Lower Colorado River Multi-Species Conservation Program

Balancing Resource Use and Conservation

2014 System-Wide Acoustic Monitoring of LCR MSCP Bat Species

U.S. DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION

March 2017

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Lower Colorado River Multi-Species Conservation Program

2014 System-Wide Acoustic Monitoring of LCR MSCP Bat Species

Prepared by:

Ronald Mixan and Joel M. Diamond, PhD

Arizona Game and Fish Department, Wildlife Contracts Branch

Lower Colorado River
Multi-Species Conservation Program
Bureau of Reclamation
Lower Colorado Region
Boulder City, Nevada
http://www.lcrmscp.gov

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ACRONYMS AND ABBREVIATIONS

AKTP	‘Ahakhav Tribal Preserve
BLCA	Beal Lake Conservation Area acoustic station
BWRNWR	Bill Williams River National Wildlife Refuge acoustic station
CNWR-Island	Cibola National Wildlife Refuge-Island Unit acoustic station
Crane’s Roost	Cibola National Wildlife Refuge Unit #1 Conservation Area acoustic station in Crane’s Roost
CVCA 1	Cibola Valley Conservation Area acoustic station #1
CVCA 2	Cibola Valley Conservation Area acoustic station #2
Havasu NWR	Havasu National Wildlife Refuge
HHCA	Hunters Hole acoustic station
Havasu NWR	Havasu National Wildlife Refuge
HNWR-Pintail	Havasu National Wildlife Refuge acoustic station in Pintail Slough
LCR	lower Colorado River
LCR MSCP	Lower Colorado River Multi-Species Conservation Program
MLWA	Mittry Lake Wildlife Area acoustic station
PSRA	Picacho State Recreation Area acoustic station
PVER 1	Palo Verde Ecological Reserve acoustic station #1
PVER 2	Palo Verde Ecological Reserve acoustic station #2
Reclamation	Bureau of Reclamation
YEW	Yuma East Wetlands acoustic station

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ABSTRACT

Acoustic bat call data were analyzed from 14 acoustic monitoring stations (Anabat™) along the lower Colorado River from October 1, 2013, through September 30, 2014. Nine stations were located within large-scale restoration projects consisting of cottonwood-willow (*Populus fremontii*, *Salix gooddingii*) and honey mesquite (*Prosopis glandulosa*) plantings as well as marsh and backwater (eight on Lower Colorado River Multi-Species Conservation Program conservation areas and one on the Colorado River Indian Tribes' 'Ahakhav Tribal Preserve). Five stations were located in existing riparian habitat along the lower Colorado River, with species composition, area, and canopy height varying across sites. The calls of eight species were evaluated: western red bat (*Lasiurus blossevilli*), western yellow bat (*Lasiurus xanthinus*), California leaf-nosed bat (*Macrotus californicus*), pale Townsend's big-eared bat (*Corynorhinus townsendii pallescens* [also known as *Plecotus townsendii pallescens and Corynorhinus townsendii townsendii]*), greater mastiff bat (*Eumops perotis*), hoary bat (*Lasiurus cinereus*), cave myotis (*Myotis velifer*), and Arizona myotis (*Myotis occultus*). Sites and species were evaluated based on relative activity (average nightly call minutes, average nightly call minutes per month, and seasonal average nightly call minutes) and occupancy (proportion of nights occupied). The sites with created habitat provided higher overall relative activity and occupancy than the existing habitat areas as well as the vast majority of relative activity and occupancy taking place during the hot season as opposed to the warm or cold season.

INTRODUCTION

This document is a summary of acoustic bat call data collected at 14 acoustic monitoring stations (Anabat™) along the lower Colorado River (LCR). The purpose of this project is to monitor bat species presence to inform the Lower Colorado River Multi-Species Conservation Program (LCR MSCP). The LCR MSCP is a multi-stakeholder Federal and non-Federal partnership responding to the need to balance the use of LCR water resources and the conservation of native species and their habitats in compliance with the Endangered Species Act. The Bureau of Reclamation (Reclamation) is the lead agency that implements the program. The LCR MSCP works toward the recovery of listed species through habitat and species conservation and reduces the likelihood of additional species listings under the Endangered Species Act.

Bats have been proposed as indicators of the integrity of natural communities and an excellent taxa for monitoring habitats because they integrate a number of resource attributes (e.g., roosting, watering, and foraging habitats) and thus a change in bat detections may indicate if habitat is declining in quantity or quality (Hutson et al. 2001; Miller et al. 2003; Miller 2010; Williams et al. 2006; Rainey et al. 2006, 2009; Jones et al. 2009). Acoustic sampling is an effective and economical means to monitor bat populations. Analyses of recordings from ultrasonic bat detectors are now widely applied when assessing bat distribution and activity over a range of temporal scales in various landscape contexts. Changes in bat species activity that suggest declining population trends or reveal limited ranges may warrant targeted investigation and shape the allocation of conservation funding support (Rainey et al. 2009). Alternatively, populations demonstrating stable or increasing population trends may require limited monitoring and funding support in the future. A key component of understanding and effectively managing bat communities is gaining a basic understanding of the inherent variation in species composition across spatial and temporal scales (Morris 1990). Understanding the variation in bat communities across time and space is fundamental for conservation efforts because managers must decide whether changes in species richness warrant management efforts.

This project targets data gaps for Reclamation's implementation of conservation measures for the western red bat (*Lasiurus blossevillii*), western yellow bat (*Lasiurus xanthinus*), pale Townsend's big-eared bat (*Corynorhinus townsendii pallescens* [also known as *Plecotus townsendii pallescens and Corynorhinus townsendii townsendii*]), and California leaf-nosed bat (*Macrotus californicus*). The LCR MSCP is required to create 765 acres of western red bat roosting habitat and 765 acres of western yellow bat roosting or foraging habitat by creating suitable habitat for these covered species.

Acoustic bat call data were collected and analyzed to document activity trends from 14 permanent stations: 8 stations at LCR MSCP conservation areas, 1 station at the Colorado River Indian Tribes' 'Ahakhav Tribal Preserve (AKTP), and 5 stations within existing riparian habitat along the LCR (existing habitat areas).

STUDY AREA

The study area consists of 14 permanent stations located along the LCR from the Havasu National Wildlife Refuge (Havasu NWR) in the north to Hunters Hole located near the Southerly International Boundary with Mexico (figure 1). The LCR MSCP conservation area stations are located at the Beal Lake Conservation Area (BLCA) on the Havasu NWR near Needles, California; the Palo Verde Ecological Reserve (PVER 1 and PVER 2) near Blythe, California; the Cibola Valley Conservation Area (CVCA 1 and CVCA 2) in Cibola, Arizona; the Cibola National Wildlife Refuge Unit #1 Conservation Area (Crane's Roost) near Cibola, Arizona; Yuma East Wetlands (YEW) in Yuma, Arizona; and Hunters Hole (HHCA) in Gadsden, Arizona (figure 1).

Conservation areas were created by the LCR MSCP through their Habitat Conservation Plan, which requires the creation of over 8,100 acres of various land cover types to provide habitat for targeted LCR MSCP covered species. Four land cover types are integrated in the LCR MSCP and include cottonwood-willow (*Populus fremontii*, *Salix gooddingii*) (5,940 acres), honey mesquite (*Prosopis glandulosa*) (1,320 acres), marsh (512 acres), and backwater (360 acres). Native species used in the conservation area plantings include coyote willow (*Salix exigua*), desert broom (*Baccharis sarothroides*), Fremont cottonwood, Goodding's willow, heliotrope (*Heliotropium curassavicum*), honey mesquite, mule fat (*Baccharis salicifolia*), quailbush (*Atriplex lentiformis*), and willow baccharis (*Baccharis salicina*). Conservation areas are planted in phases and contain a mixture of mature and maturing vegetation. In addition, some restoration sites, such as YEW and the BLCA on the Havasu NWR are taking longer to mature and have shorter canopy heights compared to sites at the Cibola Valley Conservation Area and Palo Verde Ecological Reserve.

One station is located at the AKTP in Parker, Arizona. This site was created and is managed by the Colorado River Indian Tribes. The AKTP exhibits vegetation characteristics similar to the LCR MSCP conservation areas and will be analyzed with the data from those areas.

Existing habitat stations are generally located in areas containing a mixture of native and non-native riparian vegetation that is remnant or where older small-scale planting occurred but there is no active management or irrigation of the site. The existing habitat stations are located at Pintail Slough in the Havasu NWR (HNWR-Pintail), the Bill Williams River National Wildlife Refuge (BWRNWR), the Cibola National Wildlife Refuge-Island Unit (CNWR-Island), the Picacho State Recreation Area (PSRA), and the Mittry Lake Wildlife Area (MLWA) (figure 1).

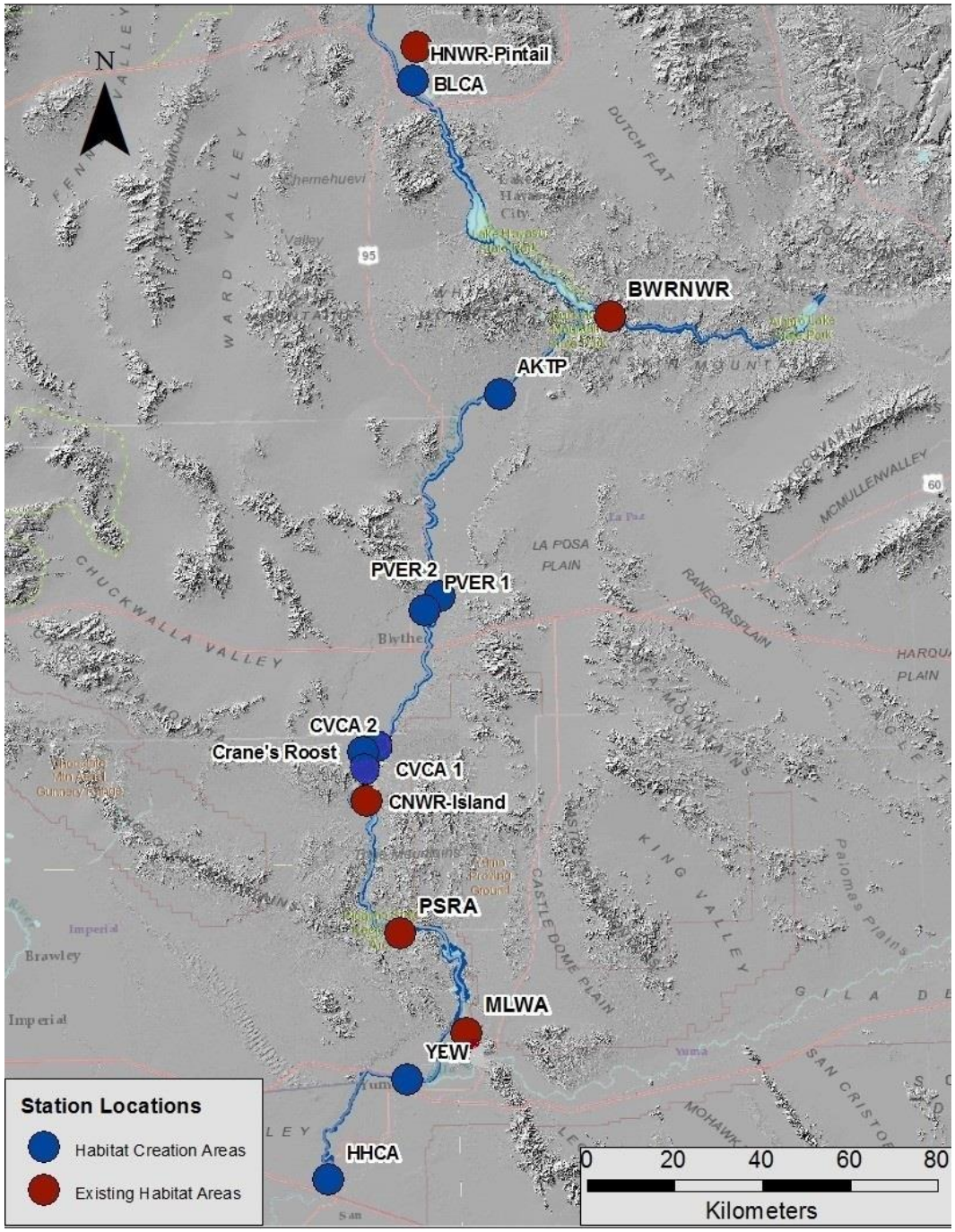

Figure 1.—Study area and station locations listed by station acronym.

METHODS

Data from permanent acoustic monitoring detectors in 14 locations (stations) along the LCR were summarized. These stations were deployed in LCR MSCP conservation areas and non-restoration areas at various times between 2007 and 2014 (table 1).

Table 1.—Station name, acronym, treatment, and year of station deployment

Station	Station acronym	Year deployed
‘Ahakhav Tribal Preserve	AKTP	2012
LCR MSCP conservation areas		
Beal Lake Conservation Area	BLCA 1	2007
Palo Verde Ecological Reserve 1	PVER 1	2012
Palo Verde Ecological Reserve 2	PVER 2	2013
Cibola Valley Conservation Area 1	CVCA 1	2011
Cibola Valley Conservation Area 2	CVCA 2	2013
Cibola National Wildlife Refuge Unit # 1 Conservation Area	Crane’s Roost	2012
Yuma East Wetlands	YEW 1	2013
Hunters Hole	HHCA	2012
Existing habitat areas		
Havasu National Wildlife Refuge-Pintail Slough	HNWR-Pintail	2014 (May)
Bill Williams River National Wildlife Refuge	BWRNWR	2008
Cibola National Wildlife Refuge-Island Unit	CNWR-Island	2008
Picacho State Recreation Area	PSRA	2008
Mittry Lake Wildlife Area	MLWA	2008

Bat vocalizations are sampled at these 14 stations, and they can be used to provide a temporal and spatial estimate of bat species diversity and presence. The acoustic monitoring devices consisted of Anabat™ II detectors with associated ZCAIM (a device that takes a frequency signal from an Anabat™ detector, detects the zero-crossings in the signal, and stores the signals on a compact flashcard), and Anabat™ SD1 and SD2 detectors (figure 2). Compact flashcards accumulated data at the rate of about 12 megabytes per night during periods of very high bat activity (about 1,500 calls per night), which is about 4 months for the 1-gigabyte cards used. Data were downloaded from the stations approximately every 4 to 6 weeks in order to address any maintenance issues. Recordings for this summary corresponded with the Federal fiscal year, beginning on October 1, 2013, and ending on September 30, 2014.

The volume of call minutes for the four LCR MSCP species (western red bats, western yellow bats, California leaf-nosed bats, and pale Townsend’s big-eared bats) were quantified along with four additional species: greater mastiff bat (*Eumops perotis*), hoary bat (*Lasiurus cinereus*), cave myotis (*Myotis velifer*), and Arizona myotis (*Myotis occultus*). Acoustic bat calls were recorded nightly from

Figure 2.—Acoustic detector.

sunset to sunrise, and the files were processed using filters and methods that have been used on previous LCR MSCP acoustic monitoring projects (Broderick 2008). Using Analook software, a series of acoustic filters were created for all eight bat species (figure 3). The analysis was based on first running files through an "All bats" filter to eliminate any files with significant background and insect noise. The remaining calls were then run through species-specific filters and analyzed individually to sort the species with similar call envelopes to the four focal species. Western red bat calls were run through two species-specific filters (a low frequency and a high frequency). The low-frequency filter detected bat calls ending between 40–47.5 kilohertz, while the high-frequency filter detected bat call ending between 52–80 kilohertz. The high-frequency filter was applied after discussions with Reclamation biologists (Broderick and Calvert 2011, personal communication) revealed they had recorded western red bat calls at higher frequencies along the LCR. Two species-specific filters were also used for greater mastiff bats and hoary bats to completely encompass their call envelopes. Pale Townsend's big-eared bats are known to emit low-intensity vocalizations in an attempt to capture their Lepidopteran prey, which makes them difficult to detect with acoustic methods (O'Farrell and Gannon 1999). Pale Townsend's big-eared bats produce a dual harmonic and cannot be positively identified unless the presence of this diagnostic harmonic is detected. The calls were compared and the filters tested on hand-release reference calls recorded along the LCR provided by Reclamation biologists (Broderick and Calvert 2011, personal

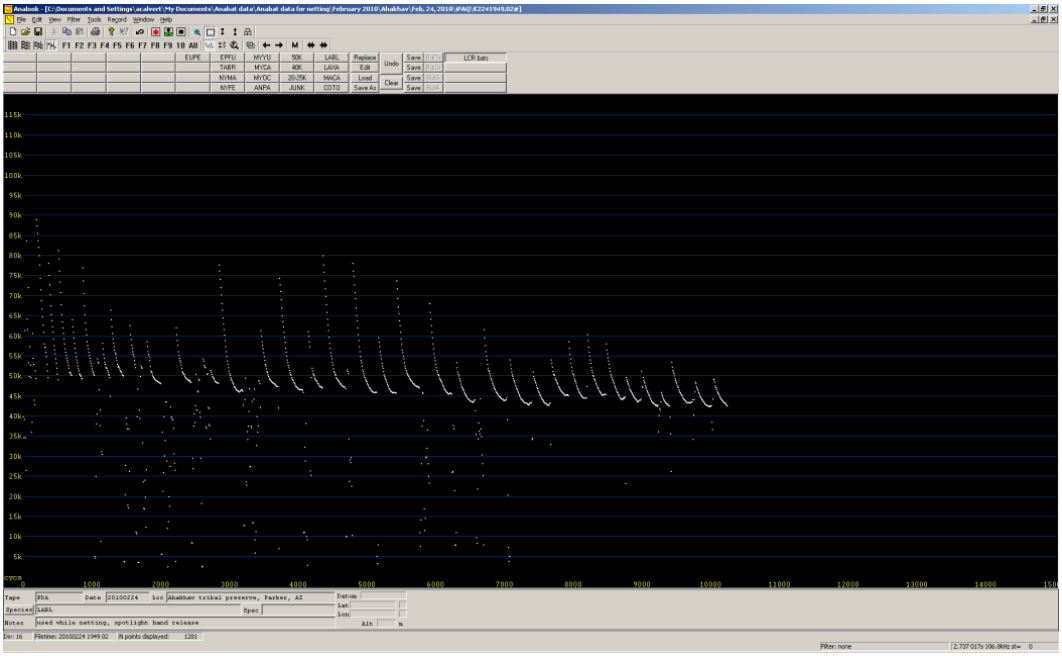

Figure 3.—Acoustic calls displayed during analyses.

communication) and from reference calls from across the Southwestern United States. All calls that were flagged as a species of interest were visually analyzed, and only those calls that could be positively identified to species are presented.

Call minutes were used in order to reduce bias in estimating bat activity at acoustic monitoring stations. A call minute is defined as a 1-minute interval in which a particular species is recorded at least once, regardless of the number of call sequences, or the number of files for that species recorded within that minute (Broderick 2010; Brown 2006; Kalcounis et al. 1999). The call minutes index reduces the bias associated with the tendency for individual bats to be detected multiple times or for multiple bats of a single species to be detected within an individual file (Miller 2001; Williams et al. 2006; Vizcarra et al. 2010). Bat minutes give a relative measure of activity while reducing the tendency to classify calls as the result of one bat making multiple calls or many bats making a single call. Therefore, the data were also analyzed using a presence/absence framework as the measure of occupancy, and the data are presented as nights occupied and proportion of nights occupied at the permanent stations. The approach is based on naïve occupancy (i.e., if the species is present and within range of the stations, it will be detected). Therefore, detection probabilities are not taken into account (i.e., imperfect detections). It should be noted that detection is indicative of presence, but non-detection of the species is not equivalent to absence (MacKenzie et al. 2002). Monitoring was limited to the distance in which the station could record reliable bat calls, and it was not known if a bat was present or absent just beyond the range of the station. Stations were compared based on average nightly call minutes per species per station as well as the total nights a species occupied the station area during the year. Because results may be biased

based on station malfunctions, data based on average nightly call minutes per month were also compared, which removed nights when a station was not recording. There is no best way to deal with stations that have malfunctioned, but it is believed the methods provide a simple, standardized way of comparing relative activity across stations and species.

RESULTS (SPECIES)

The difficulty in maintaining operational acoustic stations in the field is well documented (Rainey et al. 2009; Miller 2010; Young and Gruver 2011). The inherent operational problems with acoustic stations combined with long-term deployment of these stations (up to 6 years) resulted in inevitable maintenance issues. Continual insect and background noise exceeding the storage capacity of the compact flashcards has also been an issue with several stations. These maintenance issues and background noise have led to subsequent data gaps at stations throughout the year (table 2). Average nightly call minutes can be affected by what time of year a malfunction occurs. If a station malfunctions during the winter months when less bat activity is typically recorded, average nightly call minutes will be inflated by only recording calls during the higher activity summer months. Because average nightly call minutes do not adequately account for data gaps, the results are also presented in a temporal manner as average nightly call minutes per month. It is difficult to display average nightly call minutes per month for 8 species at 14 stations in a format that does not subject the reader to a copious amount of graphs or a few difficult-to-read graphs. To alleviate these difficulties, temporal graphs for the stations with the greatest number of nights occupied are displayed in the "Results (Species)" section, and all other temporal graphs are included as attachment 1. Data points marked with an asterisk on temporal graphs denote data gaps occurring during that month. Average nightly call minutes per month are also compared across three seasonal periods. March, April, October, and November are classified as the warm season; December, January, and February as the cold season; and May, June, July, August, and September as the hot season.

Western Red Bat

LCR MSCP Conservation Areas and the AKTP Station

The greatest average nightly call minutes for western red bats were recorded at the LCR MSCP conservation areas. The greatest average nightly call minutes were recorded at CVCA 1, followed by PVER 1 and Crane's Roost (table 3 and figure 4). The greatest number of nights occupied was recorded at CVCA 1, followed by Crane's Roost and PVER 1, with the greatest proportion of nights occupied recorded at CVCA1, followed by PVER 1 and Crane's Roost (table 3).

Table 2.—Nights recorded and data gaps for FY14

Station	Nights recorded	Data gaps
AKTP	291	October 1 – December 3 and July 19–28
LCR MSCP conservation areas		
BLCA 1	330	July 16–21, 28–31, and August 1–25
PVER 1	195	April 9–23, 26, 30, and May 1 – September 30
PVER 2	244	October 1 – November 6, 10–30, December 1–17, and March 8 – April 22
CVCA 1	365	N/A
CVCA 2	365	N/A
Crane's Roost	351	September 10–17 and July 18–23
YEW 1	118	October 1 – May 19 and September 1–16
HHCA	365	N/A
Existing habitat areas		
HNWR-Pintail	96	August 18 – September 30
BWRNWR	148	October 1 – January 23, January 27 – March 20, April 13 – May 21, and September 18–30
CNWR-Island	220	January 2–24 and March 20 – July 19
PSRA	332	June 15 – July 19
MLWA	365	N/A

The greatest average nightly call minutes per month were recorded at CVCA 1 during August (figure 5). The prevalence of data gaps at some sites, such as PVER 1, limits the ability to compare nightly averages by season across sites for this and all other species (see table 2).

Existing Habitat Stations

The greatest average nightly call minutes for western red bats were recorded at the BWRNWR, followed by HNWR-Pintail and the MLWA (table 3 and figure 4). The greatest number of nights occupied was recorded at the MLWA, followed by the BWRNWR and HNWR-Pintail, with the greatest proportion of nights occupied recorded at the BWRNWR, followed by HNWR-Pintail and the MLWA (table 3). The greatest average nightly call minutes per month were recorded at the BWRNWR during March (figure 6). The greatest average nightly call minutes were recorded at the BWRNWR during the warm season (figure 7).

Table 3.—Average nightly call minutes and nights occupied for western red bats in FY14

Station	Average nightly call minutes	Nights occupied	Proportion of nights occupied
AKTP	0.19	27	0.09
LCR MSCP conservation areas			
BLCA 1	0.61	121	0.37
PVER 1	3.27	143	0.73
PVER 2	0.58	86	0.35
CVCA 1	3.93	275	0.75
CVCA 2	0.35	89	0.24
Crane's Roost	1.55	201	0.57
YEW 1	0.60	39	0.33
HHCA	0.04	12	0.03
Existing habitat areas			
HNWR-Pintail	0.37	23	0.24
BWRNWR	1.19	61	0.41
CNWR-Island	0.10	17	0.08
PSRA	0.04	12	0.04
MLWA	0.26	65	0.18

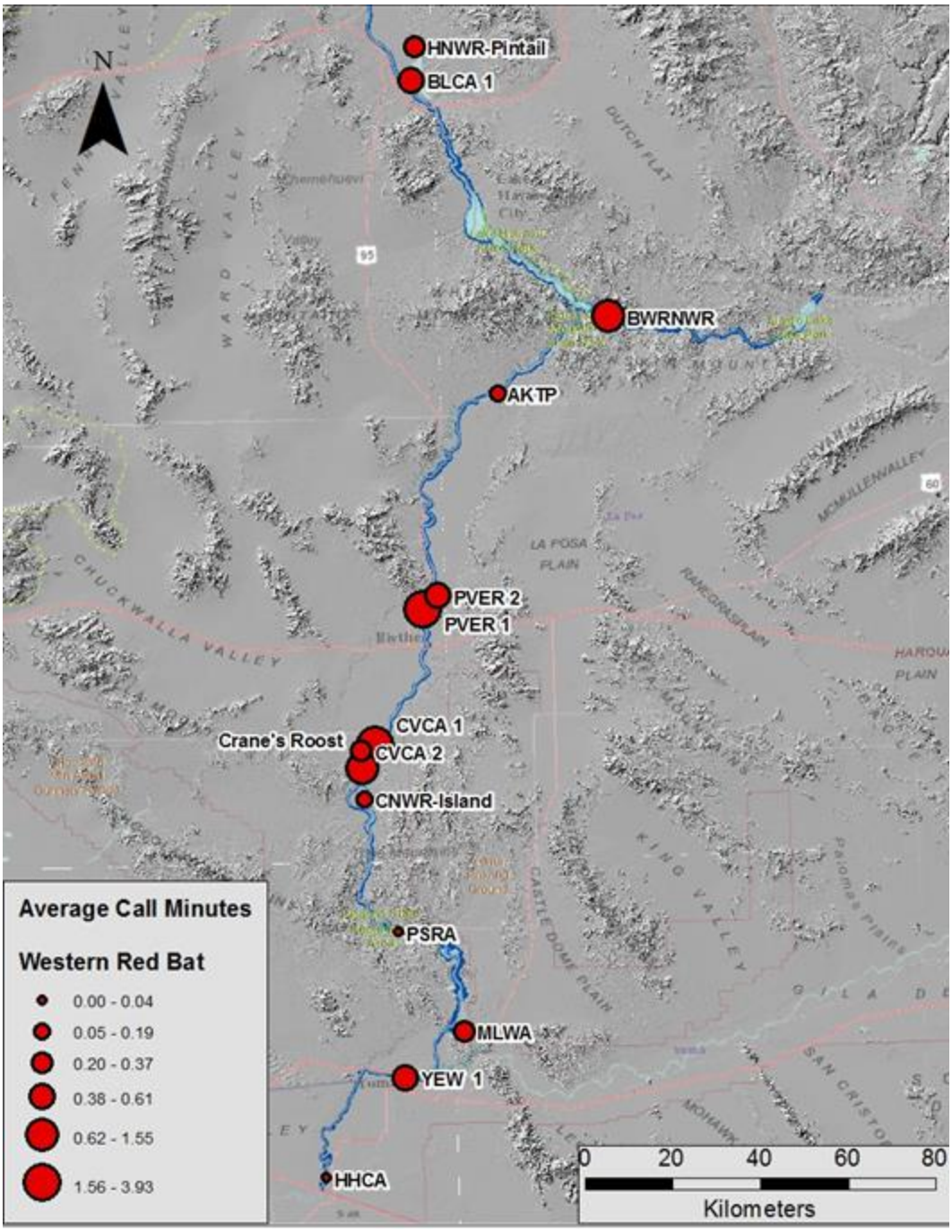

Figure 4.—Western red bat average nightly call minutes per station.

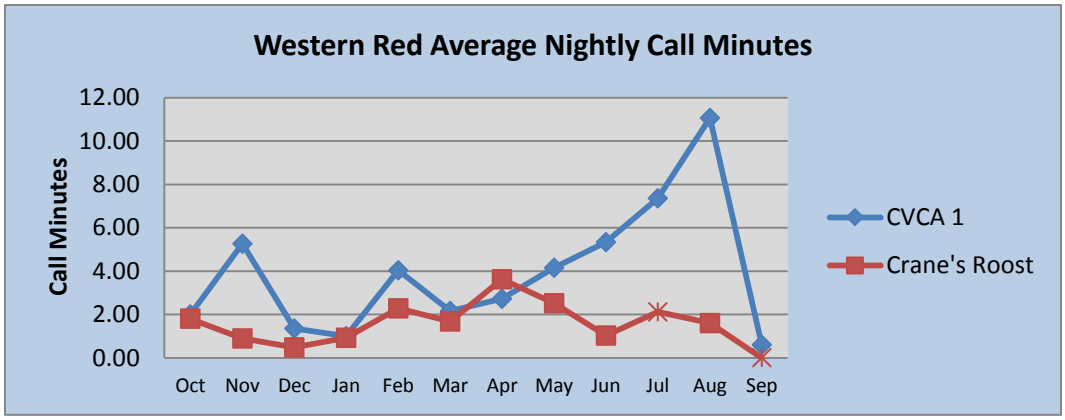

Figure 5.—Western red bat average nightly call minutes per month at LCR MSCP conservation area stations (CVCA 1 and Crane's Roost) (see attachment 1).
(Months with partial data gaps are denoted by an asterisk.)

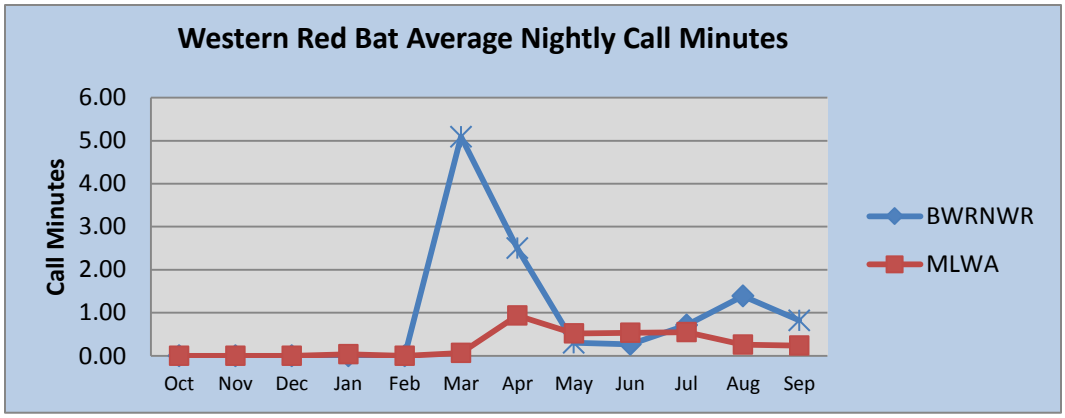

Figure 6.—Western red bat average nightly call minutes per month at existing habitat stations (BWRNWR and MLWA) (see attachment 1).
(Months with partial data gaps are denoted by an asterisk.)

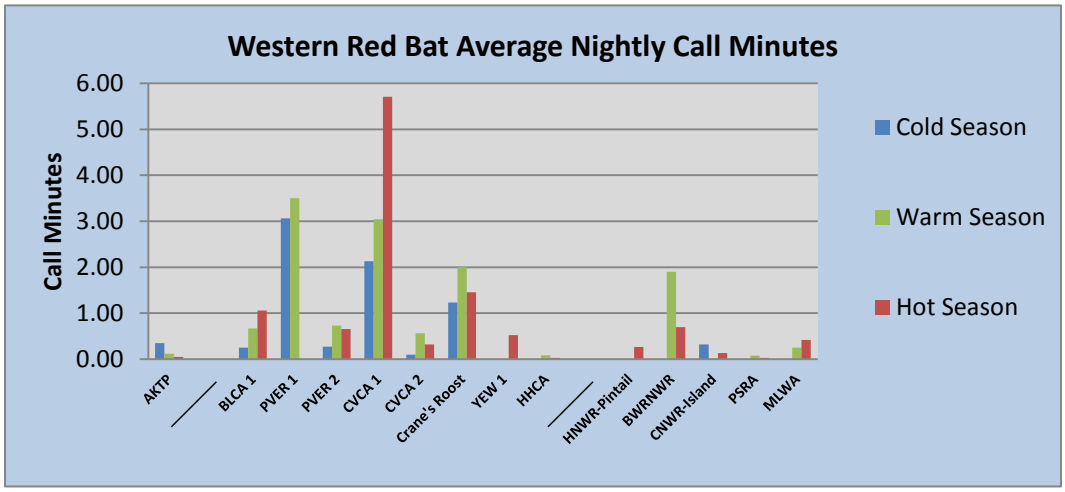

Figure 7.—Western red bat average nightly call minutes per season per station.

Western Yellow Bat

LCR MSCP Conservation Areas and the AKTP Station

As with western red bats, the greatest average nightly call minutes for western yellow bats were also recorded at LCR MSCP conservation areas and additionally the AKTP. The greatest average nightly call minutes were recorded at CVCA 1, followed by YEW and the AKTP (table 4 and figure 8). The greatest number of nights occupied was recorded at CVCA 1, followed by the AKTP and HHCA, with the greatest proportion of nights occupied recorded at YEW, followed by CVCA 1 and the AKTP (table 4). The greatest average nightly call minutes per month were recorded at CVCA 1 during July (figure 9). The greatest average nightly call minutes were recorded at CVCA 1 during the hot season (see figure 11).

Table 4.—Average nightly call minutes and nights occupied for western yellow bats in FY14

Station	Average nightly call minutes	Nights occupied	Proportion of nights occupied
AKTP	2.77	121	0.42
LCR MSCP conservation areas			
BLCA 1	0.06	14	0.04
PVER 1	0.45	14	0.07
PVER 2	1.16	88	0.36
CVCA 1	6.58	196	0.54
CVCA 2	1.05	75	0.21
Crane's Roost	0.63	60	0.17
YEW 1	3.92	75	0.64
HHCA	0.52	102	0.28
Existing habitat areas			
HNWR-Pintail	0.06	5	0.05
BWRNWR	0.68	24	0.16
CNWR-Island	0.08	2	0.01
PSRA	0.01	3	0.01
MLWA	0.23	22	0.06

Existing Habitat Stations

The greatest average nightly call minutes for western yellow bats were recorded at the BWRNWR, followed by the MLWA and CNWR-Island (see table 4 and figure 8). The greatest number of nights occupied was recorded at the BWRNWR, followed by the MLWA and HNWR-Pintail, with the greatest proportion of nights occupied recorded at the BWRNWR, followed by the MLWA and HNWR-Pintail (see table 4). The greatest average nightly call minutes per month were recorded at the BWRNWR during March (figure 10). The greatest average nightly call minutes were recorded at the BWRNWR during the warm season (figure 11).

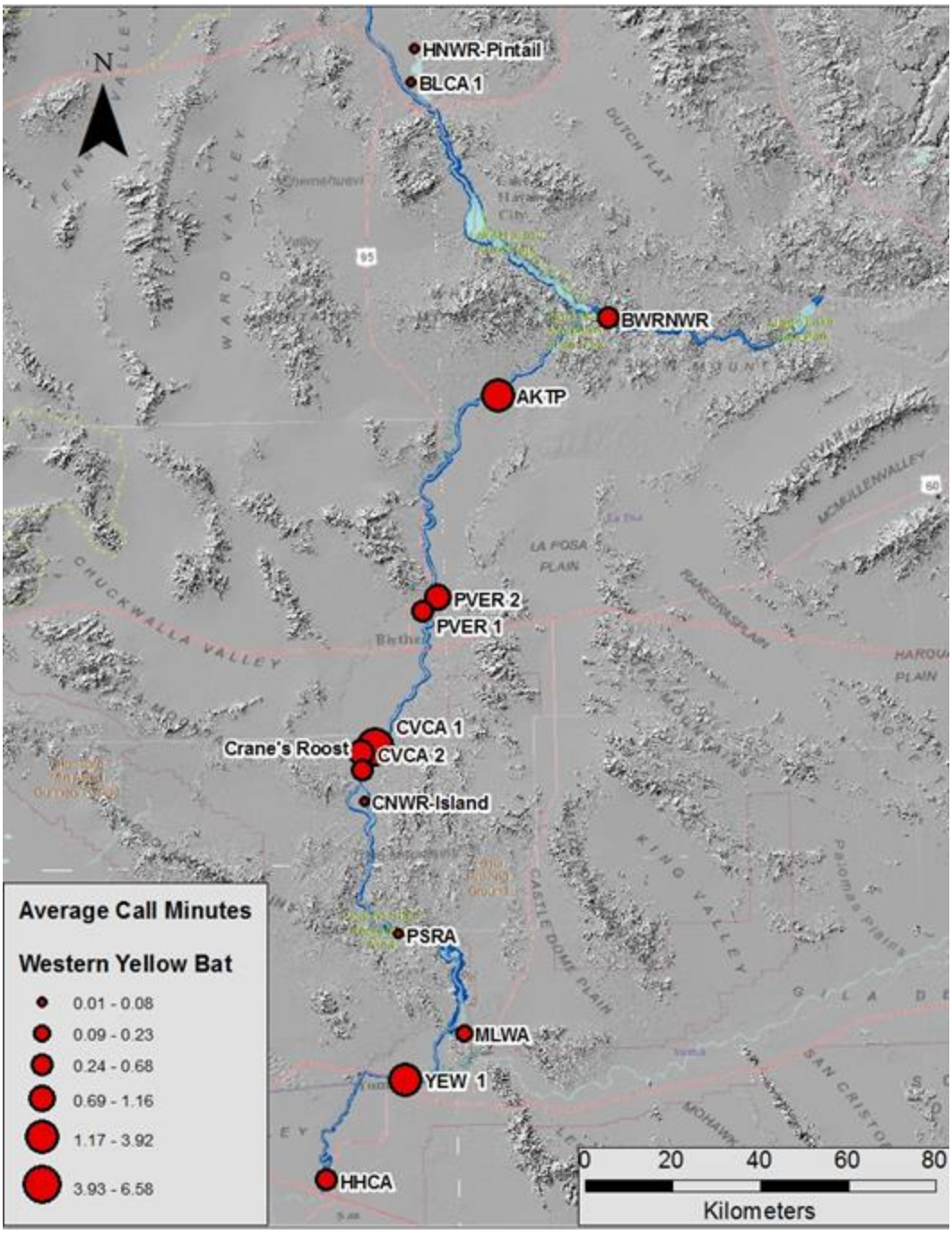

Figure 8.—Western yellow bat nightly call minutes per station.

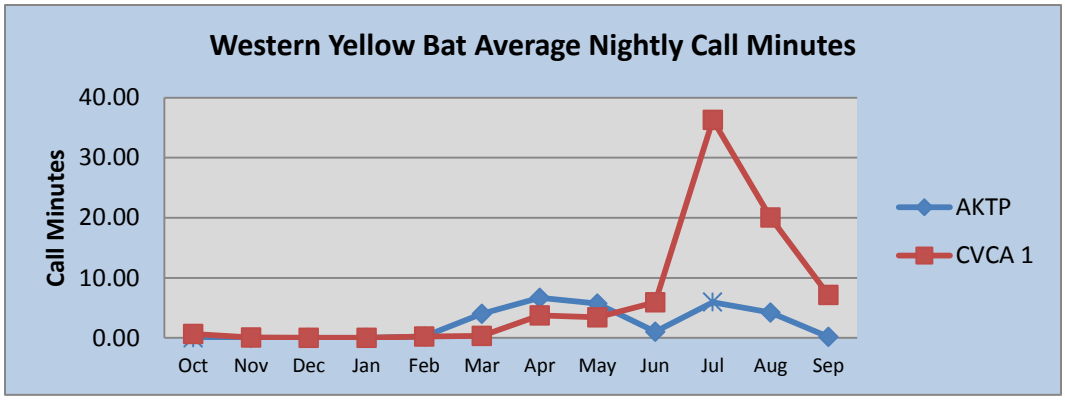

Figure 9.—Western yellow bat average nightly call minutes per month at the AKTP and LCR MSCP conservation area CVCA 1 stations (see attachment 1).
(Months with partial data gaps are denoted by an asterisk.)

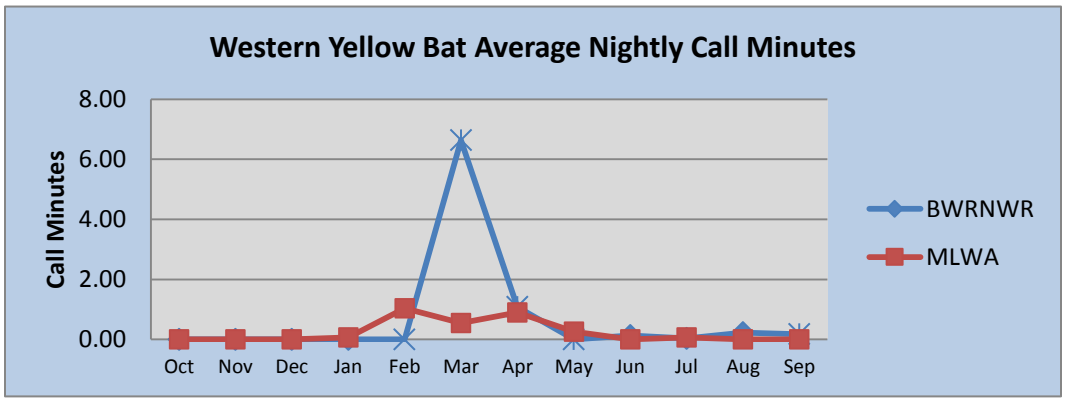

Figure 10.—Western yellow bat average nightly call minutes per month at existing habitat stations (BWRNWR and MLWA) (see attachment 1).
(Months with partial data gaps are denoted by an asterisk.)

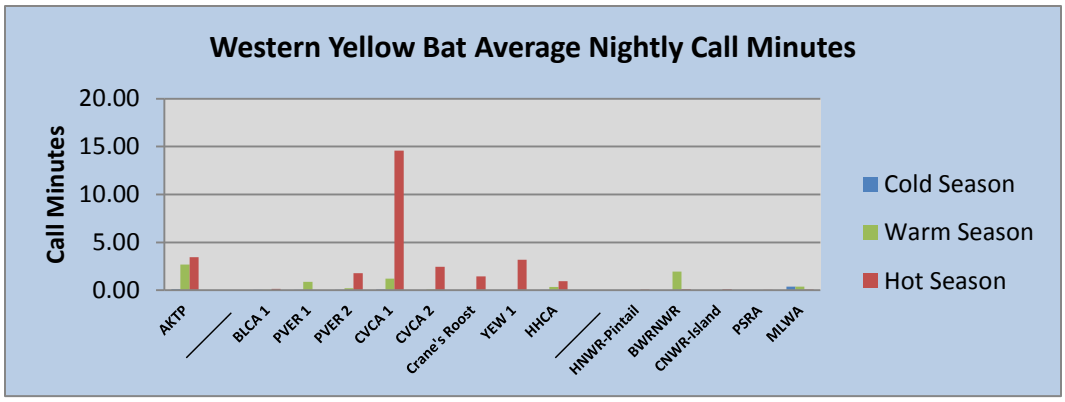

Figure 11.—Western yellow bat average nightly call minutes per season per station.

California Leaf-Nosed Bat

LCR MSCP Conservation Areas and the AKTP Station

The greatest average nightly call minutes for California leaf-nosed bats were recorded at LCR MSCP conservation areas. The greatest average nightly call minutes were recorded at YEW, followed by CVCA 2 and Crane's Roost (table 5 and figure 12). The greatest number of nights occupied was recorded at CVCA 2, followed by Crane's Roost and CVCA 1, with the greatest proportion of nights occupied recorded at YEW, followed by CVCA 2 and Crane's Roost (table 5). The greatest average nightly call minutes per month were recorded at Crane's Roost during October (figure 13). The greatest average nightly call minutes were recorded at YEW during the hot season (see figure 15).

Table 5.—Average nightly call minutes and nights occupied for California leaf-nosed bats in FY14

Station	Average nightly call minutes	Nights occupied	Proportion of nights occupied
AKTP	0.10	24	0.08
LCR MSCP conservation areas			
BLCA 1	0.08	20	0.06
PVER 1	0.03	5	0.03
PVER 2	0.06	9	0.04
CVCA 1	0.10	30	0.08
CVCA 2	0.15	42	0.12
Crane's Roost	0.14	40	0.11
YEW 1	0.25	19	0.16
HHCA	0	0	0.00
Existing habitat areas			
HNWR-Pintail	0.02	2	0.02
BWRNWR	0.07	9	0.06
CNWR-Island	0.06	11	0.05
PSRA	0.14	30	0.09
MLWA	0	0	0.00

Existing Habitat Stations

The greatest average nightly call minutes for California leaf-nosed bats were recorded at the PSRA, followed by the BWRNWR and CNWR-Island (see table 5 and figure 12). The greatest number of nights occupied was recorded at the PSRA, followed by CNWR-Island and the BWRNWR, with the greatest proportion of nights occupied recorded at the PSRA, followed by the BWRNWR and CNWR-Island (see table 5). The greatest average nightly call minutes per month were recorded at the PSRA during June (figure 14). The greatest average nightly call minutes were recorded at the PSRA during the hot season (figure 15).

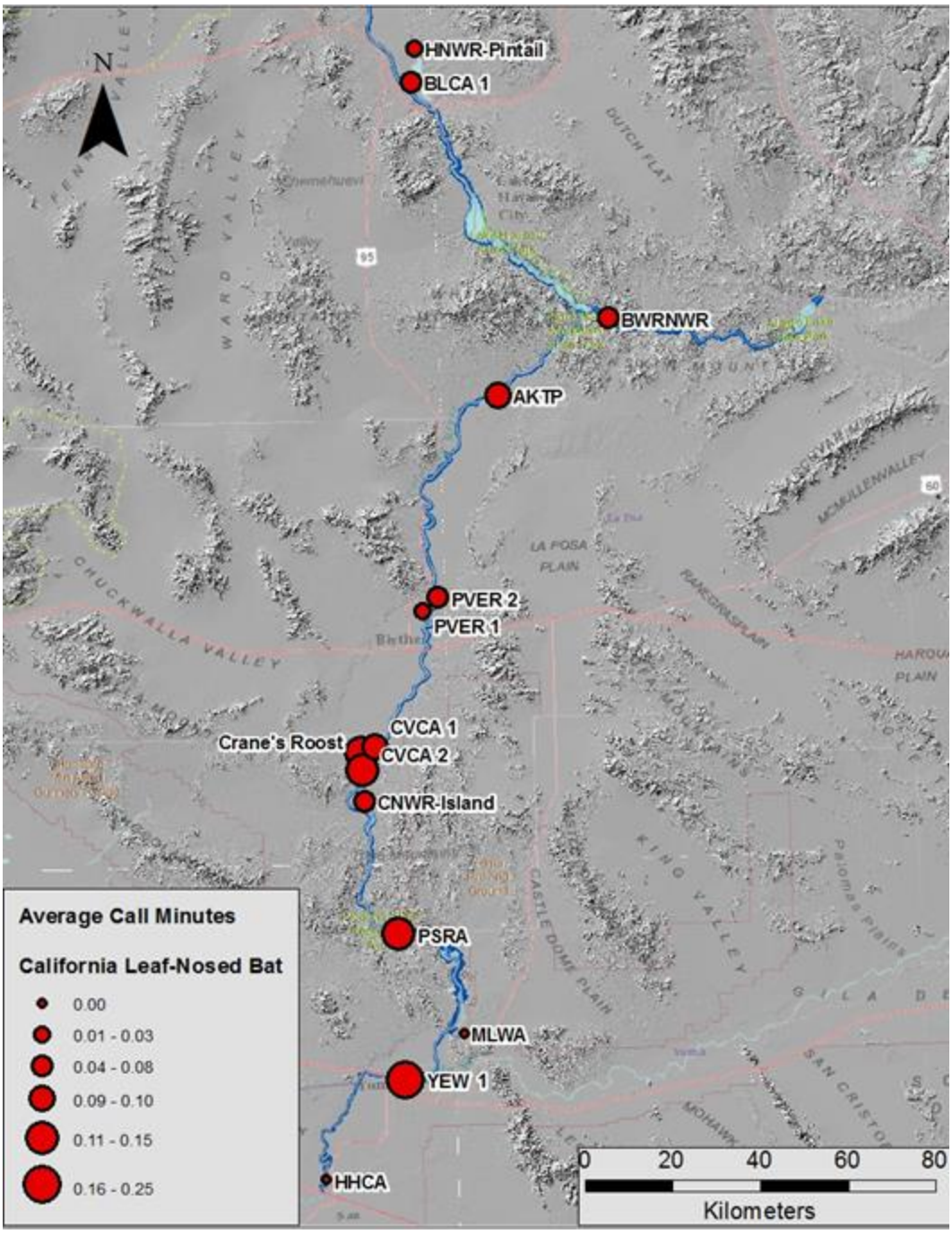

Figure 12.—California leaf-nosed bat nightly call minutes per station.

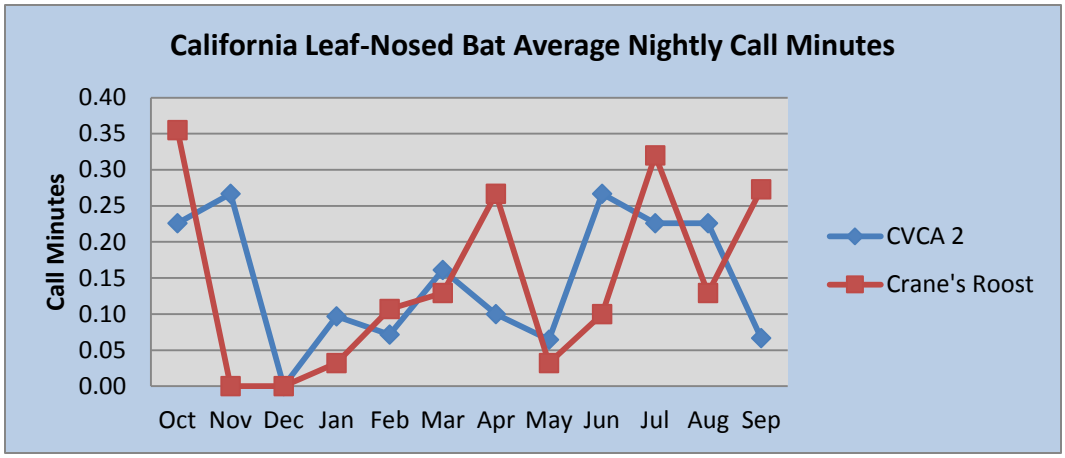

Figure 13.—California leaf-nosed bat average nightly call minutes per month at LCR MSCP conservation area station CVCA 2 (see attachment 1).
(Months with partial data gaps are denoted by an asterisk.)

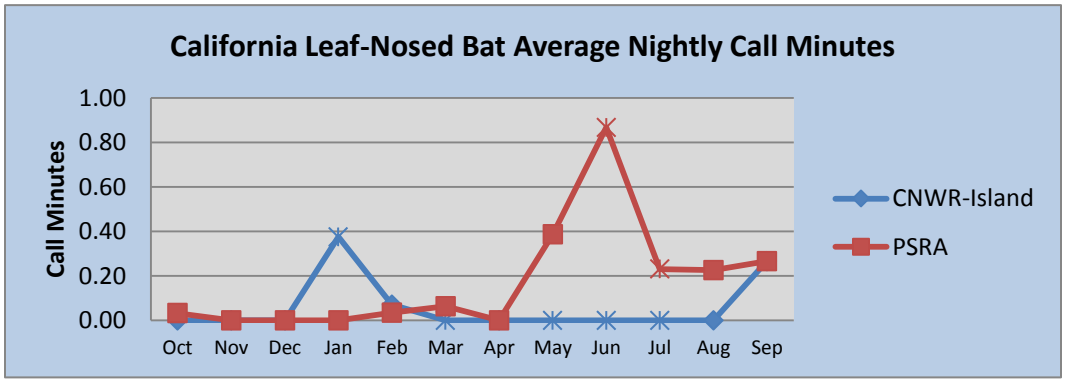

Figure 14.—California leaf-nosed bat average nightly call minutes per month at existing habitat stations (CNWR-Island and PSRA) (see attachment 1).
(Months with partial data gaps are denoted by an asterisk.)

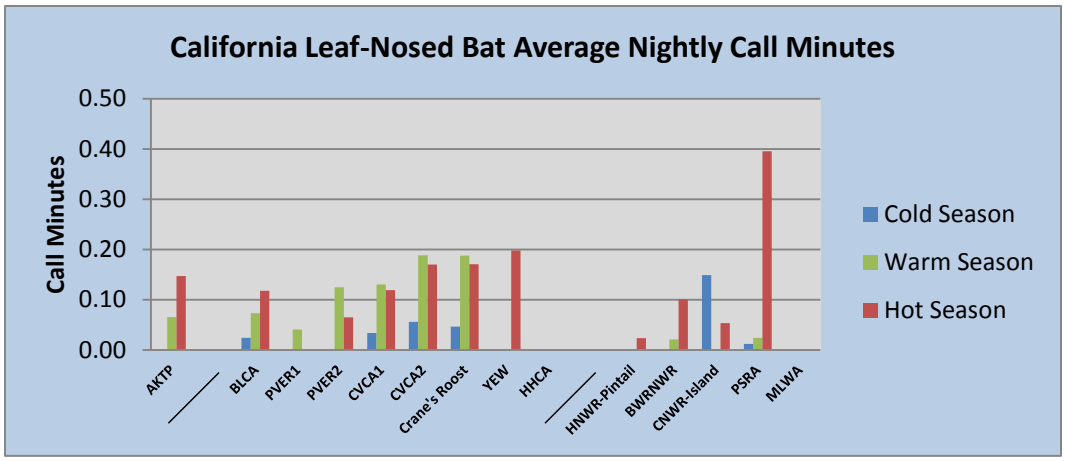

Figure 15.—California leaf-nosed bat average nightly call minutes per season per station.

Pale Townsend's Big-eared Bat

LCR MSCP Conservation Areas and the AKTP Station

The greatest average nightly call minutes for pale Townsend's big-eared bats were recorded at LCR MSCP conservation areas. The greatest average nightly call minutes were recorded at YEW and CVCA 1, followed by BLCA, PVER 1, and Crane's Roost (table 6 and figure 16). The greatest number of nights occupied was recorded at CVCA 1, followed by Crane's Roost, with the greatest proportion of nights occupied recorded at YEW, followed by CVCA 1 (table 6). The greatest average nightly call minutes were recorded at CVCA 1 during the warm season (figure 17). Because pale Townsend's big-eared bats are difficult to detect using acoustic recorders, the sample size was small; therefore, temporal figures for this species are not provided.

Table 6.—Average nightly call minutes and nights occupied for pale Townsend's big-eared bats in FY14

Station	Average nightly call minutes	Nights occupied	Proportion of nights occupied
AKTP	0.01	4	0.01
LCR MSCP conservation areas			
BLCA 1	0.02	5	0.02
PVER 1	0.02	3	0.02
PVER 2	0.01	2	0.01
CVCA 1	0.04	12	0.03
CVCA 2	0.01	5	0.01
Crane's Roost	0.02	6	0.02
YEW 1	0.04	5	0.04
HHCA	0.002	1	0.002
Existing habitat areas			
HNWR-Pintail	0	0	0.00
BWRNWR	0.01	1	0.01
CNWR-Island	0	0	0.00
PSRA	0	0	0.00
MLWA	0	0	0.00

Existing Habitat Stations

The greatest average nightly call minutes for pale Townsend's big-eared bats were recorded at the BWRNWR, with no detections at any of the other sites (see table 6 and figure 16). The greatest average nightly call minutes were recorded at the BWRNWR during the hot season (figure 17). Because pale Townsend's big-eared bats are difficult to detect using acoustic recorders, the sample size was small; therefore, temporal figures for this species are not provided.

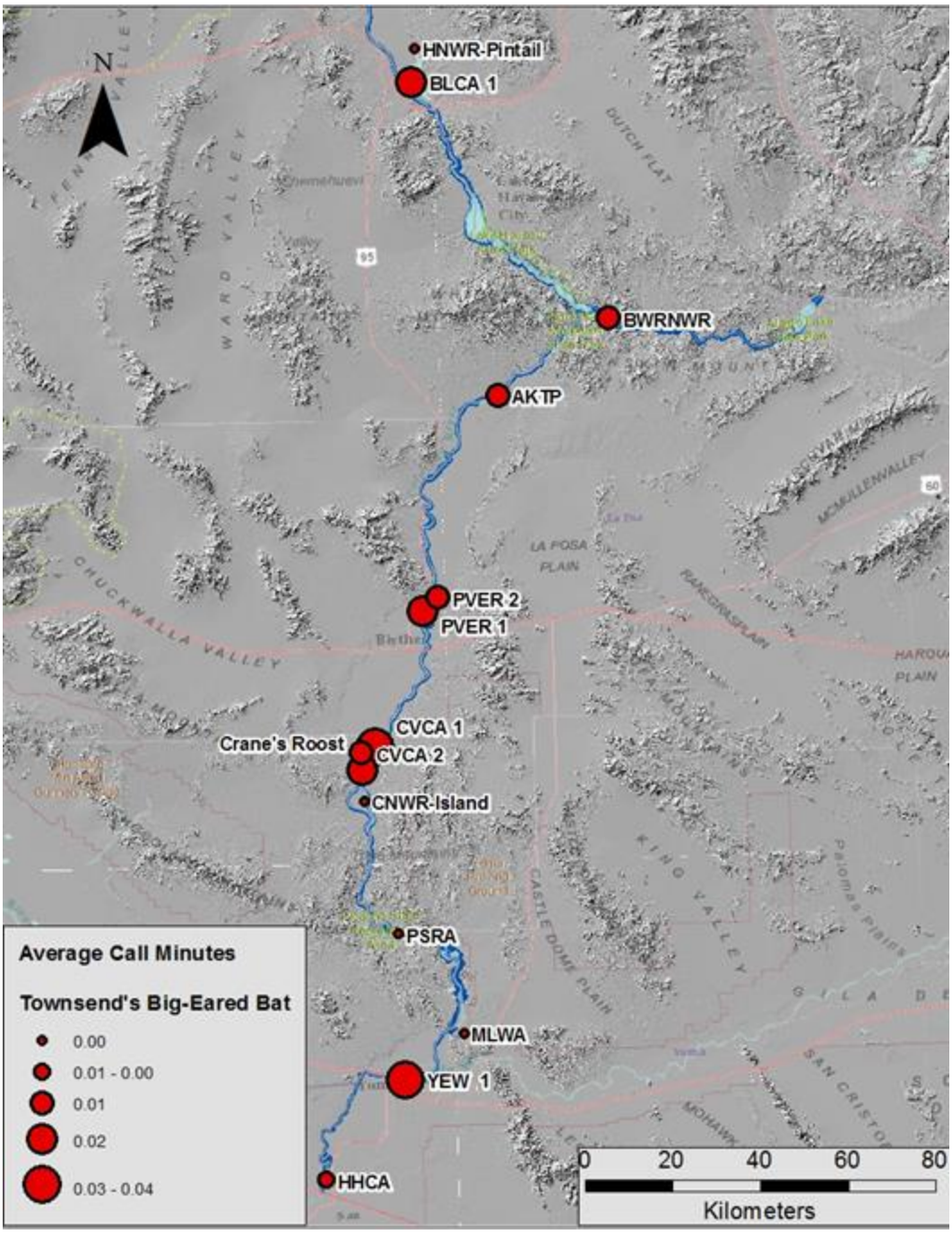

Figure 16.—Pale Townsend's big-eared bat nightly call minutes per station.

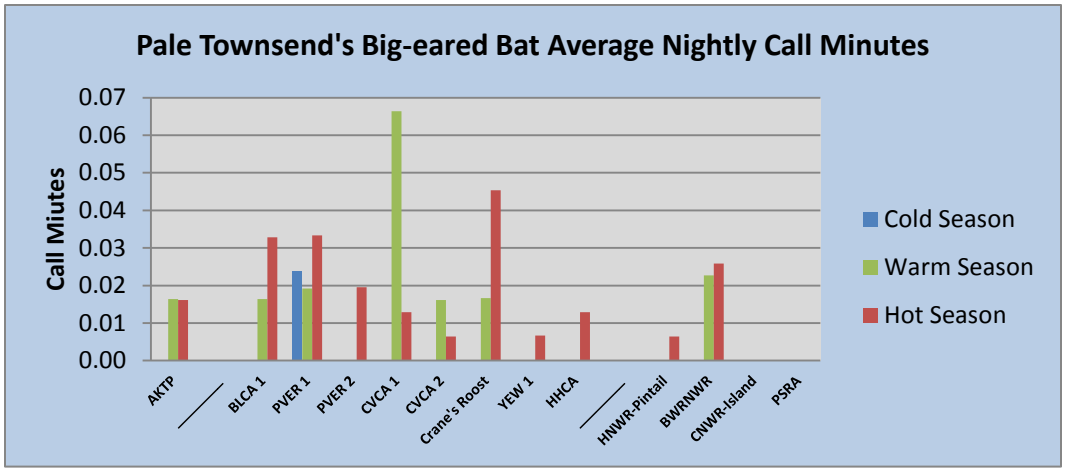

Figure 17.—Pale Townsend's big-eared bat average nightly call minutes per season per station.

Greater Mastiff Bat

LCR MSCP Conservation Areas and the AKTP Station

The greatest average nightly call minutes for greater mastiff bats were recorded at YEW, followed by the AKTP and CVCA 1 (table 7 and figure 18). The greatest number of nights occupied was recorded at CVCA 1, followed by the AKTP and Crane's Roost, with the greatest proportion of nights occupied recorded at CVCA 1, followed by YEW and the AKTP (table 7). The greatest average nightly call minutes per month were recorded at the AKTP during August (figure 19). The greatest average nightly call minutes were recorded at the AKTP during the hot season (see figure 21).

Table 7.—Average nightly call minutes and nights occupied for greater mastiff bats in FY14

Station	Average nightly call minutes	Nights occupied	Proportion of nights occupied
AKTP	2.1	106	0.36
LCR MSCP conservation areas			
BLCA 1	0.24	49	0.15
PVER 1	0.27	31	0.16
PVER 2	0.46	63	0.26
CVCA 1	0.87	145	0.40
CVCA 2	0.48	75	0.21
Crane's Roost	0.32	76	0.22
YEW 1	2.75	46	0.39
HHCA	0.25	59	0.16
Existing habitat areas			
HNWR-Pintail	1.63	49	0.51
BWRNWR	0.56	26	0.18
CNWR-Island	0.08	4	0.02
PSRA	0	0	0.00
MLWA	0.78	140	0.38

Existing Habitat Stations

The greatest average nightly call minutes for greater mastiff bats were recorded at HNWR-Pintail, followed by the MLWA and BWRNWR (see table 7 and figure 18). The greatest number of nights occupied was recorded at the MLWA, followed by HNWR-Pintail and the BWRNWR, with the greatest proportion of nights occupied recorded at HNWR-Pintail, followed by the MLWA and the BWRNWR (see table 7). The greatest average nightly call minutes per month were recorded at HNWR-Pintail during July (figure 20). The greatest average nightly call minutes were recorded at the MLWA during the hot season (figure 21).

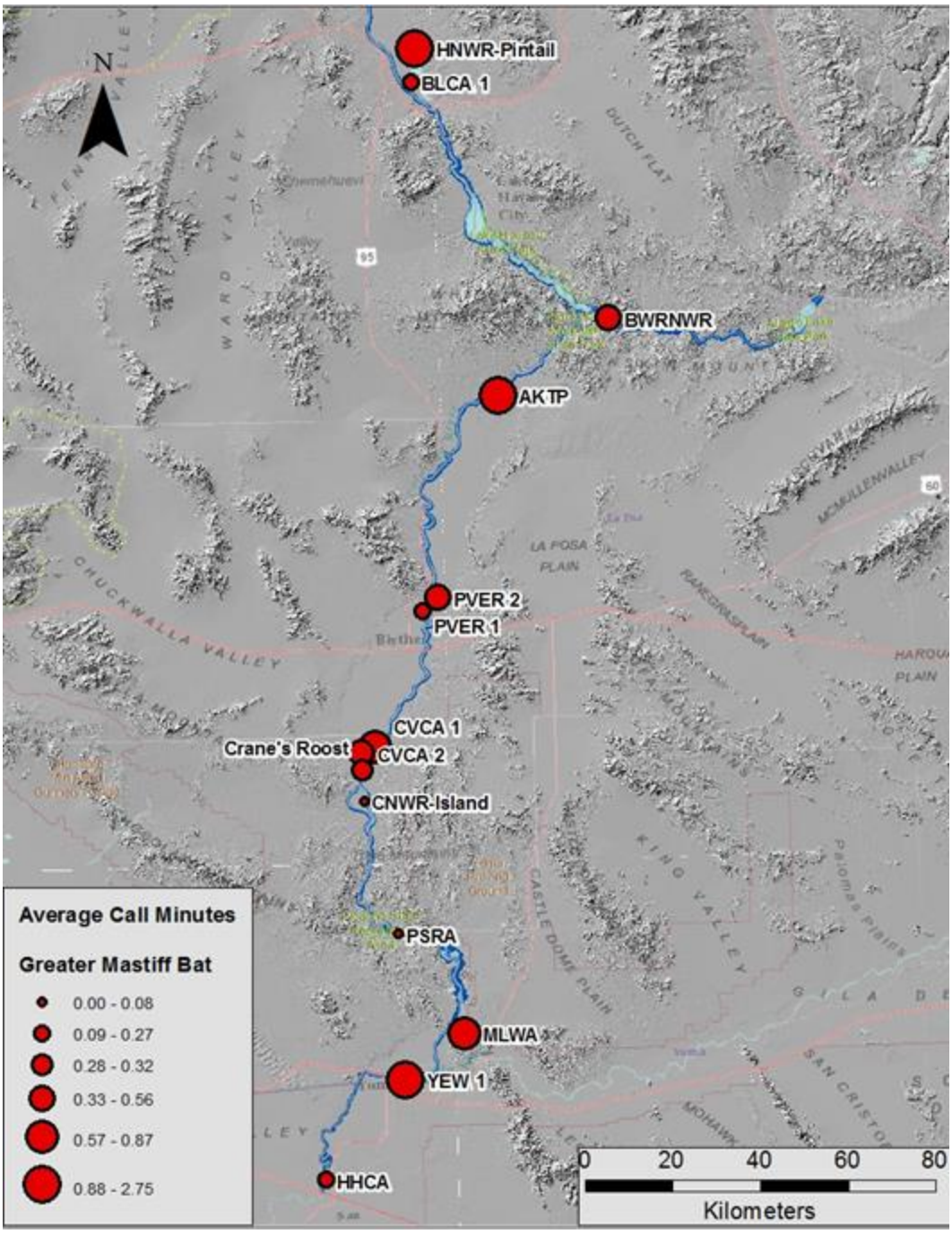

Figure 18.—Greater mastiff bat nightly call minutes per station.

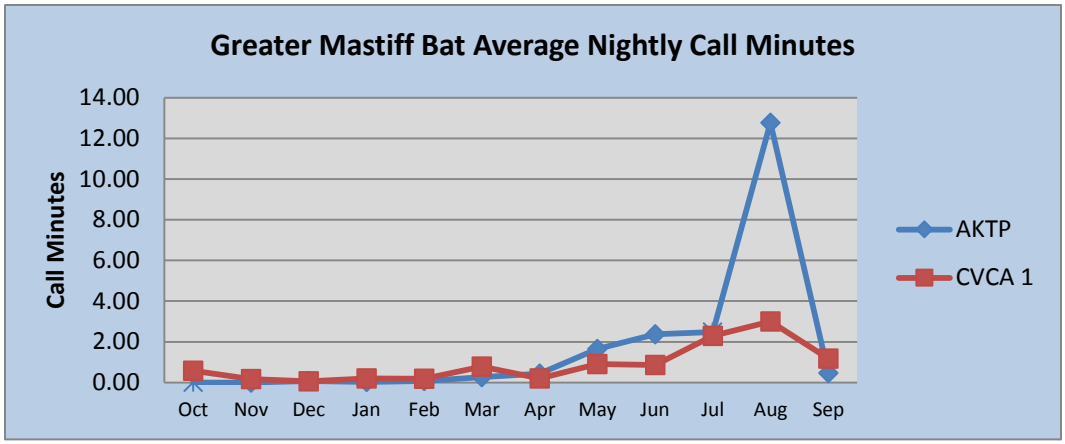

Figure 19.—Greater mastiff bat average nightly call minutes per month at the AKTP and LCR MSCP conservation area CVCA 1 stations (see attachment 1).

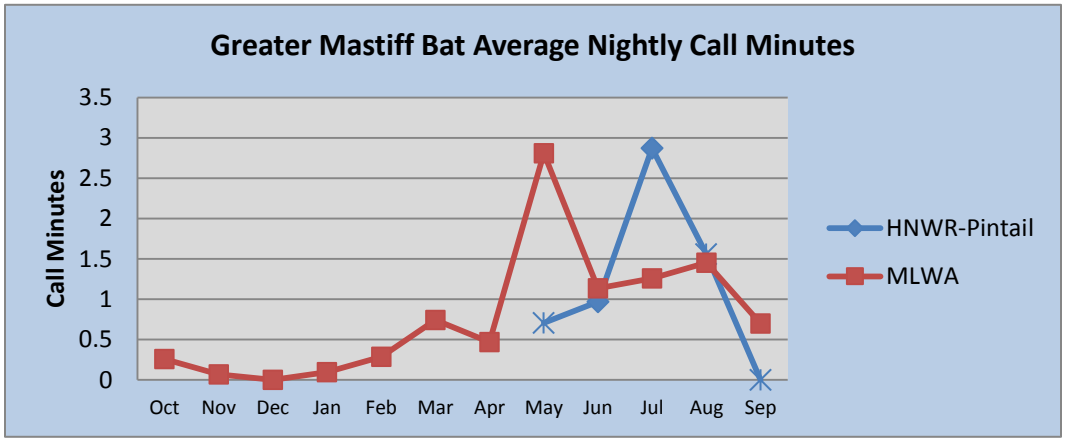

Figure 20.—Greater mastiff bat average nightly call minutes per month at existing habitat stations (HNWR-Pintail and MLWA) (see attachment 1).
(Months with partial data gaps are denoted by an asterisk. Note that data collection at the HNWR-Pintail site did not begin until May 15, 2014.)

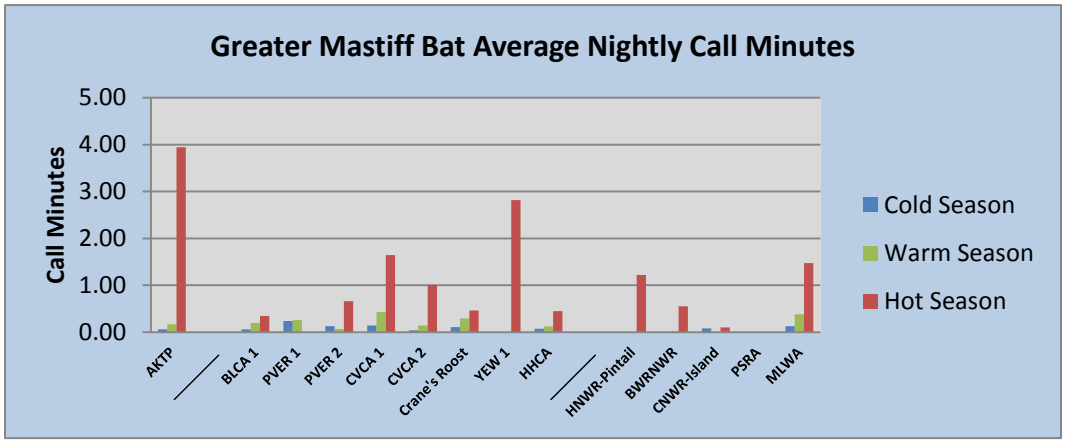

Figure 21.—Greater mastiff bat average nightly call minutes per season per station.

Hoary Bat

LCR MSCP Conservation Areas and the AKTP Station

The greatest average nightly call minutes for hoary bats were recorded at CVCA 1, followed by PVER 1 and the AKTP (table 8 and figure 22). The greatest number of nights occupied was recorded at CVCA 1, followed by PVER 1 and the AKTP, with the greatest proportion of nights occupied recorded at CVCA 1, followed by PVER 1 and the AKTP (table 8). The greatest average nightly call minutes per month were recorded at CVCA 1 during November (figure 23). The greatest average nightly call minutes were recorded at CVCA 1 during the warm season (see figure 25).

Table 8.—Average nightly call minutes and nights occupied for hoary bats in FY14

Station	Average nightly call minutes	Nights occupied	Proportion of nights occupied
AKTP	0.30	52	0.18
LCR MSCP conservation areas			
BLCA 1	0.29	42	0.13
PVER 1	2.30	93	0.48
PVER 2	0.23	35	0.14
CVCA 1	5.70	184	0.50
CVCA 2	0.15	28	0.08
Crane's Roost	0.23	44	0.13
YEW 1	0.03	3	0.03
HHCA	0.05	13	0.04
Existing habitat areas			
HNWR-Pintail	0.11	11	0.11
BWRNWR	0.01	1	0.01
CNWR-Island	0.02	4	0.02
PSRA	0.01	4	0.01
MLWA	0.04	14	0.04

Existing Habitat Stations

The greatest average nightly call minutes for hoary bats was recorded at HNWR-Pintail, followed by the MLWA and CNWR-Island (see table 8 and figure 22). The greatest number of nights occupied was recorded at the MLWA, followed by HNWR-Pintail, CNWR-Island, and the PSRA, with the greatest proportion of nights occupied recorded at HNWR-Pintail, followed by the MLWA and CNWR-Island. The greatest average nightly call minutes per month were recorded at HNWR-Pintail during May (figure 24). The greatest average nightly call minutes were recorded at the MLWA during the cold and hot season as well as HNWR-Pintail during the hot season (figure 25 and table 9).

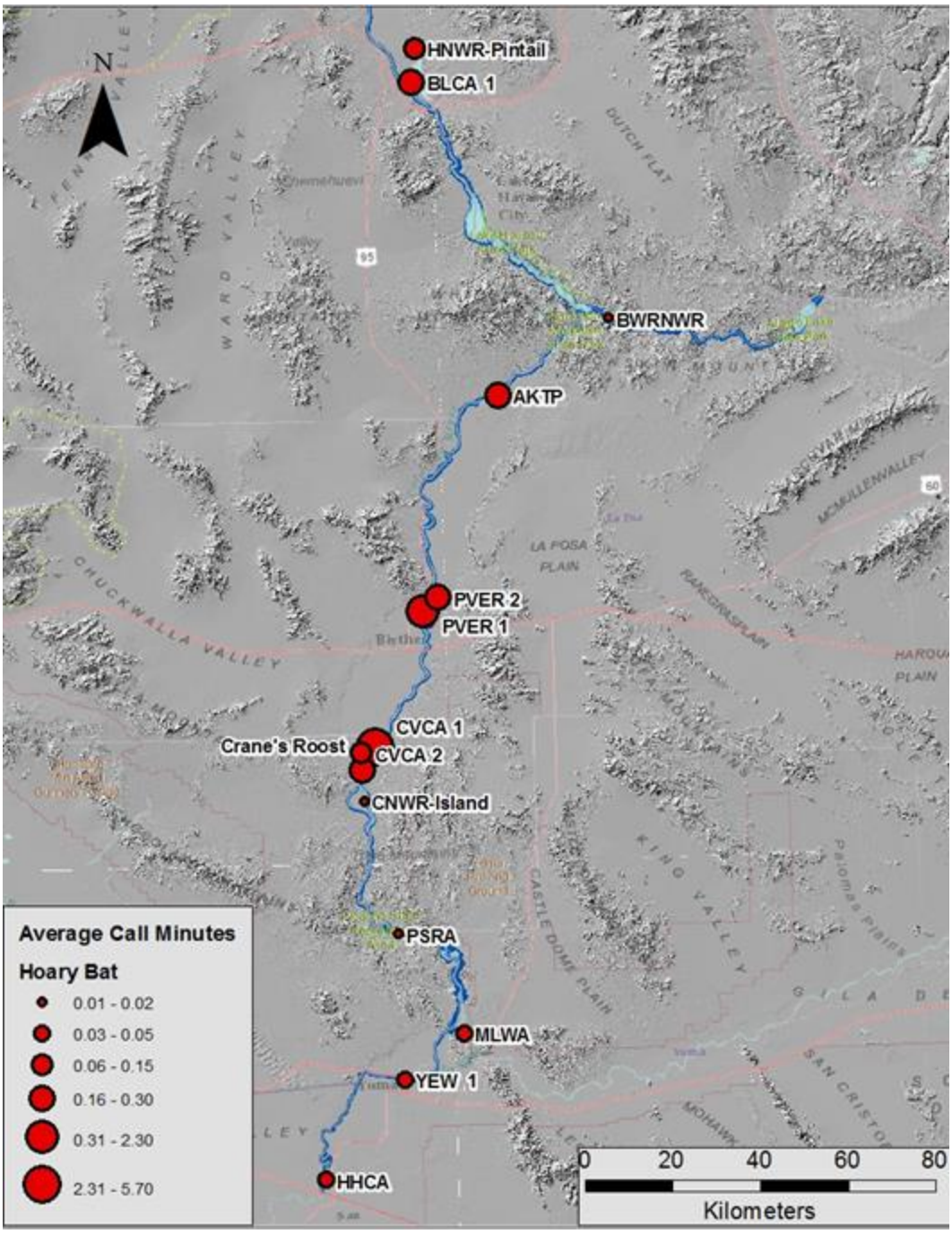

Figure 22.—Hoary bat nightly call minutes per station.

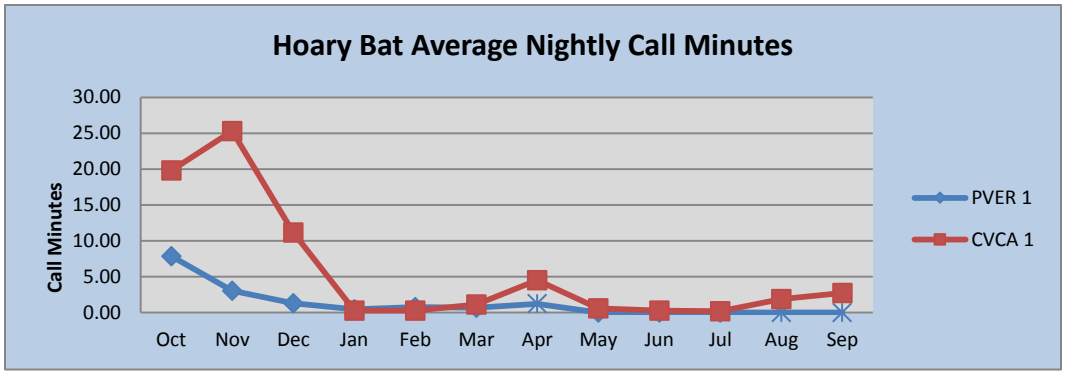

Figure 23.—Hoary bat average nightly call minutes per month at LCR MSCP conservation area stations (PVER 1 and CVCA 1) (see attachment 1).
(Months with partial data gaps are denoted by an asterisk.)

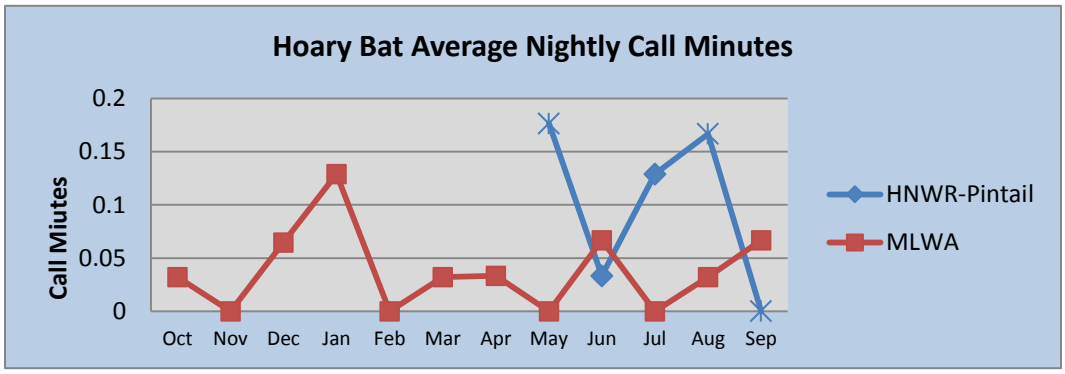

Figure 24.—Hoary bat average nightly call minutes per month at existing habitat stations (HNWR-Pintail and MLWA) (see attachment 1).
(Months with partial data gaps are denoted by an asterisk. Note that data collection at the HNWR-Pintail site did not begin until May 15, 2014.)

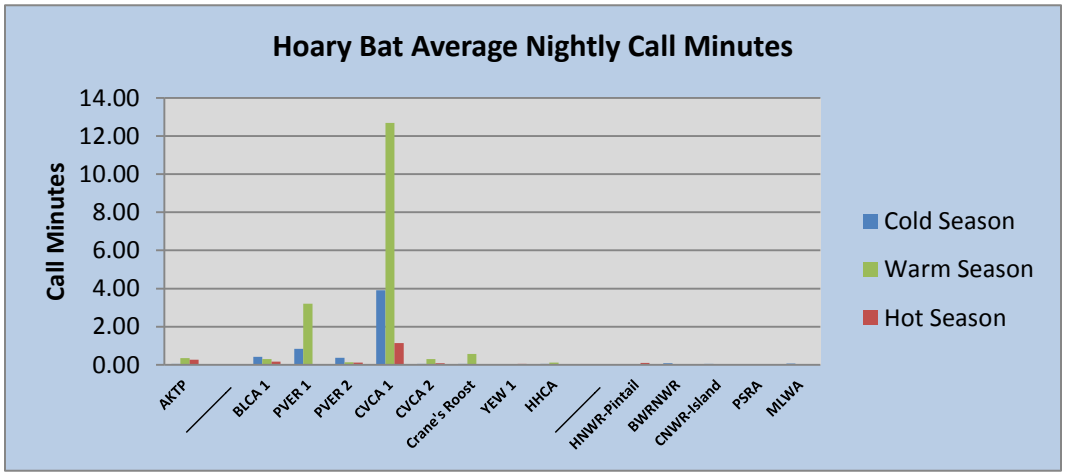

Figure 25.—Hoary bat average nightly call minutes per season per station.

Table 9.—Average nightly call minutes at existing habitat stations

Site	Cold season	Warm season	Hot season
HNWR-Pintail	0.00	0.00	0.10
BWRNWR	0.08	0.00	0.00
CNWR-Island	0.05	0.00	0.01
PSRA	0.01	0.02	0.00
MLWA	0.06	0.02	0.03

Cave Myotis

LCR MSCP Conservation Areas and the AKTP Station

The greatest average nightly call minutes for cave myotis were recorded at CVCA 1, followed by the AKTP and BLCA 1 (table 10 and figure 26). The greatest number of nights occupied was recorded at CVCA 1, followed by the BLCA 1 and AKTP, with the greatest proportion of nights occupied recorded at the AKTP, BLCA 1, and CVCA1 (table 10). The greatest average nightly call minutes per month were recorded at CVCA 1 during July (figure 27). The greatest average nightly call minutes were recorded at CVCA 1 during the hot season (see figure 29).

Table 10.—Average nightly call minutes and nights occupied for cave myotis in FY14

Station	Average nightly call minutes	Nights occupied	Proportion of nights occupied
AKTP	1.97	88	0.30
LCR MSCP conservation areas			
BLCA 1	1.45	98	0.30
PVER 1	0.06	7	0.04
PVER 2	0.60	67	0.27
CVCA 1	2.01	111	0.30
CVCA 2	1.4	75	0.21
Crane's Roost	0.26	28	0.08
YEW 1	0	0	0.00
HHCA	0	0	0.00
Existing habitat areas			
HNWR-Pintail	0.39	10	0.10
BWRNWR	0.92	64	0.43
CNWR-Island	0	0	0.00
PSRA	0	0	0.00
MLWA	0	0	0.00

Existing Habitat Stations

The greatest average nightly call minutes for cave myotis were recorded at the BWRNWR, followed by HNWR-Pintail, with no detections at the other sites (see table 10 and figure 26). The greatest number of nights occupied were recorded at the BWRNWR, followed by HNWR-Pintail, with the greatest proportion of nights occupied recorded at the BWRNWR, followed by HNWR-Pintail (see table 10). The greatest average nightly call minutes per month were recorded at the BWRNWR during June (figure 28). The greatest average nightly call minutes were recorded at the BWRNWR during the hot season (figure 29).

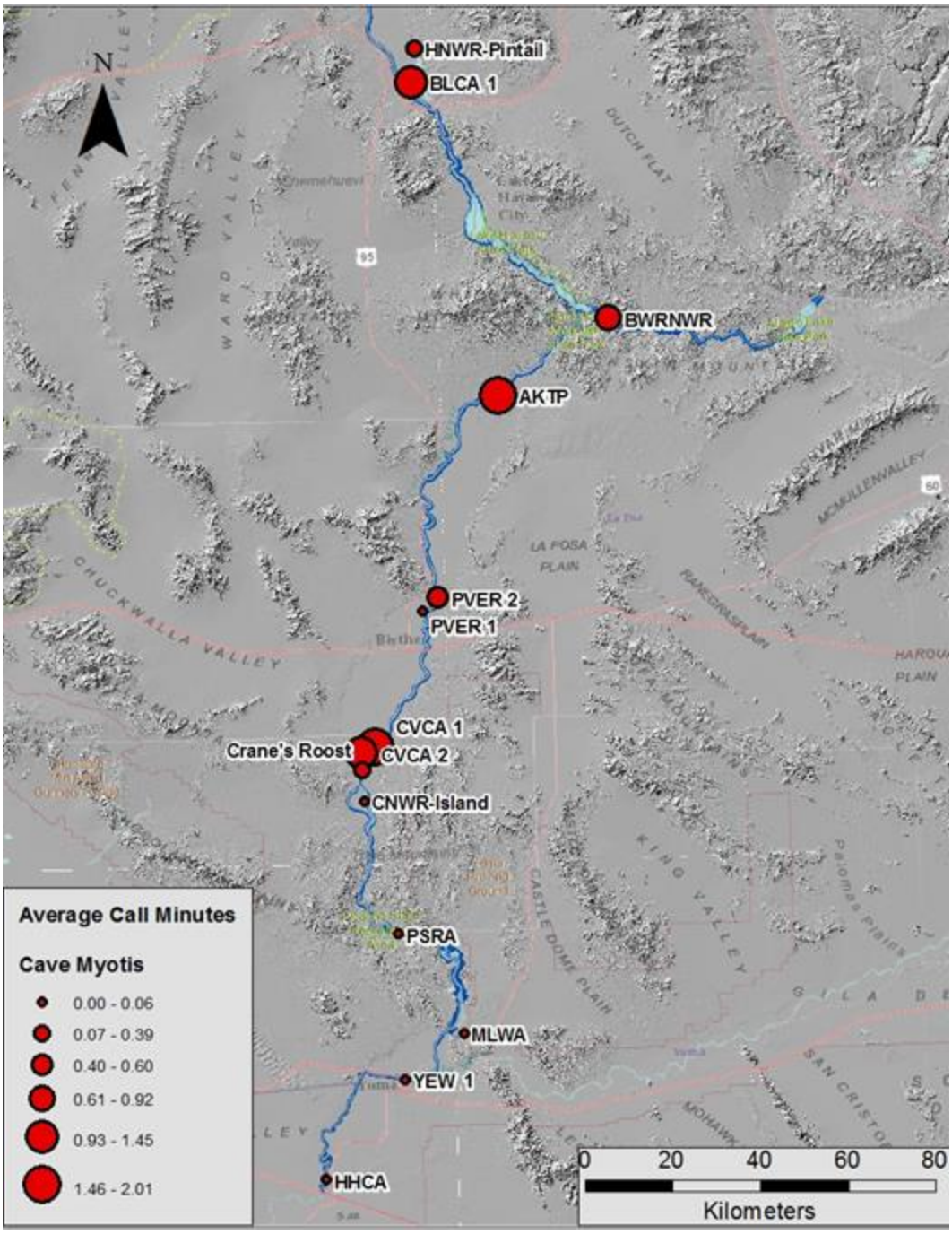

Figure 26.—Cave myotis nightly call minutes per station.

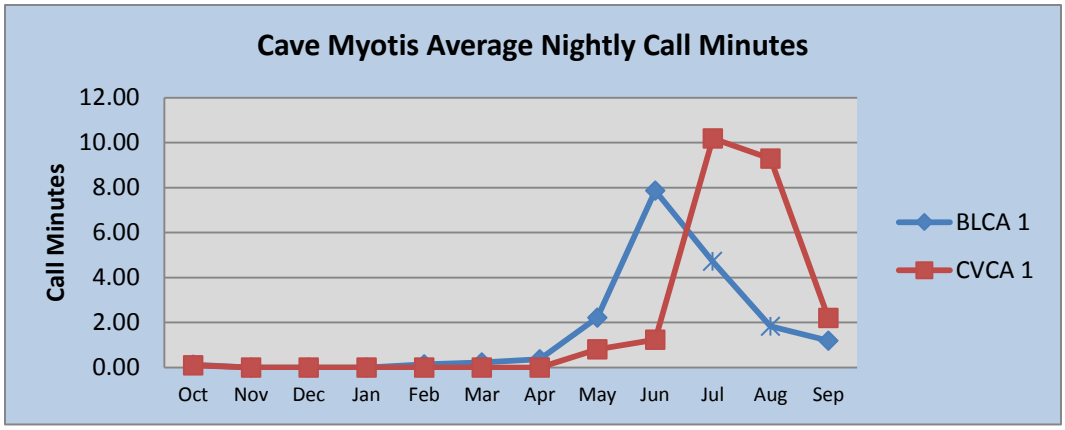

Figure 27.—Cave myotis average nightly call minutes per month at habitat creation area stations (BLCA and CVCA 1) (see attachment 1).
(Months with partial data gaps are denoted by an asterisk.)

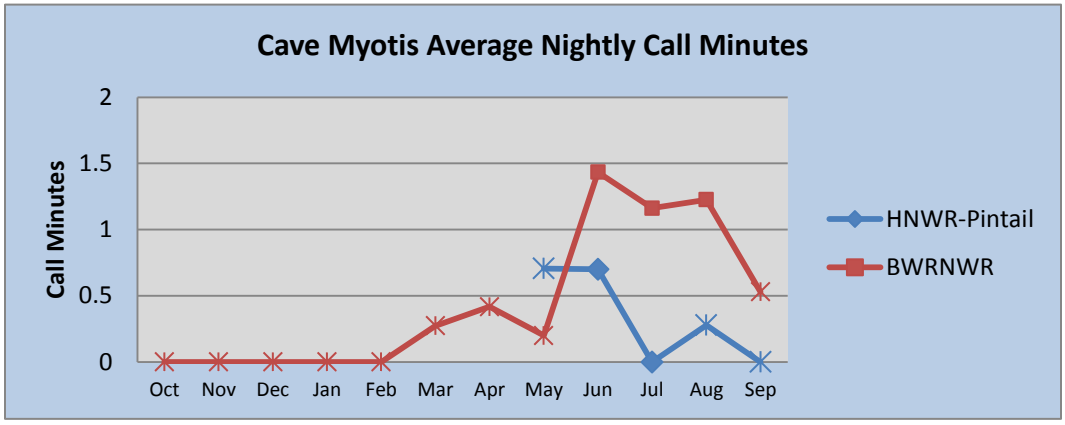

Figure 28.—Cave myotis average nightly call minutes per month at existing habitat area stations (HNWR-Pintail an BWRNWR) (see attachment 1).
(Months with partial data gaps are denoted by an asterisk. Note that data collection at the HNWR-Pintail site did not begin until May 15, 2014.)

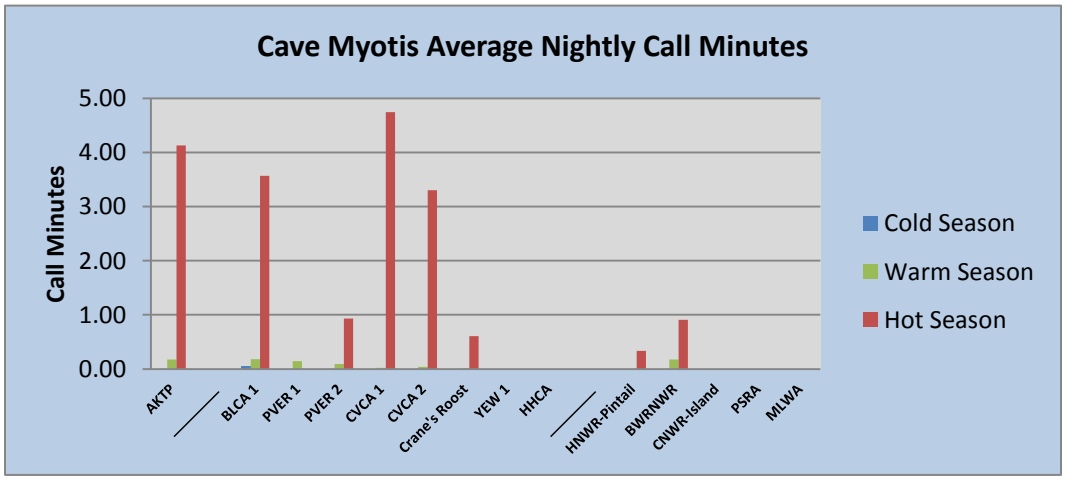

Figure 29.—Cave myotis average nightly call minutes per season per station.

Arizona Myotis

LCR MSCP Conservation Areas and the AKTP Station

The greatest average nightly call minutes for Arizona myotis were recorded at the AKTP and BLCA (table 11 and figure 31). The greatest average nightly call minutes, nights occupied, and proportion of nights occupied were recorded at the AKTP (table 11). The greatest average nightly call minutes per month were recorded at the AKTP during May (figure 31). The greatest average nightly call minutes were recorded at the AKTP during the hot season (figure 32); small sample sizes for this species were recorded at the other stations but did not merit reporting.

Table 11.—Average nightly call minutes and nights occupied for Arizona myotis in FY14

Station	Average nightly call minutes	Nights occupied	Proportion of nights occupied
AKTP	2.5	101	0.35
LCR MSCP conservation areas			
BLCA 1	0.003	1	0.00
PVER 1	0	0	0.00
PVER 2	0	0	0.00
CVCA 1	0	0	0.00
CVCA 2	0	0	0.00
Crane's Roost	0	0	0.00
YEW 1	0	0	0.00
HHCA	0	0	0.00
Existing habitat areas			
HNWR-Pintail	0.03	3	0.03
BWRNWR	0.05	8	0.05
CNWR-Island	0.01	3	0.01
PSRA	0.01	3	0.01
MLWA	0.003	1	0.00

Existing Habitat Stations

The greatest average nightly call minutes for Arizona myotis were recorded at the BWRNWR, followed by HNWR-Pintal (see table 11 and figure 31). The greatest number of nights occupied were recorded at the BWRNWR, followed by HNWR-Pintail, CNWR-Island, and the PSRA, with the greatest proportion of nights occupied recorded at the BWRNWR (see table 11).

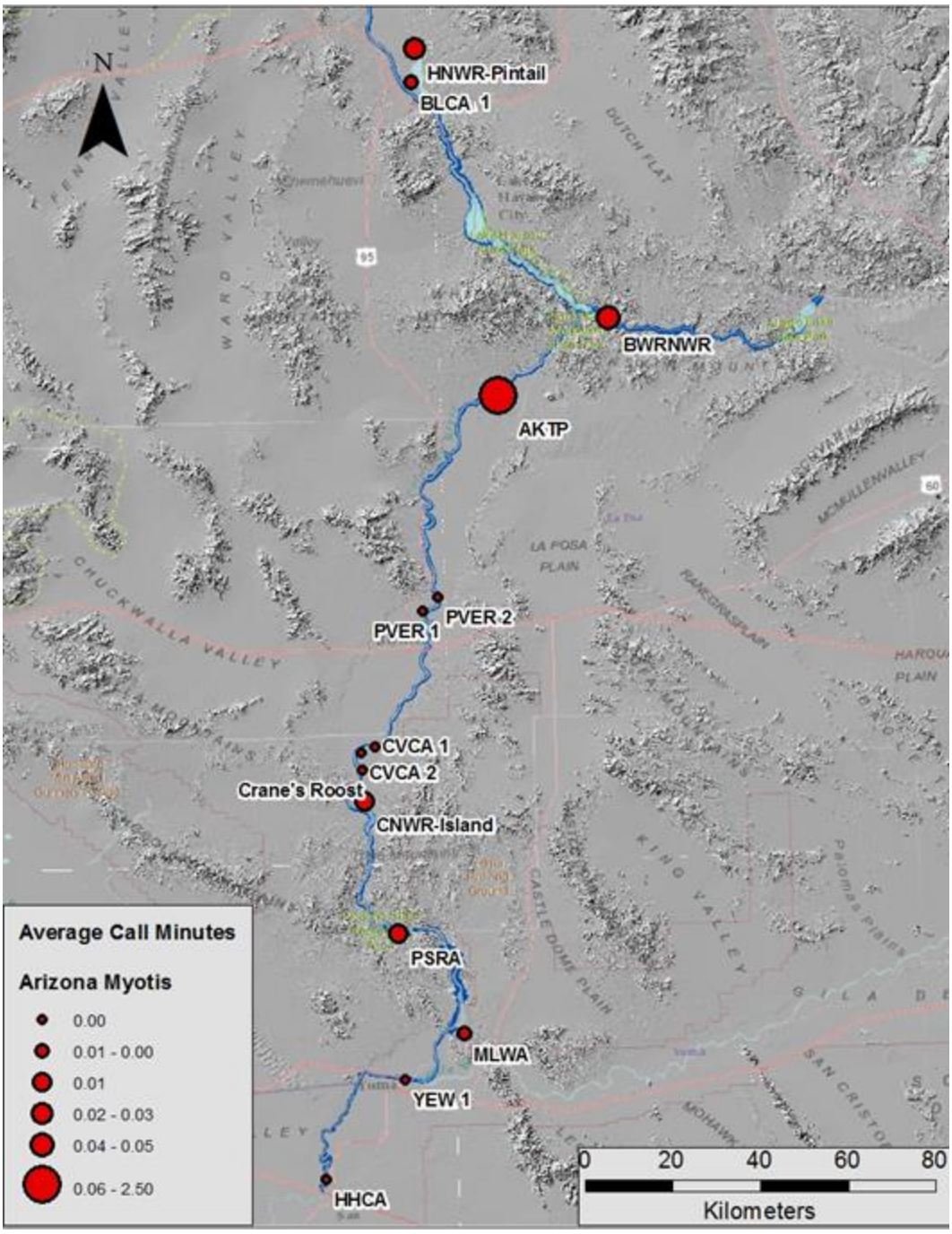

Figure 30.—Arizona myotis nightly call minutes per station.

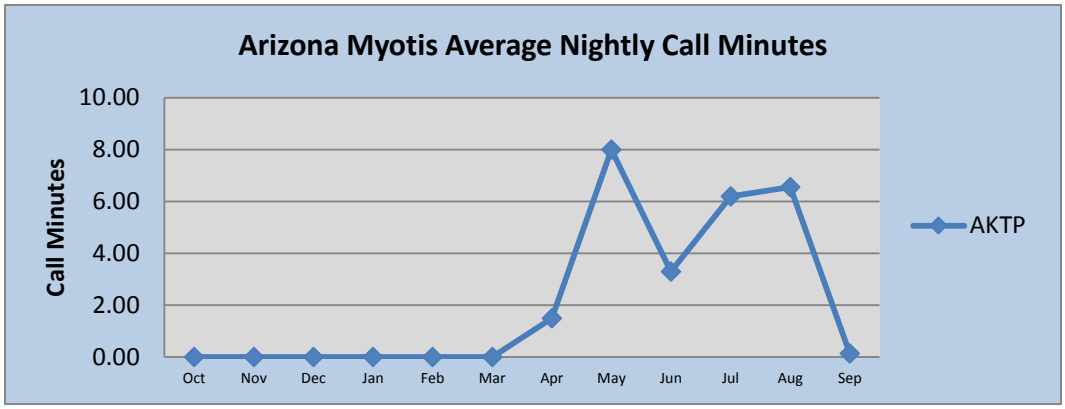

Figure 31.—Arizona myotis average nightly call minutes per month at the AKTP station (see attachment 1).

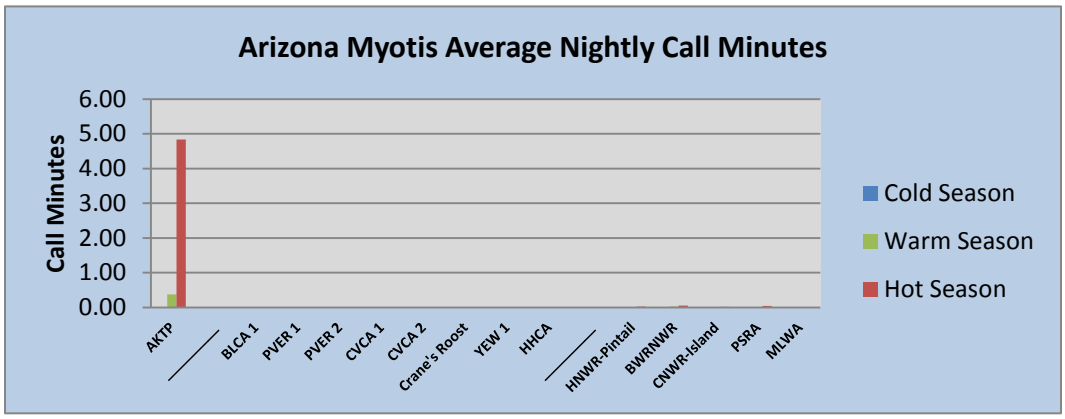

Figure 32.—Arizona myotis average nightly call minutes per season per station (see attachment 1).

RESULTS (STATIONS)

During the course of monitoring, the greatest average nightly call minutes were recorded at LCR MSCP conservation areas and the AKTP station, with CVCA 1 displaying the greatest relative activity. CVCA 1 was followed by the AKTP, YEW, PVER 1, and CVCA 2. The greatest amount of relative activity was recorded at existing habitat stations at the BWRNWR, followed by HNWR-Pintail, the MLWA, Cibola NWR-Island, and the PSRA (table 12 and figure 33).

The greatest average nightly call minutes for western red bats, western yellow bats, hoary bats, pale Townsend's big-eared bats, and cave myotis were recorded at CVCA 1. The greatest average nightly call minutes for California leaf-nosed bats, pale Townsend's big-eared bats, and greater mastiff bats were recorded at YEW. The greatest number of nightly call minutes for Arizona myotis was recorded at the AKTP. The station at the BWRNWR recorded the greatest

Table 12.—Combined average nightly call minutes and proportion of nights occupied for the evaluated species per station

Station	Nights recorded (2014)	Average nightly call minutes	Nights occupied (any species)	Proportion of nights occupied
AKTP	291	9.94	208	0.71
LCR MSCP conservation areas				
BLCA 1	330	2.75	214	0.65
PVER 1	195	6.4	175	0.90
PVER 2	244	3.10	186	0.76
CVCA 1	365	19.22	344	0.94
CVCA 2	365	3.60	228	0.62
Crane's Roost	351	3.15	247	0.70
YEW 1	118	7.6	93	0.79
HHCA	365	0.85	148	0.41
Existing habitat areas				
HNWR-Pintail	96	2.62	63	0.66
BWRNWR	148	3.49	105	0.71
CNWR-Island	220	0.35	35	0.16
PSRA	332	0.21	49	0.15
MLWA	365	1.31	182	0.50

average nightly call minutes for western red bats, western yellow bats, California leaf-nosed bats, pale Townsend's big-eared bats, cave myotis, and Arizona myotis of all the stations located in existing habitat. The greatest number of greater mastiff bats and hoary bats was recorded at HNWR-Pintail.

The greatest number and proportion of nights occupied for all species were recorded during the hot season, followed by the warm and cold season. The greatest number of nights and proportion of nights occupied were recorded during the hot and warm seasons at CVCA 1, with PVER 1 recording the most nights occupied during the cold season (table 13). PVER 1 did have the greatest proportion of nights occupied (100 percent) for the hot season, but it was based on a sample size of 4 nights, which was believed to be too small to make any inferences. CVCA 1 and PVER 1 were recorded as having the greatest proportion of nights occupied as well (table 13).

For the stations located in existing habitat, the greatest number of nights occupied was recorded during the hot and warm seasons at the MLWA, with CNWR-Island having the greatest number and proportion of nights occupied during the cold season (the BWRNWR had the greatest proportion of nights occupied during the cold season, but this was based on a sample size of 3 nights, which was believed to be too small to make any inferences). The largest proportion of nights occupied during the hot season was recorded at the MLWA and during the warm season at the BWRNWR. The MLWA and BWRNWR were recorded as having the largest proportion of nights occupied (table 13 and figure 34).

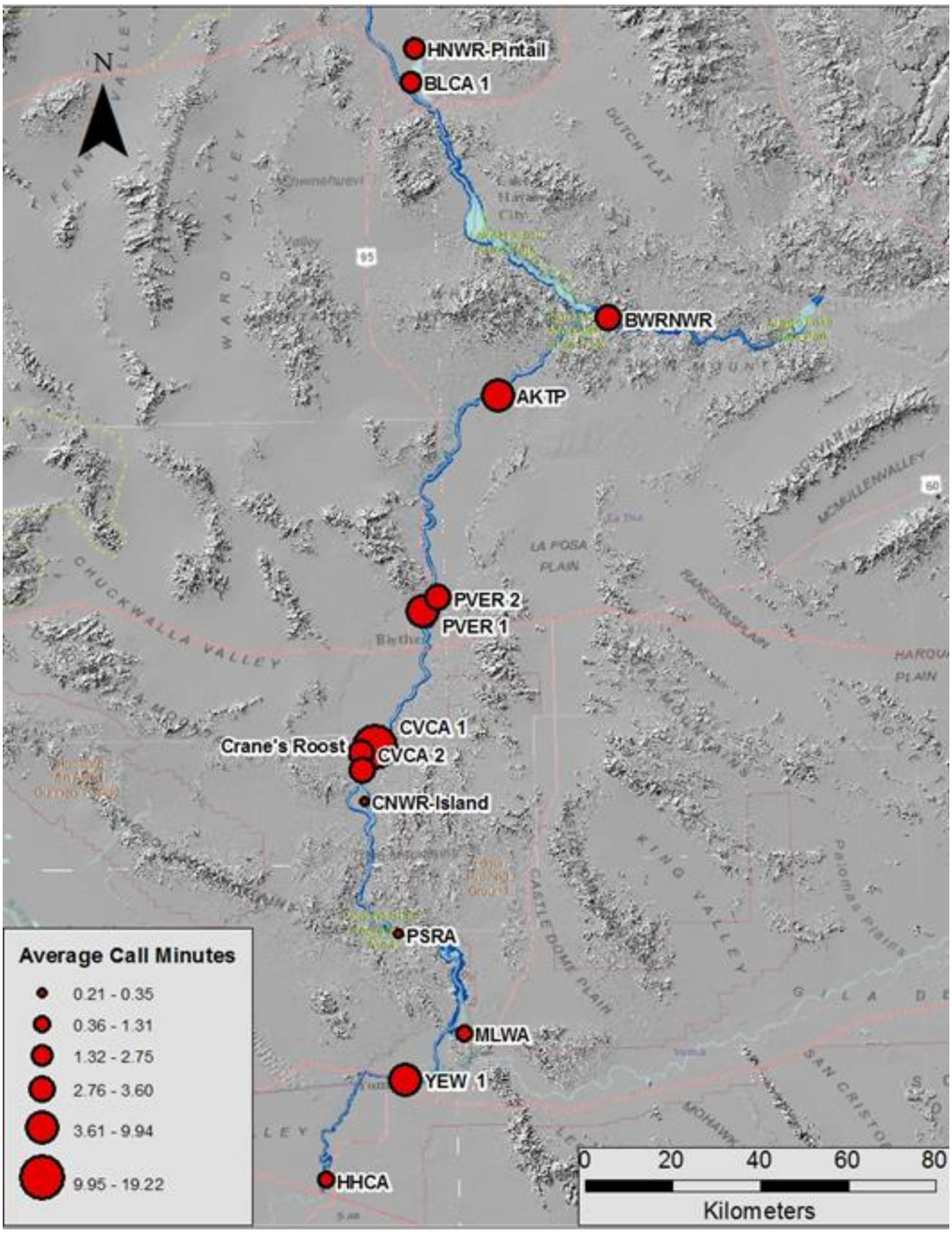

Figure 33.—Average nightly call minutes per station for all evaluated bat species.

Table 13.—Proportion of nights occupied per season for all evaluated species

Station	Cold season	Warm season	Hot season
AKTP	0.30	0.89	0.90
LCR MSCP conservation areas			
BLCA 1	0.28	0.66	0.92
PVER 1	0.87	0.89	1.00
PVER 2	0.51	0.33	0.89
CVCA 1	0.79	0.99	0.99
CVCA 2	0.18	0.61	0.90
Crane's Roost	0.48	0.83	0.74
YEW 1	0.00	0.00	0.79
HHCA	0.16	0.30	0.63
Existing habitat areas			
HNWR-Pintail*	N/A	N/A	0.67
BWRNWR	0.33	0.80	0.71
CNWR-Island	0.22	0.01	0.26
PSRA	0.02	0.12	0.27
MLWA	0.18	0.41	0.76

* Station was not installed during the cold or warm season.

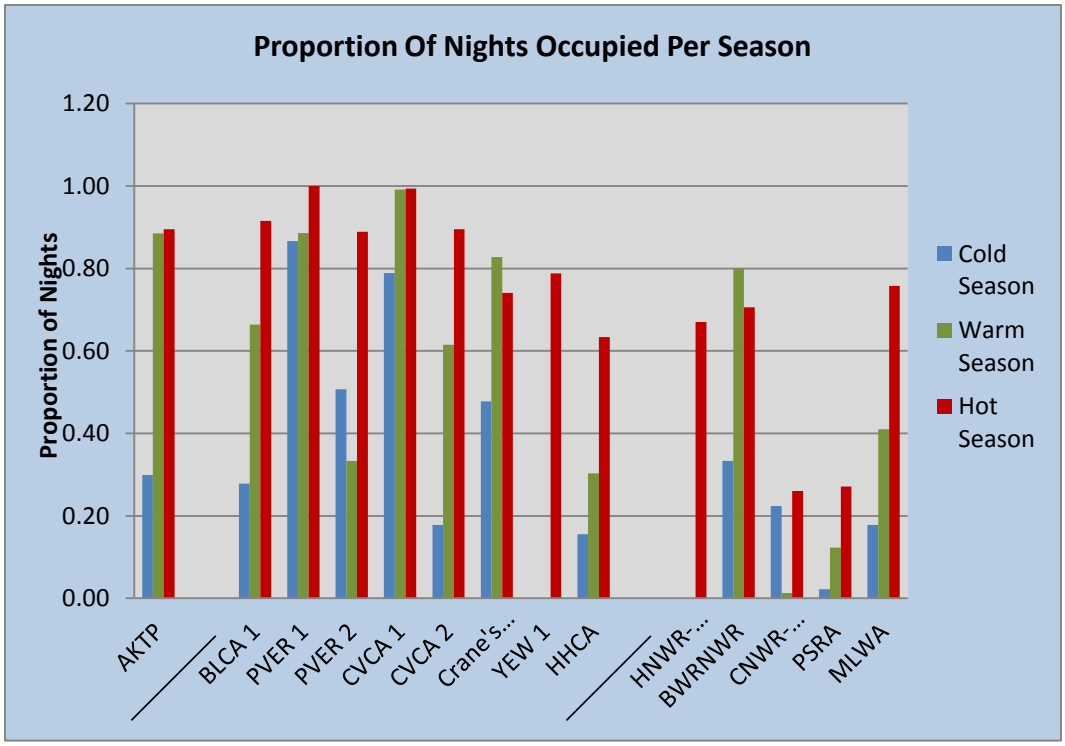

Figure 34.—Proportion of nights occupied per station, per season, for all evaluated species combined.

DISCUSSION

Station malfunctions certainly impacted the collection of nightly call minutes, nights occupied, and proportion of nights occupied at YEW 1 and PVER 1. YEW 1 had the third greatest overall activity, which was likely a product of the station malfunctioning during the winter months (no data were collected from October through mid-May) and only recording calls during the summer peak in activity. The result of this was an inflated estimate of overall activity due to the lower activity during the cooler months. Alternatively, PVER 1 malfunctioned during the hot season (no data were collected from May through September); thus, no data were collected during the summer peak in activity. Nevertheless, PVER 1 had the fourth highest activity of any site despite only recording calls during the lower activity portion of the year. The AKTP, BLCA 1, and PVER 2 had station malfunctions that had an impact on their nightly call minute averages, nights occupied, and proportion of nights occupied. The AKTP and PVER 2 had sporadic malfunctions throughout the year across seasons, so it is difficult to determine the impact this had on the average nightly call minutes, nights occupied, and proportion of nights occupied. The BLCA 1 station malfunctioned in July and August, likely lowering the average nightly call minutes, nights occupied, and proportion of nights occupied. Data were collected continuously at the HHCA station, and Crane's Roost was reliable, with no major malfunctions.

Overall, more average nightly call minutes, nights occupied, and proportion of nights occupied were recorded at stations where habitat had been created compared to areas with existing habitat. The stations with higher relative activity and occupancy generally were in areas with taller vegetation and larger total area. CVCA 1 exhibited the greatest amount of relative activity when comparing all measures of relative activity across all monitoring sites. CVCA 1 had the greatest amount of relative activity for the following species: western red and yellow bats, California leaf-nosed bats, pale Townsend's big-eared bats, greater mastiff bats, hoary bats, and cave myotis. Only the Arizona myotis did not have the highest relative activity at CVCA 1. CVCA 1 had the highest overall average of nightly call minutes per month during the warm and hot seasons and the second highest cold season minutes (PVER 1 was the highest). Other stations with a high degree of relative activity for the LCR MSCP covered and evaluation species included PVER 1, the AKTP, YEW 1, and Crane's Roost.

The greatest amount of relative activity for existing habitat stations was recorded at the BWRNWR. The BWRNWR displayed the greatest relative activity for western red and yellow bats, pale Townsend's big-eared bats, cave myotis, and Arizona myotis. The PSRA displayed the greatest relative activity for California leaf-nosed bats, the MLWA for greater mastiff bats, and HNWR-Pintail for hoary bats. The riparian corridor surrounding the BWRNWR station provides the largest continuous canopy and suitable habitat (roosting and foraging) for tree-roosting bats among the existing habitat areas monitored. The MLWA station recorded a migration pulse of western yellow bats ranging from late January to

March, and this location most likely provides suitable foraging habitat for greater mastiff bats. CNWR-Island and the PSRA displayed the least amount of relative activity overall, and both sites displayed some activity for western red bats. The PSRA had the most relative activity for California leaf-nosed bats. The PSRA has marginal habitat adjacent to the station that may have deterred bats from approaching the recorder. It may be prudent to move the location of the station to a more suitable habitat patch or increase the height of the microphone. The CNWR-Island site is still recovering from a fire that eliminated much of the surrounding vegetation that was potentially providing habitat for tree-roosting bats.

The average nightly call minutes and proportion of nights occupied for the BWRNWR and HNWR-Pintail were based on estimates from data collected during the peak in summer activity. This resulted in an inflated estimate of bat activity due to cold season data losses. However, even if the average nightly call minutes and proportion of nights occupied at the BWRNWR were inflated, past monitoring indicates that this station has the greatest amount of relative activity of the stations in existing habitat (Mixan et al. 2012, 2013). Continuous data were collected throughout the year at the MLWA, and the PSRA was reliable, with only minor problems during June and July. CNWR-Island malfunctioned from late March through mid-July, so average nightly call minutes, nights occupied, and proportion of nights occupied were underestimated.

Western red bats are a migratory riparian obligate species that usually roost solitarily in the foliage of large trees. They are moth specialists that forage over waterways or along the edges of riparian corridors (Harvey et al. 1999). Male western red bats have been captured along the LCR year round, but some are likely utilizing the river as a migratory corridor. The greatest average nightly calls minutes for western red bats were recorded at larger more mature LCR MSCP conservation areas (CVCA 1, PVER 1, and Crane's Roost). This association is likely in response to these sites providing suitable roosting (tall mature trees) and foraging (forest edge) habitat. The greatest average nightly call minutes per month were recorded at CVCA 1 during the hot season primarily during the months of June, July, and August. This time of year corresponds with the emergence of volant young, which have been recorded using CVCA 1 as a maternity site (Diamond et al. 2012). The other LCR MSCP conservation areas and the AKTP varied in their seasonal activity, with some peaking in average nightly call minutes per month during the hot season versus the warm season and vice versa. The high average nightly call minutes per month at the BWRNWR during the warm season suggests this area is a migration stopover for western red bats. The BWRNWR had the greatest average nightly call minutes of any station in existing habitat during the warm season despite not being operational during the months of October and November and only recording calls for 10 nights in March and 12 nights in April.

The greatest average nightly call minutes for western yellow bats were recorded at stations that were in close proximity to large numbers of fan palms (*Washingtonia* spp.) (CVCA 1, YEW 1, and AKTP). A previous telemetry study documented western yellow bats being captured at sites along the LCR exclusively utilizing non-native Mexican fan palms (*Washingtonia robusta*) and date palms (*Phoenix dactylifera*) as roosts (Diamond et al. 2012). The greatest average nightly call minutes per month were generally recorded during the hot season at stations in created habitat and during the warm season at stations in existing habitat, indicating western yellow bats are primarily migrating through existing habitat and rearing young near, but not in, created habitat. This corresponds to the roosting ecology for this species, as many stations in created habitat are located near agricultural fields and rural areas with large numbers of palms. In contrast, most stations in existing habitat are some distance from large tracks of suitable palm-roosting habitat.

The peak average nightly calls for California leaf-nosed bats were recorded at sites that were in close proximity to known roosts (YEW 1, CVCA 2, and CNWR 1). This species appears to be utilizing the LCR MSCP conservation areas and the AKTP as foraging habitat but is limited by the distance from suitable cavern/mine roosts. California leaf-nosed bats are passive listeners when foraging and emit lower frequency calls as they glean their prey off vegetation. Their low-frequency calls make detecting them acoustically challenging; therefore, their activity along the LCR was likely underestimated. While calls for this species are recorded at low numbers, they are recorded consistently at stations at LCR MSCP conservation areas during the warm and hot seasons, with an expected dropoff during the cold season. This species had the greatest average nightly call minutes per month of any station at the PSRA during the hot season, which was likely due to the close proximity to a California leaf-nosed bat roost.

The greatest average nightly call minutes for pale Townsend's big-eared bats were recorded at CVCA 1 and YEW 1. However, because these bats emit such a low-frequency call and there is only one known roost on the main stem of the LCR, the sampling likely does not represent the actual magnitude of activity and therefore limits any inferences that can be made. Capture surveys conducted along the LCR have indicated that this species does utilize the monitored areas as foraging habitat (Calvert 2013; Diamond et al. 2012). Thus, capture methods are a more reliable way to estimate pale Townsend's big-eared bat habitat use patterns.

Greater mastiff bats are the largest bats in the United States. They roost in crevices, shallow cliff side caves, and human-made structures (Cockrum 1960). Their roosts are located with enough height for this species to drop into flight. They forage high in the air for large moths and are difficult to capture using mist nets (Adams 2003). The greatest average nightly call minutes for greater mastiff bats were recorded at LCR MSCP conservation areas and the AKTP that are most likely providing foraging habitat or may be in close proximity to roosting habitat

for this long-distance and high-altitude foraging species (YEW 1, AKTP, and CVCA 1). The greatest average nightly call minutes per month for this species occurred during the hot season, with all stations differing on peak activity per month. This may relate to prey availability, but further study would be needed to determine the timing of this activity.

Hoary bats are the most widespread of all American bats (Adams 2003). This species is seasonally migratory, solitary, and primarily roosts among the foliage of trees. They forage for moths mostly in open habitats but seem to have a generalists diet (Black 1972). The greatest average nightly call minutes and average nightly calls per month for hoary bats were recorded at stations with larger (area) more mature (taller) trees (CVCA 1, PVER 1, and AKTP). The majority of the activity recorded for this species at stations in LCR MSCP conservation areas and the AKTP occurred during the warm season, primarily during the months of October and November. Activity at existing habitat stations was sporadic, with low numbers of detections spread across seasons. This species is seasonally migratory and uses the LCR as a migratory corridor. These larger, more mature restoration areas provide temporary foraging and roosting habitat for this species as it migrates during the spring and fall months.

The greatest average nightly call minutes for cave myotis were recorded at LCR MSCP conservation areas and the AKTP that were most likely in close proximity to roosts (CVCA 1, AKTP, and BLCA 1). The average nightly call minutes per month for this species were overwhelmingly recorded during the hot season at all sites. Much like other cavern obligate species, cave myotis are limited to foraging distance from their roost. However, cave myotis are seasonally migratory in Arizona and may be recorded while migrating between roosts. Given that the majority of activity for cave myotis is detected on the LCR during the hot season, they are likely migrating away from the river during the cold and warm seasons.

Arizona myotis roost in mines, buildings, and crevices and have even been found utilizing Mexican fan palms and date palms (Calvert and Neiswenter 2012; Diamond et al. 2012). Some researchers suggest that this species has a strong association with stable water sources (Findley et al. 1975). The greatest average nightly call minutes for Arizona myotis were recorded at the AKTP, which sits approximately 1 kilometer from the only known roost for this species along the LCR. The second highest amount of average nightly calls were recorded at the BWRNWR, which is the closest site to the AKTP (37 kilometers). This second highest amount of activity was relatively low, with only 8 nights of recorded activity at the BWRNWR compared to 101 nights of activity at the AKTP. The greatest average nightly call minutes per month for this species on the LCR occurred during the hot season. Females of this species have been documented traveling several hundred kilometers between summer and winter roosts (Adams 2003). Given that a substantial amount of activity for Arizona myotis is detected during the hot season, they are most likely migrating away from the LCR during the cold and warm seasons.

An analysis of these acoustic data suggests the LCR MSCP conservation areas are providing important roosting and foraging habitat for the evaluated species. Only marginal pockets of existing habitat remain along the main stem of the LCR, and they support less relative activity and occupancy than LCR MSCP conservation areas. The exception to this may be the BWRNWR where large tracks of Fremont cottonwoods and Goodding's willows still exist. A second acoustic detector at the BWRNWR positioned within one of these tracks of cottonwoods and willows would provide greater detail of relative activity and occupancy for this area.

It is believed that the age of the restoration sites, composition (percentages of cottonwood-willow, honey mesquite, marsh, and backwater), and plant spacing will influence overall bat activity and occupancy. In general, bats use more open stand types, such as recently clear-cut stands and/or mature forests, rather than stands with greater structural clutter, such as those in early and mid-development (Thomas 1988; Erickson and West 1996; Krusic et al. 1996; Crampton and Barclay 1998; Jung et al. 1999; Ellis et al. 2002; Patriquin and Barclay 2003; Loeb and O'Keefe 2006). Studies indicate that western red bats are more likely to be recorded at sites with sparse vegetation and a more open understory (Loeb and O'Keefe 2006; Yates and Muzika 2006). Similarly, a study conducted at LCR MSCP conservation areas found trends that western red bats select roosting areas with an open understory (Diamond et al. 2012). Analyzing relative activity and occupancy variations across sites, tree spacing, and species may provide information on the most optimal restoration design to create foraging and roosting habitat for the bat species of concern.

This long-term acoustic monitoring study provides a solid foundation and baseline data for relative activity. Augmenting it with a study design similar to Fischer et al. 2009 may provide more inference, if any is needed. Calculating the influences of the age of restoration sites, composition, and plant spacing on bat activity and occupancy may help detect patterns of use with planting designs. In addition, sampling within different phases and plant placing (3, 4, 6, and 30 feet on center) and across sites using multiple mobile detectors might identify differences in species occupancy and relative activity. Four sampling nights and five detectors have provided a large enough sample size to find variance among sites, locations within sites, and night use utilizing mixed regression models (Fischer et al. 2009).

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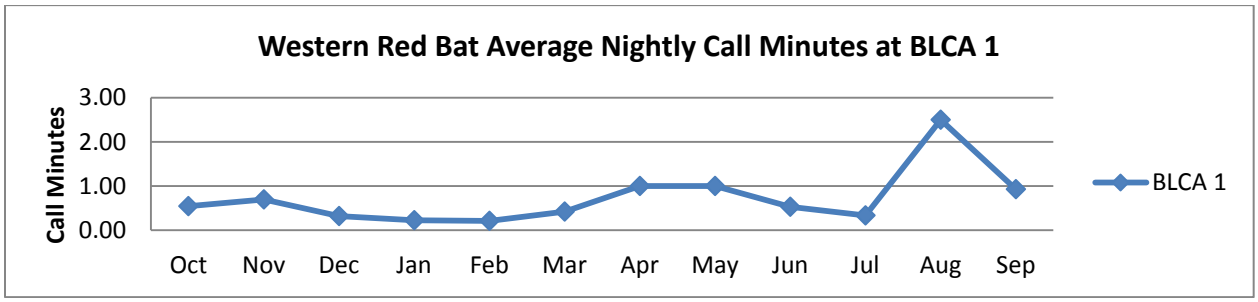
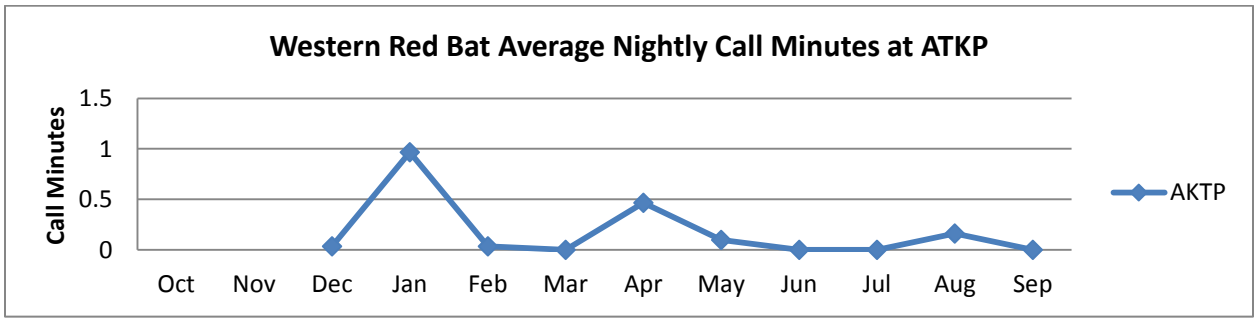
ATTACHMENT 1

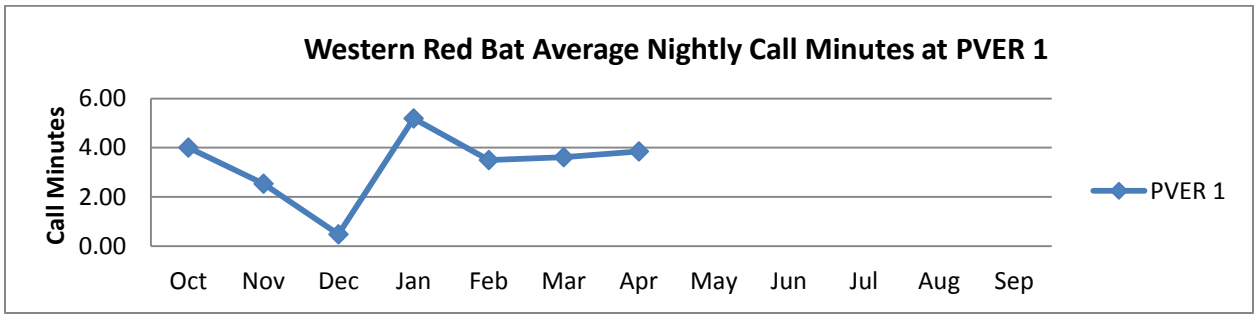
Temporal Graphs for Evaluated Species at Each Station

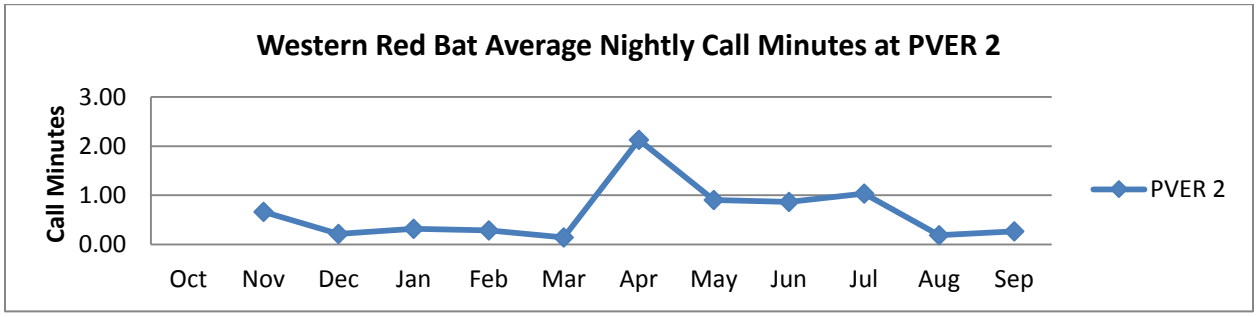
(See table 2 for data gaps and months when stations were not operational)

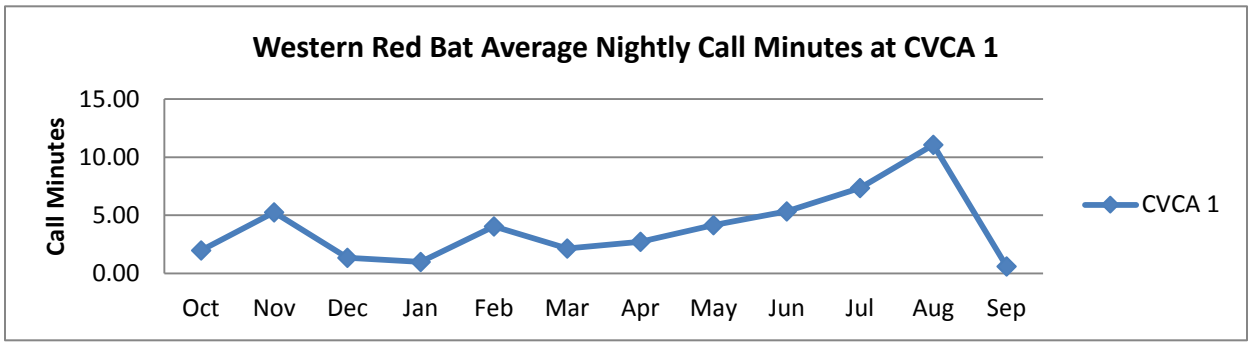
WESTERN RED BAT

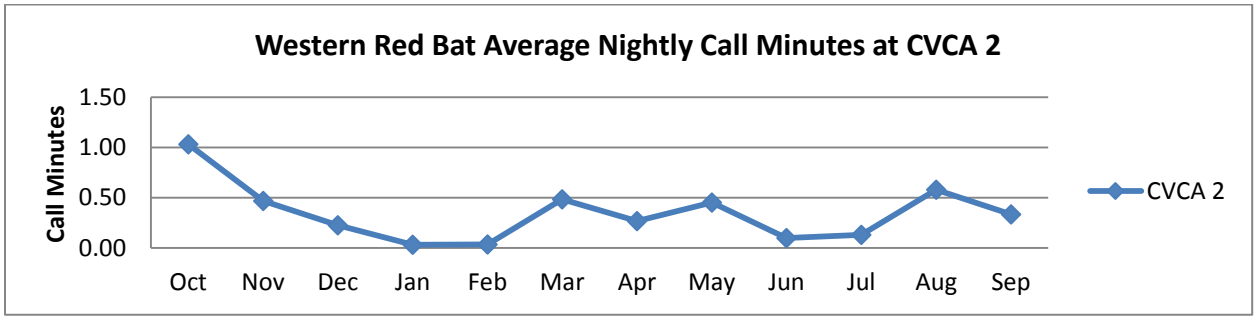


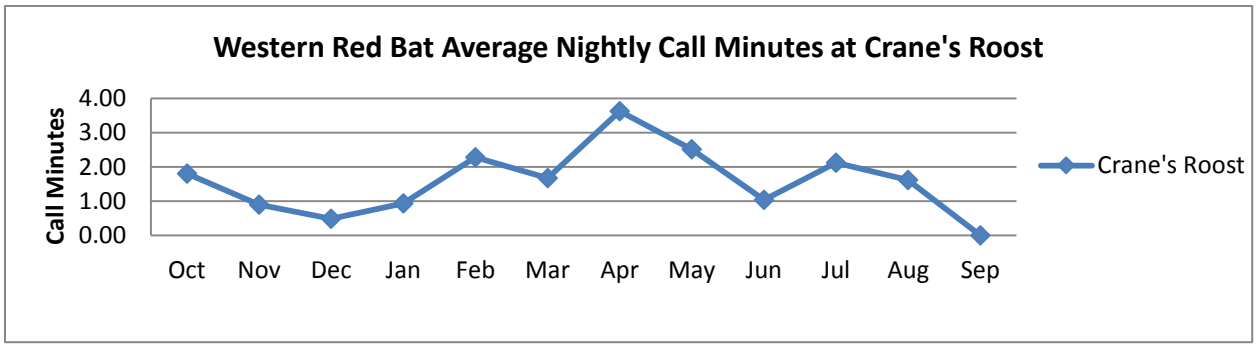


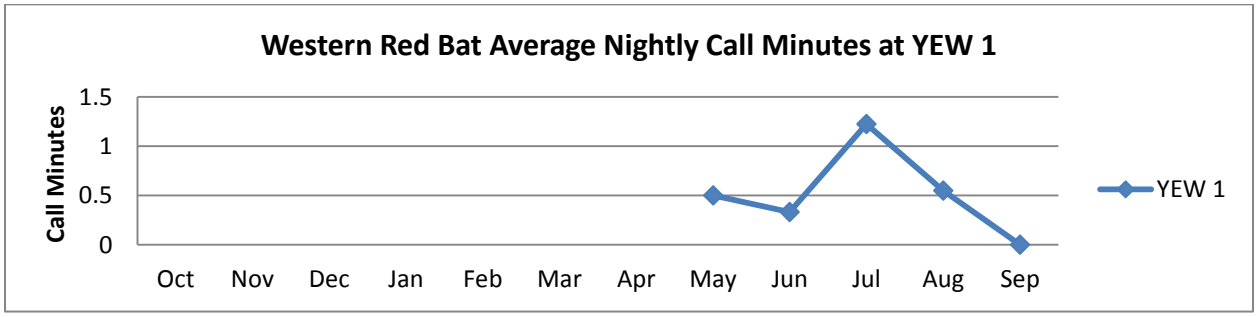


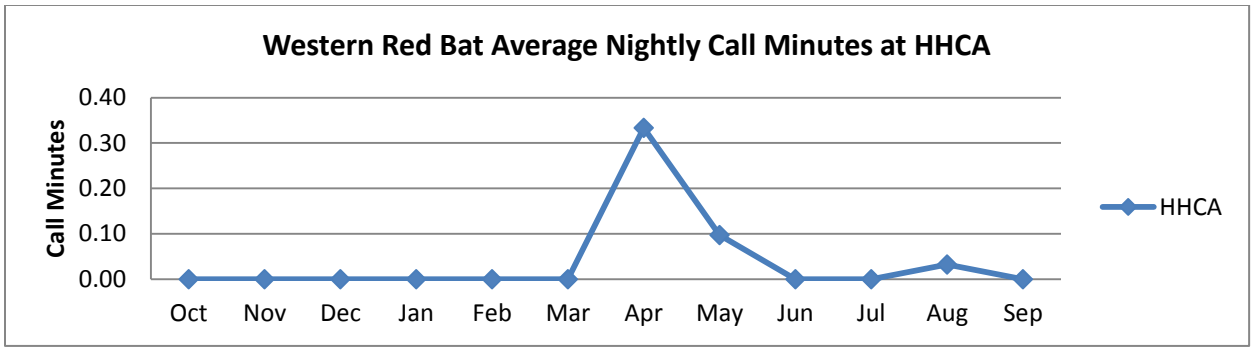


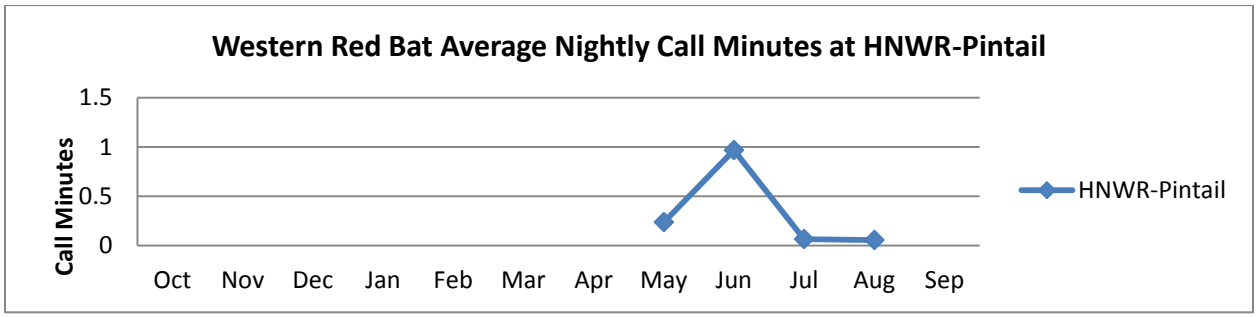

Western Red Bat Average Nightly Call Minutes at CVCA 1
Call Minutes
15.00
10.00
5.00
0.00
Oct
Nov
Dec
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
CVCA 1

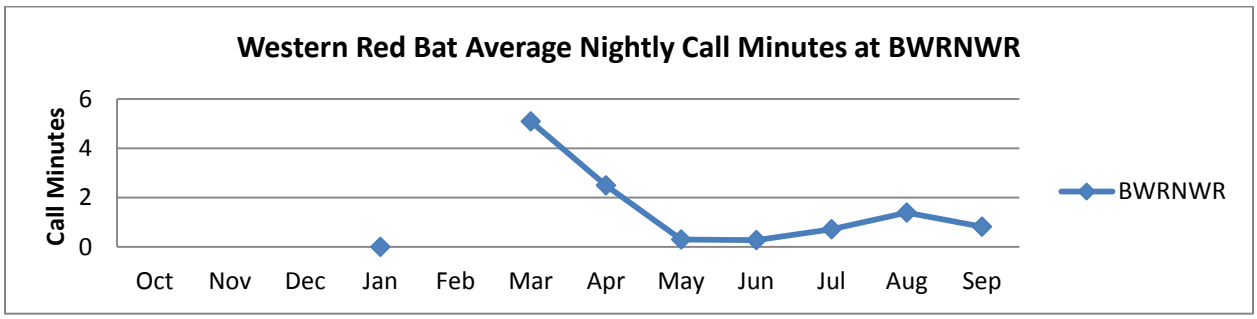

Western Red Bat Average Nightly Call Minutes at CVCA 2
Call Minutes
1.50
1.00
0.50
0.00
Oct
Nov
Dec
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
CVCA 2

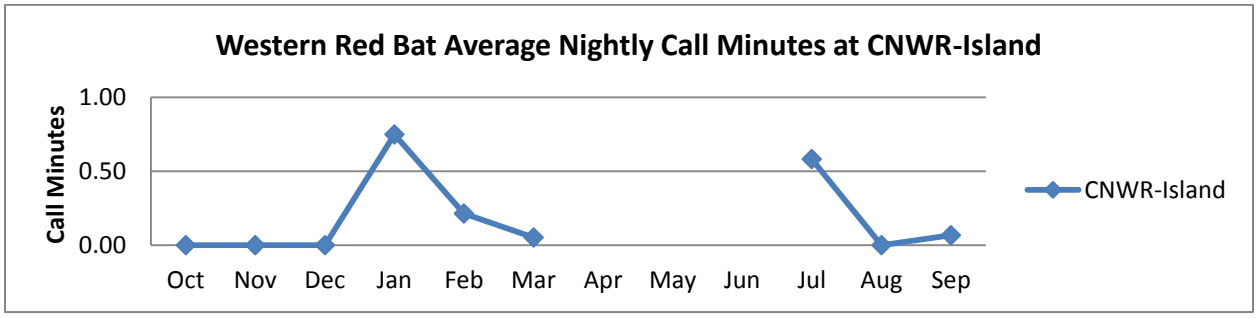

Western Red Bat Average Nightly Call Minutes at Crane's Roost
Call Minutes
4.00
3.00
2.00
1.00
0.00
Oct
Nov
Dec
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Crane's Roost

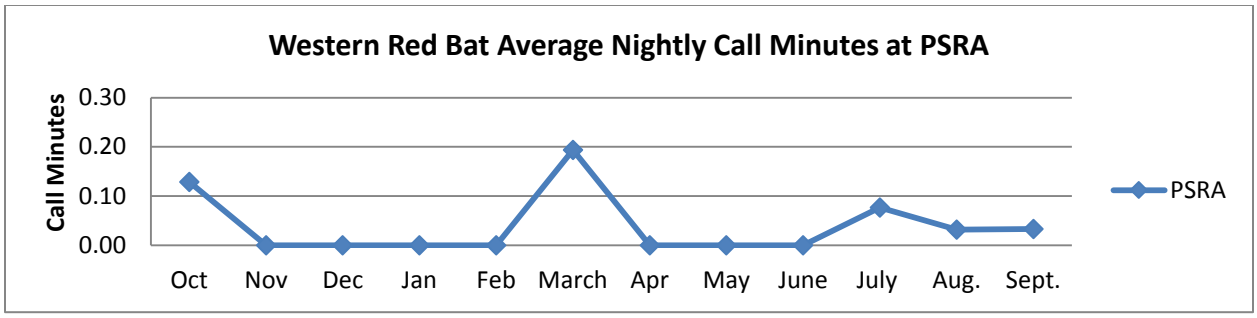

Western Red Bat Average Nightly Call Minutes at YEW 1
Call Minutes
1.5
1
0.5
0
Oct
Nov
Dec
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
YEW 1

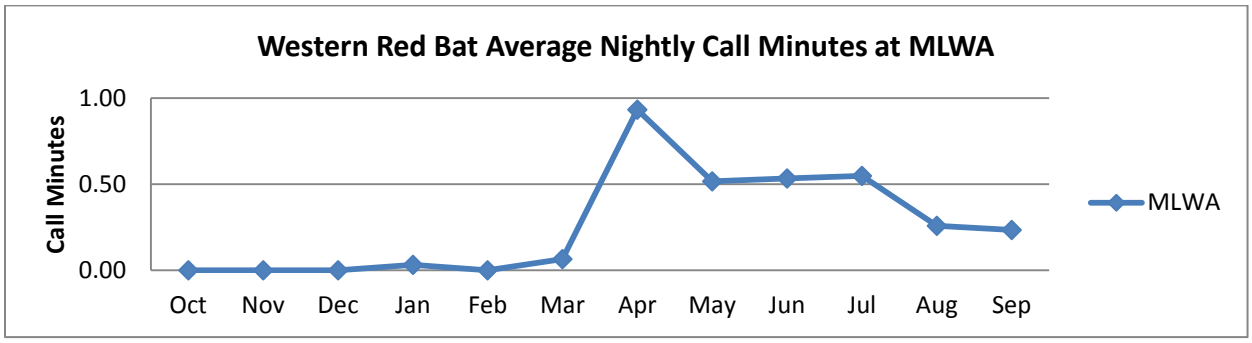

Western Red Bat Average Nightly Call Minutes at HHCA
Call Minutes
0.40
0.30
0.20
0.10
0.00
Oct
Nov
Dec
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
HHCA


Western Red Bat Average Nightly Call Minutes at HNWR-Pintail
Call Minutes
1.5
1
0.5
0
Oct
Nov
Dec
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
HNWR-Pintail

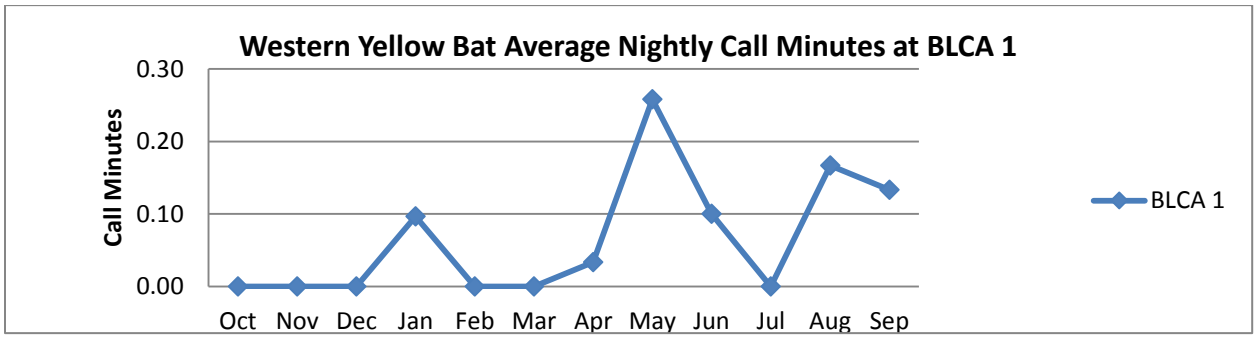

Western Red Bat Average Nightly Call Minutes at BWRNWR
Call Minutes
6
4
2
0
Oct
Nov
Dec
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
BWRNWR

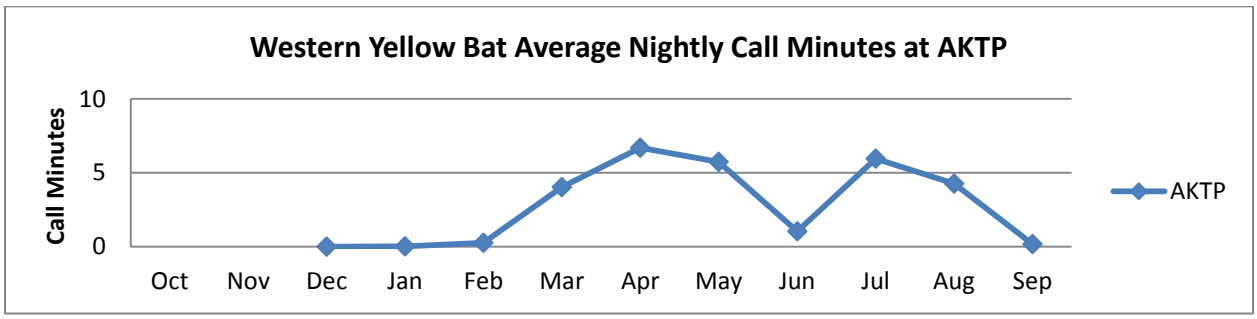

Western Red Bat Average Nightly Call Minutes at CNWR-Island
Call Minutes
1.00
0.50
0.00
Oct
Nov
Dec
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
CNWR-Island

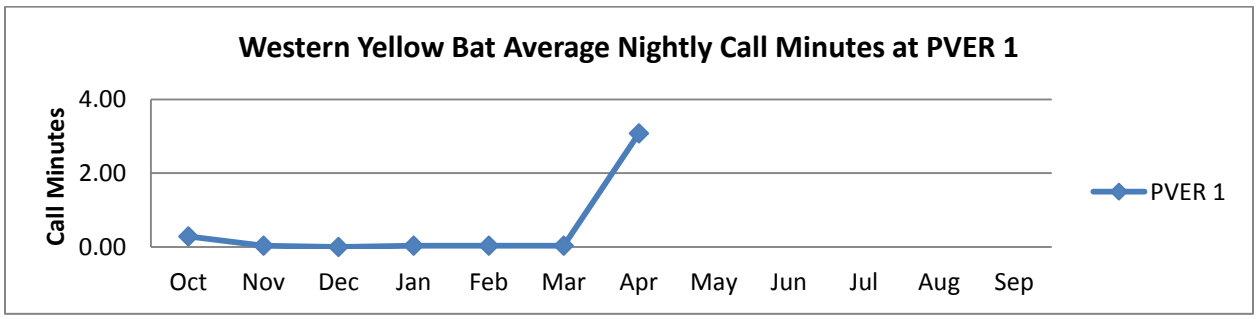

Western Red Bat Average Nightly Call Minutes at PSRA
Call Minutes
0.30
0.20
0.10
0.00
Oct
Nov
Dec
Jan
Feb
March
Apr
May
June
July
Aug.
Sept.
PSRA

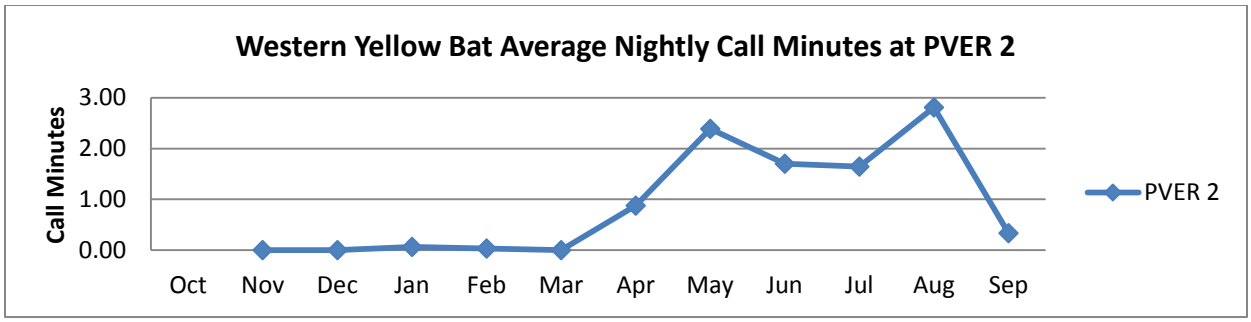

Western Red Bat Average Nightly Call Minutes at MLWA
Call Minutes
1.00
0.50
0.00
Oct
Nov
Dec
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
MLWA

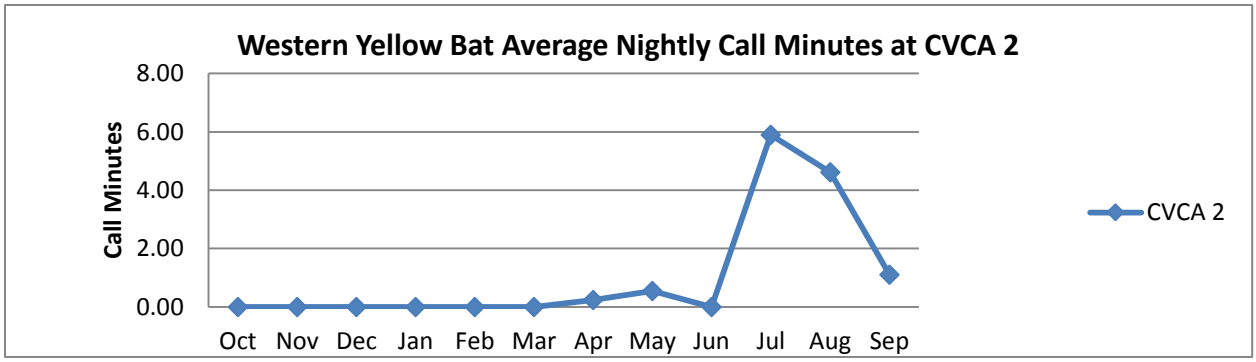
WESTERN YELLOW BAT

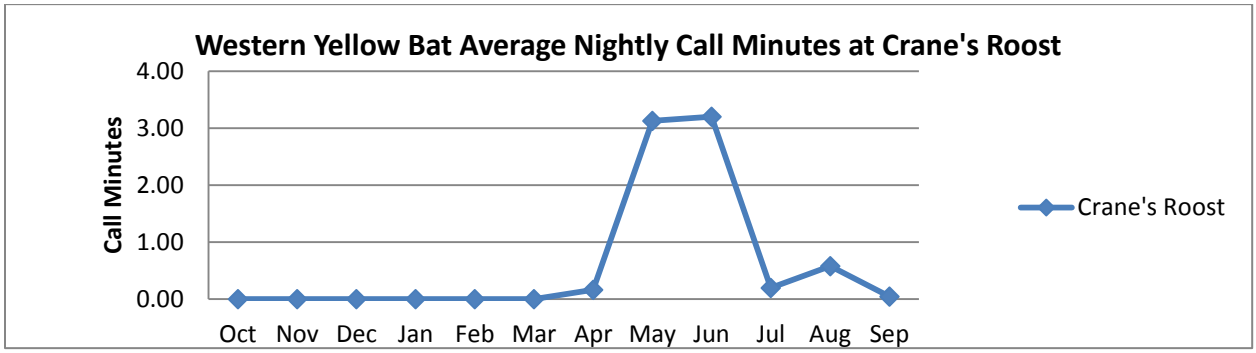


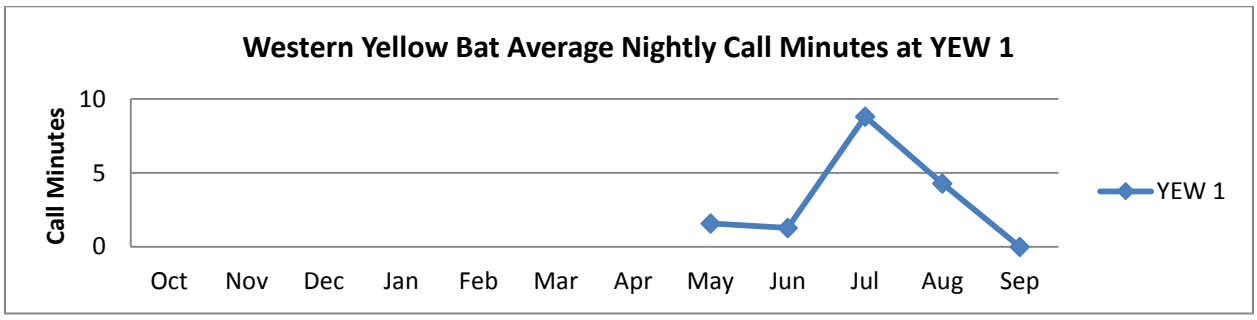


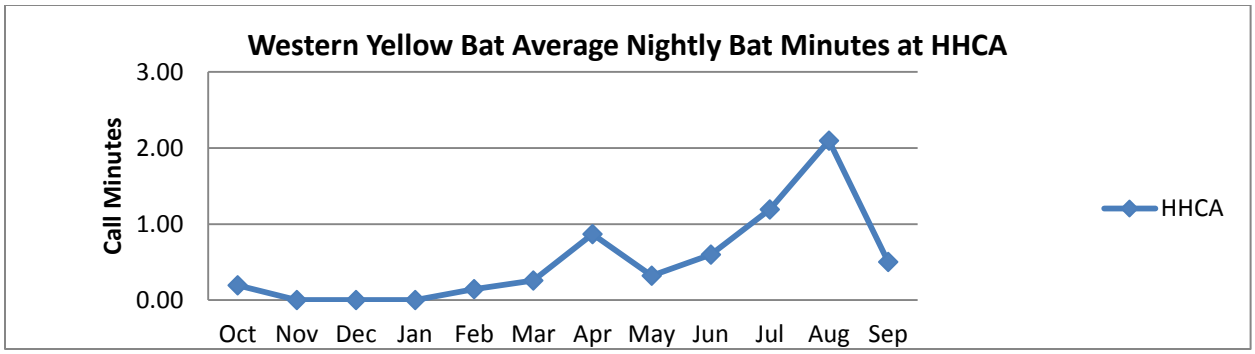


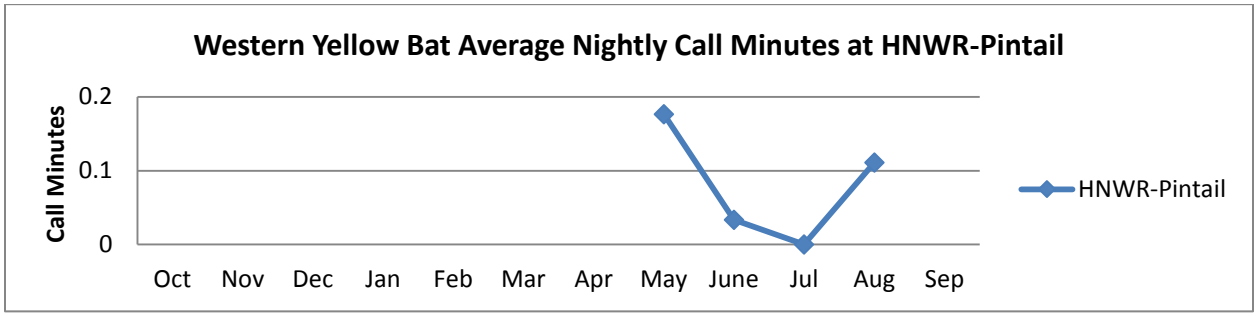


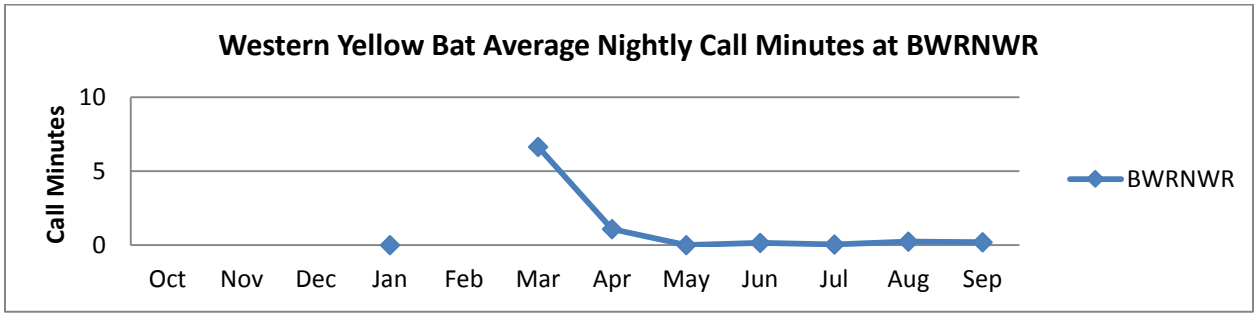

Western Yellow Bat Average Nightly Call Minutes at CVCA 2
Call Minutes
8.00
6.00
4.00
2.00
0.00
Oct
Nov
Dec
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
CVCA 2

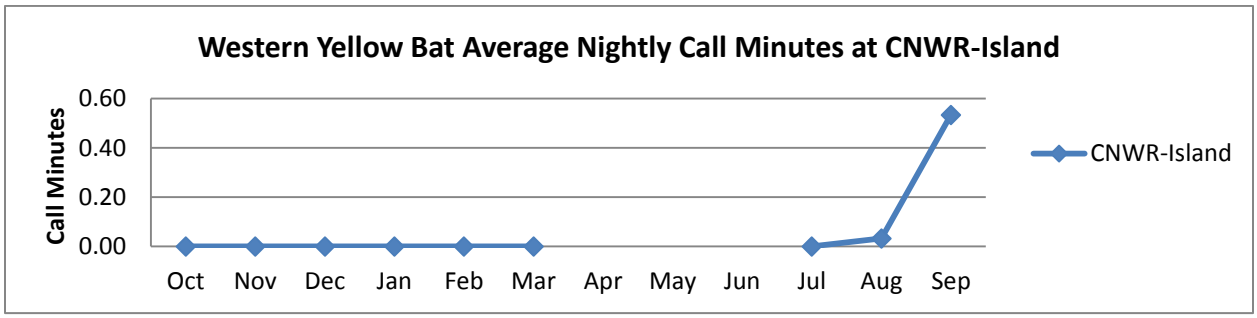

Western Yellow Bat Average Nightly Call Minutes at Crane's Roost
Call Minutes
4.00
3.00
2.00
1.00
0.00
Oct
Nov
Dec
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Crane's Roost

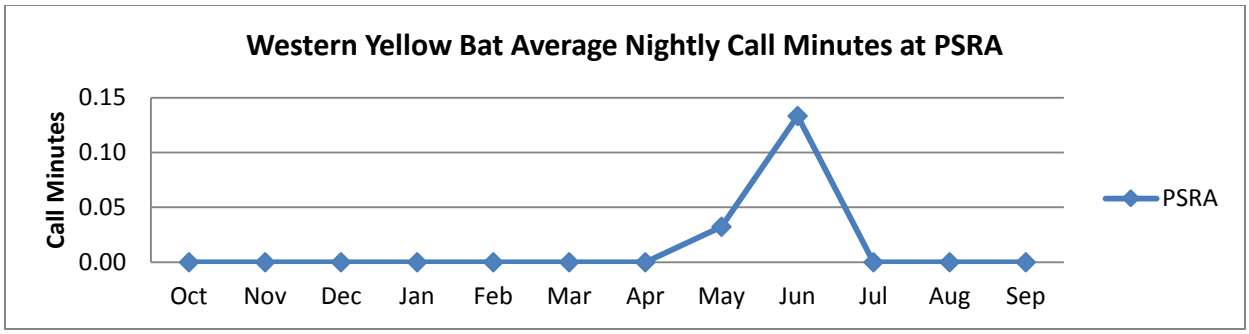

Western Yellow Bat Average Nightly Call Minutes at YEW 1
Call Minutes
10
5
0
Oct
Nov
Dec
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
YEW 1

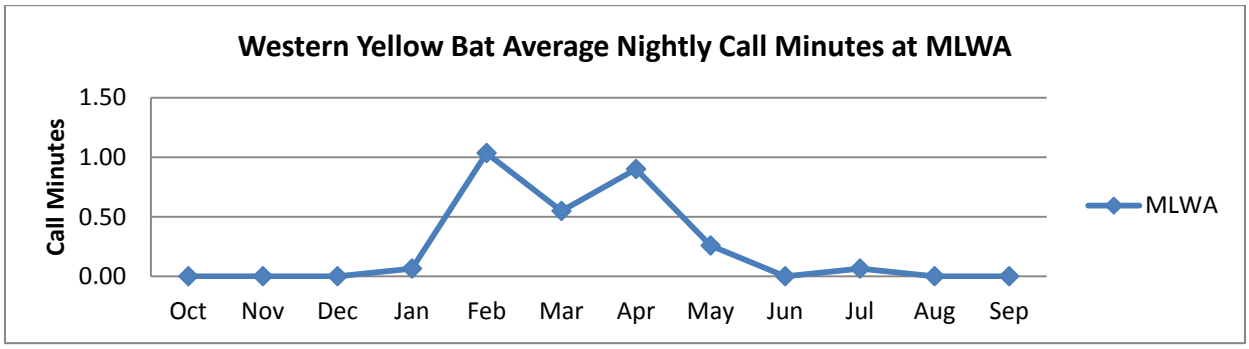

Western Yellow Bat Average Nightly Bat Minutes at HHCA
Call Minutes
3.00
2.00
1.00
0.00
Oct Nov Dec Jan Feb Mar Apr May Jun Jul Aug Sep
HHCA


Western Yellow Bat Average Nightly Call Minutes at HNWR-Pintail
Call Minutes
0.2
0.1
0
Oct Nov Dec Jan Feb Mar Apr May June Jul Aug Sep
HNWR-Pintail

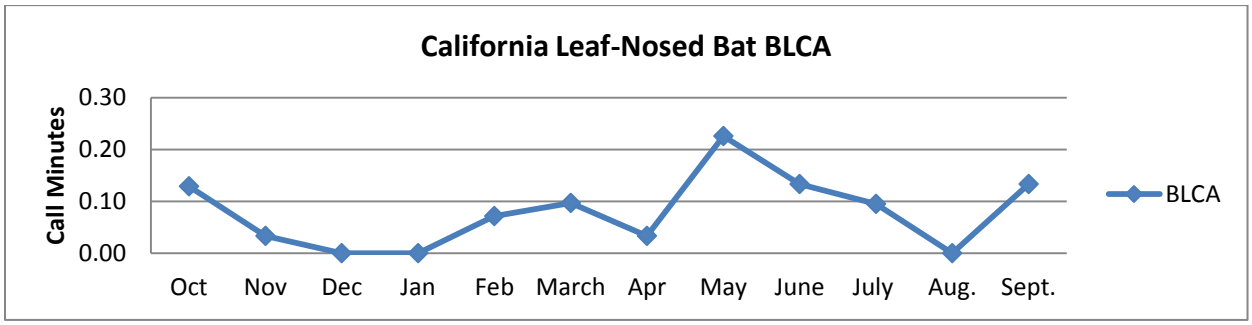

Western Yellow Bat Average Nightly Call Minutes at BWRNWR
Call Minutes
10
5
0
Oct Nov Dec Jan Feb Mar Apr May Jun Jul Aug Sep
BWRNWR

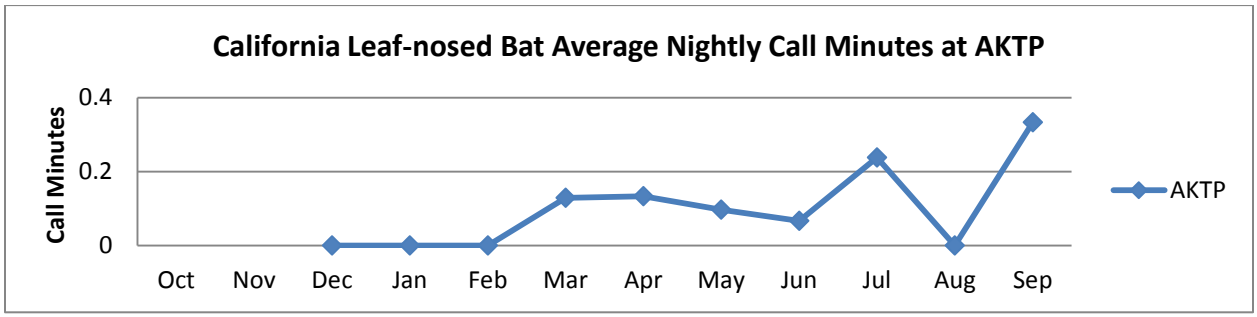

Western Yellow Bat Average Nightly Call Minutes at CNWR-Island
Call Minutes
0.60
0.40
0.20
0.00
Oct Nov Dec Jan Feb Mar Apr May Jun Jul Aug Sep
CNWR-Island

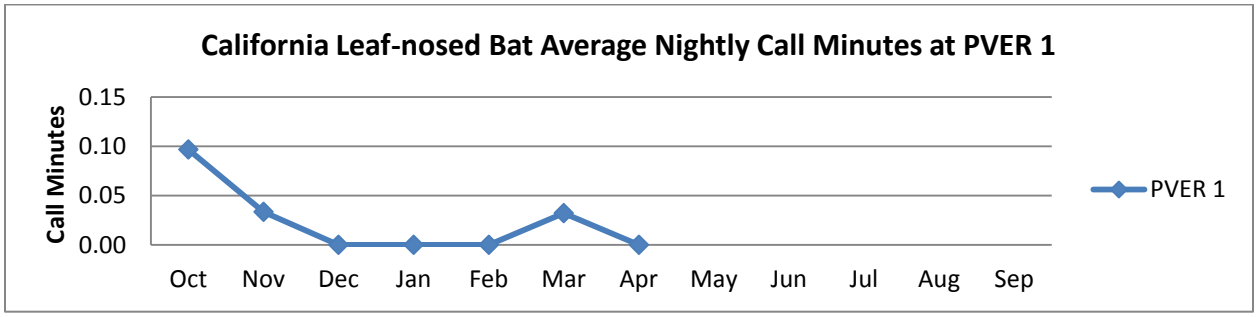

Western Yellow Bat Average Nightly Call Minutes at PSRA
Call Minutes
0.15
0.10
0.05
0.00
Oct
Nov
Dec
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
PSRA

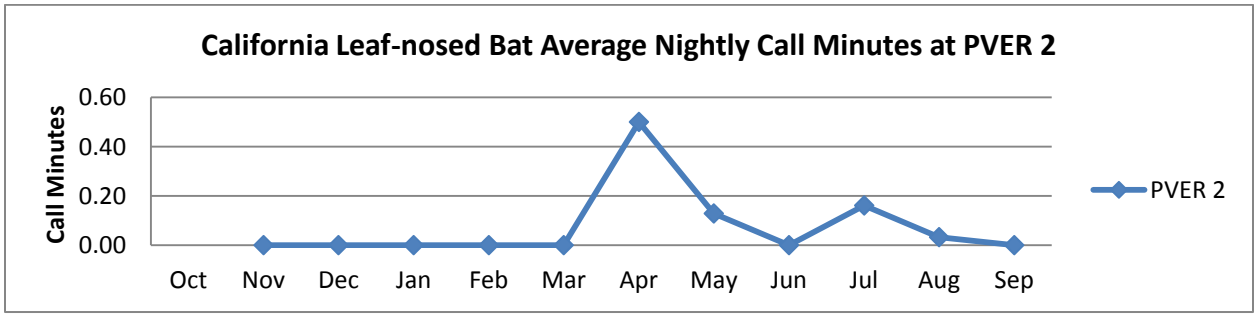

Western Yellow Bat Average Nightly Call Minutes at MLWA
Call Minutes
1.50
1.00
0.50
0.00
Oct
Nov
Dec
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
MLWA

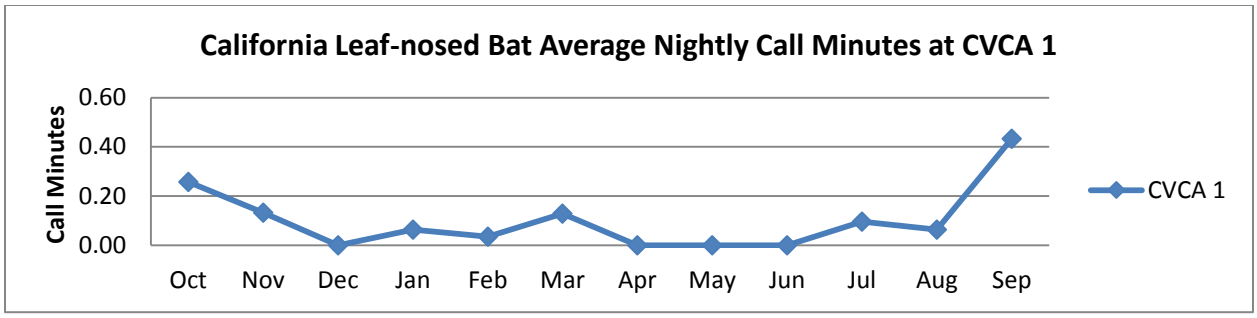
CALIFORNIA LEAF-NOSED BAT

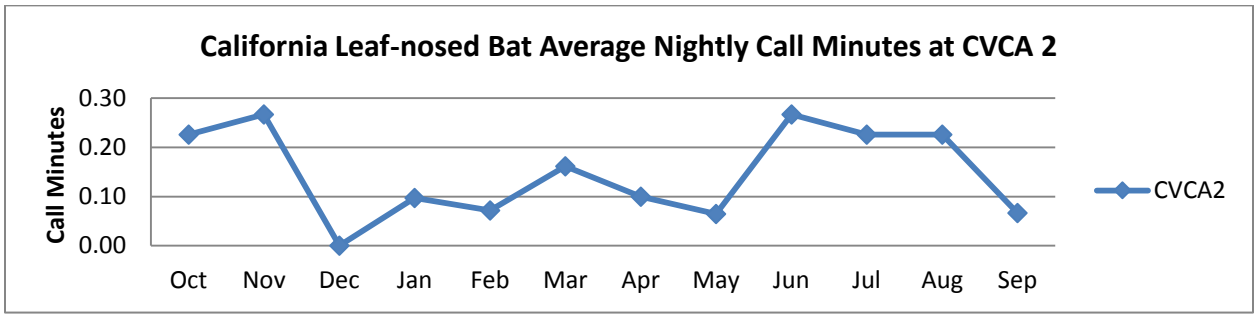


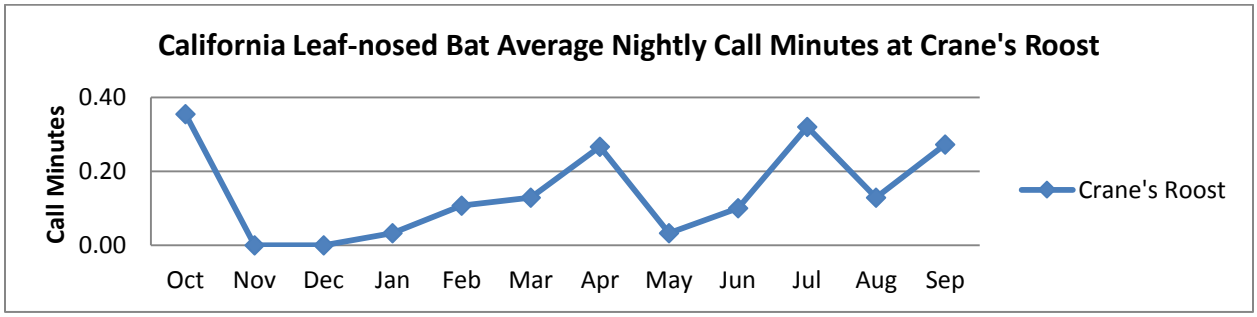


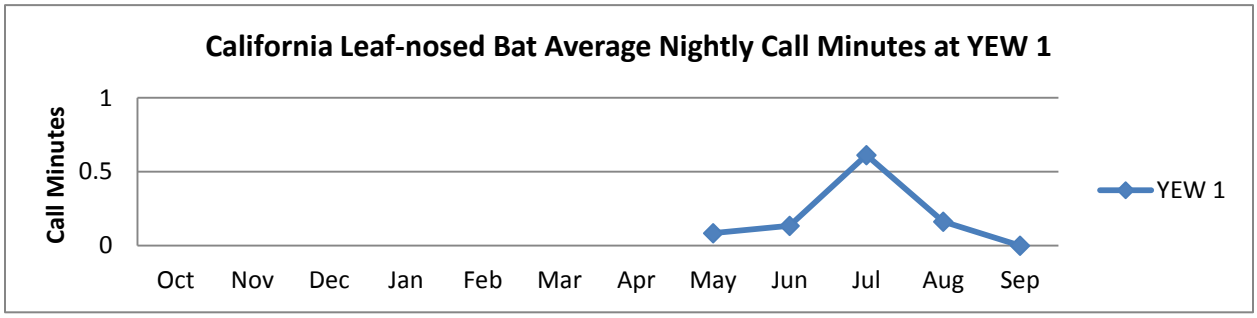


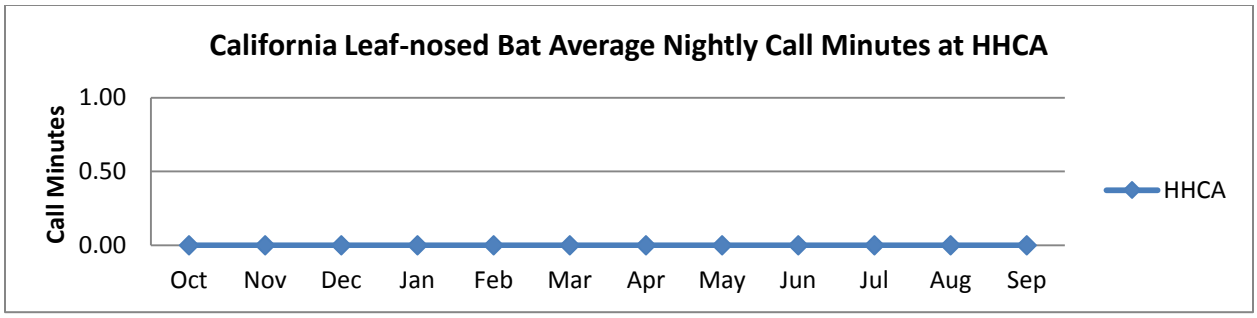


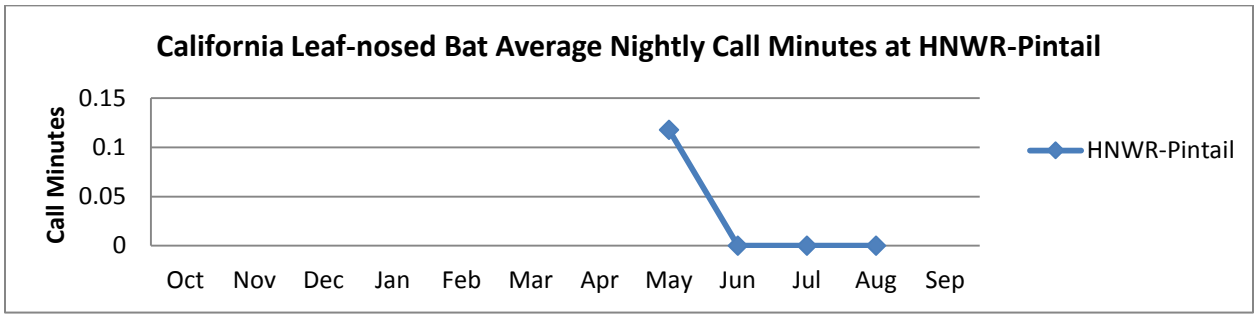

California Leaf-nosed Bat Average Nightly Call Minutes at CVCA 1
Call Minutes
0.60
0.40
0.20
0.00
Oct
Nov
Dec
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
CVCA 1

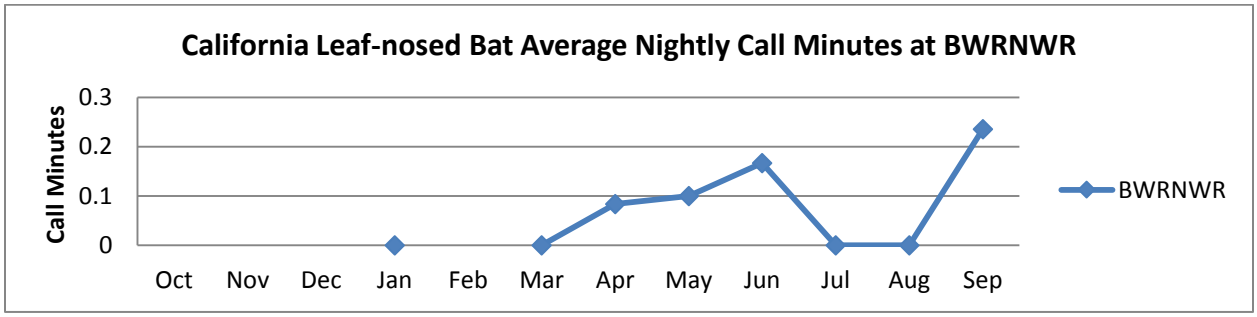

California Leaf-nosed Bat Average Nightly Call Minutes at CVCA 2
Call Minutes
0.30
0.20
0.10
0.00
Oct
Nov
Dec
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
CVCA2

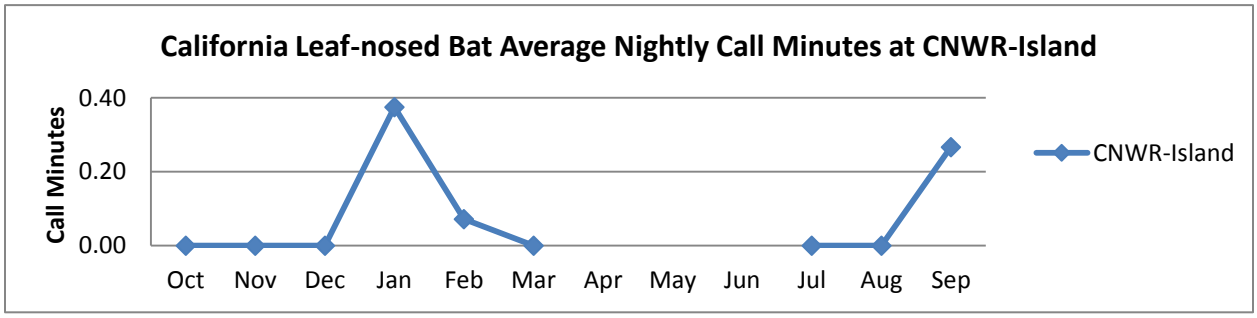

California Leaf-nosed Bat Average Nightly Call Minutes at Crane's Roost
Call Minutes
0.40
0.20
0.00
Oct
Nov
Dec
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Crane's Roost

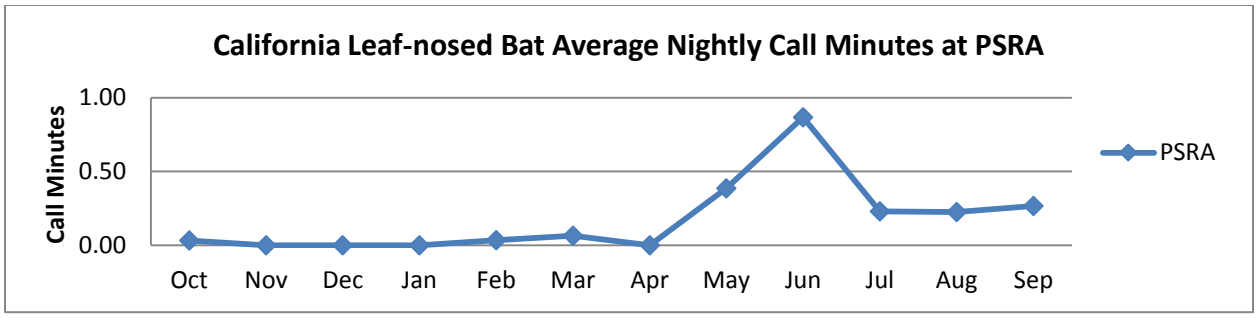

California Leaf-nosed Bat Average Nightly Call Minutes at YEW 1
Call Minutes
1
0.5
0
Oct
Nov
Dec
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
YEW 1


California Leaf-nosed Bat Average Nightly Call Minutes at HHCA
Call Minutes
1.00
0.50
0.00
Oct
Nov
Dec
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
HHCA


California Leaf-nosed Bat Average Nightly Call Minutes at HNWR-Pintail
Call Minutes
0.15
0.1
0.05
0
Oct
Nov
Dec
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
HNWR-Pintail

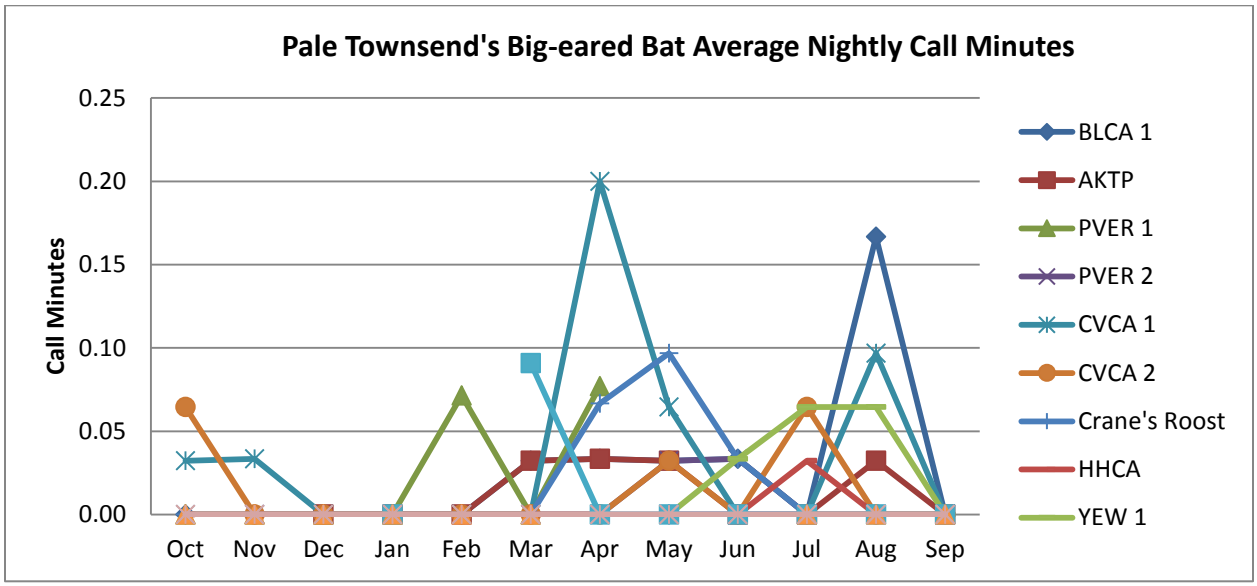

California Leaf-nosed Bat Average Nightly Call Minutes at BWRNWR
Call Minutes
0.3
0.2
0.1
0
Oct
Nov
Dec
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
BWRNWR


California Leaf-nosed Bat Average Nightly Call Minutes at CNWR-Island
Call Minutes
0.40
0.20
0.00
Oct
Nov
Dec
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
CNWR-Island

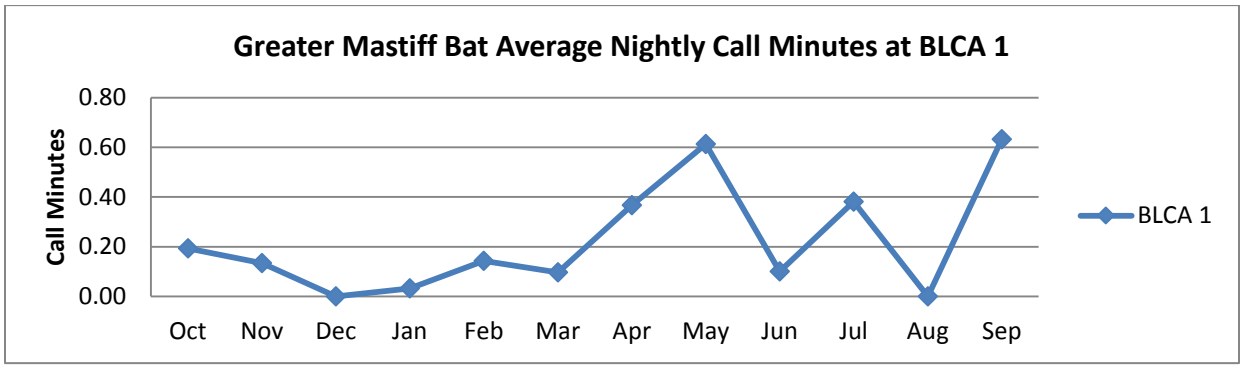

California Leaf-nosed Bat Average Nightly Call Minutes at PSRA
Call Minutes
1.00
0.50
0.00
Oct
Nov
Dec
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
PSRA

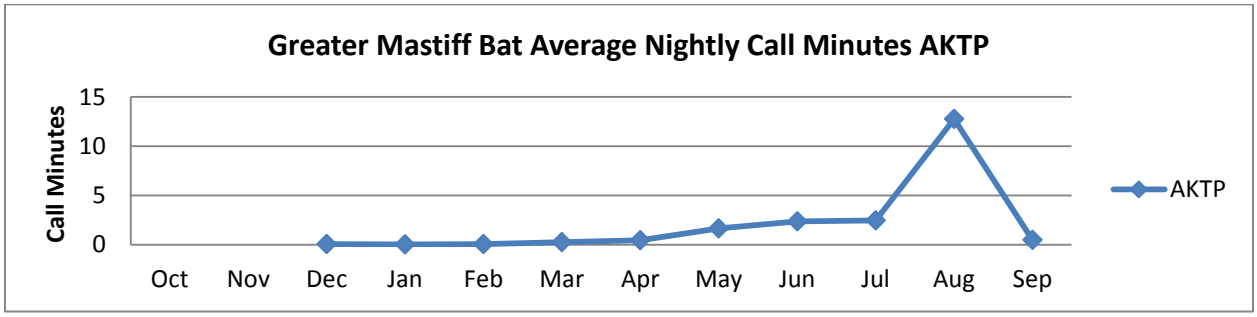
PALE TOWNSEND'S BIG-EARED BAT

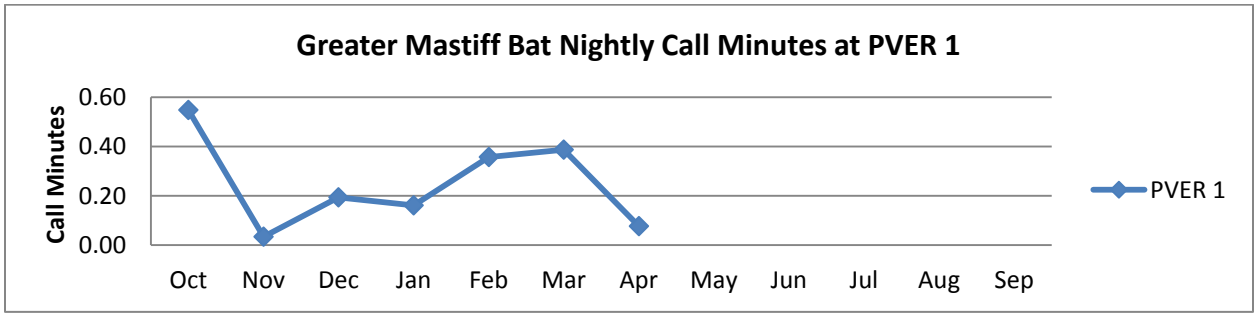
Only one graph is reported for the pale Townsend's big-eared bat because call numbers were low and sporadic across stations.

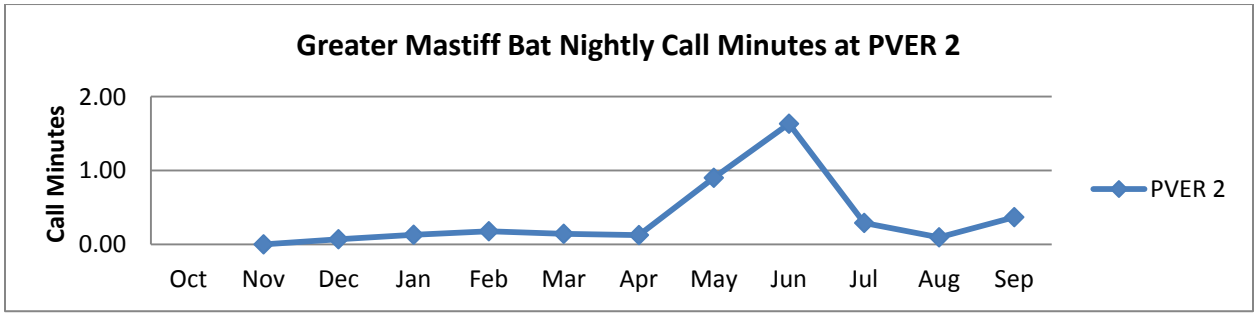


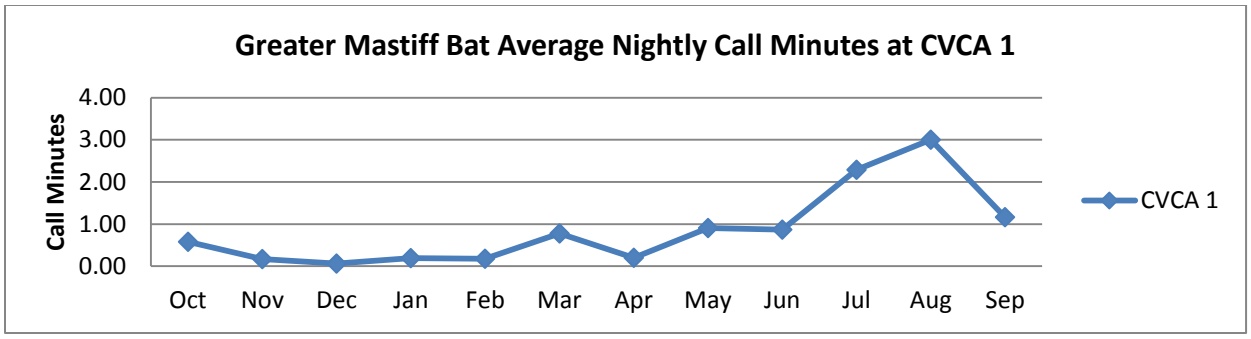
GREATER MASTIFF BAT

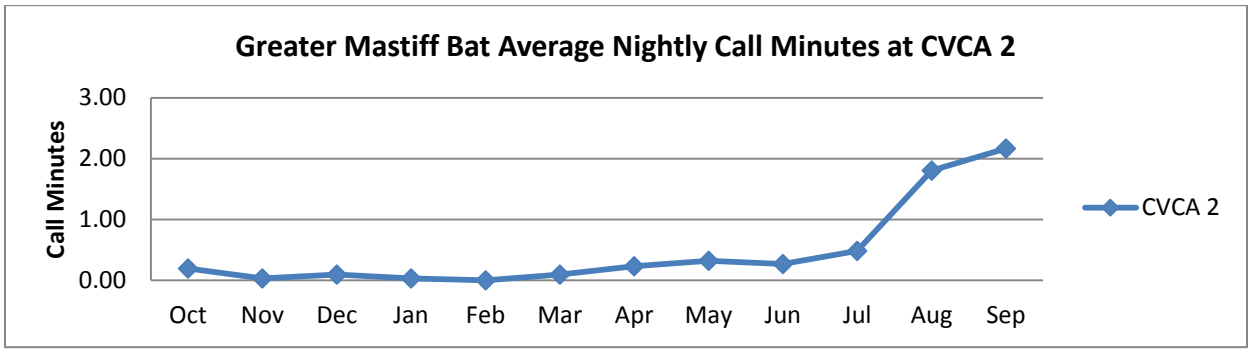


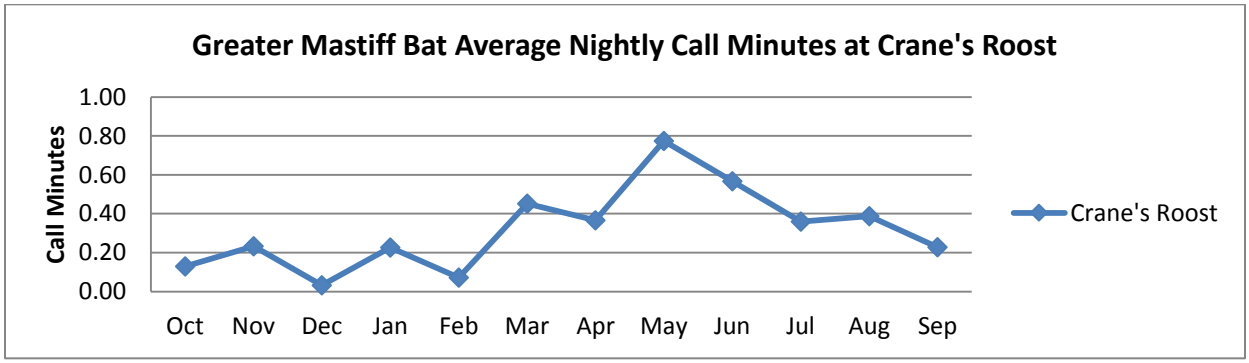


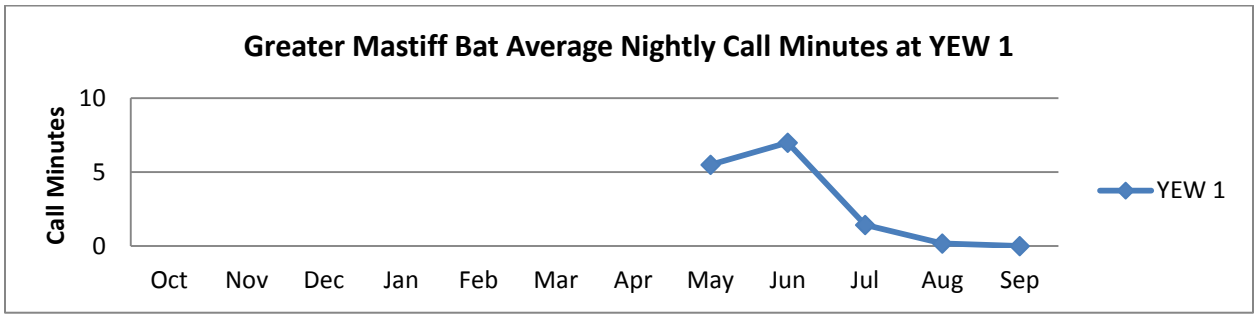


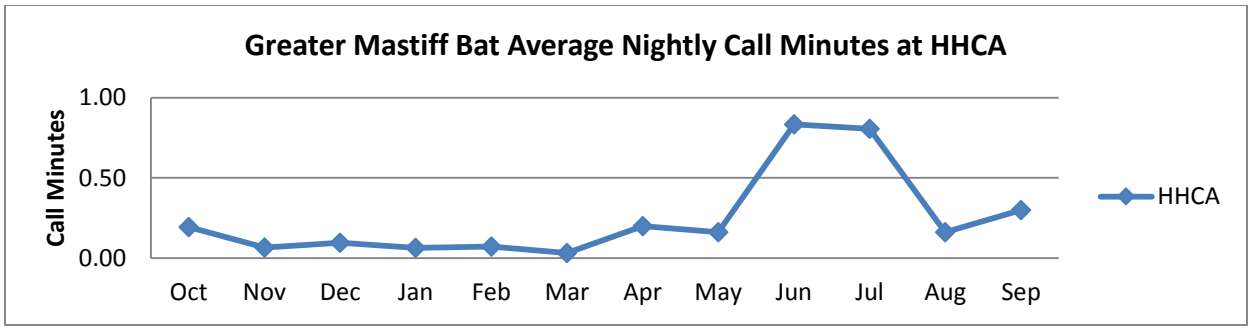


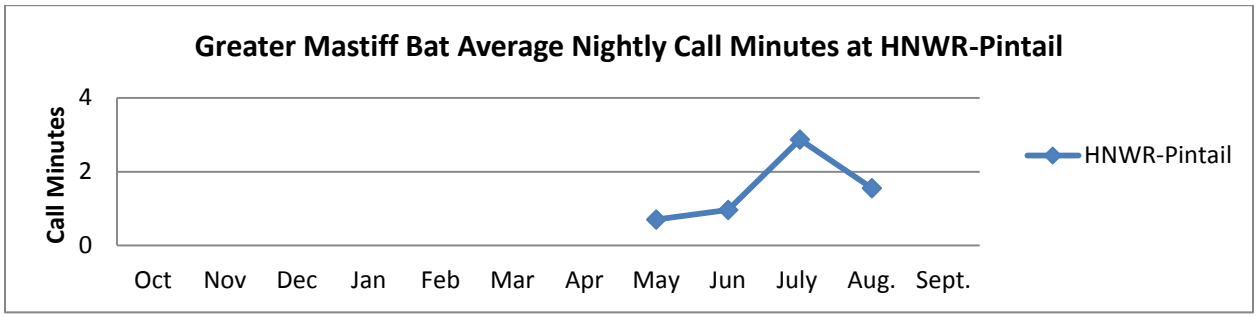

Greater Mastiff Bat Average Nightly Call Minutes at CVCA 1
Call Minutes
4.00
3.00
2.00
1.00
0.00
Oct
Nov
Dec
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
CVCA 1

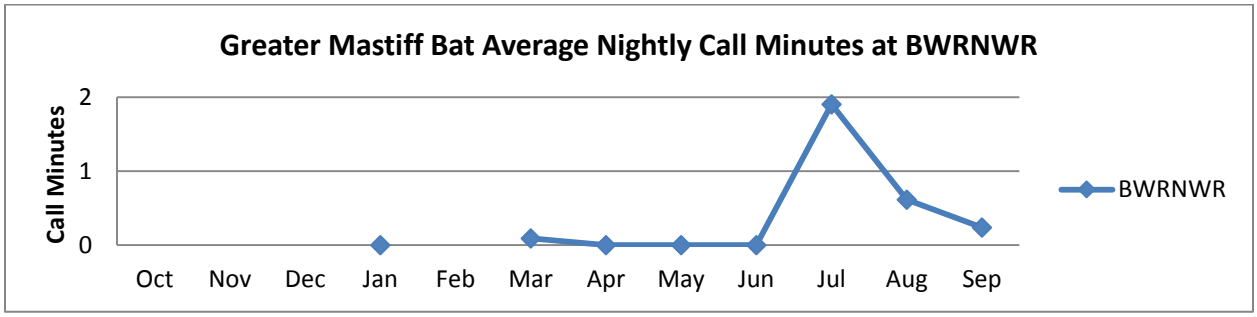

Greater Mastiff Bat Average Nightly Call Minutes at CVCA 2
Call Minutes
3.00
2.00
1.00
0.00
Oct
Nov
Dec
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
CVCA 2

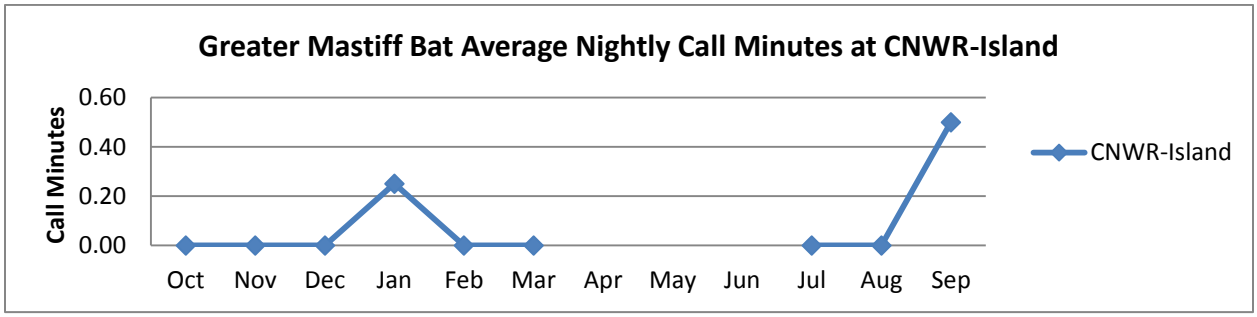

Greater Mastiff Bat Average Nightly Call Minutes at Crane's Roost
Call Minutes
1.00
0.80
0.60
0.40
0.20
0.00
Oct
Nov
Dec
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Crane's Roost

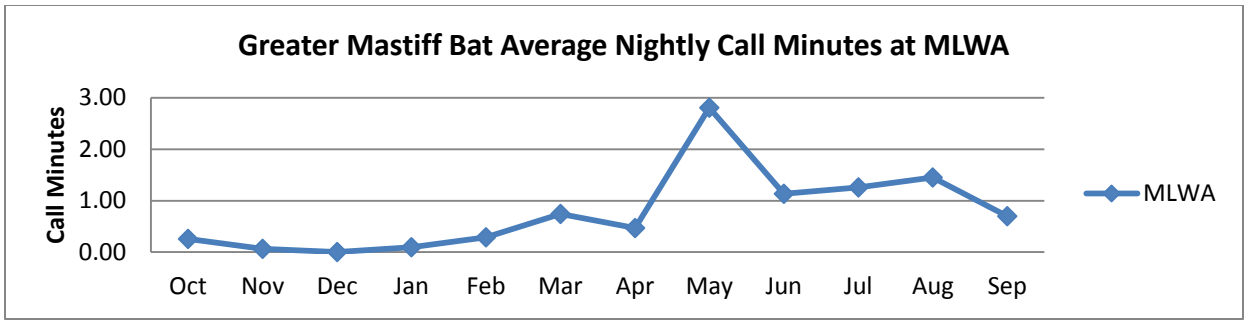

Greater Mastiff Bat Average Nightly Call Minutes at YEW 1
Call Minutes
10
5
0
Oct
Nov
Dec
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
YEW 1


Greater Mastiff Bat Average Nightly Call Minutes at HHCA
Call Minutes
1.00
0.50
0.00
Oct
Nov
Dec
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
HHCA

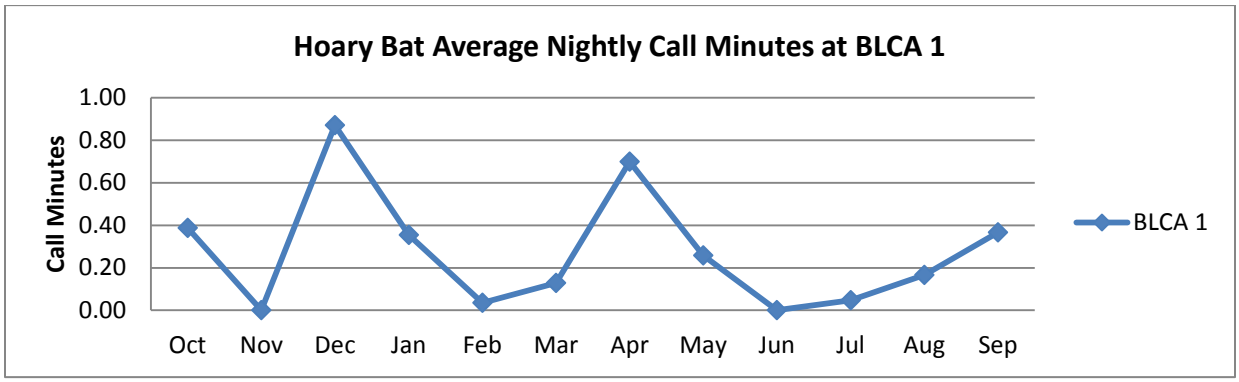

Greater Mastiff Bat Average Nightly Call Minutes at HNWR-Pintail
Call Minutes
4
2
0
Oct
Nov
Dec
Jan
Feb
Mar
Apr
May
Jun
July
Aug.
Sept.
HNWR-Pintail

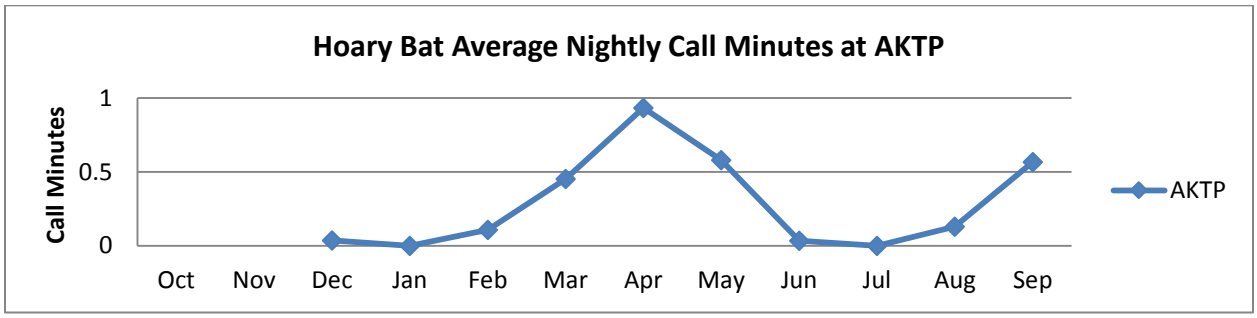

Greater Mastiff Bat Average Nightly Call Minutes at BWRNWR
Call Minutes
2
1
0
Oct
Nov
Dec
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
BWRNWR

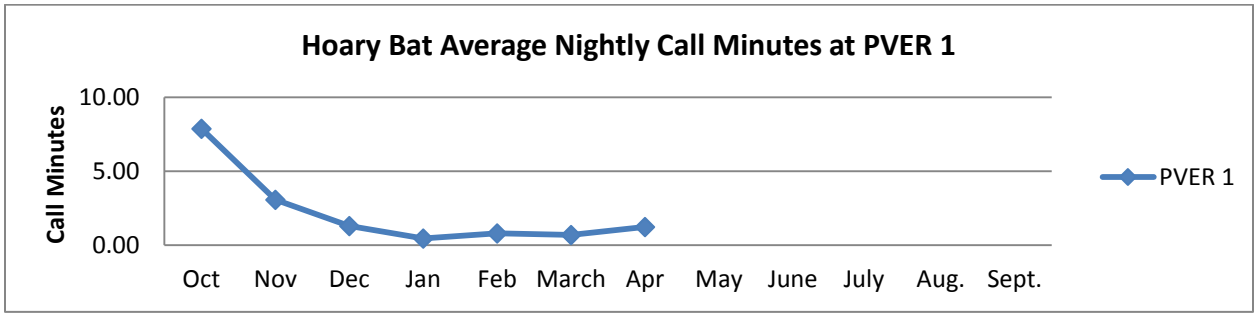

Greater Mastiff Bat Average Nightly Call Minutes at CNWR-Island
Call Minutes
0.60
0.40
0.20
0.00
Oct
Nov
Dec
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
CNWR-Island

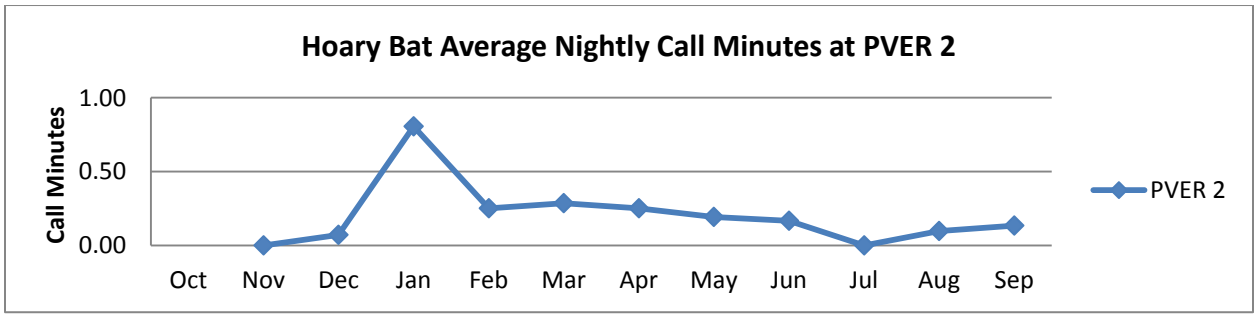

Greater Mastiff Bat Average Nightly Call Minutes at MLWA
Call Minutes
3.00
2.00
1.00
0.00
Oct
Nov
Dec
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
MLWA

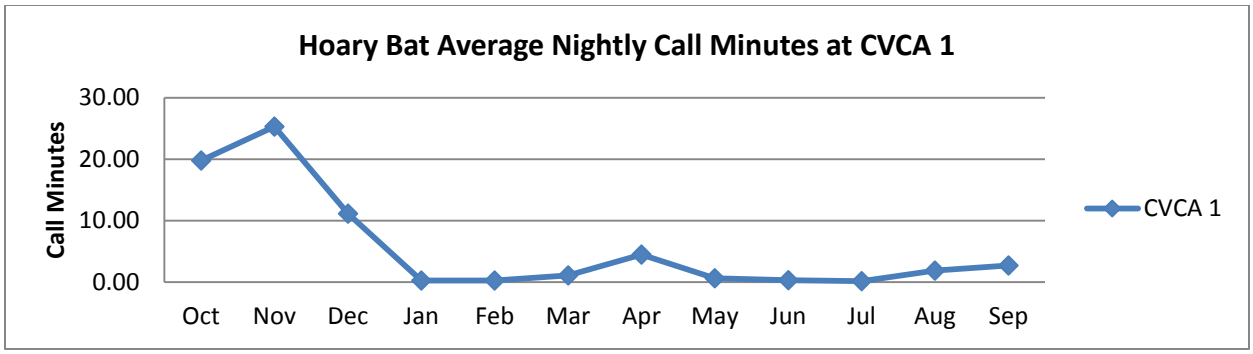
HOARY BAT

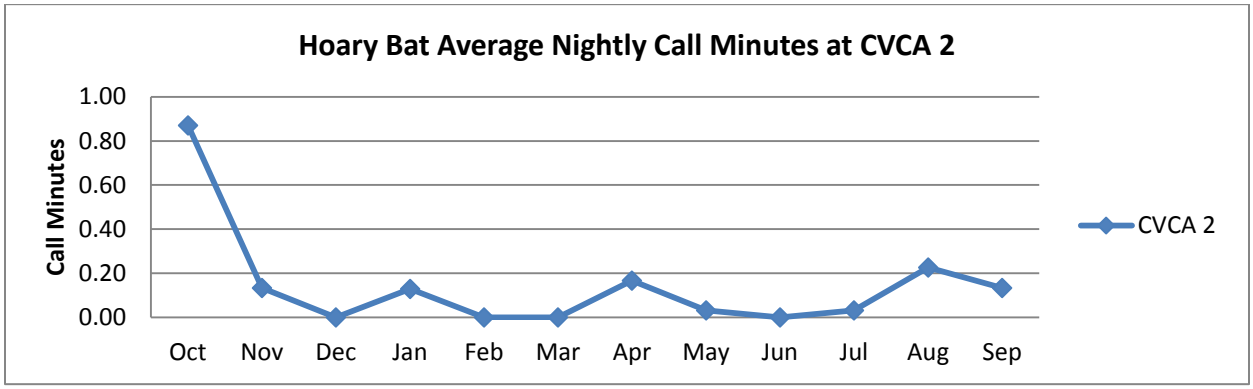

Hoary Bat Average Nightly Call Minutes at BLCA 1
Call Minutes
1.00
0.80
0.60
0.40
0.20
0.00
Oct
Nov
Dec
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
BLCA 1

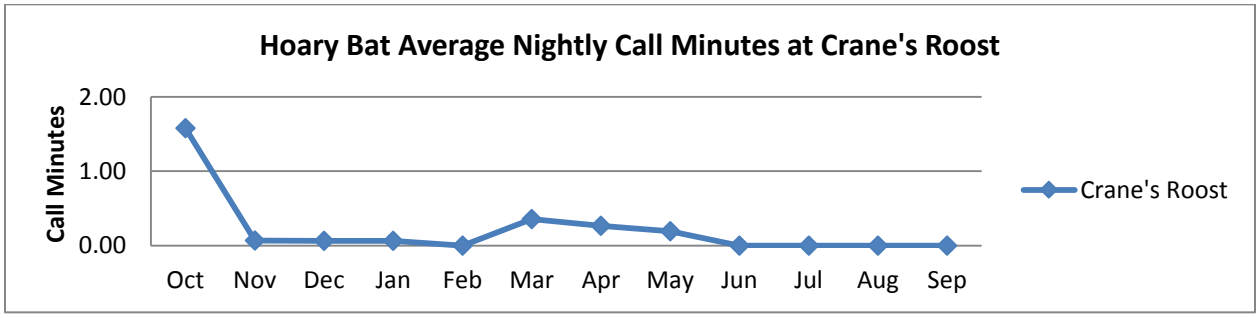

Hoary Bat Average Nightly Call Minutes at AKTP
Call Minutes
1
0.5
0
Oct
Nov
Dec
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
AKTP

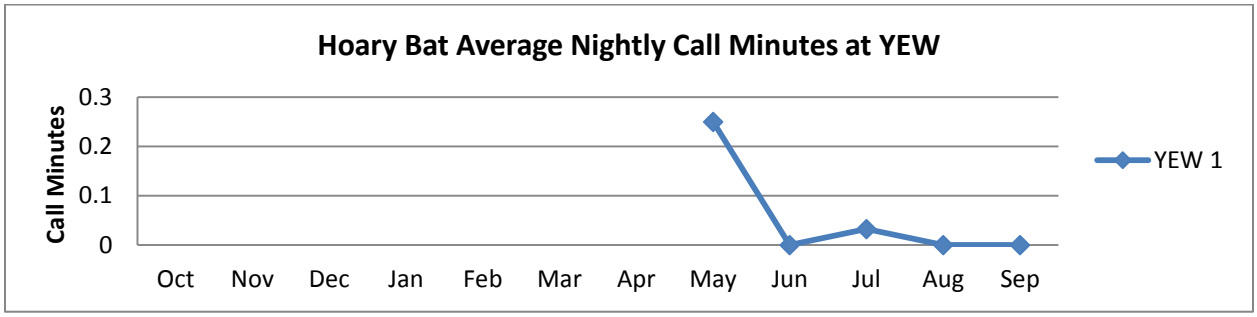

Hoary Bat Average Nightly Call Minutes at PVER 1
Call Minutes
10.00
5.00
0.00
Oct
Nov
Dec
Jan
Feb
March
Apr
May
June
July
Aug.
Sept.
PVER 1

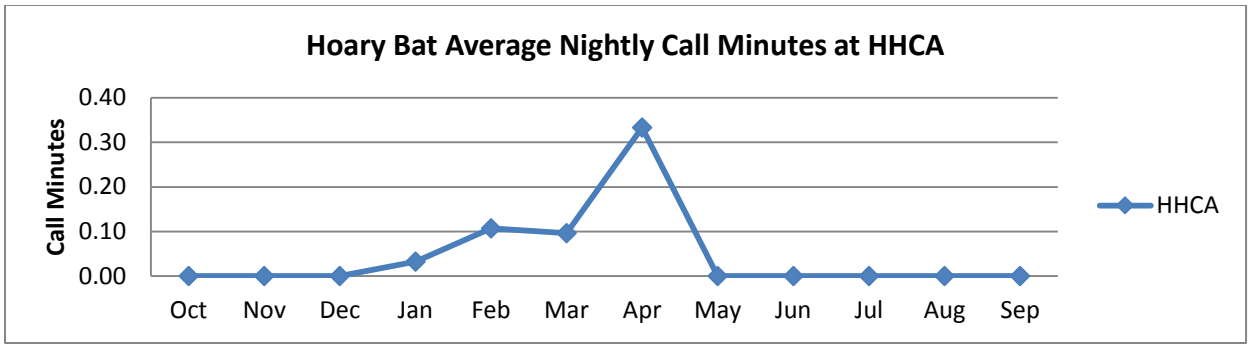

Hoary Bat Average Nightly Call Minutes at PVER 2
Call Minutes
1.00
0.50
0.00
Oct
Nov
Dec
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
PVER 2

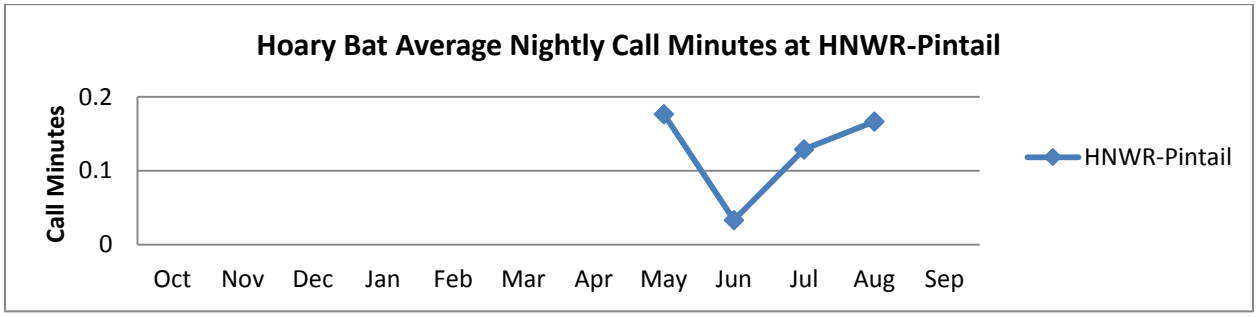

Hoary Bat Average Nightly Call Minutes at CVCA 1
Call Minutes
30.00
20.00
10.00
0.00
Oct
Nov
Dec
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
CVCA 1

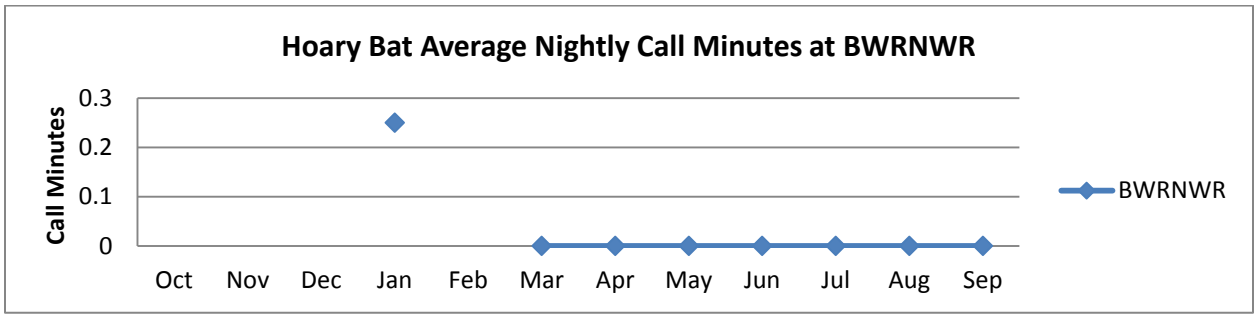

Hoary Bat Average Nightly Call Minutes at CVCA 2
Call Minutes
1.00
0.80
0.60
0.40
0.20
0.00
Oct
Nov
Dec
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
CVCA 2

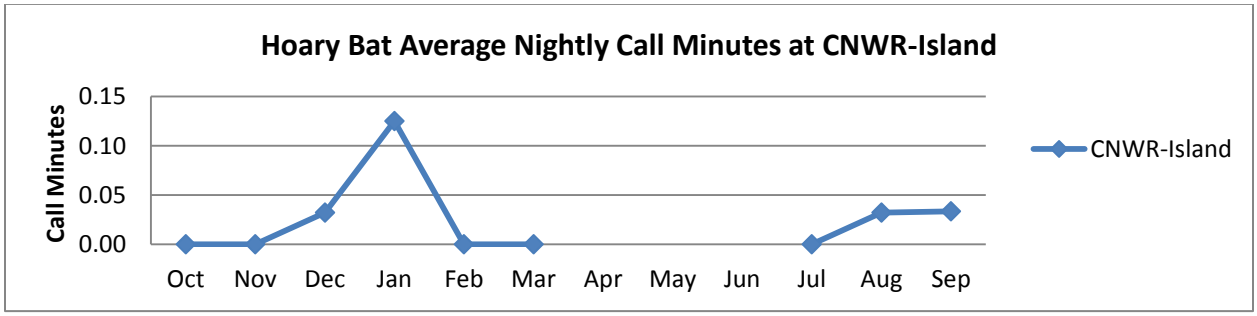

Hoary Bat Average Nightly Call Minutes at Crane's Roost
Call Minutes
2.00
1.00
0.00
Oct
Nov
Dec
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Crane's Roost

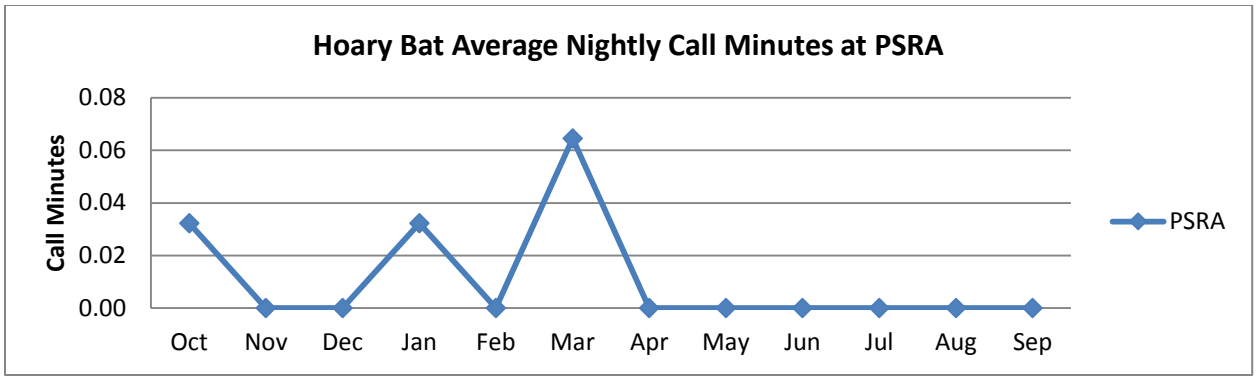

Hoary Bat Average Nightly Call Minutes at YEW
Call Minutes
0.3
0.2
0.1
0
Oct
Nov
Dec
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
YEW 1

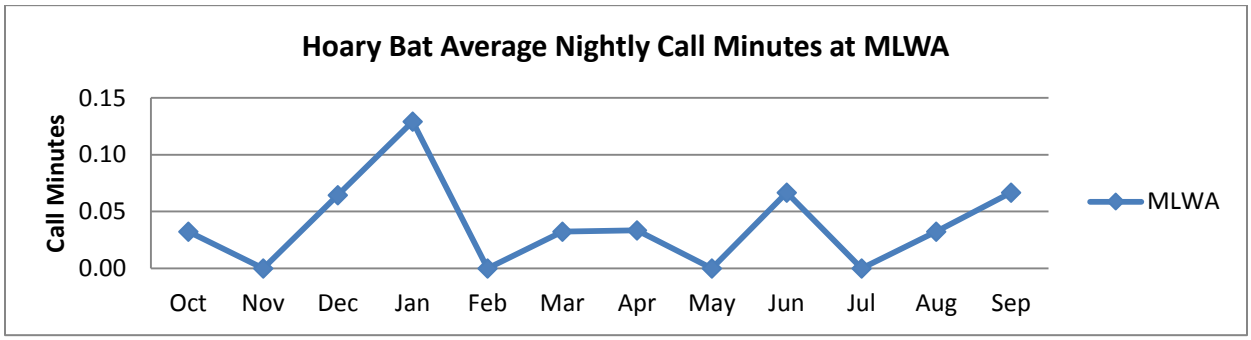

Hoary Bat Average Nightly Call Minutes at HHCA
Call Minutes
0.40
0.30
0.20
0.10
0.00
Oct
Nov
Dec
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
HHCA


Hoary Bat Average Nightly Call Minutes at HNWR-Pintail
Call Minutes
0.2
0.1
0
Oct
Nov
Dec
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
HNWR-Pintail

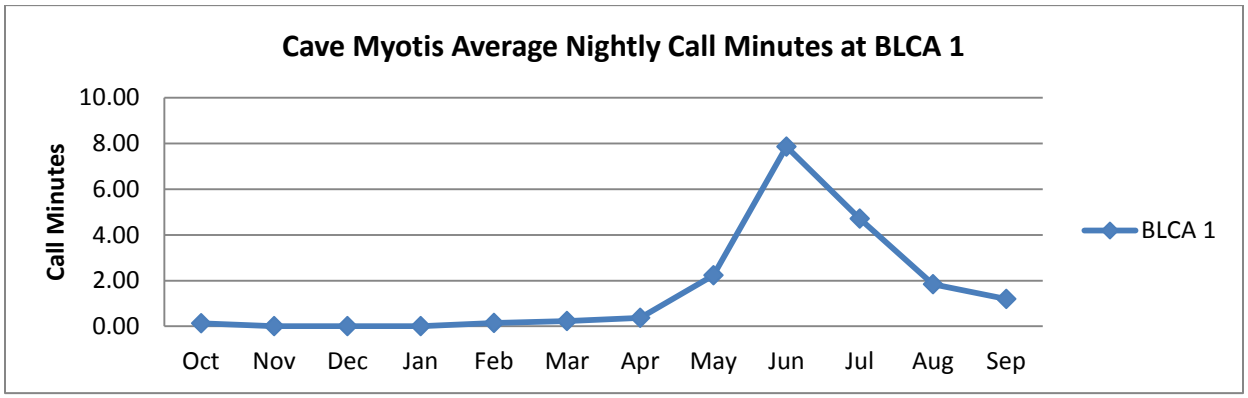

Hoary Bat Average Nightly Call Minutes at BWRNWR
Call Minutes
0.3
0.2
0.1
0
Oct
Nov
Dec
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
BWRNWR

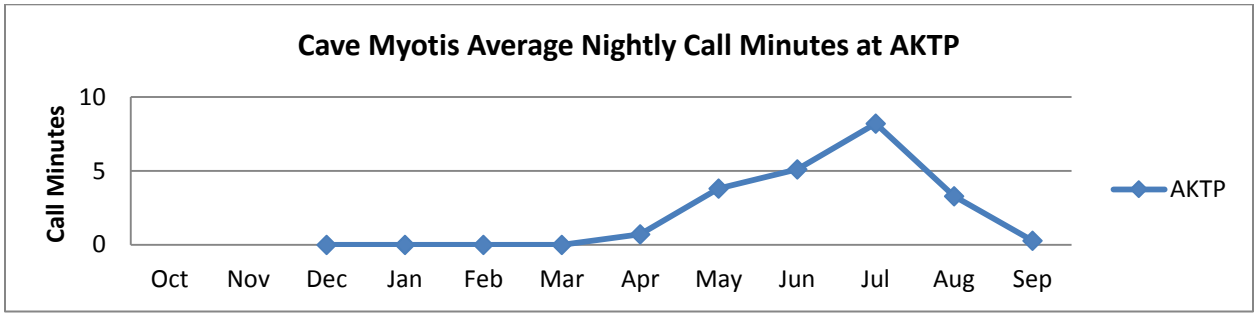

Hoary Bat Average Nightly Call Minutes at CNWR-Island
Call Minutes
0.15
0.10
0.05
0.00
Oct
Nov
Dec
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
CNWR-Island

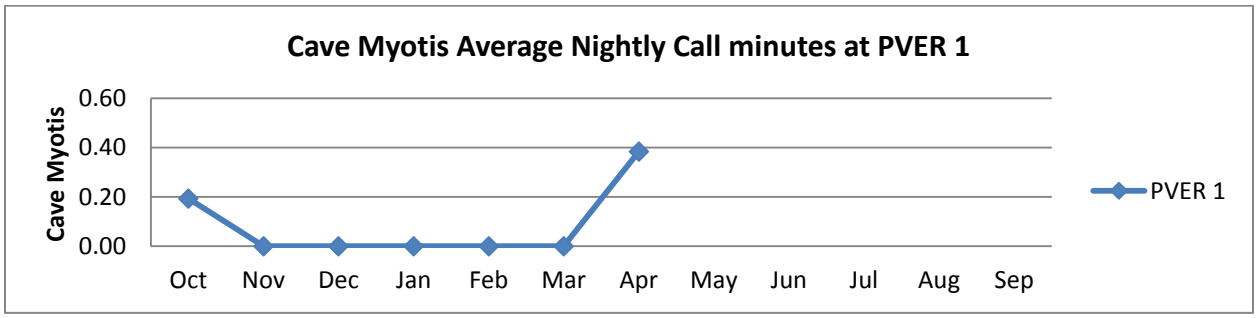

Hoary Bat Average Nightly Call Minutes at PSRA
Call Minutes
0.08
0.06
0.04
0.02
0.00
Oct
Nov
Dec
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
PSRA

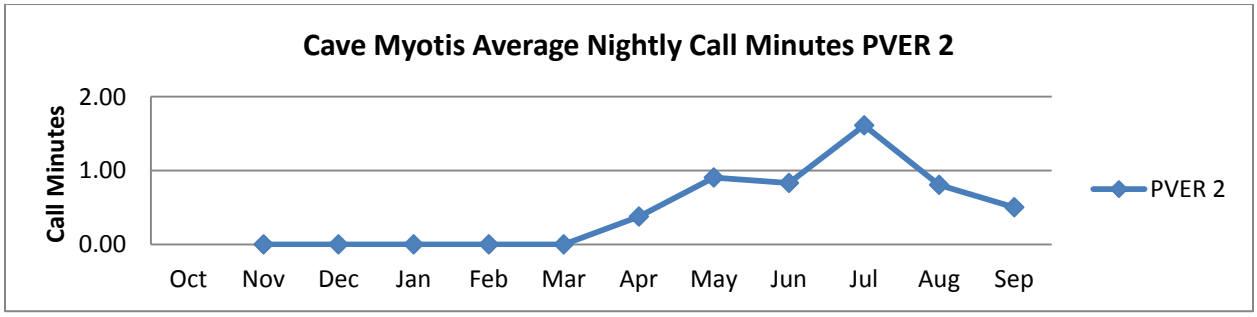

Hoary Bat Average Nightly Call Minutes at MLWA
Call Minutes
0.15
0.10
0.05
0.00
Oct
Nov
Dec
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
MLWA

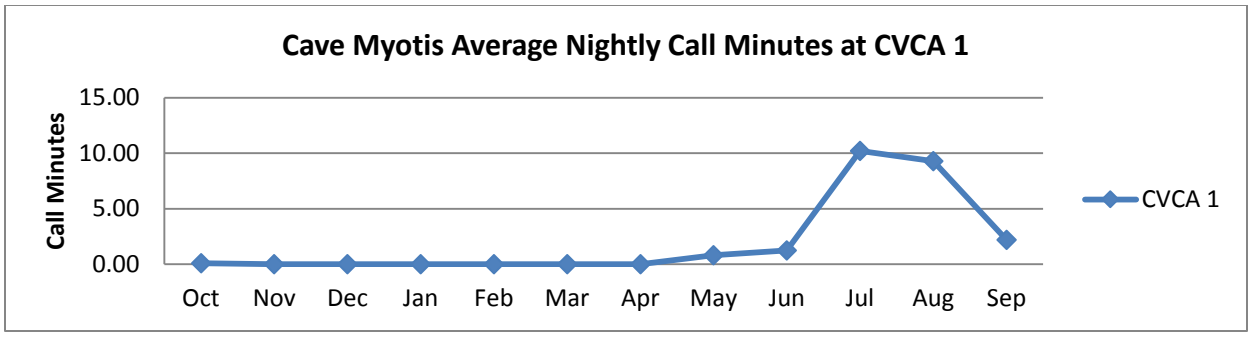
CAVE MYOTIS

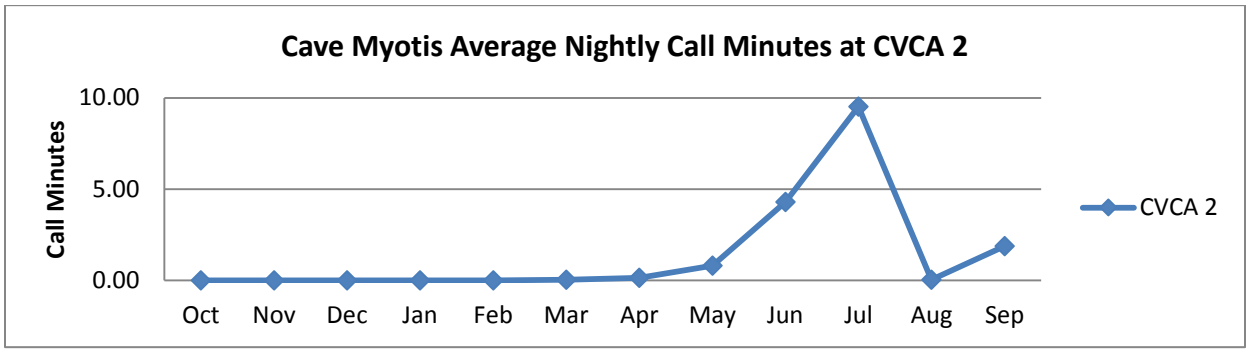

Cave Myotis Average Nightly Call Minutes at BLCA 1
Call Minutes
10.00
8.00
6.00
4.00
2.00
0.00
Oct
Nov
Dec
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
BLCA 1

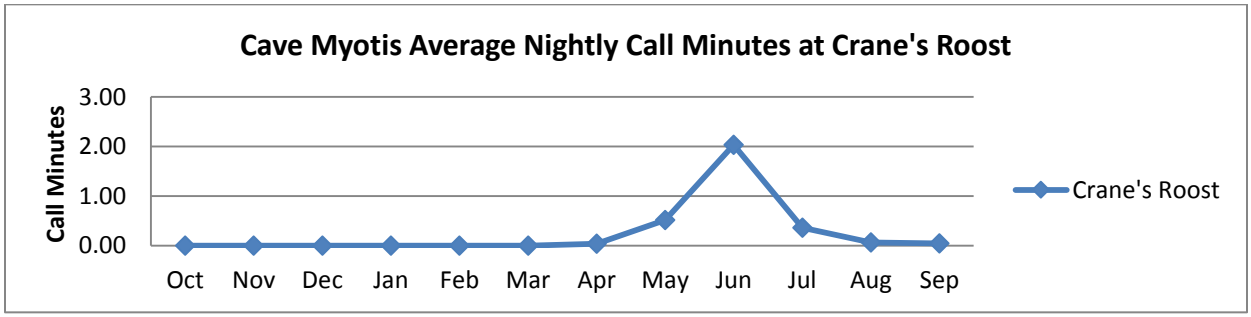

Cave Myotis Average Nightly Call Minutes at AKTP
Call Minutes
10
5
0
Oct
Nov
Dec
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
AKTP

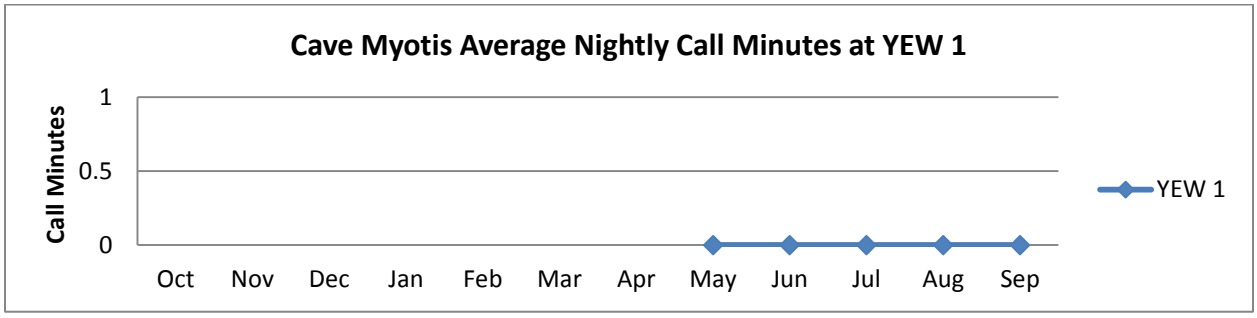

Cave Myotis Average Nightly Call minutes at PVER 1
Cave Myotis
0.60
0.40
0.20
0.00
Oct
Nov
Dec
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
PVER 1

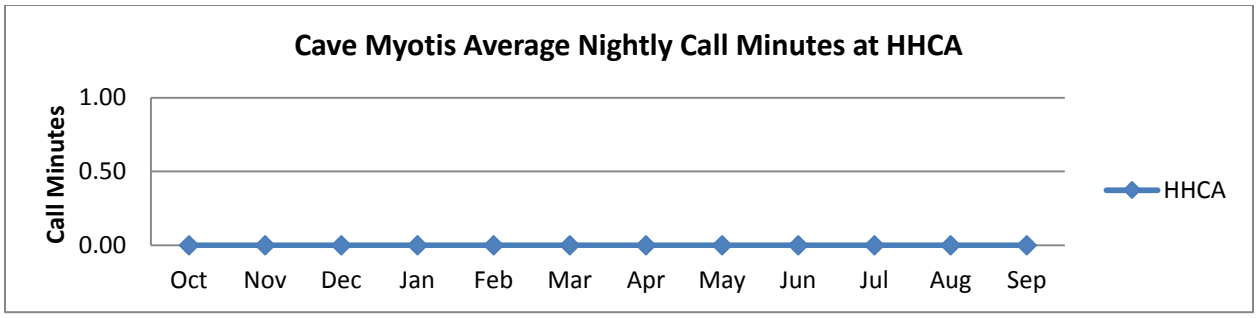

Cave Myotis Average Nightly Call Minutes PVER 2
Call Minutes
2.00
1.00
0.00
Oct
Nov
Dec
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
PVER 2

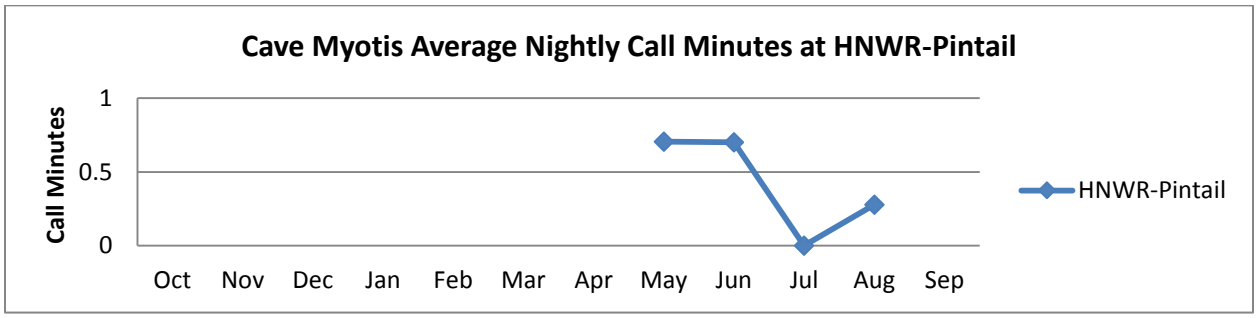

Cave Myotis Average Nightly Call Minutes at CVCA 1
Call Minutes
15.00
10.00
5.00
0.00
Oct
Nov
Dec
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
CVCA 1

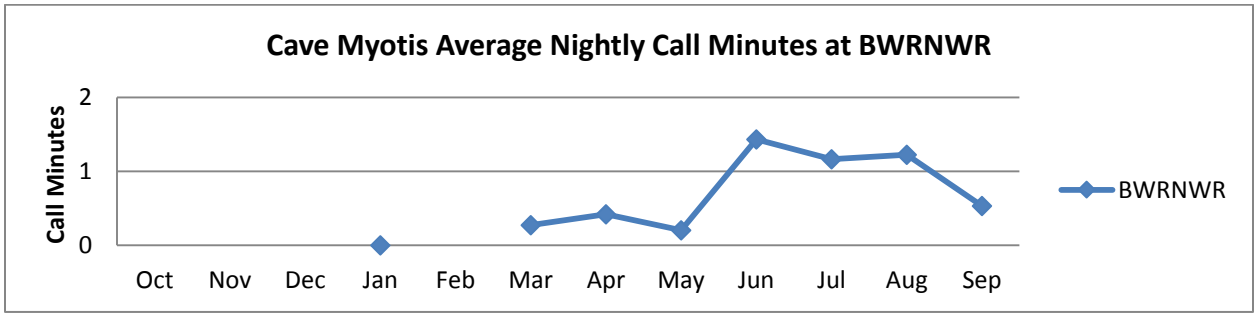

Cave Myotis Average Nightly Call Minutes at CVCA 2
Call Minutes
10.00
5.00
0.00
Oct
Nov
Dec
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
CVCA 2

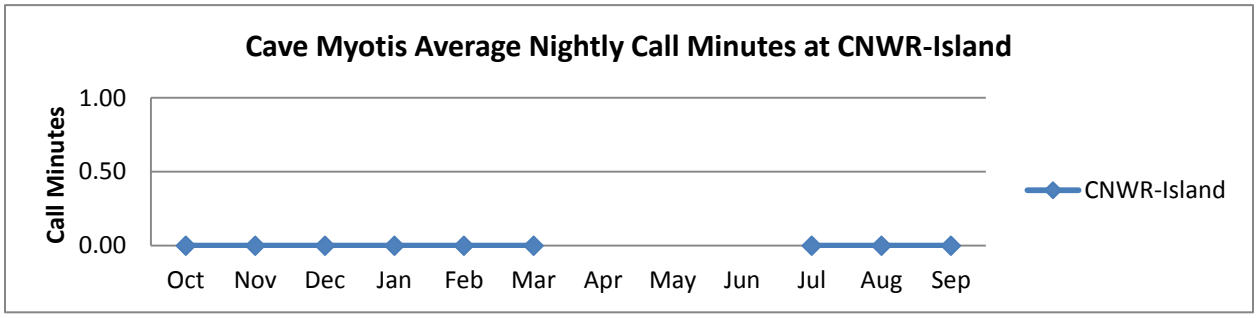

Cave Myotis Average Nightly Call Minutes at Crane's Roost
Call Minutes
3.00
2.00
1.00
0.00
Oct
Nov
Dec
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Crane's Roost

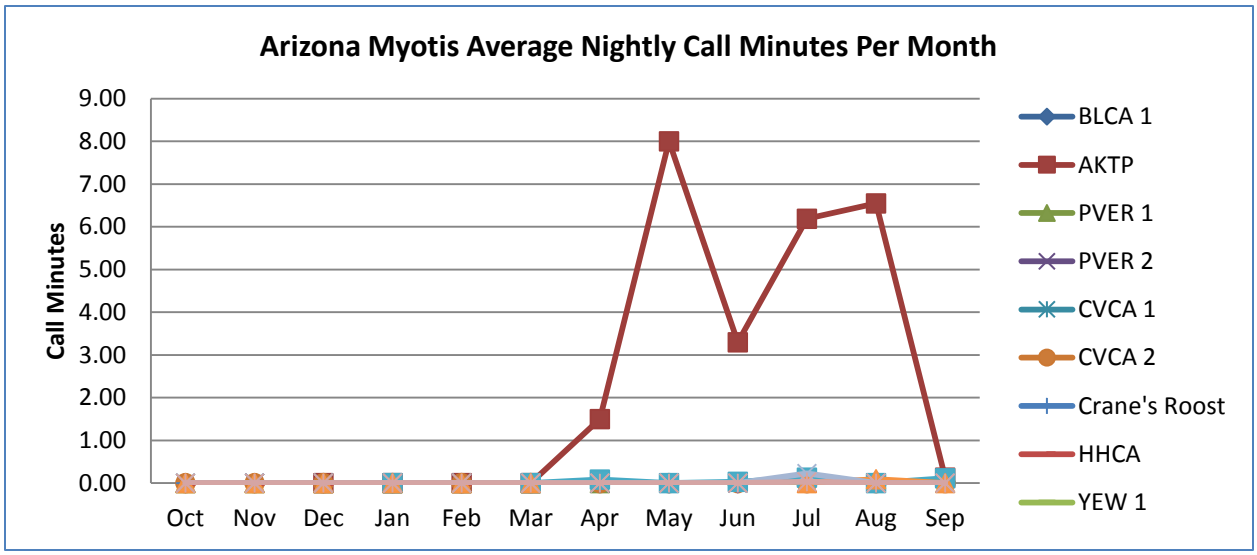

Cave Myotis Average Nightly Call Minutes at YEW 1
Call Minutes
1
0.5
0
Oct
Nov
Dec
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
YEW 1


Cave Myotis Average Nightly Call Minutes at HHCA
Call Minutes
1.00
0.50
0.00
Oct
Nov
Dec
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
HHCA


Cave Myotis Average Nightly Call Minutes at HNWR-Pintail
Call Minutes
1
0.5
0
Oct
Nov
Dec
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
HNWR-Pintail


Cave Myotis Average Nightly Call Minutes at BWRNWR
Call Minutes
2
1
0
Oct
Nov
Dec
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
BWRNWR


Cave Myotis Average Nightly Call Minutes at CNWR-Island
Call Minutes
1.00
0.50
0.00
Oct
Nov
Dec
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
CNWR-Island

ARIZONA MYOTIS

Only one graph for the Arizona myotis is reported because the call numbers were low and sporadic across stations, with the exception of the Colorado River Indian Tribes' 'Ahakhav Tribal Preserve (AKTP).