

30 April 2025

Our ref: 25GWS10241

Holcim Australia Pty Ltd
Hume Highway
Marulan
NSW 2579

Attention: Wayne Beattie

Dear Wayne,

Lynwood Quarry, Marulan Biodiversity Offset Area Fauna Survey 2025

Eco Logical Australia Pty Ltd (ELA) was engaged by Holcim Australia to undertake a Fauna Assessment of the Lynwood Quarry Project's Biodiversity Offset Area (BOA), in Marulan NSW. This was conducted in compliance with condition 2 of the approval requirements outlined in an Email dated 26 August 2024 by the Commonwealth Department of Climate Change, Energy, the Environment and Water (DCCEEW).

This letter describes the methods and results of the baseline Fauna Assessment conducted between the period of 11 February and 5 March 2025.

If you have any questions regarding the information presented in this letter, please contact me on 0456072551.

Regards,



Michael Gregor
Ecologist

Appendix A Methodology and results

1.1. Fauna Assessment

The Fauna Assessment conducted for the Lynwood Quarry Project, in Marulan NSW, was based on multifaceted baseline surveys undertaken on two different field trips conducted across the Biodiversity Offset Area (BOA), by two teams of ELA Ecologists between the 11th of February and the 5th of March 2025. This approach included the deployment of monitoring devices for 22 nights (remote cameras and ultrasonic detectors), as well as a series of other field surveys conducted by both ELA teams, as detailed below.

1.1.1. Remote Cameras

Ten Reconyx remote cameras were deployed across the BOA in areas that were considered to have high potential for fauna activity (Figure 2). They were installed across the BOA on 11 and 12 February by ELA ecologists Elliott Poulter and Ryan El Kassouf. Nine cameras were installed at or near ground level targeting terrestrial fauna, and one camera was installed on a tree in an area with several visible hollows, targeting arboreal fauna. Cameras were placed in areas with signs of animal activity or areas with good quality habitat, such as burrows or hollow logs and were baited with universal bait (rolled oats, peanut butter and honey mixture). All cameras were collected on the 5 March 2025 by ELA ecologists Hamish Pritchard and Tim Finter.

The remote cameras analysis identified thirteen fauna species within the BOA, of which ten were native species and three were introduced (exotic and domestic). No threatened species were recorded. domestic sheep (*Ovis aries*) were recorded in the northern section of the BOA, while European red foxes (*Vulpes vulpes*) were prominent throughout the area, even recorded hunting in pairs. The results for each camera is shown in Table 1.

1.1.2. Ultrasonic Detectors

Four Titley Anabat Swift bat detectors were installed by ELA ecologists Elliott Poulter and Ryan El Kassouf on 11 and 12 February, at locations considered to have high potential for microbat use across the BOA (**Error! Reference source not found.**). All cameras were collected on the 5 March 2025 by ELA ecologists Hamish Pritchard and Tim Finter.

The ultrasonic analysis is provided in Appendix B.

1.1.3. Bird Surveys

In total, eight Bird surveys were conducted by both ELA team (4 dawn surveys and 4 dusk surveys). These consisted of a 20-minute bird census survey (using binoculars) within a search area of 2 ha in suitable habitat (Figure 2). The surveys were undertaken by ELA ecologists Elliott Poulter and Ryan El Kassouf over the afternoon of 11 February, morning and afternoon of 12 February and the morning of 13 February. Afternoon bird surveys were also conducted by ELA ecologists Hamish Pritchard and Tim Finter on the 4 and 5 March. Morning surveys occurred between 06:00 and 10:00 and afternoon surveys between 16:00 and 19:00. Rainy weather affected bird activity on the afternoon of the 11 February, but bird activity was considered reasonably high at most other survey times.

The bird survey results are provided in Table 2.

1.1.4. Spotlight surveys

Two spotlight surveys for nocturnal fauna were undertaken by ELA ecologists Hamish Pritchard and Tim Finter across the BOA on the nights 4 and 5 March 2025 (Figure 2). Surveys commenced after sunset beginning at approximately 20:00. Both nights were cool in temperature, clear conditions with some clouds and a moon in its first quarter. Spotlighting transects targeted areas containing canopy vegetation and ground structural habitat such as logs, timber and rocky areas to increase likelihood of observation for a variety of species including arboreal mammals, reptiles and amphibians. Transects varied in length, dependant on the patch of vegetation being surveyed, but all were spaced at least 100 m apart. Transects were transversed with both ecologists spaced at least 50 meters apart to increase coverage of vegetation and minimise double counting of individuals.

The spotlighting surveys only identified *Trichosurus vulpecula* (common brushtail possum) and *Pseudocheirus peregrinus* (ringtail possum) during the second transect on the first night of surveying. No other species were recorded during these nocturnal surveys.

1.2. Discussion

Seventy-three fauna species were identified across all field survey efforts. Of which, five were threatened native species, five exotic fauna species and sixty two non-threatened native species. The full list of species is shown in Table 3. The species identified only as potentially present from the ultrasonic analysis have been excluded from this list. Additional surveys with more targeted methods would be required to confirm the presence of these species.

The remote camera analysis and surveys identified a low level of small mammals with only one *Antechinus* sp detected during the 22 nights of camera surveys. Additional to this a high density of European red fox was detected with the species identified at all ground level camera locations. The high density of foxes will likely continue to impact small mammal densities if left unmanaged. Foxes and other pest species should be controlled as part of a wider landscape pest control plan to reduce numbers.

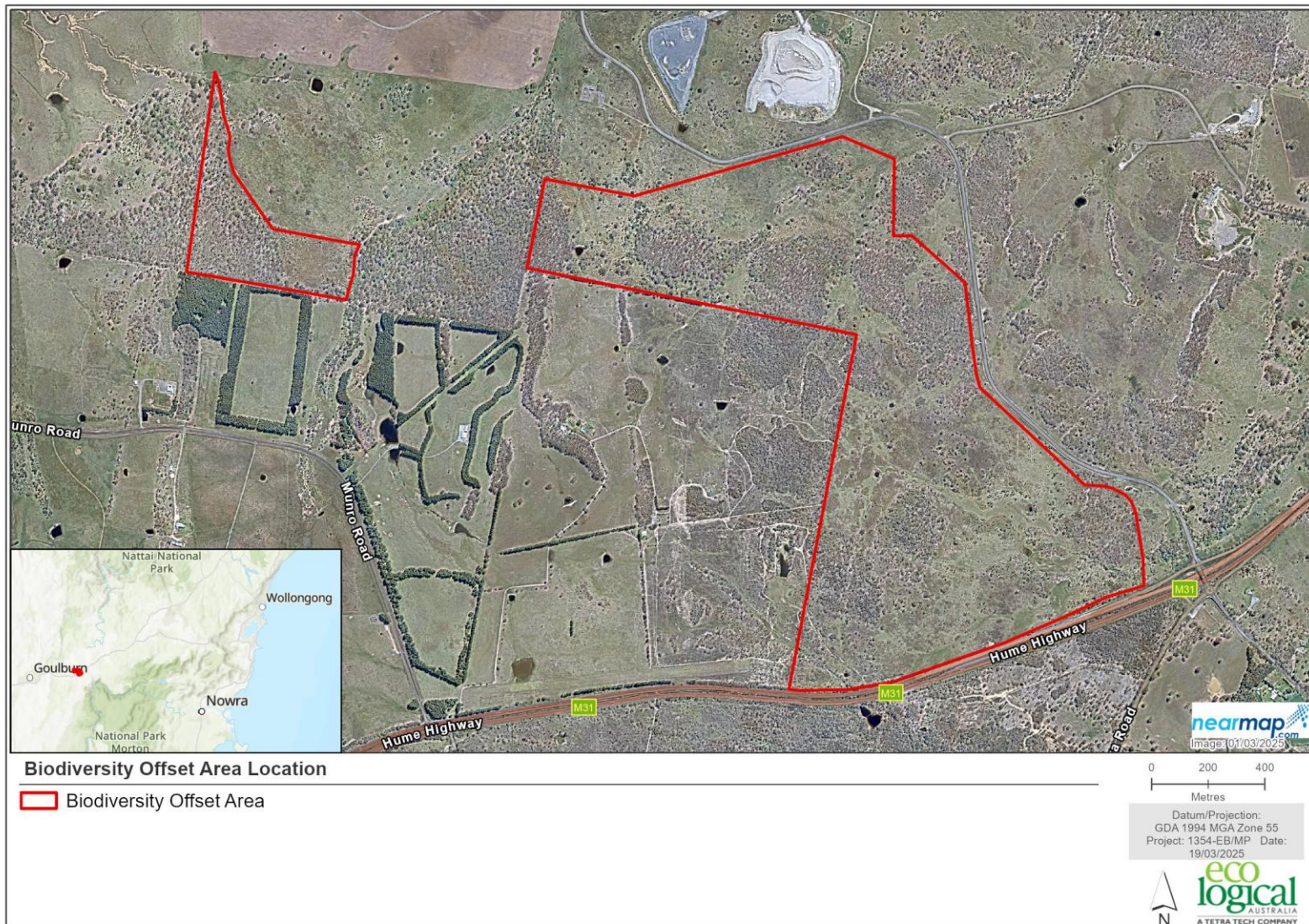


Figure 1: Biodiversity Offset Area Location

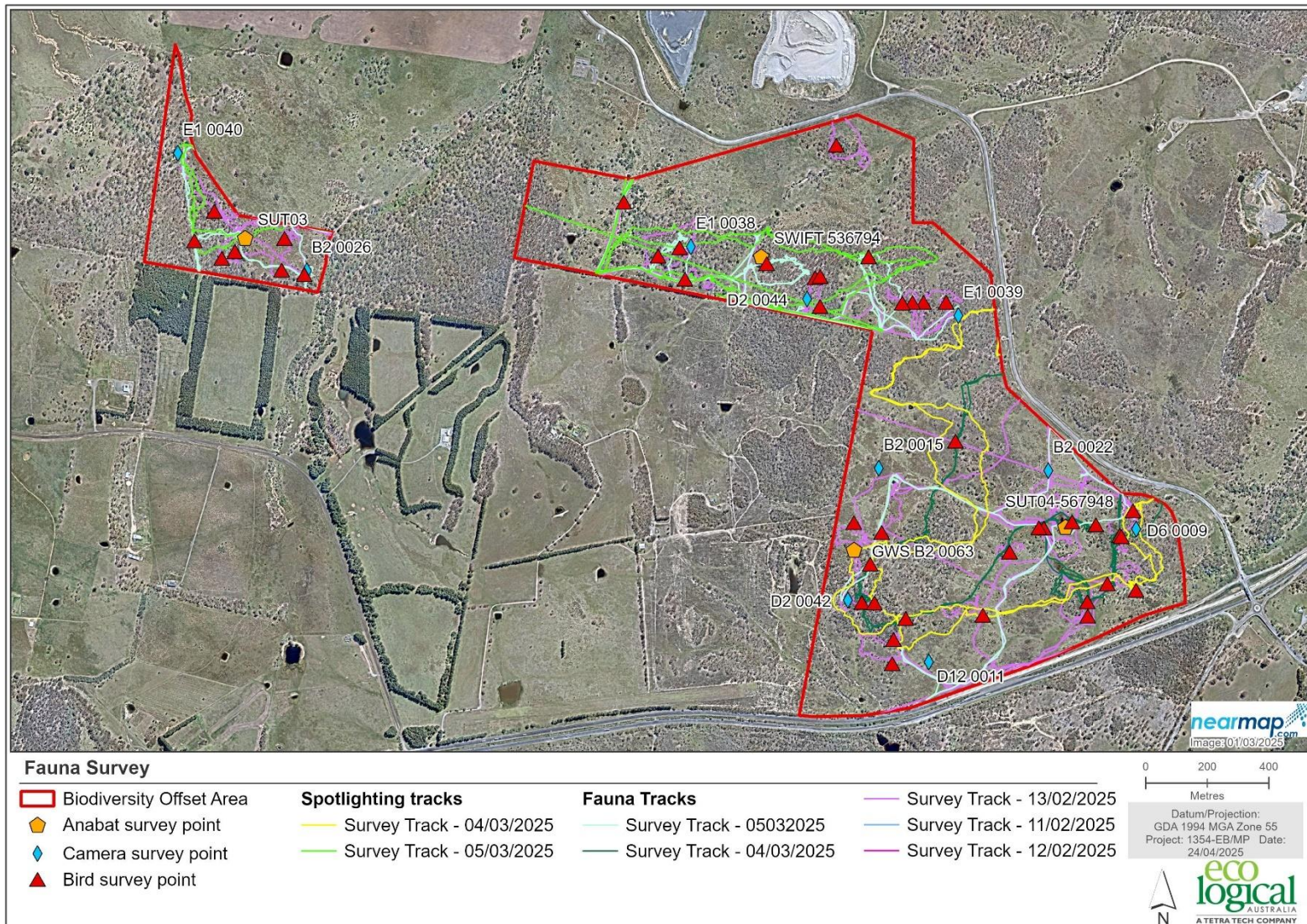


Figure 2: Fauna survey effort

Table 1: Fauna results from remote cameras

Fauna type	Species name	Common name	Photo analysis										
			B2 0015	B2 0022	B2 0026	B2 0042	D12 0011	D2 0044*	D6 0009	E1 0038	E1 0039	E1 0040	
Exotic	<i>Lepus europaeus occidentalis</i>	European Brown Hare			X					X	X		
	<i>Vulpes vulpes</i>	European Red Fox	X	X	X	X	X		X	X	X	X	X
	<i>Ovis aries</i>	Domestic Sheep											X
Native	<i>Gymnorhina tibicen</i>	Australian Magpie	X							X			
	<i>Ardea pacifica</i>	Pacific Heron	X										
	<i>Anas superciliosa</i>	Pacific Black Duck	X										
	<i>Wallabia bicolor</i>	Swamp Wallaby	X		X	X	X	X	X	X	X	X	X
	<i>Macropus giganteus</i>	Eastern Grey Kangaroo	X	X	X	X	X	X	X	X	X	X	X
	<i>Petaurus breviceps</i>	Sugar Glider							X				
	<i>Trichosurus vulpecula</i>	Common Brushtail Possum									X		
	<i>Vombatus ursinus</i>	Wombat								X			
	<i>Antechinus sp.</i>												X
	<i>Varanus varius</i>	Lace Monitor									X		

Table 2: Bird results from surveys

Bird Species	Common Name	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	
<i>Acanthiza lineata</i>	Striated Thornbill																X																	X	
<i>Acanthiza nana</i>	Yellow Thornbill																						X												
<i>Acanthiza pusilla</i>	Brown Thornbill		X			X	X							X			X		X	X		X	X			X			X	X	X			X	
<i>Acanthiza reguloides</i>	Buff-rumped Thornbill		X	X	X			X						X		X	X			X			X	X			X				X				
<i>Aegotheles cristatus</i>	Australian Owlet-nightjar							X																											
<i>Anas superciliosa</i>	Pacific Black Duck																																		
<i>Anthochaera carunculata</i>	Red Wattlebird							X				X																							
<i>Aquila audax</i>	Wedge-tailed Eagle											X										X			X										
<i>Ardea pacifica</i>	White-necked Heron																	X																	
<i>Cacomantis flabelliformis</i>	Fan-tailed Cuckoo											X										X													
<i>Caligavis chrysops</i>	Yellow-faced Honeyeater						X																	X											
<i>Colluricincla harmonica</i>	Grey Shrike-thrush		X				X			X						X					X							X							
<i>Calyptorhynchus lathami</i>	Glossy Black-Cockatoo																					X													
<i>Coracina novaehollandiae</i>	Black-faced Cuckooshrike	X					X		X			X										X	X					X	X						
<i>Corcorax melanorhamphos</i>	White-winged Chough				X																														
<i>Cormobates leucophaea</i>	White-throated Treecreeper		X	X	X	X	X	X	X	X						X	X					X				X				X	X	X	X	X	X
<i>Corvus coronoides</i>	Australian Raven	X	X		X		X	X	X					X			X						X						X		X	X	X	X	X
<i>Corvus mellori</i>	Little Raven						X														X														
<i>Cracticus torquatus</i>	Grey Butcherbird	X			X	X	X	X	X					X			X					X							X			X	X		
<i>Cygnus atratus</i>	Black Swan								X																										
<i>Dacelo novaeguineae</i>	Laughing Kookaburra	X														X																			
<i>Daphoenositta chrysoptera</i>	Varied Sittella												X																						
<i>Eolophus roseicapilla</i>	Galah				X	X			X																										
<i>Gerygone mouki</i>	Brown Gerygone																							X											
<i>Gerygone olivacea</i>	White-throated Gerygone																						X	X											
<i>Grallina cyanoleuca</i>	Magpie-lark				X	X	X		X																										
<i>Gymnorhina tibicen</i>	Australian Magpie	X			X	X	X	X	X			X		X		X	X	X	X	X	X	X			X	X			X						
<i>Hirundo neoxena</i>	Welcome Swallow																																		
<i>Malurus cyaneus</i>	Superb Fairywren	X	X		X					X	X	X		X		X	X	X		X					X	X		X							
<i>Manorina melanocephala</i>	Noisy Miner				X	X	X		X			X																	X	X					
<i>Neochmia temporalis</i>	Red-browed Finch				X												X	X	X					X		X									
<i>Nesoptilotis leucotis</i>	White-eared Honeyeater																							X											
<i>Pachycephala rufiventris</i>	Rufous Whistler				X	X					X												X						X						
<i>Pardalotus punctatus</i>	Spotted Pardalote	X			X			X																					X	X		X	X		
<i>Pardalotus striatus</i>	Striated Pardalote							X																											
<i>Petroica boodang</i>	Scarlet Robin				X			X															X			X									
<i>Phaps chalcoptera</i>	Common Bronzewing					X																													
<i>Philemon corniculatus</i>	Noisy Friarbird	X					X				X	X				X			X				X												
<i>Platycercus elegans</i>	Crimson Rosella	X			X	X	X	X															X				X		X	X		X	X		X
<i>Platycercus eximius</i>	Eastern Rosella																												X						
<i>Psephotus haematonotus</i>	Red-rumped Parrot								X																							X			
<i>Rhipidura albiscapa</i>	Grey Fantail		X		X			X														X	X			X		X	X	X	X	X	X	X	X
<i>Rhipidura leucophrys</i>	Willie Wagtail																							X		X									

Bird Species	Common Name	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	
<i>Sericornis frontalis</i>	White-browed Scrubwren												X					X	X																
<i>Strepera graculina</i>	Pied Currawong		X			X										X	X																		
<i>Sturnus vulgaris</i>	Common Starling					X																													
<i>Synoicus ypsilophorus</i>	Brown Quail					X																													
<i>Zosterops lateralis</i>	Silvereeye						X							X			X	X		X															

Table 3: Full list of fauna species identified within the BOA

Fauna Type and Class	Species name	Common name
Exotics		
Mammalia	<i>Lepus europaeus occidentalis</i>	European Brown Hare
	<i>Ovis aries</i>	Domestic Sheep
	<i>Rusa unicolor</i>	Sambar Deer
	<i>Sturnus vulgaris</i>	Common Starling
Aves	<i>Vulpes vulpes</i>	European Red Fox
Threatened Natives		
Mammalia	<i>Miniopterus orianae oceanensis</i>	Large Bent-winged Bat
Aves	<i>Calyptorhynchus lathamii</i>	
	<i>Daphoenositta chrysoptera</i>	
	<i>Petroica boodang</i>	Scarlet Robin
	<i>Pyrrholaemus sagittatus</i>	Speckled Warbler
Non-Threatened Natives		
Mammalia		
	<i>Macropus giganteus</i>	Eastern Grey Kangaroo
	<i>Petaurus breviceps</i>	Sugar Glider
	<i>Pseudocheirus peregrinus</i>	Eastern Ringtail Possum
	<i>Trichosurus vulpecula</i>	Common Brushtail Possum
	<i>Wallabia bicolor</i>	Swamp Wallaby
	<i>Austronomus australis</i>	White-striped Free-tailed Bat
	<i>Chalinolobus morio</i>	Chocolate Wattled Bat
Aves		
	<i>Acanthiza lineata</i>	Striated Thornbill
	<i>Acanthiza nana</i>	Yellow Thornbill
	<i>Acanthiza pusilla</i>	Brown Thornbill
	<i>Acanthiza reguloides</i>	Buff-rumped Thornbill
	<i>Aegotheles cristatus</i>	Australian Owlet-nightjar
	<i>Anas superciliosa</i>	Pacific Black Duck
	<i>Anthochaera carunculata</i>	Red Wattlebird
	<i>Aquila audax</i>	Wedge-tailed Eagle
	<i>Ardea pacifica</i>	White-necked Heron
	<i>Cacomantis flabelliformis</i>	Fan-tailed Cuckoo
	<i>Caligavis chrysops</i>	Yellow-faced Honeyeater
	<i>Colluricincla harmonica</i>	Grey Shrikethrush
	<i>Coracina novaehollandiae</i>	Black-faced Cuckooshrike
	<i>Corcorax melanorhamphos</i>	White-winged Cough
	<i>Cormobates leucophaea</i>	White-throated Treecreeper
	<i>Corvus coronoides</i>	Australian Raven
	<i>Corvus mellori</i>	Little Raven
	<i>Cracticus torquatus</i>	Grey Butcherbird
	<i>Cygnus atratus</i>	Black Swan

Fauna Type and Class	Species name	Common name
	<i>Dacelo novaeguineae</i>	Laughing Kookaburra
	<i>Daphoenositta chrysoptera</i>	Varied Sittella
	<i>Eolophus roseicapilla</i>	Galah
	<i>Gerygone mouki</i>	Brown Gerygone
	<i>Gerygone olivacea</i>	White-throated Gerygone
	<i>Grallina cyanoleuca</i>	Magpie-lark
	<i>Gymnorhina tibicen</i>	Australian Magpie
	<i>Hirundo neoxena</i>	Welcome Swallow
	<i>Malurus cyaneus</i>	Superb Fairywren
	<i>Manorina melanocephala</i>	Noisy Miner
	<i>Neochmia temporalis</i>	Red-browed Finch
	<i>Nesoptilotis leucotis</i>	White-eared Honeyeater
	<i>Pachycephala rufiventris</i>	Rufous Whistler
	<i>Pardalotus punctatus</i>	Spotted Pardalote
	<i>Pardalotus striatus</i>	Striated Pardalote
	<i>Phaps chalcoptera</i>	Common Bronzewing
	<i>Philemon corniculatus</i>	Noisy Friarbird
	<i>Platycercus elegans</i>	Crimson Rosella
	<i>Platycercus eximius</i>	Eastern Rosella
	<i>Psephotus haematonotus</i>	Red-rumped Parrot
	<i>Rhipidura albiscapa</i>	Grey Fantail
	<i>Rhipidura leucophrys</i>	Willie Wagtail
	<i>Sericornis frontalis</i>	White-browed Scrubwren
	<i>Strepera graculina</i>	Pied Currawong
	<i>Synoicus ypsilophorus</i>	Brown Quail
	<i>Zosterops lateralis</i>	Silvereye
Reptilia		
	<i>Chelodina longicollis</i>	Eastern Snake-necked Turtle
	<i>Hemiergis talbingoensis</i>	Eastern three-toed Earless Sunskink
	<i>Lampropholis delicata</i>	Dark-flecked Garden Sunskink
	<i>Pseudechis porphyriacus</i>	Red-bellied Black Snake
Amphibia		
	<i>Crinia parinsignifera</i>	Eastern Sign-bearing Froglet
	<i>Crinia signifera</i>	Common Eastern Froglet
	<i>Limnodynastes tasmaniensis</i>	Spotted Marsh Frog
	<i>Litoria peronii</i>	Peron's Tree Frog
	<i>Litoria verreauxii</i>	Whistling Tree Frog
	<i>Uperoleia laevigata</i>	Smooth Toadlet

Appendix B Ultrasonic analysis



Lynwood Quarry BGWMP update, Marulan NSW

Ultrasonic call analysis microbat report

Holcim (Australia) Pty Ltd

Document Tracking

Project Name: Lynwood Quarry BGWMP update

Project Number: 25GWS10241

Project Manager: Michael Gregor

Version	Prepared by	Reviewed by	Approved by	Status	Date
V2	Kylie Lopes	Rodney Armistead	May-Le Ng & Frank Lemckert	Final	02/05/2025

Contents

1. Background	1
2. Methods	1
1.1. Ultrasonic data collected at the study area.....	1
1.2. Candidate species	2
1.3. Call analysis	2
1.3.1. General rules for bat call identification	2
1.3.2. Limitations of call analysis	3
1.4. Reporting	4
3. Results	4
1.5. Species occurrence	5
4. Discussion and conclusion	6
5. References	6

List of Tables

Table 1. Location of survey sites and information on data recorded at all sites.	1
Table 2. Settings for the four detectors deployed.	2
Table 3. Occurrence of bat species at four sites in the study area.	5
Table 4: Occurrence of bat species by complex.....	5

List of Appendices

- Appendix A Candidate Species
- Appendix B Example calls from this dataset

2. Background

The purpose of this project was to undertake targeted species surveys for microchiropteran bats (microbats) and to analyse ultrasonic bat call data to determine the species assemblage present within the Lynwood Quarry Box Gum Woodlands Management Plan (BGWMP) site in Marulan, NSW (the study area). This report forms part of the required *Environment Protection and Biodiversity Protection Act 1999* (EPBC Act) annual monitoring required for the site (for EPBC Act approval 2012/6560). The species assemblages will give an indication of the health and structure of the habitat provided and help to support continuation/adaptation of management actions on the site.

There is a dam located within the study area as well as woodland habitat and derived native grassland. There are no known subterranean roost habitats or rocky areas containing escarpments, potential overhangs or outcrops within the study area. However, some caves occur approximately 10 km to the south of the site.

This survey was undertaken to:

- Identify the microbat species present at the site.

This report contains a brief description of the methods for ultrasonic recording of microbat calls, describes the methods used to analyse the microbat call data and provides the results of this analysis for the project.

3. Methods

1.1. Ultrasonic data collected at the study area

Four sites were surveyed passively using Song Meter Mini Bats (Wildlife Acoustics) recording in Waveform Audio File Format (WAV). Detectors were deployed between 11 January 2025 and 6 March 2025, and each detector was set to record ultrasonic call data across the entire night (recording commenced at dusk and concluded at dawn). A total of 16 survey nights were analysed from this survey, there were periods of undesirable weather within the survey period. Four nights of data captured during clear weather were selected for each detector for analysis period (4 nights from each detector) ensuring that periods of undesirable weather were omitted. The detector locations, survey dates, survey effort, and brief habitat description are summarised in Table 4. Settings for each of the detectors are in Table 5.

Table 4. Location of survey sites and information on data recorded at all sites.

Site ID	GPS location	Dates surveyed	No. detector nights	No. files	Habitat description
SUT03	149.945043°E 34.720707°S	11/02/25 - 14/02/25	4	596	Within Box Gum Woodland habitat, 500 m from a dam (to the SW). Habitat trees are nearby.
SUT04	149.974902°E 34.728583°S	20/02/25, 24/02/25, 28/02/25, 02/03/25	4	3,207	Within grassland habitat, no habitat trees present. Less than 20 m from a dam.

Site ID	GPS location	Dates surveyed	No. detector nights	No. files	Habitat description
SUT07	149.967410°E 34.729288°S	13/02/25, 26/02/25, 01/03/25, 03/03/25	4	4,497	Woodland fringe, habitat trees present. Within 200 m of a dam.
SWIFT536794	149.962735°E 34.720785°S	15/02/25, 21/02/25, 27/02/25, 03/03/25	4	2,372	Woodland fringe, habitat trees present. Within 500 m of a dam.
TOTAL	-	-	16	10,672	

Table 5. Settings for the four detectors deployed.

Site ID	Make and model	Gain/ Sensitivity	Trigger freq. (kHz)	Min. event time (ms)	Trigger window (sec)	Max. file length (sec)
SUT03	Anabat Swift	10	10 - 250	2	2	10
SUT04	Anabat Swift	12	10 - 250	2	2	10
SUT07	Anabat Swift	14	10 - 250	2	2	10
SWIFT536794	Anabat Swift	12	1 - 18	2	2	15

1.2. Candidate species

The study area is located on the border of the Southern and the Sydney Basin bioregion as described in (Pennay et al. 2004). Prior to analysing the data, a candidate list of microbat species known to, or deemed likely to occur in the region (approximately a 10km radius of the study area) was prepared by completing a search and a review of the Australian Bat Society 'BatMap' (2021), NSW BioNet database search tool (NSW DCCEEW 2025), and the Atlas of Living Australia website (2023). This search and review identified 19 microbat species that had previously been recorded or were considered likely to occur within a 10 km radius of the study areas (Appendix C).

1.3. Call analysis

Calls were analysed in Anabat Insight version 2.1.2-0-g3566bf9 (Titley Scientific 2025). Files were first run through the 'All Bats' filter to separate bat calls from noise files. Files that passed the 'All Bats' filter were processed through a decision tree that grouped and labelled files based on characteristic frequency (Fc) bands and removed files containing less than 3 pulses. 'Noise files' that don't meet these requirements are automatically moved to the Trash Folder. As a check, a sample of the trash files was viewed to ensure no useful bat calls were present.

Species were manually verified using the 'Bat calls of New South Wales' regional echolocation guide (Pennay et al. 2004) and the accompanying reference library of calls downloaded from the NSW Department of Environment and Planning website. Bat calls were analysed by Ecologist/Ultrasonic Bat Call Analyst, Kylie Lopes (Eco Logical Australia, ELA) with a subsample of calls reviewed by Senior Ecologist/ Ultrasonic Bat Call Analyst, Rodney Armistead (Rodney Armistead Environmental Consultant).

1.3.1. General rules for bat call identification

Bat call analysis uses species-specific call characteristics and parameters, including call shape, characteristic frequency, initial slope and time between pulses (Reinhold et al. 2001), to identify species

present at a location from the calls captured within the call dataset. To ensure reliable and accurate results, the following protocols (adapted from Lloyd, Goldingay & Law 2006) were followed:

- Call sequences not attributed to microbat calls (e.g. insect buzzes, wind, rain and anthropogenic noise) were dismissed from analysis,
- Recorded calls containing less than three pulses were not analysed and these sequences were labelled as unidentifiable, being too short to confidently determine the identity of the species producing the call (Law et al. 1999).
- Search phase calls were used in the analysis, rather than feeding buzzes or social calls (McKenzie et al. 2002). Feeding buzzes were only identified if there were sufficient search phase pulses before or after to aid the identification. Social calls are not typical of species, provide poor descriptive power and cannot be used for identification purposes.
- Call sequences of inferior quality (e.g. high proportion of fragmented pulses, high level of background noise or interference) and therefore not able to be identified to any bat species are labelled as unidentifiable.
- For those calls that are useful to identify the species making the call, two categories of confidence were used (Mills et al. 1996):
 - Present: the quality and structure of the call profile is such that the bat species may not be confused with other species
 - Potentially present: the quality and structure of the call profile is such that the bat species may be confused with other species that produce similar call profiles.

1.3.2. Limitations of call analysis

The study area occurs on the boundary of the two described bioregions (Southern and Sydney basin). The characteristic frequency can vary among some species between these bioregions due to this, calls can be difficult to attribute definitively to a species and complexes may be required.

Many microbat species produce calls that overlap in call profile parameters and cannot always be separated. Additionally, weather and climatic conditions affect the detectability of calls, and the quality of those calls recorded. Calls were only positively identified to species level when the defining characteristics were present and there was no chance of confusion between species with overlapping and / or similar calls. Calls that could not be positively identified to species level due to intermediate characteristics between multiple species were therefore given a species or genus complex.

Chalinolobus dwyeri calls may have an overlapping characteristic frequency (Fc) with *Saccolaimus flaviventris* between the 21 kHz – 23 kHz range. However, *C. dwyeri* calls can easily be distinguished from other species by the combination of the low frequencies and distinct pattern of alternating hooked pulses present in search phase calls around the 25 kHz frequency.

Chalinolobus gouldii, *Ozimops ridei* and *Micronomus norfolkensis* can be difficult to separate due to overlapping frequencies and similarities in pulse shape when individuals are responding to clutter. *Chalinolobus gouldii* was separated if Fc was approximately 28 to 33 kHz with alternating hockey stick shaped pulses present (Pennay et al. 2004). Non-alternating, relatively flat calls were assigned to *O. ridei* (Fc ≈ 30 kHz). *Micronomus norfolkensis* can be distinguished when the calls are of good quality with a characteristic tabletop shape (flat call with a downward sweeping start and end) and Fc between 32 – 35 kHz (Pennay et al. 2004).

Scoteanax rueppellii calls can overlap with *Falsistrellus tasmaniensis* and *Scotorepens orion*. *Falsistrellus tasmaniensis* calls lack upsweeping tails but can be difficult to distinguish if this characteristic is not

obvious in the data due to call quality recorded. Where calls overlap in Fc and could not be separated, a multi-species complex was used.

Miniopterus orianae oceanensis calls may overlap with *Vespadelus darlingtoni*, *V. regulus* and *V. vulturnus*. *Miniopterus orianae oceanensis* can be distinguished if the calls have a down-sweeping tail, long characteristic section and/or uneven consecutive pulses (Pennay et al. 2004). *Vespadelus vulturnus* sequences can be separated from *V. regulus* call sequences if the Fc is higher than 49 kHz and upsweeping curved pulses are present. *Vespadelus darlingtoni* and *V. regulus* can overlap within the boundary between these bioregions and will be considered as a complex.

Myotis macropus calls are difficult to reliably separate from *Nyctophilus* spp. *Myotis macropus* calls are steep, near vertical frequency modulated (FM) and can have a central kink. Calls start at between 70 – 80 kHz and usually drop to between 35 – 40 kHz. *Myotis macropus* call pulse shape is generally not uniform, whereas *Nyctophilus* spp. pulses are mostly parallel and uniform (Greg Ford, Pers. Comm). *Myotis macropus* can sometimes be separated by having a pulse interval <75ms, and an initial slope that is greater than 400 OPS (Pennay et al. 2004). Sometimes they can be separated if call recordings are of a very high quality allowing for specific features within *M. macropus* calls to be seen. However, in most cases, it is not possible to distinguish *M. macropus* from *Nyctophilus* spp. and as such will be considered as a species complex.

1.4. Reporting

This report adheres to the standards outlined by the Australasian Bat Society Inc. for reporting on microbat surveys using bat detectors (Australasian Bat Society 2006). Species taxonomic lists and nomenclature adheres to Armstrong et al. (2020).

4. Results

A total of 10,672 files were analysed from 4 sites within the Lynwood Quarry BGWMP study area, NSW. Detectors were deployed at an appropriate time of year to survey for the target microbat species (as outlined in DPIE 2021). Of the files recorded, 5,125 were deemed to be 'noise' and did not pass the 'All Bats' and 'minimum 3 pulse' filters. A sample set of these 'noise' files were checked to ensure that the filter was operating correctly and to confirm that no bat calls were being incorrectly removed. These files were anthropogenic noise, insects and other non-identifiable sounds. No bat calls were found within the 'noise' files. A total of 5,547 files passed the 'All Bats' and 'minimum 3 pulse' filters and were then sorted by characteristic frequency and given species labels based on these metrics. Files were selectively manually checked.

Data was of comparable quality from all detectors except SUT07. Approximately 79% of recorded files on SUT07 were 'noise' files that didn't pass initial filters (3,576 out of 4,497 calls), of the files that passed filters none were found to contain identifiable bat calls. The sensitivity for SUT07 was high (set at 14) which may account for some of the noise captured but is unlikely to account for the lack of bat calls within the files, this is addressed further in Section 5. Efforts were made to extract calls from within the files using modifications to analysis settings in case the noise was obscuring bat calls within the files, however no bat calls were found.

Despite undesirable trigger frequency settings for SWIFT536794 (min Fc 1 kHz, max Fc 18 kHz) this detector recorded a comparable number of species to SUT03 and SUT04. The call quality captured by this detector was less than that captured by SUT03 and SUT04. A smaller proportion of calls were able to be identified to species level and as a result, many were deemed to indicate potential presence of species within complexes.

Due to call complexities within this region, and a high number of non-typical call patterns and potential social calls, many species were only able to be identified into complexes.

1.5. Species occurrence

Bat species occurrence at all sites, including those found within complexes, are listed in Table 6 with their presence and potential presence (due to lack of identifying features or detection of a complex) at each detector. Species complexes are shown in Table 7. Representative calls for the species from this dataset are included in Appendix D.

Table 6. Occurrence of bat species at four sites in the study area.

Scientific name	SUT03	SUT04	SUT07	SWIFT536794
<i>Austronomus australis</i>	✓	✓	-	✓
<i>Chalinolobus gouldii</i>	P	✓	-	✓
<i>Chalinolobus morio</i>	✓	-	-	-
<i>Falsistrellus tasmaniensis*</i>	P	P	-	P
<i>Miniopterus orianae oceanensis*</i>	P	✓	-	P
<i>Myotis macropus*</i>	P	P	-	P
<i>Nyctophilus geoffroyi</i>	P	P	-	P
<i>Nyctophilus gouldi</i>	P	P	-	P
<i>Ozimops ridei</i>	P	P	-	P
<i>Scoteanax rueppellii*</i>	P	P	-	P
<i>Scotorepens orion</i>	P	P	-	P
<i>Vespadelus darlingtoni</i>	P	P	-	P
<i>Vespadelus regulus</i>	P	P	-	P
<i>Vespadelus vulturnus</i>	P	P	-	P

✓ = species present, P = species potentially present, * listed species (BC Act) ** listed species (EPBC Act)

Table 7: Occurrence of bat species by complex

Scientific name	SUT03	SUT04	SUT07	SWIFT536794
<i>Chalinolobus gouldii</i> / <i>Ozimops ridei</i>	✓	✓	-	✓
<i>Falsistrellus tasmaniensis*</i> / <i>Scoteanax rueppellii*</i> / <i>Scotorepens orion</i>	✓	✓	-	✓
<i>Myotis macropus*</i> / <i>Nyctophilus geoffroyi</i> / <i>Nyctophilus gouldi</i>	✓	✓	-	✓
<i>Miniopterus orianae oceanensis*</i> / <i>Vespadelus darlingtoni</i> / <i>Vespadelus regulus</i>	✓	✓	-	✓
<i>Vespadelus darlingtoni</i> / <i>Vespadelus regulus</i>	✓	✓	-	✓
<i>Vespadelus vulturnus</i> / <i>Chalinolobus morio</i>	✓	✓	-	✓

✓ = species complex present, * listed species (BC Act) ** listed species (EPBC Act)

5. Discussion and conclusion

This report forms part of the required *Environment Protection and Biodiversity Protection Act 1999* (EPBC Act) annual monitoring required for the site (for EPBC Act approval 2012/6560). Results of this report may be used with past data to provide an indication of trends through time.

The species identified, or potentially identified, are representative of those known and expected to occur within the region. There were at least four and up to fourteen species recorded during this survey (Table 6). No species listed under the EPBC Act were detected, but one confirmed present and up to three species potentially present are listed under the *NSW Biodiversity Conservation Act 2016* (BC Act).

The threatened species confirmed to be present was:

- *Miniopterus orianae oceanensis* (vulnerable – BC Act).

The three threatened species evaluated to be potentially present included:

- *Falsistrellus tasmaniensis* (vulnerable – BC Act)
- *Myotis macropus* (vulnerable – BC Act)
- *Scoteanax rueppellii* (vulnerable – BC Act).

Miniopterus orianae oceanensis was positively identified at one site and potentially present at two other sites. *Falsistrellus tasmaniensis*, *Myotis macropus*, and *S. rueppellii* were potentially identified at three sites as part of species complexes.

Many calls could not be identified to a species level, either due to call quality or call type (social or atypical call). Most species were labelled as potentially occurring due to being part of a complex.

Detector SUT07 recorded no identifiable calls. This data contained a very large number of noise files that were not removed by filters. Analysis settings (such as smoothness, zoom and colour display) were adjusted to attempt to show bat calls that may be present within the noise, but none were found.

6. References

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Appendix C Candidate Species

Scientific name	Common name	Fc for Marulan region (kHz)	Other call features
<i>Austronomus australis</i>	White-striped Free-tailed Bat	10 - 15	Mostly flat, but sloped, pulses
<i>Chalinolobus dwyeri</i> */**	Large-eared Pied Bat	22 - 23.5	Alternating pulses
<i>Chalinolobus gouldii</i>	Gould's Wattled Bat	27.5 - 32.5	Alternating pulses
<i>Chalinolobus morio</i>	Chocolate Wattled Bat	48 -52.5	Down sweeping tail
<i>Falsistrellus tasmaniensis</i> *	Eastern False Pipistrelle	35.5 – 40.5	No tail or occasionally down sweeping
<i>Micronomus norfolkensis</i> *	Eastern Coastal Free-tailed Bat	32 -35	Tabletop pulses with other steeper and curved pulses present
<i>Miniopterus orianae oceanensis</i> *	Large Bent-winged Bat	44 - 47	Curved with Down sweeping tail
<i>Myotis macropus</i> *	Southern Myotis	35/40 -70/80	Near vertical, kinks at 47 and 35 kHz. <75 ms pulse interval & >400 OPS
<i>Nyctophilus geoffroyi</i>	lesser long-eared bat	35/47 -65/80	Near vertical
<i>Nyctophilus gouldi</i>	Gould's long-eared bat	35/47 -65/80	Near vertical
<i>Ozimops ridei</i>	Ride's Free-tailed Bat	28.5-31	Mostly flat
<i>Phoniscus papuensis</i> *	Golden-tipped Bat	Max 80-160	Very high start frequency, near vertical
<i>Rhinolophus megaphyllus</i>	Eastern Horseshoe Bat	66.5 - 70	Tabletop pulses, high frequency
<i>Saccolaimus flaviventris</i> *	Yellow-bellied Sheath-tailed Bat	17.5 - 22.5	Harmonics
<i>Scoteanax rueppellii</i> *	Greater Broad-nosed Bat	32 - 36.5	Curved with either no tail or down sweeping.
<i>Scotorepens orion</i>	Eastern Broad-nosed Bat	34.5 - 37	Curved with either no tail or down sweeping. Fk>38
<i>Vespadelus darlingtoni</i>	Large Forest Bat	40 - 44	Upsweeping or absent tail
<i>Vespadelus regulus</i>	Southern Forest Bat	40 – 44.5	Up-sweeping tail
<i>Vespadelus vulturnus</i>	Little Forest Bat	49 – 53.5	Up-sweeping tail

* listed species (BC Act) ** listed species (EPBC Act)

Appendix D Example calls from this dataset

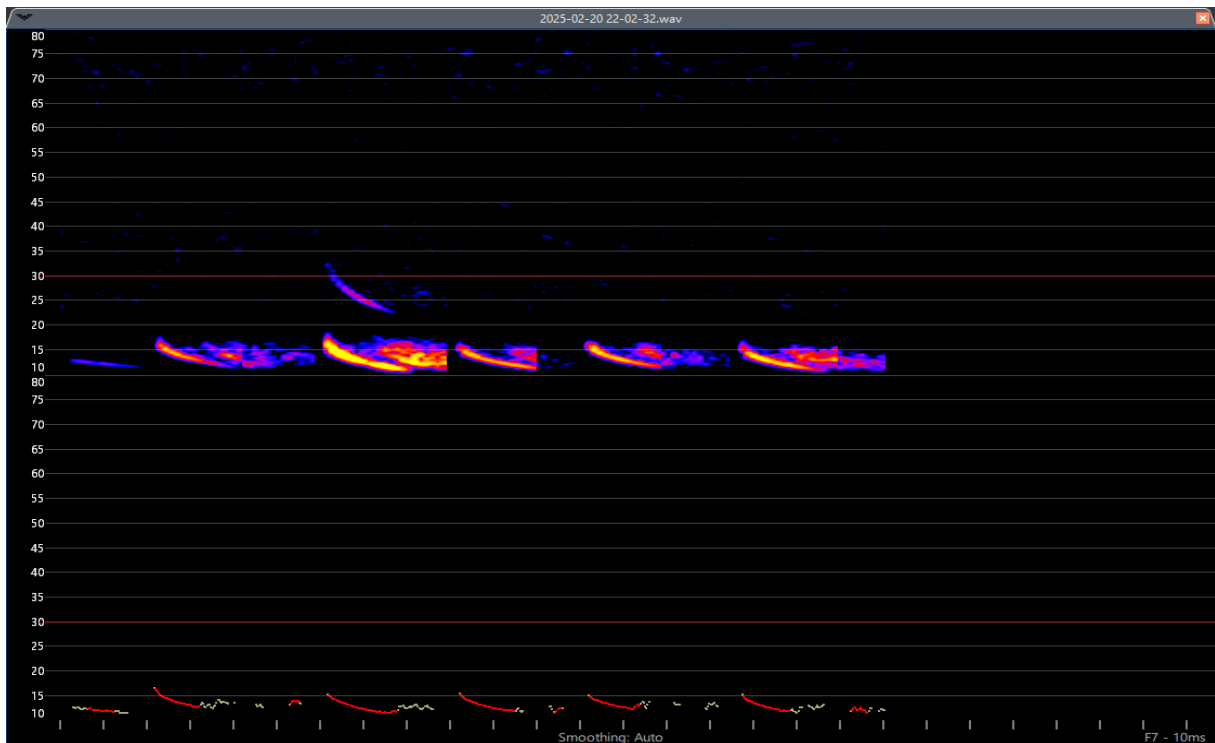


Figure 1. Example call of *Austronomus australis* recorded at SUT04. Top: full spectrum view of the call, bottom: zero crossing view of the call in Anabat Insight version 2.1.2-0-g3566bf9. Settings are time compressed, F7 zoom level, time on the x-axis with ticks 10 ms apart and frequency on the y-axis.

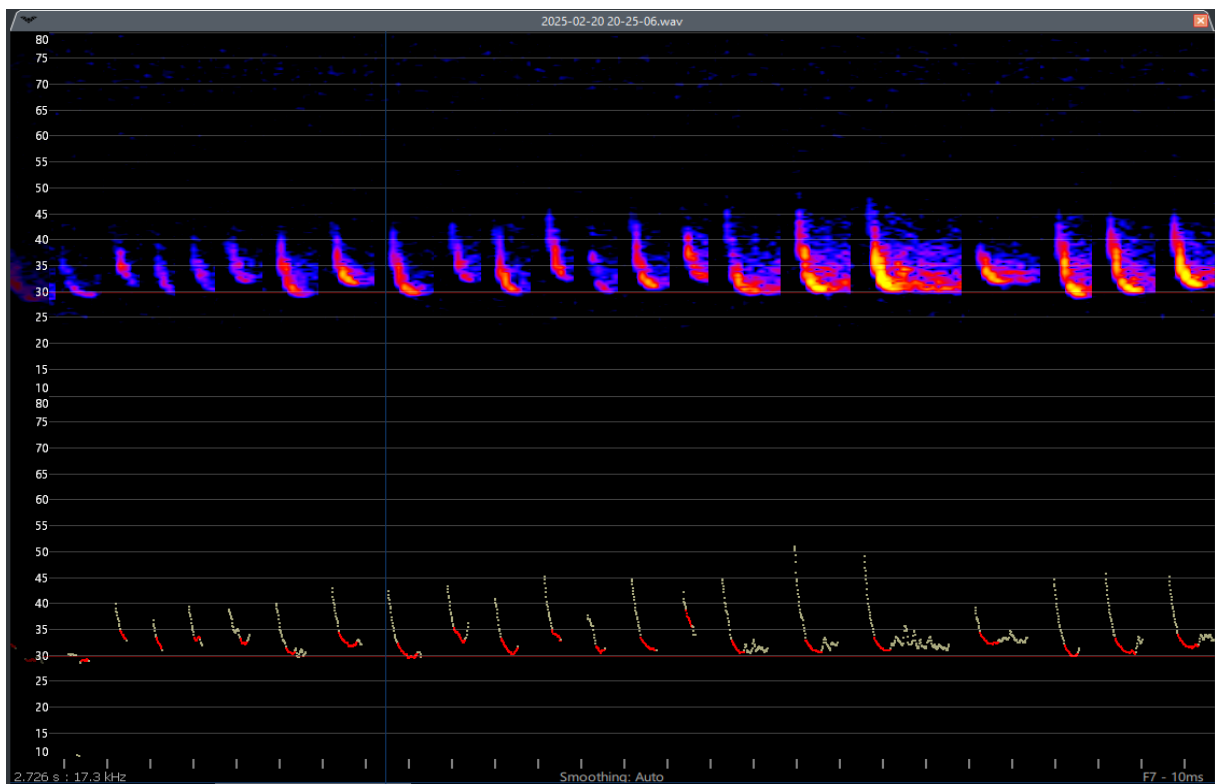


Figure 2. Example call of *Chalinolobus gouldii* recorded at SUT04. Top: full spectrum view of the call, bottom: zero crossing view of the call in Anabat Insight version 2.1.2-0-g3566bf9. Settings are time compressed, F7 zoom level, time on the x-axis with ticks 10 ms apart and frequency on the y-axis.

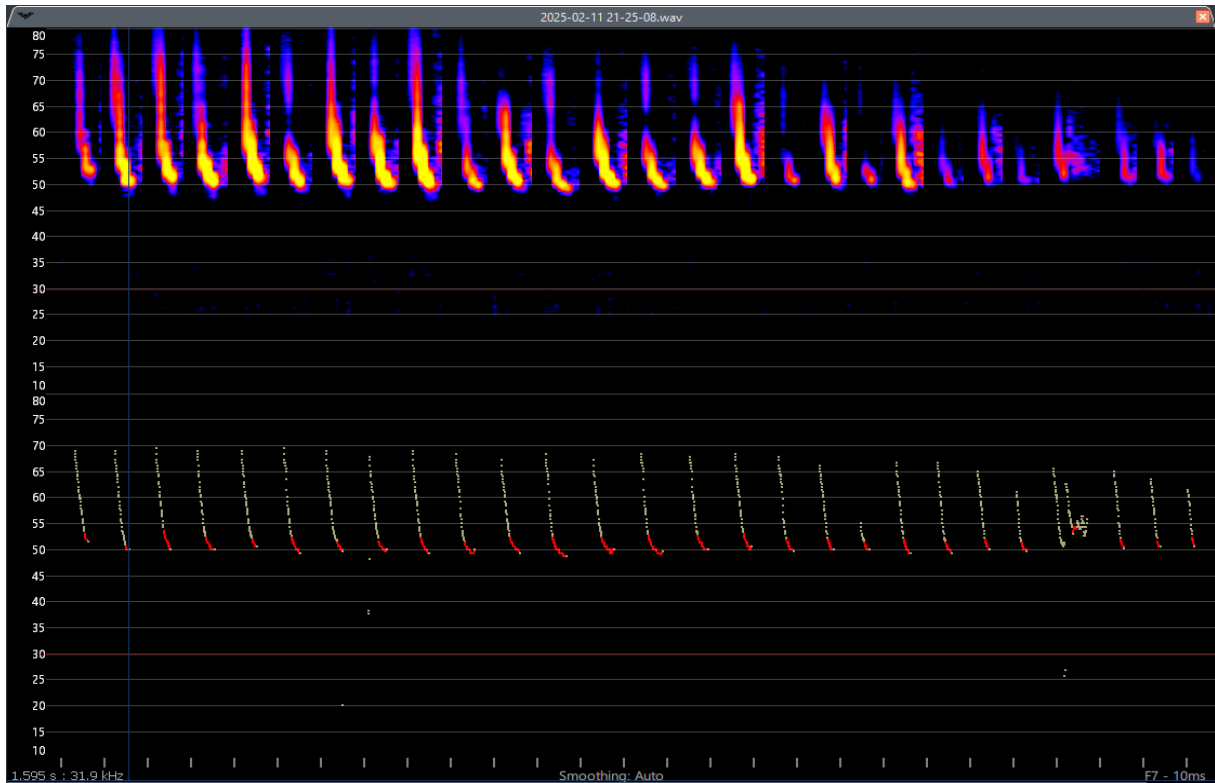


Figure 3. Example call of *Chalinolobus morio* recorded at SUT03. Top: full spectrum view of the call, bottom: zero crossing view of the call in Anabat Insight version 2.1.2-0-g3566bf9. Settings are time compressed, F7 zoom level, time on the x-axis with ticks 10 ms apart and frequency on the y-axis.

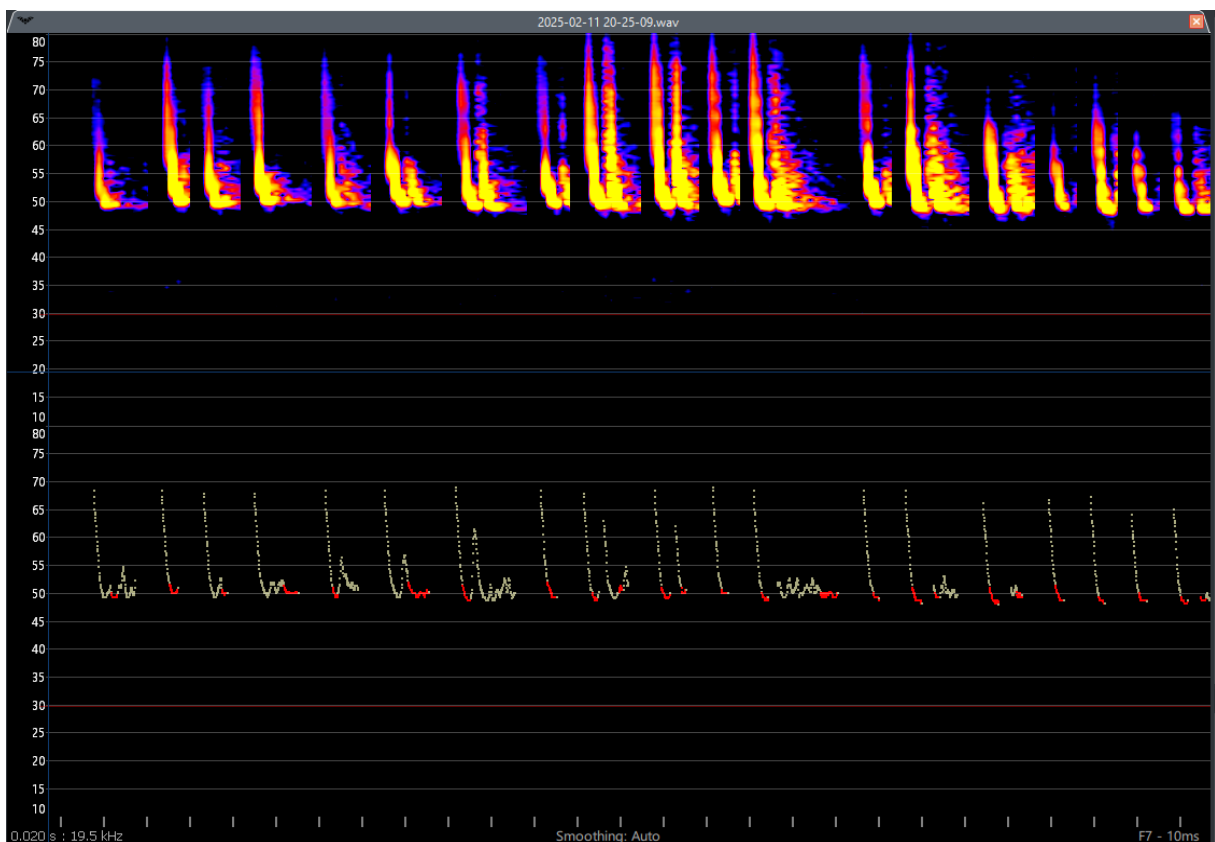


Figure 4. Example call of [*Chalinolobus morio*/*Vespadelus vulturinus*] species complex recorded at SUT03. Top: full spectrum view of the call, bottom: zero crossing view of the call in Anabat Insight version 2.1.2-0-g3566bf9. Settings are time compressed, F7 zoom level, time on the x-axis with ticks 10 ms apart and frequency on the y-axis.

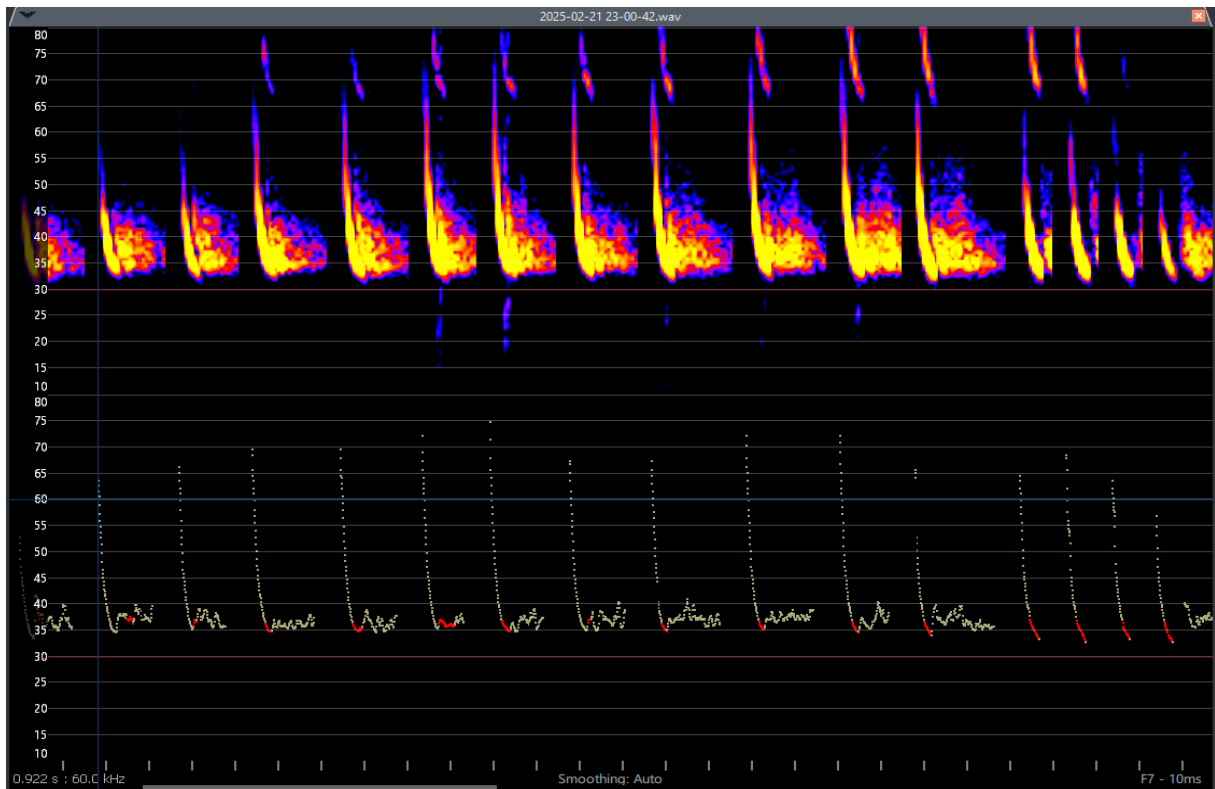


Figure 5. Example call of [*Falsistrellus tasmaniensis*/*Scoteanax rueppellii*/*Scotorepens orion*] species complex recorded at SWIFT36794. Top: full spectrum view of the call, bottom: zero crossing view of the call in Anabat Insight version 2.1.2-0-g3566bf9. Settings are time compressed, F7 zoom level, time on the x-axis with ticks 10 ms apart and frequency on the y-axis.

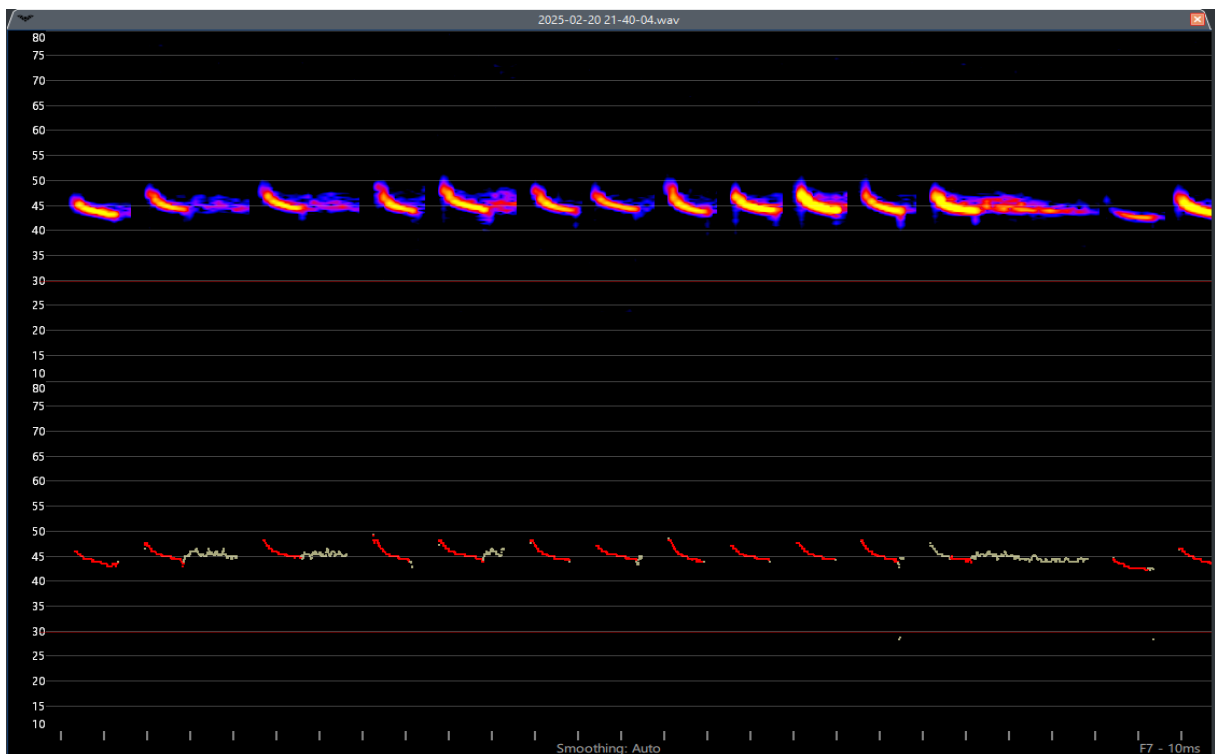


Figure 6. Example call of *Miniopterus orianae oceanensis* recorded at SUT04. Top: full spectrum view of the call, bottom: zero crossing view of the call in Anabat Insight version 2.1.2-0-g3566bf9. Settings are time compressed, F7 zoom level, time on the x-axis with ticks 10 ms apart and frequency on the y-axis.

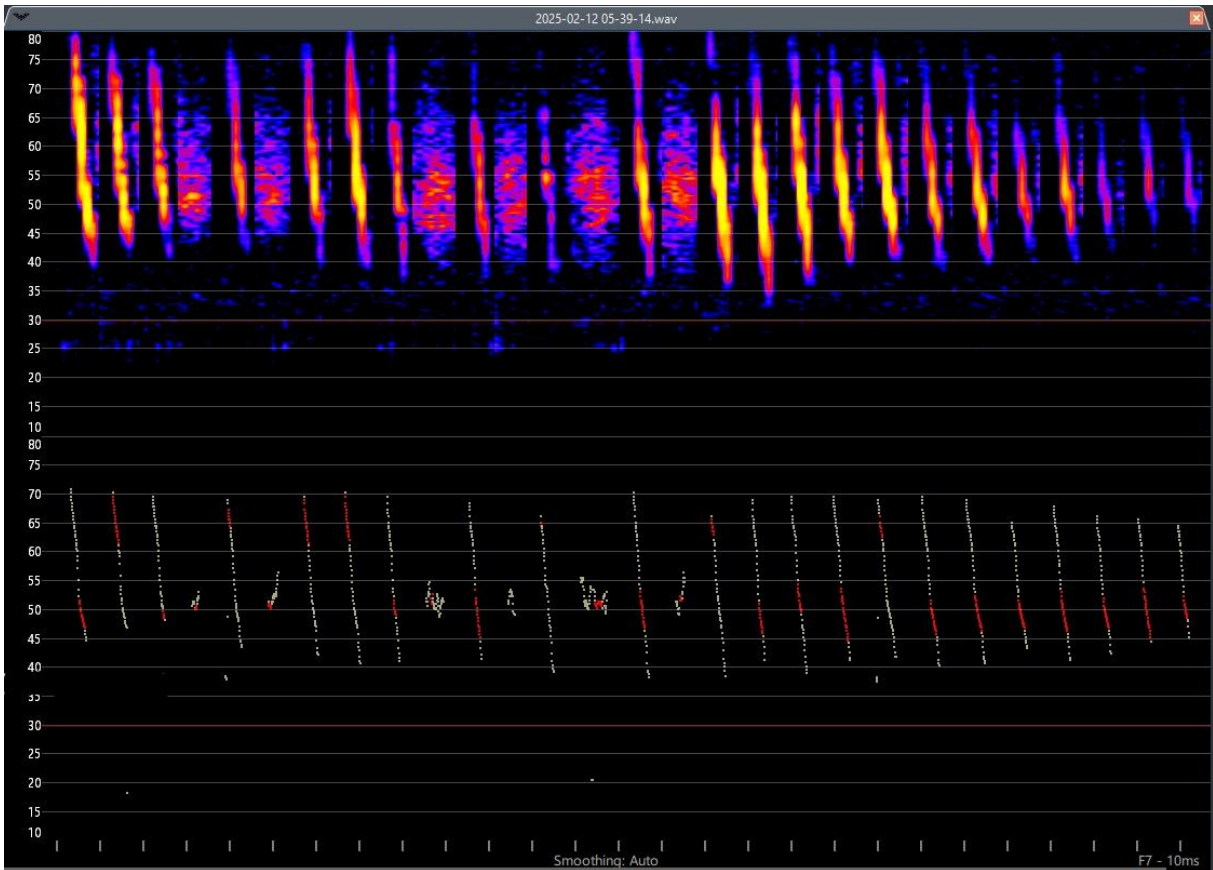


Figure 7. Example call of *Myotis macropus*/*Nyctophilus geoffroyi*/*Nyctophilus gouldi* species complex recorded at SUT03. Top: full spectrum view of the call, bottom: zero crossing view of the call in Anabat Insight version 2.1.2-0-g3566bf9. Settings are time compressed, F7 zoom level, time on the x-axis with ticks 10 ms apart and frequency on the y-axis.

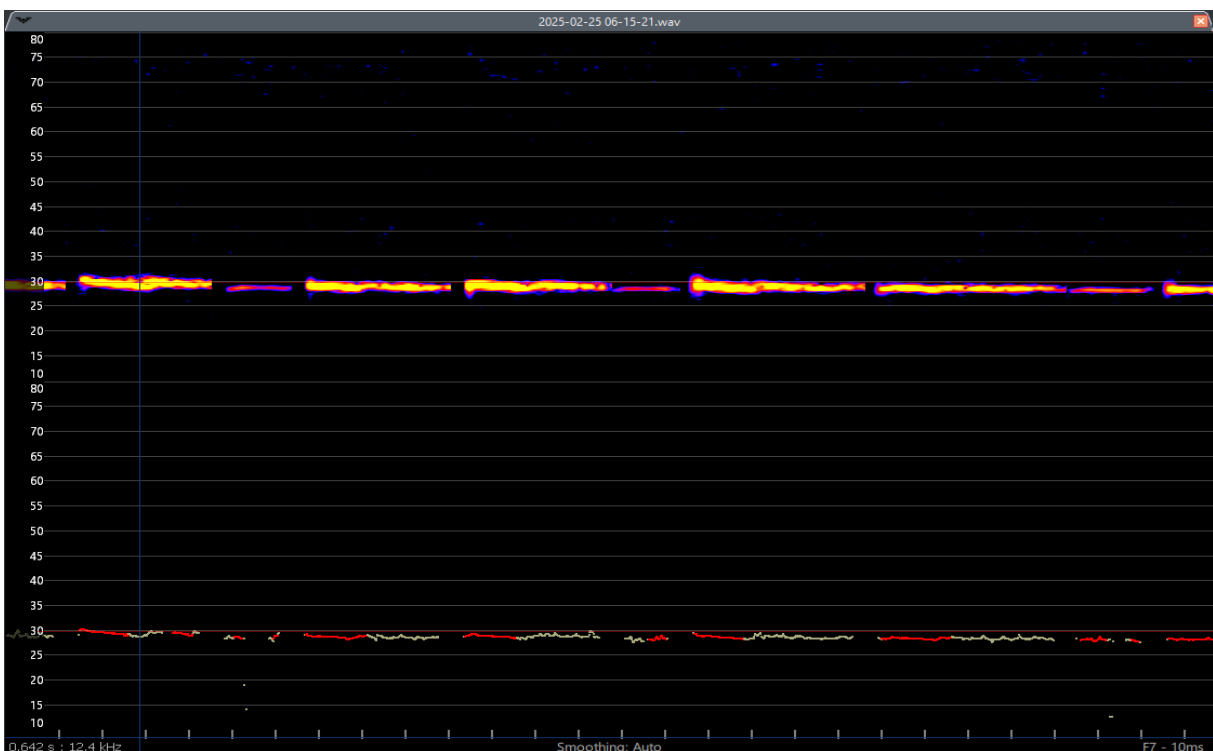


Figure 8. Example call of *Ozimops ridei* recorded at SUT04. Top: full spectrum view of the call, bottom: zero crossing view of the call in Anabat Insight version 2.1.2-0-g3566bf9. Settings are time compressed, F7 zoom level, time on the x-axis with ticks 10 ms apart and frequency on the y-axis.

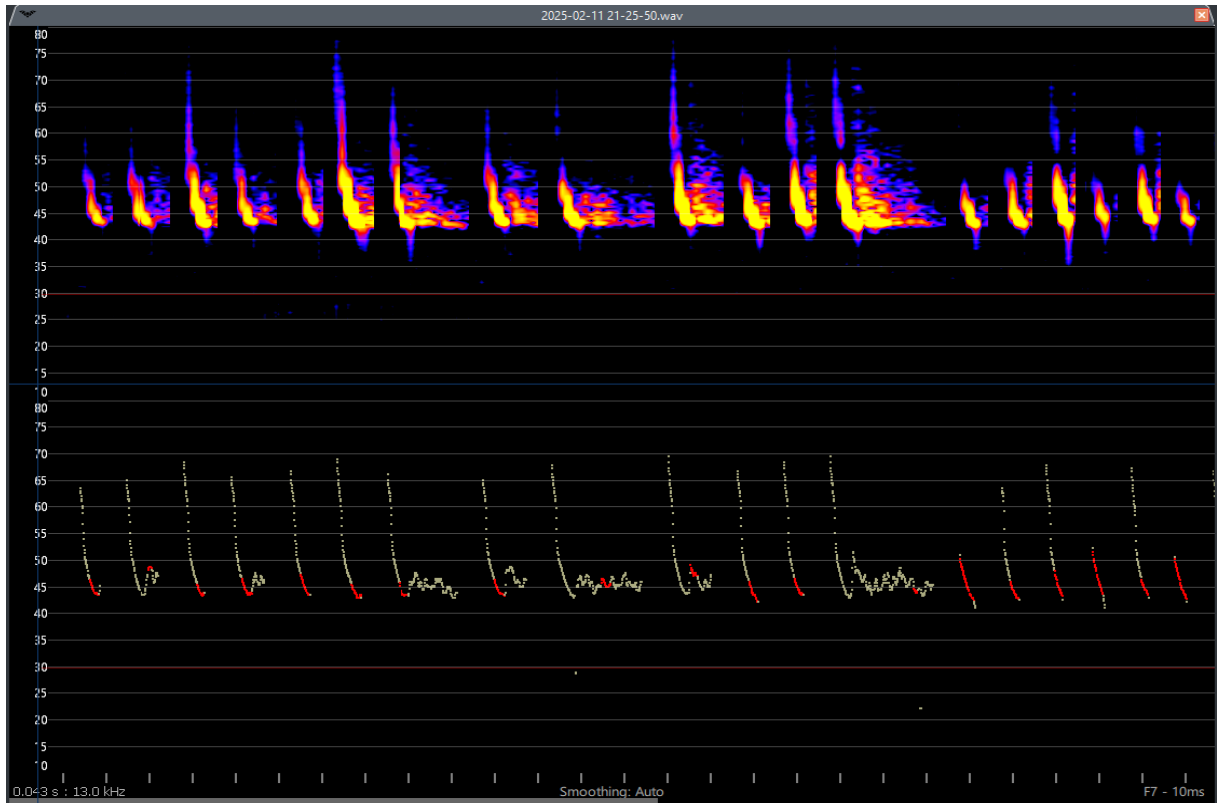


Figure 9. Example call of [*Vespadelus darlingtoni*/*Vespadelus regulus*/*Miniopterus orianae oceanensis*] species complex recorded at SUT03. Top: full spectrum view of the call, bottom: zero crossing view of the call in Anabat Insight version 2.1.2-0-g3566bf9. Settings are time compressed, F7 zoom level, time on the x-axis with ticks 10 ms apart and frequency on the y-axis.

