# Lower Colorado River Multi-Species Conservation Program

*Balancing Resource Use and Conservation*

# 2017 System-Wide Acoustic Monitoring of LCR MSCP Bat Species

Work conducted under LCR MSCP
Work Task D9

U.S. DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION

July 2018

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# Lower Colorado River Multi-Species Conservation Program

## 2017 System-Wide Acoustic Monitoring of LCR MSCP Bat Species

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**Multi-Species Conservation Program**
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# ACRONYMS AND ABBREVIATIONS

| | |
|---|---|
| BWRNWR 1 | Bill Williams River National Wildlife Refuge acoustic station #1 |
| CNWR-Island | Cibola National Wildlife Refuge-Island Unit acoustic station |
| e.g. | *exempli gratia* (for example) |
| 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 1 | Mittry Lake Wildlife Area acoustic station #1 |
| PSRA 1 | Picacho State Recreation Area acoustic station #1 |

## Symbols

| | |
|---|---|
| % | percent |
| ™ | trademark |

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# ABSTRACT

Acoustic bat call data were analyzed from five acoustic monitoring stations (Anabat™) along the lower Colorado River from June 1 to August 31, 2010, through 2017. These stations are located within system-wide monitoring sites that consist of existing habitat along the lower Colorado River, with vegetation species composition, area, and canopy height varying across sites. The calls of four bat species were analyzed: the western red bat (*Lasiurus blossevilli*), western yellow bat (*Lasiurus xanthinus*), California leaf-nosed bat (*Macrotus californicus*), and the pale Townsend's big-eared bat (*Corynorhinus townsendii pallescens* = *Plecotus townsendii pallescens* = *C. townsendii townsendii*). Sites and species were evaluated based on greatest average nightly call minutes and daily occupancy. Average nightly call minutes and occupancy varied widely among sites, years, and species. Western red and yellow bats were recorded with the greatest average nightly call minutes at the Mittry Lake Wildlife Area, and California leaf-nosed bats were recorded with the greatest average nightly call minutes at the Picacho State Recreation Area. Pale Townsend's big-eared bat calls were not recorded during the 2017 sampling season, likely due to the quiet nature of their calls. Therefore, it is unknown if pale Townsend's big-eared bats were present near the acoustic monitoring stations.

# INTRODUCTION

This document is a summary of acoustic bat call data collected from five acoustic monitoring stations (Anabat™) along the lower Colorado River (LCR). The purpose of this project is to monitor the presence of bat species 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. This program works toward the recovery of listed species through habitat and species conservation and reduces the likelihood of additional species being listed under the Endangered Species Act.

Bats have been proposed as indicators of the integrity of natural communities and are 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 activity magnitude or diversity may indicate a decline in habitat 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 activity. 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 activities warrant management efforts.

This project targets the presence of the western red bat (*Lasiurus blossevillii*), western yellow bat (*Lasiurus xanthinus*), California leaf-nosed bat (*Macrotus californicus*), and the pale Townsend's big-eared bat (*Corynorhinus townsendii pallescens = Plecotus townsendii pallescens = C. townsendii townsendii*), within system-wide monitoring sites. Genetic analyses on the pale Townsend's big-eared bat indicate that the LCR is likely in the range of the Pacific Townsend's big-eared bat (*C. townsendii townsendii)* rather than the pale Townsend's big-eared bat (Piaggio and Perkins 2005). Bats recorded along the LCR will be referred to as the pale Townsend's big-eared bat in this report, as the name change has not yet been verified by the U.S. Fish and Wildlife Service. 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 (average nightly call minutes and proportion of nights occupied) from the five permanent acoustic monitoring stations located in riparian habitat along the LCR that have not been restored by the LCR MSCP (system-wide monitoring sites) for future comparison with these trends at LCR MSCP conservation areas.

# STUDY AREA

The study area consists of five Anabat™ stations located along the LCR from the Havasu National Wildlife Refuge in the north to the Mittry Lake Wildlife Area located near Yuma, Arizona (see figure 1). System-wide monitoring sites were 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 was no active management or irrigation of the site. The extent of the canopy cover and overall composition varies across sites. The system-wide monitoring stations were located at Pintail Slough in the Havasu National Wildlife Refuge (HNWR-Pintail), Bill Williams River National Wildlife Refuge acoustic station # 1 (BWRNWR 1), the Cibola National Wildlife Refuge-Island Unit (CNWR-Island), Picacho State Recreation Area acoustic station #1 (PSRA 1), and Mittry Lake Wildlife Area acoustic station # 1 (MLWA 1) (table 1; figure 1).

Table 1.—Station name, acronym, treatment, number of nights recorded during the sampling period, and year of station deployment

| Station | Station acronym | Nights recorded, 2017 | Year deployed |
|---|---|---|---|
| Havasu National Wildlife Refuge-Pintail Slough | HNWR-Pintail | 92 | 2014 (May) |
| Bill Williams River National Wildlife Refuge | BWRNWR 1 | 75 | 2008 |
| Cibola National Wildlife Refuge-Island Unit | CNWR-Island | 92 | 2008 |
| Picacho State Recreation Area | PSRA 1 | 92 | 2008 |
| Mittry Lake Wildlife Area | MLWA 1 | 88 | 2008 |

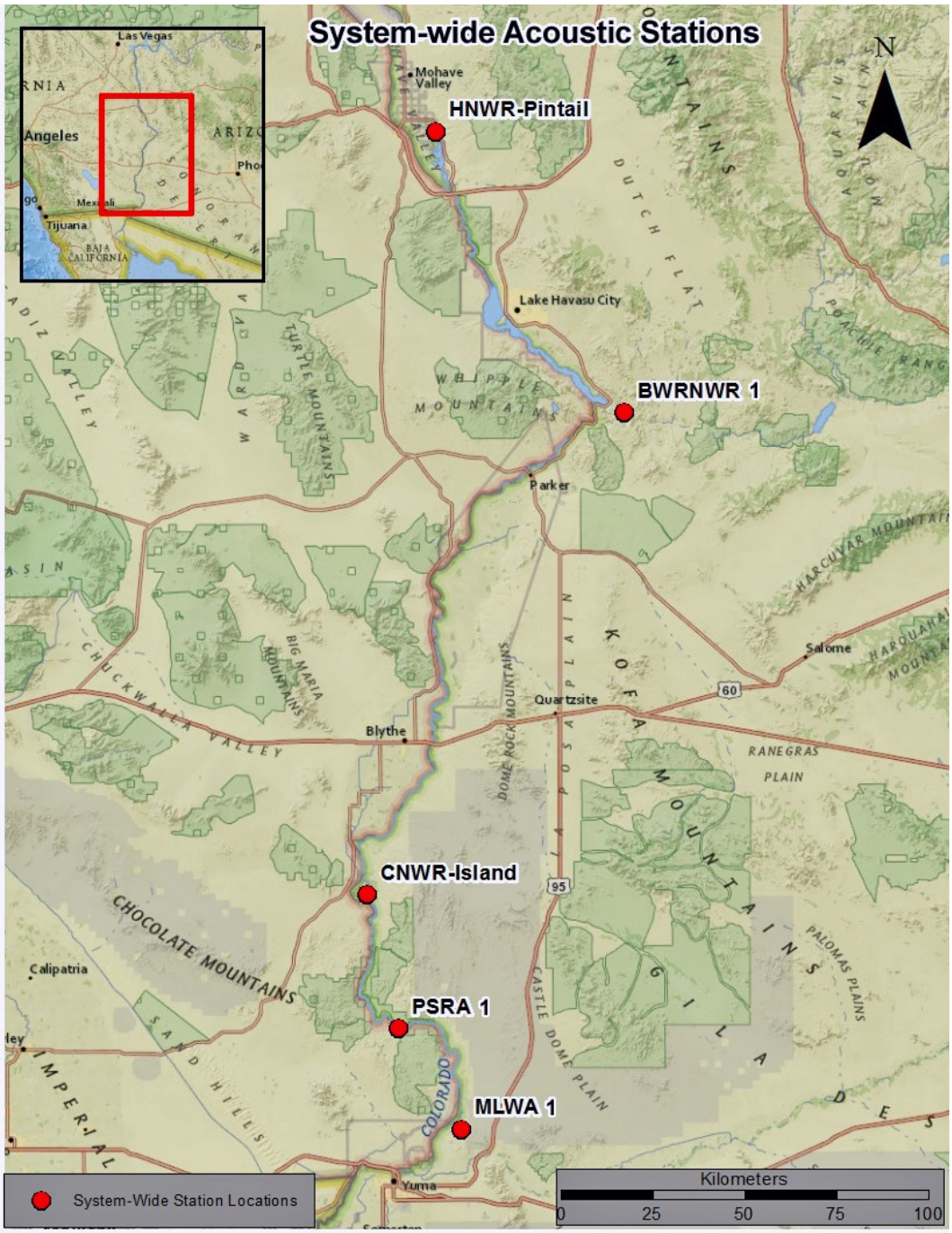


**Figure 1.—Study area system-wide acoustic stations.**

# METHODS

Data were summarized from long-term Anabat™ detectors at five locations along the LCR (see figure 1). These stations were deployed in system-wide monitoring sites in 2008, with HNWR-Pintail added in May 2014 (see table 1). These five stations provide a temporal and spatial estimate of bat activity (measured

with average nightly call minutes and daily occupancy). They consist 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. Compact flashcards at the stations accumulated data at the rate of about 12 megabytes per night during periods of high bat detections (about 1,500 calls per night), and at that rate, they can store 4 months of data on a 1-gigabyte SD card. In order to determine summer use, each station was deployed from June 1 to August 31. The stations were surveyed and data downloaded during June, July, and August, with an additional trip in May to address any maintenance issues.

During the 2017 sampling session, equipment malfunctions resulted in periods of data loss. A technical error at MLWA 1 led to no data being recorded from June 1 through 4, 2017. The CF card at BWRNWR 1 filled to capacity with insect noise; therefore, no data were recorded from August 1 through August 17, 2017. CNWR-Island, PSRA 1 and HNWR-Pintail operated continuously and recorded nightly data from June 1 through August 31, 2017.

Acoustic bat calls were quantified across four LCR MSCP species at each station: western red bats, western yellow bats, California leaf-nosed bats, and pale Townsend's big-eared bats. Acoustic bat calls were recorded nightly from sunset to sunrise, and the files were processed using filters and methods developed for LCR MSCP acoustic monitoring projects (Broderick 2008). Using Analook software, a series of acoustic filters were created for the focal bat species. The analysis was based on first running files through an "All bats" filter to eliminate any files with significant background and insect noise. Then, the remaining calls were run through species-specific filters and analyzed individually to sort out species with similar call envelopes to the four focal species. Western red bat calls were then 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 calls ending between 52–80 kilohertz. The high-frequency filters were applied after discussions with Bureau of Reclamation biologists (S. Broderick and A. Calvert 2011, personal communication) revealed that western red bat calls at higher frequencies along the LCR had been recorded. 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). They 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 Bureau of Reclamation biologists (S. Broderick and A. Calvert 2011, personal communication) and reference calls from across the Southwestern United States. All calls that were flagged as a species of interest were visually verified, and only those calls that fit all of the call parameters for the given species and that could confidently be identified are presented.

Call minutes were used in order to reduce bias in estimating bat activity at Anabat™ stations. A call minute is 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). This call minutes index reduced 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 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. Data were also analyzed using daily occupancy and 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 is 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 by proportion of 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. As such, the comparisons among stations represent a qualitative measure of activity and are not to be extrapolated to evaluate population dynamics or occupancy trends. These methods provide a simple, standardized way of comparing activity across the stations and species. In this document, a detailed analysis of data collected during the 2017 sampling season is presented as well as a comparison of the 2017 findings with those of the previous sampling years.

# RESULTS

## 2017 Acoustic Detections

### Western Red Bat

The greatest average nightly call minutes for western red bats were recorded at MLWA 1, with the greatest proportion of nights occupied also recorded at MLWA 1, followed by CNWR-Island and BWRNWR 1, PSRA 1, and HNWR-Pintail (table 2). The greatest average nightly call minutes were recorded at MLWA 1 in June, BWRNWR 1, PSRA 1 and MLWA 1 in July, and the BWRNWR 1 in August, with the greatest average nightly call minutes recorded at MLWA 1 (0.46 per night) (figure 2). The greatest proportion of nights occupied was recorded at MLWA 1 in June, PSRA 1 and MLWA 1 in July, and BWRNWR 1 in August, with the greatest occupancy recorded at MLWA 1 in June (35% of nights occupied) (figure 3).

Table 2.—Western red bat average nightly call minutes and nights occupied at system-wide monitoring sites, June 1 – August 31, 2017

| Station | Average nightly call minutes | Nights occupied | Proportion of nights occupied |
|---|---|---|---|
| HNWR-Pintail | 0.03 | 3 | 0.03 |
| BWRNWR 1 | 0.17 | 10 | 0.13 |
| CNWR-Island | 0.14 | 12 | 0.13 |
| PSRA 1 | 0.12 | 8 | 0.09 |
| MLWA 1 | 0.24 | 18 | 0.20 |

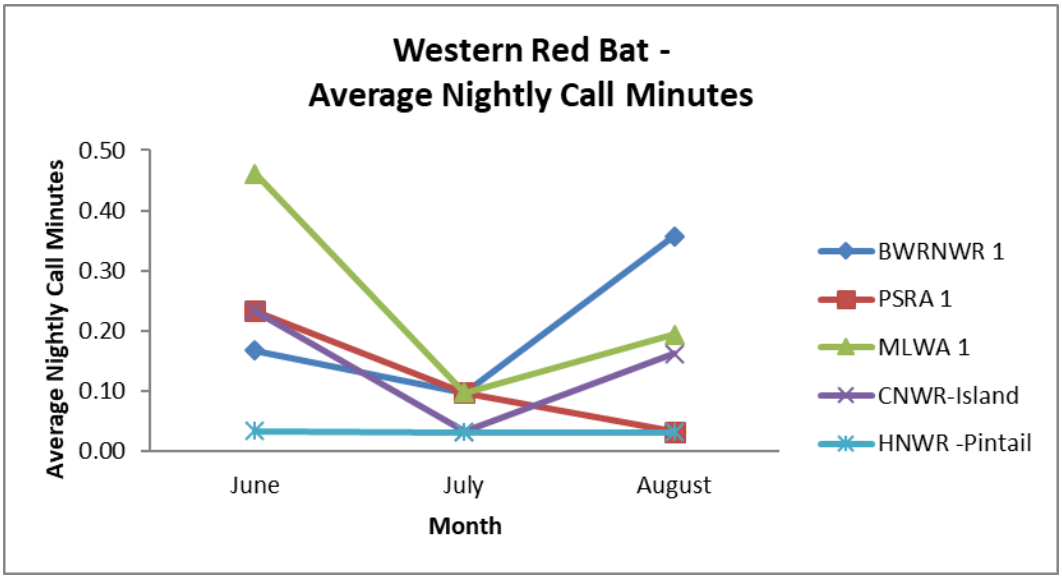


**Figure 2.—Western red bat average nightly call minutes.**

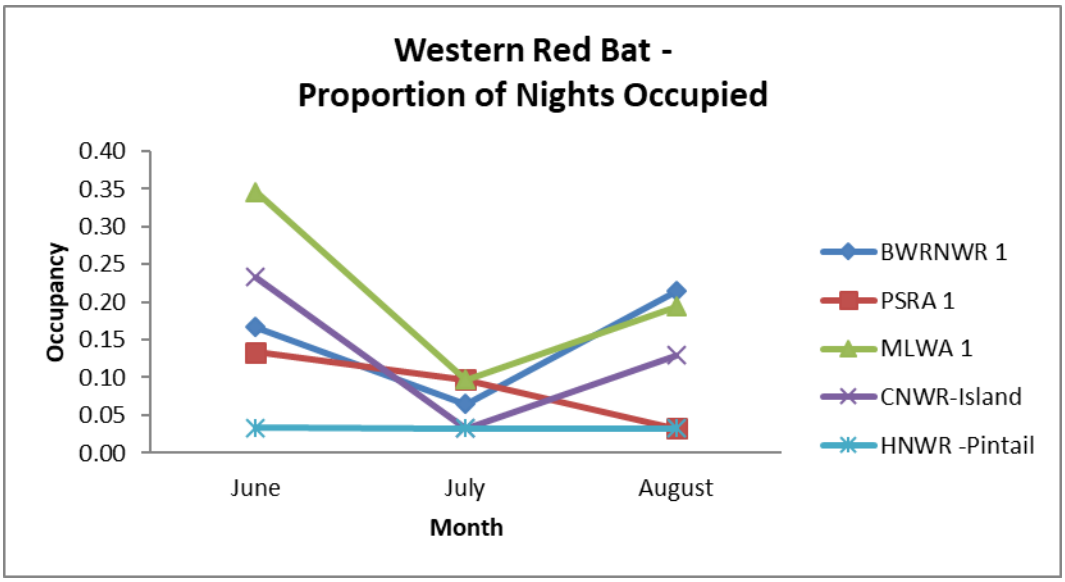


**Figure 3.—Western red bat proportion of nights occupied.**

## Western Yellow Bat

The greatest average nightly call minutes for western yellow bats were recorded at MLWA 1, with the greatest proportion of nights occupied also recorded at MLWA 1, followed by PSRA 1, HNWR-Pintail, and CNWR-Island (table 3). No western yellow bats were detected at BWRNWR 1. The greatest average nightly call minutes were recorded at CNWR-Island and PSRA 1 in June, MLWA 1 in July, and HNWR-Pintail in August, with the greatest average nightly call minutes recorded at MLWA 1 in July (0.13 per night) (figure 4). The greatest proportion of nights occupied was recorded at CNWR-Island and PSRA 1 in June, MLWA 1 in July, and HNWR-Pintail in August, with the greatest occupancy recorded at CNWR-Island and PSRA 1 in June (10% of nights occupied) (figure 5).

Table 3.—Western yellow bat average nightly call minutes and nights occupied at system-wide monitoring sites, June 1 – August 31, 2017

| Station | Average nightly call minutes | Nights occupied | Proportion of nights occupied |
|---|---|---|---|
| HNWR-Pintail | 0.03 | 3 | 0.03 |
| BWRNWR 1 | 0.00 | 0 | 0.00 |
| CNWR-Island | 0.03 | 3 | 0.03 |
| PSRA 1 | 0.04 | 4 | 0.04 |
| MLWA 1 | 0.07 | 5 | 0.06 |

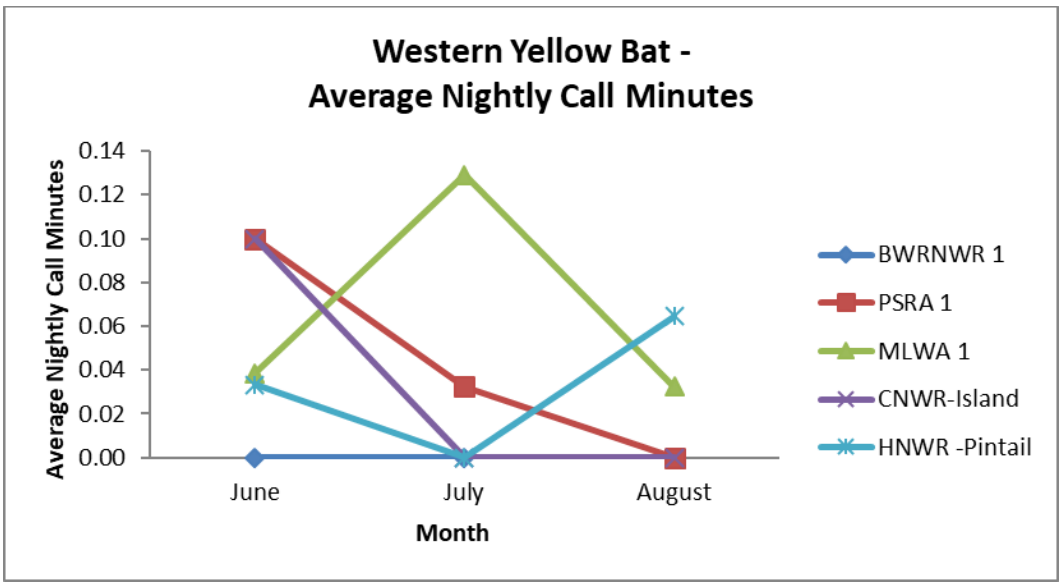


**Figure 4.—Western yellow bat average nightly call minutes.**

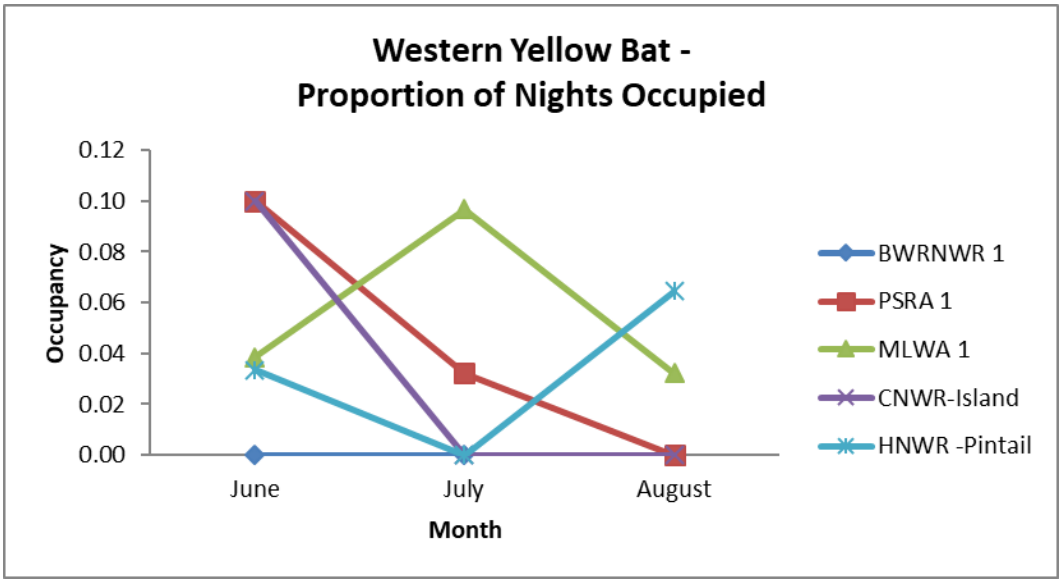


**Figure 5.—Western yellow bat proportion of nights occupied.**

## California Leaf-nosed Bat

The greatest average nightly call minutes for California leaf-nosed bats were recorded at BWRNWR 1, with the greatest proportion of nights occupied also recorded at PSRA 1, followed by BWRNWR 1, CNWR-Island, MLWA 1, and HNWR-Pintail (table 4). The greatest average nightly call minutes were recorded at BWRNWR 1 in June, MLWA 1 in July, and PSRA 1 in August, with the greatest average nightly call minutes recorded at the BWRNWR 1 in June (0.37 per night) (figure 6). The greatest proportion of nights occupied was recorded at the BWRNWR 1 in June and at PSRA 1 in July and August, with the greatest occupancy recorded at PSRA 1 in August (29% of nights occupied) (figure 7).

Table 4.—California leaf-nosed bat average nightly call minutes and nights occupied at system-wide monitoring sites, June 1 – August 31, 2017

| Station | Average nightly call minutes | Nights occupied | Proportion of nights occupied |
|---|---|---|---|
| HNWR-Pintail | 0.01 | 1 | 0.01 |
| BWRNWR 1 | 0.19 | 11 | 0.15 |
| CNWR-Island | 0.11 | 10 | 0.11 |
| PSRA 1 | 0.21 | 17 | 0.18 |
| MLWA 1 | 0.09 | 6 | 0.07 |

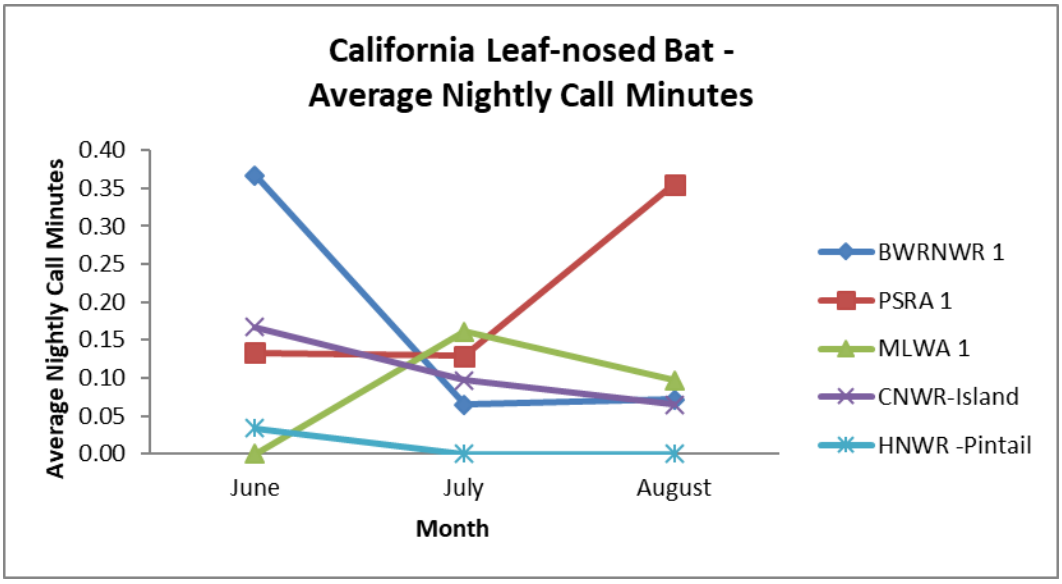


**Figure 6.—California leaf-nosed bat average nightly call minutes.**

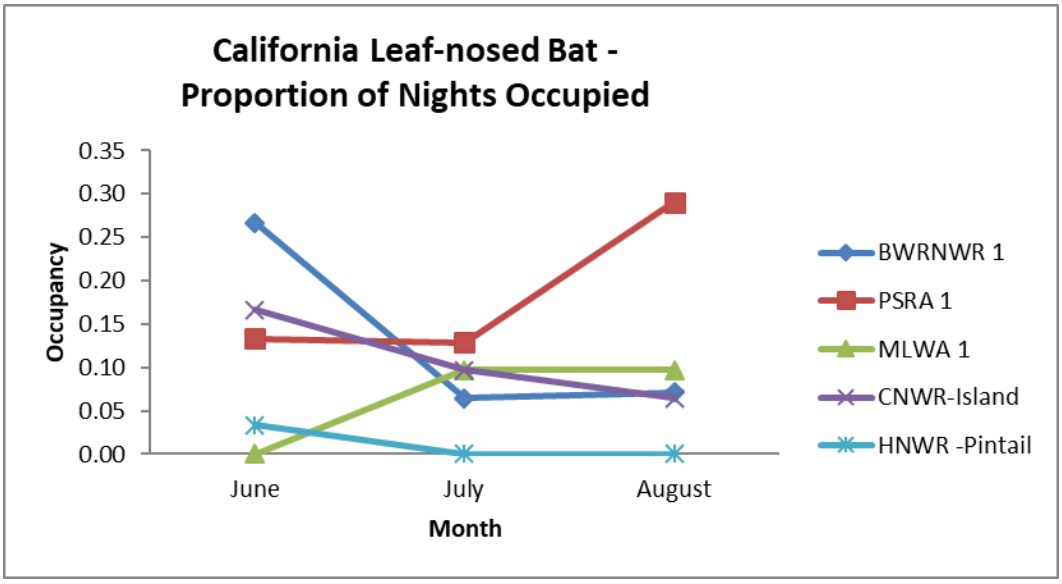


**Figure 7.—California leaf-nosed bat proportion of nights occupied.**

### Pale Townsend's Big-eared Bat

Because of the conservative method of identifying Townsend's big-eared bat (*C. townsendii*) calls to species and subspecies, and the nature of their whispering calls, no pale Townsend's big-eared bat calls were recorded during 2017.

## Yearly Detections 2010–2017

### Western Red Bat

#### *Western Red Bat – BWRNWR 1*

The greatest average nightly call minutes and proportion of nights occupied at BWRNWR 1 were recorded during the 2010 season followed by 2014, 2015, 2011, 2012, 2016, 2013, and 2017 (figure 8). The 2013 and 2017 seasons had an equal amount of average nightly call minutes, but 2013 had a greater proportion of nights occupied. The 2010 season had the greatest activity, with an average of 0.98 nightly call minutes and 58% of nights occupied, as compared to the 2017 season with an average of 0.17 nightly call minutes and 13% of nights occupied.

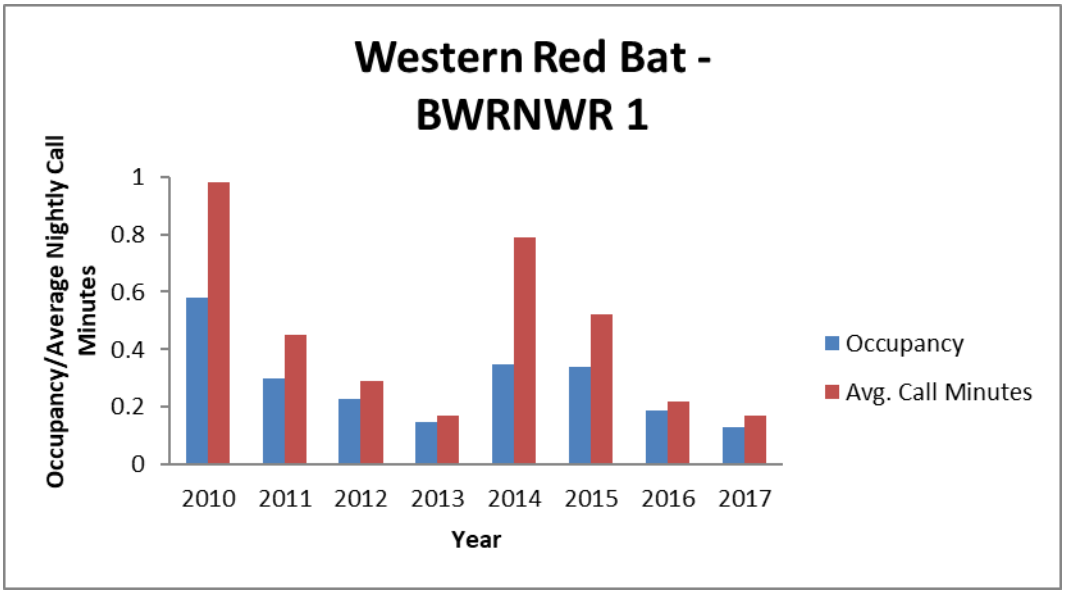


**Figure 8.—Western red bat average nightly call minutes and proportion of nights occupied at BWRNWR 1.**

### *Western Red Bat – CNWR-Island*

The greatest average nightly call minutes and proportion of nights occupied at CNWR-Island were recorded during the 2010 season followed by 2011, 2016, 2014, 2017, 2012, and 2013 (figure 9). No western red bats were detected at CNWR-Island during the 2015 season. The 2010 season had the greatest activity, with an average of 0.82 nightly call minutes and 42% of nights occupied, as compared to the 2015 season, when no western red bats were detected.

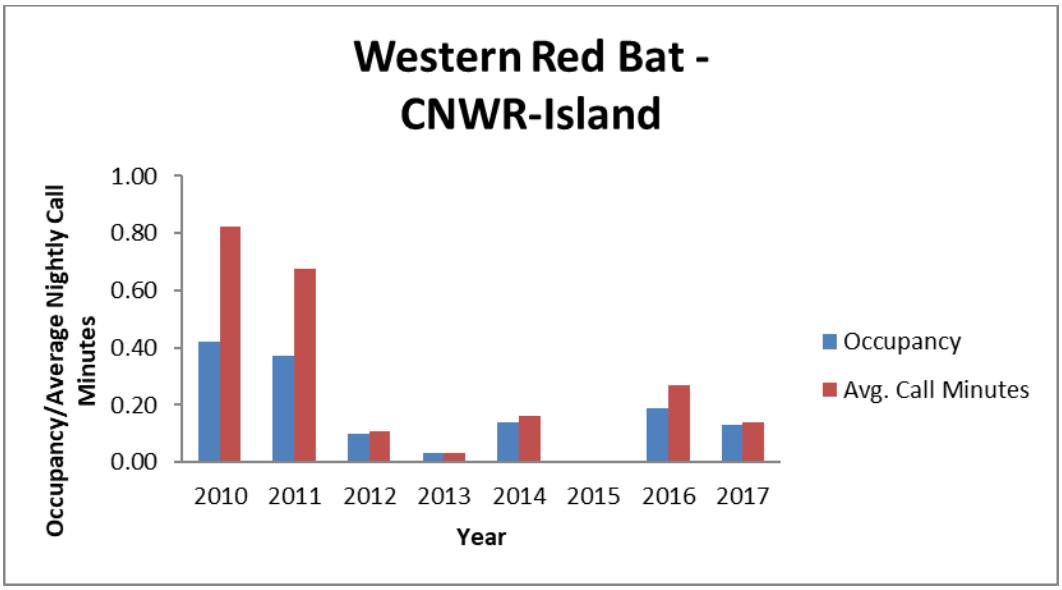


**Figure 9.—Western red bat average nightly call minutes and proportion of nights occupied CNWR-Island.**

### *Western Red Bat – MLWA 1*

The greatest average nightly call minutes at MLWA 1 were recorded during the 2014 and 2011 seasons followed by 2016, 2013, 2012, 2010, 2017, and 2015 (figure 10). The proportion of nights occupied at MLWA 1 did not correspond with average nightly call minutes in that greater average nightly call minutes and proportion of nights occupied did not necessarily parallel each other over years. A given year could have higher average nightly call minutes but not necessarily a higher proportion of nights occupied than another year and vice versa. Greater average nightly call minutes were recorded during the 2016 season compared to 2013, but the 2013 season had a greater proportion of nights occupied than 2016. This difference in average nightly call minutes and proportion of nights occupied may be attributed to the detector malfunction in 2016, with only the latter part of August being documented at MLWA 1. The greatest proportion of nights occupied at MLWA 1 was recorded during the 2014 season followed by 2011, 2013, 2016, 2012, 2010 and 2017 (were equal), and 2015. The 2014 season had the greatest activity, with an average of 0.45 nightly call minutes and 36% of nights occupied, as compared to the 2015 season with an average of 0.13 nightly call minutes and 12% of nights occupied.

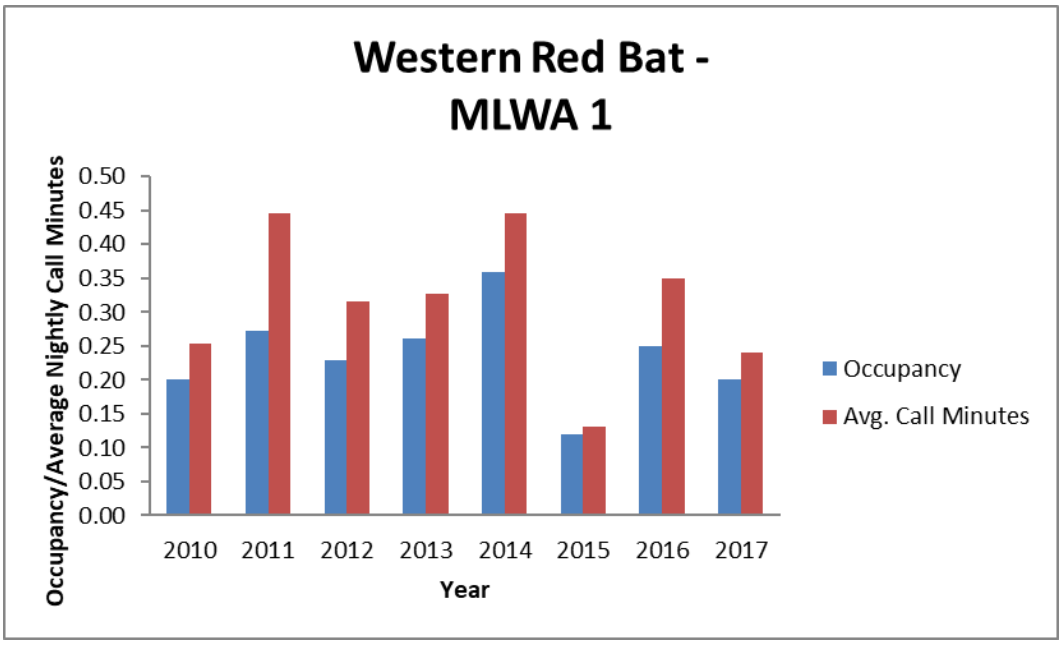


**Figure 10.—Western red bat average nightly call minutes and proportion of nights occupied at MLWA 1.**

### *Western Red Bat – PSRA 1*

The greatest average nightly call minutes and proportion of nights occupied at PSRA 1 were recorded during the 2016 season followed by 2011, 2013, 2017, 2012, 2014, and 2015 (figure 11). No western red bats were detected at PSRA 1 during the 2010 season. The 2016 season had the greatest activity, with an average of 0.2 nightly call minutes and 16% of nights occupied, as compared to the 2010 season, when no western red bats were detected.

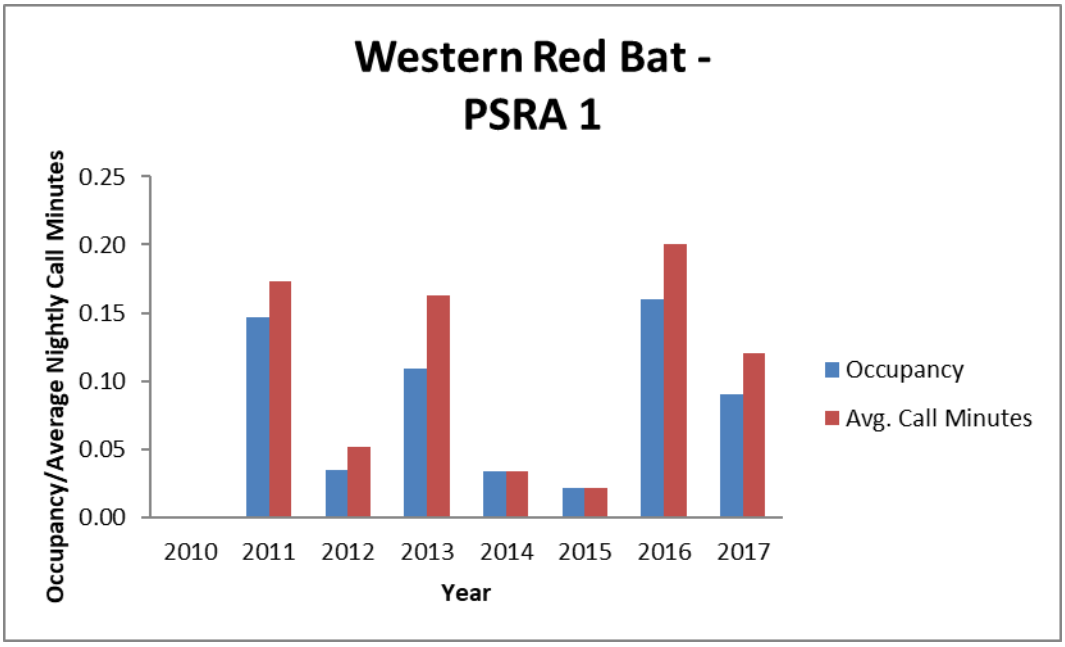


**Figure 11.—Western red bat average nightly call minutes and proportion of nights occupied at PSRA 1.**

### *Western Red Bat – HNWR-Pintail*

The greatest average nightly call minutes and proportion of nights occupied at HNWR-Pintail were recorded during the 2014 season followed by 2015, 2016 and 2017 (figure 12). The 2014 season had the greatest activity, with an average of 0.46 nightly call minutes and 24% of nights occupied, as compared to the 2017 season with an average of 0.03 call minutes and 3% of nights occupied.

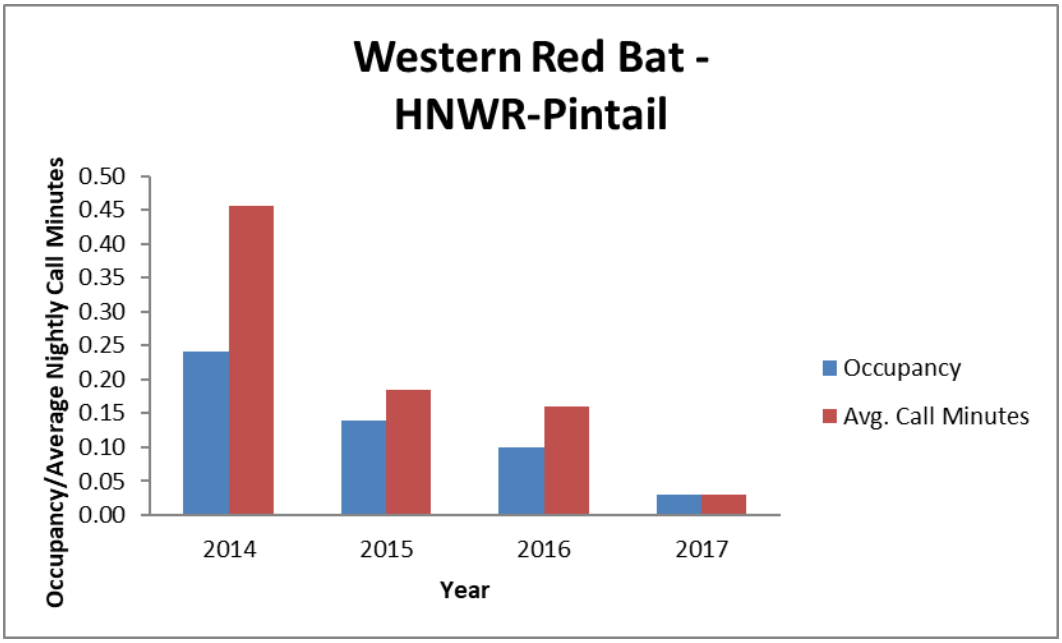


**Figure 12.—Western red bat average nightly call minutes and proportion of nights occupied at HNWR-Pintail.**

## Western Yellow Bat

### *Western Yellow Bat – BWRNWR 1*

The greatest average nightly call minutes and proportion of nights occupied at BWRNWR 1 were recorded during the 2010 season followed by 2014, 2016, 2012 and 2013, 2011, and 2015 (figure 13). No western yellow bats were detected at BWRNWR 1 during the 2017 season. The 2010 season had the greatest activity, with an average of 0.13 nightly call minutes and 12% of nights occupied, as compared to 2017, when no western yellow bats were detected.

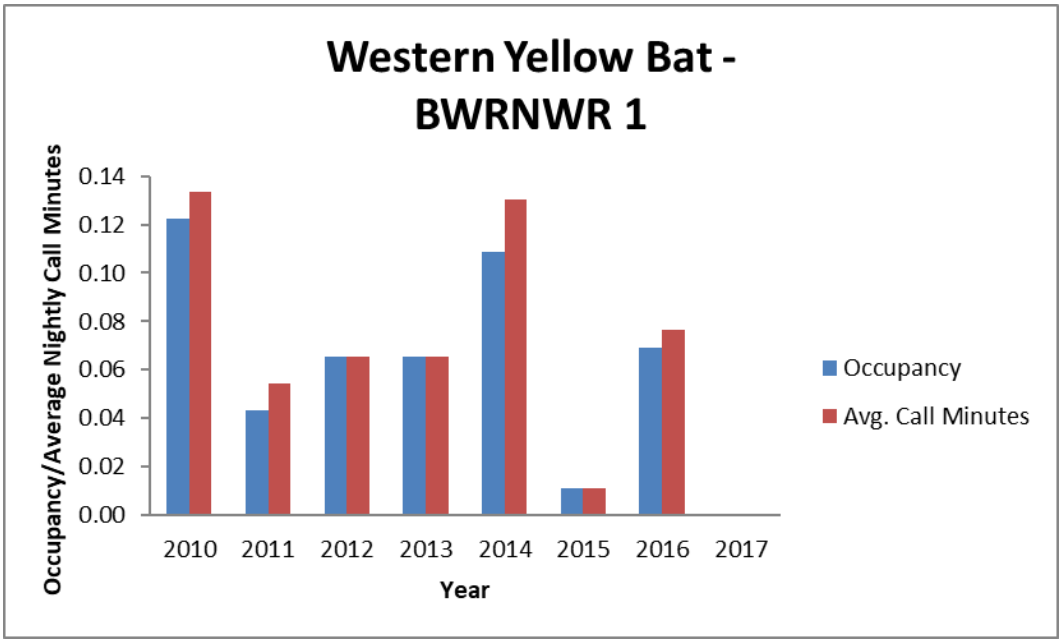


**Figure 13.—Western yellow bat average nightly call minutes and proportion of nights occupied at BWRNWR 1.**

### *Western Yellow Bat – CNWR-Island*

The greatest average nightly call minutes were recorded at CNWR-Island during the 2011 season followed by 2010, 2012, 2016, 2017, and 2014. The proportion of nights occupied at CNWR-Island did not correspond with average nightly call minutes. The 2010 and 2012 seasons had the same proportion of nights occupied, but 2010 had higher average nightly call minutes. The 2012 and 2016 seasons had the same average nightly call minutes, but the 2012 season had a higher proportion of nights occupied. The greatest proportion of nights occupied was documented during the 2011 season followed by 2010 and 2012, 2016, 2017, and 2014 (figure 14). No western yellow bats were detected at CNWR-Island during the 2013 or 2015 seasons. The 2011 season had the greatest activity, with an average of 0.28 nightly call minutes and 15% of nights occupied, as compared to the 2013 and 2015 seasons, when no western yellow bats were detected.

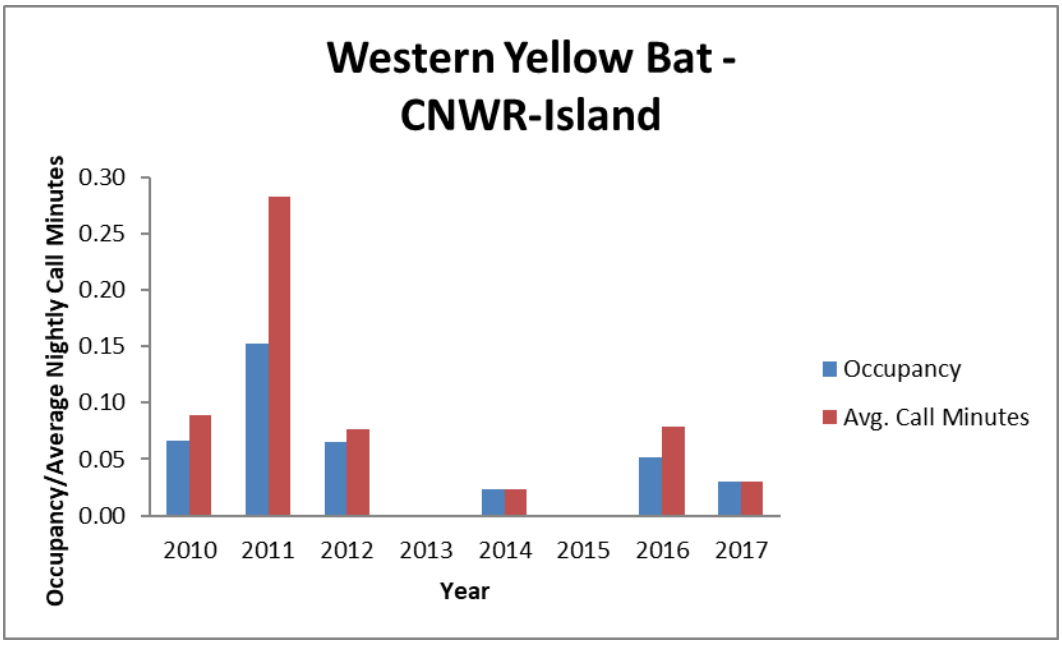


**Figure 14.—Western yellow bat average nightly call minutes and proportion of nights occupied at CNWR-Island.**

### *Western Yellow Bat – PSRA 1*

The greatest average nightly call minutes and proportion of nights occupied at PSRA 1 were documented during the 2011 and 2017 seasons followed by 2012 and 2014, and 2013 and 2016 (figure 15). No western yellow bats were detected at PSRA 1 during the 2010 or 2015 seasons. The 2011 and 2017 seasons had the greatest activity, with an average of 0.04 nightly call minutes and 4% of nights occupied, as compared to the 2010 and 2015 seasons, when no western yellow bats were detected.

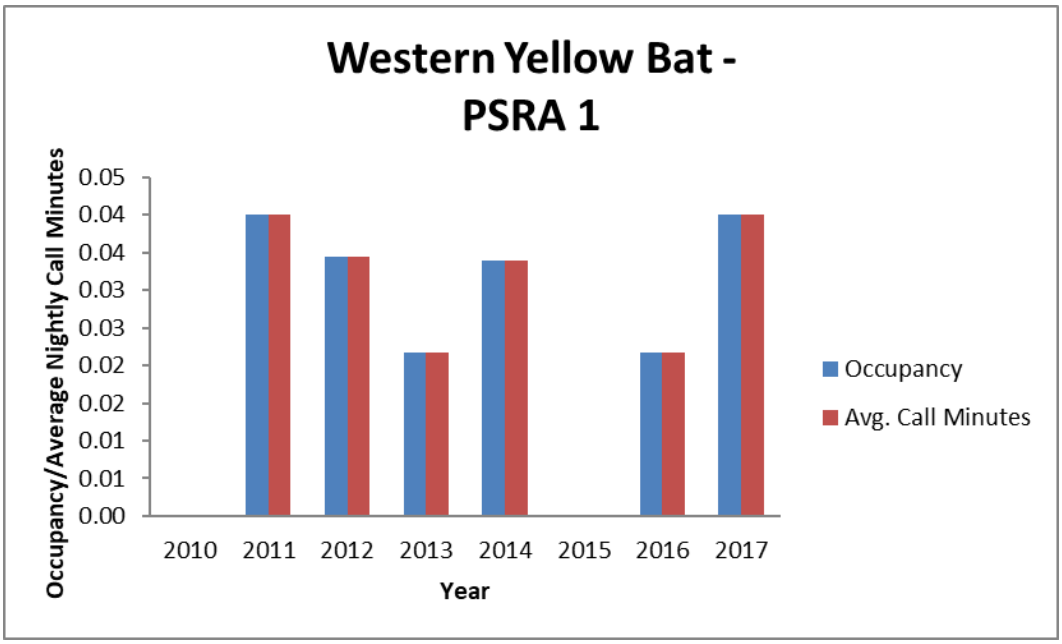


**Figure 15.—Western yellow bat average nightly call minutes and proportion of nights occupied at PSRA 1.**

### *Western Yellow Bat – MLWA 1*

The greatest average nightly call minutes at MLWA 1 were recorded during the 2010 season, followed by 2017, 2012, 2013, and 2015, 2011, and 2014 (figure 16). No western yellow bats were detected at MLWA 1 during the 2016 season. The proportion of nights occupied did not correspond with the average nightly call minutes at MLWA 1. The 2012, 2013, and 2015 seasons all had the same average nightly call minutes, with the 2015 season having a lower proportion of nights occupied than 2012 and 2013. The 2012 and 2013 seasons had equal average nightly call minutes and proportion of nights occupied. The 2011 and 2014 seasons also had equal average nightly call minutes and proportion of nights occupied. The greatest proportion of nights occupied was documented during the 2010 season followed by 2017, 2012, 2013 and 2015, and 2011 and 2014. The 2010 season had the greatest activity, with an average of 0.16 nightly call minutes and 13% of nights occupied, as compared to the 2016 season, when no western yellow bats were detected.

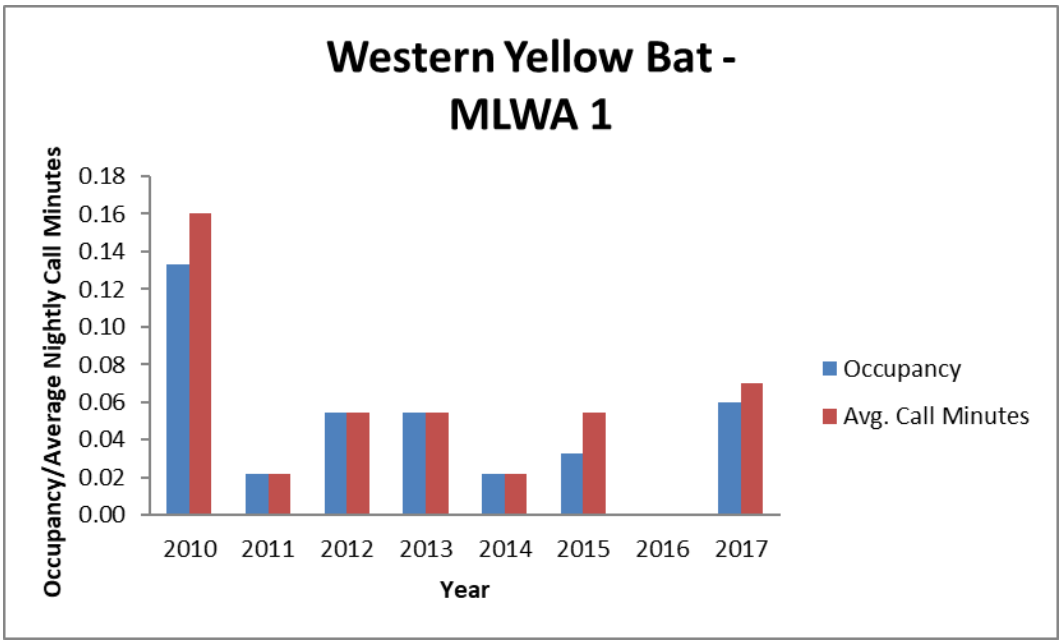


**Figure 16.—Western yellow bat average nightly call minutes and proportion of nights occupied at MLWA 1.**

### *Western Yellow Bat – HNWR-Pintail*

The greatest average nightly call minutes and proportion of nights occupied at HNWR-Pintail were recorded during the 2015 season followed by 2016, 2014, and 2017 (figure 17). The 2015 season recorded the greatest activity, with an average of 0.06 nightly call minutes and 4.6% of nights occupied, as compared to the 2017 season with an average of 0.03 nightly call minutes and 3% of nights occupied.

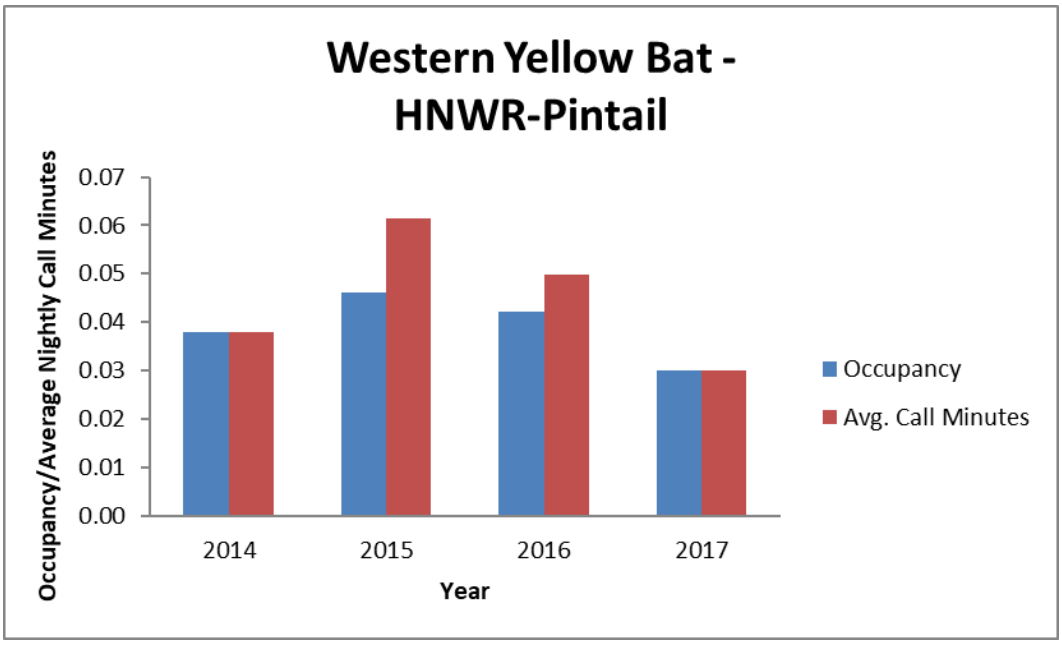


**Figure 17.—Western yellow bat average nightly call minutes and proportion of nights occupied at HNWR-Pintail.**

## California Leaf-nosed Bat

### *California Leaf-nosed Bat – BWRNWR 1*

The greatest average nightly call minutes at BWRNWR 1 were recorded during the 2013 season followed by 2017, 2016, 2015, 2012, 2014, and 2010 (figure 18). No California leaf-nosed bats were detected at BWRNWR 1 during the 2011 season. The proportion of nights occupied at the BWRNWR 1 did not correspond with average nightly call minutes. The 2016 season had higher average nightly call minutes but a lower proportion of nights occupied than the 2015 season. The greatest proportion of nights occupied were recorded during the 2013 season followed by 2017, 2015, 2016, 2012, 2014 and 2010. The 2013 season had the greatest activity, with an average of 0.61 nightly call minutes and 38% of nights occupied, as compared to the 2011 season, when no California leaf-nosed bats were detected.

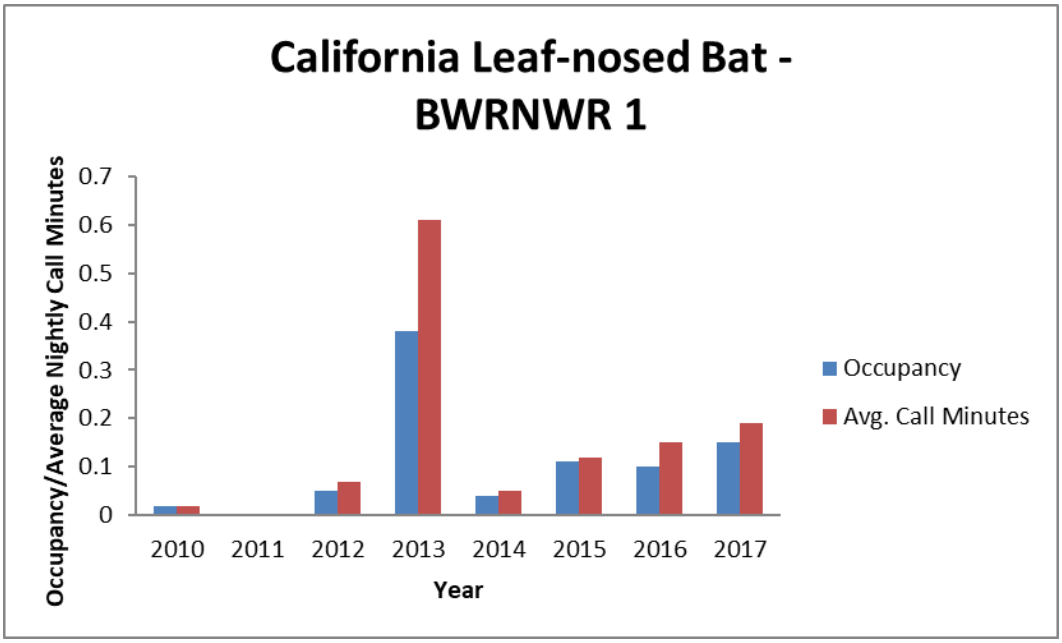


**Figure 18.—California leaf-nosed bat average nightly call minutes and proportion of nights occupied at BWRNWR 1.**

### *California Leaf-nosed Bat – CNWR-Island*

The greatest average nightly call minutes at CNWR-Island were recorded during the 2010 and 2017 seasons followed by 2012, 2016, 2011, 2015, and 2013 (figure 19). No California leaf-nosed bats were detected at CNWR-Island activity during the 2014 season. The proportion of nights occupied at CNWR-Island did not correspond with average nightly call minutes. The 2010 and 2017 seasons had an equal amount of average nightly call minutes, but the 2017 had a higher proportion of nights occupied. The 2010 and 2017 seasons had the greatest activity, with an average of 0.11 nightly call minutes, and 2017 had the greatest proportion of nights occupied (11%) as compared to the 2014 season, when no California leaf-nosed bats were detected.

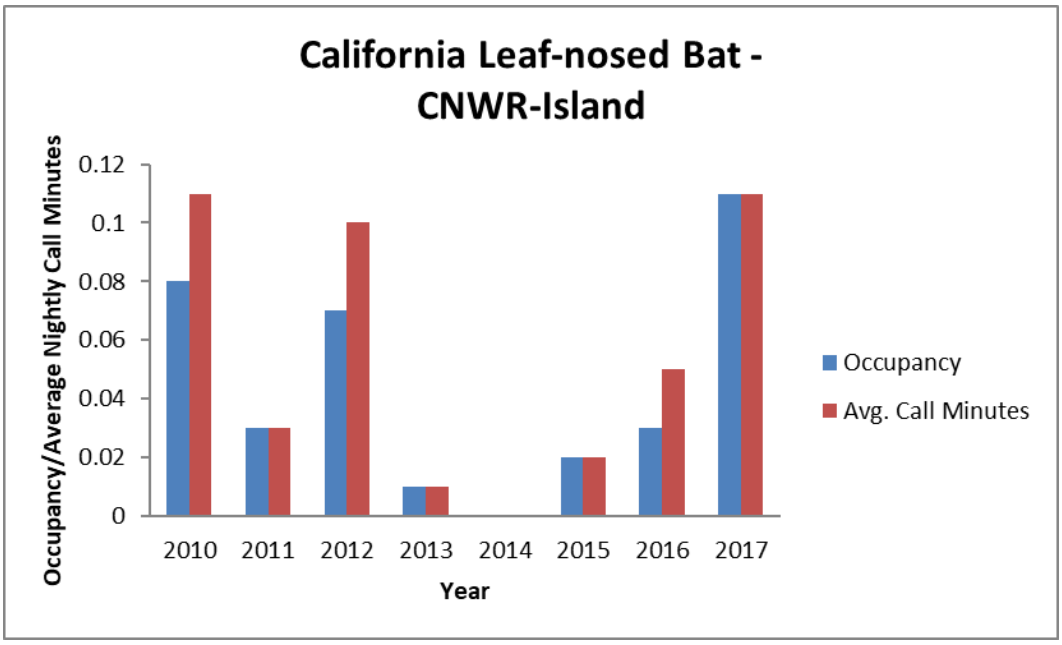


**Figure 19.—California leaf-nosed bat average nightly call minutes and proportion of nights occupied at CNWR-Island.**

### *California Leaf-nosed Bat – PSRA 1*

The greatest average nightly call minutes were recorded at PSRA 1 during the 2013 and 2014 season followed by 2012, 2015, 2016, and 2011 and 2017 (figure 20). No California leaf-nosed bats were detected at PSRA 1 during the 2010 season. The proportion of nights occupied at PSRA 1 did not correspond with average nightly call minutes. The 2013 and 2014 seasons had the same average nightly call minutes, but the 2013 season had a higher proportion of nights occupied. The 2012 and 2015 seasons had the same proportion of nights occupied, but the 2012 season had higher average nightly call minutes. The 2011 and 2016 seasons also had the same proportion of nights occupied, with 2016 having higher average nightly call minutes. The 2011 and 2017 seasons had an equal amount of average nightly call minutes, but 2011 had a slightly higher proportion of nights occupied. The greatest proportion of nights occupied were documented during the 2013 season followed by 2014, 2012, 2015, 2011, 2016 and 2017. The 2013 season had the greatest activity, with an average of 0.39 nightly call minutes and 28% of nights occupied, as compared to the 2010 season, when no California leaf-nosed bats were detected.

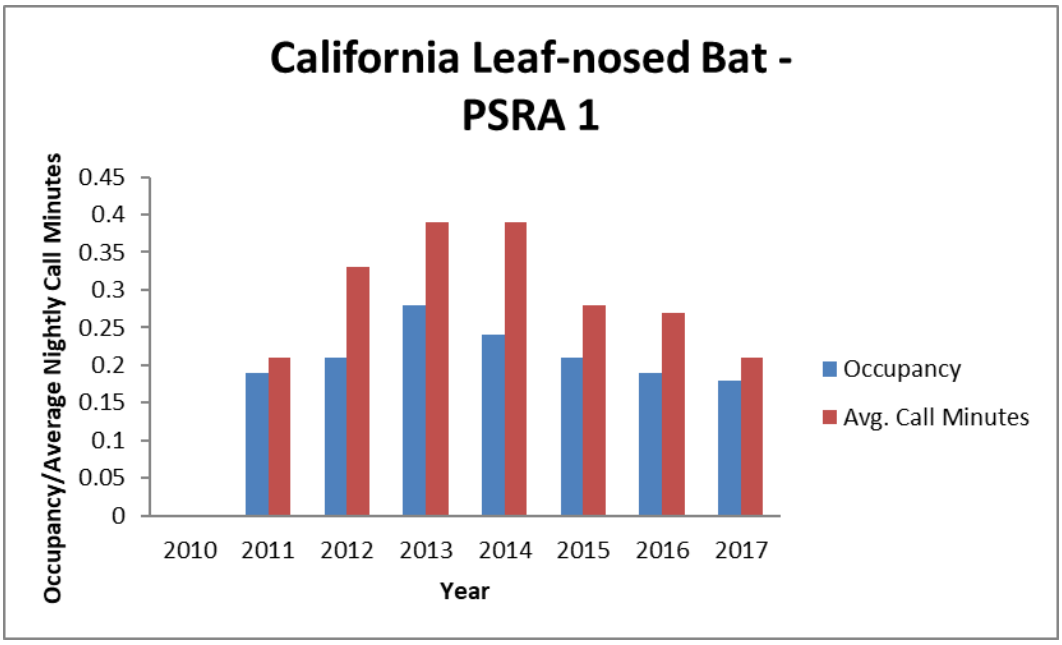


**Figure 20.—California leaf-nosed bat average nightly call minutes and proportion of nights occupied at PSRA 1.**

### *California Leaf-nosed Bat – MLWA 1*

The greatest average nightly call minutes at MLWA 1 were documented during the 2016 season followed by 2010, 2013, 2017, 2011, and 2012 (figure 21). No California leaf-nosed bats were detected at MLWA 1 during the 2014 or 2015 seasons. The proportion of nights occupied at MLWA 1 did not correspond with average nightly call minutes in all cases. The 2013 and 2017 seasons had an equal proportion of nights occupied, but 2013 had a greater number of average nightly call minutes. The 2016 season had the greatest activity, with an average of 0.30 nightly call minutes and 20% of nights occupied, as compared to the 2014 and 2015 seasons, when no California leaf-nosed bats were detected.

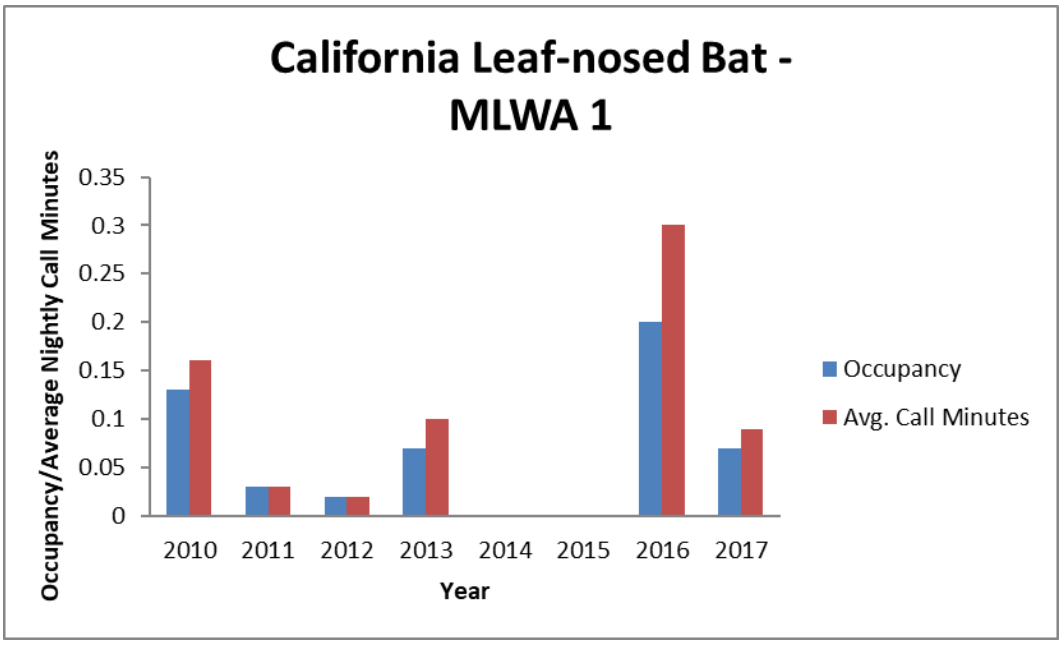


**Figure 21.—California leaf-nosed bat average nightly call minutes and proportion of nights occupied at MLWA 1.**

### *California Leaf-nosed Bat – HNWR-Pintail*

The greatest average nightly call minutes and proportion of nights occupied at HNWR-Pintail were documented during the 2017 season (figure 22). No California leaf-nosed bats were detected at HNWR-Pintail during the 2014, 2015, or 2016 seasons.

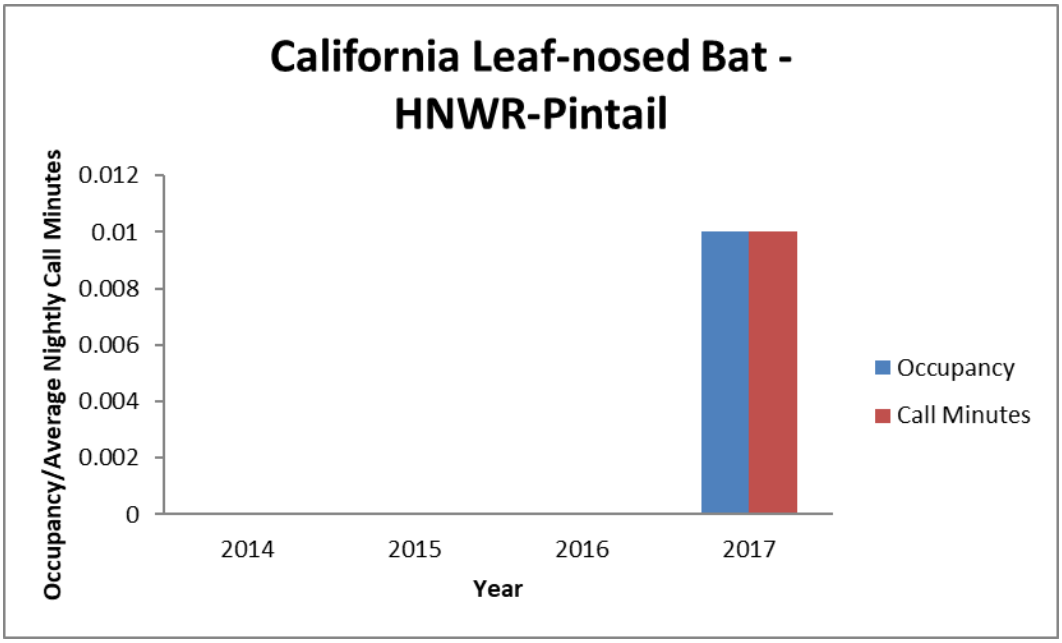


**Figure 22.—California leaf-nosed bat average nightly call minutes and proportion of nights occupied at HNWR-Pintail.**

# DISCUSSION

## Western Red Bat

The greatest average nightly call minutes and proportion of nights occupied for western red bats in 2017 was recorded at MLWA 1. The second greatest average nightly call minutes for western red bats in 2017 was recorded at the BWRNWR 1, followed by CNWR-Island, PSRA 1, and HNWR-Pintail. The detection rate (based on average nightly call minutes) for western red bats at CNWR-Island had been low from 2012 through 2015, with some variation between years. A fire occurred at CNWR-Island on August 29, 2011, burning the surrounding Fremont cottonwood-Goodding's willow (*Populus fremontii-Salix gooddingii*) (hereafter cottonwood-willow) habitat that may have served as roosting and foraging habitat for western red bats. The average nightly call minutes recorded in 2016 represented the greatest western red bat activity recorded at CNWR-Island following the 2011 fire. A focal assessment indicated that the cottonwood-willow habitat had begun to recover to pre-fire levels in

2016. As a result, a possible increase in western red bat average nightly call minutes in 2017 was hypothesized, but a slight decrease from the 2016 average nightly call minutes levels was recorded.

Western red bat activity fluctuated from year to year across all of the other sites. The greatest average nightly call minutes and occupancy for western red bats was recorded at the BWRNWR 1 in 2010, with another peak in 2014 followed by declines in both measurements. The lowest proportion of nights occupied for the BWRNWR 1 was documented in 2017. MLWA 1 varies from year to year but overall seems to be the most consistent site from 2010–17, with the greatest average nightly call minutes and occupancy recorded in 2011 and 2014 and a low in 2015. PSRA 1 varies as well, with low overall activity. The greatest average nightly call minutes and occupancy at PSRA 1 were recorded during the 2016 season. The 2016 and 2017 seasons at PSRA 1 have had the least difference in average nightly call minutes and occupancy for consecutive years since surveys began at this station. Data from HNWR-Pintail have documented decreasing average nightly call minutes and proportion of nights occupied each year from 2014 through 2017. This lower detection of activity and proportion of nights occupied may be attributed to a fire at HNWR-Pintail that started on August 8, 2015. The area surrounding the station burned, but left it operational, and a patch of cottonwoods near the station were also left unburned.

The greatest overall average nightly call minutes and occupancy for western red bats between 2010 and 2017 was recorded at the BWRNWR 1 followed by MLWA 1, CNWR-Island, HNWR-Pintail, and PSRA 1. The greatest average nightly call minutes and proportion of nights occupied aggregated across all system-wide acoustic stations occurred during the 2010 season followed by 2011, 2014, 2016, 2012, 2013 and 2015, and 2017. The 2015 and 2017 season had an equal amount of proportion of nights occupied, but 2015 had higher average nightly call minutes.

## Western Yellow Bat

The greatest average nightly call minutes and proportion of nights occupied for western yellow bats in 2017 was recorded at MLWA 1, followed by PSRA 1, and then CNWR-Island and HNWR-Pintail with equal activity. No western yellow bats were detected at the BWRNWR 1 in 2017. Overall, low levels of activity were measured at system-wide monitoring sites during June, July, and August. This species has been documented using system-wide monitoring sites largely during migration periods (May and September) (Mixan and Diamond 2014). Western yellow bats almost exclusively utilize non-native palms (*Washingtonia robusta* and *Washingtonia filifera*) as roosts. These palms are dispersed sparsely around system-wide monitoring sites. This sparse dispersal of roosting habitat is likely associated with the lack of western yellow bat activity documented during the June, July, and August sampling period.

Across all system-wide monitoring sites, activity for western yellow bats varied between 2010 and 2017. The greatest activity at BWRNWR 1 was recorded in 2010 and 2014. The lowest activity at BWRNWR 1 was recorded in 2017. CNWR-Island varies from year to year, with the greatest activity of any year and any station recorded in 2011. The lowest activity recorded at CNWR-Island was documented in 2013 and 2015. Activity at PSRA 1 was consistently low from 2010 through 2017, with the greatest activity recorded in 2011 and 2017. The lowest activity at PSRA 1 was recorded during the 2010 and 2015 seasons. Peak activity at MLWA 1 occurred during the 2010 season followed by a drop to low, variable activity beginning in the 2011 season through 2017, with the lowest activity recorded in 2016. Again, activity was consistently low from 2014 through 2017 at HNWR-Pintail, with the greatest activity recorded in 2015 and the lowest in 2017. The greatest average nightly call minutes for western yellow bats between 2010 and 2017 was documented at BWRNWR 1 and CNWR-Island, with the BWRNWR 1 having slightly higher occupancy. BWRNWR 1 and CNWR-Island were followed by MLWA 1, HNWR-Pintail, and PSRA 1 in activity and occupancy.

The greatest average nightly call minutes and proportion of nights occupied aggregated across all system-wide acoustic stations occurred during the 2010 and 2011 seasons. The 2010 season saw higher occupancy than 2011, but the 2011 season had higher average nightly call minutes than the 2010 season. The 2010 and 2011 seasons were followed by 2012, 2014, 2016, 2013, 2017 and 2015.

## California Leaf-nosed Bat

The greatest proportion of nights occupied for California leaf-nosed bats in 2017 was at PSRA 1 followed by the BWRNWR 1, CNWR-Island, MLWA1, and HNWR-Pintail. The activity patterns documented at system-wide monitoring sites in 2017 are consistent with the overall average nightly call minutes and occupancy recorded from 2010 through 2016. Across all system-wide monitoring sites, activity for California leaf-nosed bats varied between 2010 and 2017. California leaf-nosed bat activity, average nightly call minutes, and the proportion of nights occupied was highest at BWRNWR 1 during the 2013 season but consistently low before and after that year, with the least activity occurring in 2011. Average nightly call minutes and the proportion of nights occupied were highest at CNWR-Island during the 2010 and 2017 seasons, with 2017 having greater occupancy. Lower average nightly call minutes and the proportion of nights occupied were recorded from 2013 through 2015, with no activity recorded in 2014. The greatest average nightly call minutes and the proportion of nights occupied was documented at PSRA 1 during the 2013 and 2014 seasons, with 2013 having a higher rate of occupancy. California leaf-nosed bats were first detected acoustically at PSRA 1 in 2011 and stayed fairly consistent through 2017. Average nightly call minutes and the proportion of nights occupied at MLWA 1 were greatest during the 2016 season. Both average nightly call

minutes and the proportion of nights occupied varied from year to year at MLWA 1, with no California leaf-nosed bats recorded during the 2014 or 2015 seasons. No California leaf-nosed bats were recorded at HNWR-Pintail from 2014 through 2016. A single call was documented during the 2017 season, making this the first activity documented at HNWR-Pintail during the months of June, July, and August since the station was established in May 2014.

The greatest average nightly call minutes and proportion of nights occupied varied and did not correspond from season to season. Some seasons would have greater occupancy than another season that may have had greater average nightly call minutes and vice versa. The greatest average nightly call minutes and proportion of nights occupied aggregated across all system-wide acoustic stations occurred during the 2013 season followed by 2016 and 2017. The 2016 season had greater average nightly call minutes than 2017, but they had an equal amount of occupancy. The 2017 season had higher occupancy than the 2012 season, but 2012 had higher average nightly call minutes. The 2014 season had higher average nightly call minutes than 2015, but the 2015 season had greater occupancy than 2014. The 2010, 2011, and 2014 seasons all had an equal amount of occupancy, with 2014 having the greatest average nightly call minutes followed by 2010 and 2011. The 2011 season saw higher occupancy than 2010, but the 2010 season had higher average nightly call minutes than the 2011 season. This pattern of average nightly call minutes and occupancy can be attributed to more concentrated activity during the nights when bats were recorded, which would result in higher average nightly call minutes but not a higher proportion of nights occupied. Conversely, bats could have been documented with lower levels of average nightly call minutes with higher occupancy than years with concentrated activity, but they would be documented with less average nightly call minutes if activity was higher and concentrated in another given year.

## Pale Townsend's Big-eared Bat

Because of the conservative method of identifying pale Townsend's big-eared bat calls to species and subspecies, and the nature of their whispering calls, no calls were recorded at any site in 2017. One pale Townsend's big-eared bat call was recorded during 2016 monitoring at BWRNWR 1. Other calls were recorded between 2010 and 2016 during June, July, and August: two calls and 2 days of occupancy at BWRNWR 1 in 2013 and one call and 1 day of occupancy at CNWR-Island in 2013.

## Summer Residency

Summer residency for western red bats and western yellow bats at system-wide monitoring sites along the LCR varies from year to year, and these species are likely present in low density as compared to the conservation areas (Mixan and

Diamond 2016). Historically, little documentation for these species had been reported along the LCR. Western yellow bats were first documented along the LCR in Yuma, Arizona (Constantine 1966), with single yearly records occurring in the 1980s (Constantine 1998) and 1990s (Brown 1996). Western yellow bats were also captured at BWRNWR 1 in the 1990s (Brown 1996). They have now been captured in at least seven LCR MSCP conservation areas and use these areas frequently to forage (Diamond et al. 2012). The level of activity detected for western yellow bats at system-wide monitoring sites may be consistent with activity along the LCR, pre-implementation of the conservation areas. Western red bat documentation along the LCR was similarly lacking. Western red bats had been captured in tributaries of the LCR (including at BWRNWR 1) and recorded acoustically in 2001 and 2002 at the Havasu and Imperial National Wildlife Refuges (Brown 2006), but the first western red bat captured along the main stem of the LCR occurred in 2009 at the ‘Ahakhav Tribal Preserve (Calvert and Neiswenter 2012). As with western yellow bats, the activity detected for western red bats at system-wide monitoring sites may be consistent with activity along the LCR, pre-implementation of the conservation areas.

California leaf-nosed bats were first documented along the LCR by Grinnell (1918) and are year-round residents with several large maternity, bachelor, and winter roosts. California leaf-nosed bat distribution and activity is limited by the distance they forage from their cavern roosts. Activity at system-wide monitoring sites is likely comparable to historical activity along the LCR, though foraging affinities may have changed for this species as conservation areas matured. California leaf-nosed bats are foraging generalists, and it is plausible that conservation areas may be supporting a more abundant or preferred prey source than system-wide monitoring sites, thus attracting more activity.

Pale Townsend’s big-eared bats were first documented by Grinnell (1914), and like California leaf-nosed bats, are year-round residents along the LCR, though with fewer known roosts. As already mentioned, this species is difficult to detect with acoustic monitoring, leading to difficulty in assessing activity.

The activity from 2010 through 2017 for covered and evaluation species at system-wide monitoring sites on a macroscale seems to fluctuate among years and sites, with no major long-term increases or decreases in activity.

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