mitigation measures exist.
IRREPLACEABLE LOSS OF RESOURCES		
This describes the degree to which resources will be irreplaceably lost as a result of a proposed activity.		
1	No loss of resource.	The impact will not result in the loss of any resources.
2	Marginal loss of resource	The impact will result in marginal loss of resources.
3	Significant loss of resources	The impact will result in significant loss of resources.
4	Complete loss of resources	The impact is result in a complete loss of all resources.
DURATION		
This describes the duration of the impacts on the environmental parameter. Duration indicates the lifetime of the impact as a result of the proposed activity		
1	Short term	The impact and its effects will either disappear with mitigation or will be mitigated through natural process in a span shorter than the construction phase (0 – 1 years), or the impact and its effects will last for the period of a relatively short construction period and a limited recovery time after construction, thereafter it will be entirely negated (0 – 2 years).
2	Medium term	The impact and its effects will continue or last for some time after the construction phase but will be mitigated by direct human action or by natural processes thereafter (2 – 10 years).
3	Long term	The impact and its effects will continue or last for the entire operational life of the development, but will be mitigated by direct human action or by natural processes thereafter (10 – 50 years).
4	Permanent	The only class of impact that will be non-transitory. Mitigation either by man or natural process will not occur in such a way or such a time span that the impact can be considered transient (Indefinite).
CUMULATIVE EFFECT		
This describes the cumulative effect of the impacts on the environmental parameter. A cumulative effect/impact is an effect which in itself may not be significant but may become significant if added to other existing or potential impacts emanating from other similar or diverse activities as a result of the project activity in question.		
1	Negligible Cumulative Impact	The impact would result in negligible to no cumulative effects
2	Low Cumulative Impact	The impact would result in insignificant cumulative effects
3	Medium Cumulative impact	The impact would result in minor cumulative effects

4	High Cumulative Impact	The impact would result in significant cumulative effects
INTENSITY / MAGNITUDE		
Describes the severity of an impact		
1	Low	Impact affects the quality, use and integrity of the system/component in a way that is barely perceptible.
2	Medium	Impact alters the quality, use and integrity of the system/component but system/ component still continues to function in a moderately modified way and maintains general integrity (some impact on integrity).
3	High	Impact affects the continued viability of the system/component and the quality, use, integrity and functionality of the system or component is severely impaired and may temporarily cease. High costs of rehabilitation and remediation.
4	Very high	Impact affects the continued viability of the system/component and the quality, use, integrity and functionality of the system or component permanently ceases and is irreversibly impaired (system collapse). Rehabilitation and remediation often impossible. If possible rehabilitation and remediation often unfeasible due to extremely high costs of rehabilitation and remediation.
SIGNIFICANCE		
Significance is determined through a synthesis of impact characteristics. Significance is an indication of the importance of the impact in terms of both physical extent and time scale, and therefore indicates the level of mitigation required. This describes the significance of the impact on the environmental parameter. The calculation of the significance of an impact uses the following formula: **(Extent + probability + reversibility + irreplaceability + duration + cumulative effect) x magnitude/intensity.** The summation of the different criteria will produce a non weighted value. By multiplying this value with the magnitude/intensity, the resultant value acquires a weighted characteristic which can be measured and assigned a significance rating.		
Points	**Impact Significance Rating**	**Description**
6 to 28	Negative Low impact	The anticipated impact will have negligible negative effects and will require little to no mitigation.
6 to 28	Positive Low impact	The anticipated impact will have minor positive effects.
29 to 50	Negative Medium impact	The anticipated impact will have moderate negative effects and will require moderate mitigation measures.
29 to 50	Positive Medium impact	The anticipated impact will have moderate positive effects.

51 to 73	Negative High impact	The anticipated impact will have significant effects and will require significant mitigation measures to achieve an acceptable level of impact.
51 to 73	Positive High impact	The anticipated impact will have significant positive effects.
74 to 96	Negative Very high impact	The anticipated impact will have highly significant effects and are unlikely to be able to be mitigated adequately. These impacts could be considered "fatal flaws".
74 to 96	Positive Very high impact	The anticipated impact will have highly significant positive effects.

4 RESULTS AND DISCUSSION

4.1 Land Use, Vegetation, Climate and Topography

The study area falls over the Bushmanland Arid Grassland and Lower Gariep Broken Veld vegetation units as defined by Mucina and Rutherford (2006), the surrounding vegetation units are Northern Upper Karoo, Bushmanland Vloere, Bushmanland Basin Shrubland and Upper Karoo Hardeveld (**Figure 6**).

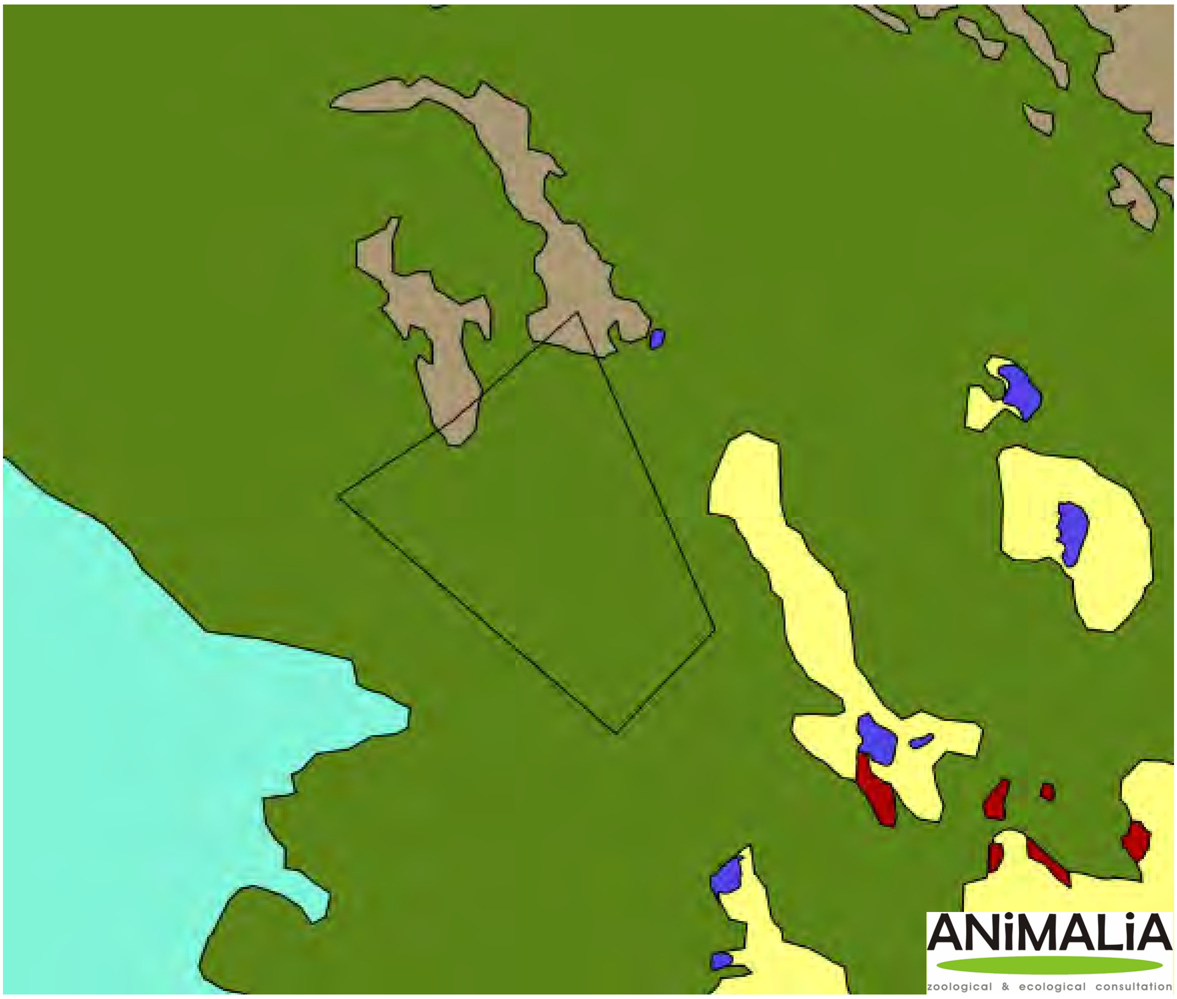
Bushmanland Arid Grassland is considered to be Least Threatened, however only less than 1% of this vegetation type is currently protected in South Africa. Tussock grasses and dwarf shrubland dominate this vegetation type with no endemic plants present. Shallow lime-rich soils support the plant life and underneath the soil are the Ecca and Beaufort geological groups. The summers are hot and dry with an average daily maximum of 36°C, while winters are icy cold with an average daily minimum of 4°C. The average annual rainfall is only 189mm with peaks in late autumn and early summer, but varies considerably from year to year (Mucina and Rutherford 2006).

The Lower Gariep Broken Veld vegetation unit consists of hills and low mountains, slightly irregular plains and some rugged terrain. The vegetation is sparse and is dominated by shrubs and dwarf shrubs with widely scattered low trees. The mean annual precipitation ranges from 70mm to 240mm, with mean maximum and minimum temperatures of 39.7°C and -4.1°C for January and July respectively. The unit has a least threatened conservation status (Mucina and Rutherford 2006).

Vegetation units and geology are of great importance as these may serve as suitable sites for the roosting of bats and support of their foraging habits (Monadjem *et al.* 2010). Houses and buildings may also serve as suitable roosting spaces (Taylor 2000; Monadjem *et al.* 2010). The importance of the vegetation units and associated geomorphology serving as potential roosting and foraging sites have been described in **Table 2** below.

Table 2: Potential of the vegetation to serve as suitable roosting and foraging spaces for bats.

Vegetation Unit	Roosting Potential	Foraging Potential	Comments
Bushmanland Arid Grassland	Low	Low-Moderate	Very little natural roosting space is available and may be limited to the few buildings/man-made structures on site. Foraging will mostly be by open space foraging bats species with strong seasonality.
Lower Gariep Broken Veld	Low	Moderate	The vegetation unit does not present a lot of roosting potential apart from low trees and man-made structures. The unit can provide adequate foraging opportunities, especially for open air foraging bat species.



Northern Upper Karoo
Bushmanland Basin Shrubland
Bushmanland Arid Grassland
Lower Gariep Broken Veld
Bushmanland Vloere
Upper Karoo Hardeveld
Site Boundary

Figure 6: Vegetation units present on the Aletta 1 WEF study area (Mucina and Rutherford 2006).

4.2 Literature Based Species Probability of Occurrence

"Probability of Occurrence" is assigned based on consideration of the presence of roosting sites and foraging habitats on the site, compared to literature described preferences. The probability of occurrence is indicative of the likelihood of encountering the bat species on site.

The column of "Likely risk of impact" describes the likelihood of risk of fatality from direct collision or barotrauma with wind turbine blades for each bat species. The risk was assigned by Sowler *et al.* (2016) based on species distributions, altitudes at which they fly and distances they traverse; and assumes a 100% probability of occurrence. The ecology of most applicable bat species recorded in the vicinity of the site is discussed below.

Table 3: Table of species that may be roosting or foraging in the study area and the possible site specific roosts (Monadjem *et al.* 2010).

Species	Common name	Probability of occurrence (%)	Conservation status	Possible roosting habitat on site	Possible foraging habitat utilised on site	Likelihood of risk of fatality (Sowler *et al.*, 2016)
Rhinolophus clivosus	Geoffroy's horseshoe bat	10 - 20	Least Concern	Roosts in caves, mine adits and hollows (man-made and natural).	It is associated with a variety of habitats including arid savanna, woodland and riparian forest. Clutter forager that may only possibly be found in denser drainage systems. Relatively small foraging range	Low
Nycteris thebaica	Egyptian slit-faced bat	10 - 20	Least Concern	Roosts in caves, aardvark burrows, culverts under roads and the trunks of large trees and hollows (man-made or natural). Roosting space unlikely on site.	It appears to occur throughout the savanna and karoo biomes, but avoids open grasslands. May be found in denser drainage systems. Relatively small foraging range and an open space forager	Low
Sauromys petrophilus	Roberts's flat-headed bat	60 - 70	Least Concern	Roosts in narrow cracks and under slabs of exfoliating rock. Closely associated with rocky habitats in dry woodland, mountain fynbos or arid scrub.	Open space forager with relatively large foraging range.	High
Tadarida aegyptiaca	Egyptian free-tailed bat	Confirmed	Least Concern	Roost during the day, rock crevices, under exfoliating rocks, in hollow trees, and behind the bark of dead trees. The species has also taken to roosting in buildings, in particular roofs of houses. The farm buildings are the most likely roosting space.	It forages over a wide range of habitats; its preferences of foraging habitat seem independent of vegetation. It seems to forage in all types of natural and urbanised habitats with a relatively large foraging range. Open space forager	High
Miniopterus natalensis	Natal long-fingered bat	Confirmed (in very low numbers)	Near Threatened	It is cave/mine dependent and hence the availability of suitable roosting sites is a critical factor in determining its presence. It may be found in the Copperton copper mines. Have been found roosting singly or in small groups inside culverts and manmade hollows.	Forages around the edge of clutters of vegetation, and may therefore avoid most of the site and may only be found at the denser drainage systems. It is also dependant on open surface water sources.	Medium - High
Cistugo seabrae	Angolan wing-gland bat	40 - 50	Near Threatened	It is restricted to the arid western parts of southern Africa, typically in desert and semi-desert conditions. Not a common bat.	Not well known, once netted at a dry stream bed in 2006 close to Vredesvallei.	Not known

Eptesicus hottentotus	Long-tailed serotine	30 - 40	Least Concern	It is a crevice dweller roosting in rock crevices, expansion joints in bridges and road culverts	It seems to prefer woodland habitats, but has been caught in granitic hills and near rocky outcrops. Clutter edge forager	Medium
Myotis tricolor	Temmink's myotis	20 - 30	Least Concern	Roosts gregariously in caves, but have been found roosting singly or in small groups inside culverts and manmade hollows.	It is restricted to areas with suitable caves or hollows, which may explain its absence from flat and featureless terrain; its close association with mountainous areas may therefore be due to its roosting requirements.	Medium - High
Neoromicia capensis	Cape serotine	Confirmed	Least Concern	Roosts under the bark of trees, at the base of aloe leaves, and inside the roofs of houses. The farm buildings are the most likely roosting space.	It appears to tolerate a wide range of environmental conditions from arid semi-desert areas to montane grasslands, forests, and savannas. Highly adaptable species, but a clutter edge forager limiting its utilisation of the site.	Medium - High

4.3 Ecology of bat species that may be largely impacted by the Aletta 1 WEF

There are several bat species in the vicinity of the site that occur commonly in the area. These species are of importance based on their likelihood of being impacted by the proposed WEF, due to high abundances and certain behavioural traits. The relevant species are discussed below.

Tadarida aegyptiaca

The Egyptian Free-tailed Bat, *Tadarida aegyptiaca*, is a Least Concern species as it has a wide distribution and high abundance throughout South Africa, and is part of the Free-tailed bat family (Molossidae). It occurs from the Western Cape of South Africa, north through to Namibia and southern Angola; and through Zimbabwe to central and northern Mozambique (Monadjem *et al*. 2010). This species is protected by national legislation in South Africa (ACR 2010).

They roost communally in small (dozens) to medium-sized (hundreds) groups in caves, rock crevices, under exfoliating rocks, in hollow trees and behind the bark of dead trees. *Tadarida aegyptiaca* has also adapted to roosting in buildings, in particular roofs of houses (Monadjem *et al*. 2010). Thus man-made structures and large trees on the site would be important roosts for this species.

Tadarida aegyptiaca forages over a wide range of habitats, flying above the vegetation canopy. It appears that the vegetation has little influence on foraging behaviour as the species forages over desert, semi-arid scrub, savanna, grassland and agricultural lands. Its presence is strongly associated with permanent water bodies due to concentrated densities of insect prey (Monadjem *et al*. 2010).

The Egyptian Free-tailed bat is considered to have a High likelihood of risk of fatality due to wind turbines (Sowler *et al.* 2016). Due to the high abundance and widespread distribution of this species, high mortality rates due to wind turbines would be a cause of concern as these species have more significant ecological roles than the rarer bat species.

After a gestation of four months, a single young is born, usually in November or December, when females give birth once a year. In males, spermatogenesis occurs from February to July and mating occurs in August. Maternity colonies are apparently established by females in November.

Neoromicia capensis

Neoromicia capensis is commonly called the Cape serotine and has a conservation status of Least Concern as it is found in high numbers and is widespread over much of Sub-Saharan Africa.

High mortality rates of this species due to wind turbines would be a cause of concern as *Neoromicia capensis* is abundant and widespread and as such has a more significant role to play within the local ecosystem than the rarer bat species. They do not undertake migrations and thus are considered residents of the site.

It roosts individually or in small groups of two to three bats in a variety of shelters, such as under the bark of trees, at the base of aloe leaves, and under the roofs of houses. They will use most man-made structures as day roosts which can be found throughout the site and surrounding areas (Monadjem *et al*. 2010).

They are tolerant of a wide range of environmental conditions as they survive and prosper within arid semi-desert areas to montane grasslands, forests, and savannas; indicating that they may occupy several habitat types across the site, and are amenable towards habitat changes. They are however clutter-edge foragers, meaning they prefer to hunt on the edge of vegetation clutter mostly, but can occasionally forage in open spaces. They are thought to have a Medium-High likelihood of risk of fatality due to wind turbines (Sowler *et al.* 2016).

Mating takes place from the end of March until the beginning of April. Spermatozoa are stored in the uterine horns of the female from April until August, when ovulation and fertilisation occurs. They give birth to twins during late October and November but single pups, triplets and quadruplets have also been recorded (van der Merwe 1994 and Lynch 1989).

Miniopterus natalensis

Miniopterus natalensis, also commonly referred to as the Natal long-fingered bat, occurs widely across the country but mostly within the southern and eastern regions and is listed as Near Threatened (Monadjem *et al*., 2010). This bat is a cave-dependent species and identification of suitable roosting sites may be more important in determining its presence in an area than the presence of surrounding vegetation. It occurs in large numbers when roosting in caves with approximately 260 000 bats observed making seasonal use of the De Hoop Guano Cave in the Western Cape, South Africa. Culverts and mines have also been observed as roosting sites for either single bats or small colonies. Separate roosting sites are used for winter hibernation activities and summer maternity behaviour, with the winter hibernacula generally occurring at higher altitudes in more temperate areas and the summer hibernacula occurring at lower altitudes in warmer areas of the country (Monadjem *et al*., 2010)

Mating and fertilisation usually occur during March and April and is followed by a period of delayed implantation until July/August. Birth of a single pup usually occurs between October and December as the females congregate at maternity roosts (Monadjem *et al.,* 2010 & Van Der Merwe, 1979).

The Natal long-fingered bat undertakes short migratory journeys between hibernaculum and maternity roosts. Due to this migratory behaviour, they are considered to be at high risk of fatality from wind turbines if a wind farm is placed within a migratory path (Sowler *et al.* 2016). The mass movement of bats during migratory periods could result in mass casualties if wind turbines are positioned over a mass migratory route and such turbines are not effectively mitigated. Very little is known about the migratory behaviour and paths of *Miniopterus natalensis* in South Africa with migration distances exceeding 150 kilometres. If the site is located within a migratory path the bat detection systems should detect high numbers and activity of the Natal long-fingered bat. This will be examined over the course of the 12-month monitoring survey.

A study by Vincent *et al.* (2011) on the activity and foraging habitats of Miniopteridae found that the individual home ranges of lactating females were significantly larger than that of pregnant females. It was also found that the bats predominately made use of urban areas (54%) followed by open areas (19.8%), woodlands (15.5%) orchards and parks (9.1%) and water bodies (1.5%) when selecting habitats. Foraging areas were also investigated with the majority again occurring in urban areas (46%), however a lot of foraging also occurred in woodland areas (22%), crop and vineyard areas (8%), pastures, meadows and scrubland (4%) and water bodies (4%).

Sowler *et al.* (2016) advise that *Miniopterus natalensis* faces a medium to high risk of fatality due to wind turbines. This evaluation was based on broad ecological features and excluded migratory information.

4.4 Transects

Transect data was used to analyse the accuracy of the bat sensitivity map.

4.4.1 First Site Visit

Figure 7 below indicates the transect routes during the first site visit. Transect routes were not calculated and were carried out randomly based on available access to the farms and condition of the farm roads. The SM2BAT+ Real time expansion type detector was used. **Table 4** displays the sampling effort and weather conditions prevalent during transect surveys.

Table 4: Transect distance, duration and average weather conditions experienced during the second transect

Date	**Distance (km)**	**Duration (hours and minutes)**	**Temperature (˚C)**	**Rain (mm)**	**Wind speed (km/h)**
22 July 2015	45.1	3hr 14min	15	0.6	21.6
23 July 2015	55	3hr 50 min	12	0.0	18

Figure 7: Transect routes across the site over the first site visit.

Figure 7 above displays that zero bat passes were detected over the course of the transect sampling period for the first site visit. This was most likely due to the cold and windy weather conditions influencing the bat activity. Bats are generally less active in adverse weather conditions.

4.4.2 Second Site Visit

Figure 8 below indicates the transect routes during the second site visit. Transect routes were not calculated and were carried out randomly based on available access to the farms and condition of the farm roads. The SM2BAT+ Real time expansion type detector was used. **Table 5** displays the sampling effort and weather conditions prevalent during transect surveys.

Table 5: Transect distance, duration and average weather conditions experienced during the second transect

Date	Distance (km)	Duration (hours and minutes)	Temperature (˚C)	Rain (mm)	Wind speed (km/h)
20 October 2015	62.2	3hr 28min	28	0.0	18
21 October 2015	51.9	3hr 24 min	30	0.0	18
22 October 2015	75.4	5hr 29 min	25	0.0	18

Figure 8 below displays a few bat passes of three different species that were detected across the site during transects. The species detected are *Miniopterus natalensis, Neoromicia capensis* and *Tadarida aegyptiaca.* Their spatial distribution was relatively spread across the study area with detection in the vicinity of buildings and houses

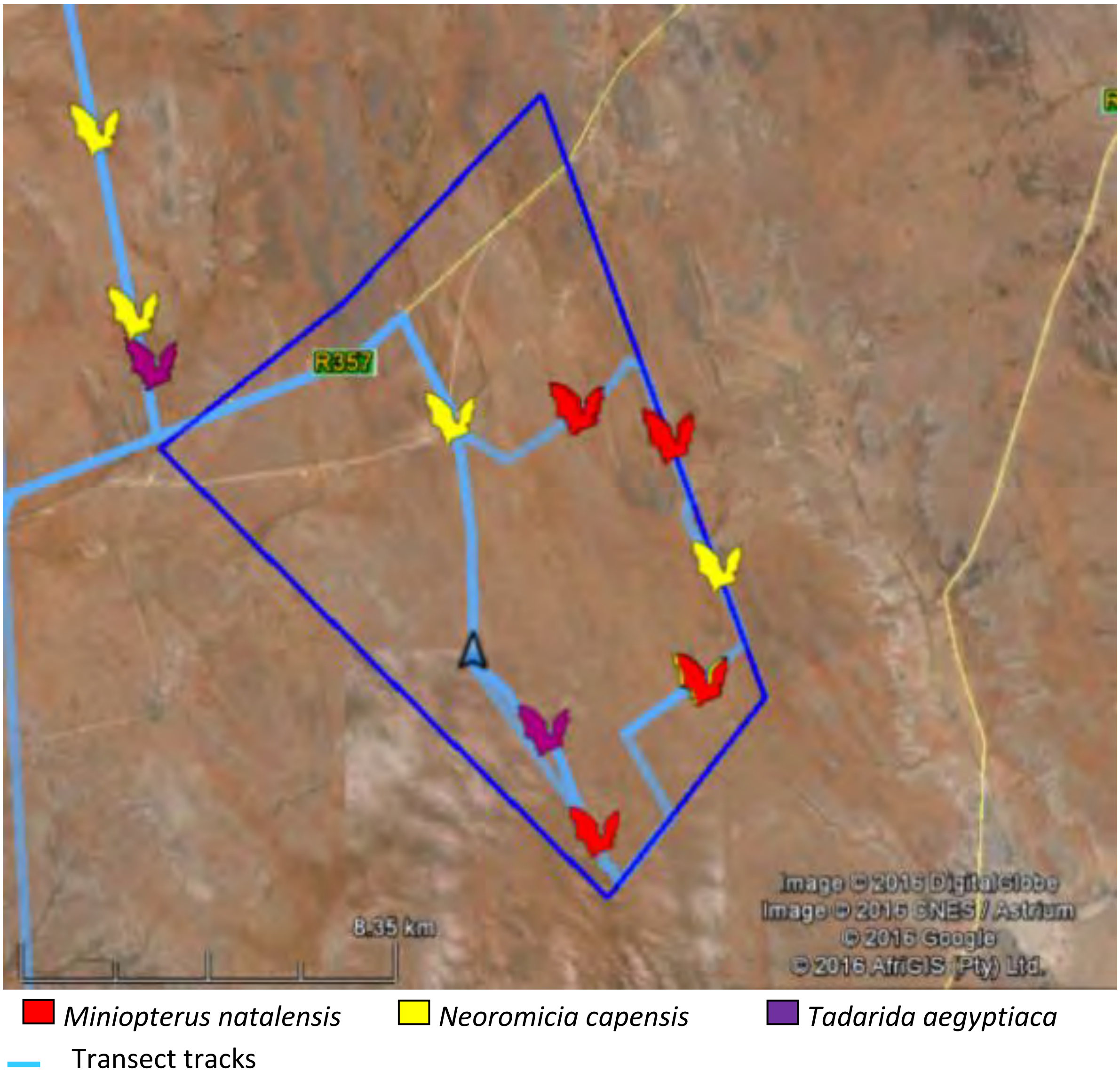


Figure 8: Transect routes across the site over the second site visit.

4.4.3 Third Site Visit

Figure 9 below indicates the transect routes during the third site visit. **Table 6** displays the sampling effort and weather conditions prevalent during transect surveys.

Table 6: Transect distance, duration and average weather conditions experienced during the second transect

Date	Distance (km)	Duration (hours and minutes)	Temperature (˚C)	Rain (mm)	Wind speed (km/h)
10 February 2016	18.7	1hr 51min	33	0.0	9.6

Miniopterus natalensis   Neoromicia capensis   Tadarida aegyptiaca

Transect tracks

Figure 9: Transect routes across the site over the third site visit.

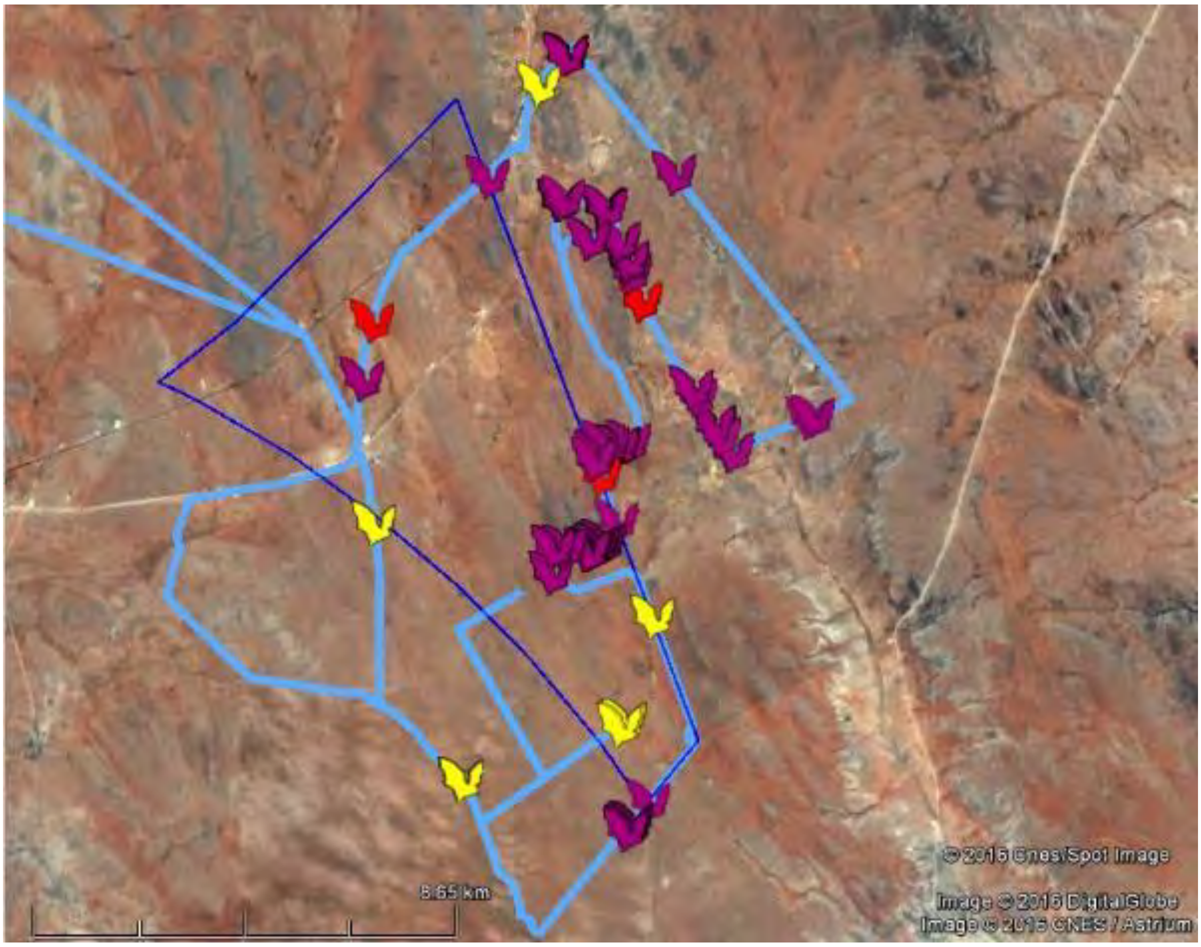
Figure 9 above displays a high concentration of *Tadarida aegyptiaca* passes near the centre of the study area, near buildings and houses. These manmade structures provide a suitable roosting place and protection from weather and predators. This bat species seems to be opportunistically utilising those features. Thus, they will be buffered in the bat sensitivity map (Section 4.5).

4.4.4 Fourth Site Visit

Figure 10 below indicates the transect routes during the fourth site visit. **Table 7** displays the sampling effort and weather conditions prevalent during transect surveys.

Table 7: Transect distance, duration and average weather conditions experienced during the second transect

Date	Distance (km)	Duration (hours and minutes)	Temperature (˚C)	Rain (mm)	Wind speed (km/h)
11 April 2016	56.4	3hr 24min	25.67	0.0	9.3
12 April 2016	65.8	4hr 08min	26.67	0.0	10.3
13 April 2016	52.6	3hr 30min	27.67	0.0	8
14 April 2016	48.4	2hr 21min	28.67	0.0	8



Miniopterus natalensis *Neoromicia capensis* *Tadarida aegyptiaca*
Transect tracks

Figure 10: Transect routes across the site over the fourth site visit.

Generally increased bat activity was detected over the fourth site visit across most of the study area. The weather conditions hosted higher bat activity than the previous sampling seasons. *Tadarida aegyptiaca* was the most abundant bat species detected over the study area.

4.4.5 Fifth Site Visit

Figure 11 below indicates the transect routes during the fifth site visit. **Table 8** displays the sampling effort and weather conditions prevalent during transect surveys. Decreased bat activity was detected over the fifth site visit across the study area. The low bat activity can be due to the transect being conducted during a winter month. *Tadarida aegyptiaca* was the only bat specie detected over the study area.

Table 8: Transect distance, duration and average weather conditions experienced during the second transect

Date	Distance (km)	Duration (hours and minutes)	Temperature (˚C)	Rain (mm)	Wind speed (km/h)
9 July 2016	57.8	3hr 10min	17	0.0	7.3

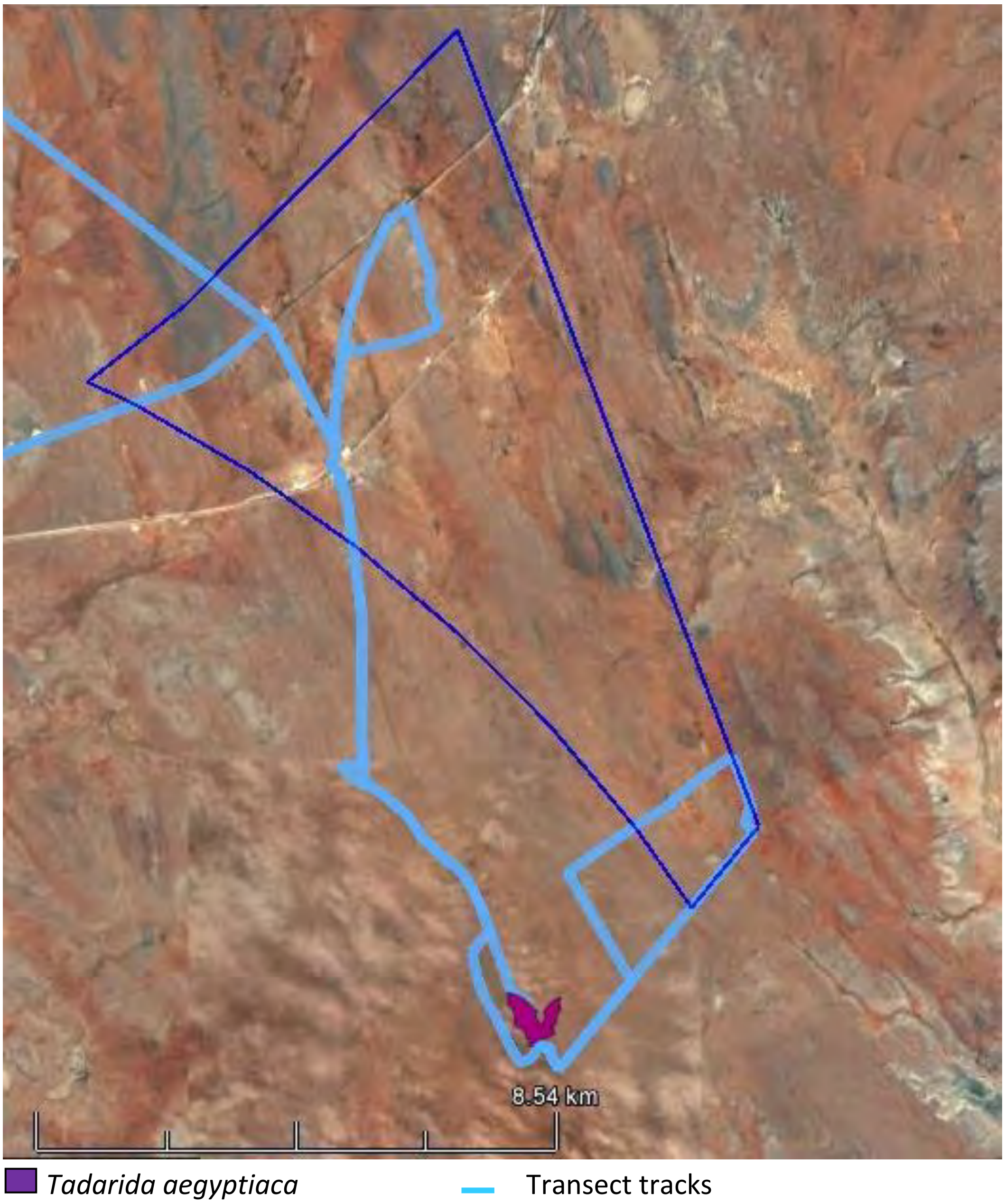


Figure 11: Transect routes across the site over the fifth site visit.

4.5 Sensitivity Map

Figure 12 depicts the sensitive areas of the site, based on features identified to be important for foraging and roosting of the species that are most probable to occur on site. Thus the sensitivity map is based on species ecology and habitat preferences. This map can be used as a pre-construction mitigation in terms of improving turbine placement with regards to bat preferred habitats on site.

Table 9: Description of parameters used in the construction of a sensitivity map

Last iteration	June 2015
High sensitivity buffer	250m radial buffer
Moderate sensitivity buffer	100m radial buffer
Features used to develop the sensitivity map	Manmade structures, such as houses, barns, sheds and road culverts, these structures provide easily accessible roosting sites.
	The presence of probable hollows/overhangs, rock faces and clumps of larger woody plants. These features provide natural roosting spaces and tend to attract insect prey.
	The different vegetation types and presence of riparian/water drainage habitat is used as indicators of probable foraging areas.
	Open water sources, be it man-made farm dams or natural streams and wetlands, are important sources of drinking water and provide habitat that host insect prey.
	Areas frequented often by cattle and livestock (e.g. congregation areas and kraal areas) were assigned a moderate sensitivity since large groups of animals tend to attract insects.

The areas designated as having a High Bat Sensitivity **(Table 10)** implicates that no turbines should be placed in these areas and their respective buffer zones, due to the elevated impacts it can have on bat mortalities. If turbines are located within the Moderate Bat Sensitivity zone or buffer zone, they must receive special attention and preference for post-construction monitoring and implementation of mitigations during the operational phase (if mitigation is found to be required).

Table 11: Description of sensitivity categories utilized in the sensitivity map

Sensitivity	Description
Moderate Sensitivity	Areas of foraging habitat or roosting sites considered to have significant roles for bat ecology. Turbines within or close to these areas must acquire priority (not excluding all other turbines) during pre/post-construction studies and mitigation measures will need to be applied immediately from the start of operation.
High Sensitivity	Areas that are deemed critical for resident bat populations, capable of elevated levels of bat activity and support greater bat diversity than the rest of the site. These areas are 'no-go' areas and turbines must not be placed in these areas and their buffers.

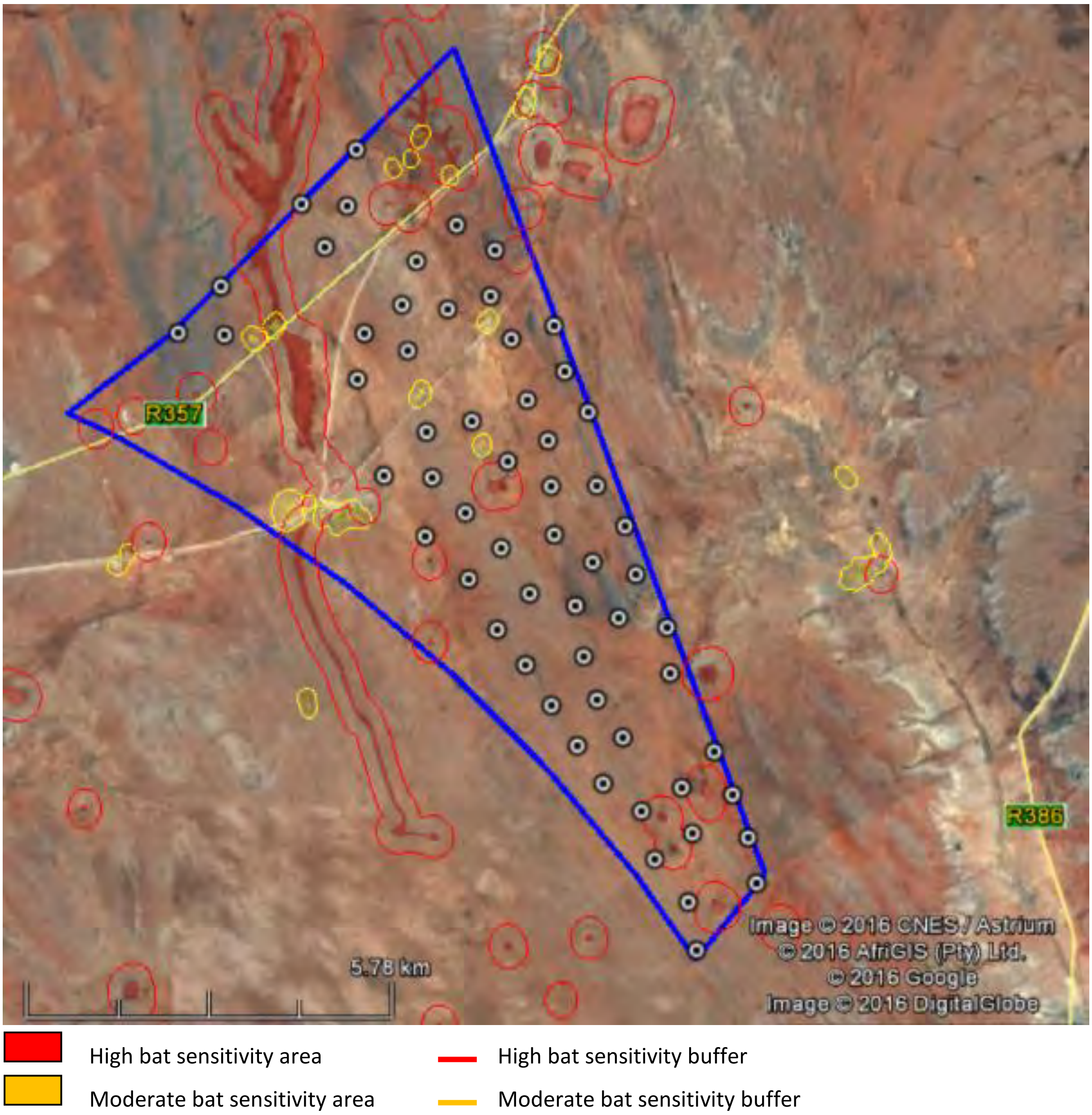


Figure 12: Bat sensitivity map of the Aletta WEF site and proposed turbine layout

The turbine layout is respective of the bat sensitve areas and their buffer zones. It does not encroach on the sensitive areas and thus is deemed acceptable relative to the bat monitoring study.

4.6 Passive Data

4.6.1 Abundances and Composition of Bat Assemblages

Average bat passes detected per bat detector night (nights on which detectors recorded correctly) and total number of bat passes detected over the monitoring period by all systems are displayed in **Figures 13 - 16**. Four bat species were detected namely *Tadarida aegyptiaca, Neoromicia capensis, Miniopterus natalensis,* and *Eptesicus hottentotus.*

Neoromicia capensis and *Tadarida aegyptiaca* were most commonly detected across both of the monitoring systems. These abundant species are of a large value to the local ecosystems as they provide a greater contribution to most ecological services than the rarer species due to their higher numbers.

The migratory species, *Miniopterus natalensis*, was detected by all monitoring systems and is rather prevalent on site. The relative abundance of this species was highest, as detected by all monitoring systems, over the months of September - October 2015 and February - April 2016 (**Figures 15 – 16**).

Bat activity detected at 80m monitoring height was low when compared with the monitoring results from 10m height (**Figure 13**). The greatest total bat abundance was detected by the 10m microphone of the meteorological mast.

Bat activity, especially with *Neoromicia capensis,* was generally higher over October 2015 for the Short Mast 1. The Met Mast has higher activity during January 2016 with the bat species *Tadarida aegyptiaca* (**Figures 15 – 16**). Generally, bat activity was low over the winter months with a sharp increase in spring. The elevated activity was more or less maintained over summer and has gradually declined into autumn.

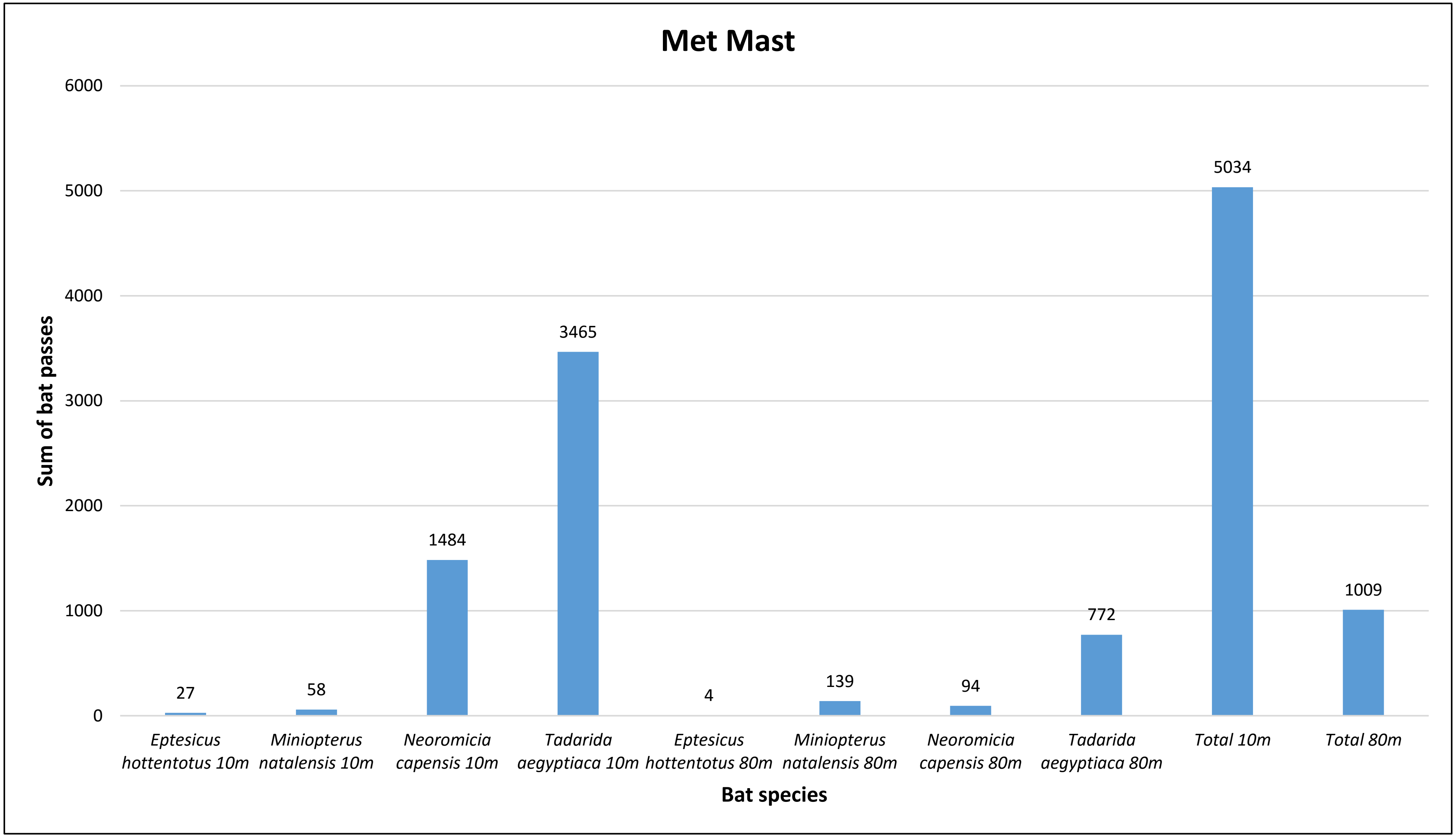


Figure 13: Total bat passes recorded over the monitoring period by the detector mounted on the Met Mast.

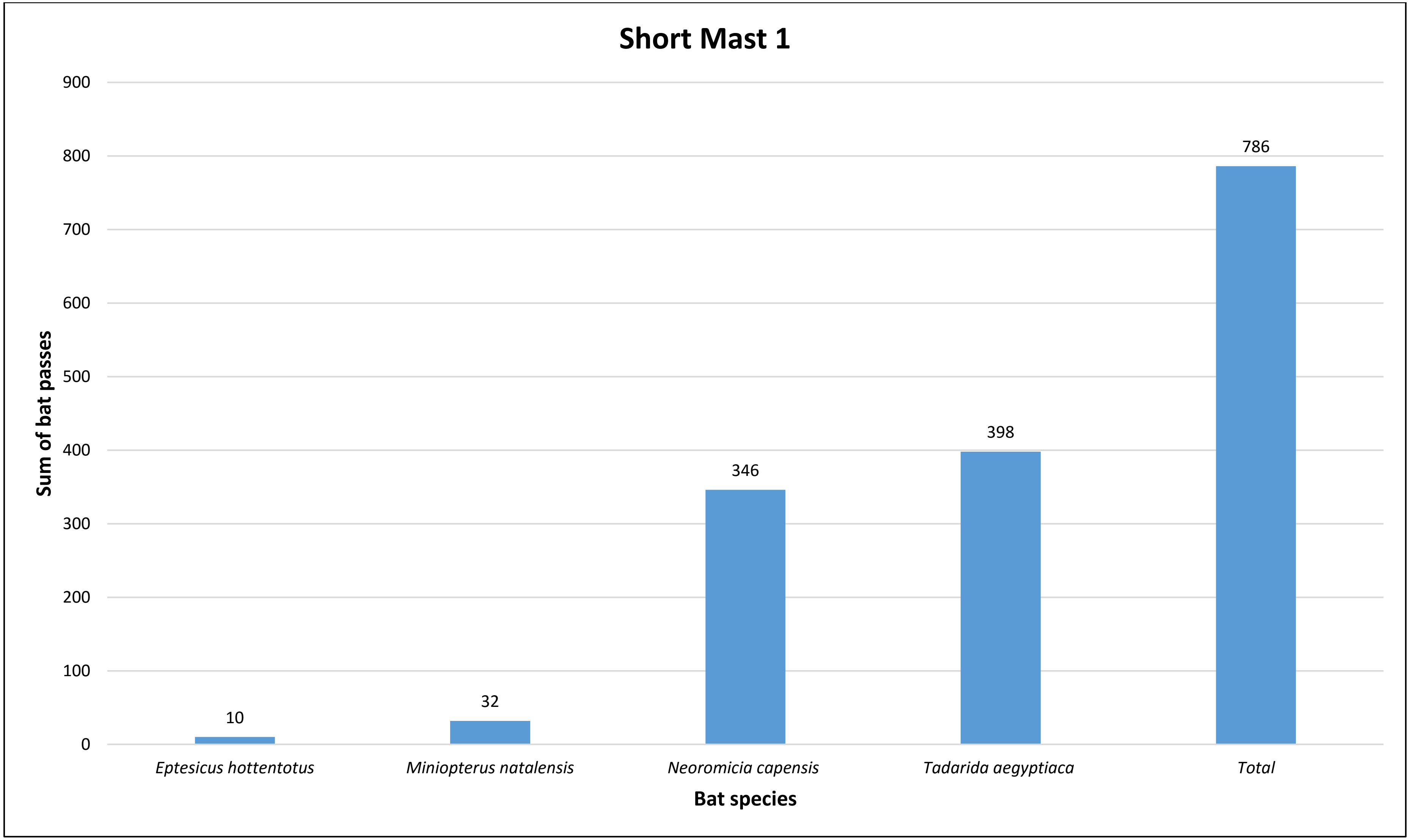


Figure 14: Total bat passes recorded over the monitoring period by the detector mounted on Short Mast 1.

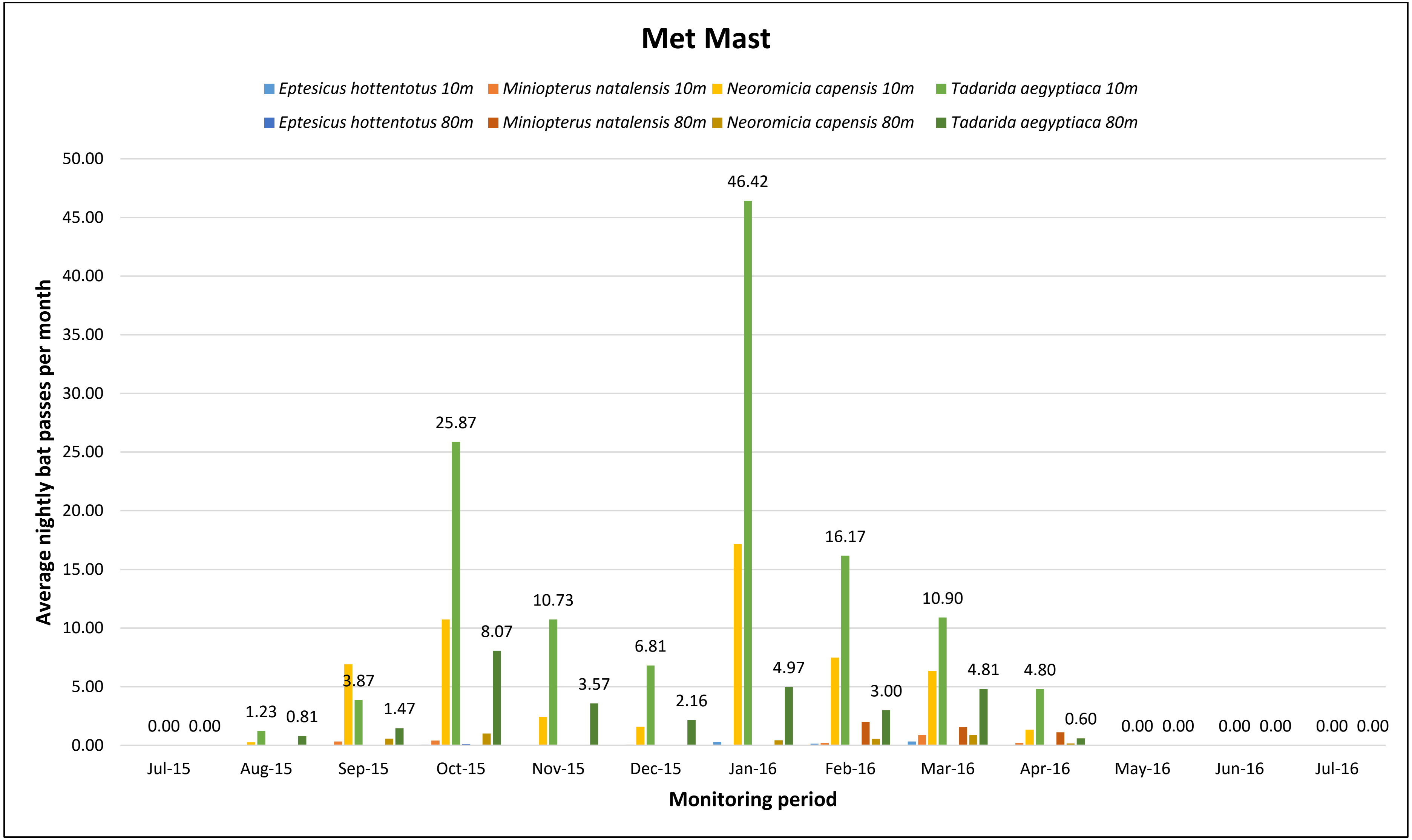


Figure 15: Average bat passes recorded per month by the detector mounted on the Met Mast.

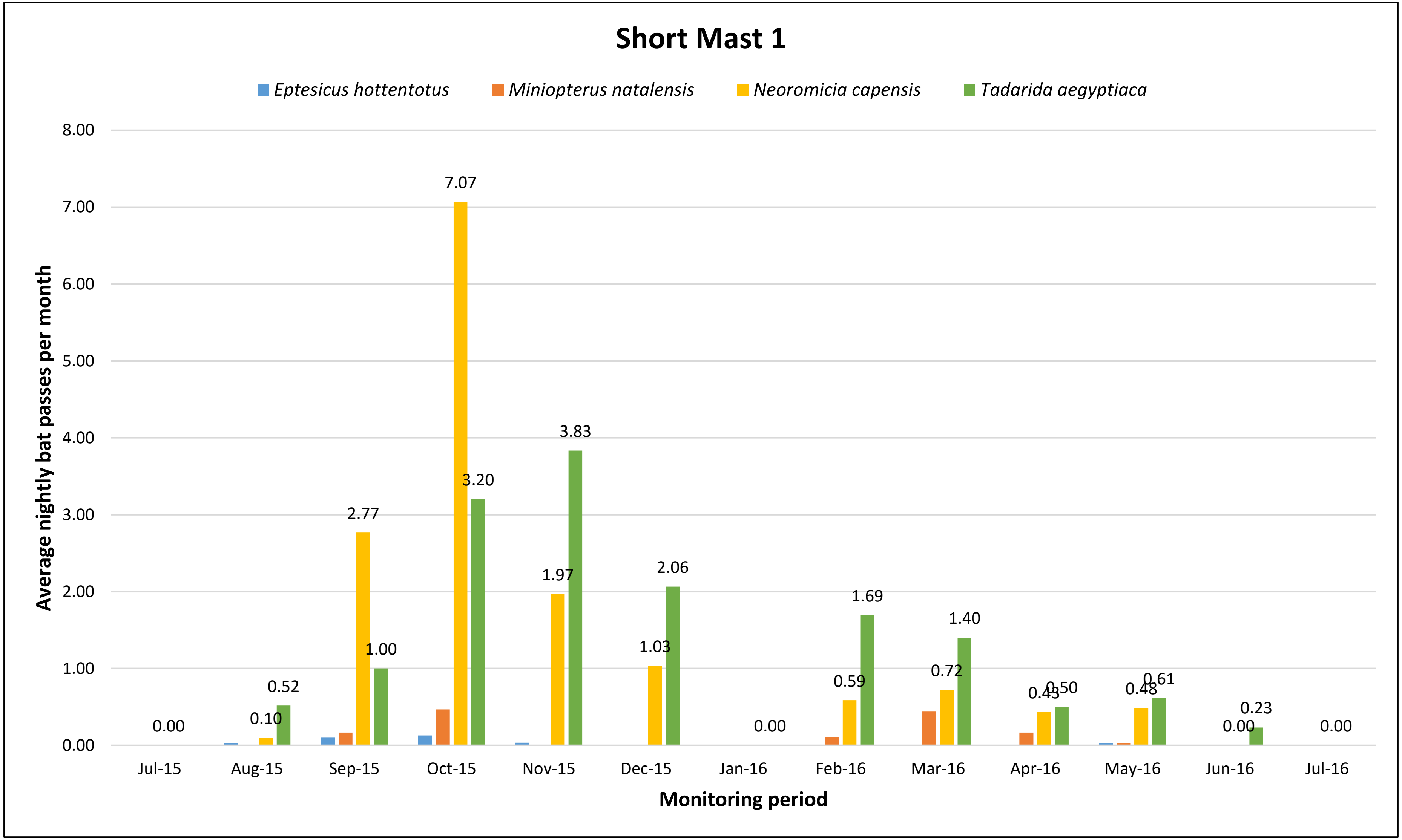


Figure 16: Average bat passes recorded per month by the detector mounted on Short Mast 1.

4.6.2 Temporal Distribution

The sum of all bat passes recorded by the monitoring systems of the particular species are displayed per night over the entire monitoring period (**Figures 17 - 18**). The peak activity times identified are mostly an amalgamation of the temporal distribution of *Neoromicia capensis* and *Tadarida aegyptiaca* as they were the species detected more often by a substantial margin.

The peak activity periods determined from **Figures 17 – 18** are as follows:

Met Mast

- 15 October – 30 November 2015
- 1 – 31 January 2016

Short Mast

- 16 September - 12 October 2015
- 19 October – 27 November 2015
- 23 December 2015 – 20 March 2016

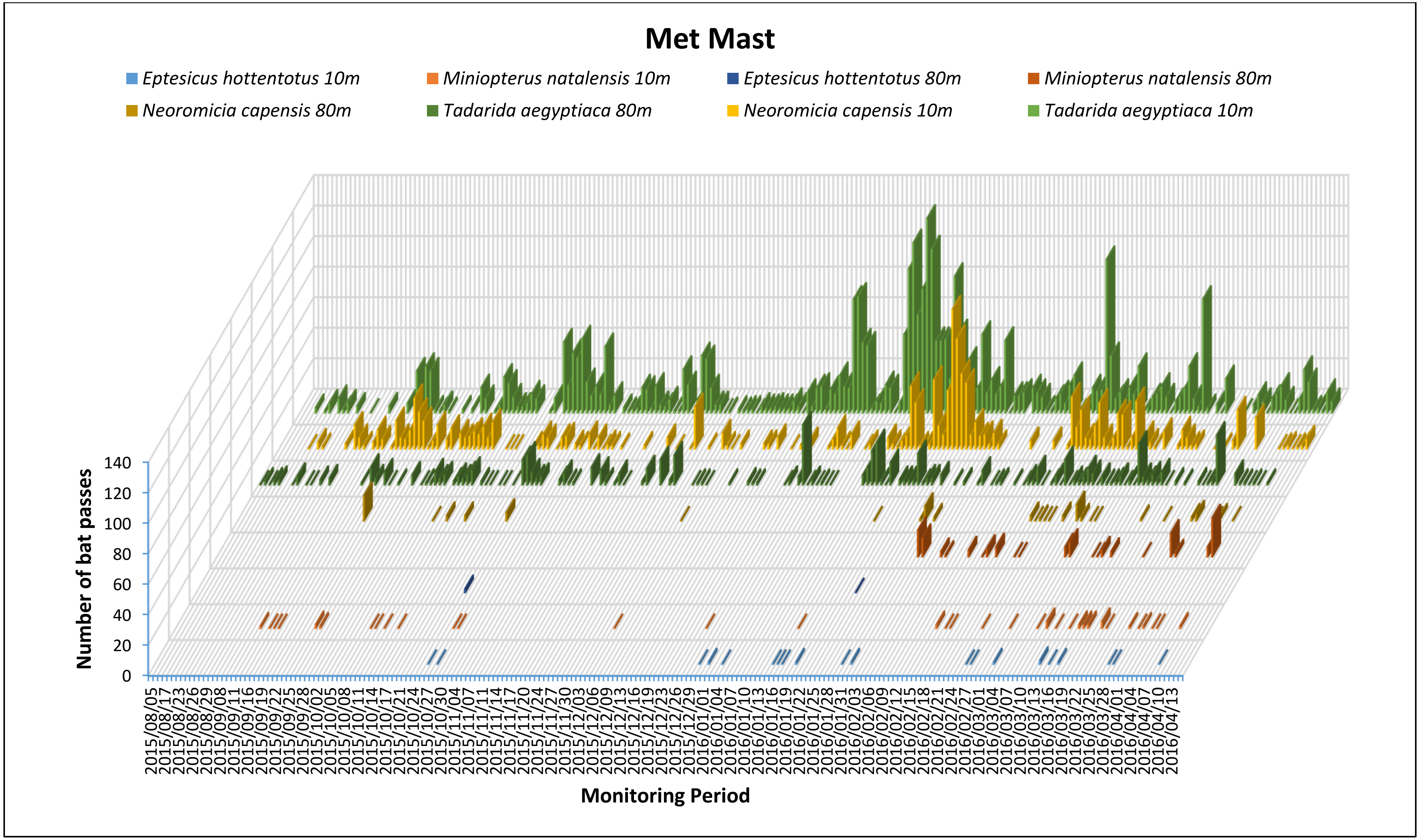


Figure 17: Temporal distribution of bat passes detected by the Met Mast.

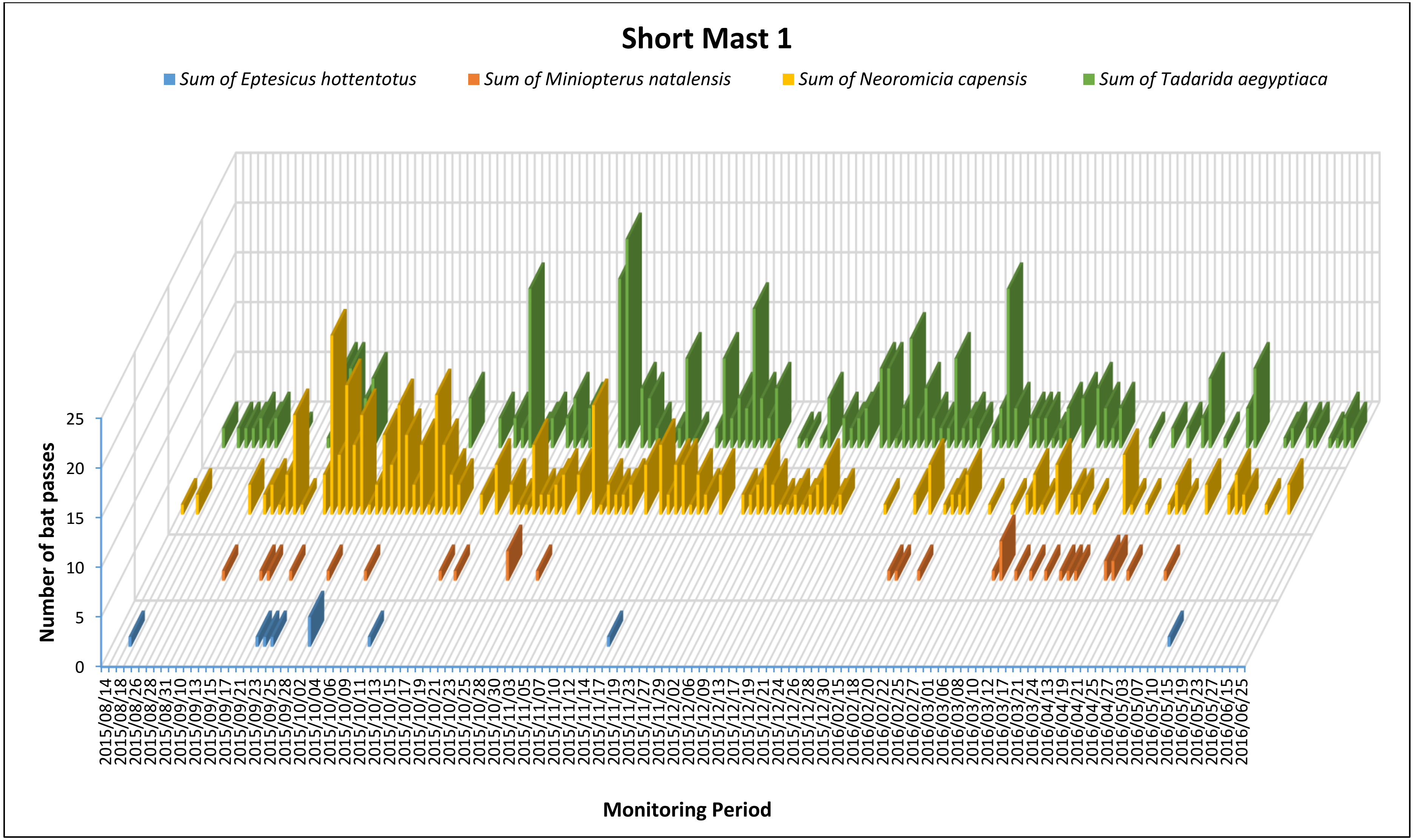


Figure 18: Temporal distribution of bat passes detected by Short Mast 1.

4.6.3 Distribution of bat activity across the night per season

The distribution of bat activity across the night, per season, has been analysed in this section **(Figure 19 – 23)**. The 12-month monitoring period was divided based on generic calendar seasons outlined **Table 12**.

Table 12: Time frame of each season

Season	**Monitoring period**
Winter	1 June – 31 August
Spring	1 September – 30 November
Summer	1 December – 28 February
Autumn	1 March – 31 May

The number of bat passes per 10-minute interval over the seasonal monitoring periods were summed to generate the figures of bat activity over the time of night. Higher levels of activity indicate preference for activity over a particular period of the night. These periods will then be used to inform mitigation implementation when and where needed. Once again, peak activity times are mostly an amalgamation of the activity of *Tadarida aegyptiaca* and *Neoromicia capensis,* especially at 10m height. The figures show that there are seldom cases of other species being highly active in the absence of high activity levels of these two abundant species.

Miniopterus natalensis had an increase in activity, especially at 80m height, near the Met Mast during the autumn months (**Figure 21**). It is likely that this species migrates to nearby roosts over autumn and is therefore more prevalent in the area over such time, but not necessarily that the project site is located within the migration path followed for this movement.

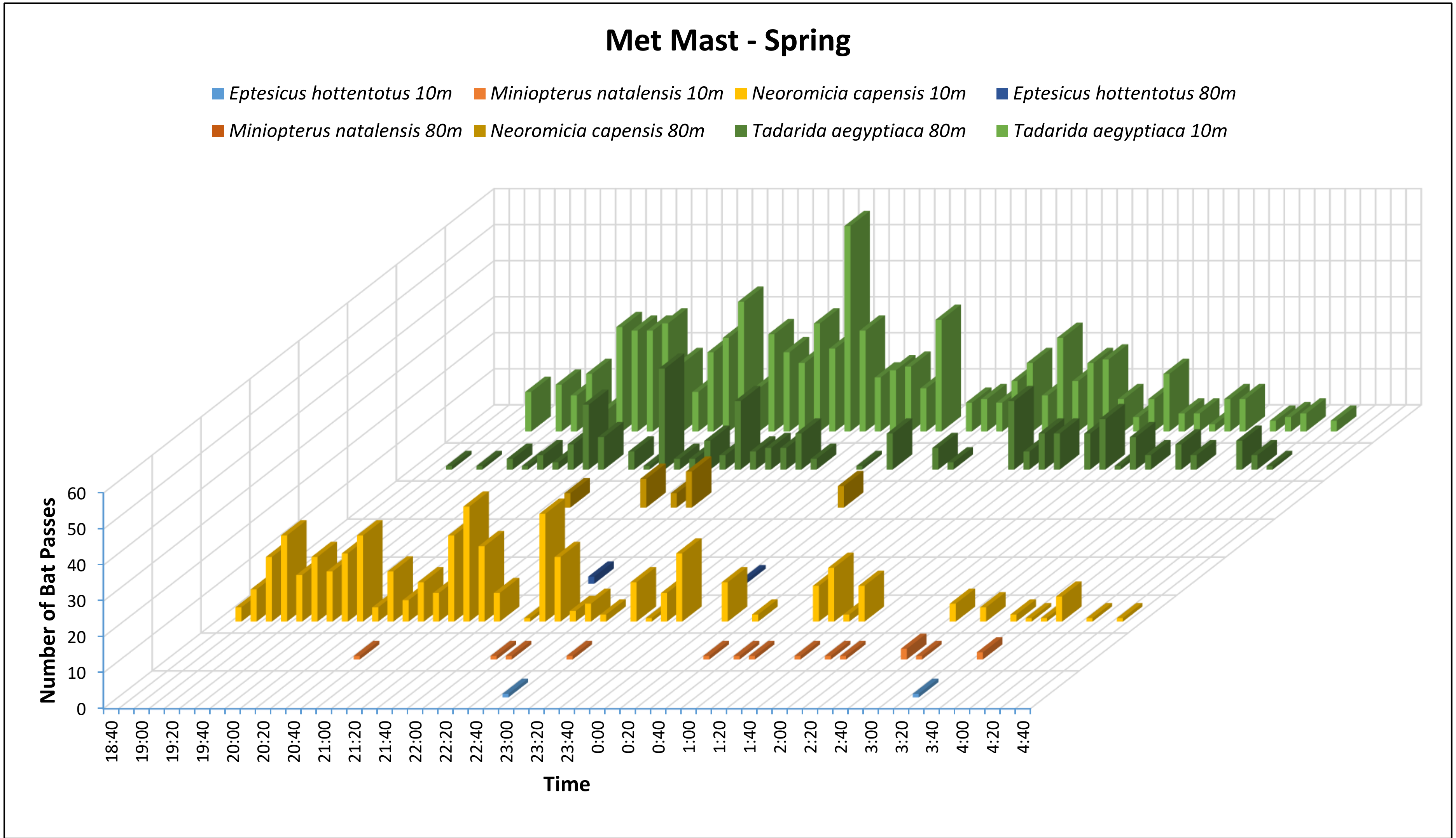


Figure 19: Temporal distribution of activity across the night as detected by Met Mast in spring.

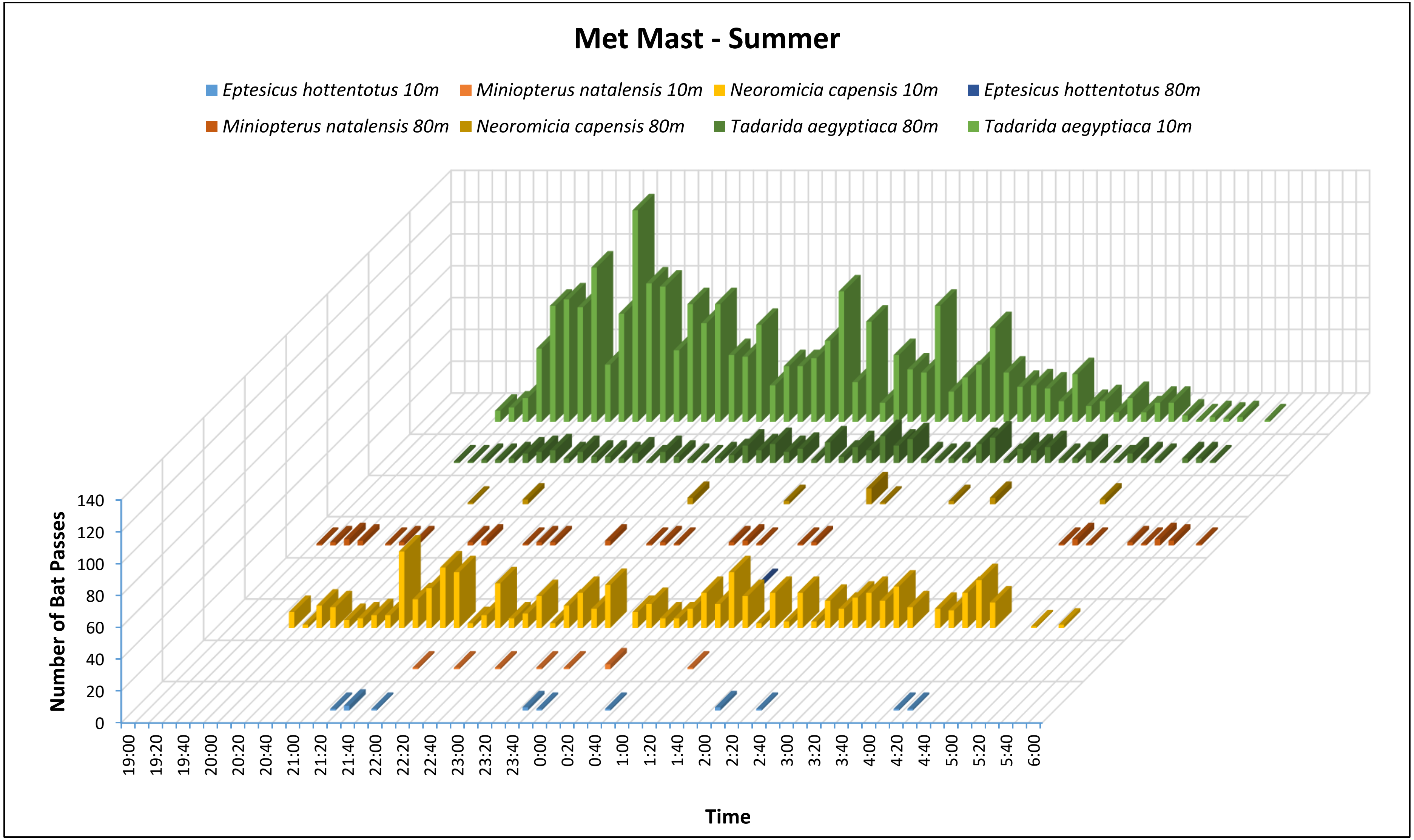


Figure 20: Temporal distribution of activity across the night as detected by Met Mast in summer.

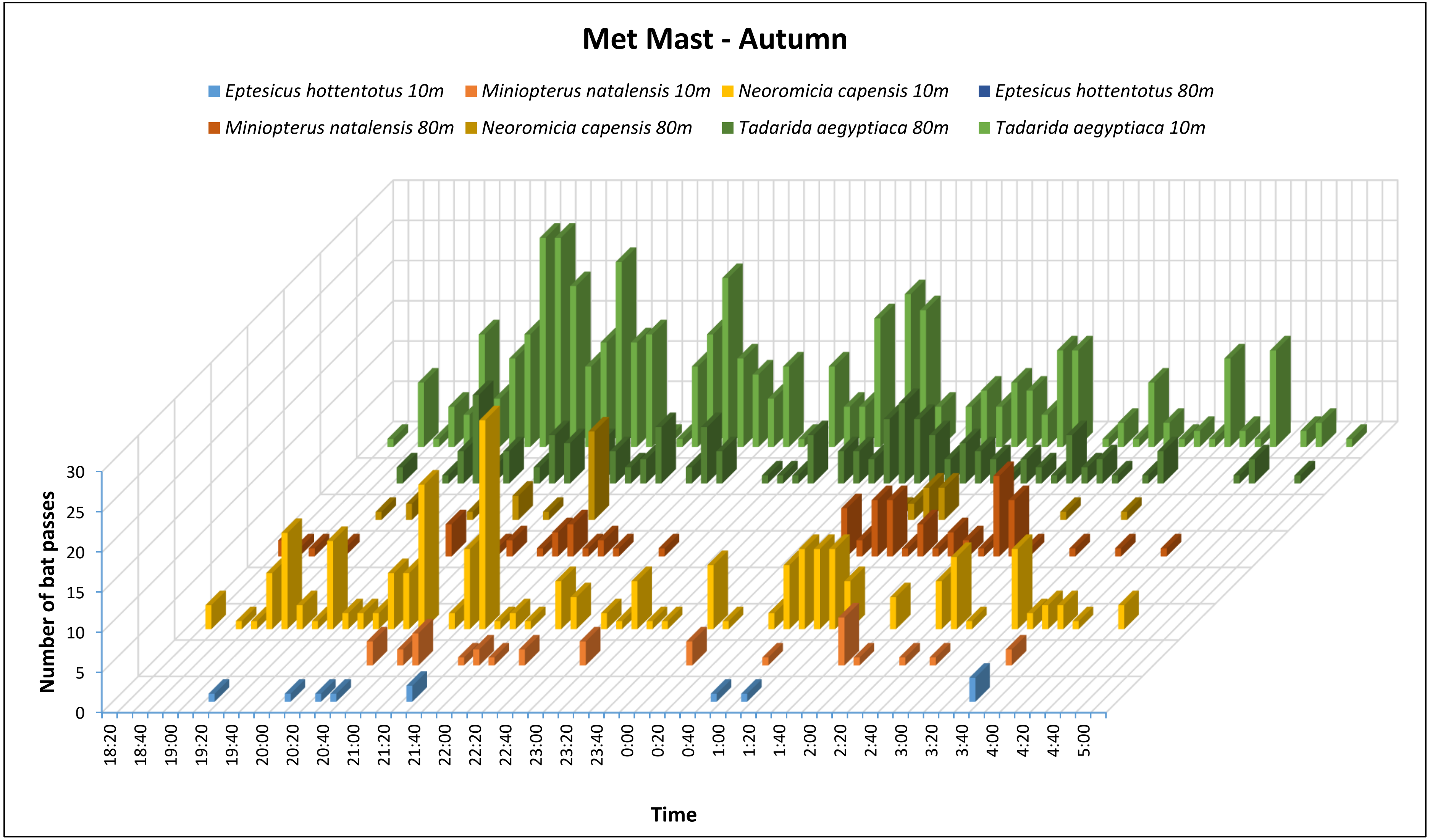


Figure 21: Temporal distribution of activity across the night as detected by Met Mast in autumn.

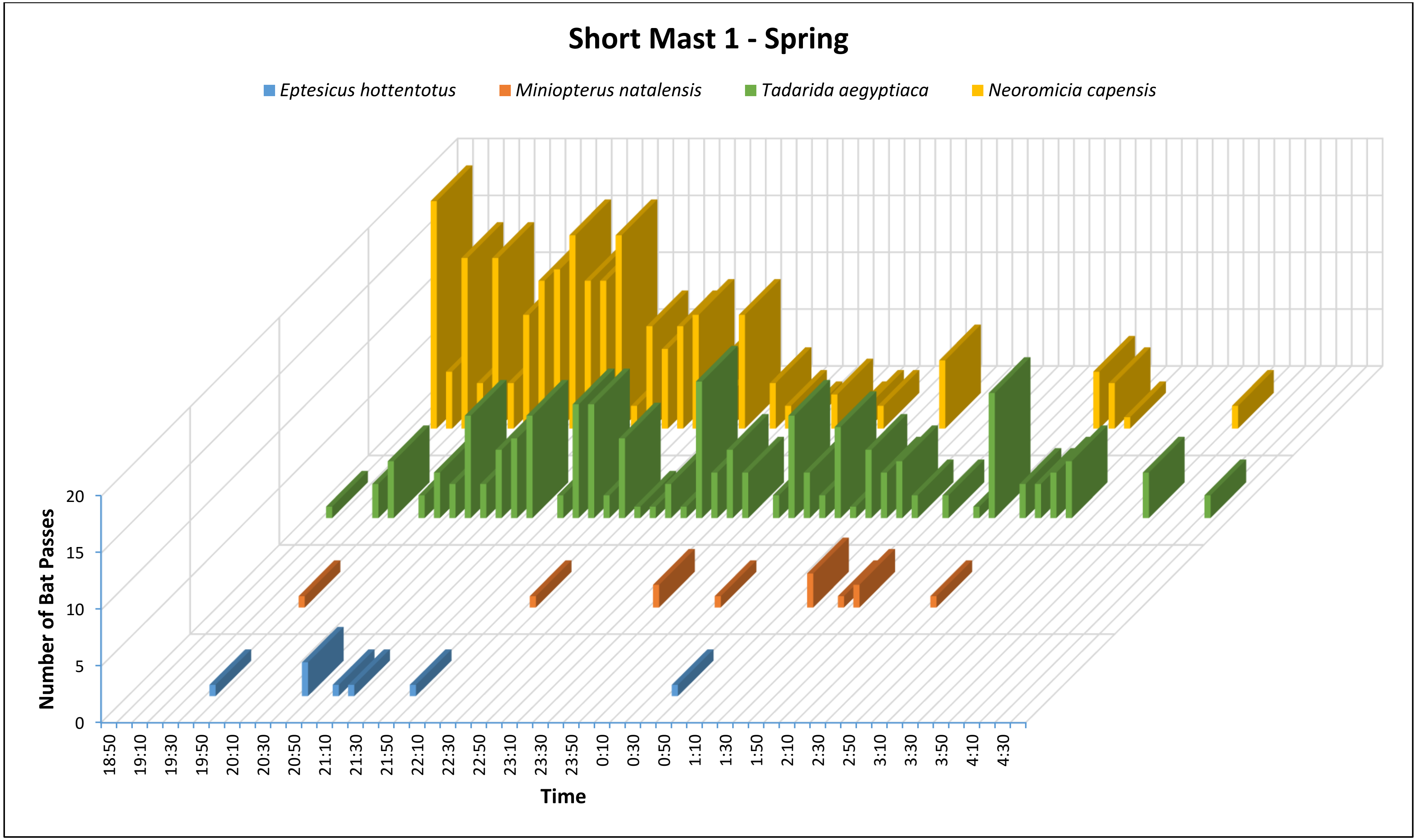


Figure 22: Temporal distribution of activity across the night as detected by the Short Mast in spring.

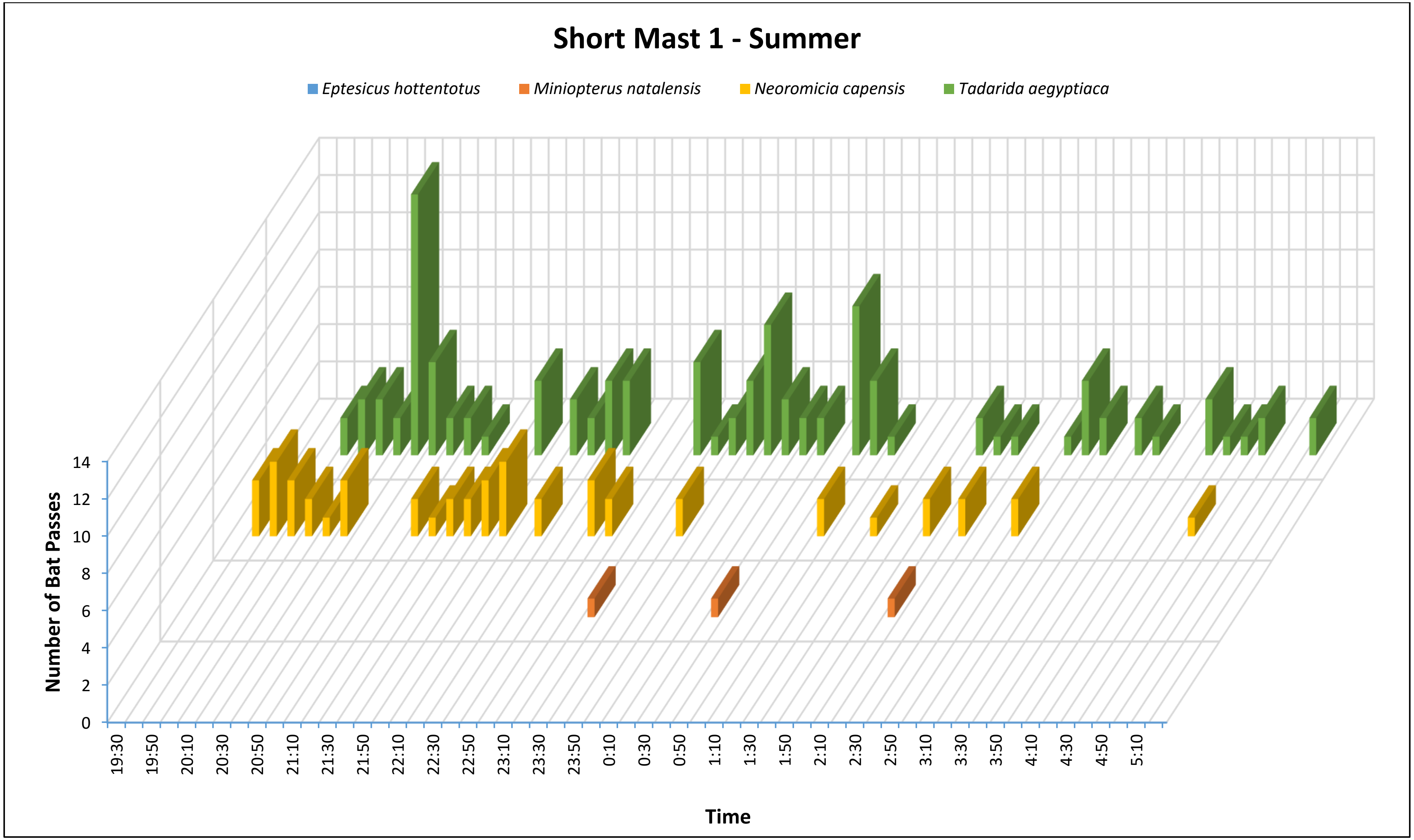


Figure 23: Temporal distribution of activity across the night as detected by the Short Mast in summer.

4.6.4 Relation between Bat Activity and Weather Conditions

Several sources of literature describe how numerous bat species are influenced by weather conditions. Weather may influence bats in terms of lowering activity, changing time of emergence and flight time. It is also important to note the environmental factors are never isolated and therefore a combination of the environmental factors can have synergistic or otherwise contradictory influences on bat activity. For example, a combination of high temperatures and low wind speeds will be more favourable to bat activity than low temperatures and low wind speed, whereas low temperature and high wind speed will be the least favourable for bats. Below are short descriptions of how wind speed, temperature and barometric pressure influences bat activity.

Wind speed

Some bat species show reduced activity in windy conditions. Strong winds have been found to suppress flight activity in bats by making flight difficult (O'Farrell *et al.* 1967). Several studies at proposed and operating wind facilities in the United States have documented discernibly lower bat activity during 'high' wind speeds (Arnett *et al*. 2010).

Wind speed and direction also affects availability of insect prey as insects on the wing often accumulate on the lee side of wind breaks such as tree lines (Peng *et al.* 1992). At edges exposed to wind, flight activity of insects, and thus bats may be suppressed and at edges to the lee side of wind, bat activity may be greater. This relationship is used in the sensitivity map whereby the larger vegetation and man-made structures provide shelter from the wind. However, the turbine localities are usually situated on the ridges such that they will be in areas exposed to the wind and not protected by vegetation or structure.

Temperature

Flight activity of bats generally increases with temperature. Flights are of shorter duration on cooler nights and extended on warmer nights. Rachwald (1992) noted that distinct peaks of activity disappeared in warm weather such that activity was mostly continuous through the night. During nights of low temperatures bats intensified foraging shortly after sunset (Corbet and Harris 1991).

Peng (1991) found that many families of aerial dipteran (flies) insects preferred warm conditions for flight. A preference among insects for warm conditions has been reported by many authors suggesting that temperature is an important regulator of bat activity, through its effects on insect prey availability.

The results below present figures of the sum of bat passes that were detected within specific wind speed and temperature categories. However, the distribution of bat activity within each wind speed and temperature range may be biased due to the frequency of occurrence of each wind speed and temperature range. Thus the number of bat passes were 'normalised' wherein the frequency with which each wind speed and temperature range were recorded was taken into account. The 'normalised' sum of bat passes per wind speed and temperature range are presented below. Cumulative percentages of the normalised sum of bat passes per wind speed and temperature ranges are also presented. The lowest wind speed at which 80% of bats were detected (of the normalised sum of bat passes) are used to inform mitigation, if needed.

The aim of this analysis is to determine the wind speed and temperature range within which 80% of bat passes are detected. These values of wind speed and temperature are used to mitigate turbine operation where needed based on conserving 80% of detected bat passes, keeping in mind the synergistic or otherwise contradictory effects that the combination of wind speeds and temperatures can have on bat activity.

Time periods used in the analysis below for each monitoring system were identified in Sections 4.6.2 and 4.6.3 as periods of elevated activity. The analysis was only performed for time frames of the highest activity levels. The time periods used in the analysis below corresponds with the time periods and systems used to inform mitigation in Section 6.

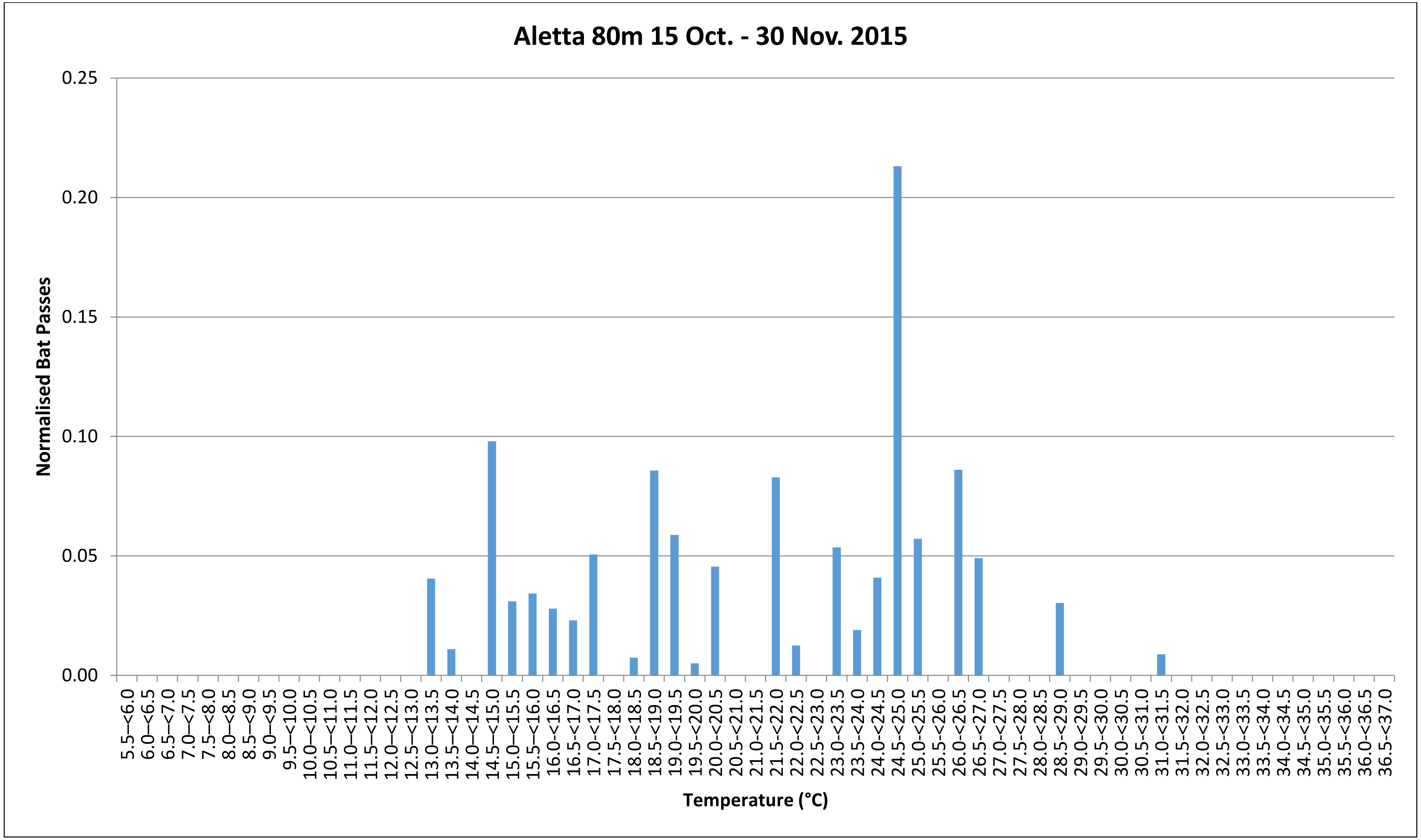


Figure 24: Sum of bat passes (Normalised) per Temperature category for Aletta 1 Met mast (15 Oct – 30 Nov 2015).

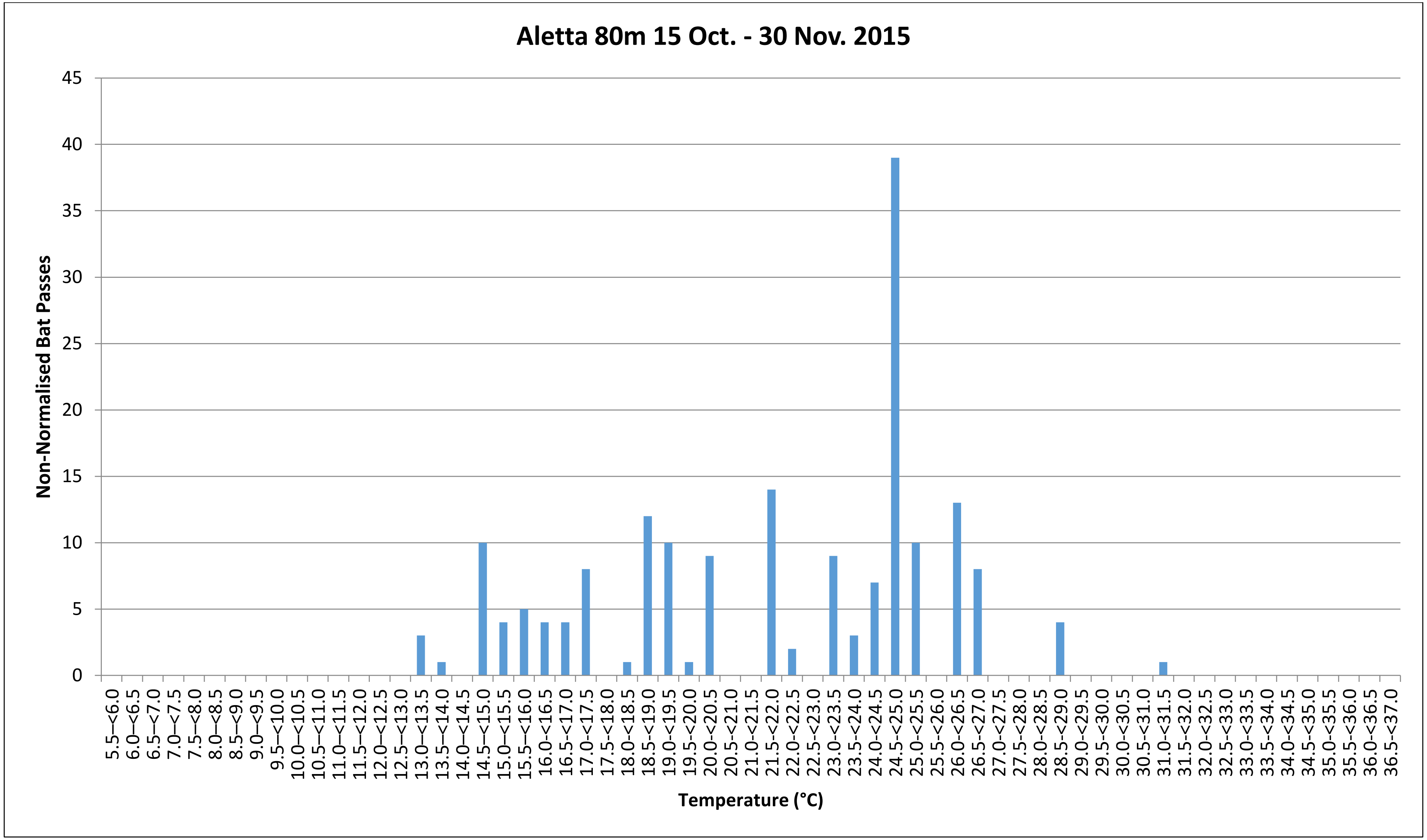


Figure 25: Sum of bat passes (Non-normalised) per Temperature category for Aletta 1 Met mast (15 Oct – 30 Nov 2015).

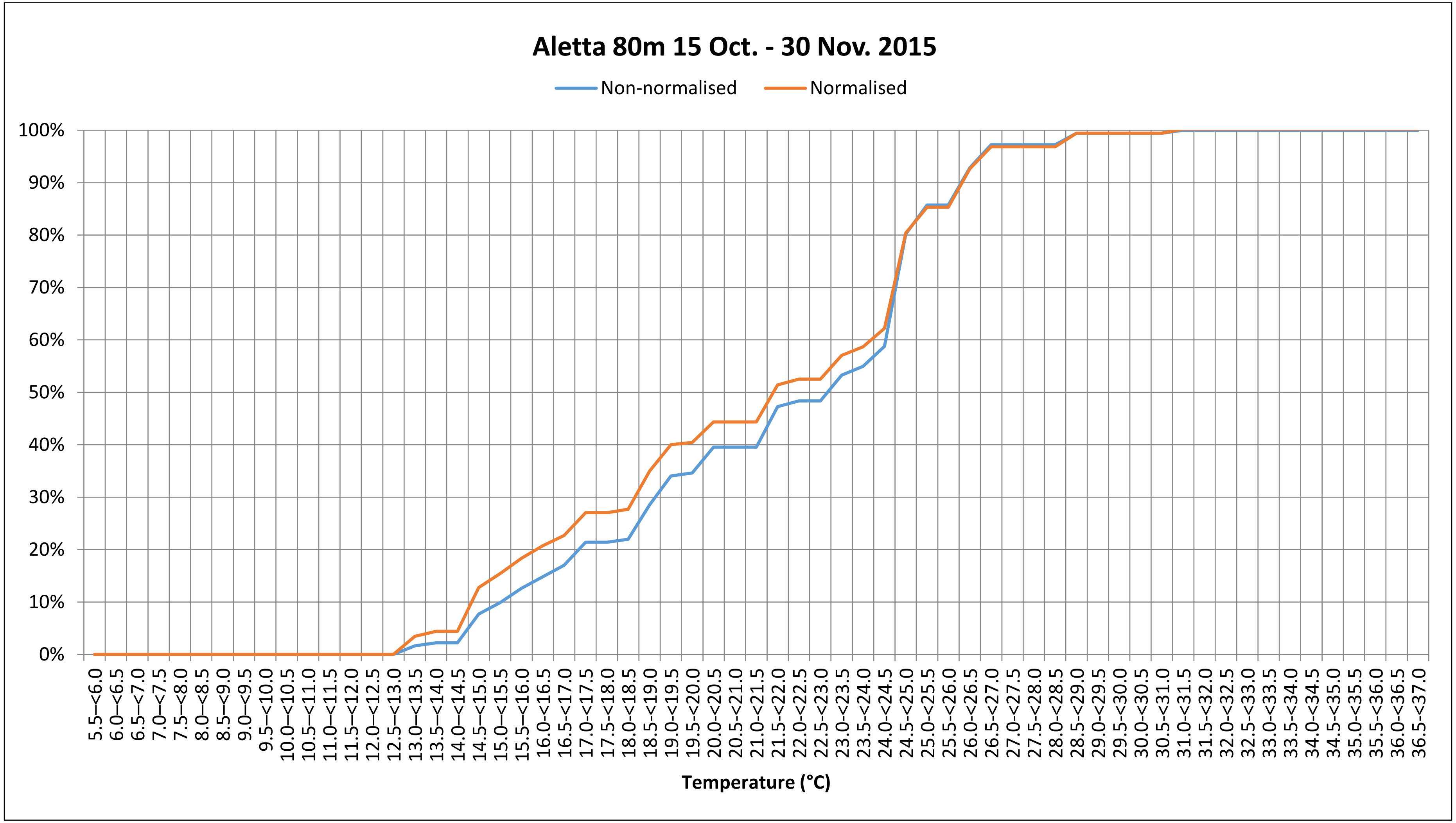


Figure 26: Cumulative percentage of normalised and non-normalised bat passes per temperature category for Aletta 1 Met mast (15 Oct – 30 Nov 2015).

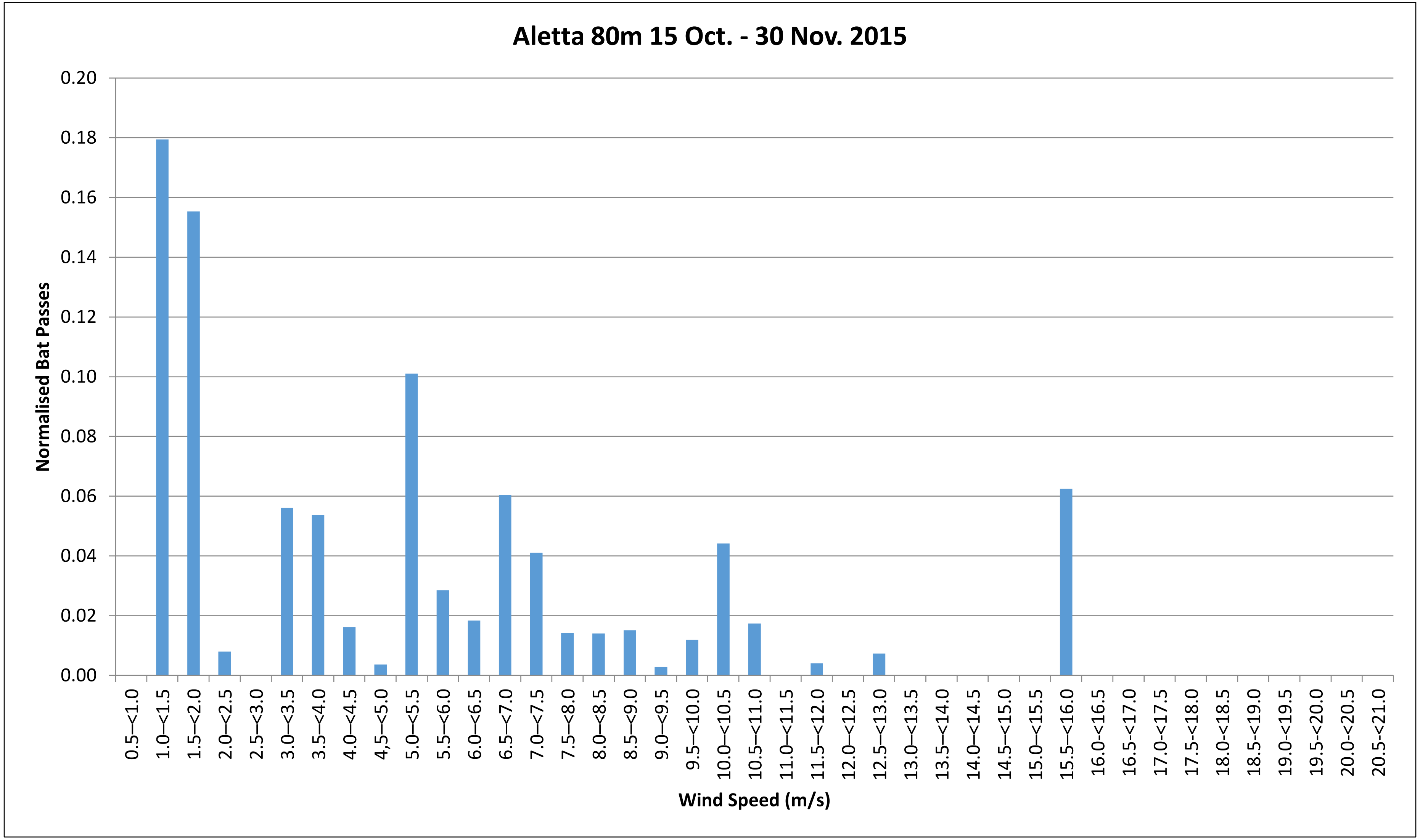


Figure 27: Sum of bat passes (Normalised) per Wind Speed category for Aletta 1 Met mast (15 Oct – 30 Nov 2015).

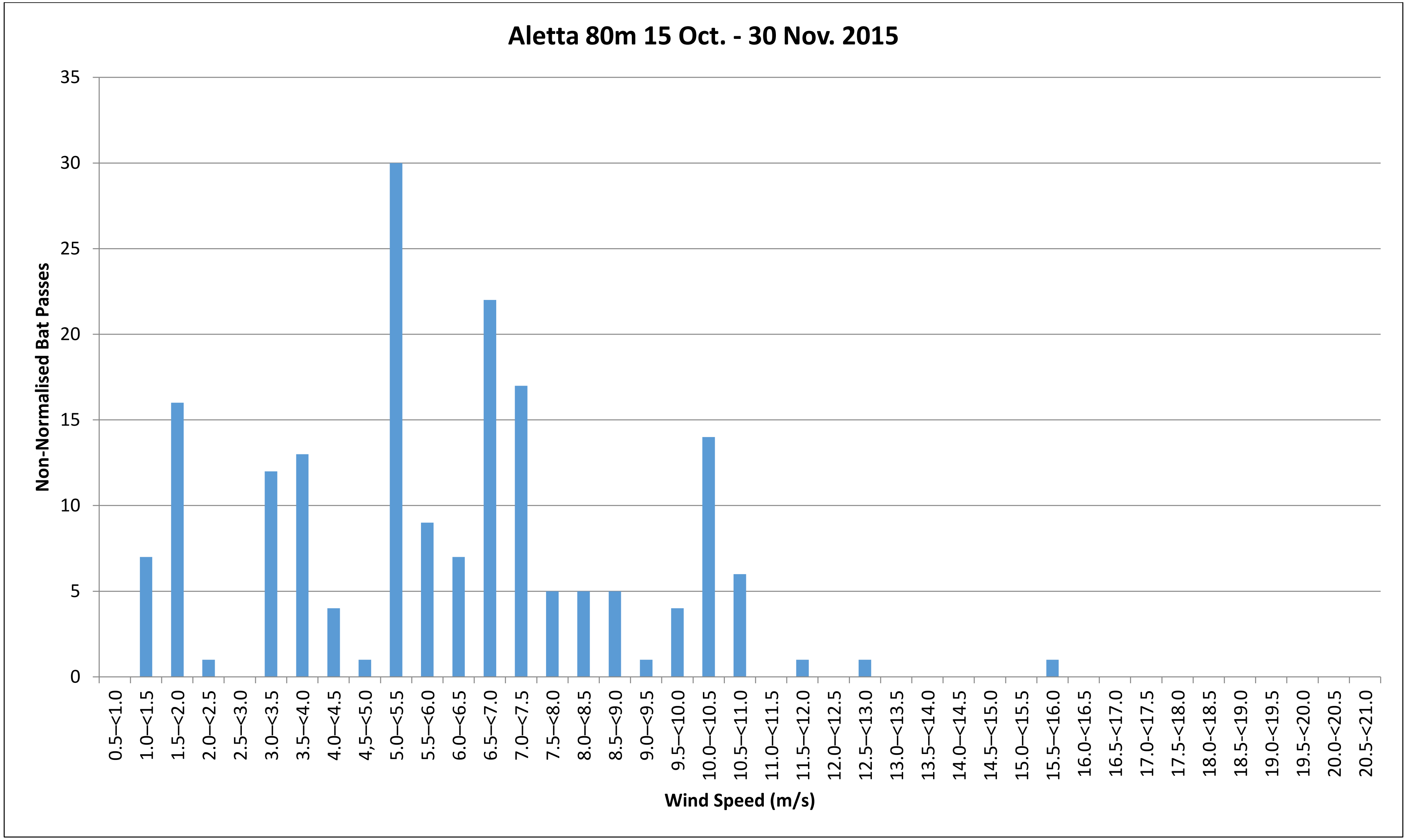


Figure 28: Sum of bat passes (Non-normalised) per Wind Speed category for Aletta 1 Met mast (15 Oct – 30 Nov 2015).

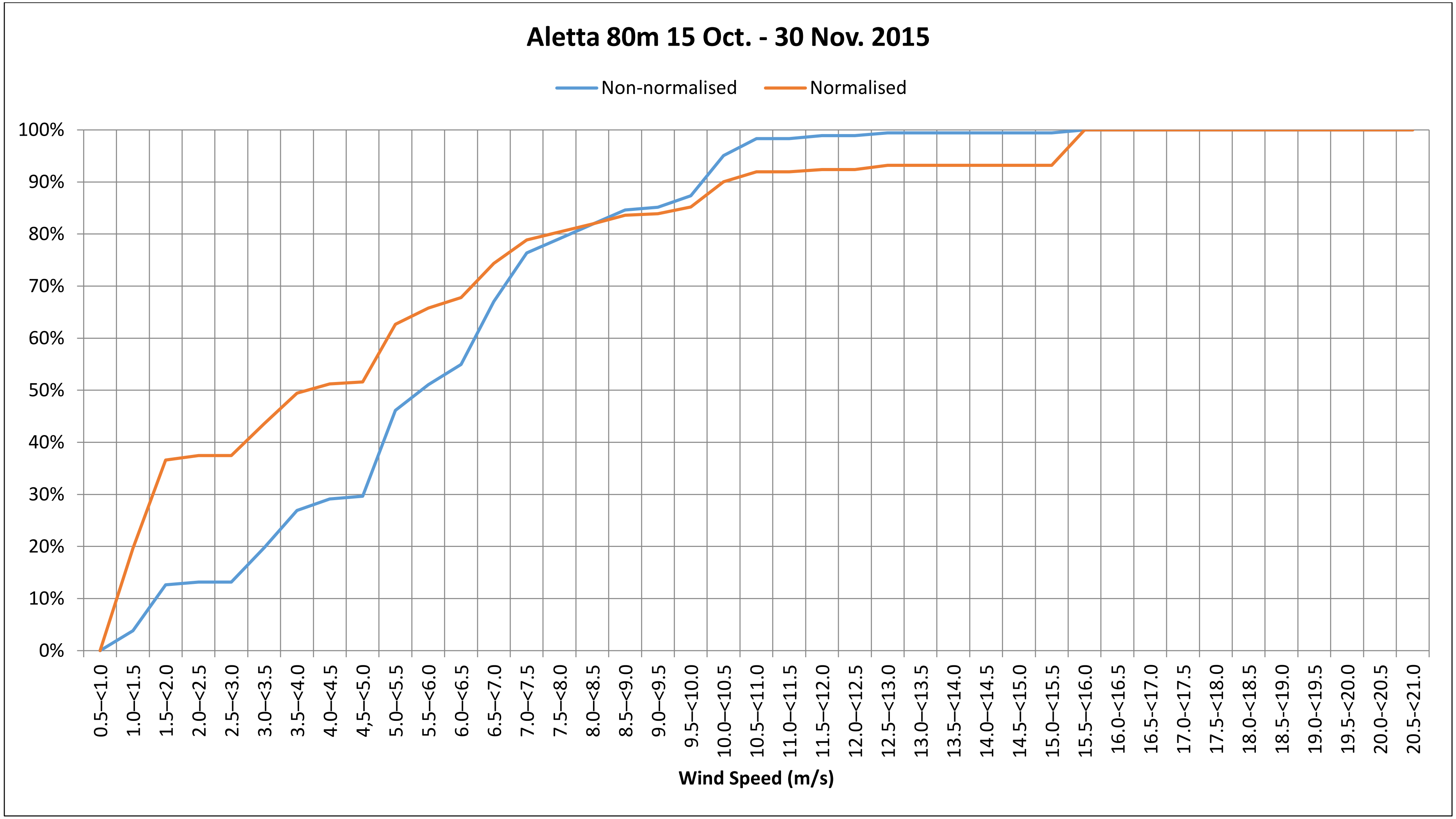


Figure 29: Cumulative percentage of normalised and non-normalised bat passes per Wind Speed category for Aletta 1 Met mast (15 Oct – 30 Nov 2015).

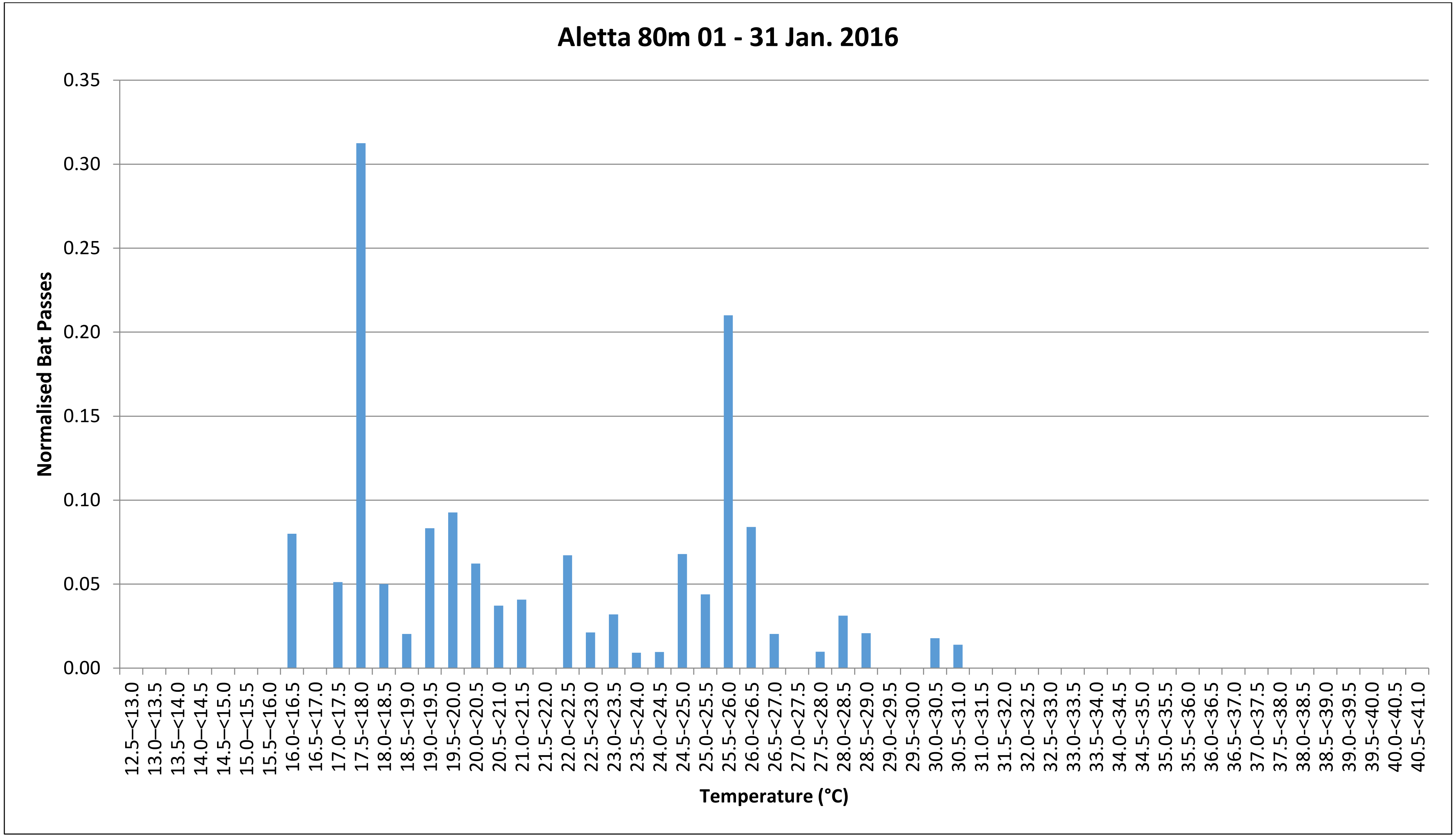


Figure 30: Sum of bat passes (Normalised) per Temperature category for Aletta 1 Met mast (01 – 31 January 2016).

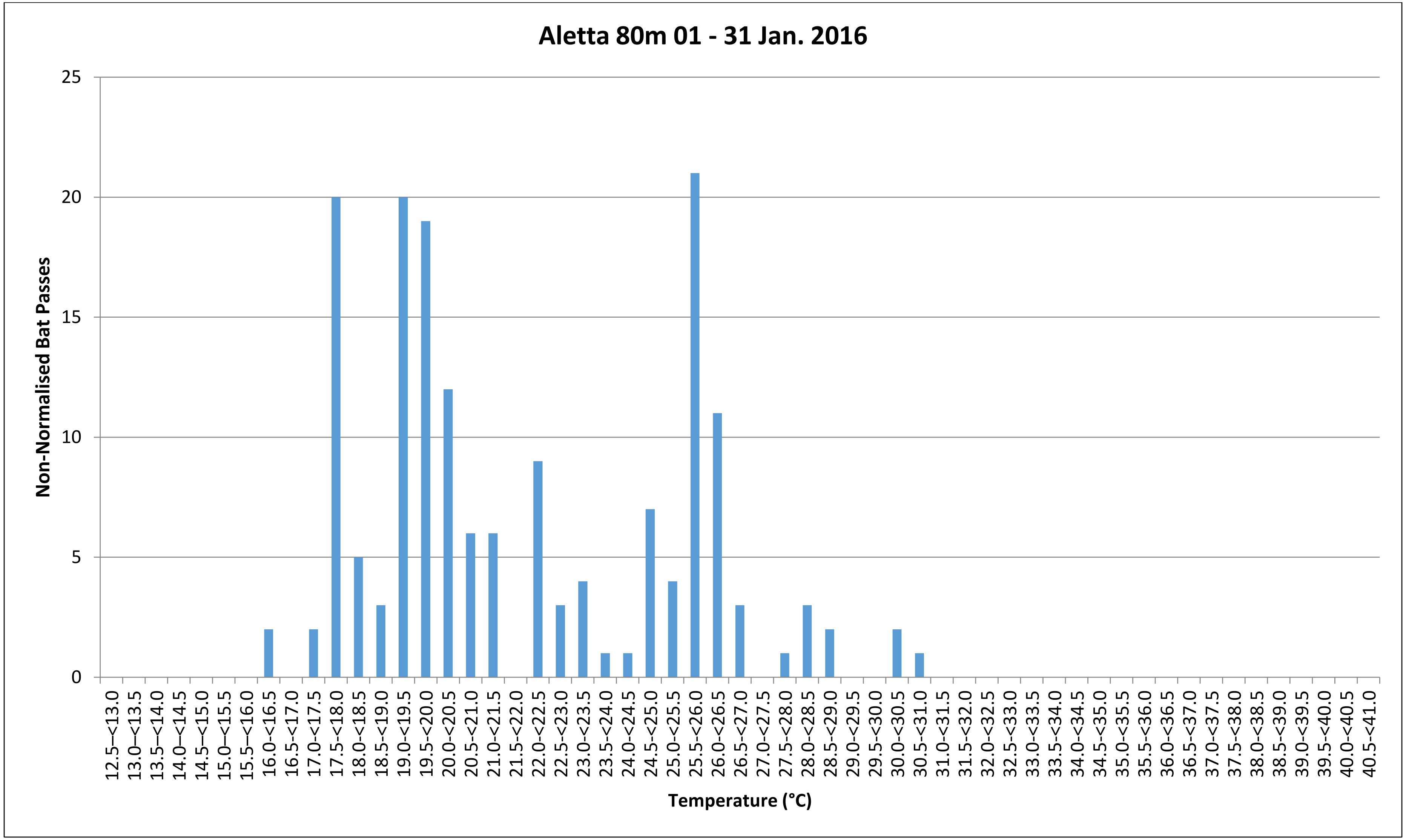


Figure 31: Sum of bat passes (Non-normalised) per Temperature category for Aletta 1 Met mast (01 – 31 January 2016).

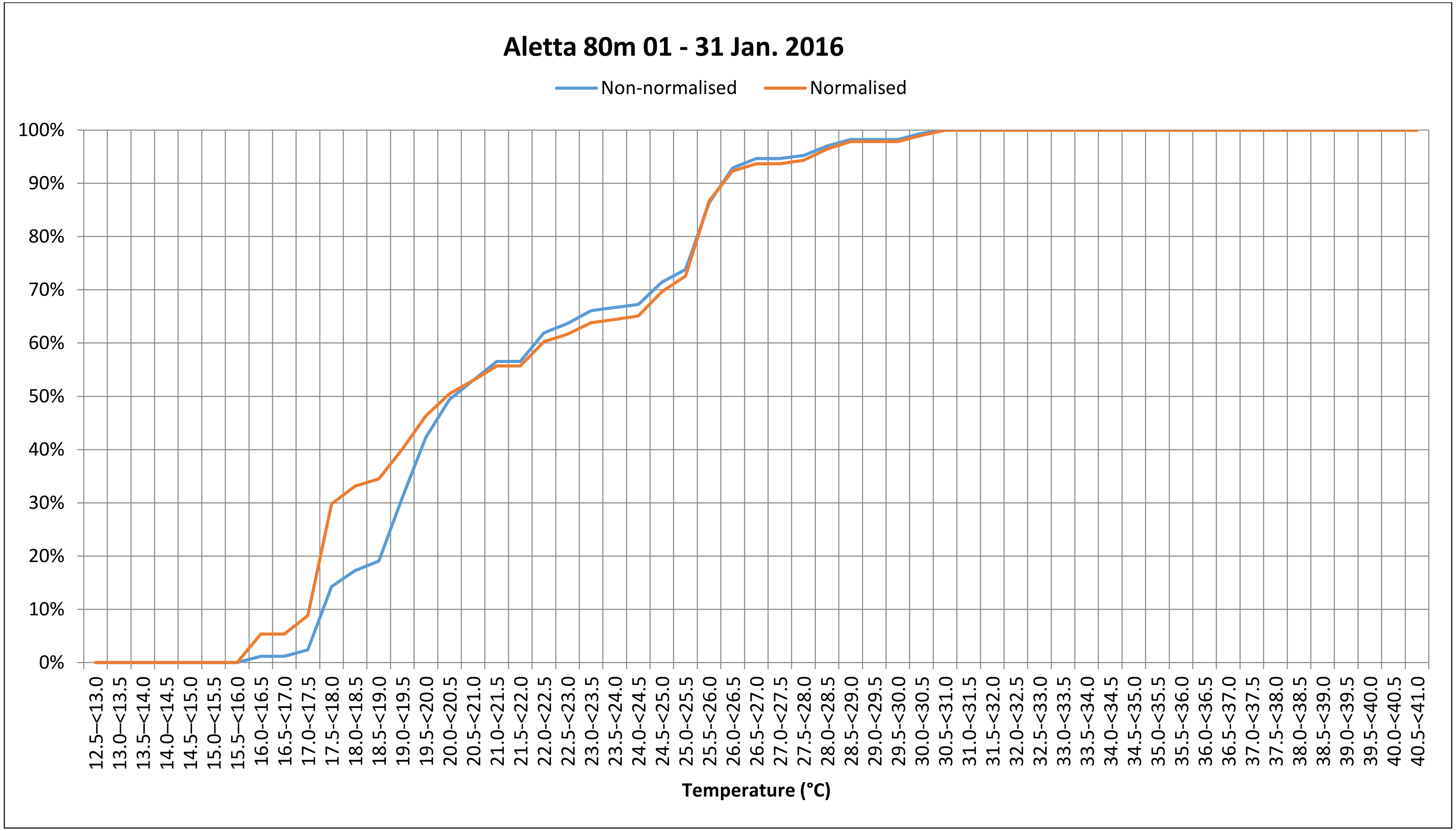


Figure 32: Cumulative percentage of normalised and non-normalised bat passes per Temperature category for Aletta 1 Met mast (01 – 31 January 2016).

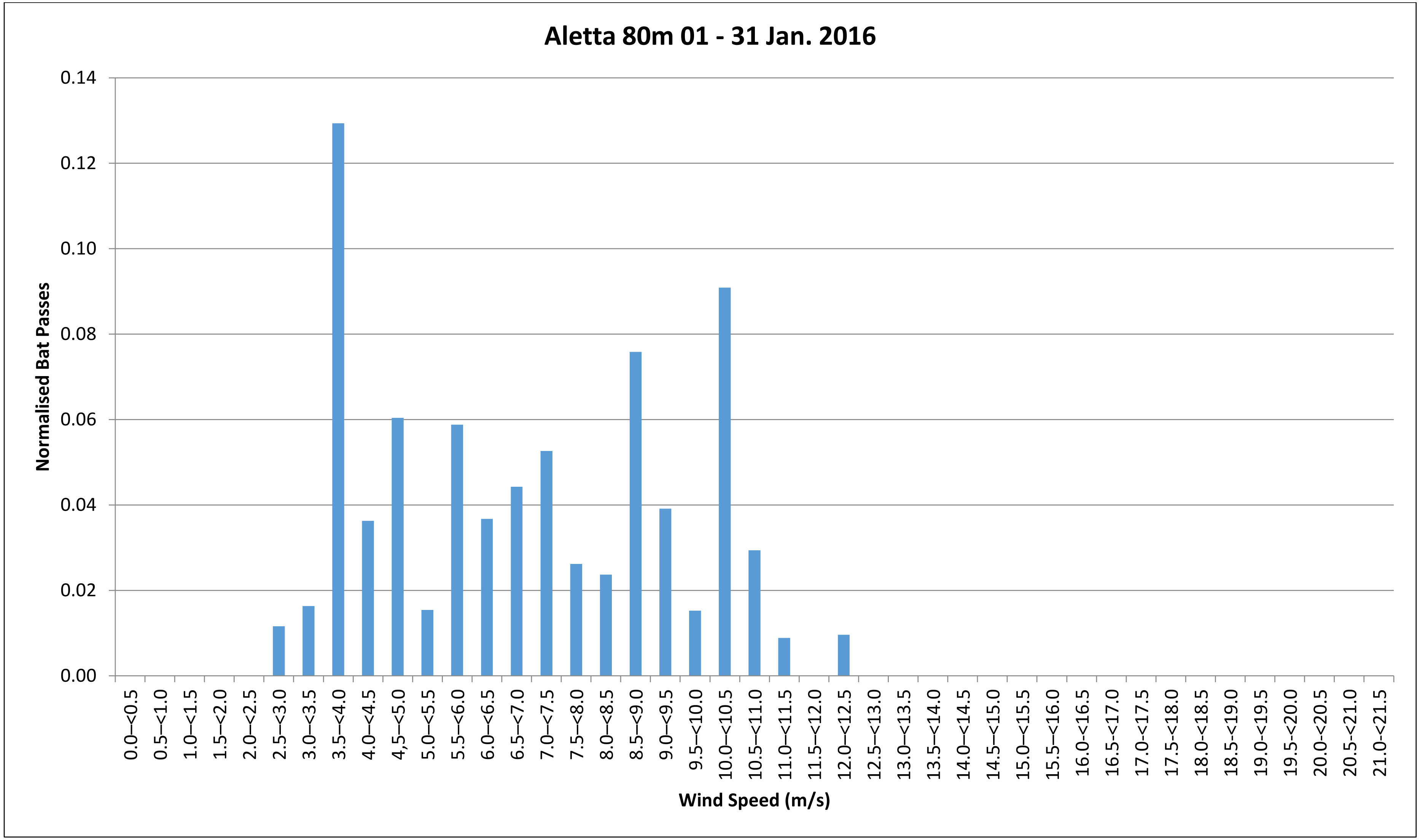


Figure 33: Sum of bat passes (Normalised) per Wind Speed category for Aletta 1 Met mast (01 – 31 January 2016).

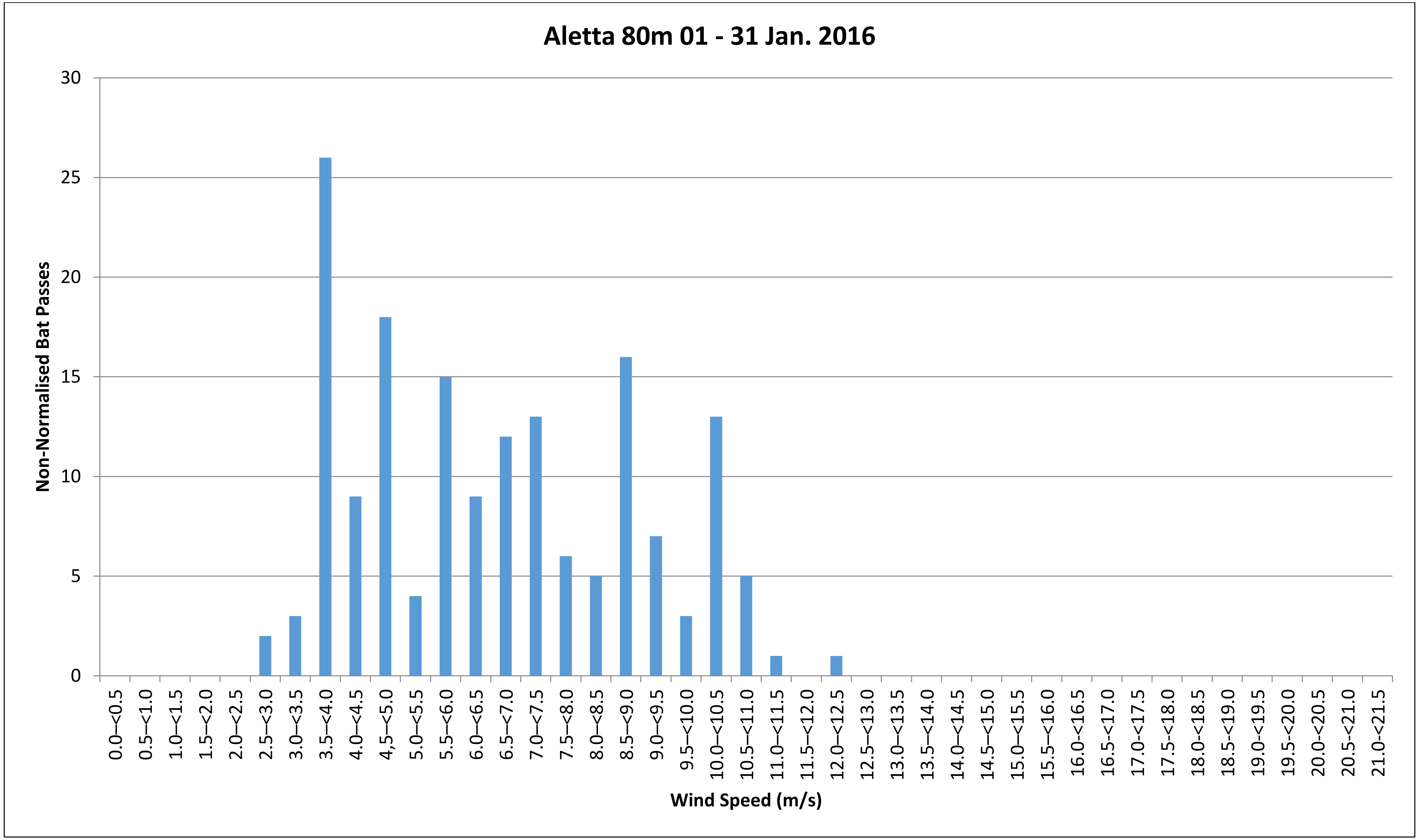


Figure 34: Sum of bat passes (Non-normalised) per Wind Speed category for Aletta 1 Met mast (01 – 31 January 2016).

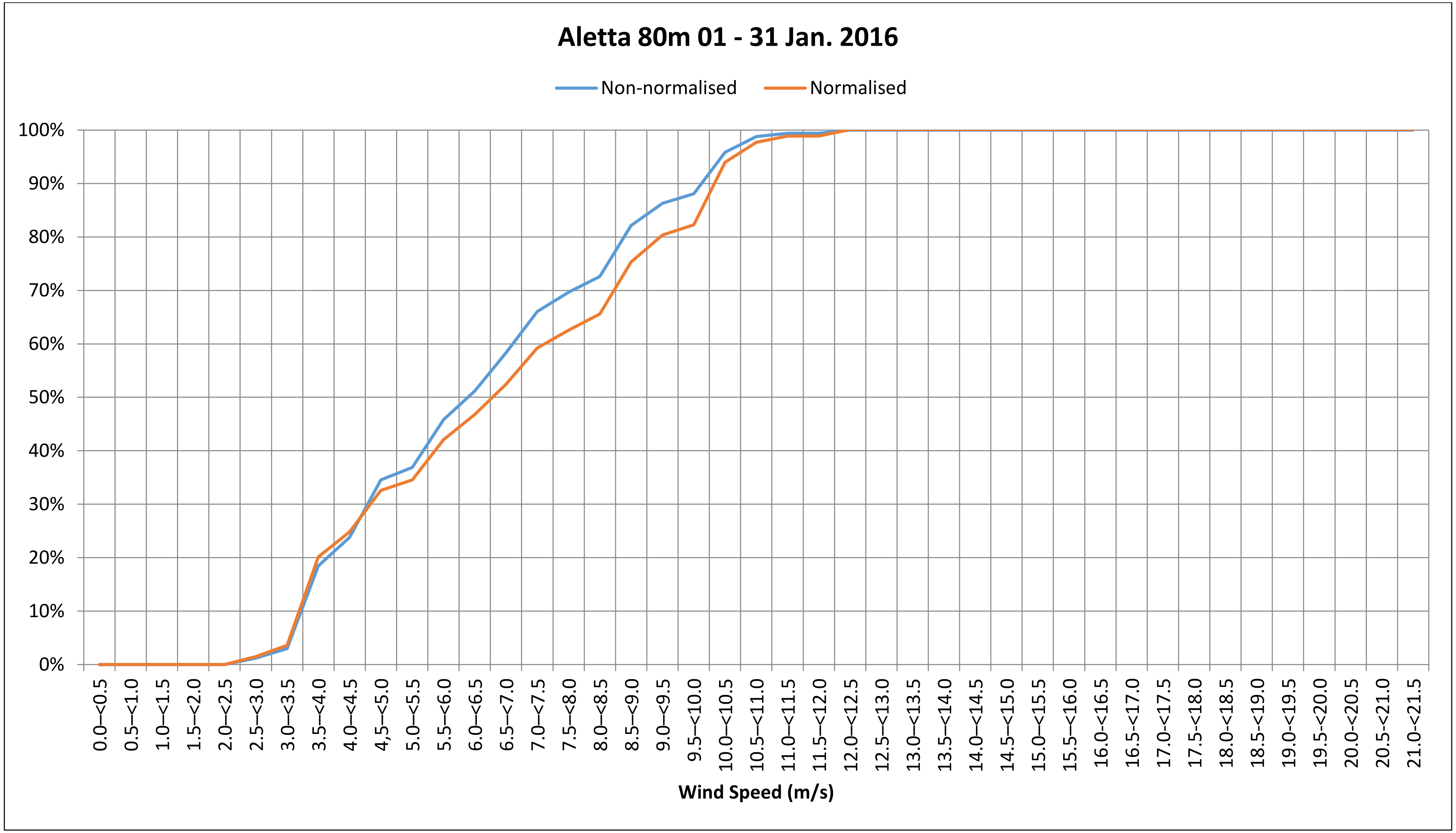


Figure 35: Cumulative percentage of normalised and non-normalised bat passes per Wind Speed category for Aletta 1 Met mast (01 – 31 January 2016).

5 IMPACT ASSESSMENT OF PROPOSED WEF ON BAT FAUNA

5.1 Construction phase

5.1.1 Impact: Destruction of bat roosts due to earthworks and blasting

IMPACT TABLE FORMAT		
Environmental Parameter	Bat populations will be impacted upon through earthworks and blasting close to bat roosts.	
Issue/Impact/Environmental Effect/Nature	Earthworks and blasting close to bat roosts will negatively affect bat populations by direct mortality and via roost destruction.	
Extent	If bat roosts are found to be within the site, blasting will have a negative effect on the bat populations in the local area.	
Probability	There is a reasonable probability of the impact occurring.	
Reversibility	Blasting occurring at bat roosts will cause damage to the bat population in the area. Recovery of the bat population is possible over a longer time period, such as several generations of bat reproduction. However, loss of the physical roost will be irreversible.	
Irreplaceable loss of resources	If blasting and earthworks occurs close to a bat roost, it will be destroyed and lost.	
Duration	The impact will be of short duration, as blasting and earthworks will only occur during construction phase.	
Cumulative effect	Moderate to high effect, as the destruction of the bat roosts impact the population numbers within a large area which in effect will impact the insect numbers.	
Intensity/magnitude	Blasting of bat roosts will cause mortality to the bats inhabiting the roosts, and will negatively impact the population and ecosystem.	
Significance Rating	The anticipated impact will have significant effects and will require significant mitigation measures to achieve an acceptable level of impact.	
	Pre-mitigation impact rating	Post mitigation impact rating
Extent	2	1
Probability	3	1
Reversibility	4	2
Irreplaceable loss	4	2
Duration	1	1
Cumulative effect	3	1
Intensity/magnitude	4	2
Significance rating	- 68 (high negative)	- 16 (low negative)
Mitigation measures	Adhere to the sensitivity map during turbine placement and do not carry out blasting works within a delineated bat sensitivity area or buffer zone. Blasting should be minimised and used only when necessary.	

IMPACT TABLE FORMAT					
Environmental parameter	**Issues**	**Pre-mitigation impact rating**	**Average**	**Rating post mitigation**	**Average**
Bat populations and roosts	Earthworks and blasting close to bat roosts	-68	-68 High Negative Impact	-16	-16 Low Negative Impact

5.1.2 Impact: Loss of foraging habitat

IMPACT TABLE FORMAT		
Environmental Parameter	Loss of foraging habitat within the site boundaries.	
Issue/Impact/Environmental Effect/Nature	Small areas of foraging habitat will be permanently lost by construction of turbines and access roads. Temporary foraging habitat loss will also occur during construction for storage areas and movement of heavy vehicles.	
Extent	Loss of foraging habitat will be contained within the boundaries of the development site.	
Probability	Definite probability	
Reversibility	Depending on the degree of habitat loss, it will be partly reversed with some mitigation measures, especially in more sensitive areas. Minimal foraging habitat will be permanently lost.	
Irreplaceable loss of resources	In areas where vegetation is removed for roads and turbines, there will be a loss of habitat resources, but the scale is small.	
Duration	The impact will be of a long duration, past the operation of the development.	
Cumulative effect	Low effect, as the removal of habitat will cause a decrease in the number of bat numbers and insect numbers within the immediate area.	
Intensity/magnitude	Blasting of bat roosts will cause mortality to the bats inhabiting the roosts, and will negatively impact the population and system.	
Significance Rating	The anticipated impact will have moderate negative effects and will require mitigation measures.	
	Pre-mitigation impact rating	Post mitigation impact rating
Extent	1	1
Probability	3	1
Reversibility	3	1
Irreplaceable loss	3	2
Duration	3	2
Cumulative effect	2	1
Intensity/magnitude	2	1

IMPACT TABLE FORMAT		
Significance rating	- 30 (medium negative)	- 8 (low negative)
Mitigation measures	Adhere to the sensitivity map. Keep to designated areas when storing building materials, resources, turbine components and/or construction vehicles. Keep to designated roads with all construction vehicles. Damaged areas not in use after construction should be rehabilitated by an experienced vegetation succession specialist.	

Environmental parameter	**Issues**	**Pre-mitigation impact rating**	**Average**	**Rating post mitigation**	**Average**
Foraging Habitat	Loss of foraging habitat due to construction of turbines, roads, storage areas and heavy vehicles.	-30	-30 Medium Negative Impact	-8	-8 Low Negative Impact

5.2 Operational phase

5.2.1 Impact: Bat mortalities due to direct turbine blade impact or barotrauma during foraging activities (not migration)

IMPACT TABLE FORMAT	
Environmental Parameter	Impact on bat population numbers via mortalities due to direct turbine blade collision or barotrauma during foraging activities.
Issue/Impact/Environmental Effect/Nature	Bat mortalities due to direct blade impact or barotrauma during foraging activities (not migration). The concerns of foraging bats in relation to wind turbines is discussed in Section 2.2. If the impact is too severe (e.g. in the case of no mitigation) local bat populations may not recover from mortalities.
Extent	The impact will be contained within the boundaries of the development site.
Probability	There is a definite chance of the impact occurring.
Reversibility	The impact will occur throughout the lifespan of the wind facility. Population numbers may take very long to recover. Population and diversity genetics may be permanently altered.
Irreplaceable loss of resources	Bat population numbers will decrease in the area; will take several generations to restore the population if the impact is removed.
Duration	The impact will be of long duration, past the operational phase of the development. It will take some time for the population to achieve its previous numbers after the impact.

IMPACT TABLE FORMAT		
Cumulative effect	High effect, as the decrease in bat numbers will in effect cause an increase in the number of insects in the area which changes the ecosystem of the area.	
Intensity/magnitude	Very high intensity impact on the bat population numbers in the area.	
Significance Rating	The anticipated impact will have highly significant effects and precise mitigations will be required to be developed over time as the wind farm operates and further data is collected.	
	Pre-mitigation impact rating	Post mitigation impact rating
Extent	1	1
Probability	4	2
Reversibility	4	2
Irreplaceable loss	3	2
Duration	3	3
Cumulative effect	4	3
Intensity/magnitude	4	2
Significance rating	- 76 (very high negative)	- 26 (low negative)
Mitigation measures	Adhere to the sensitivity maps, avoid areas of bat sensitivity and their associated buffers. Adhere to operational mitigation measures that may be deemed necessary during the operational monitoring assessment.	

Environmental parameter	**Issues**	**Pre-mitigation impact rating**	**Average**	**Rating post mitigation**	**Average**
Local bat population numbers	Bat mortalities due to direct blade impact or barotrauma during foraging activities (not migration)	-76	-76 Very High Negative Impact	-26	-26 Low Negative Impact

5.2.2 Impact: Artificial lighting

IMPACT TABLE FORMAT	
Environmental Parameter	Impact on bat populations, foraging behaviour and diversity.
Issue/Impact/Environmental Effect/Nature	During operation, strong artificial lights that may be used at the turbine base or immediate surrounding infrastructure, the light will attract insects and thus bats. This will significantly increase the likelihood of blade collision and barotrauma to bats foraging around such lights. Additionally, only certain species of bats will readily forage around strong lights, whereas others avoid such

IMPACT TABLE FORMAT		
	lights even if there is insect prey available, which can draw insect prey away from other natural areas and thereby artificially favor only certain species.	
Extent	Artificial lighting will be contained within the boundaries of the development site.	
Probability	There is a probable chance of the impact occurring.	
Reversibility	Yes, the impact is reversible.	
Irreplaceable loss of resources	No	
Duration	The impact will be of a long-term duration, the lifespan of the development. It will take some time to reverse the impact.	
Cumulative effect	During operational phase strong artificial lights used at the work environment during night time will attract insects and thereby also bats. However only certain species of bats will readily forage around strong lights, whereas others avoid such lights even if there is insect prey available. This can draw insect prey away from other natural areas and thereby artificially favour certain species, affecting bat diversity in the area.	
Intensity/magnitude	Artificial lighting in the area will change the diversity of the bat species in the area. This will negatively affect the system.	
Significance Rating	The anticipated impact will have moderate negative effects and will require mitigation measures.	
	Pre-mitigation impact rating	Post mitigation impact rating
Extent	1	1
Probability	4	1
Reversibility	2	1
Irreplaceable loss	2	1
Duration	3	2
Cumulative effect	3	2
Intensity/magnitude	2	1
Significance rating	- 30 (medium negative)	- 8 (low negative)
Mitigation measures	Utilise lights with wavelengths that attract less insects (low thermal/infrared signature). If not required for safety or security purposes, lights should be switched off when not in use or equipped with passive motion sensors.	

Environmental parameter	**Issues**	**Pre-mitigation impact rating**	**Average**	**Rating post mitigation**	**Average**
Bat populations and diversity.	Strong artificial lights used at the turbine base or immediate	-30	-30 Medium Negative Impact	-8	-8 Low Negative Impact

	surrounding infrastructure which will attract insects and thereby also bats.				

5.3 Decommissioning phase

No significant impacts have been identified for the decommissioning phase.

5.4 Comparative Assessment of Alternatives

Key

PREFERRED	The alternative will result in a low impact / reduce the impact
FAVOURABLE	The impact will be relatively insignificant
NOT PREFERRED	The alternative will result in a high impact / increase the impact
NO PREFERENCE	The alternative will result in equal impacts

Alternative	Preference	Reasons (incl. potential issues)
SUBSTATION AND O & M BUILDING ALTERNATIVES		
Option 1	No preference	The location and specification of the substation and Operation and Management building does not have an impact on the bat fauna.
Option 2	No preference	The location and specification of the substation and Operation and Management building does not have an impact on the bat fauna.

6 PROPOSED INITIAL MITIGATION MEASURES AND DETAILS

The correct placement of wind farms and of individual turbines can significantly lessen the impacts on bat fauna in an area, and should be considered as the preferred option for mitigation. The tables below are based on the passive data collected. They infer mitigation be applied during the peak activity periods and times, and when the advised wind speed and temperature ranges are prevailing simultaneously (considering conditions in which 80% of bat activity occurred), if found to be necessary during operational monitoring. Bat activity at 80m height were used, with wind speed data at 79.6 m and temperature data at 4.5 meters.

The below is a preliminary guideline and may be applied to whichever turbine/s are identified in the operational bat monitoring assessment to require mitigations, based on accepted threshold levels at the time of decision making and operation.

Table 13: A guideline to the times of implementation of mitigation measures that may be required if found to be necessary during operational monitoring (considering more than 80% bat activity, normalised data).

Terms of mitigation implementation	
Peak activity (times to implement curtailment/ mitigation)	15 October – 30 November over the time of sunset – 02:00
Environmental conditions in which to implement curtailment/ mitigation	Wind speed below 7.5m/s *And simultaneously* Temperature above 16°C
Autumn peak activity (times to implement curtailment/ mitigation)	01 – 31 January over the time of sunset – 03:00
Environmental conditions in which to implement curtailment/ mitigation	Wind speed below 9.0m/s *And simultaneously* Temperature above 17.5°C

Where mitigation by location is not possible, other options that may be utilized include curtailment, blade feathering, blade lock, acoustic deterrents or light lures. The following terminology applies:

Curtailment:

Curtailment is defined as the act of limiting the supply of electricity to the grid during conditions when it would normally be supplied. This is usually accomplished by locking or feathering the turbine blades.

Cut-in speed:

The cut-in speed is the wind speed at which the generator is connected to the grid and producing electricity. For some turbines, their blades will spin at full or partial RPMs below cut-in speed when no electricity is being produced.

Feathering or Feathered:

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. Normally operating turbine blades are angled almost perpendicular to the wind at all times.

Free-wheeling:

Free-wheeling occurs when the blades are allowed to rotate below the cut-in speed or even when fully feathered and parallel to the wind. In contrast, blades can be "locked" and cannot rotate, which is a mandatory situation when turbines are being accessed by operations personnel.

Increasing cut-in speed:

The turbine's computer system (referred to as the Supervisory Control and Data Acquisitions or SCADA system) is programmed to a cut-in speed higher than the manufacturer's set speed, and turbines are programmed to stay locked or feathered at 90° until the increased cut-in speed is reached over some average number of minutes (usually 5 – 10 min), thus triggering the turbine blades to pitch back "into the wind" and begin to spin normally and produce power.

Blade locking or feathering that renders blades motionless below the manufacturers cut in speed, and don't allow free rotation without the gearbox engaged, is more desirable for the conservation of bats than allowing free rotation below the manufacturer's cut in speed. This is because bats can still collide with rotating blades even when no electricity is being produced.

Acoustic deterrents:

Are a developing technology and will need further investigation closer to time of wind farm operation, opportunities to test such devices may be available during operation of the facility.

Light lures:

Refer to the concept where strong lights are placed on the periphery (or only a few sides) of the wind farm to lure insects and therefore bats away from the turbines. However, the long term effects on bat populations and local ecology of this method is unknown.

Habitat modification:

With the aim of augmenting bat habitat around the wind farm in an effort to lure bats away from turbines, is not recommended. Such a method can be adversely intrusive on other fauna and flora and the ecology of the areas being modified. Additionally, it is unknown whether such a method may actually increase the bat numbers of the broader area, causing them to move into the wind farm site due to resource pressure.

Currently the most effective method of mitigation, after correct turbine placement, is alteration of blade speeds and cut-in speeds under environmental conditions favourable to bats.

A basic "6 levels of mitigation" (by blade manipulation or curtailment), from light to aggressive mitigation is structured as follows:

1. No curtailment (free-wheeling is unhindered below manufacturer's cut in speed so all momentum is retained, thus normal operation).
2. Partial feathering (45-degree angle) of blades below manufacturer's cut-in speed in order to allow the free-wheeling blades half the speed it would have had without feathering (some momentum is retained below the cut in speed).
3. Ninety degree feathering of blades below manufacturer's cut-in speed so it is exactly parallel to the wind direction as to minimize free-wheeling blade rotation as much as possible without locking the blades.
4. Ninety degree feathering of blades below manufacturer's cut-in speed, with partial feathering (45-degree angle) between the manufacturer's cut-in speed and mitigation cut-in conditions.
5. Ninety degree feathering of blades below mitigation cut in conditions.
6. Ninety degree feathering throughout the entire night.

However, actual impacts on bats will be monitored during the operational phase monitoring, and the recommended mitigation measures and levels of feathering will be adjusted according to the results of the operational monitoring. This is an adaptive management approach, and it is crucial that any suggested changes to the initial proposed mitigation schedule be implemented within maximum 2 weeks from the date of the recommendation, unless the recommendation refers to a time period later in the future (e.g. the following similar season/climatic condition).

7 CUMULATIVE IMPACT ASSESSMENT

Several renewable energy development applications have been submitted and/or authorized within the immediate area of the proposed Aletta WEF. **Figure 36** below displays these areas. The impact of the Aletta wind energy facility was assessed in **Section 5** above; this section assesses the cumulative impact of all renewable energy developments within the area.

The bat sensitivity assessment reports could not be obtained for all of the neighbouring renewable energy developments, of which most are PV Solar energy applications. The final pre-construction bat sensitivity reports for the authorized Copperton WEF and Garop WEF were used where applicable.

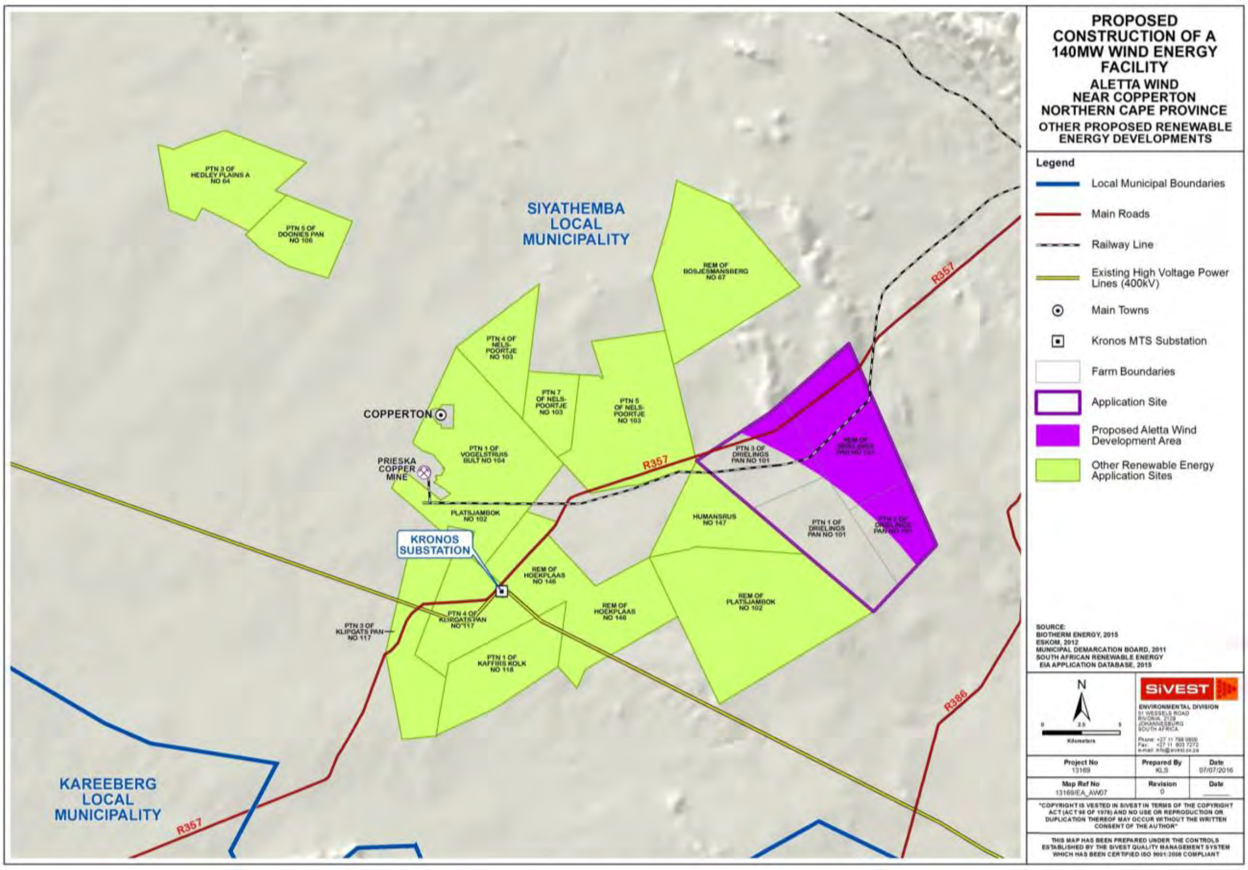
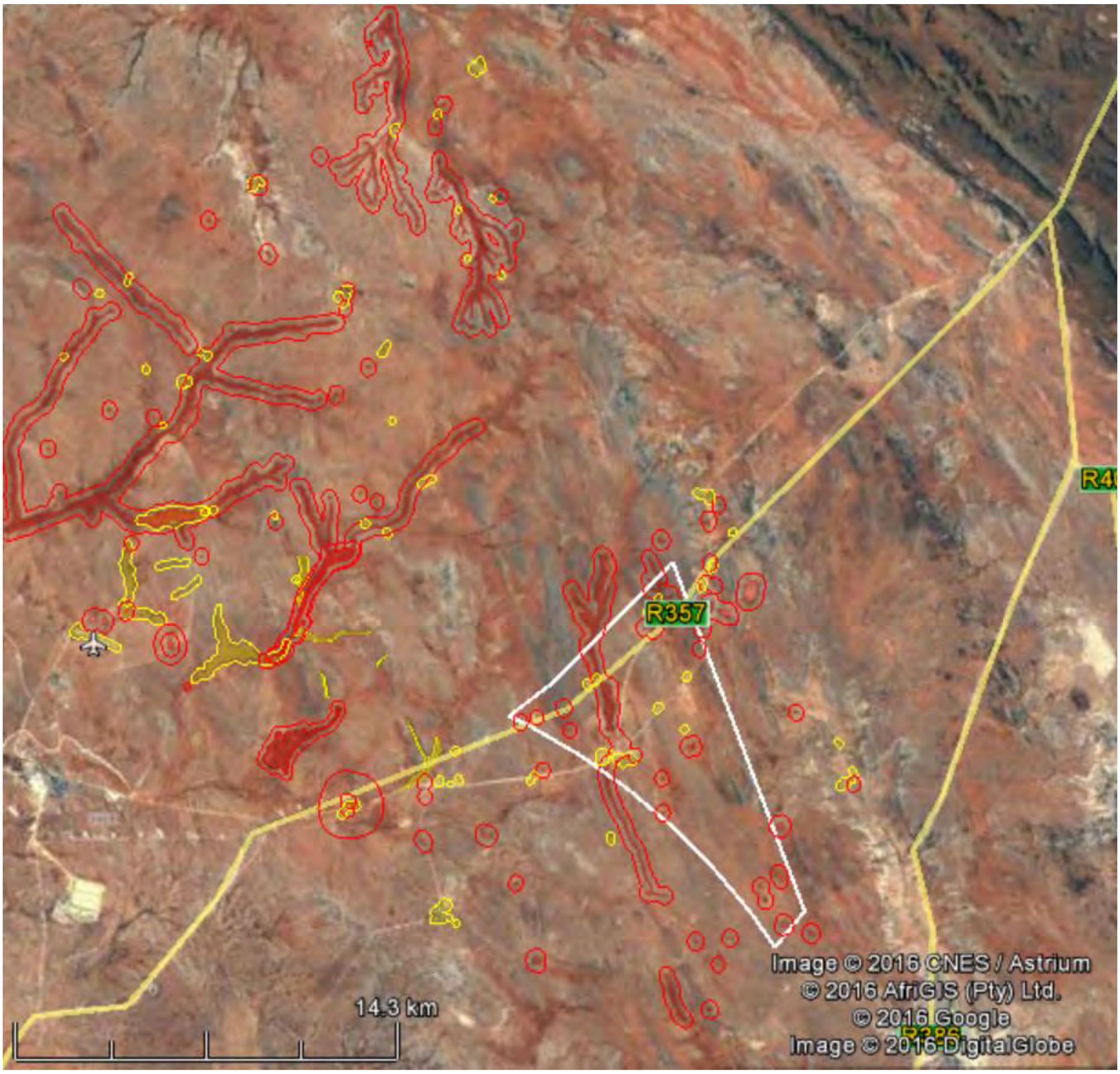


Figure 36: Proposed and approved renewable energy developments in a 10km, 20km and 30km radius of the Aletta WEF site.

7.1 Bat Sensitivity Map

Figure 37 below displays bat sensitivity maps of several wind farms neighbouring the Aletta WEF (namely the Copperton WEF, Garop WEF). The bat sensitivity maps were inspected for congruency of sensitive areas and similarities in their buffer distances. The sensitivity map of the Aletta WEF is sufficient when assessed with neighbouring site sensitivity maps.

The sensitivity maps were also used to assess whether the Aletta WEF turbine layout intersects interlinking bat sensitivity habitats between the different sites i.e. valley areas, rivers and streams, mountain ridges. The topography and habitats across the larger area is generally flat, homogenous and relatively low in bat sensitive features. Thus, the Aletta WEF turbine layout does not traverse large scale ecological corridors or ecological areas of connectivity. The existing bat sensitivity map is sufficient in this regard.



High bat sensitivity area	High bat sensitivity buffer
Moderate bat sensitivity area	Moderate bat sensitivity buffer

Figure 37: Bat sensitivity maps of wind farm areas neighbouring Aletta WEF (white boundary)

7.1 Cumulative Impact Assessment Rating

The main impact on bats that raises concern from a cumulative impact assessment point of view is the bat mortalities due to direct turbine blade collision or barotrauma during operation. There is potential for mass loss of locally active bats and migratory bats from the area due to cumulative mortality from wind turbines of several neighbouring wind farms. This impact is assessed below:

IMPACT TABLE FORMAT	
Environmental Parameter	Bat population numbers and diversity.
Issue/Impact/Environmental Effect/Nature	Cumulative bat mortalities due to direct blade collision or barotrauma during foraging – cumulative impact (resident and migrating bats affected). Mortalities of bats due to wind turbines during foraging and migration can have significant ecological consequences as the bat species at risk are insectivorous and thereby contribute significantly to the control of nocturnal flying insects. On a wind farm specific level insect numbers in a certain habitat can increase if significant numbers of bats are killed off. But if such an impact is present on multiple wind farms in close vicinity of each other, insect numbers can increase regionally and possibly cause outbreaks of colonies of certain insect species. There is also the risk of complete loss of certain bat species from the area (namely *Tadarida aegyptiaca* and *Neoromicia capensis*).
Extent	Regional (3)
Probability	Definite (4)
Reversibility	Partly reversible (2). The impact will occur throughout the lifespan of the wind energy facility as well as other facilities in the area, therefore bat population numbers may take very long to recover. There is a higher probability for population and diversity genetics to be permanently altered in cumulative impacts.
Irreplaceable loss of resources	Significant loss of resources (3). Bat population numbers will decrease across the region, species may be lost regionally.
Duration	Long term (3). The impact will be of long duration, over the operational life span of the wind farm. It will take a significant time period for the population to achieve its previous numbers after the removal of the impact.
Cumulative effect	High cumulative impact (4). Mortalities of bats due to wind turbine collision or barotrauma during foraging and/or migration can have significant ecological consequences as the bat species at risk are insectivorous, and thereby contribute significantly to the control of nocturnal flying insects. If large numbers of a population of a resident species are lost to this impact, it will most likely lead to destabilization of the species population and ultimately possible extinction from the area. If migrating bats are killed off it can have detrimental effects on the ecology of the caves that the specific colonies utilise. This is since bat guano is the primary form of energy input into a cave ecosystem, and no sunshine which is needed for photosynthesis exists in cave ecosystems.
Intensity/magnitude	High (3).
Significance Rating	The anticipated impact will have highly significant.

IMPACT TABLE FORMAT		
	Pre-mitigation impact rating	Post mitigation impact rating
Extent	3	3
Probability	4	2
Reversibility	2	2
Irreplaceable loss	3	2
Duration	3	3
Cumulative effect	4	3
Intensity/magnitude	3	2
Significance rating	- 57 (High negative)	- 30 (Medium negative)
Mitigation measures	Drainage areas can serve as commuting corridors for bats in the larger area, potentially lowering the cumulative effects of several WEF's in an area if the drainage areas are avoided during turbine placement and are well buffered. Also, adhere to recommended mitigation measures for this project during the operational phase study, and it is essential that project specific mitigations be applied and adhered to for each project. Adhere to the sensitivity map during any further turbine layout revisions, and avoid placement of turbines in bat sensitive areas and their buffers.	

7.2 Mitigation Measures

The final pre-construction bat monitoring reports of Copperton WEF and Garop WEF call for curtailment to mitigate bat mortalities during an ecological phenomenon that was identified to cause large increases in bat activity. Peak annual rainfall usually occurs within the months of November to March, which stimulates a mass emergence of insects which in turn causes an influx of insectivorous bats into the area. This phenomenon is generally initiated by the first instance of 7.5mm rain per week.

The blades of all turbines of the Aletta WEF must be feathered below manufacturers cut in speed as to not allow for free-wheeling from 1 November to 31 March. Bat activity is markedly higher over low wind speed periods. Preventing free-wheeling should not affect energy production significantly and will be a significant bat conservation mitigation measure.

Based on accepted threshold levels effective at the time of decision making during the operational phase, and only if elevated bat mortalities are found during the operational monitoring, the following **Table 14** serves as a guideline of mitigation measures that may need to be implemented in such a case. The affected turbines to which such mitigation may apply are 18, 28, 33, 34, 38, 41, 48 and 49.

Table 14: A guideline to the times of implementation of mitigation measures that may be required if found to be necessary during operational monitoring (considering more than 80% bat activity, normalised data).

Terms of mitigation implementation	
Peak activity (times to implement curtailment/ mitigation)	15 October – 30 November (or after the first instance of 7.5mm rain per week), over the time of sunset – 02:00
Environmental conditions in which to implement curtailment/ mitigation	Wind speed below 7.5m/s *And simultaneously* Temperature above 16°C
Autumn peak activity (times to implement curtailment/ mitigation)	01 – 31 January (or after the first instance of 7.5mm rain per week), over the time of sunset – 03:00
Environmental conditions in which to implement curtailment/ mitigation	Wind speed below 9.0m/s *And simultaneously* Temperature above 17.5°C

If found to be required, the mitigation must be applied during the peak activity periods and times, and when the advised wind speed and temperature ranges are prevailing simultaneously (considering conditions in which 80% of bat activity occurred). Bat activity at 80m height were used, with wind speed data at 79.6 m and temperature data at 4.5 meters.

8 CONCLUSION

The site was first visited in July 2015 wherein two SM2BAT+ detectors were installed on one 10m mast, and one meteorological mast. The long-term monitoring study aims to identify bat species at risk of fatality to wind turbines, and patterns in their activity and distributions (temporal and spatial).

A number of technical failures occurred with the Short Mast 1 monitoring system. The failures should not compromise the study since the met mast system was operating over the time frames of which the Short Mast was not operational.

Neoromicia capensis and *Tadarida aegyptiaca* were most commonly detected across both of the monitoring systems. These abundant species are of a large value to the local ecosystems as they provide a greater contribution to most ecological services than the rarer species due to their higher numbers.

The migratory species, *Miniopterus natalensis*, was detected by all monitoring systems and is prevalent on site. *Miniopterus natalensis* had an increase in activity, especially at 80m height, near the Met Mast during the autumn months (**Figure 21**). *Miniopterus natalensis* had a gradual increase in activity from spring through to autumn.

Bat activity detected at 80m monitoring height was low when compared with the monitoring results from 10m height (**Figure 13**). The greatest total bat abundance was detected by the 10m microphone of the meteorological mast.

Bat activity, especially with *Neoromicia capensis,* was generally higher over October 2015 for the Short Mast 1. The Met Mast has higher activity during January 2016 with the bat species *Tadarida aegyptiaca* (**Figures 15 – 16**). Generally, bat activity was low over the winter months with a sharp increase in spring. The elevated activity was maintained over summer and has gradually declined into autumn.

A sensitivity map was drawn up indicating potential roosting and foraging habitat (**Figure 12**). The Moderate bat sensitivity areas and associated buffer zones must be prioritised during operational monitoring and preferably be avoided during turbine placement, if another feasible option is available. The High Bat Sensitivity areas are expected to have elevated levels of bat activity and support greater bat diversity. High Bat Sensitivity areas are 'no – go' areas due to expected elevated rates of bat fatalities due to wind turbines. No turbines are allowed to be placed in High Bat Sensitivity areas and their associated buffers.

The turbine layout is respective of the bat sensitivity map since no turbines are encroaching on any sensitive area or the respective buffer. Thus the layout is deemed acceptable with regards to the bat monitoring study.

Based on accepted threshold levels effective at the time of decision making during the operational phase, and only if elevated bat mortalities are found during the operational monitoring, **Tables 13 & 14** serves as a guideline of mitigation measures that may need to be implemented in such a case. However, actual impacts on bats will be monitored during the operational phase monitoring, and the recommended mitigation measures and levels of curtailment will be adjusted according to the results of the operational monitoring.

The blades of all turbines of the Aletta WEF must be feathered below manufacturers cut in speed as to not allow for free-wheeling from 1 November to 31 March. Bat activity is markedly higher over low wind speed periods. Preventing free-wheeling should not affect energy production significantly and will be a significant bat conservation mitigation measure.

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Reviewed and signed off by:

Monika Moir

Zoologist and Ecologist

MSc (Biodiversity & Conservation, UJ)

Pr.Sci.Nat. – SACNASP

(Zoological Science)

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