Nicola Naturalist Society

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SURVEYS OF GREAT BASIN SPADEFOOTS IN THE DOUGLAS LAKE PLATEAU GRASSLANDS: 2024 PROGRESS REPORT

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ABSTRACT

This progress report covers year three of a five-year project 2022-2026 to map and monitor Great Basin Spadefoots (*Spea intermontana*) in the grasslands of the Douglas Lake Plateau near Merritt, BC. This amphibian species is listed as Threatened in Canada. The Douglas Lake grasslands support one of the primary breeding concentrations in British Columbia. The project is an extension of the five-year amphibian monitoring project our club completed under the guidance of professional herpetologists in 2011-2015. Roadside call surveys involved listening for the nocturnal calls of breeding Spadefoots and other amphibians for five minutes at stations located 800 m apart. In 2024 we completed seven nights of roadside surveys covering 79 stations. Spadefoots were recorded at 18 stations (23%) and Pacific Tree Frogs (*Pseudacris regilla*) at 22 stations (28%). On one road route Spadefoots were recorded at 5 out of 12 stations in 2024, whereas none were recorded at these stations in 2023, thereby showing the value of multi-year surveys.

In 2024 with increased funding we expanded the project with the acquisition of automated sound recorders (Song Meters), remote water temperature recorders (Hobo Pendants) and weather monitors (Kestrel Drop loggers). Song Meters and their matching temperature sensors were deployed between 7 May and 5 July 2024 at five widely-spaced ponds on the Douglas Lake Plateau. Spadefoot calling was recorded at all five sites. In total we accumulated 225 nights and 2,295 hours of sound recordings. Given this overwhelming amount of data our analysis is still in a preliminary stage, focused on the timing of calls through the night and the effects of water and air temperatures and wind at two ponds: PEN13 and UNB01. The preliminary analysis involved listening to recordings for 20 seconds at 5-minute intervals between 21:00 and 05:00 and recording a calling score every five minutes (0 = no calling; 1 = one Spadefoot calling with long gaps between calls; 2 = two Spadefoots calling but regular gaps between calls; 3 = full chorus or three or more Spadefoots calling, with few or no gaps between calls). The peak of calling activity, as well as most full choruses, occurred between 22:00 and 01:00 at both PEN13 and UNB01 sites (n = 45 and 49 nights, respectively). Mean calling scores were positively correlated with water temperature, with most calling when water was above 11^{o}C and very little calling below 9^{o}C. Air temperatures showed a similar positive relationship, except that high calling scores sometimes occurred when air temperatures were low (below 5.5^{o}C) but water temperatures remained high (10-17^{o}C). Calling rates were low on most nights after 24 June despite warm water and air temperatures. Spadefoots were calling for at least two months (beginning on 9 May and some still calling on 5 July), but with considerable night-to-night variation, linked with water temperature. Our data add valuable information for monitoring Spadefoots across their range and for understanding their local biology, habitat preferences and likely effects of climate change.

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INTRODUCTION

The Nicola Naturalist Society has done surveys for Great Basin Spadefoots (*Spea intermontana*) for eight years. In 2011-2015, with the guidance of professional herpetologists, our club mapped and monitored all amphibians across a 7,200 km^2 area centred on the Nicola Valley and developed roadside call surveys for breeding Spadefoots (Ovaska et al. 2016). In 2022-2026 we have undertaken to repeat and extend these roadside surveys using the same protocol. In addition, in 2024 we began deploying autonomous sound recorders and weather loggers to better understand the seasonality, nightly variation and effects of weather on the vocalizations of breeding Spadefoots. The ongoing roadside surveys are funded by a grant to BC Nature from an anonymous donor, while the new automated monitoring is funded by a Club Support Grant from the BC Naturalists' Foundation and BC Nature, supplemented by a generous donation from an anonymous club supporter.

The Spadefoot is an enigmatic amphibian with a highly restricted range in southern British Columbia. The species is listed as Threatened in Canada (COSEWIC 2019) and is on the provincial Blue List of Special Concern (BC Conservation Data Centre 2002). The Douglas Lake Plateau grasslands are one of the few places in the province that support a reasonable breeding population of this little amphibian. Climate change affecting precipitation, temperatures and ground and pond water levels is having serious negative impacts on the availability of suitable breeding ponds in our area (Coelho 2015). These grasslands are within easy access (40-100 km) from Merritt where our club is based. Our Spadefoot data contribute essential information on the distribution, annual trends and local factors affecting this species in our province. Our Spadefoot data are already being used to assess the suitability of the Douglas Lake Plateau as a Key Biodiversity Area (KBA) and will be used by researchers and wildlife managers across the species' range.

Great Basin Spadefoots spend much of their lives buried (as deep as 2 m below the surface) in sandy soils (Garner 2012). In late spring they emerge, begin feeding on insects and worms and move to shallow ponds where they breed (Garner 2012, Hales 2018, Hales and Larsen 2019). Adult males attract females to the breeding sites by emitting loud croaking calls, audible to humans for almost 1 km. It is these mating calls that our surveys monitor and tally in this project as indicators of the animals numbers and distribution (details under Methods below). Many of the breeding ponds are on private ranchlands and the roadside call surveys allow us to reliably map and monitor the Spadefoots without having to intrude on private lands.

Our roadside surveys have been valuable in mapping the locations of likely breeding ponds in the grasslands of the Douglas Lake Plateau. Analysis of our data shows that the Spadefoot's calling is affected by local weather conditions. We also lack a good understanding of the seasonal and nightly trends in calling. For these reasons, in 2024 we initiated the use of autonomous sound recorders paired with remote weather and water sensors to determine how these factors affect the timing and interpretation of our long-term data. The information coming from this expanded study will also contribute to understanding the biology of this species. The extensive use of trained volunteers in this project, with the guidance of professional biologists, allows very effective use of the funding.

This report is in two parts: Part A covers the third year of our 2022-2026 roadside surveys; Part B covers the testing and preliminary analysis of the data from the autonomous sound recorders and weather sensors.

PART A: 2024 ROADSIDE CALL SURVEYS

The 2022-2026 roadside call surveys aim to repeat and expand those done in the Nicola Valley grasslands in 2011-2015 (Ovaska et al. 2016). Repeating surveys across a 10-year interval provides essential information on long-term trends and threats, while extended sampling adds to the known breeding sites. Spadefoots, like most amphibians, are sensitive to the climatic changes our region is experiencing, including prolonged droughts, heatwaves, reductions in groundwater and ponds, and changes in vegetation. For further details on the rationale of these surveys see our 2023 report (Nicola Naturalist Society 2023). Full analysis of these roadside call data will be undertaken at the end of the five-year sampling period in 2026. This report covers the 2024 sampling.

ROADSIDE CALL SURVEY METHODS

Following our 2011-2015 survey protocols, night-time call surveys follow pre-determined road routes, each with listening stations 800 m apart. Surveys are undertaken during the early breeding season (May and June) when the males are calling. In 2024, surveys were done between 23 May and 21 June. At each station, the number, direction and approximate distance of Spadefoot calls were recorded for a 5-minute interval. We also recorded calls or sightings of Pacific Tree Frogs (*Pseudacris regilla*), Western Toads (*Anaxyrus boreas*), Common Nighthawks (*Chordeiles minor*), Common Poorwill (*Phalaenoptilus nuttallii*) and any owls. Information on birds and amphibians contributes to the status of the Douglas Lake Plateau Important Bird & Biodiversity Area (IBA) which is transiting to a Key Biodiversity Area (KBA).

All surveys were undertaken by Nicola Naturalist Society members as volunteers. The project funding covered travel costs. All the 2024 observers had participated in the 2022 or 2023 Spadefoot surveys and were trained in the methods used. In 2024 we had sufficient funds to hire a part-time coordinator (Loretta Holmes) to facilitate running the surveys and contribute to data entry.

Appendix 1 shows the standard form used during the call surveys. The form explains the information recorded, including: names of observers; date and time; weather at the start and end of the survey; and comments on survey conditions. At each survey station the following information was collected during the 5-minute listening period (see Appendix 1 for details): station code; the UTM location from a GPS; numbers of passing cars; noise index; and records of other animals detected. Amphibian calls were recorded as: species code (e.g., SPIN for Spadefoot, PSRE for Pacific Tree Frog); call index (coded as: 0 = no calling; 1 = one Spadefoot calling with long gaps between calls; 2 - two Spadefoots calling but regular gaps between calls; and 3 = full chorus or three or more Spadefoots calling); proximity of calling frogs (Near <400 m or Far >400 m) and the direction of the calls (see Appendix 1 for details).

RESULTS – ROADSIDE CALL SURVEYS

Tables 1 and 2 summarise 2024 surveys. Appendix 2 provides the details of each survey station.

In total we undertook seven nights of survey, covering 8 routes and 79 survey stations. Six volunteers participated in surveys and the total volunteer time (including data analysis and report writing) totalled over 50 person-hours. Calling Spadefoots were recorded at 18 of the 79 stations (22.8%) and at 10 of these stations there was a full chorus (call index 3) indicating a well-used breeding site. Four stations had Spadefoots calling from two distinct directions, indicating more than one breeding pond nearby (Appendix 2). We sampled three stations that were not previously surveyed, providing additional information on local distribution.

Table 1. Great Basin Spadefoot roadside surveys 2024 - details on each survey. See field data sheet for weather codes.

Route code	Route name	Date	No. of stations	Observers*	Start time	End time	Start Temp [C]	End Temp [C]	Start rain	End rain	Start cloud	End cloud	Start wind	End wind	Comments
DL	Douglas Lake Road	23-May-24	12	AB,LH	21:25	23:21	10	10	0	0	51-95	51-95	2	2	Some rain earlier today; cool wind
LAU	Lauder Road	24-May-24	12	LH, CG	21:32	23:22	9	7	0	0	<5	<5	1	0	Light wind at start
QUIL	Quilchena Creek	24-May-24	10	LH, CG	21:30	22:04	11	7	0	0	<5	<5	1	2	Windy
HAM	Hamilton Commonage	28-May-24	6	AB	21:50	23:05	9	3	0	0	5-50	51-95	2	2	Clear, windy in exposed places - cold wind all survey
LUN	Lundbom	01-Jun-24	11	LH, CG, JH	21:30	23:28	9	10	0	0	5-50	<5	1	0	Beginning near large dirt-bike camp (noisy)
PEN	Pennask Road	09-Jun-24	13	LH, LJ, VN	21:36	23:40	15	14	1	0	51-95	<5	2	2	Earlier rain, thunder, lightning
DL	Douglas Lake Road	21-Jun-24	15	LH, CG	21:47	23:34	14	10	0	0	5-50	5-50	0	1	Summer Solstice

* Observers: AB - Alan Burger; CG - Craig Gartner; JH-Jasmine Hathway; LH - Loretta Holmes; LJ - Liis Jeffries; VN - Vic Newton.

Table 2. Summary of roadside call surveys in 2024 showing the number of stations at which various responses (Call Indices) were recorded for Great Basin Spadefoot and Pacific Tree Frog.

A) Great Basin Spadefoot				Spadefoot Call Index					
Route	Station codes	Date	No. of stations sampled	0	1	2	3	# stations with response	% response
Douglas Lake main (a)	DL 01-12	23-May-24	12	6	2	1	3	6	50.0
Lauder Road	LAU 01-12	20-May-24	12	7	0	3	2	5	41.7
Quilchena Creek Road	QC 01-10	25-May-24	10	10	0	0	0	0	0.0
Hamilton Commonage	HAM 01-03, X4 & X5; PEN13	28-May-24	6	5	1	0	0	1	16.7
Lundbom	LU 01-10	01-Jun-24	11	0	0	0	0	0	0.0
Pennask	PEN 21-24	09-Jun-24	13	7	0	1	5	6	46.2
Douglas Lake main (b)	DL 13-27	21-Jun-24	15	15	0	0	0	0	0.0
Totals			79	50	3	5	10	18	22.8

B) Pacific Tree Frog				Pacific Tree Frog Call Index					
Route	Station codes	Date	No. of stations sampled	0	1	2	3	# stations with response	% response
Douglas Lake main (a)	DL 01-12	23-May-24	12	11	1	0	0	1	8.3
Lauder Road	LAU 01-12	20-May-24	12	10	0	2	0	2	16.7
Quilchena Creek Road	QC 01-10	25-May-24	10	6	0	3	1	4	40.0
Hamilton Commonage	HAM 01-03, X4 & X5; PEN13	28-May-24	6	6	0	0	0	0	0.0
Lundbom	LU 01-10	01-Jun-24	11	0	4	2	5	11	100.0
Pennask	PEN 21-24	09-Jun-24	13	13	0	0	0	0	0.0
Douglas Lake main (b)	DL 13-27	21-Jun-24	15	11	4	0	0	4	26.7
Totals			79	57	9	7	6	22	27.8

The value of multi-year sampling was clearly demonstrated in 2024. The 12 stations on the Lauder Road route yielded no Spadefoot or Pacific Tree Frog calls on 2 June 2023, in the first year that route was sampled. But on 24 May 2024 Spadefoots were at five Lauder stations (42%) and Tree Frogs at two (17%)(Table 2). A single year of sampling would have missed those breeding records.

We also tallied the frequency and locations of calling by Pacific Tree Frogs (Table 2). This species was recorded at 22 of the 79 stations (27.8%) with a full chorus at six stations. Out of 37 stations where amphibian calling was recorded, only two (stations DL08 and LAU04; Appendix 2) had both

Spadefoots and Tree Frogs, suggesting differing habitat requirements for these two species in our sampling area.

Other species of interest reported included Great Horned Owl (3 stations), Short-eared Owl (5 stations), possible Boreal Owl (1 station), possible Western Screech-owl (1 station), Common Poorwill (6 stations), Common Nighthawk (5 stations) and numerous other birds (Appendix 2).

PART B: AUTOMATED SOUND RECORDERS & WEATHER SENSORS

BACKGROUND

Based on our years of surveys we identified three major limitations to the application of the roadside call survey method:

a) We lack quantified information on the seasonal chronology of breeding in our area;
b) We don't have quantified data on the timing of calling through the night; and,
c) We don't understand the effects of weather on calling activity, especially temperature, precipitation and wind.

These knowledge gaps limit our ability to effectively plan survey times and limit our interpretation of survey data. We and other Spadefoot researchers have confirmed that calling activity is highly variable, but the factors behind this variability are poorly known. Breeding attempts appear to be influenced by very local factors like precipitation, temperature and the water levels in small temporary ponds (COSEWIC 2019). Day-to-day variation in call activity is common but the factors affecting this are not known. Lack of reliable information on breeding chronology also affects confirmation of breeding by surveys for tadpoles at suspected breeding ponds. Great Basin Spadefoot tadpoles develop very rapidly under optimal warm-water conditions and we consequently need to know when to visit ponds to find them. Location of breeding ponds is critical information for the conservation of this threatened species and for their inclusion in protected areas and KBAs.

METHODS

To address these limitations and provide other Spadefoot researchers and managers more quantified data on Spadefoot vocalizations, we acquired the following automated sound recorders and weather sensors:

- Five Wildlife Acoustics Song Meter AA Minis. https://www.wildlifeacoustics.com/products/song-meter-mini-2-aa
- Five Hobo Pendant MX Water Temperature loggers. https://www.onsetcomp.com/products/data-loggers/mx2201
- Two Kestrel DROP D3 data logger to record temperature, humidity, heat index, dew point and pressure trends. https://www.itm.com/product/kestrel-drop-d3-wireless-environmental-data-logger-tan?gad_source=1&gclid=EAIaIQobChMI9-SqpNnTggMVCs3CBB2a8QW6EAYYAiABEgIUA_D_BwE

We also purchased 40 high-quality rechargeable Panasonic AA Eneloop and 2 high-quality Panasonic AA battery chargers, plus locks and SD cards.

The five locations where these devices were deployed were selected on the basis of accessibility, proximity to ponds where Spadefoots were previously reported and to cover wide spatial range within our primary study area. These locations are given in Table 3 and shown in Figure 1.

Table 3. Locations where automated sound recorders and weather sensors were deployed in 2024.

Location Code	Location	UTM coordinates Zone	Easting	Northing	Elevation (m)
PEN13	Pond north of station PEN13 - on power pole	10 U	683025	5550289	1195
POND2	Pond #2 off Hamiton Commonage road	10 U	685614	5552800	1220
HAM01	Between ponds at station AM_HAM01	10 U	683774	5552258	1171
UNB01	Upper Nicola Band Reserve pond	10 U	694654	5562691	1005
DL07	Douglas Lake Ranch at airstrip pond near DL07	10 U	702347	5560762	838

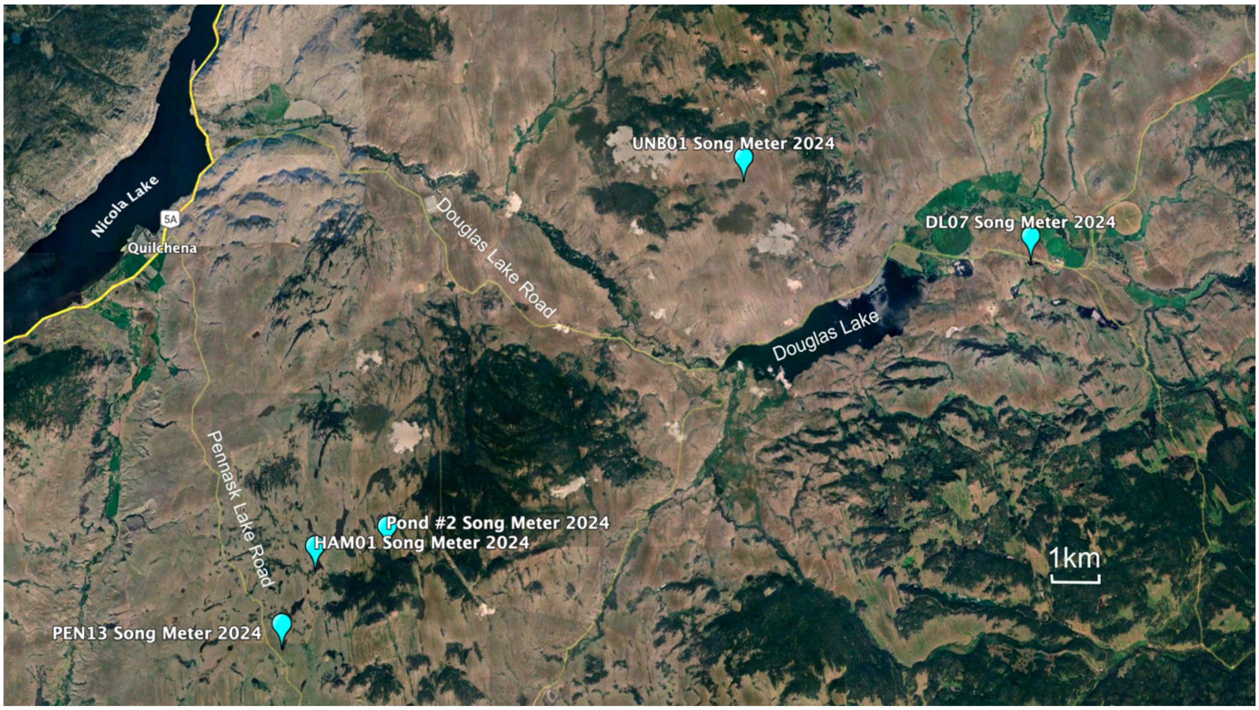

Figure 1. Locations where 5 sound recorders and paired weather sensors were deployed in 2024.


Figure 2. Song Meter sound recorder and Hobo Pendant water temperature recorder deployed at the Pennask Lake Road PEN13 pond. This site produced high-quality Spadefoot recordings and was selected for the preliminary analysis reported here.

The Douglas Lake Plateau is a windy place and we discovered that Song Meters deployed in trees frequently had poor recordings due to the rustling of leaves in the wind. The three locations where these units were placed on poles provided clearer recordings, but they too were regularly affected by strong winds.

For this pilot analysis we selected the recordings from two stations: Pennask Lake Road PEN13 and Upper Nicola Band Reserve UNB01 (Table 3, Figure 1). These sites were less affected by wind interference and preliminary scans showed regular Spadefoot calling. The Song Meters record sounds in WAV files covering 1-hour intervals. Recordings were programmed to start at 20:00 each day (changed to 21:00 after 3 weeks due to very few Spadefoot calls in the first hour) and end at 05:00 the following morning. In order to extract Spadefoot calls from many hours of recordings a computer algorithm identifying Spadefoot calls would be the most efficient approach. We were unable to locate a suitable algorithm and in the interim undertook a manual analysis of each recording. We listened for Spadefoot calls in each night's recording at 5-minute intervals, for 20 seconds at each interval (longer if there was uncertainty about the frequency of calling). This was done as follows:

- The WAV files were played on QuickTime Player on a MacPro computer.
- The QuickTime display manager, which shows the duration and time progress of the recording, was overlaid on the computer monitor with a ruler showing 5-minute intervals across the hour. This allowed the listener to click on each 5-minute interval and track the recording for 20 seconds or more.
- In order to match the call ratings with those used in the Roadside Call Surveys (see Appendix 1) the Spadefoot calling at each 5-minute interval was ranked as:
  - 0 – no calling heard;
  - 1 – one Spadefoot calling with long gaps between calls;
  - 2 – two Spadefoots calling but regular gaps between calls;
  - 3 – full chorus or three or more Spadefoots calling, with few or no gaps between calls.
- We made notes of wind, rain and other interference audible on the recordings.
- Data were saved to an Excel spreadsheet for analysis.

The Hobo Pendant water temperature loggers were mounted on rebar rods pushed into the pond bottom, and positioned ~10 cm below the water surface (Figure 2). They had to be re-positioned regularly as the water levels receded. These loggers recorded water temperature at 1-hour intervals throughout their deployment.

The Kestrel weather loggers recorded air temperature, humidity, heat index, dew point and pressure every 30 minutes. One Kestrel weather logger was deployed 3 m up in a tree 10 m from the HAM01 sound recorder and 2.0 km from the PEN13 site analysed in this report. The other Kestrel logger was deployed at the UNB01 site on a post alongside the sound recorder.

RESULTS – AUTONOMOUS SOUND RECORDINGS

The Song Meter sound recorders and their matching temperature sensors were deployed between 7 May and 5 July 2024, with a later start at two sites (Table 4). Preliminary scans of the recordings showed Spadefoot calling at all five locations. In total we accumulated 225 nights and 2,295 hours of recordings. Given this overwhelming amount of data our analysis is still in a preliminary stage, focused on the timing of calls through the night and the effects of temperature at the PEN13 and UNB01 sites.

Table 4. Dates and duration of deployment of automated sound recorders in 2024.					
Location Code	Location	Date started	Date ended	No. nights	No. hours
PEN13	Pond north of station PEN13 - on power pole	7 May	5 July	45*	405
POND2	Pond #2 off Hamiton Commonage road	7 May	5 July	59	531
HAM01	Between ponds at station AM_HAM01	7 May	5 July	59	531
UNB01	Upper Nicola Band Reserve pond	17 May	5 July	49	441
DL07	Douglas Lake Ranch at airstrip pond near DL07	23 May	5 July	43	387
Totals				255	2295
*The PEN13 recorder failed to record any data between 8th and 22nd June					

Timing of Spadefoot calling through the night – We analysed the scores of Spadefoot calling (scores 0-3) at the PEN13 site over 45 nights between 7 May and 4 July 2024 (Figure 3). Very few calls and no full choruses were recorded before 21:00. The peak of calling was between 22:00 and 01:30 with a gradual decline between 23:00 and 04:00. Full chorus calling (score = 3) had a similar trend, with 20% or more of nights showing choruses between 22:00 and 01:30. At most, 60% of the nights had calling (Figure 3A) and 45% had a full chorus (Figure 3B).

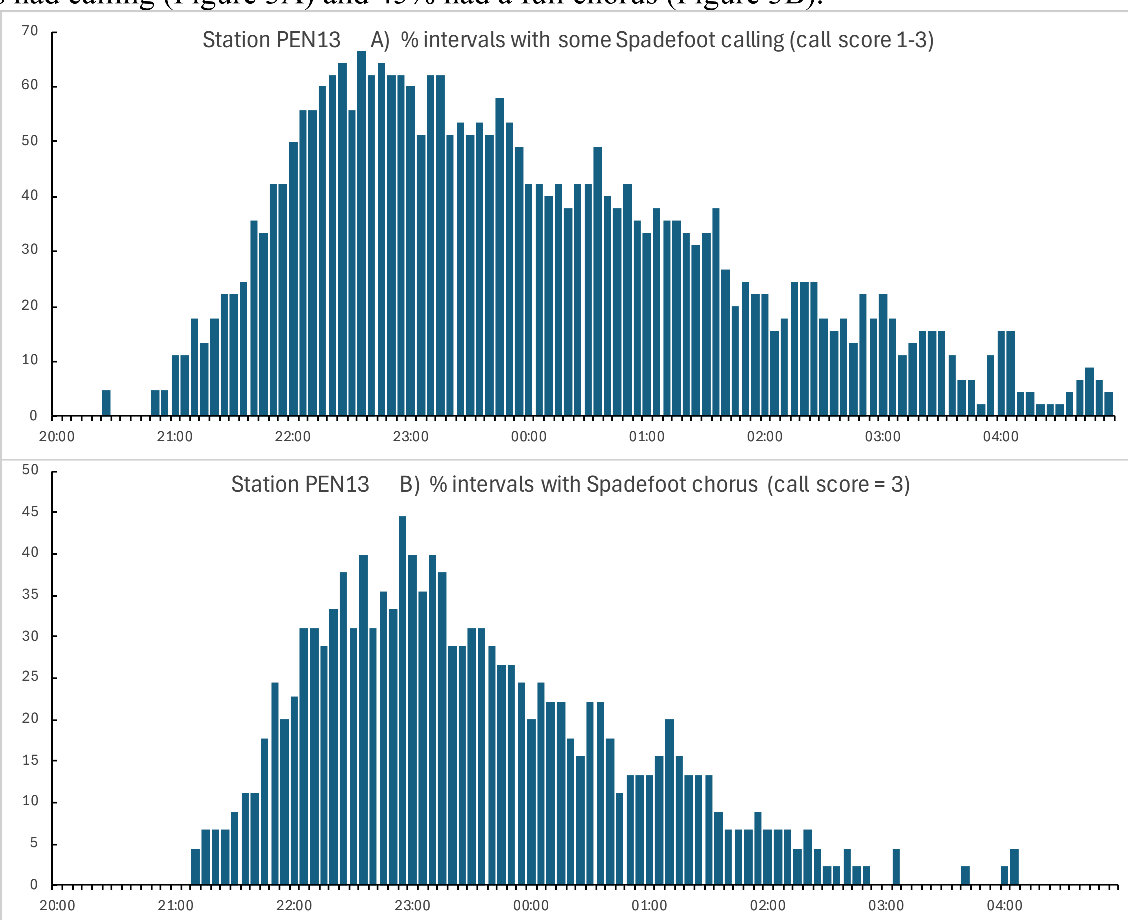

Figure 3. Percentage of 5-minute intervals that included Spadefoot calls between 7 May and 24 June 2024 (n = 45 nights) at the Pennask Lake Road PEN13 site. The upper graph (A) shows 5-minute intervals with any Spadefoot calling (scores 1-3) and the lower graph (B) shows intervals with a full chorus (score = 3).

Night-time trends at the UNB01 site, recorded from 17 May through 4 July were similar (Figure 4). Calling began after 21:00 and the peak of calling, and of full choruses was between 22:00 and 01:00. Here too, there was a gradual decline in calling after 23:00.

Information on the chronology of calling through the night is very helpful for designing optimal night surveys. More detailed analyses here were focused on calling between 22:00 and 01:00 to cover the core period of multiple calling.

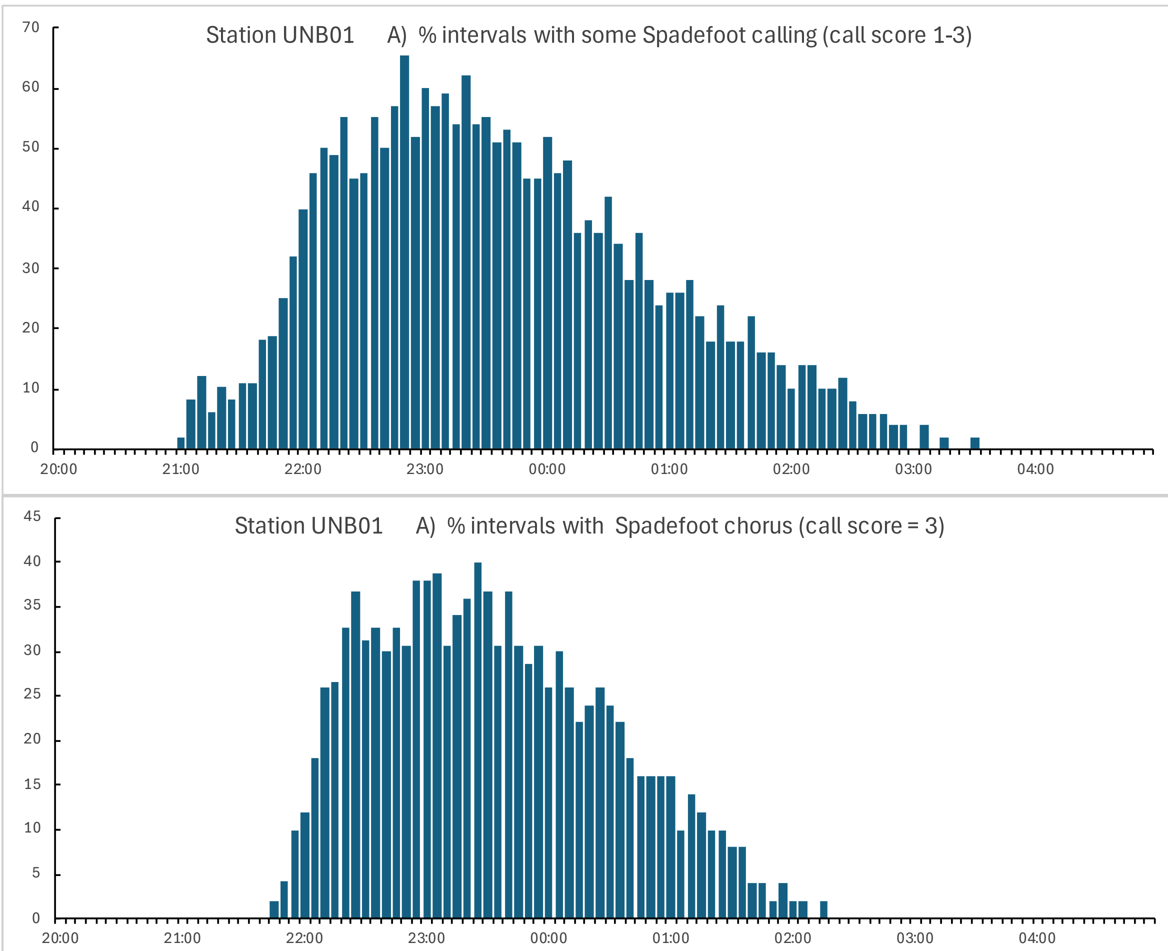

Figure 4. Percentage of 5-minute intervals that included Spadefoot calls between 17 May and 4 July 2024 (n = 49 nights) at the Upper Nicola Band Reserve UNB01 site. The upper graph (A) shows 5-minute intervals with any Spadefoot calling (scores 1-3) and the lower graph (B) shows intervals with a full chorus (score = 3).

Effects of temperature and wind on calling – The Hobo Pendant loggers recorded water temperature hourly between 7 May and 5 July 2024 at the PEN13 site and between 17 May and 5 July at the UNB01 site (Figure 5). The shallow water at the deployment sites, where Spadefoots gathered and tadpoles were found, showed large daily fluctuations in temperature, approaching 20°C on some days. There were also more prolonged temperature trends, such as the warm periods 8-16 May, 1-3 June and 7-11 June (Figure 5). Overall, the smaller and more sheltered UNB01 pond had warmer water and slightly less variable temperatures than the PEN13 pond.

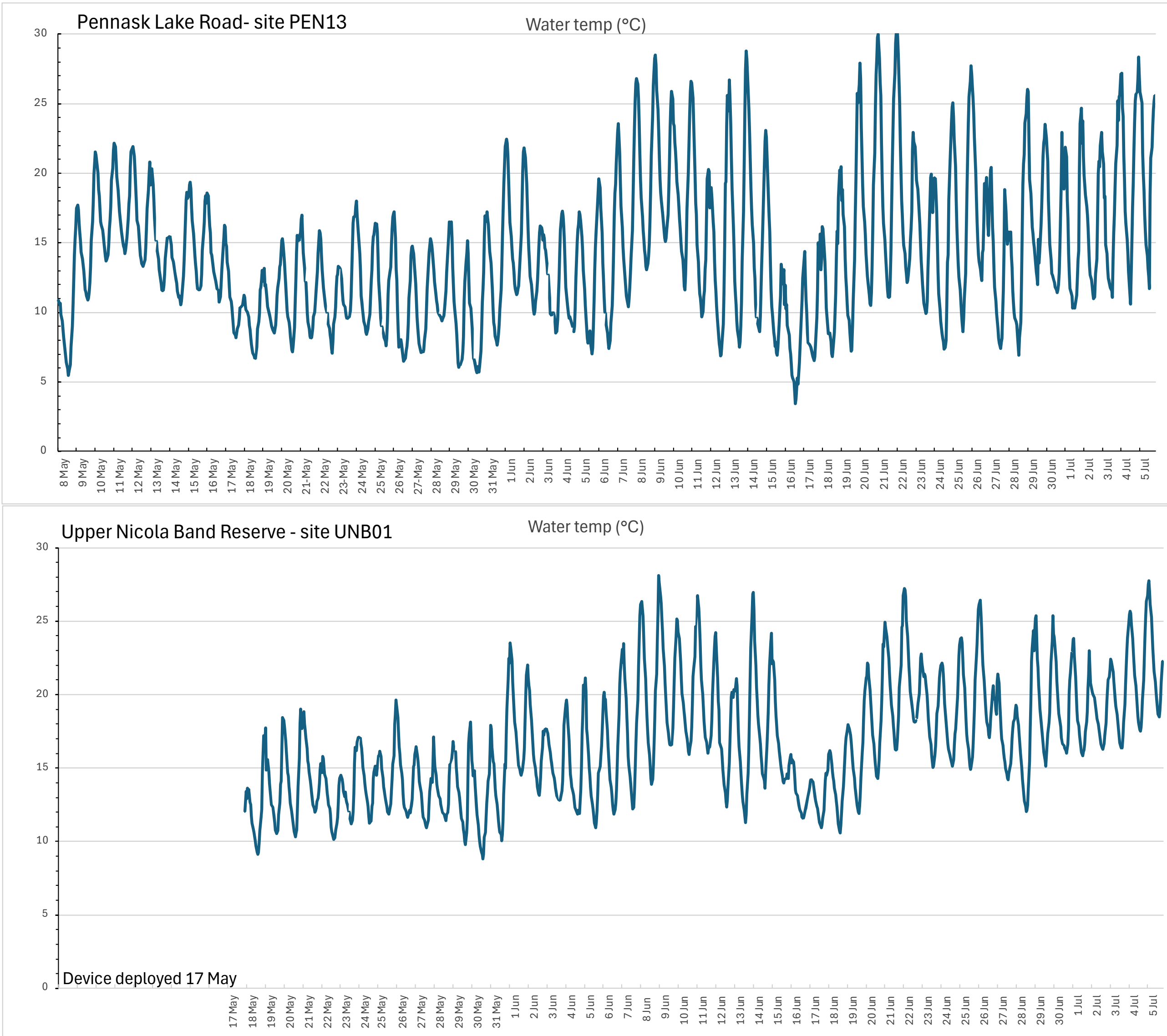

Figure 5. Water temperature recorded at hourly intervals at the PEN13 and UNB01 ponds between 7 May and 5 July 2024.

Water temperature had a strong effect on the frequency of Spadefoot calls (Figure 6). Mean calling scores from the core night period (22:00 – 01:00) were compared with mean water temperatures from overlapping times (i.e., between 21:00 and 01:00). At the PEN13 site, mean call scores higher than 1 (indicating multiple Spadefoots calling for most of the sampling period 22:00-01:00) did not occur when water temperatures were below 9ºC. Nights with mean water temperatures above 11ºC consistently had high calling scores, except for a few nights towards the end of the calling season (after 24 June). No calling was recorded at this site on the nights of 7 and 8 May even though water temperatures were relatively high (averaging 7.6 and 13.1ºC, respectively). This was at the start of the breeding season and these data were not included in the temperature comparison.

The relationship between calling rates and water temperature were more complex at the UNB01 site, although higher calling scores all occurred at temperatures above 13ºC (Figure 6). Mean water temperatures here were never below 11ºC during the sampling period. With warm temperatures, most nights with low calling scores either had strong winds (shown with W in Figure 6) or were toward the end of the calling season (after June 24).

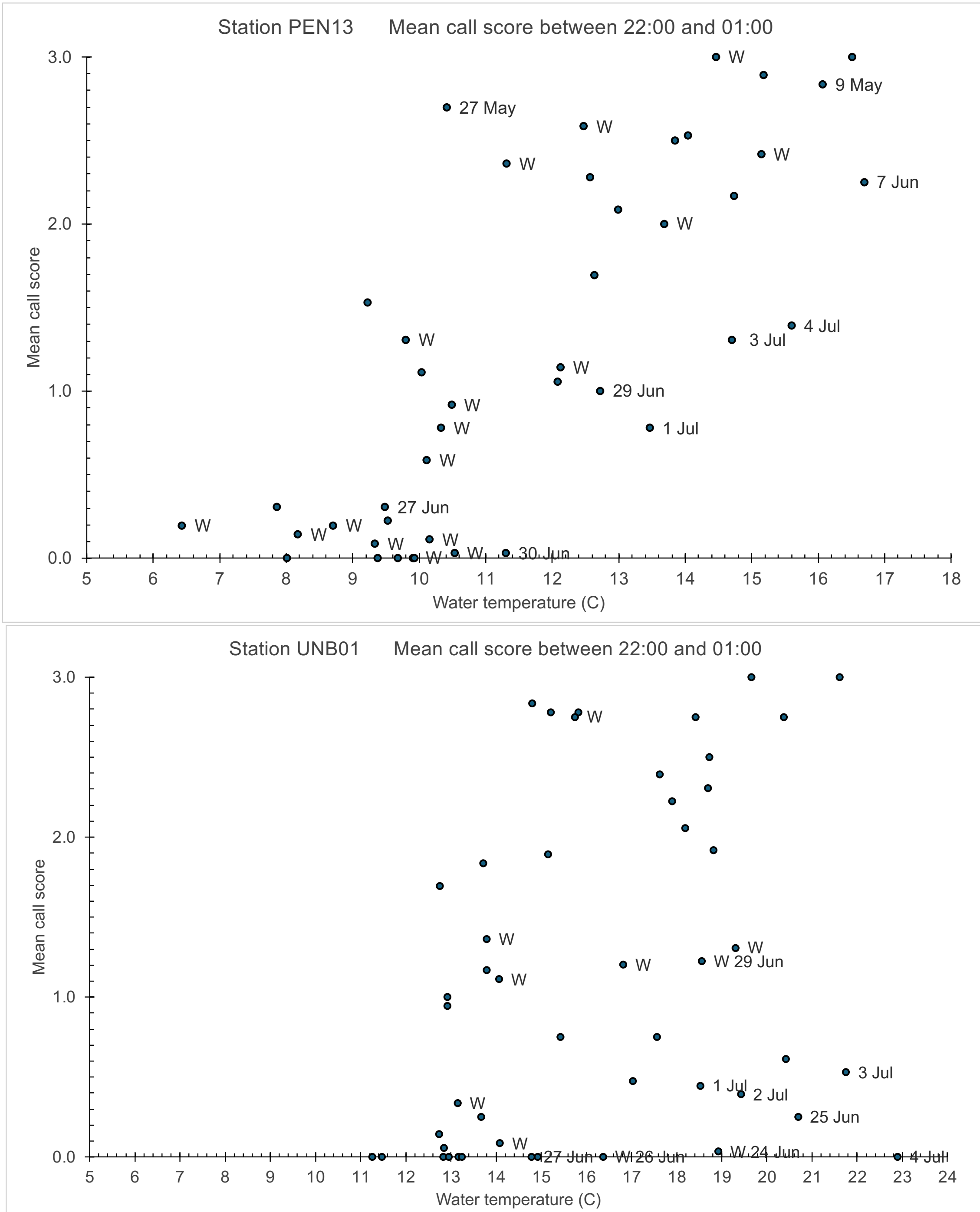

Figure 6. Mean call score in the period 22:00 – 01:00 compared with mean water temperature (21:00-02:00) at PEN13 site on 45 nights between 9 May and 5 July 2024 and at UNB01 site on 49 nights between 17 May and 5 July 2024. Nights with persistent strong winds are labelled with W. The points labelled 9 May, 27 May and 7 Jun for PEN13 are nights in which high calling scores occurred with warm water temperatures but low air temperatures (see explanation below). Other dates are shown where calling rates were low despite warm water temperatures towards the end of the season (after 24 June).

The effects of wind on Spadefoot calling are more difficult to determine. Wind speed was not measured directly but from the sound recordings it was obvious when strong winds were blowing. Nights with prolonged strong winds are labelled with a W in Figure 6. At the more exposed PEN13 site, most of the low calling scores that were clustered between water temperatures of 9-11°C were on windy nights. But at both sites, several nights with high calling scores and warm water also had strong winds. This suggests that high winds might inhibit calling when water temperatures are marginal but have less effect when the water is warm.

Air temperature, measured at the nearest Kestrel logger location at the HAM01 site, also showed large daily fluctuations, often with a daily range of 15-20°C (Figure 7). Air temperature fluctuations were even greater at the UNB01 site, but the extreme high temperatures (>30°C) were due to the Kestrel sensor on a fence post exposed to direct sunlight on some days.

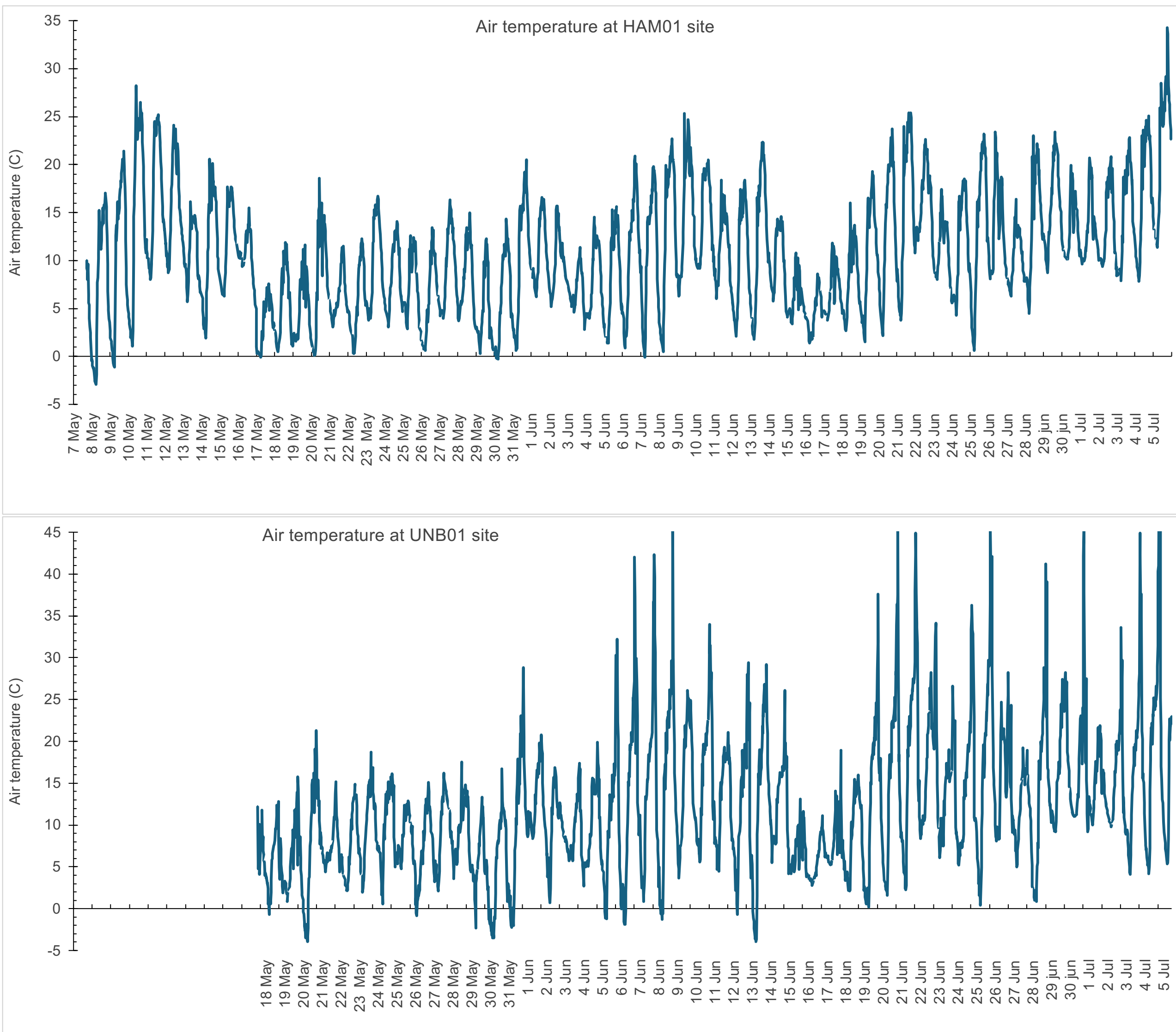

Figure 7. Air temperatures recorded at 30-minute intervals at the HAM01 site between 7 May and 5 July 2024 and at the UNB01 site from 17 May through 5 July.

At the PEN13 site, Spadefoot calling (averaged over the time of peak calling, 22:00-01:00) had a strong positive relationship with air temperature (Figure 8), but the trend was less consistent than with water temperature. In particular, high calling scores were recorded on three nights (9 May, 27 May and 7 June) when air temperatures were relatively low, averaging below 5.5°C during the sampling period (see labelled points in Figure 8). In each case water temperatures were high during the sampling period (16.1, 10.4 and 16.7ºC, respectively; see also Figure 6) and there had been an afternoon of warm air (means for the period noon to 19:00 were 14.8, 14.1 and 17.5ºC, respectively). Calling scores were also low on warm nights late in the calling season, after 24 June (see dates shown in Figure 8). Apart from these conditions, average calling scores above 1 consistently occurred with mean air temperatures above 5ºC after 22:00.

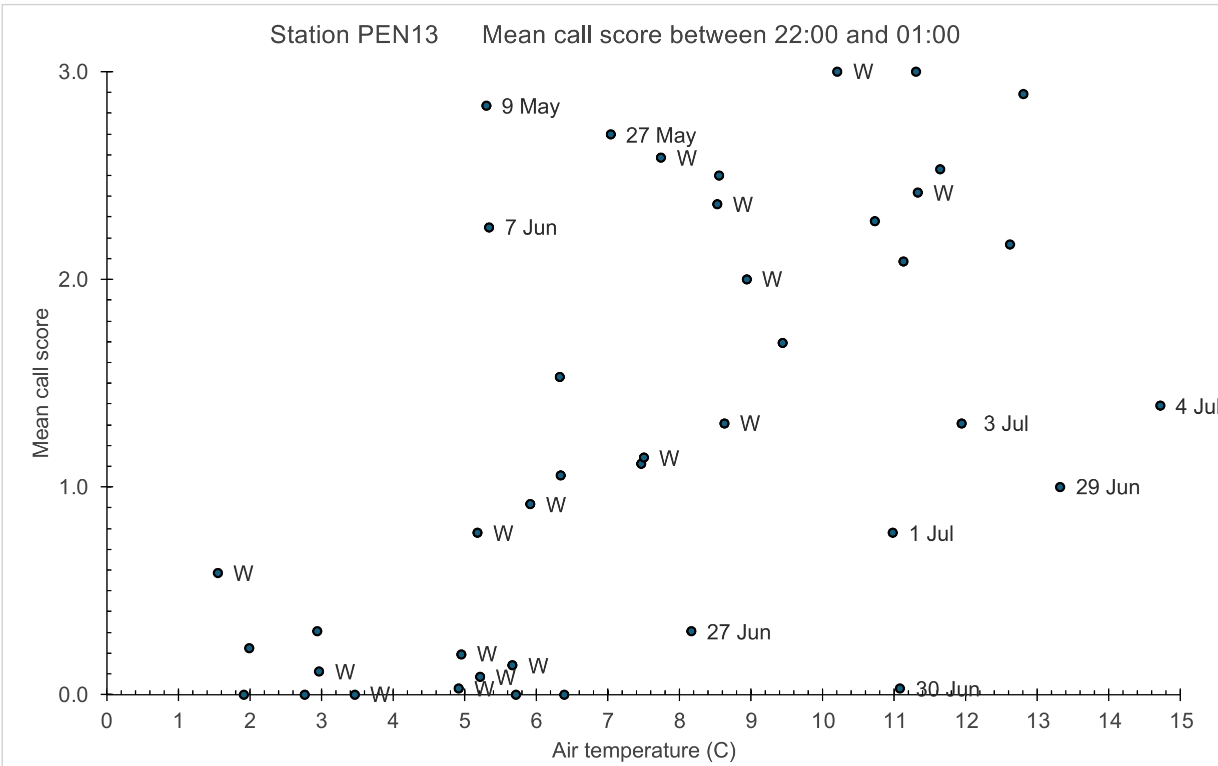

Figure 8. Mean call score at PEN13 site in the period 22:00 – 01:00 compared with mean air temperature (21:00-02:00) recorded 2.0 km away at the HAM01 site on 45 nights between 9 May and 5 July 2024. Nights with persistent strong winds are labelled with W. The points labelled 9 May, 27 May and 7 Jun are nights in which high calling scores occurred during relatively low air temperatures but warm water temperatures (see text for details). Low calling scores also occurred on warm nights late in the season, after 24 June.

Again, the relationship between calling scores and air temperature was more complex at the UNB01 site (Figure 9). This was largely due to two factors. First, on three anomalous nights (5, 12 and 18 June) high calling scores were recorded when air temperatures were low (mean <4ºC) but water temperatures were high (>15ºC). Secondly, as with the PEN13 site, calling scores were low late in the season (after 24 June) despite warm air temperatures. Discounting these effects, high calling scores generally occurred with air temperatures above 5ºC.

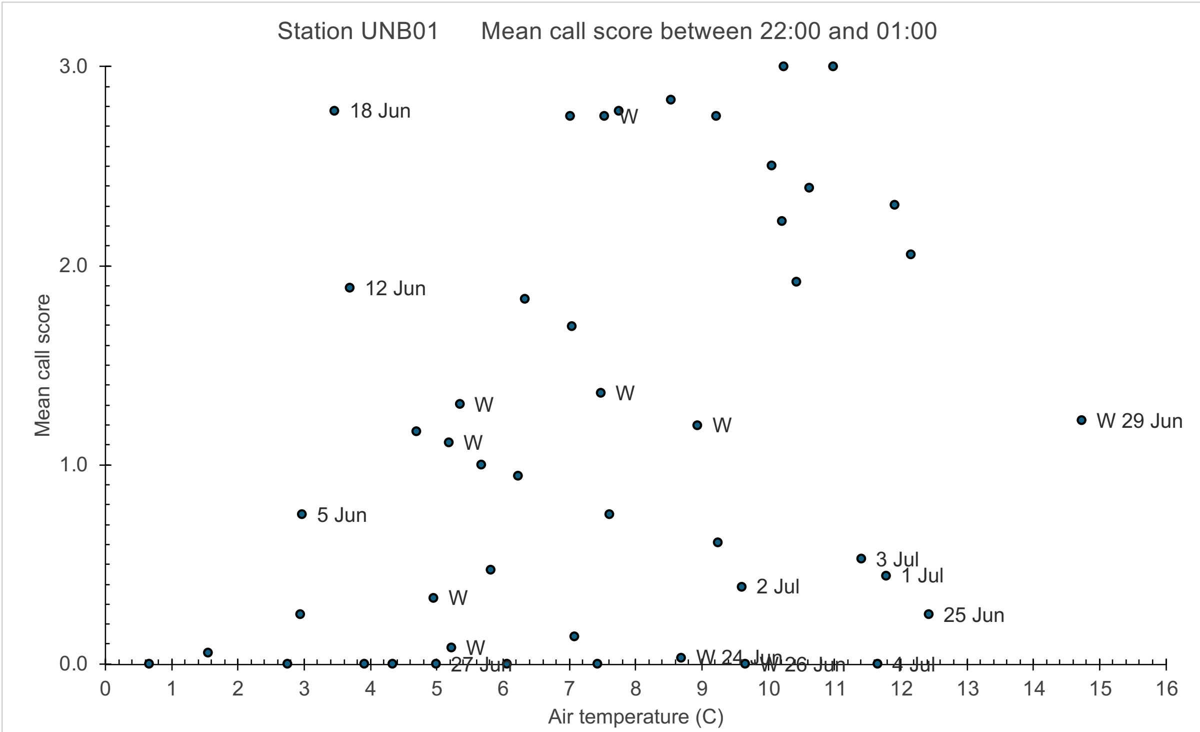

Figure 9. Mean call score at UNB01 site in the period 22:00 – 01:00 compared with mean air temperature (21:00-02:00) recorded at the same station for 49 nights. Nights with persistent strong winds are labelled with W. The points labelled 5, 12 and 18 June were nights with cold air (mean <4°C) but warm water temperatures (mean >15 °C).

Seasonal trends – Figure 10 shows the nightly records of calling, full chorus calling and water temperature from 7 May through 5 July at the PEN13 pond. Unfortunately the sound recorder failed to record part of this period. No calling was recorded on the first two nights of recorder deployment (7 and 8 May), but frequent calling and choruses began on 9 May. Thereafter, some calling was recorded on most nights, continuing until the recorders were removed on 5 July.

Figure 11 shows the same data for the UNB01 pond. Recordings began on 17 May but no spadefoots were calling until 22 May. Calling frequencies varied throughout the sampling period, influenced by water temperatures (see above for details).

At both sampling sites Spadefoot calling was recorded for most of May and June and might have continued beyond the time when recording stopped on 5 July. These data indicate a long two-month period of Spadefoot calling. Male Spadefoots were still calling at the time when there were already large tadpoles in the same ponds (see next section). Throughout the sampling period, calling rates varied considerably; nights with no full chorus and reduced calling corresponded to low water temperatures (as shown in Figure 6). Towards the end of the recording period (24 June through 5 July) calling was more sporadic and full chorus calling was rare (Figures 10 and 11). These data indicate that optimal times for Spadefoot surveys are between 9 May and 24 June, but there will still be nights in this period when there is little or no calling.

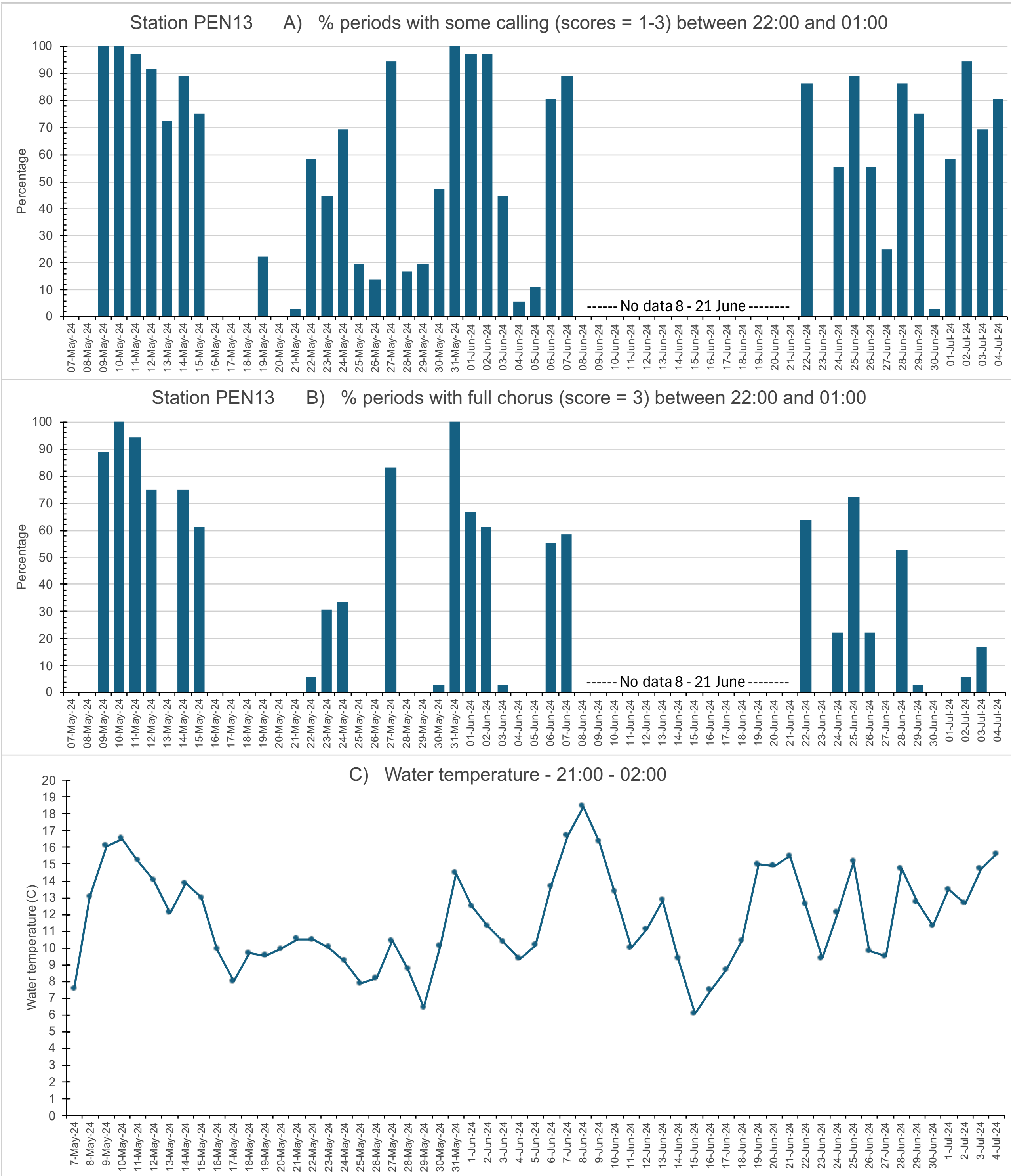

Figure 10. Seasonal trends in Spadefoot calling (A), full chorus (B) and water temperature (C) at the PEN13 pond in 2024. The calling data were from 22:00 to 01:00 each night and the temperature means were from 21:00 – 02:00. The dates show the evening that recording began.

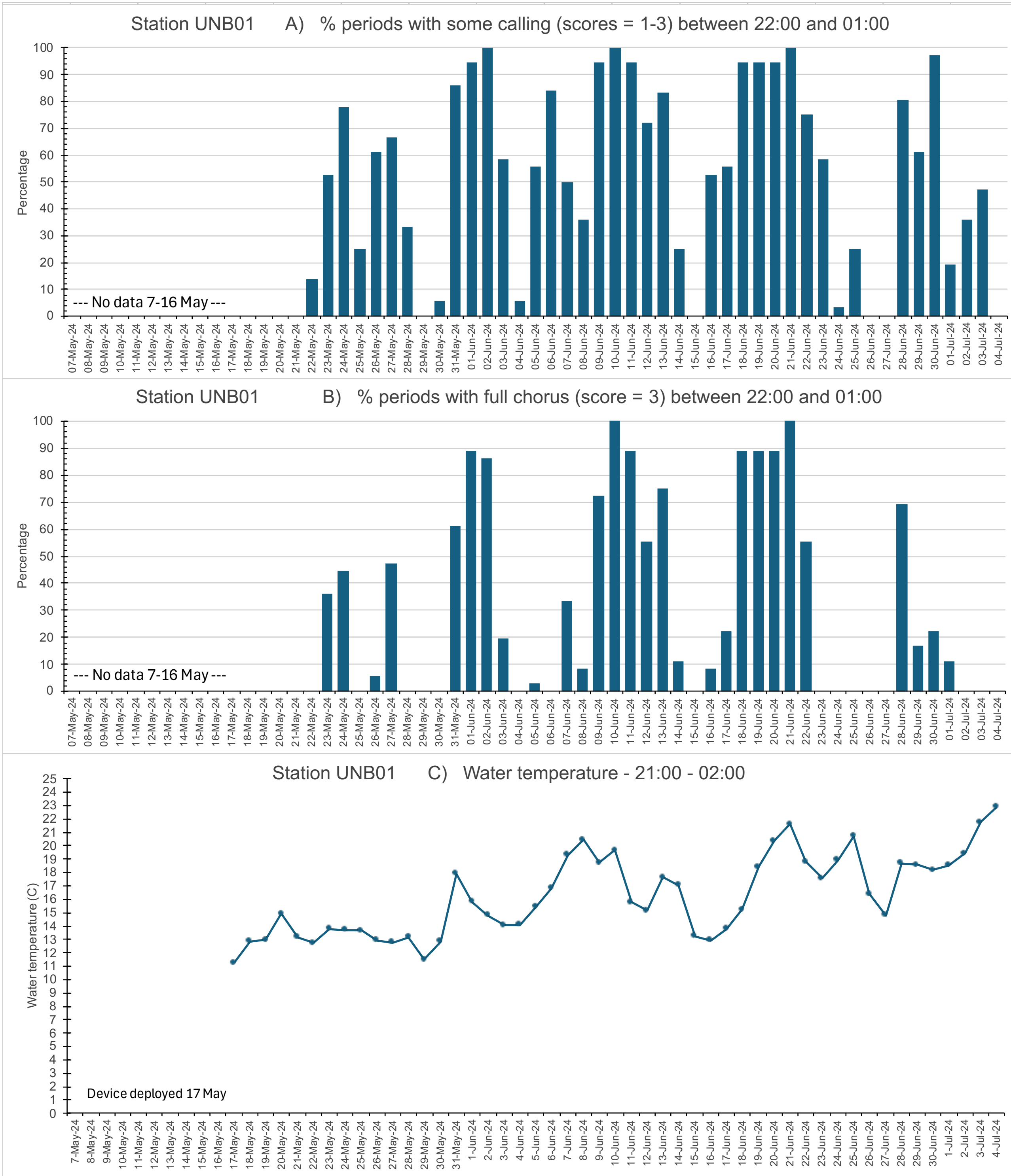

Figure 11. Seasonal trends in Spadefoot calling (A), full chorus (B) and water temperature (C) at the UNB01 pond in 2024. The calling data were from 22:45 to 02:30 each night and the temperature means were from 22:00 – 03:00. The dates show the evening that recording began.

TADPOLE SURVEYS

Toward the end of the breeding season we searched for Spadefoot tadpoles at the five sites where we had deployed the automated sound recorders (Table 5). Spadefoot tadpoles were located at two sites (PEN13 and UNB01). At two other stations (POND2 and DL07) dense pond vegetation prevented a thorough search and at the HAM01 site the small pond near the Song Meter had dried up well before the end of the calling season. Spadefoot tadpoles were also found at one additional pond next to Minnie Lake Road (Table 5).

Table 5. Ponds searched for Great Basin Spadefoot tadpoles in 2024								
						UTM coordinates		
Location		Song Meter site	Date	Evidence of Spadefoots	Other amphibians*	Zone	Easting	Northing
POND2	Hamilton Commonage	Yes	22-Jun-24	None found - dense pond vegetation	None	10U	685614	5552800
HAM01	Hamilton Commonage	Yes	22-Jun-24	None found - small pond dried up. Large pond not fully searched	None	10U	683774	5552258
UNB01	Upper Nicola Band Reserve	Yes	05-Jul-24	40+ tadpoles of different sizes	AMBO & PSRE tadpoles	10U	694654	5562691
DL07	Douglas Lake Ranch airport	Yes	05-Jul-24	None - but pond vegetation prevents through search	None	10U	702347	5560762
PEN13	Pond at Pennask Lake Road	Yes	05-Jul-24	30+ tadpoles close to Song Meter	None	10U	683025	5550289
-	Pond on Minnie Lake Road	No	05-Jul-24	30+ tadpoles at the south end	None	10U	688311	5546691
*AMBO = Western Toad; PSRE = Pacific Tree Frog								

DISCUSSION and CONCLUSIONS

Our ongoing roadside call surveys are providing multi-year data on the distribution of breeding Spadefoots in the Douglas Lake Plateau grasslands. Once we have completed the planned 2022-2026 surveys these will provide a valuable comparison with the 2011-2015 surveys in the same area and at many of the same survey stations. With the changing climate producing major effects on precipitation, temperatures and pond water retention in our area, such multi-year and multi-decadal data are extremely valuable to assess a sensitive species like the Great Basin Spadefoot.

The results summarised here from the automated sound recorders and temperature loggers are just the start of a full analysis. This report includes data from two stations covering most of the breeding season. Nevertheless, the data analysed so far provide essential insights into the biology of Spadefoots in our area and provide valuable guidance on improving any surveys for this species throughout its range.

The occurrence of Spadefoot calling and the number of males calling (as indicated by the calling scores) were both strongly related to water temperature and, with some deviations, to air temperature. High rates of calling were found on a few days when air temperatures dropped markedly after dark but water temperatures remained high. It is no surprise that amphibians sitting in the water are more sensitive to water temperature than air temperature. We are beginning to get good quantitative data to guide our survey protocols (see below) and provide better information on what aquatic habitats and climatic conditions would be suitable for Spadefoot breeding in our area.

The effects of wind and precipitation on calling remain unclear. From these data it appears that prolonged strong winds inhibited calling when water temperatures were marginally suitable (i.e., 9-11°C, Figure 6), but when water temperatures were above 11°C winds had less noticeable effects. Similarly, calling occurred when the sound recordings showed evidence of rain. For a more rigorous analysis of these factors we would need automated wind and rain recorders.

The sound recordings indicate that the local Spadefoots have a long breeding period, with male Spadefoots calling for at least two months. The variability in calling, and especially full chorus calling, from night to night helps to explain why we sometimes fail to hear Spadefoots on our roadside surveys, even in the middle of the calling season. This variability is tied to fluctuations in water temperatures in the shallows where the Spadefoots congregate, indicating that this needs to be taken into account when doing surveys.

What do these results mean to improve survey protocols that use Spadefoot calls to determine location and relative abundance? The sound recorder data indicate that surveys should be between 9 May and 24 June, but even in this period there will be nights with little or no calling. Repeated surveys and multi-year sampling is therefore essential for reliable detection of breeding locations. With our current protocol, roadside surveys begin around 21:30 (e.g., Table 1), but the analyses of calling at the PEN13 and UNB01 ponds (Figures 3 and 4) indicate that surveys starting at 22:00 are more likely to detect calling and full choruses. Most roadside surveys take about two hours (Table 1), so surveys within the period 22:00 to 01:00 would cover the expected peak of calling and choruses. In addition, these data indicate that surveys should not be done when air temperatures are at or below 5ºC, unless there is evidence that water temperatures are high. Nights with prolonged strong winds should also be avoided. Ideally water temperatures in breeding ponds should be the guiding factor but for a roadside survey those are logistically more difficult to obtain than air temperature. Once we have analysed the data from the full set of sound recordings we will review our protocols for future seasons.

Still to come:

- Analysis of the sound recordings and weather data from the other three stations with automated recorders. This will allow assessment of the consistency of the trends reported here across a range of breeding locations.
- Continued search for a computer algorithm to identify Great Basin Spadefoot calls and speed up the very demanding extraction of call data from the recordings. We have discussed this with amphibian researchers in B.C., but need to expand our search to include U.S. researchers.
- Soliciting university professors who might use this project as a graduate thesis project, thereby allowing more sophisticated and detailed statistical analysis of the huge database.
- Future deployment of our equipment to provide a multi-year perspective of the nightly timing and seasonal chronology of calling and the effects of weather. The addition of automated wind and rain recorders would provide useful information.
- Modification of our roadside survey protocol to take into account the results of this analysis. In particular we plan to begin surveys at 22:00 in the evening instead of 21:30 and avoid surveys when temperatures and wind are sub-optimal for calling.

ACKNOWLEDGEMENTS

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A Great Basin Spadefoot tadpole at the PEN13 pond – 5 July 2024. Photo: Alan Burger

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Appendix 1 – Roadside survey data sheet

Nicola Naturalist Society - Spadefoot Surveys

Amphibian Call Survey Datasheet

Route name:

Date: **Start time:** **Start temp:**

Observers: **End time:** **End temp:**

Rain (start): None drizzle light moderate **Rain (end): None drizzle light moderate**
Cloud % (start): <5 5-50 51-95 >95 **Cloud % (end): <5 5-50 51-95 >95**
Wind (start): 0 1 2 3 4 **Wind (end): 0 1 2 3 4**

Comments on conditions:

Call station #	WPT # or UTM	Species code[1]	Call index[2]	Near /Far[3]	Dir.[4]	# cars pass	Noise index[5]	Comments

[1]Columbia Spotted Frog: RALU; Western Toad: AMBO; Pacific Tree Frog: PSRE; Spadefoot: SPIN
[2] Call index: 1: individual calls distinct/not overlapping; 2: some overlapping calls; 3: full chorus
[3]Far (F) – if very faint; Near (N) – if clearly near (e.g., within 400 m); otherwise leave blank.
[4]Dir: approximate compass bearing (e.g., N, NE, ENE, etc. or give actual bearing in degrees – true not magnetic)
Use separate lines for calls coming from different directions at the same station.
[5]Noise index: 0: no effect (e.g. owl calling); 1: low (e.g. dog barking, distant traffic, 1 car passing, wind rustling leaves); 2: moderate (e.g. 2-5 cars passing); 3:high (continuous traffic nearby, 6-10 cars passing); 4: very high (e.g. continuous traffic passing, construction noise)
Record any changes in weather during the survey

Appendix 2. Great Basin Spadefoot surveys 2024 - details on each station (some stations that use 2 or more lines are boxed)

Route code	Date	Station code	Survey sequence	UTM coordinates			Species code*	Call index	Near (N) Far (F)	Direction	# cars	Noise index	Comments, including other animals reorded
				Zone	Easting	Northing							
DL	23-May-24	DL01**	12	10U	697837	5559973	SPIN	1	N	WSW	0	0	SPIN calling from two directions near and far
DL	23-May-24	DL01**	12	SPIN calling from 2 directions			SPIN	1	F	WSW	0	0	SPIN calling from two directions near and far
DL	23-May-24	DL02	11	10U	698379	5560557	0	0	0	0	0	0	
DL	23-May-24	DL03	10	10U	698831	5561177	SPIN	3	N	S	0	0	
DL	23-May-24	DL04	9	10U	699643	5560893	SPIN	2	N	WSW	1	0	
DL	23-May-24	DL05	8	10U	700606	5560827	0	0	0	0	1	0	
DL	23-May-24	DL06	7	10U	701178	5560968	0	0	0	0	0	0	CAGO
DL	23-May-24	DL07	6	10U	701933	5560911	SPIN	1	F	SE	0	0	WISN, CAGO
DL	23-May-24	DL08**	5	10U	702735	5560739	SPIN	3	N	SSW	0	0	SPIN calling stopped after 3 minutes. SORA, KILL
DL	23-May-24	DL08**	5	Two species recorded			PSRE	1	N	SSW	0	0	
DL	23-May-24	DL09**	4	10U	703857	5560606	SPIN	3	F	W	1	0	SPIN calling from two directions
DL	23-May-24	DL09**	4	SPIN calling from 2 directions			SPIN	3	F	NW	1	0	SPIN calling from two directions
DL	23-May-24	DL10	3	10U	703987	5561335	0	0	0	0	0	1	Sora 1, WISN 1. Minor river noise
DL	23-May-24	DL11	2	10U	705893	5564721	0	0	0	0	0	0	**New station**
DL	23-May-24	DL12	1	10U	706719	5565281	0	0	0	0	0	0	GWTE 1, CAGO 3, WISN 1, VESP 3, SASP 1
LAU	24-May-24	LAU01	13	10U	693061	5568405	SPIN	3	N	100E	0	0	Cow
LAU	24-May-24	LAU02	12	10U	692466	5567641	0	0	0	0	0	0	GHOW(?), UNK?
LAU	24-May-24	LAU03	11	10U	691975	5566962	PSRE	2	F	240SW	0	0	GHOW(?), UNK?
LAU	24-May-24	LAU04**	10	10U	691522	5566290	SPIN	2	N	270W	0	0	No birds, calls consistant & overlapping
LAU	24-May-24	LAU04**	9	Two species recorded			PSRE	2	N	270W	0	0	nothing
LAU	24-May-24	LAU05	8	10U	690894	5565848	SPIN	2	F	165S	0	0	nothing
LAU	24-May-24	LAU06	7	10U	690178	5565599	SPIN	2	F	170S	0	0	nothing
LAU	24-May-24	LAU07	6	10U	689868	5565035	SPIN	3	F	148SE	0	0	Cow, person instructing not to go into field
LAU	24-May-24	LAU08	5	10U	689177	5564811	0	0	0	0	0	0	SEOW, Cottonwood leaves rustling
LAU	24-May-24	LAU09	4	10U	688775	5564028	0	0	0	0	0	1	SEOW, Cottonwood leaves rustling
LAU	24-May-24	LAU10	3	10U	688353	5563458	0	0	0	0	0	1	Nicola River, Sub-station hum?, SEOW
LAU	24-May-24	LAU11	2	10U	688268	5562641	0	0	0	0	0	1	Nicola River, Sub-station hum?, SEOW
LAU	24-May-24	LAU12	1	10U	687812	5552228	0	0	0	0	0	1	Nicola River, AMRO
QC	25-May-24	QC01	1	10U	677859	5559192	PSRE	2	F	170S	0	1	Quilchena Creek
QC	25-May-24	QC02	2	10U	678541	5558937	PSRE	2	F	250W	0	0	Quilchena Creek
QC	25-May-24	QC03	3	10U	678690	5558270	PSRE	2	N	352N	0	1	Quilchena Creek, cow, GHOW (visual)
QC	25-May-24	QC04	4	10U	678675	5557493	0	0	0	0	0	1	Cow, apiary, snipe, veery (Merlin)
QC	25-May-24	QC05	5	10U	678885	5556945	0	0	0	0	0	1	Quilchena Creek
QC	25-May-24	QC06	6	10U	678468	5556312	PSRE	3	N	217SW	0	1	Quilchena Creek, dog, SPSA (Merlin?)
QC	25-May-24	QC07	7	10U	678367	5555502	0	0	0	0	0	1	Quilchena Creek, Whitetail deer, COPO(?)
QC	25-May-24	QC08	8	10U	678401	5554657	0	0	0	0	0	1	Quilchena Creek, Whitetail deer, COPO(?), ILM
QC	25-May-24	QC09	9	10U	678387	5553906	0	0	0	0	0	1	Quilchena Creek
QC	25-May-24	QC10	10	10U	678435	5553109	0	0	0	0	0	2	Quilchena Creek; COPO On road
HAM	28-May-24	HAMX5	1	10U	685480	5552744	0	0	0	0	0	0	**New station**
HAM	28-May-24	HAMX4	2	10U	684791	5552324	SPIN	1	N	S	0	1	**New station**. Minor wind noise
HAM	28-May-24	HAM01	3	10U	683986	5552269	0	0	0	0	0	1	Minor wind noise
HAM	28-May-24	HAM02	4	10U	683506	5551650	0	0	0	0	0	1	Minor wind noise
HAM	28-May-24	HAM03	5	10U	682845	5551252	0	0	0	0	0	2	Minor wind noise & trees rustling
PEN	28-May-24	PEN13	6	10U	682857	5550252	0	0	0	0	0	0	Cold breeze
LUN	01-Jun-24	LUN01	1	10U	667748	5549203	PSRE	1	F	230SW	0	1	Highway traffic (poss WSOW)
LUN	01-Jun-24	LUN02	2	10U	668052	5549914	PSRE	1	N	80E	0	0	Wind
LUN	01-Jun-24	LUN03	3	10U	668702	5550211	PSRE	3	N	20SE-230S	0	1	Wind, Bull elk
LUN	01-Jun-24	LUN04	4	10U	669384	5550390	PSRE	3	N	30SE-230S	0	0	Wind
LUN	01-Jun-24	LUN05	5	10U	669868	5550725	PSRE	1	F	170S	0	3	0
LUN	01-Jun-24	LUN06	6	10U	670465	5551203	PSRE	1	F	210SW	0	3	UNK bird
LUN	01-Jun-24	LUN11	7	10U	670447	5551824	PSRE	3	N	230W	0	0	Wind, coyotes, COPO
LUN	01-Jun-24	LUN07	8	10U	671170	5551591	PSRE	3	N	E	0	0	Wind now 3, AMCO
LUN	01-Jun-24	LUN08	9	10U	688775	5564028	PSRE	3	N	120SE-190S	0	0	WISN
LUN	01-Jun-24	LUN09	10	10U	672992	5552430	PSRE	2	N	215SW	1	2	UNK bird
LUN	01-Jun-24	LUN10	11	10U	672992	5552430	PSRE	2	N	315N	0	2	chip spar, AMRO, RWBL, WISN, SWTH
PEN	09-Jun-24	PEN01	13	10U	680200	5558771	SPIN	3	F	205SW	0	0	
PEN	09-Jun-24	PEN02	12	10U	680301	5557962	SPIN	3	F	245SW	0	0	
PEN	09-Jun-24	PEN03	11	10U	680636	5557229	0	0	0	0	0	1	Airplane
PEN	09-Jun-24	PEN04	10	10U	680315	5556494	0	0	0	0	0	1	
PEN	09-Jun-24	PEN05	9	10U	680350	5555720	0	0	0	0	0	0	
PEN	09-Jun-24	PEN06	8	10U	680701	5555019	0	0	0	0	0	0	Bull
PEN	09-Jun-24	PEN07	7	10U	681084	5554398	0	0	0	0	0	0	Cow
PEN	09-Jun-24	PEN08	6	10U	681186	5553612	0	0	0	0	0	0	Cow, coyotes, unk electrical buzz
PEN	09-Jun-24	PEN09	5	10U	681316	5552804	0	0	0	0	0	0	cow
PEN	09-Jun-24	PEN10	4	10U	681808	5552239	SPIN	3	F	30NE	0	0	Nothing
PEN	09-Jun-24	PEN11**	3	10U	682209	5551533	SPIN	1	F	130SE	0	0	AMRO
PEN	09-Jun-24	PEN11**	3	SPIN calling from 2 directions			SPIN	2	F	50NE	0	0	AMRO
PEN	09-Jun-24	PEN12**	2	10U	682500	5550918	SPIN	3	F	55NE	0	0	Cow, horse, KILL
PEN	09-Jun-24	PEN12**	2	SPIN calling from 2 directions			SPIN	3	F	35NE	0	0	Cow, horse, KILL
PEN	09-Jun-24	PEN13	1	10U	682857	5550252	SPIN	3	N	25NE	0	0	Raining, COPO x 2 on road
DL	21-Jun-24	DL13	1	10U	707393	5565707	0	0	0	0	0	0	WISN, KILL, (Merlin; Boreal Owl?)
DL	21-Jun-24	DL14	2	10U	707980	5566279	0	0	0	0	0	1	Sprinklers, SORA, creek noise
DL	21-Jun-24	DL15	3	10U	708709	5566624	0	0	0	0	0	1	Sprinklers
DL	21-Jun-24	DL16	4	10U	709485	5566795	0	0	0	0	0	1	Sprinklers
DL	21-Jun-24	DL17	5	10U	709900	5567436	0	0	0	0	0	0	COLO, WISN, UNK duck
DL	21-Jun-24	DL18	6	10U	709859	5568223	0	0	0	0	0	0	CONI, WISN
DL	21-Jun-24	DL19	7	10U	710064	5569031	0	0	0	0	0	0	CONI
DL	21-Jun-24	DL20	8	10U	710186	5569819	PSRE	1	F	180S	0	0	CONI, Coyote
DL	21-Jun-24	DL21	9	10U	710643	5570548	PSRE	1	N	300NW	0	0	CONI, SORA, Beaver
DL	21-Jun-24	DL22	10	10U	711186	5571087	PSRE	1	F	0N	0	0	KILL, MALL, WISN, unk duck,
DL	21-Jun-24	DL23	11	10U	711747	5571662	PSRE	1	F	21SW	0	1	WISN, leaves
DL	21-Jun-24	DL24	12	10U	712065	5572369	0	0	0	0	0	0	WISN, KILL, COLO, VESP
DL	21-Jun-24	DL25	13	10U	712723	5572826	0	1	F	190	0	0	WISN, CONI, AMRO, human voices
DL	21-Jun-24	DL26	14	10U	713328	5573364	0	0	0	0	0	0	SEOW, KILL, WISN, CAMPSITE
DL	21-Jun-24	DL27	15	11U	286825	5574047	0	0	0	0	0	0	WISN, SASP, VESP, UNK duck, cows

* Species codes: SPIN - Great Basin Spadefoot (*Spea intermontana*); PSRE - Pacific Tree Frog (*Pseudacris regilla*)

**Two lines are used when calling is detected from 2 different directions, or if 2 species are detected at the same station.

Bird codes in Appendix 2

AMCO – American Coot
AMRO – American Robin
CAGO – Canada Goose
COLO – Common Loon
CONI – Common Nighthawk
COPO – Common Poorwill
GHOW – Great Horned Owl
GWTE – Green-winged Teal
KILL - Killdeer
MALL - Mallard
RWBL – Red-winged Blackbird
SASP – Savannah Sparrow
SEOW – Short-eared Owl
SORA - Sora
SPSA – Spotted Sandpiper
SWTH – Swainson's Thrush
VESP – Vesper Sparrow
WEME – Western Meadowlark
WISN – Wilson's Snipe