

**Fortescue Metals Group
North Star Pilbara Leaf-nosed Bat colony;
Cave 13 and Fig Pool activity monitoring;
March 2014 to March 2015**

Prepared for Fortescue Metals Group

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Document Revision History

Date	Issue	Revision History
25 May 2014	A	Initial draft prepared for Fortescue
26 March 2015	B	Second draft incorporating data to 10 March 2015
10 April 2015	1	Formal issue to Fortescue

Executive Summary

A Pilbara Leaf-nosed Bat (*Rhinonicteris aurantia* Pilbara form) (PLNb) diurnal roost has been documented in a cave complex known as Cave 13 at the Fortescue Metal Group's (Fortescue) North Star Iron Ore Project, approximately 120 km south of Port Hedland in the Pilbara, Western Australia (Bat Call 2013a). A permanent spring nearby at Fig Pool has also been recognised as a primary foraging location for the species (Bat Call 2013a).

Long term monitoring of the activity levels of the PLNb at Cave 13 and Fig Pool began in early March 2014.

The aims of the monitoring were to:

- Measure the nightly activity levels at both the cave and the pool,
- Measure nightly, monthly and seasonal variation of the bats activity at the cave entrance and thereby assess the ongoing health of the roost and any impact due to nearby mine development activities,
- Measure nightly, monthly and seasonal variation of the bats foraging activities at the pool and thereby confirm its importance as a primary foraging location for the species.

The results of the study show that the usage by the PLNb at Cave 13 was variable over the 12 month period. Initial activity at the cave in March 2014 was consistent with a primary foraging location for the species, but not a diurnal roost. During April and May 2014, the activity pattern changed to one consistent with diurnally roosting bats being present at the cave similar to that observed in April 2013. Following a two month period in June and July when activity was consistent with foraging only, diurnally roosting bats returned in August. By October, activity was again limited to foraging and this continued until March 2015. This last period covered the known reproductive season for the species (Churchill *et al.* 2008)

A perceived drop in activity from March 2014 to March 2015 is considered to be due to the drier than normal wet season without any cyclonic rainfall events.

The monitoring has confirmed that:

- a) PLNb continue to have an ongoing presence within the North star project area during the construction phase of the project,
- b) PLNb did not use Cave 13 as a diurnal roost for large segments of the monitoring period particularly during the reproductive months,
- c) It is highly unlikely that Cave 13 was used by any PLNb for breeding and raising young (i.e. a maternity roost),
- d) PLNb did use both Cave 13 and Fig Pool as preferred foraging locations during the entire monitoring period, and
- e) There is at least one other diurnal roost, probably maternal, within 15 km of Cave 13.

Introduction

Fortescue commissioned Bat Call WA (Bat Call) to conduct an ongoing bat monitoring program for the North Star project in the Pilbara, WA, beginning in March 2014. The monitoring includes the nightly recording of vulnerable Pilbara Leaf-nosed Bat (PLNb) (DoE 2014) activity at a known roost entrance (Cave 13), and at a foraging location nearby, the permanent spring fed Fig Pool. The locations of Cave 13 and Fig Pool are depicted in Figure 1 and coordinates are given in Appendix B. The species had been detected previously at both locations (Bat Call 2013a). This study provides an analysis of the species detection levels at both locations over a 12 month period.

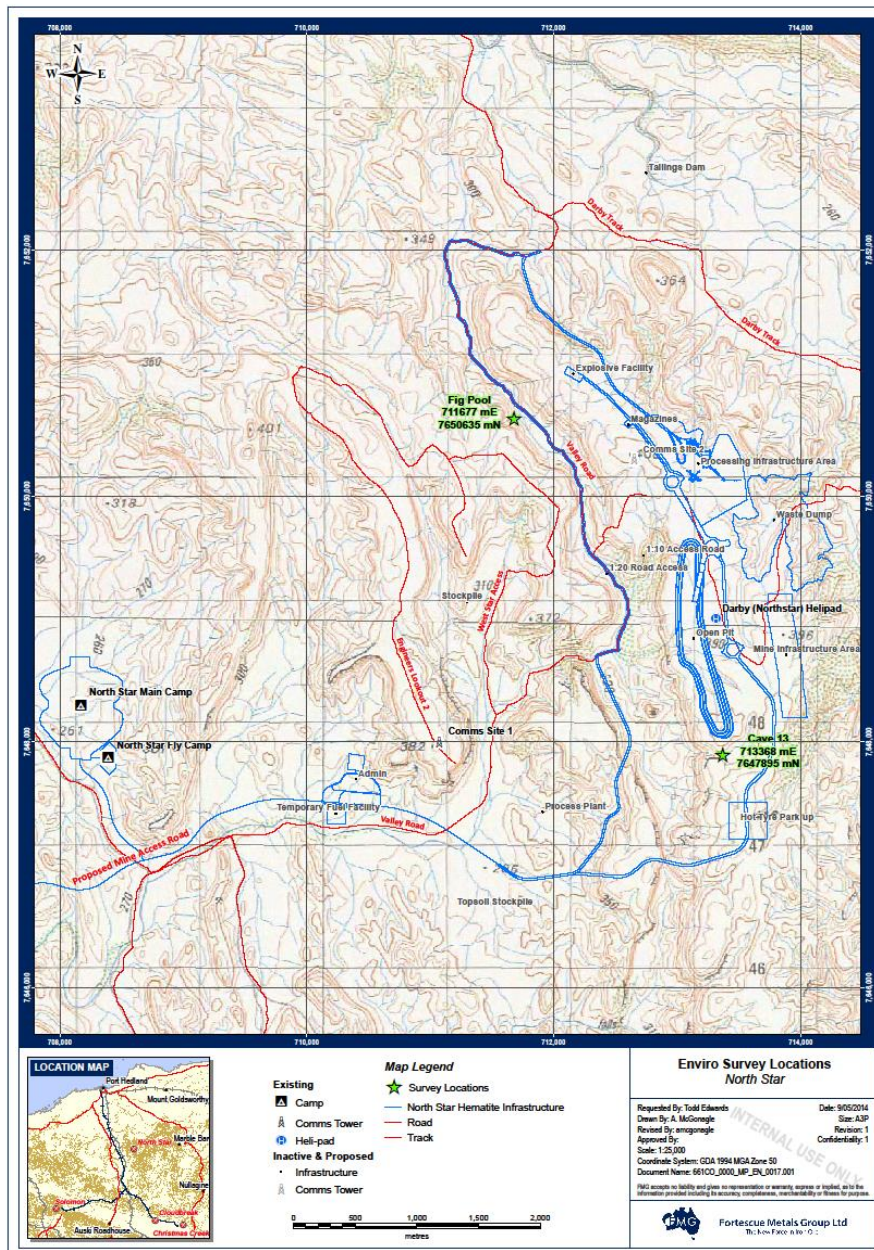


Figure 1: Location of the Fortescue’s North Star project approximately 120 km south of Port Hedland in the Pilbara, WA. The two monitoring locations are at Cave 13 and Fig Pool

Methodology

Survey Team

Mr Robert Bullen of Bat Call specified the equipment to be used for the survey, calibrated and installed it. Mr Bullen has also reviewed the recordings made and has provided the analysis contained herein.

Survey Timing and Weather

The monitoring has run from the 8th March 2014 to the 10th March 2015. Ambient weather after February 2014 has been typical of the Pilbara's annual seasonal cycle with the notable absence of any major cyclonic rainfall events during the 2014/15 wet season. The analysis presented below includes temperature and rainfall data from the closest Bureau of Meteorology station at Marble Bar (station 4106). Times for sunrise, sunset and the corresponding civil twilights were taken from the Geoscience Australia website. Note that civil twilight typically follows sunset and precedes sunrise by approximately 25 minutes at the latitude of North Star.

Bat Observations

Full-spectrum ultrasonic bat detector (SM2BAT+ (384 kHz) model Wildlife Acoustics, USA) was selected for use for this monitoring program as this system is proven to be superior in recording PLNb calls to other bat detector systems used previously at this site. The settings used on the SM2 detector are targeting PLNb and are given in Appendix A. The detectors were mounted on tripods approximately 0.8 m above ground level to minimise call echoes and ground based fauna and flora noise.

At Cave 13 the SM2 was placed approximately 2 m inside the entrance against the western wall (Plate 1) to record numbers of bats passing. The omnidirectional microphone was oriented horizontally and across the axis of the cave to detect bats entering and exiting the cave equally. The bat's presence was confirmed by recording diagnostic 120 kHz ultrasonic calls (or passes) (McKenzie and Bullen 2009). In this study a PLNb call is a discreet series of ultrasonic pulses that range from 1 to over 30 pulses in length.

At Fig Pool, the SM2 was placed on the west bank of a permanent pool (Plate 2) beneath an overhanging cliff. The microphone was horizontal and was oriented across the axis of the pool.

Both detectors were powered by 12 volt (420 CCA) automotive batteries that were charged during the day using a 20W solar panel fitted with a 14.5 V regulator. The panels were mounted horizontally on wind proof stands in locations receiving full sun (Plate 3).

The SM2 recordings, once reformatted as .wav files, were then reviewed using COOL EDIT 2000 (Now available as AUDITION from Adobe Systems Inc.). This displayed each call sequence to confirm identification using reference call data from McKenzie and Bullen (2009). Bat activity levels were then assessed by counting the calls recorded in 30 minute blocks between sunset and sunrise.

Difficulties with firmware in the SM2 units resulted in the failure to record some data. At Cave 13, only sporadic data collection was achieved between September 2014 and February 2015. At Fig Pool, some data was not collected between July 2014 and January 2015. From December to February, Anabat Express detectors (Titley Scientific, Australia) were used at both sites to supplement the SM2 data. Having limited battery capacity, these units were unable to provide continuous backup. Twenty six and fourteen nights of data were collected using these units at the Cave13 entrance and Fig Pool respectively.



Plate 1: SM2 in Cave 13 entrance. The SM2 was placed approximately 2 m inside the entrance against the western wall.



Plate 2. Fig Pool SM2 detector location. The detector is circled in the background with its microphone orientated across the permanent pool. The solar panel was placed approximately 50 m to the east in full sun.



Plate 3: Typical installation of the solar panel providing power to the SM2 detector at Cave 13.

Survey Limitations

All aspects of the survey including site access, Bat Call team make-up and experience levels, equipment used, logistics and safety support provided by Fortescue were suitable for the task. SM2 detector was specified as it is proven to be superior to other detector systems in recording PLNb in passive monitoring mode and in all types of weather.

Difficulties with firmware in the SM2 units resulted in the failure to record some data. However data collected at both sites were adequate to achieve the objectives of the study.

Headcount of PLNb at the site is impossible to calculate precisely from ultrasonic recordings due to the possibility of multiple passes by individual bats. A count of calls (passes) is therefore used to establish an activity level of PLNb.

Results

Pilbara Leaf-nosed Bat nightly activity pattern at Cave 13 and Fig Pool

PLNb were detected at the cave on all but one night of the study (Figure 2) when the detector was functioning normally. The maximum number of calls detected on any night was 6840 on the 4th June 2014 and the minimum number detected was 1 on several nights during December and January 2015. No calls were detected at Cave 13 on the 6th January 2015. At the pool the maximum and minimum call counts were 930 and 0 respectively. The maximum count was recorded on 4th July and the minimum was recorded on several nights during December 2014.

The Cave 13 data showed a pattern of increasing call counts from March to May 2014 with a second activity peak in August (Figure 2). Nightly activity levels from March and April were typically over 1500 calls per night. The count then rose to over 4000 in May and over 5000 in August. It then dropped through 2000 in September to less than 300 per night from November 2014 to March 2015.

The call count at Fig Pool showed a different pattern from the cave with no increase from March to May 2014 being apparent. Activity was at very low levels during these months with average nightly totals being less than 100. The count rose to over 400 in July 2014 and then dropped to less than 100 per night from September to March 2015.

Nightly call temporal patterns at both sites for each month of the study show the changing nature of the overnight activity (Figure 3). For the months March and April 2014, the patterns at Cave 13 showed a monomodal shape with peak activity occurring late at night. A weak bimodal pattern with a second peak within 2 hours of twilight is evident in May, July and August 2014. Activity then falls to very low levels during December 2014 and January 2015 and then recovers to approximately 200 calls per night during February and March with both months showing a monomodal pattern.

The pattern at Fig Pool shows a continuous usage across the night for all months of the study in line with a preferred foraging location. A strong early evening peak is evident during June and July 2014.

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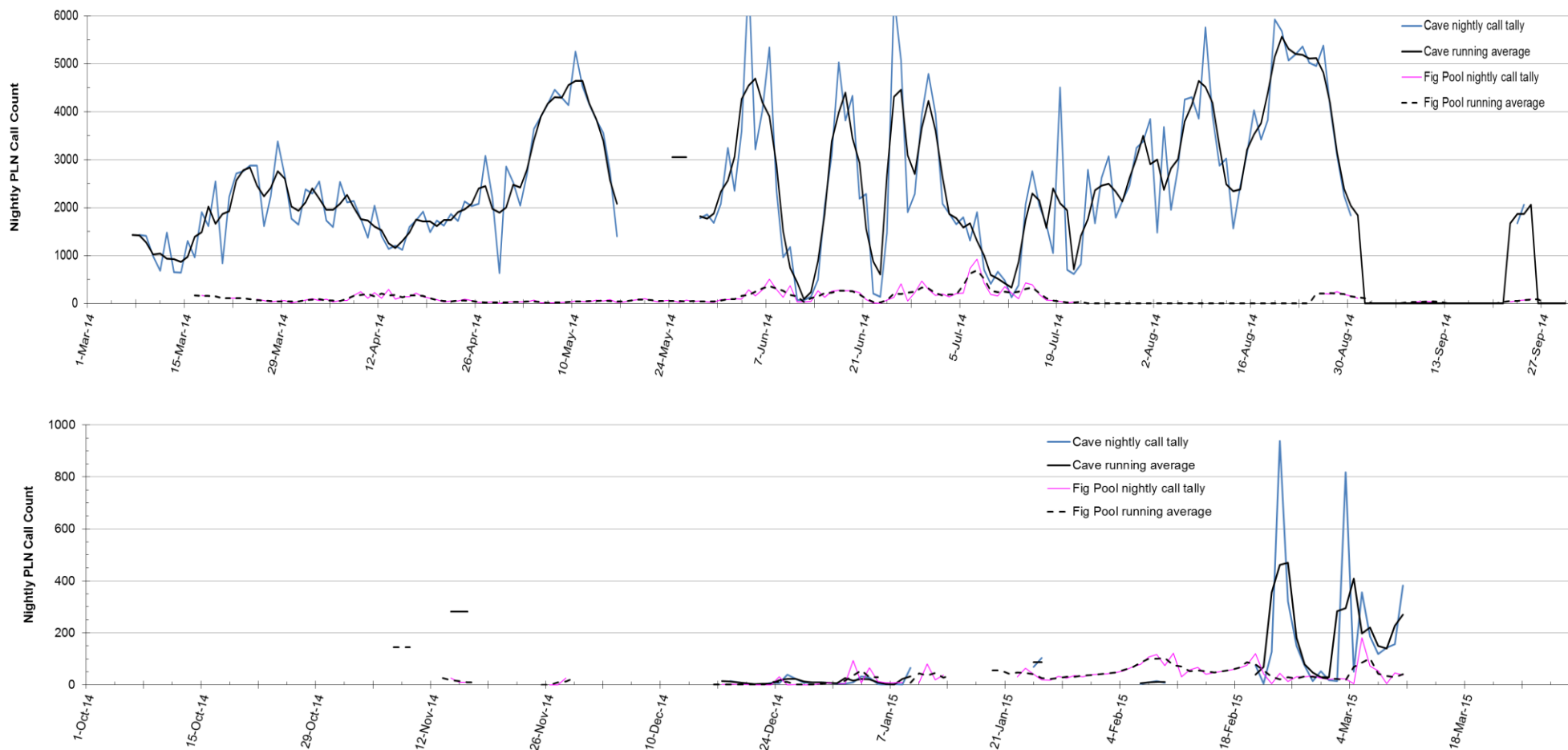
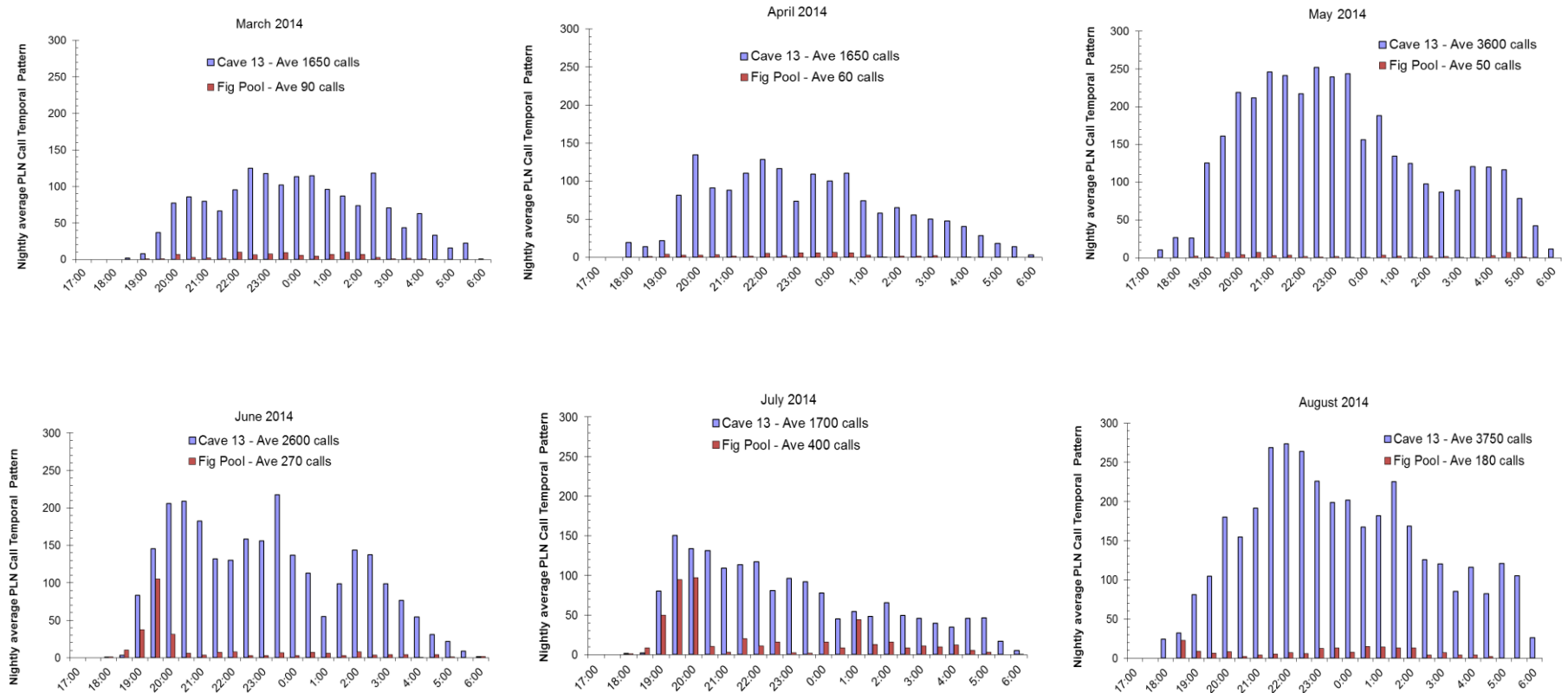
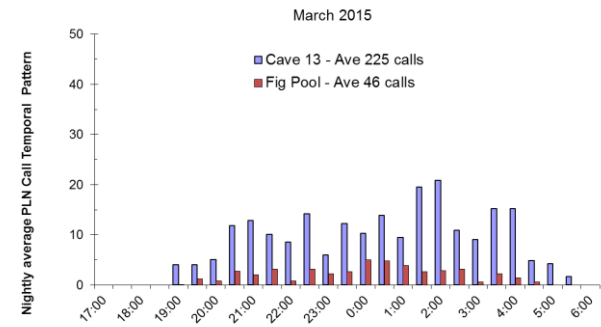
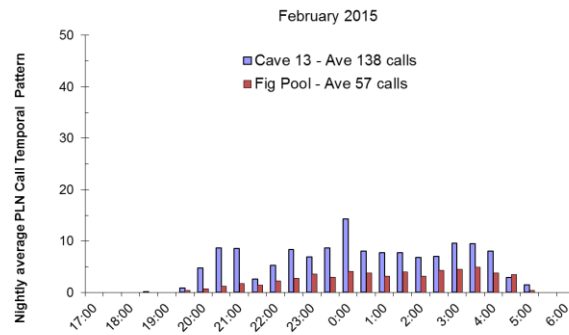
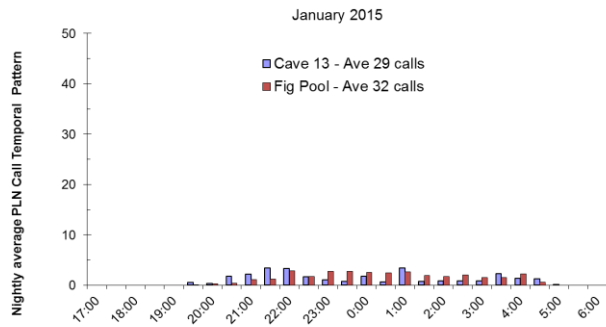
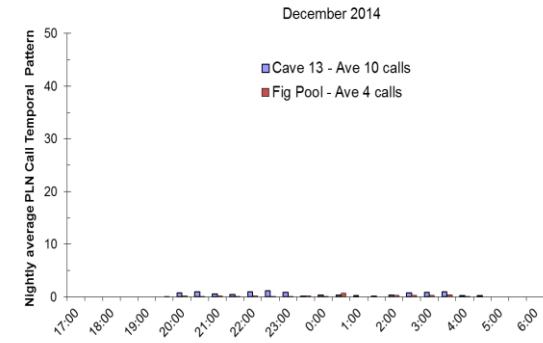
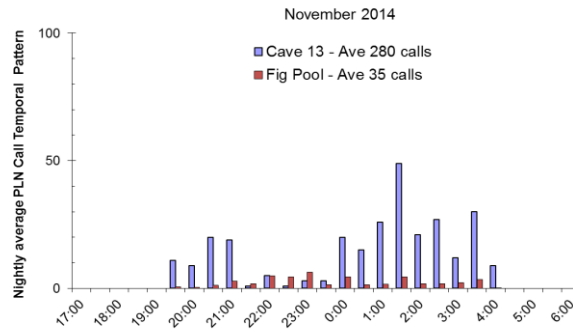
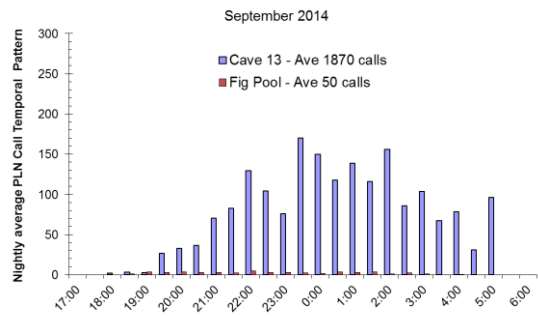


Figure 2. Pattern of Pilbara Leaf-nosed Bat calls detected at Cave 13 entrance and at Fig Pool between 8th March 2014 and 10th March 2015. A running average over three nights is also presented (black lines). Note the different nightly call count scale from October onward.

Figure 3. Nightly temporal call patterns at Cave 13 and Fig Pool for each month between March 2014 and March 2015. At the entrance of Cave 13 the majority of months show a monomodal pattern with peak activity rising to an average of 3750 calls per night in August 2014. A weak bimodal pattern is evident in May, July and August 2014. Activity then falls to very low levels from November 2014 to January 2015 and then recovers to approximately 200 calls per night during February and March. Note that no data was collected during October 2014 due to equipment failure. At Fig Pool the call counts rose from less than 100 per night prior to June 2014 to a peak of 400 calls per night in July and dropped to less than 100 from September 2014 onward. Fig Pool activity is spread evenly across the night for all months except June and July which show a peak after twilight.



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Pilbara Leaf-nosed Bat emergence and return timing.

Nightly timing of bat calls at Cave 13 and Fig Pool are presented in Figures 4 to 7. The patterns show that the first detections at both sites were typically over an hour after sunset (or 40 minutes after civil twilight) for the majority of the months (Table 1). At Cave 13, the periods from late April to end May 2014 and during August and September 2014 show timing differentials of less than half an hour from sunset indicating that the first calls were recorded close to civil twilight (Table 1). This pattern was repeated in the morning. Note that there are calls on the 19 March 2014, 10 April 2014 and 20 February 2015 that have similar timing differentials. These data together with the bimodal nightly temporal pattern of calls indicate that PLNb were roosting at Cave 13 during late April, May, August and September 2014. The data also indicate that PLNb were visiting the cave nightly to forage but not roosting from March to late April 2014, June to July 2014 and from November 2014 to March 2015 with the exception of the three nights in March 2014, April 2014 and February 2015 noted. The absence of roosting over the 2014/15 wet season coincides with the reproductive cycle for the species, being monomodal with birth by January and weaning by March (Churchill *et al.* 2008 for the northern Orange leaf-nosed bat form supported by data in Bat Call 2013b and author's unpublished observations for PLNb).

Timing of the latest calls at the pool and cave showed a similar pattern to emergence times. The data show that the time differentials of calls at the cave before morning twilight were typically over 30 minutes except during the periods from late April to end May and from mid-July to September 2015 (Table 1).

Calls were detected at Fig Pool before Cave 13 on many occasions during April, June and July 2014 and from December 2014 to March 2015 (Figure 7). The PLNb detected on these occasions must originate from a diurnal roost other than Cave 13. The significance of this is considered in Discussion.

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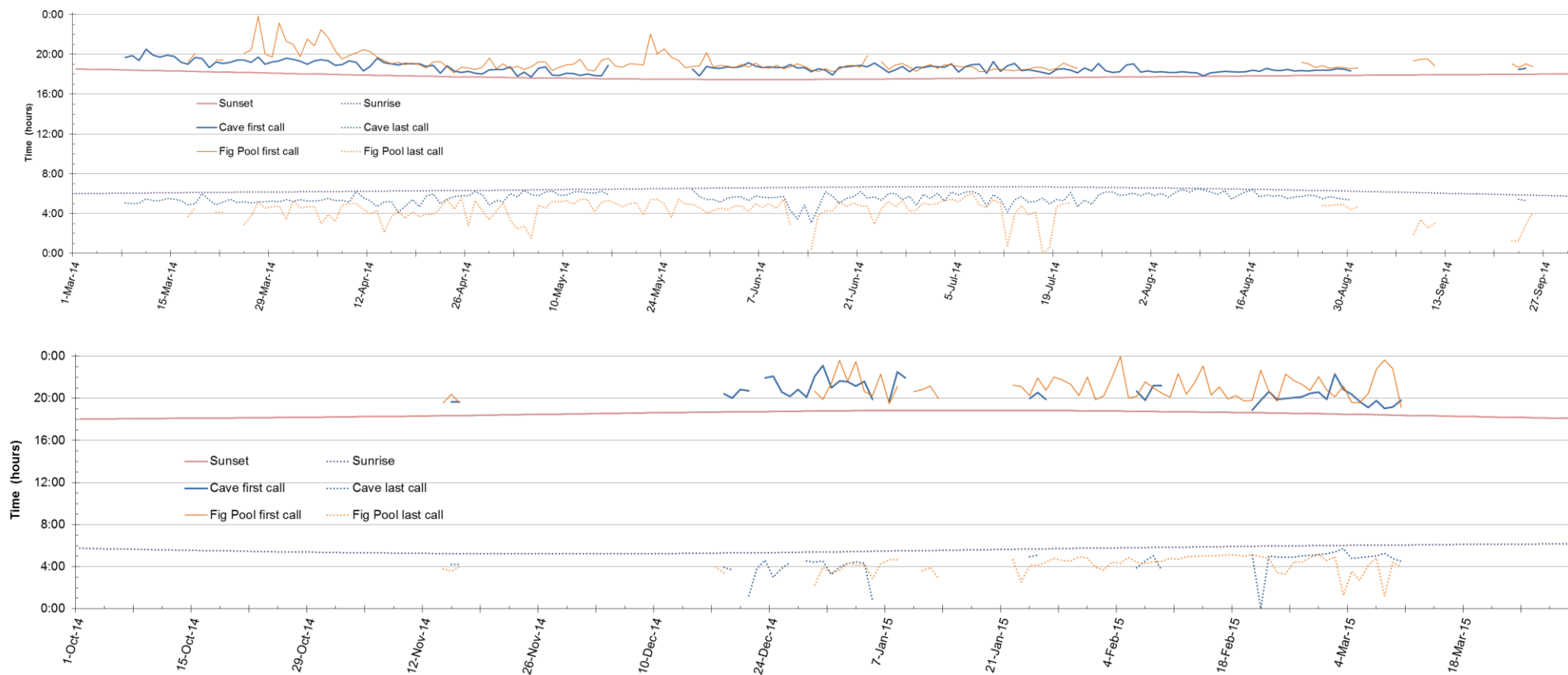


Figure 4: Nightly timing of Pilbara Leaf-nosed Bat calls at North Star. Curves represent the times of sunset, sunrise and the earliest and latest records of calls at both sites. The patterns show that the first detections at both sites were typically over an hour after sunset for the majority of the months. The periods from late April to late May 2014 and during August and September 2014 show timing differentials of less than half an hour indicating that the first calls were recorded close to civil twilight. This pattern was repeated prior to sunrise. There is are calls on the 19 March 2014, 11 April 2014 and 20 February 2015 that have similar timing differentials.

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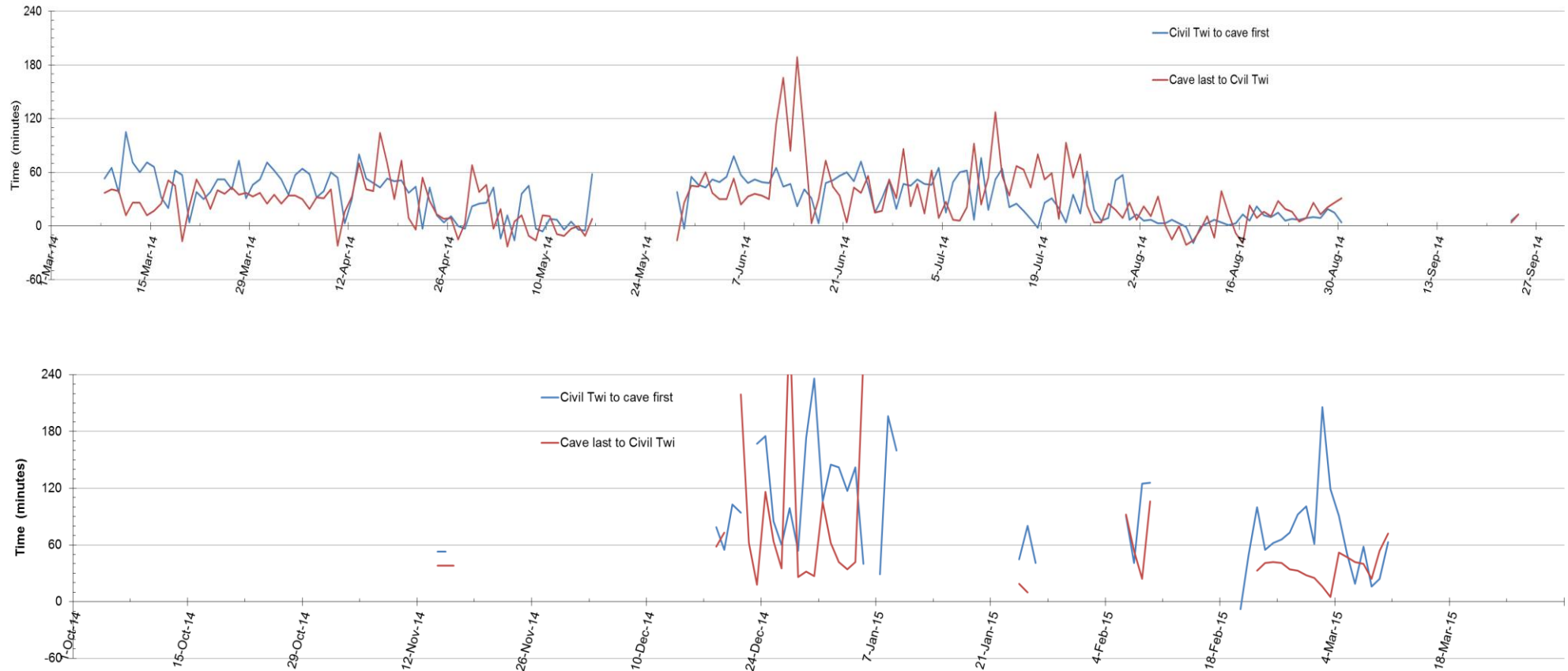


Figure 5: Nightly timing of Pilbara Leaf-nosed Bat calls at Cave 13. Curves represent the number of minutes that earliest and latest calls were detected after evening civil twilight and before morning civil twilight. The patterns confirm that the nightly activity pattern changed from late April to the end of May with the cave’s first call being detected within minutes of civil twilight during this period. This pattern reoccurred from the end of July to the end of August. At all other times, with the exception of the 19 March 2014, 10 April 2014 and 20 February 2015, the first call was detected after civil twilight. These data suggest that PLNb were roosting at Cave 13 during May and August 2014 and individual bats roosted overnight at the cave at other times.

Table 1. Average time in minutes with std. deviation for both sites for the various periods where the PLNb are indicated to be using/not using Cave 13 as a diurnal roost.

	1 March to 25 April 2014	26 April to 31 May 2014	1 June to 31 July 2014	1 Aug to 30 Sept 2014	1 Oct 2014 to 10 March 2015
PLNb appear to be roosting at Cave 13	No	Yes	No	Yes	No
Cave 13 – Civil twi. to first call (minutes)	46.7 ± 21.0	17.3 ± 24.5	39.3 ± 20.6	7.0 ± 7.2	90.0 ± 53.4
Cave 13 – Last call to civil twi. (minutes)	32.1 ± 21.4	10.2 ± 23.8	46.8 ± 37.7	9.8 ± 15.7	62.8 ± 65.3
Fig Pool – Civil twi. to first call (minutes)	101.8 ± 72.3	68.8 ± 45.4	46.6 ± 19.2	37.5 ± 18.5	119.3 ± 69.4
Fig Pool – Last call to civil twi. (minutes)	121.9 ± 86.9	92.3 ± 57.4	113.6 ± 80.2	134.4 ± 74.5	74.0 ± 56.9

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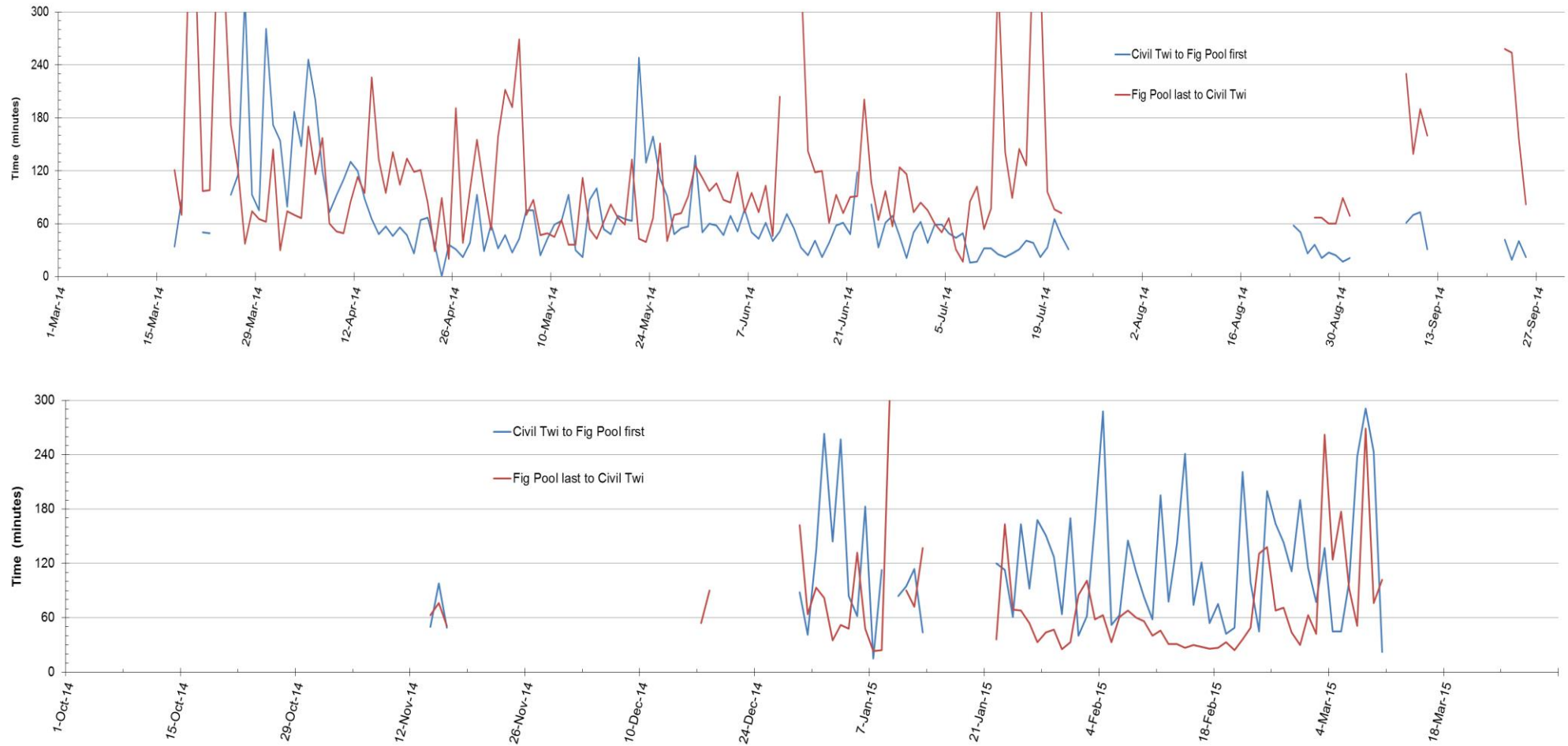


Figure 6: Nightly timing of Pilbara Leaf-nosed Bat calls at Fig Pool. Curves represent the number of minutes that earliest and latest calls were detected after evening civil twilight and before morning civil twilight. The data show that the time differentials were typically over 30 minutes during the study. Note that on a small number of mornings, the last call was before midnight and is therefore off scale.

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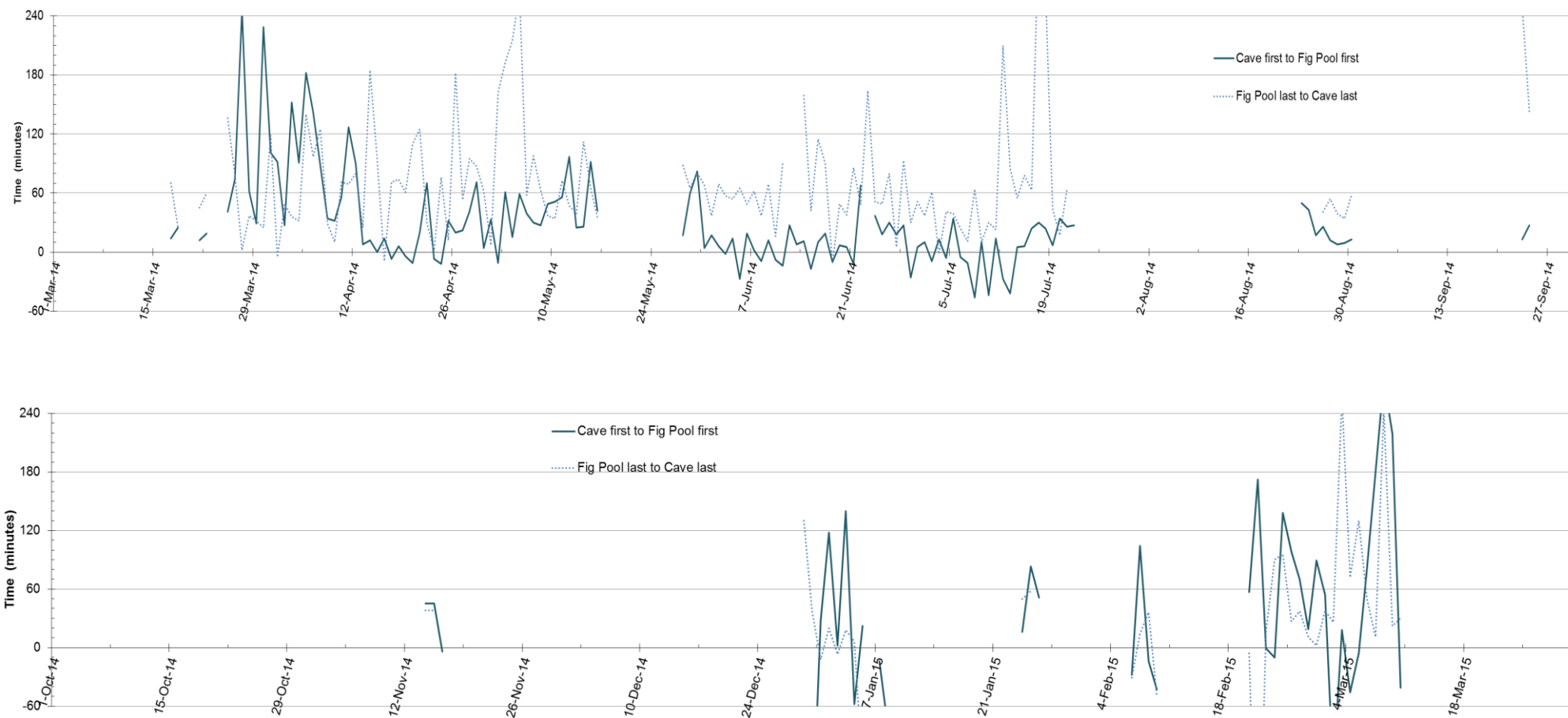


Figure 7: Nightly timing of Pilbara Leaf-nosed Bat calls at North Star. Curves represent timing differential between the earliest and latest calls at Cave 13 and Fig Pool. The evening differential clearly shows the periods in mid-April, during June and July and from late 2014 onward where bats were detected at the Pool well before bats were detected at the cave.

Effect of season on Pilbara Leaf-nosed Bat activity

Comparison of PLNb calls at both Cave 13 and Fig Pool with the prevailing temperature and rainfall conditions is shown in Figure 8. The data indicates that the peak activity at Cave 13 corresponded to the cooler months from April to September. Short activity peaks lasting a few days tend to follow days when rainfall was recorded nearby at Marble Bar.

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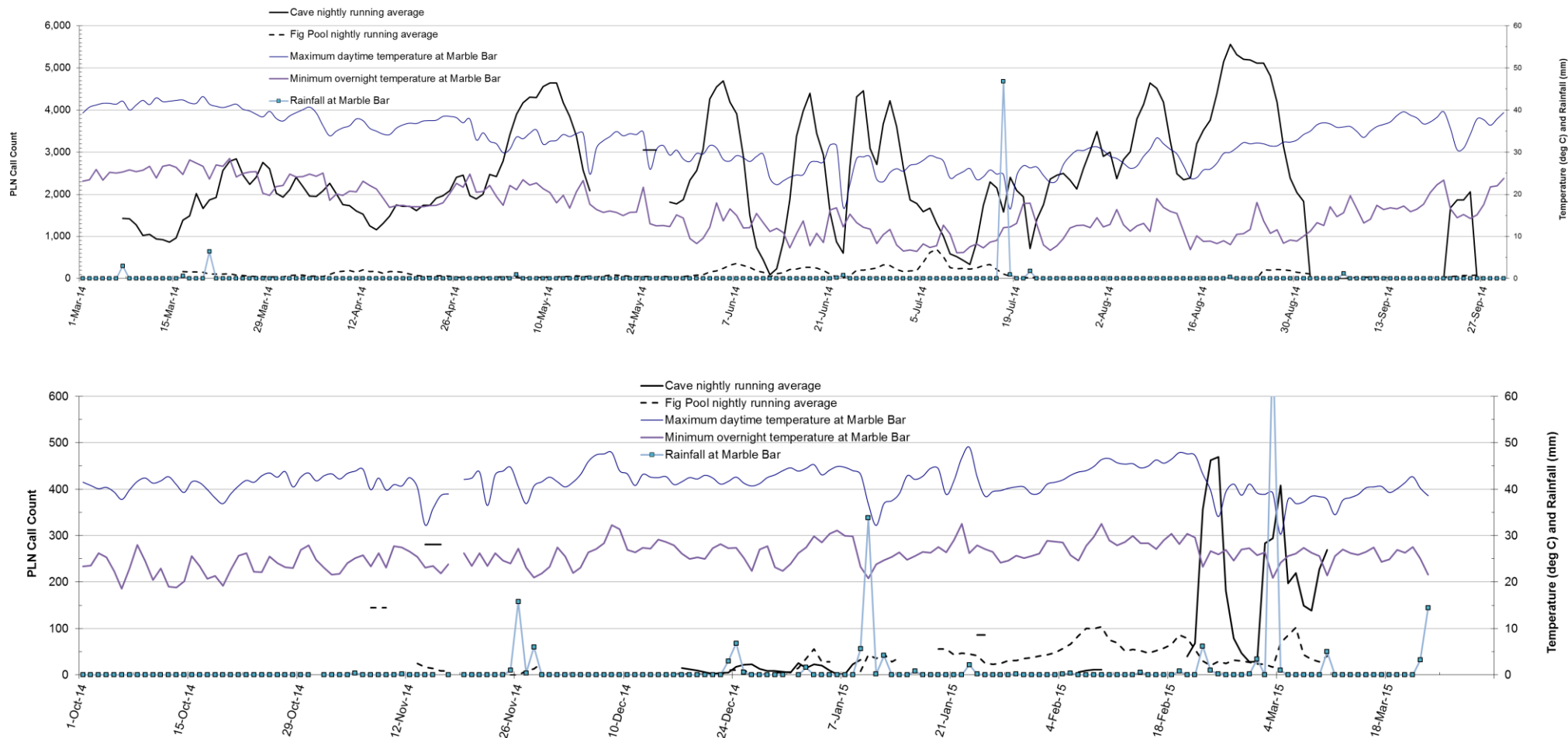


Figure 8. Comparison of bat calls with the prevailing temperature and rainfall conditions. This data indicates that the peak activity at cave 13 corresponded to the cooler months from April to September. Short activity peaks lasting a few days tend to follow period when rainfall was recorded. Note that Marble Bar rainfall on the 3rd March 2015 was 72.8 mm.

Discussion

The initial result of the monitoring is that the PLNb have an ongoing presence at the North Star project and at Cave 13 and Fig Pool in particular. The change from monomodal to bimodal nightly activity at Cave 13 entrance in April and again in August together with the timing data indicates that the use of the cave by PLNb changed from a preferred foraging location in March 2014 to a diurnal roost (as was detected in 2013) with a bimodal pattern in May and again in August 2014. From November 2014 to March 2015 the patterns reverted to those of a preferred foraging location. It is also significant that the call numbers were low in the breeding months of March 2014 and from September to March 2015 compared with the cooler months of May through August further confirming that the PLNb were not using Cave 13 as a maternal roost. It would be expected that during the breeding months prior to weaning (September to January) the reproducing females would be more active with multiple movement to and from the cave being measured giving higher call counts. Following weaning in February and March, it would be expected that the call counts would increase further with the movement of the sub-adult bats beginning to forage. Neither of these increases are evident in the Cave 13 data.

Monitoring data from another PLNb diurnal roost known to be a stable maternal roost has indicated that the PLNb emergence timing over a 9 month period corresponds approximately to civil twilight. At that site the range of emergence times was between 25 minutes before and 26 minutes after civil twilight (average -2.4 ± 7.1 minutes) (Bat Call 2013b). This site also exhibits a strongly bimodal temporal pattern of nightly calls during the breeding months of September to March. A similar emergence pattern is evident at other known roost entrances where measured emergence times vary from -6 to +11 minutes from civil twilight together with bimodal activity patterns (author's unpublished data). At foraging sites in continual use that are close to permanent diurnal roosts, the monomodal activity pattern for all months except the late dry season, together with the timing of first detections are also consistent year round with first calls detected well after civil twilight and last calls detected well before civil twilight (e.g. Bat Call 2013b; author's unpublished data).

The data show that for the months when no roosting activity is evident at cave 13 (i.e. monomodal temporal pattern and late first call timing), the first calls at Fig Pool often occur before those of Cave 13, up to 30 minutes prior during the drier months of June and July and up to 3 hours prior during January and February 2015. This is evidence that there is at least

one other permanent diurnal roost in the district. This combined with the change in timing differential between the detection of bats at Cave 13 and civil twilight from approximately 40 minutes when no roosting is evident to approximately 10 minutes in May and August suggests that the foraging bats were flying no more than 10 to 15 km from their diurnal roost to Cave 13 at their known mode flight speed of approximately 20 kph (McKenzie and Bullen 2009).

On each occasion that a rainfall event of 5mm or more was measured at Marble Bar, Cave 13 call counts increased during the following five days. This is evident in late March, mid July, late December 2014, mid and late February 2015. Each of these months have been shown to support foraging activity only at the cave and it is probable that it offers improved foraging following rain, most likely with an increase in the number of midges swarming inside its entrance. It is probable that the reduction in activity level between March 2014 and March 2015 is the result of the dryer than usual 2015 season with no cyclonic rainfall events impacting North Star. No similar pattern of activity increase following rain is evident at Fig Pool. The only pattern apparent at the pool is the increase in activity from approximately 100 calls to over 400 calls per night as the 2014 dry season began in June and July followed by the drop off to less than 100 again during the wetter months in early 2015. This would be expected with the reduced amount of surface water available during the dry season making Fig Pool a preferred site for drinking. This is also evident in the nightly temporal call pattern for those months which both show a peak of activity early in the evening.

In conclusion therefore the data show:

- a) PLNb continue to be present at North Star during the construction phase of the project,
- b) PLNb did not use Cave 13 as a diurnal roost for large segments of the monitoring period particularly during the reproductive months,
- c) It is highly unlikely that Cave 13 was used by any PLNb for breeding and raising young (i.e. a maternity roost),
- d) PLNb did use both Cave 13 and Fig Pool as preferred foraging locations during the entire monitoring period, and
- e) There is at least one other diurnal roost, probably maternal, within 15 km of Cave 13.

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Appendix A. SM2 Audio settings used during survey.

Parameter	Setting
Sample rate	384,000 kHz
Channel used	Left
Compression protocol	WAC4 (12 bit audio samples)
Gain - left channel	0.00
Digital high pass filter Left channel	fs/4 (giving 96 kHz minimum frequency)
Triggering level Left channel	6SNR (adaptive +6 dB triggering)
Triggering window Left channel	1.0 sec.

Note: These settings are as recommended in Wildlife Acoustics (2010) except the high pass filter. This is set to 96 kHz to selectively record only Pilbara Leaf-nosed Bats.

Appendix B. Location of Cave 13 and Fig Pool monitoring stations.

	Zone	Easting	Northing
Cave 13	50K	713365	7647870
Fig Pool	50K	711675	7650630