Specialised Zoological

Acoustic analysis and bat call identification from Tathra, Western Australia

Prepared for **Umwelt (Australia) Pty Ltd**

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SZ project reference **SZ770**

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Version history

Date	Note
2025-09-18	Progress draft
2025-09-19	Final version

Contents

Summary

Project scope

Bat identifications from bat detector sound files are provided from the proposed Tathra Wind Farm project area, c. 15 km east of Eneabba in the Shire of Carnamah, Western Australia. The scope of the analysis extended to determining the presence of all bat species and how ‘common’ each was.

Dataset

The dataset submitted for analysis comprised two parts:

1. Recordings from bat detectors set at stationary sites over four separate surveys (**Table 1**; **Figure 1**). This comprised a total of 223,528 full spectrum WAV-format sound files recorded with Titley Scientific Anabat Ranger ultrasonic recorders (sampling rate 500 kHz; file durations 3 – 10 seconds), at 73 sites over 238 survey nights (3 –10 nights per site) for the period 5 October 2024 to 12 March 2025.
2. Recordings from a Met Mast site from three surveys (November 2024; January 2025; March 2025; sound file totals included in the above overall total), with detectors placed at ground level, 30 metres altitude (one facing east, one facing west) and 100 metres altitude (one facing east, one facing west) (**Table 2**; **Figure 1**).

Species detections

Six species of bat were identified unambiguously (**Table 3**; **Figure 2**). In addition, the possibility remains that an additional species (Inland Broad-nosed Bat *Scotorepens balstoni*) could be present—the authoritative extent of its range (Milne et al. 2023) is outside the project area and there was no unambiguous indication of its presence, but some of its calls could be mistaken for calls of the Southern Forest Bat *Vespadelus regulus*.

Calculated metrics of ‘bat activity’

In addition to presence/absence, two primary metrics were calculated (**Appendix 1**):

Rate of Encounter—number of sound files with calls of each species (commonly referred to as ‘activity’);

Frequency of Detection—proportion of survey nights that each species was detected.

The two most common species were Gould’s Wattled Bat *Chalinolobus gouldii* (with an undocumented proportion of calls from the Western Free-tailed Bat *Ozimops kitcheneri* adding to the total); and the Southern Forest Bat *Vespadelus regulus* (**Tables 4–7**; **Figures 3–4**).

The totals provided are suitable as a baseline for future monitoring because recording positions were standardised, and an objective approach to the classification and validation of bat calls was used.

Collision Risk

Given the calculations of Frequency of Detection, the risk of collision with wind turbines was calculated for each species based on a standardised scheme developed by Specialised Zoological (**Appendix 2**). The three most common species, plus the White-striped Free-tailed Bat *Austronomus australis*, had the highest calculated Collision Risk.

Patterns of detection at Met Masts

Only two call types were detected above ground level on the Met Mast: the call type associated with *C. gouldii* and *O. kitcheneri*; and that of *A. australis* (**Figure 5**). These observations correspond well with the scheme presented in **Appendix 2**, although activity was much less from 30 metres and above.

Activity levels over the night

There was a clear difference in the Rate of Encounter from the time of sunset (total number of sound files across all surveys; summarised in 30-minute periods) for each bat species detected (**Figure 6**). There was also a difference in the pattern of detections amongst species. For example, the call type associated with *C. gouldii* and *O. kitcheneri* had maximal activity within the first few hours after sunset, plus a peak before dawn. A similar maximal level of activity was present after sunset for *V. regulus* but there was no peak of activity in the early morning. The level of activity of *A. australis*, while relatively low, appeared to increase gradually after sunset, peaking after five hours before decreasing again.

Methods

Automated analyses and manual validations

A multi-step acoustic analysis procedure developed to process large full spectrum echolocation recording datasets from insectivorous bats (Armstrong et al. 2021a,b) was applied to the passive site-based recordings made on the survey. Firstly, the WAV files were scanned for bat echolocation calls using several parameter sets in the software SCAN'R version 1.8.3 (Binary Acoustic Technology), which also provides measurements (SCAN'R parameters) from each putative bat pulse. The outputs were then used to determine if putative bat pulses measured in SCAN'R could be identified to species. This was done using a custom [R] language application and accessory scripts that performed four main tasks:

1. Undertook a Discriminant Function Analysis on training data from representative calls from south-western Australia;
2. From the measurements of each putative bat pulse from SCAN'R, calculated values for the first two Discriminant Functions that could separate the echolocation call types derived from the analysis of training data, and plotted these resulting coordinates over data ellipses representing one standard deviation of the variation for the defined call types;
3. Facilitated an inspection in a spectrogram of multiple examples of each call type for each recording night by opening the original WAV files containing pulses of interest in ADOBE AUDITION version 25.0 (**Appendix 3**); and
4. Facilitated the compilation of filenames for sound files that contained bat echolocation.

The compilation of detections and calculation of plots and statistics was performed using a custom script written in the [R] statistical computing language. A significant effort for this particular analysis was given to developing a new standardised way for rejecting noise and background signals based on selected parameters from the SCAN'R output—before classification of the remaining signals into bat echolocation call types. Following clustering of the denoised dataset, a list of the sound files with signals in each of the call type clusters was produced. Each of these sound files was opened and inspected in ADOBE AUDITION, and all false positive detections were removed. In summary, automated processes removed noise (and a proportion of poor-quality bat echolocation sequences) and grouped echolocation call types; and then a manual validation process removed any remaining false positive detections. Thus, false positive rate (incorrect identifications) is zero, and false negative rate (incorrect rejections) is standardised based on clustering thresholds.

Species were identified based on information in the author's unpublished material and Churchill (2008). Nomenclature follows Jackson and Groves (2015). Identifications were supported by distribution information in a curated source of distribution records maintained by the Australasian Bat Society, Inc. (https://www.ausbats.org.au/batmap.html) (Milne et al. 2023).

Comments on identifications

Most species were identified unambiguously, but calls with a characteristic frequency in the range of 25 – 33 kHz were derived from either Gould's Wattled Bat *Chalinolobus gouldii* or the Western Free-tailed Bat *Ozimops kitcheneri*. Only a relatively small proportion of call examples could be attributed unambiguously to the correct species, especially using the automated identification system applied here. Thus, while both species were present, all calculations of Rate of Encounter and Frequency of Detection were made based on the number of files with calls of either species.

Some clutter calls of the Southern Forest Bat *Vespadelus regulus* can be mistaken for calls of the Lesser Long-eared Bat *Nyctophilus geoffroyi*.

Limitations

The identifications presented in this report have been made within the following context:

1. The identifications made herein were based on the ultrasonic acoustic data recorded and provided by a 'third party' (the client named on the front of this report).
2. The scope of this report extended to providing information on the identification of bat species in bulk ultrasonic recordings. Further extended comment on these species and the possible impacts of a planned project on bat species were not part of the scope.
3. In the case of the present report, the recording equipment was not set up or supplied by Specialised Zoological. The equipment was operated by the third party during the survey.
4. Other than the general location of the study area, Specialised Zoological has not been provided with detailed information about the survey area, has not made a visit to observe the habitats available for bats, nor have we visited the specific project areas on a previous occasion.
5. Specialised Zoological has had no input into the overall design and timing of this bat survey, recording site placement, nor the degree of recording site replication.
6. The identifications listed herein have been made to the best of our ability given the available materials, and Specialised Zoological reserves the right to re-examine the data and revise any identification following a query. It is the client's and / or proponent's responsibility to provide supporting evidence for any identification, which might require follow-up trapping effort or non-invasive methods such as video recordings. Specialised Zoological bears no liability for any follow-up work that may be required to support an identification based initially on the analysis of acoustic recordings undertaken and reported on here.
7. There are a variety of factors that affect the 'detectability' and encounter rates of each bat species, given the frequency, power and shape characteristics of their calls; the foraging and flight behaviour of different species; and the type and condition of recording equipment. Further information on the analysis and the various factors that can impinge on the reliability of identifications can be provided upon request.
8. The analysis of ultrasonic recordings is one of several methods that can be used to survey for bats, and comprehensive surveys typically employ more than one method. If an identification in the present report is ambiguous or in question, a trapping programme would help to resolve the presence of the possibilities in the project area.
9. Values in the tables of this report might change in subsequent analyses because of the re-application of a refined classification in the Collision Risk scheme.
10. This version of the document supersedes any previous version. Drafts and all previous versions are not authorised by us for submission to the regulator or the public domain.

References

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Table 1. Summary of sites from which recordings were collected and analysed (Vantage Points).

Vantage Point	Ranger No.	Serial	First night	Last night	Latitude	Longitude	Nights
October 2024							
VP01	R05	111533	5/10/2024	7/10/2024	-29.79298	115.391617	3
VP02	R06	111572	7/10/2024	9/10/2024	-29.838444	115.431641	3
VP03	R17	798926	5/10/2024	7/10/2024	-29.777905	115.458054	3
VP04	R14	111587	5/10/2024	7/10/2024	-29.76556	115.432419	3
VP05	R20	111603	6/10/2024	10/10/2024	-29.713411	115.428696	5
VP06	R02	111590	5/10/2024	7/10/2024	-29.735388	115.482262	3
VP08	R30	111520	4/10/2024	6/10/2024	-29.735075	115.518135	3
VP09	R19	111601	5/10/2024	7/10/2024	-29.753532	115.537384	3
VP10	R11	111677	5/10/2024	8/10/2024	-29.815165	115.450813	4
VP11	R16	111613	5/10/2024	7/10/2024	-29.833151	115.499496	3
VP12	R12	798955	5/10/2024	8/10/2024	-29.857283	115.512466	4
VP13	R09	111560	5/10/2024	7/10/2024	-29.756269	115.490738	3
VP14	R18	798999	5/10/2024	7/10/2024	-29.882429	115.493668	3
VP15	R15a	798927	7/10/2024	9/10/2024	-29.904394	115.510399	3
VP16	R01	111582	4/10/2024	6/10/2024	-29.908289	115.460823	3
VP17	R13	799004	5/10/2024	7/10/2024	-29.893641	115.432343	3
VP18	R07	111558	5/10/2024	7/10/2024	-29.911324	115.391373	3
November 2024							
Met Mast ground	R43	111664	15/11/2024	23/11/2024	-31.964977	115.916763	9
VP01	R01	111582	19/11/2024	23/11/2024	-29.791536	115.391312	5
VP02	R14	111587	15/11/2024	19/11/2024	-31.965109	115.916603	5
VP03	R05	111533	21/11/2024	23/11/2024	-29.778101	115.457794	3
VP04	R09	111560	21/11/2024	23/11/2024	-29.763306	115.432289	3
VP05	R18	798999	18/11/2024	20/11/2024	-29.713501	115.428612	3
VP06	R09	111560	18/11/2024	20/11/2024	-29.735352	115.482262	3
VP07	R42	799094	18/11/2024	20/11/2024	-29.756233	115.491035	3
VP08	R05	111533	18/11/2024	20/11/2024	-29.73543	115.518539	3
VP09	R42	799094	21/11/2024	22/11/2024	-29.75354	115.53791	2
VP10	R17	798926	21/11/2024	23/11/2024	-29.815178	115.45153	3
VP11	R15	798927	21/11/2024	23/11/2024	-29.83396	115.499954	3
VP12	R11	111677	21/11/2024	23/11/2024	-29.857512	115.51442	3
VP13	R17	798926	18/11/2024	20/11/2024	-29.838518	115.431725	3
VP14	R11	111677	18/11/2024	20/11/2024	-29.881763	115.497025	3
VP15	R15	798927	18/11/2024	20/11/2024	-29.904402	115.510399	3
VP16	R30	111520	NR	.	.	.	
VP17	R13	799004	18/11/2024	20/11/2024	-29.893641	115.432533	3
VP18	R08	111572	18/11/2024	20/11/2024	-29.911434	115.391197	3
January 2025							
Met Mast ground	R17	798926	10/01/2025	19/01/2025	-29.781002	115.456772	10
VP01	R20	111603	11/01/2025	13/01/2025	-29.791609	115.391289	3
VP02	R16	111613	11/01/2025	13/01/2025	-29.801287	115.413818	3
VP03	R07	111558	10/01/2025	12/01/2025	-29.777893	115.458092	3
VP04	R12	798955(SD1)	11/01/2025	13/01/2025	-29.763163	115.431885	3
VP05	R15	798927	11/01/2025	13/01/2025	-29.713673	115.428612	3
VP06	R14	111587	8/01/2025	13/01/2025	-29.801435	115.413528	6

Vantage Point	Ranger No.	Serial	First night	Last night	Latitude	Longitude	Nights
VP07	R15	798927	14/01/2025	16/01/2025	-29.756222	115.490807	3
VP08	R01	111582	11/01/2025	13/01/2025	-29.735491	115.5186	3
VP09	R09	111560	11/01/2025	13/01/2025	-29.753593	115.537338	3
VP10	R30	111520	11/01/2025	12/01/2025	-29.815214	115.451126	2
VP11	R40	111549	11/01/2025	13/01/2025	-29.833166	115.499443	3
VP12	R03	111574	10/01/2025	11/01/2025	-29.857325	115.512352	2
VP13	R06	111579	11/01/2025	14/01/2025	-29.838484	115.43161	4
VP14	R18	798999	10/01/2025	12/01/2025	-29.88306	115.49295	3
VP15	R19	111601	10/01/2025	12/01/2025	-29.904167	115.510368	3
VP16	R20	111603(SD2)	14/01/2025	16/01/2025	-29.791609	115.391289	3
VP17	R04	111563	11/01/2025	13/01/2025	-29.893633	115.432472	3
VP18	R02	111590	11/01/2025	13/01/2025	-29.91119	115.391014	3
March 2025							
Met Mast ground	R06	111579	10/03/2025	12/03/2025	-29.781042	115.456741	3
VP01	R40	111549	10/03/2025	12/03/2025	-29.791386	115.391289	3
VP02	R41	111537	10/03/2025	12/03/2025	-29.801291	115.413773	3
VP03	R14	111587	10/03/2025	12/03/2025	-29.777933	115.458107	3
VP04	R02	111590	10/03/2025	12/03/2025	-29.763391	115.431931	3
VP05	R43	111664	10/03/2025	12/03/2025	-29.71357	115.428726	3
VP07	R19	111601	10/03/2025	12/03/2025	-29.756229	115.490807	3
VP08	R05	111533	10/03/2025	12/03/2025	-29.735424	115.518509	3
VP09	R11	111677	10/03/2025	12/03/2025	-29.753687	115.537369	3
VP10	R08	111572	11/03/2025	13/03/2025	-29.815279	115.450859	3
VP11	R15	798927	10/03/2025	12/03/2025	-29.833179	115.499336	3
VP12	R16	111613	10/03/2025	12/03/2025	-29.857321	115.512482	3
VP13	R07	111558	10/03/2025	12/03/2025	-29.838493	115.431595	3
VP14	R04	111563	10/03/2025	12/03/2025	-29.882458	115.493408	3
VP15	R18	798999	10/03/2025	12/03/2025	-29.904415	115.510414	3
VP16	R30	111520	11/03/2025	13/03/2025	-29.908031	115.460548	3
VP17	R13	799004	10/03/2025	12/03/2025	-29.893612	115.432518	3
VP18	R12	798955	10/03/2025	12/03/2025	-29.911194	115.390984	3
Totals							
October 2024	**17**						**55**
November 2024	**19**						**63**
January 2025	**19**						**66**
March 2025	**18**						**54**
Overall	**73**						**238**

Table 2. Summary of sites from which recordings were collected and analysed (Vantage Points).

Met Mast Positions	Ranger No.	Serial	First night	Last night	Latitude	Longitude	Nights
November 2024							
Met Mast ground	R43	111664	15/11/2024	23/11/2024	-31.964977	115.916763	9
Met Mast 30 m East	R40	111549	20/11/2024	23/11/2024	-29.781055	115.456787	4
Met Mast 30 m West	R12	798955	20/11/2024	22/11/2024	-29.781046	115.456718	3
Met Mast 100 m East	R16	111613	21/11/2024	23/11/2024	-29.780981	115.456741	3
Met Mast 100 m West	R20	111603	19/11/2024	22/11/2024	-29.781055	115.456856	4
January 2025							
Met Mast ground	R17	798926	10/01/2025	19/01/2025	-29.781002	115.456772	10
Met Mast 30 m East	R08	111572	10/01/2025	15/01/2025	-29.781017	115.456757	6
Met Mast 30 m West	R11	111677	10/01/2025	31/01/2025	-29.78101	115.456787	22
Met Mast 100 m East	R13	799004	11/01/2025	14/01/2025	-29.781328	115.457016	4
Met Mast 100 m West	R05	111533	10/01/2025	1/02/2025	-29.781006	115.456703	23
March 2025							
Met Mast ground	R06	111579	10/03/2025	12/03/2025	-29.781042	115.456741	3
Met Mast 30 m West?	R03	111574	10/03/2025	12/03/2025	-29.78105	115.456772	3
Met Mast 30 m East	R42	799094	10/03/2025	12/03/2025	-29.781075	115.456757	3
Met Mast 100 m East	R01	111582	10/03/2025	12/03/2025	-29.781023	115.456787	3
Met Mast 100 m West	R09	111560	10/03/2025	12/03/2025	-29.781038	115.456772	3
Totals							
November 2024	**5**						**23**
January 2025	**5**						**65**
March 2025	**5**						**15**
Overall	**15**						**103**

Table 3. Species identified in the dataset from all sites combined. The predicted 'presence' (defined as 'occasional or regular forays into this range') above 50 metres in altitude is an authoritative designation based on accumulated casual field observations and general knowledge from various sources, and as a precautionary consideration in the absence of data collected in a systematic study (K. Armstrong).

Predicted presence above 50 m altitude		
	VESPERTILIONIDAE	
Medium	Gould's Wattled Bat	*Chalinolobus gouldii*
Medium	Chocolate Wattled Bat	*Chalinolobus morio*
Low	Lesser Long-eared Bat	*Nyctophilus geoffroyi*
Medium	Southern Forest Bat	*Vespadelus regulus*
	MOLOSSIDAE	
High	White-striped Free-tailed Bat	*Austronomus australis*
Medium	Western Free-tailed Bat	*Ozimops kitcheneri*

Table 4. Summary of Rate of Encounter for each species over all nights combined per survey.

	A. australis	*C. gouldii+ O. kitcheneri*	*C. morio*	*N. geoffroyi*	*V. regulus*
October 2024	60	1,495	10	25	510
November 2024	21	1,052	3	3	226
January 2025	6	2,839	2	47	589
March 2025	136	1,278	9	52	1,440
Grand Total	**223**	**6,664**	**24**	**127**	**2,765**

Table 5. Summary of Frequency of Detection for each species over all nights combined per survey (* no Met Mast data included; # only Met Mast data from ground level was included in the calculations, with data from 30 m and 100 m in altitude excluded).

	A. australis	*C. gouldii+ O. kitcheneri*	*C. morio*	*N. geoffroyi*	*V. regulus*	No. nights
October 2024*	0.35	0.87	0.18	0.27	0.78	**55**
November 2024#	0.11	0.73	0.03	0.05	0.49	**63**
January 2025#	0.05	0.92	0.03	0.38	0.52	**66**
March 2025#	0.57	0.93	0.07	0.50	0.76	**54**
Overall#	**0.25**	**0.86**	**0.08**	**0.29**	**0.63**	**238**

Table 6. Rate of Encounter (with Frequency of Detection as a summary) for each species over each night in each survey at Vantage Points.

Vantage Point	Ranger No.	Serial	Night	*A. australis*	*C. gouldii+ O. kitcheneri*	*C. morio*	*N. geoffroyi*	*V. regulus*
October 2024								
VP01	R05	111533	5/10/2024	0	53	1	5	41
			6/10/2024	0	5	0	1	78
			7/10/2024	1	15	1	0	102
VP02	R06	111572	7/10/2024	0	23	0	0	0
			8/10/2024	0	8	0	0	0
			9/10/2024	0	13	0	0	4
VP03	R17	798926	5/10/2024	0	0	0	0	3
			6/10/2024	0	0	0	0	2
			7/10/2024	0	1	0	0	0
VP04	R14	111587	5/10/2024	0	3	0	0	0
			6/10/2024	0	3	0	0	0
			7/10/2024	3	1	0	1	1
VP05	R20	111603	6/10/2024	0	3	0	0	1
			7/10/2024	0	3	0	0	0
			8/10/2024	0	2	0	2	0
			9/10/2024	1	0	0	0	0
			10/10/2024	0	1	1	0	2
VP06	R02	111590	5/10/2024	0	5	0	0	2
			6/10/2024	0	0	0	0	2
			7/10/2024	1	2	0	0	1
VP08	R30	111520	4/10/2024	0	2	0	0	3
			5/10/2024	1	0	0	0	1
			6/10/2024	0	0	0	0	0
VP09	R19	111601	5/10/2024	0	1	0	0	20
			6/10/2024	1	4	0	0	10
			7/10/2024	3	6	0	1	13
VP10	R11	111677	5/10/2024	14	245	1	2	10
			6/10/2024	3	176	1	1	11
			7/10/2024	2	193	1	0	16
			8/10/2024	1	271	0	0	5
VP11	R16	111613	5/10/2024	0	9	0	0	1
			6/10/2024	0	27	1	1	0
			7/10/2024	0	30	0	0	5
VP12	R12	798955	5/10/2024	12	8	0	0	2
			6/10/2024	1	8	0	0	9
			7/10/2024	0	7	0	0	9
			8/10/2024	6	10	0	0	5
VP13	R09	111560	5/10/2024	0	12	0	1	4
			6/10/2024	1	3	0	2	1
			7/10/2024	0	0	0	0	3
VP14	R18	798999	5/10/2024	3	45	1	0	9
			6/10/2024	0	38	0	0	17

Vantage Point	Ranger No.	Serial	Night	*A. australis*	*C. gouldii+ O. kitcheneri*	*C. morio*	*N. geoffroyi*	*V. regulus*
			7/10/2024	3	26	0	0	21
VP15	R15a	798927	7/10/2024	1	39	0	1	27
			8/10/2024	0	29	1	2	23
			9/10/2024	0	17	0	2	18
VP16	R01	111582	4/10/2024	0	6	0	0	0
			5/10/2024	0	28	0	0	3
			6/10/2024	0	19	0	0	1
VP17	R13	799004	5/10/2024	0	38	0	0	13
			6/10/2024	0	17	0	0	3
			7/10/2024	0	18	0	1	0
VP18	R07	111558	5/10/2024	2	8	0	0	1
			6/10/2024	0	9	0	0	4
			7/10/2024	0	5	1	2	3
Frequency of Detection				**0.35**	**0.87**	**0.18**	**0.27**	**0.78**

Vantage Point	Ranger No.	Serial	Night	*A. australis*	*C. gouldii+ O. kitcheneri*	*C. morio*	*N. geoffroyi*	*V. regulus*
November 2024								
Met Mast ground	R43	111664	15/11/2024	0	0	0	0	0
			16/11/2024	0	0	0	0	0
			17/11/2024	0	0	0	0	0
			18/11/2024	0	0	0	0	0
			19/11/2024	0	1	0	0	0
			20/11/2024	0	1	0	0	2
			21/11/2024	0	8	0	0	0
			22/11/2024	0	6	0	0	0
			23/11/2024	0	3	0	0	3
VP01	R01	111582	19/11/2024	0	2	0	0	7
			20/11/2024	0	1	0	0	26
			21/11/2024	0	1	0	0	7
			22/11/2024	0	0	0	0	0
			23/11/2024	0	0	0	0	0
VP02	R14	111587	15/11/2024	0	0	0	0	0
			16/11/2024	0	0	0	0	0
			17/11/2024	0	0	0	0	0
			18/11/2024	0	0	0	0	0
			19/11/2024	1	41	0	0	3
VP03	R05	111533	21/11/2024	0	5	0	0	0
			22/11/2024	0	11	0	0	0
			23/11/2024	0	2	0	0	2
VP04	R09	111560	21/11/2024	0	3	0	0	0
			22/11/2024	0	1	0	0	0

Vantage Point	Ranger No.	Serial	Night	*A. australis*	*C. gouldii+ O. kitcheneri*	*C. morio*	*N. geoffroyi*	*V. regulus*
			23/11/2024	0	1	0	0	0
VP05	R18	798999	18/11/2024	0	9	0	0	12
			19/11/2024	0	11	0	0	15
			20/11/2024	0	3	0	0	4
VP06	R09	111560	18/11/2024	0	1	0	0	5
			19/11/2024	0	1	0	0	4
			20/11/2024	0	0	0	0	0
VP07	R42	799094	18/11/2024	0	0	0	0	1
			19/11/2024	0	0	0	0	0
			20/11/2024	0	0	0	0	0
VP08	R05	111533	18/11/2024	0	0	0	0	0
			19/11/2024	0	0	0	0	0
			20/11/2024	0	0	0	0	0
VP09	R42	799094	21/11/2024	1	39	0	0	1
			22/11/2024	0	64	0	0	2
VP10	R17	798926	21/11/2024	0	5	0	0	1
			22/11/2024	0	17	0	0	0
			23/11/2024	0	1	0	0	2
VP11	R15	798927	21/11/2024	0	14	0	0	0
			22/11/2024	0	27	0	0	0
			23/11/2024	0	47	0	0	1
VP12	R11	111677	21/11/2024	0	16	0	0	0
			22/11/2024	2	4	0	0	0
			23/11/2024	1	2	0	0	2
VP13	R17	798926	18/11/2024	0	6	0	1	5
			19/11/2024	0	38	0	1	9
			20/11/2024	0	5	0	0	6
VP14	R11	111677	18/11/2024	5	272	0	0	31
			19/11/2024	1	187	0	0	7
			20/11/2024	0	97	0	0	0
VP15	R15	798927	18/11/2024	9	8	1	1	35
			19/11/2024	0	25	0	0	17
			20/11/2024	0	4	0	0	7
VP17	R13	799004	18/11/2024	0	6	0	0	0
			19/11/2024	0	1	0	0	3
			20/11/2024	0	2	0	0	2
VP18	R08	111572	18/11/2024	0	30	0	0	0
			19/11/2024	0	14	0	0	3
			20/11/2024	0	6	2	0	1
Frequency of Detection				**0.11**	**0.73**	**0.03**	**0.05**	**0.49**

January 2025								
Met Mast ground	R17	798926	10/01/2025	0	12	0	0	0
			11/01/2025	0	9	0	0	0
			12/01/2025	0	2	0	0	0

Vantage Point	Ranger No.	Serial	Night	*A. australis*	*C. gouldii+ O. kitcheneri*	*C. morio*	*N. geoffroyi*	*V. regulus*
			13/01/2025	0	12	0	0	0
			14/01/2025	0	16	0	0	0
			15/01/2025	0	1	0	0	1
			16/01/2025	0	2	0	0	0
			17/01/2025	0	2	0	0	0
			18/01/2025	0	2	0	1	0
			19/01/2025	0	2	0	2	0
VP01	R20SD1	111603	11/01/2025	0	34	0	0	13
			12/01/2025	0	30	0	0	3
			13/01/2025	0	45	0	0	5
VP02	R16	111613	11/01/2025	0	106	0	2	2
			12/01/2025	0	107	0	1	2
			13/01/2025	0	11	0	0	4
VP03	R07	111558	10/01/2025	0	6	0	0	0
			11/01/2025	0	9	0	0	1
			12/01/2025	0	5	0	0	1
VP04	R12SD1	798955	11/01/2025	0	63	0	2	2
			12/01/2025	0	89	0	1	0
			13/01/2025	0	14	0	0	2
VP05	R15	798927	11/01/2025	0	311	0	0	66
			12/01/2025	0	199	0	0	2
			13/01/2025	0	122	0	1	0
VP06	R14	111587	8/01/2025	0	0	0	0	0
			9/01/2025	0	0	0	0	0
			10/01/2025	0	0	0	0	0
			11/01/2025	0	11	0	1	0
			12/01/2025	0	12	0	1	0
			13/01/2025	0	9	0	0	0
VP07	R15	798927	14/01/2025	0	54	0	0	0
			15/01/2025	0	23	0	0	1
			16/01/2025	0	7	1	0	2
VP08	R01	111582	11/01/2025	0	23	0	0	2
			12/01/2025	0	46	0	0	0
			13/01/2025	0	28	0	0	1
VP09	R09	111560	11/01/2025	0	17	0	1	14
			12/01/2025	3	24	0	0	16
			13/01/2025	0	20	0	2	18
VP10	R30	111520	11/01/2025	0	240	0	4	6
			12/01/2025	0	199	0	2	2
VP11	R40	111549	11/01/2025	0	7	0	0	1
			12/01/2025	0	3	0	0	0
			13/01/2025	0	4	0	3	2
VP12	R03	111574	10/01/2025	0	2	0	0	0
			11/01/2025	0	0	0	0	0
VP13	R06	111579	11/01/2025	0	9	0	6	6
			12/01/2025	0	13	0	1	1

Vantage Point	Ranger No.	Serial	Night	*A. australis*	*C. gouldii+ O. kitcheneri*	*C. morio*	*N. geoffroyi*	*V. regulus*
			13/01/2025	0	0	0	0	0
			14/01/2025	0	17	0	2	1
VP14	R18	798999	10/01/2025	1	88	0	0	131
			11/01/2025	0	156	0	1	105
			12/01/2025	0	126	0	0	67
VP15	R19	111601	10/01/2025	0	126	0	2	37
			11/01/2025	0	110	0	4	54
			12/01/2025	1	124	0	3	16
VP16	R20SD2	111603	14/01/2025	0	9	0	0	0
			15/01/2025	0	22	0	1	0
			16/01/2025	0	21	0	1	2
VP17	R04	111563	11/01/2025	0	1	0	0	0
			12/01/2025	0	1	0	0	0
			13/01/2025	0	2	0	0	0
VP18	R02	111590	11/01/2025	0	32	0	1	0
			12/01/2025	0	14	1	0	0
			13/01/2025	0	10	0	1	0
Frequency of Detection				**0.05**	**0.92**	**0.03**	**0.38**	**0.52**

Vantage Point	Ranger No.	Serial	Night	*A. australis*	*C. gouldii+ O. kitcheneri*	*C. morio*	*N. geoffroyi*	*V. regulus*
March 2025								
Met Mast ground	R06	111579	10/03/2025	6	7	0	0	0
			11/03/2025	2	2	0	0	1
			12/03/2025	10	0	0	0	1
VP01	R40	111549	10/03/2025	2	1	0	0	3
			11/03/2025	0	11	0	1	27
			12/03/2025	0	5	0	2	14
VP02	R41	111537	10/03/2025	0	0	0	0	0
			11/03/2025	0	0	0	0	0
			12/03/2025	0	0	0	0	0
VP03	R14	111587	10/03/2025	1	8	3	0	160
			11/03/2025	0	5	0	3	116
			12/03/2025	2	5	0	3	40
VP04	R02	111590	10/03/2025	1	6	0	2	0
			11/03/2025	0	17	0	0	5
			12/03/2025	2	20	0	0	4
VP05	R43	111664	10/03/2025	5	56	1	0	67
			11/03/2025	0	31	0	1	189
			12/03/2025	1	41	0	0	34
VP07	R19	111601	10/03/2025	0	38	0	0	5
			11/03/2025	2	10	0	0	6

Vantage Point	Ranger No.	Serial	Night	*A. australis*	*C. gouldii+ O. kitcheneri*	*C. morio*	*N. geoffroyi*	*V. regulus*
			12/03/2025	0	12	0	4	5
VP08	R05	111533	10/03/2025	0	13	0	0	0
			11/03/2025	0	6	0	0	2
			12/03/2025	1	5	0	0	1
VP09	R11	111677	10/03/2025	2	45	0	2	33
			11/03/2025	3	67	0	0	19
			12/03/2025	1	29	0	1	25
VP10	R08	111572	11/03/2025	5	147	4	2	19
			12/03/2025	11	64	0	1	23
			13/03/2025	3	94	0	0	9
VP11	R15	798927	10/03/2025	3	18	0	0	0
			11/03/2025	1	9	0	0	2
			12/03/2025	2	4	0	1	0
VP12	R16	111613	10/03/2025	1	12	0	1	0
			11/03/2025	7	11	0	1	1
			12/03/2025	18	12	0	0	1
VP13	R07	111558	10/03/2025	0	15	0	0	0
			11/03/2025	2	9	0	2	3
			12/03/2025	0	11	0	1	3
VP14	R04	111563	10/03/2025	0	33	0	0	9
			11/03/2025	1	45	0	1	283
			12/03/2025	1	28	1	3	142
VP15	R18	798999	10/03/2025	0	26	0	1	72
			11/03/2025	3	41	0	6	70
			12/03/2025	3	58	0	5	36
VP16	R30	111520	11/03/2025	0	28	0	1	2
			12/03/2025	0	27	0	2	2
			13/03/2025	0	16	0	1	1
VP17	R13	799004	10/03/2025	0	26	0	0	0
			11/03/2025	0	20	0	1	1
			12/03/2025	5	13	0	1	0
VP18	R12	798955	10/03/2025	0	29	0	0	2
			11/03/2025	0	20	0	0	2
			12/03/2025	1	21	0	2	0
Frequency of Detection				**0.57**	**0.93**	**0.07**	**0.50**	**0.76**

Table 7. Rate of Encounter for each species over each night in each survey at Met Masts.

Vantage Point	Ranger No.	Serial	Night	*A. australis*	*C. gouldii+ O. kitcheneri*	*C. morio*	*N. geoffroyi*	*V. regulus*
November 2024								
Met Mast ground	R43	111664	15/11/2024	0	0	0	0	0
			16/11/2024	0	0	0	0	0
			17/11/2024	0	0	0	0	0
			18/11/2024	0	0	0	0	0
			19/11/2024	0	1	0	0	0
			20/11/2024	0	1	0	0	2
			21/11/2024	0	8	0	0	0
			22/11/2024	0	6	0	0	0
			23/11/2024	0	3	0	0	3
Met Mast 30 m East	R40	111549	20/11/2024	1	1	0	0	0
			21/11/2024	0	0	0	0	0
			22/11/2024	0	0	0	0	0
			23/11/2024	0	0	0	0	0
Met Mast 30 m West	R12	798955	20/11/2024	0	1	0	0	0
			21/11/2024	0	1	0	0	0
			22/11/2024	0	0	0	0	0
Met Mast 100 m East	R16	111613	21/11/2024	0	0	0	0	0
			22/11/2024	0	0	0	0	0
			23/11/2024	0	0	0	0	0
Met Mast 100 m West	R20	111603	19/11/2024	0	0	0	0	0
			20/11/2024	0	0	0	0	0
			21/11/2024	0	0	0	0	0
			22/11/2024	0	0	0	0	0
January 2025								
Met Mast ground	R17	798926	10/01/2025	0	12	0	0	0
			11/01/2025	0	9	0	0	0
			12/01/2025	0	2	0	0	0
			13/01/2025	0	12	0	0	0
			14/01/2025	0	16	0	0	0
			15/01/2025	0	1	0	0	1
			16/01/2025	0	2	0	0	0
			17/01/2025	0	2	0	0	0
			18/01/2025	0	2	0	1	0
			19/01/2025	0	2	0	2	0
Met Mast 30 m East	R08	111572	10/01/2025	0	0	0	0	0
			11/01/2025	0	0	0	0	0
			12/01/2025	0	1	0	0	0
			13/01/2025	0	3	0	0	0
			14/01/2025	0	1	0	0	0
			15/01/2025	0	0	0	0	0
Met Mast 30 m West	R11	111677	10/01/2025	0	0	0	0	0
			11/01/2025	0	1	0	0	0
			12/01/2025	0	2	0	0	0

Vantage Point	Ranger No.	Serial	Night	*A. australis*	*C. gouldii+ O. kitcheneri*	*C. morio*	*N. geoffroyi*	*V. regulus*
			13/01/2025	0	0	0	0	0
			14/01/2025	0	2	0	0	0
			15/01/2025	0	0	0	0	0
			16/01/2025	0	0	0	0	0
			17/01/2025	0	0	0	0	0
			18/01/2025	0	0	0	0	0
			19/01/2025	0	0	0	0	0
			20/01/2025	0	0	0	0	0
			21/01/2025	0	0	0	0	0
			22/01/2025	0	0	0	0	0
			23/01/2025	0	0	0	0	0
			24/01/2025	0	0	0	0	0
			25/01/2025	0	0	0	0	0
			26/01/2025	0	0	0	0	0
			27/01/2025	0	0	0	0	0
			28/01/2025	0	0	0	0	0
			29/01/2025	0	0	0	0	0
			30/01/2025	0	0	0	0	0
			31/01/2025	0	2	0	0	0
Met Mast 100 m East	R13	799004	11/01/2025	0	1	0	0	0
			12/01/2025	0	0	0	0	0
			13/01/2025	0	0	0	0	0
			14/01/2025	0	0	0	0	0
Met Mast 100 m West	R05	111533	10/01/2025	0	0	0	0	0
			11/01/2025	0	4	0	0	0
			12/01/2025	0	0	0	0	0
			13/01/2025	0	0	0	0	0
			14/01/2025	0	0	0	0	0
			15/01/2025	0	0	0	0	0
			16/01/2025	0	1	0	0	0
			17/01/2025	0	0	0	0	0
			18/01/2025	0	0	0	0	0
			19/01/2025	0	0	0	0	0
			20/01/2025	0	0	0	0	0
			21/01/2025	0	0	0	0	0
			22/01/2025	0	0	0	0	0
			23/01/2025	1	0	0	0	0
			24/01/2025	0	0	0	0	0
			25/01/2025	0	0	0	0	0
			26/01/2025	0	0	0	0	0
			27/01/2025	0	0	0	0	0
			28/01/2025	0	0	0	0	0
			29/01/2025	0	0	0	0	0
			30/01/2025	0	0	0	0	0
			31/01/2025	0	0	0	0	0
March 2025								

Vantage Point	Ranger No.	Serial	Night	*A. australis*	*C. gouldii+ O. kitcheneri*	*C. morio*	*N. geoffroyi*	*V. regulus*
Met Mast ground	R06	111579	10/03/2025	6	7	0	0	0
			11/03/2025	2	2	0	0	1
			12/03/2025	10	0	0	0	1
Met Mast 30 m East	R42	799094	10/03/2025	4	0	0	0	0
			11/03/2025	1	0	0	0	0
			12/03/2025	9	0	0	0	0
Met Mast 30 m West?	R03	111574	10/03/2025	2	0	0	0	0
			11/03/2025	1	0	0	0	0
			12/03/2025	11	1	0	0	0
Met Mast 100 m East	R01	111582	10/03/2025	0	0	0	0	0
			11/03/2025	0	0	0	0	0
			12/03/2025	0	0	0	0	0
Met Mast 100 m West	R09	111560	10/03/2025	0	0	0	0	0
			11/03/2025	0	0	0	0	0
			12/03/2025	0	0	0	0	0

Table 8. Calculated Collision Risk Scores for each species based on the recorded frequencies of detection (from all surveys combined; see *Appendix 2*).

		High altitude likelihood	Altitude category	Frequency across the surveys	Frequency category	Risk Score	Collision Risk
VESPERTILIONIDAE							
Gould's Wattled Bat	*Chalinolobus gouldii*	Medium	2	0.86	4	8	High
Chocolate Wattled Bat	*Chalinolobus morio*	Medium	2	0.08	1	2	Low
Lesser Long-eared Bat	*Nyctophilus geoffroyi*	Low	1	0.29	2	2	Low
Southern Forest Bat	*Vespadelus regulus*	Medium	2	0.63	3	6	Medium
MOLOSSIDAE							
White-striped Free-tailed Bat	*Austronomus australis*	High	3	0.25	2	6	Medium
Western Free-tailed Bat	*Ozimops kitcheneri*	Medium	2	0.86	4	8	High

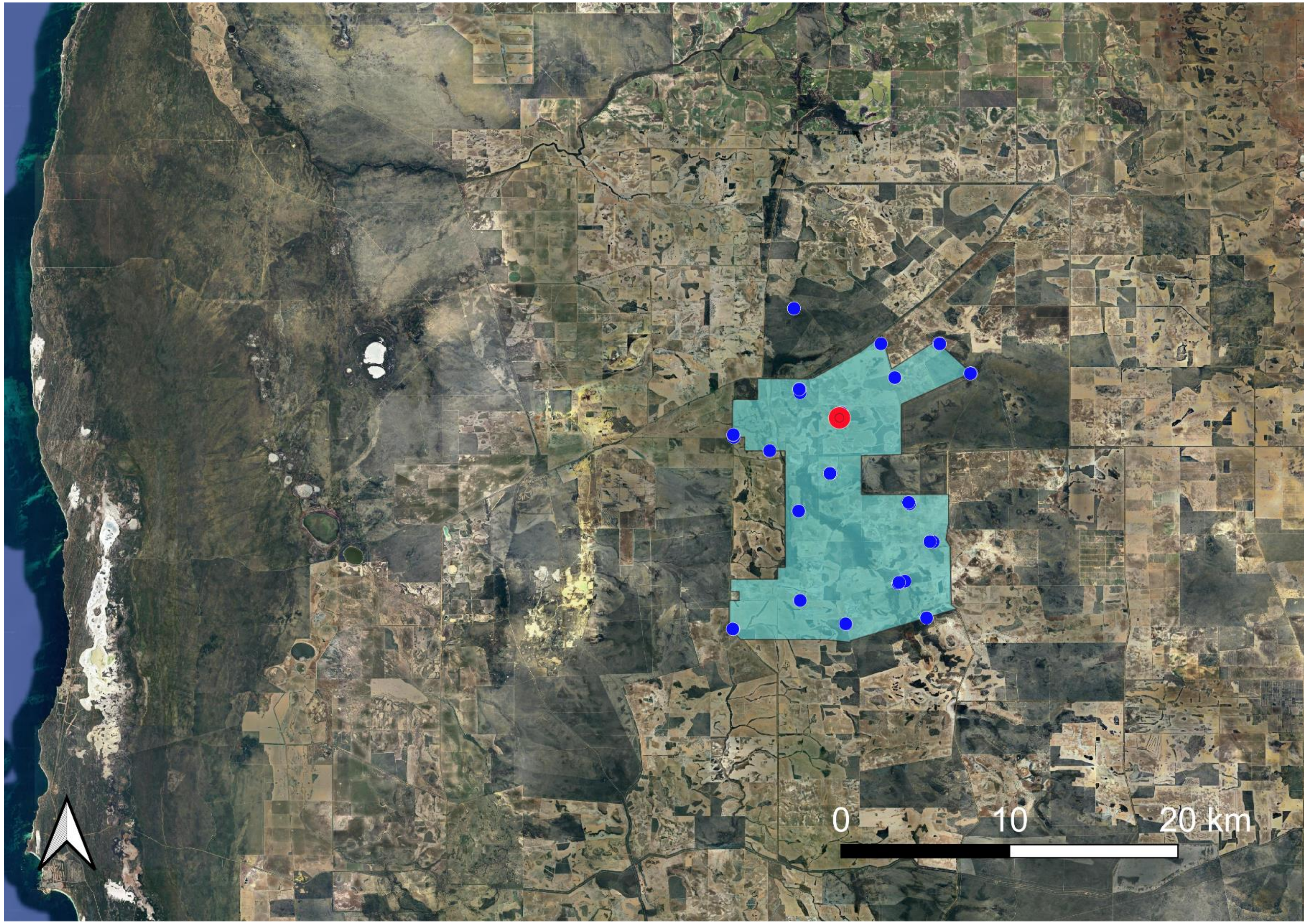

Figure 1. Locations of recording sites at Tathra, Western Australia (blue: Vantage Points; red: Met Mast).

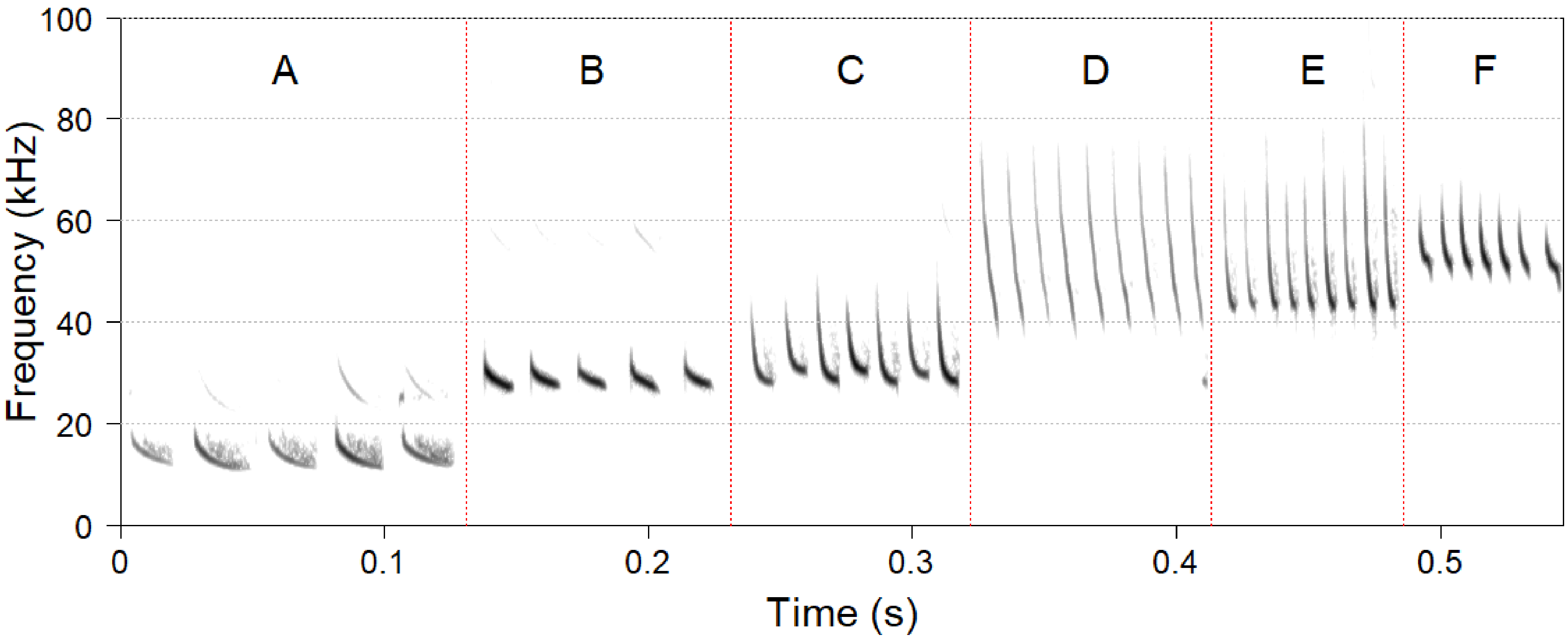

Figure 2. Representative echolocation call sequence portions of the species identified (**A**: *Austronomus australis*; **B**: *Ozimops kitcheneri*; **C**: *Chalinolobus gouldii*; **D**: *Nyctophilus geoffroyi*; **E**: *Vespadelus regulus*; **F**: *Chalinolobus morio*; time between pulses has been compressed).

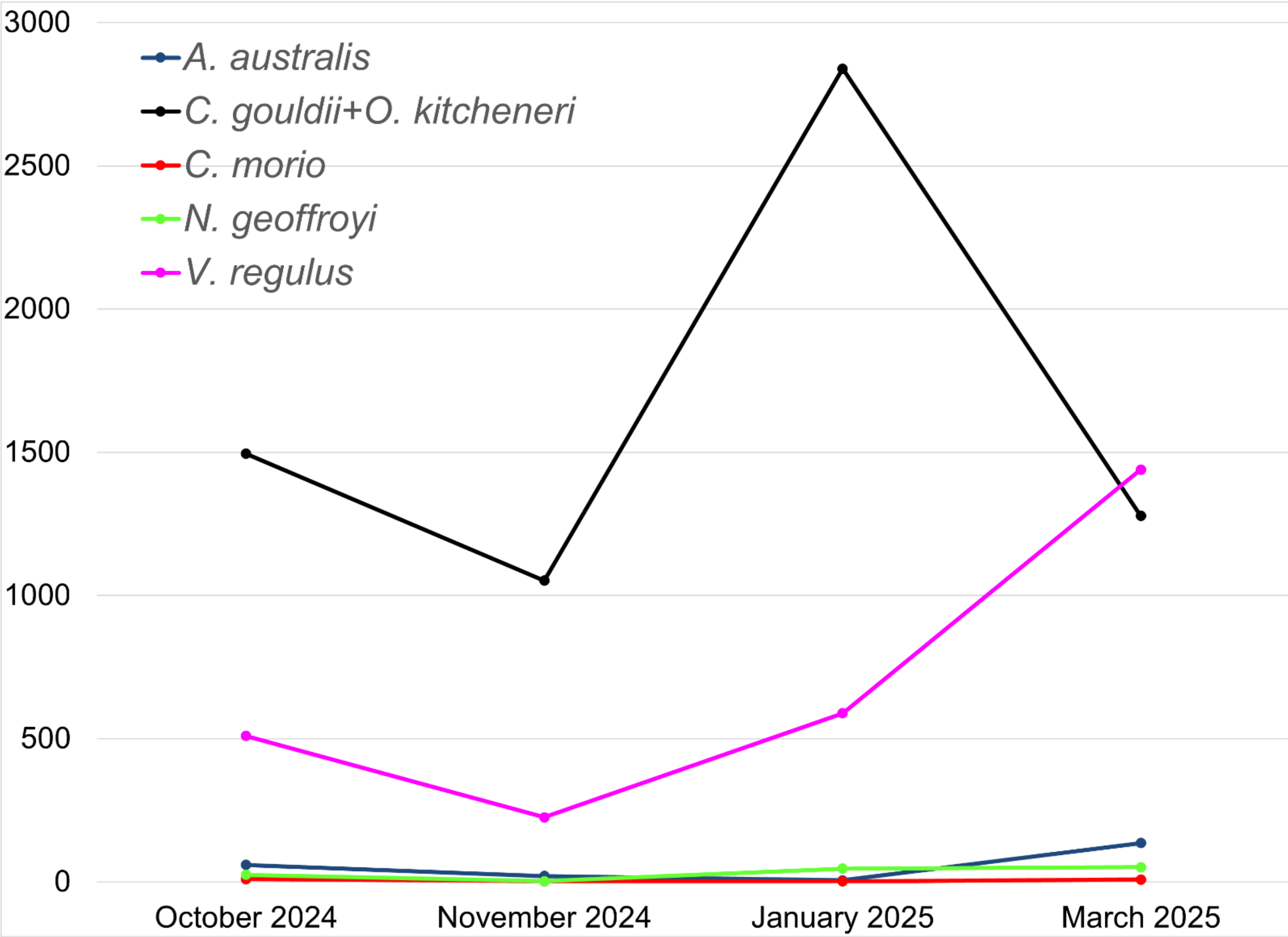

Figure 3. Rate of Encounter for each bat species over all nights combined per survey.

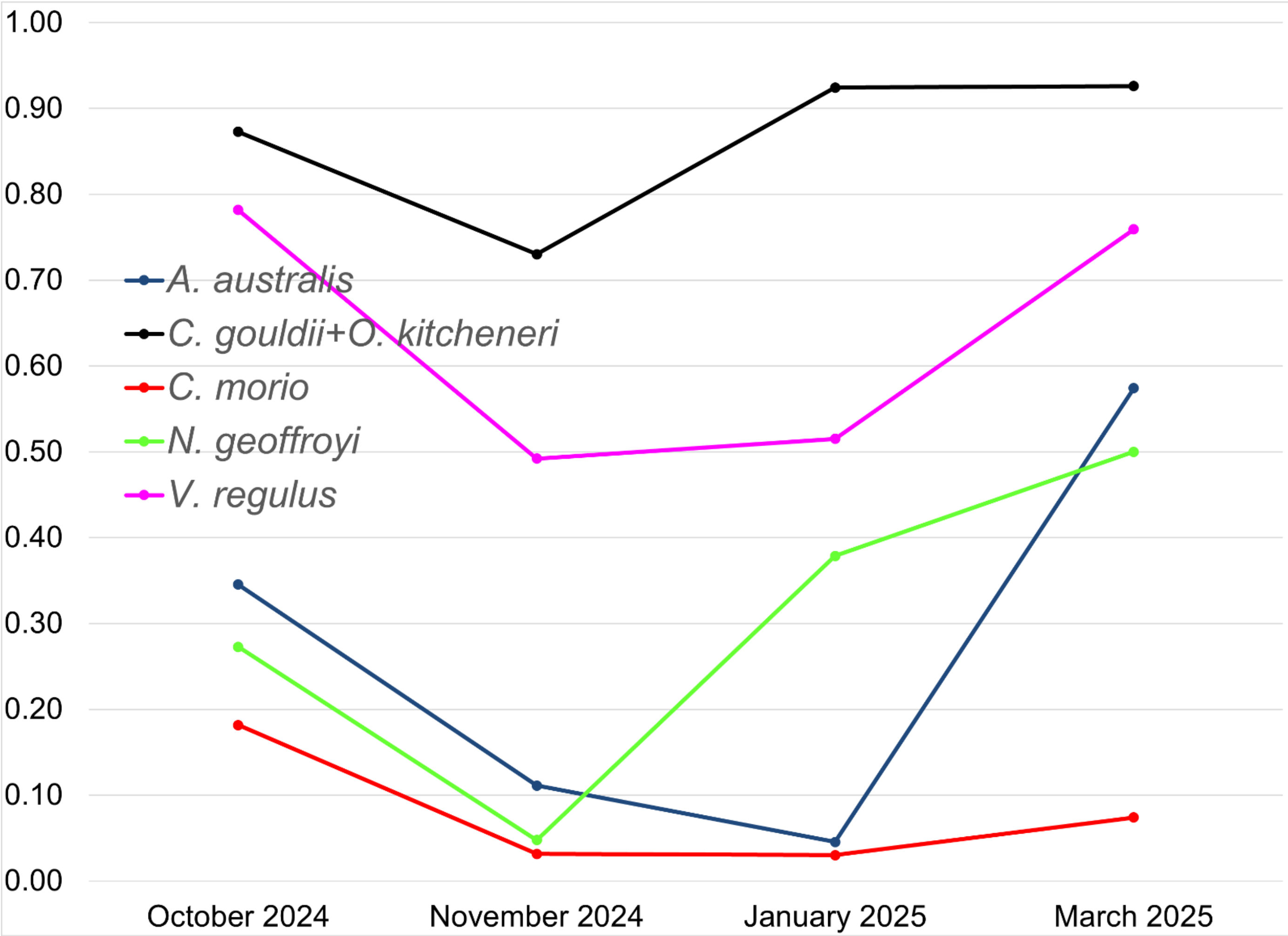

Figure 4. Frequency of Detection for each bat species over all nights combined per survey.

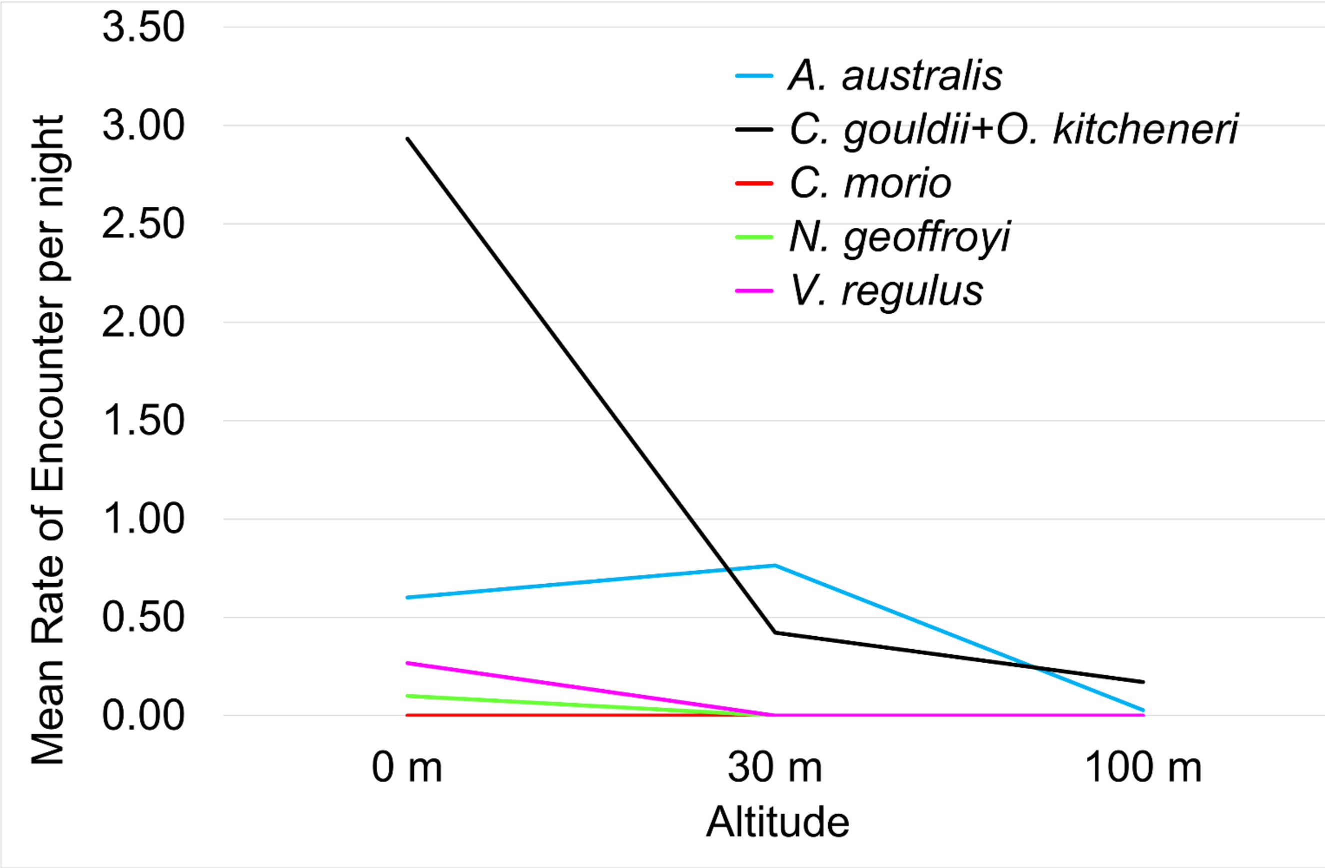

Figure 5. Patterns of Rate of Encounter (averaged over all nights) for each species at each sampling height.

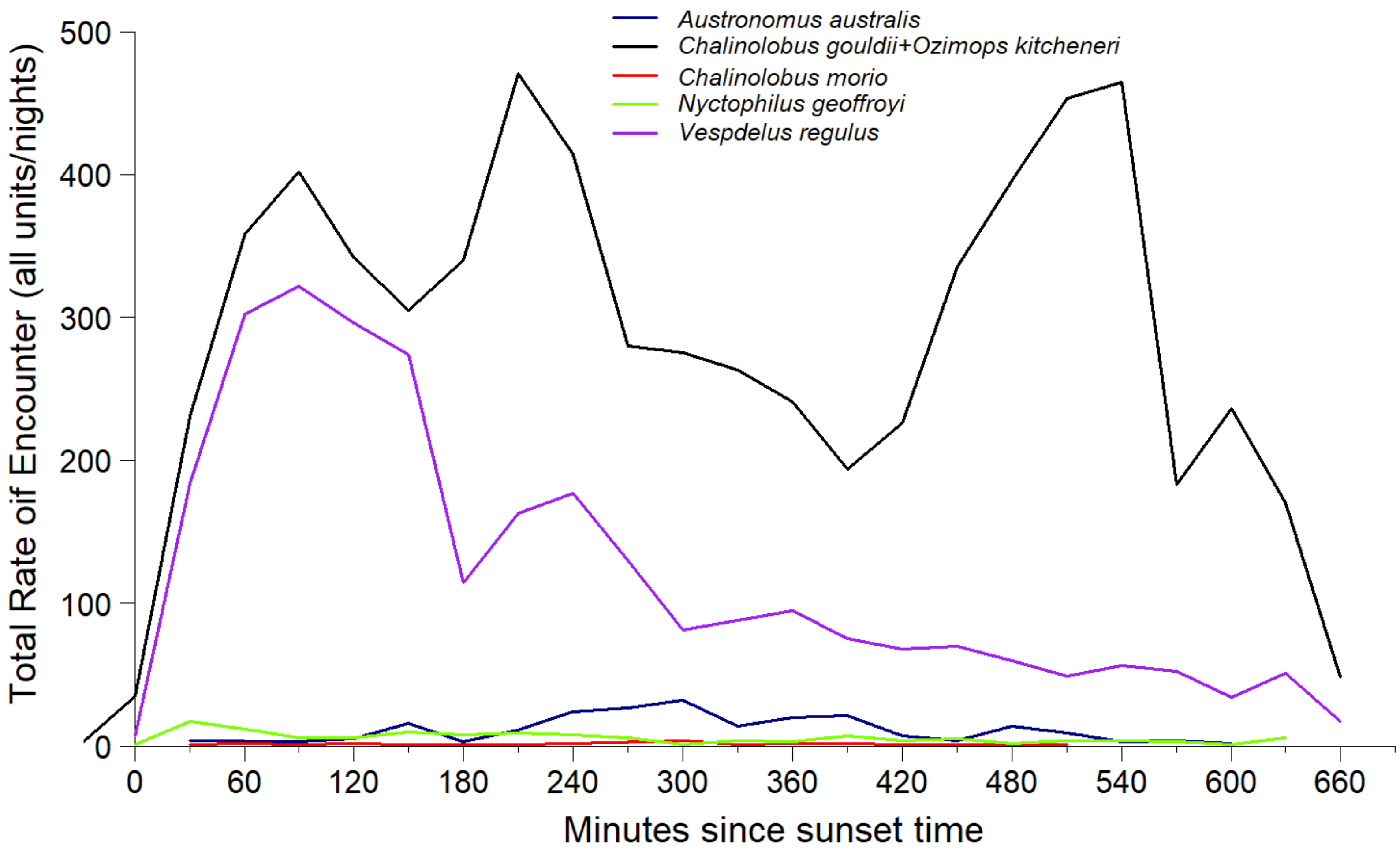

Figure 6. Comparison of activity levels between the two bat species detected and over the course of the night (calculated by summing all Rates of Encounter per species and dividing into 30-minute bins after the calculated time of sunset).

Appendix 1. Choosing metrics

Careful consideration was given to choosing a metric to estimate how common each species of bat was in the project area. It is important to understand the limitations of bat detector recordings for questions that seek an understanding of 'commonness'. Several metrics were deemed to be inappropriate given these limitations, and the chosen metrics were considered in the context of an appropriately-worded question and its assumptions.

Number of individuals. Bat detectors cannot be used to estimate true abundance (number of individuals) because it is not possible to determine how many individuals contribute to a particular ultrasonic recording. Thus, it is not possible to determine 'local population size' directly.

Relative abundance. Likewise, it is not possible to calculate relative abundance, because this metric is also derived from a count—it is the proportion or percentage of individuals of one species compared to the total number of individuals from all species within a given community or ecosystem. The output metric is a decimal value between 0 and 1 that sums to 1.0 across all species at a particular site.

Activity levels ('Rate of Encounter' herein). The number of WAV files containing a call type for each recording night at each site (with the duration of each WAV file standardised and stated). In pre-construction environmental assessments for wind energy projects in other parts of Australia, it is common for consultancy reports to contain compiled totals of the number of bat detector sound files that contain an echolocation sequence of each species. This measure is compared over time (seasonal and yearly survey periods) at the same sites to document trends in levels of presence, and differences between major habitat types; and it is sometimes compared across project areas and regions. This is a reasonable approach but there are numerous biases that contribute to the totals for each species, and reports do not always state them explicitly or make mention of how they were controlled:

- Some individual bats might linger near a particular bat detector for longer periods than other species or individuals, inflating how common they appear to be. This can be addressed somewhat by maximising the number of sampling site replicates and sampling nights.
- How well the echolocation calls of certain species, especially those of conservation significance, can be distinguished from the calls of other bat species.
- The consistency with which the same and different analysts will allocate particular echolocation sequence examples to candidate species within and across datasets when manually identifying calls from spectrogram images.
- The consistency and accuracy of the performance of custom automated identification routines developed by different analysts in commercial software programmes (e.g., Titley Scientific ANABAT INSIGHT; Wildlife Acoustics KALEIDOSCOPE); and in comparison to the more advanced custom system used here.
- The lack of standard identification models for regions or species of interest.

- Biases in sampling design, such as habitat representation, microphone orientation and microphone condition, and bat detector types (some models of certain brands have microphones with different capabilities), and trigger settings on bat detectors.

Occupancy ('Frequency of Detection' herein). This is a measure based on Species Richness; it reports the proportion of sampling sites plus nights where each species was detected. Ideally the number of sampling nights per site would be standardised where bat detectors are left for more than one night, so sampling effort and therefore probability of detection would be equivalent amongst sites. The output metric is a decimal value between 0 and 1 that does not sum to 1.0 across all species. In this report the term 'Frequency of Detection' is used to avoid confusion with a more sophisticated approach called 'occupancy modelling' (*sensu* MacKenzie et al. 2002), which accounts for (estimates) detectability and reports the probability that a site is truly occupied.

Given the sampling design and the various constraints discussed above, two appropriate metrics for wind energy projects are **Frequency of Detection** and **Rate of Encounter**. These metrics can directly address the following question:

How common is each species of bat across the project area?

The assumptions include:

- The sampling design and intensity (sampling sites and nights) was sufficient to provide a good estimate.
- Microphone condition in the bat detectors was good and relatively consistent amongst units.
- The detectability of each species is approximately equal (this will be violated for some species).

Appendix 2. Collision Risk

To understand the Collision Risk of different bat species for wind energy projects, it can be useful to apply a modified generic risk matrix (**Box 1**).

In place of 'Probability' (rows), this scheme uses the Frequency of Detection values calculated across all sites surveyed, as sorted into four frequency ranges between 0 and 1.

In place of 'Consequence' (columns), it uses three likelihood categories of the species being present above 50 metres in altitude (turbine absent). The predicted 'presence' (defined as 'occasional or regular forays into this range') above 50 metres in altitude is an authoritative designation based on accumulated casual field observations and general knowledge from various sources, and as a precautionary consideration in the absence of data collected in a systematic study (K. Armstrong). If a better, quantitative, understanding of how often different species occur in different altitudinal bands (in this project area specifically), this would require the application of either a specialist radar, or a stereo thermal vision system paired with an ultrasonic recorder.

The final score in the matrix is then divided and used to derive three collision risk categories.

Box 1. A Collision Risk score calculator (**above**), and derived categorisation of risk level (**below**).

	Likelihood of presence above 50 metres altitude	**Low**	**Medium**	**High**
Frequency of detection		1	2	3
0 – 0.25	1	1	2	3
0.25 – 0.50	2	2	4	6
0.50 – 0.75	3	3	6	9
0.75 – 1.0	4	4	8	12

Risk Score from matrix	**Collision Risk**
1 – 2	Low risk
3 – 6	Medium risk
7 – 12	High risk