Acoustic Monitoring for Lower Colorado River Bat Species

September 2002 to May 2007
Lower Colorado River Multi-Species Conservation Program
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U.S. Fish and Wildlife Service
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Salt River Project Agricultural Improvement and Power District
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Yuma Irrigation District
Yuma Mesa Irrigation and Drainage District

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Nevada Department of Wildlife
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Basic Water Company

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Hualapai Tribe
Colorado River Indian Tribes
Chemehuevi Indian Tribe

Conservation Participant Group
Ducks Unlimited
Lower Colorado River RC&D Area, Inc.
The Nature Conservancy

Other Interested Parties Participant Group
QuadState Local Governments Authority
Desert Wildlife Unlimited
Lower Colorado River
Multi-Species Conservation Program

Acoustic Monitoring for Lower Colorado River Bat Species

September 2002 to May 2007

Prepared by:
Matarango Museum
Robert Berry, Ph.D. (acoustic recordings)
Dr. Patricia Brown and William Rainey (records compilation)
Susan Broderick (acoustic analysis)
### ACRONYMS AND ABBREVIATIONS

<table>
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<tr>
<td>Bill Williams River NWR</td>
<td>Bill Williams River National Wildlife Refuge</td>
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<tr>
<td>Cibola NWR</td>
<td>Cibola National Wildlife Refuge</td>
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<tr>
<td>Havasu NWR</td>
<td>Havasu National Wildlife Refuge</td>
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<td>Imperial NWR</td>
<td>Imperial National Wildlife Refuge</td>
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<tr>
<td>LCR</td>
<td>lower Colorado River</td>
</tr>
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<td>LCR MSCP</td>
<td>Lower Colorado River Multi-Species Conservation Program</td>
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<tr>
<td>USFWS</td>
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Executive Summary

Surveys of bat presence were conducted along the lower Colorado River between Hoover Dam and the Southerly International Boundary with Mexico from 2002 through 2007 using acoustic bat detectors. A variety of Titley Scientific Anabat acoustic bat detectors were tested and used during the study. Acoustic bat detectors were deployed for all or part of 382 nights in at least 128 locations and recorded 104,435 identifiable bat calls. Sixteen species were identified. In addition, bat calls that had overlapping, similar call characteristics were also identified. The species detected included the western red bat (*Lasiurus blossevillii*) and western yellow bat (*Lasiurus xanthinus*), which are Lower Colorado River Multi-Species Conservation Program (LCR MSCP) covered species; the California leaf-nosed bat (*Macrotus californicus*) and pale Townsend’s big-eared bat (*Corynorhinus townsendii pallescens = Plecotus townsendii pallescens = C. townsendii townsendii*), which are LCR MSCP evaluation species; and the pallid bat (*Antrozous pallidus*), big brown bat (*Eptesicus fuscus*), western mastiff bat (*Eumops perotis*), hoary bat (*Lasiurus cinereus*), California myotis (*Myotis californicus*), Arizona myotis (*Myotis occultus*), cave myotis (*Myotis velifer*), Yuma myotis (*Myotis yumanensis*), pocketed free-tailed bat (*Nyctinomops femorosaccus*), big free-tailed bat (*Nyctinomops macrotis*), canyon bat (*Parastrellus hesperus*), and the Mexican free-tailed bat (*Tadarida brasiliensis*).
INTRODUCTION

Acoustic bat surveys were conducted along the lower Colorado River (LCR) from near Davis Dam to the Southerly International Boundary with Mexico near San Luis, Arizona, from 2002 through 2007. This study was funded by the Lower Colorado River Multi-Species Conservation Program (LCR MSCP) to provide a more complete understanding of the LCR bat assemblage in the past versus the assemblage present today and to test and refine the protocols for using newly developed acoustic bat sampling equipment. LCR MSCP covered bat species include the western red bat (*Lasiurus blossevillii*) and western yellow bat (*Lasiurus xanthinus*) and two evaluation species, the California leaf-nosed bat (*Macrotus californicus*) and pale Townsend’s big-eared bat (*Corynorhinus townsendii pallescens = Plecotus townsendii pallescens = C. townsendii townsendii)*.

In 2002, Anabat acoustic bat detectors, developed by Titley Scientific, were revolutionary in that for the first time a portable detector could be deployed in the field that was rugged and reliable and could be operated remotely. Additionally, the acoustic bat calls recorded could be identified to species or species groups using the accompanying Analook software. Work conducted previously by Dr. Robert Berry and Dr. Patricia Brown established the protocols that would later be used by the newly established LCR MSCP in its bat monitoring program for sampling in the field and species identification (Brown and Berry 2003; Brown 2006). Dr. Robert Berry was in charge of acoustic monitoring from 2000 until his death in February 2008. The analysis of his data was conducted between 2004 and 2016 and is the result of hundreds of hours of research and analysis by Susan Broderick, William Rainey, and Dr. Patricia Brown. This report was prepared in 2016 to document the results of the 2002–07 acoustic monitoring project.

During the initial bat pilot project (Brown and Berry 2003), 15 bat species were detected along the LCR by utilizing a combination of acoustic recording techniques, roost surveys, and mist netting. Since then, mist netting and acoustic detection have helped to document an additional species, the Arizona myotis (*Myotis occultus*), a species assumed to have been extirpated along the LCR. This species was discovered foraging, and roosting nearby, at the ‘Ahakhav Tribal Preserve south of Parker, Arizona, and at the Cibola Valley Conservation Area north of Cibola, Arizona (Calvert 2009, 2010; Calvert and Neiswenter 2012). The Yuma myotis (*Myotis yumanensis*) forages over open, still water and has apparently increased in numbers with the creation of lakes along the LCR. Yuma myotis, canyon bats (*Parastrellus hesperus*), California myotis (*Myotis californicus*), and Mexican free-tailed bats (*Tadarida brasiliensis*) are the most common species along the LCR; however, with restoration efforts, tree-roosting species, such as western red bats, hoary bats (*Lasiurus cinereus*), and western yellow bats, are now more frequently detected along the river.
STUDY AREAS

This report covers acoustic sampling conducted on the LCR from the fall of 2002 through the spring of 2007. The study area consists of nine regions extending from Hoover Dam to Yuma, Arizona (figure 1).

- **Region 1** includes the area along the LCR from Hoover Dam to Bullhead City. Acoustic sampling in this region concentrated on sites around Lake Mohave (figure 2).

- **Region 2** extends from the Bullhead City area through the Havasu National Wildlife Refuge (Havasu NWR) (figure 3). Acoustic sample sites focused on the Topock Marsh area as well as other areas within the Havasu NWR.

- **Region 3** encompasses Lake Havasu from the lower boundary of the Havasu NWR to Parker Dam (figure 4). Acoustic sampling sites concentrated on Lake Havasu as well as mines and unique habitats in the area.

- **Region 4** encompasses the Bill Williams River National Wildlife Refuge (Bill Williams River NWR) (figure 4).

- **Region 5** extends from the confluence of the Bill Williams River with the Colorado River down to Parker, Arizona (figure 4). Acoustic sampling concentrated in the Parker Strip area.

- **Region 6** extends from Parker, Arizona, to Interstate 10 near Blythe, California, and Ehrenberg, Arizona, and encompasses areas along both sides of the Colorado River (figure 5).

- **Region 7** extends from Interstate 10 to the lower boundary of the Cibola National Wildlife Refuge (Cibola NWR) along both sides of the Colorado River (figure 5). Acoustic sampling sites were concentrated in the Cibola NWR.

- **Region 8** extends from the lower boundary of the Cibola NWR to Imperial Dam and encompasses the Imperial National Wildlife Refuge (Imperial NWR) (figure 5).

- **Region 9** extends from Imperial Dam to the Southerly International Boundary with Mexico near San Luis, Arizona (figure 6). Acoustic sampling concentrated along the Colorado River below Imperial Dam, sites in wetlands near Yuma, Arizona, and the Morelos Dam on the Colorado River near Yuma.

A table showing the sample sites and nights surveyed for each region is included in attachment 1.
Figure 1.—Acoustic bat survey regions along the LCR.
Acoustic surveys in Region 1 were conducted at four sites in the general vicinity of Lake Mohave in July and October 2003, three sites in January and May 2004, seven sites in 2005, and four sites in 2007 (see figure 2 and attachment 1).
Figure 3.—Acoustic bat survey locations in Region 2.
The approximate locations of sample sites are identified by blue points on the map.

Region 2 acoustic sampling was conducted at seven sites in the general area of Topock Marsh and the Havasu NWR during October 2002, six sites in May and October 2003, four sites during June 2004, six sites in January and May 2005, and one site in September 2006 (see figure 3 and attachment 1).
Figure 4.—Acoustic bat survey locations in Regions 3, 4, and 5. The approximate locations of sample sites are identified by blue points on the map.

**Region 3** surveys were conducted at four sites in October 2002; nine sites in January 2003, with some sites also sampled in October, February or May; nine sites mostly in January or May 2004; and six sites in January and May 2005. **Region 4** surveys were conducted at three sites in October 2002; six sites in 2003 from 1 to 3 nights during January, May, and/or October; six sites in 2004 from 1 to 4 nights during February, May, June, and/or July; nine sites in 2005, ranging from 2 to 7 nights during January or May, mostly and occasionally in July; two sites in September 2006; and six sites in January 2007. **Region 5** surveys were conducted at three sites in October 2002; seven sites in 2003, ranging from 1 to 6 nights mostly during January and/or May and occasionally July; seven sites in 2004 for 1 or 2 nights in January, February, or June; five sites in January and occasionally May 2005; one site in September 2006; and four sites in January 2007 (see figure 4 and attachment 1).
Region 6 surveys were conducted at four sites in January and May 2003, five sites in January and February 2005, and three sites in January 2007. Region 7 surveys were conducted at 4 sites in October 2002; 11 sites in January and/or May 2003, with 1 site sampled for 5 nights in January, July, and October; 5 sites in February or June 2004; 4 sites in February or June 2005; 3 sites in January, February, or May 2006; and 5 sites in January 2007. Region 8 surveys were conducted at 6 sites in October 2002; 19 sites in an extensive sampling effort in 2003 ranging from 1 night to 8 nights during January, May, and/or July; 9 sites from 1 to 6 nights during February, April, May, and/or June 2004; 9 sites from 1 to 5 nights during February and/or May 2005; 3 sites in January or June 2006; and 3 sites in January 2007 (see figure 5 and attachment 1).
Region 9 surveys were conducted at 6 sites in January, February, and May 2003; 21 sites in February, April, and May 2004; 6 sites in May 2005; and 5 sites in January 2007 (see figure 6 and attachment 1). Acoustic bat survey efforts concentrated on both sides of the Colorado River from Imperial Dam through the Mittry Lake area as well as sites near Picacho, California, and sites near Yuma, Arizona.
METHODS

Acoustic Data Collection

Acoustic bat surveys were conducted using a variety of Titley Scientific Anabat acoustic bat detectors. As the technology was developed, increasingly sophisticated equipment was used. Dr. Robert Berry worked closely with Chris Corben (Analook software developer) to test and refine the new Anabat bat detectors. In 2002, Anabat detectors recorded calls onto either a tape recorder or a laptop computer powered by a deep-cycle recreational vehicle or marine battery (Brown and Berry 2003). This early equipment was replaced by Anabat II bat detectors coupled to zero-crossing analysis interface modules (ZCAIMs), and later by Anabat SD1 detectors (ZCAIM and detector combined in a single unit), as outlined by Brown (2006), which allowed bat calls to be recorded directly onto compact flash cards.

Bat Call Analysis

The minimum frequency, duration, and shape of each call sequence (bat pass) was compared with reference calls from libraries of positively identified bats from throughout the Western United States as well as reference calls recorded on the LCR following the method outlined in Thomas et al. (1987). A bat pass is defined as a call sequence of duration greater than 0.5 millisecond and consisting of more than two individual calls (Thomas 1988; O’Farrell and Gannon 1999).

A bat call minute (bat minute) is a relative activity index that eliminates the bias of overestimating bat relative abundance if multiple files of the same individual were recorded in a short period of time or underestimating bat abundance because of multiple individuals recorded within a single file (Kalcounis et al 1999; Brown 2006). A call minute indicates that a given species is present if it was recorded at least once within a 1-minute period regardless of the number of call sequences recorded within that minute. The highest rating a bat species can have is 60 in an hour, indicating that the species (but not necessarily the same individual) is recorded continuously during the hour (Brown 2006; Williams et al 2006; Miller 2001).

One of the most challenging aspects of bat call identification is the frequent overlap of call characteristics among bat species. The habitat the bat is flying over, wind, humidity, the presence of ponded water, decibels of calls (“shouters” such as big brown bats (*Eptesicus fuscus*) produce 110-decibel calls versus “whisperers” such as the pallid bat (*Antrozous pallidus*) that produce 60-decibel calls), and the presence of other bats of the same species or other species in the same airspace may all play a role in call identification. These challenges have been well documented by many bat researchers and are summarized by the
Western Bat Working Group (2004). A species group was assigned in cases where there were significant portions of the call envelope (all the characteristic calls of a species) that overlapped with other bat species. Table 1 identifies the bat species, and table 2 identifies the species groups used for post-analysis bat monitoring.

Table 1.—Bat species identified along the LCR

<table>
<thead>
<tr>
<th>Scientific name</th>
<th>Common name</th>
<th>Species code</th>
</tr>
</thead>
<tbody>
<tr>
<td>Antrozous pallidus</td>
<td>Pallid bat</td>
<td>ANPA</td>
</tr>
<tr>
<td>Corynorhinus townsendii (= Plecotus townsendii)</td>
<td>Townsend’s big-eared bat</td>
<td>PTBB</td>
</tr>
<tr>
<td>Subspecies: Corynorhinus townsendii pallescens = Plecotus townsendii pallescens = C. townsendii townsendii</td>
<td>(including the subspecies found along the LCR commonly referred to as the pale Townsend’s big-eared bat)</td>
<td></td>
</tr>
<tr>
<td>Eptesicus fuscus</td>
<td>Big brown bat</td>
<td>EPFU</td>
</tr>
<tr>
<td>Eumops perotis</td>
<td>Western mastiff bat</td>
<td>EUPE</td>
</tr>
<tr>
<td>Lasiurus blossevillii</td>
<td>Western red bat</td>
<td>WRBA</td>
</tr>
<tr>
<td>Lasiurus cinereus</td>
<td>Hoary bat</td>
<td>LACI</td>
</tr>
<tr>
<td>Lasiurus xanthinus</td>
<td>Western yellow bat</td>
<td>WYBA</td>
</tr>
<tr>
<td>Macrotus californicus</td>
<td>California leaf-nosed bat</td>
<td>CLNB</td>
</tr>
<tr>
<td>Myotis californicus</td>
<td>California myotis</td>
<td>MYCA</td>
</tr>
<tr>
<td>Myotis occultus*</td>
<td>Arizona myotis</td>
<td>MYOC</td>
</tr>
<tr>
<td>Myotis velifer</td>
<td>Cave myotis</td>
<td>MYVE</td>
</tr>
<tr>
<td>Myotis yumanensis</td>
<td>Yuma myotis</td>
<td>MYYU</td>
</tr>
<tr>
<td>Nyctinomops femorosaccus</td>
<td>Pocketed free-tailed bat</td>
<td>NYFE</td>
</tr>
<tr>
<td>Nyctinomops macrotis</td>
<td>Big free-tailed bat</td>
<td>NYMA</td>
</tr>
<tr>
<td>Parastrellus hesperus</td>
<td>Canyon bat</td>
<td>PAHE</td>
</tr>
<tr>
<td>Tadarida brasiliensis</td>
<td>Mexican free-tailed bat</td>
<td>TABR</td>
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</table>

* The Arizona myotis was the one new species identified during the course of the study.
Table 2.—Bat call groups along the LCR
(These groups consist of species with overlapping, similar call characteristics that cannot be identified to a single species.)

<table>
<thead>
<tr>
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<th>Overlapping calls of:</th>
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<tr>
<td>15–19</td>
<td>Pocketed free-tailed bat (<em>Nyctinomops femorosaccus</em>), hoary bat, and Mexican free-tailed bat</td>
</tr>
<tr>
<td>20–24</td>
<td>Pocketed free-tailed bat, hoary bat, and Mexican free-tailed bat</td>
</tr>
<tr>
<td>24–30</td>
<td>Big brown bat, Mexican free-tailed bat, and pallid bat</td>
</tr>
<tr>
<td>30–35</td>
<td>Big brown bat, Mexican free-tailed bat, and pallid bat</td>
</tr>
<tr>
<td>35–40</td>
<td>Arizona myotis and cave myotis (<em>Myotis velifer</em>)</td>
</tr>
<tr>
<td>40–44</td>
<td>Yuma myotis and canyon bat</td>
</tr>
<tr>
<td>45–55</td>
<td>California myotis, Yuma myotis, canyon bat, and California leaf-nosed bat</td>
</tr>
<tr>
<td>50–55</td>
<td>California myotis, Yuma myotis, and California leaf-nosed bat</td>
</tr>
<tr>
<td>55–65</td>
<td>California myotis and California leaf-nosed bat</td>
</tr>
<tr>
<td>My40</td>
<td>Dr. Robert Berry’s myotis category – cave myotis and Yuma myotis</td>
</tr>
<tr>
<td>My50</td>
<td>Dr. Robert Berry’s myotis category – California myotis and Yuma myotis</td>
</tr>
</tbody>
</table>

Susan Broderick was the acoustic analyst for this project because of her extensive experience with acoustic surveys conducted at habitat conservation areas as part of the LCR MSCP from 2007 through 2014 (Broderick 2013a, 2013b and 2016). The continuity of keeping the same analyst helped to ensure that the analysis of the call files collected for this project was consistent with the analysis conducted from 2007 to 2015.

**RESULTS**

**Test and Refine the Protocols for Acoustic Bat Monitoring**

As stated in the “Methods” section above, a variety of Titley Scientific Anabat acoustic bat detectors were tested and used during the study. Dr. Robert Berry worked closely with Chris Corben (Analook software developer) to test and refine the new Anabat bat detectors. As the technology was developed, increasingly sophisticated equipment was used. In 2002, Anabat detectors recorded calls onto
either a tape recorder or a laptop computer powered by a deep-cycle recreational vehicle or marine battery (Brown and Berry 2003). This early equipment was replaced by Anabat II bat detectors coupled to ZCAIMs, and later by Anabat SD1 detectors (ZCAIM and detector combined in a single unit), as outlined by Brown (2006), which allowed bat calls to be recorded directly onto compact flash cards.

Calls from bat species were recorded and used to identify the calls recorded on the acoustic bat detectors. Acoustic bat detectors were deployed for all or part of 382 nights in at least 128 locations (attachment 1) and recorded 104,435 identifiable bat calls. Sixteen species could be identified using this acoustic monitoring method. In addition, bat calls that had overlapping, similar call characteristics were also identified. Species groups were created consisting of bats with overlapping, similar call characteristics, as done by Betts (1998), Rainey et al. (2009), and the Western Bat Working Group (2004) (see table 2), and these were used to identify species and species groups when bats could not be identified to a single species acoustically.

**Bat Assemblage Detection Results**

The results of 6 years of exploratory acoustic bat surveys from the fall of 2002 through the spring of 2007 are presented using the same five groups of species used by Brown and Berry (2003). The five categories are:

1. Species that were at one time relatively abundant along the LCR and were apparently extirpated or restricted to relatively few areas. This group includes the Arizona myotis, cave myotis (Myotis velifer), and the Townsend’s big-eared bat (all subspecies present along the LCR).

2. Species that were relatively common along the LCR. This group includes the canyon bat, Yuma myotis, California myotis, and the Mexican free-tailed bat.

3. Species that were found along the entire LCR, but were less abundant, possibly because of restricted roosting or foraging habitat preferences. This group includes the big brown bat, pallid bat, pocketed free-tailed bat (Nyctinomops femorosaccus), western mastiff bat (Eumops perotis), and the California leaf-nosed bat.

4. Species that may occur sporadically along the LCR or have very restricted habitat requirements. This group includes the hoary bat, western yellow bat, western red bat, spotted bat (Euderma maculatum), and the big free-tailed bat (Nyctinomops macrotis).
5. Species for which there are currently no confirmed records for the LCR, but they may be detected in the future. This group includes the Allen’s big-eared bat (*Idionycteris phyllotis*), Mexican long-tongued bat (*Choeronycteris mexicana*), and the lesser long-nosed bat (*Leptonycteris curasoae*).

It is important to note that this was an exploratory acoustic sampling effort; therefore, the total bat minutes for a species can be influenced by the species’ activity in the area, weather, the number of survey locations for each region and year, and how long the bat detector was deployed each night. Some detectors were set out only during mine exit counts for a few hours, and some detectors were deployed for the entire night. The data shown in figures 7–22 give a guide of how readily a particular species is detected. The number of bat calls cannot be used to estimate the abundance of bats. The bats need to pass near the acoustic detector in order to be recorded, and it is impossible to determine if it is same bat being recorded multiple times or many different individuals.

**Category 1 – Bats Restricted to Relatively Few Areas**

**Arizona Myotis**

Arizona myotis were detected in Regions 2, 4, and 5 (figure 7). Total bat minutes ranged from 1 to 9, with Region 2 (Havasu NWR area) having the highest number of bat minutes. This species was not detected in Regions 1, 3, 6, 7, 8, or 9. The only two known roosts of this species are in Regions 6 and 7. Although no Arizona myotis have been detected in Region 2 with acoustic detectors, this was the region in which the first historical capture of Arizona myotis and a description of the species (type locality) occurred.

![Arizona Myotis](chart)

**Figure 7.**—Arizona myotis total bat minutes, 2002–07, for each region.
Cave Myotis

Cave myotis (figure 8) were detected in every region except Region 9 (below Imperial NWR), although some were at low levels. Region 1 (Lake Mohave area) had only 1 bat minute recorded in 2003. Peak activity was recorded in Region 4 (Bill Williams River NWR) and in Region 5 (Parker Strip). Two cave myotis roosts are located in Planet Mine and in the Californian Mine near the Parker Strip.

Figure 8.—Cave myotis total bat minutes, 2002–07, for each region.
**Townsend’s Big-eared Bat**

Townsend’s big-eared bats were detected acoustically at extremely low levels at all of the national wildlife refuges (Regions 2, 4, 5, 7, and 8) as well as the Parker Strip (figure 9) (note the scale on the y-axis). In spite of multi-year acoustic sampling at the Bill Williams River NWR, only 3 bat minutes were recorded. The Mountaineer Mine in Region 6 is the only known roost for these bats along the main LCR, and recordings made outside the mine did not even detect this “whispering” bat. This species is currently a LCR MSCP evaluation species.

It is assumed that most of the Townsend’s big-eared bats are pale Townsend’s big-eared bats (*Corynorhinus townsendii pallescens* = *Plecotus townsendii pallescens* = *C. townsendii townsendii*). 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 (*Corynorhinus townsendii townsendii*) rather than the pale Townsend’s big-eared bat (Piaggio and Perkins 2005).

![Figure 9](image-url)

**Figure 9.—** Townsend’s big-eared bat total bat minutes, 2002–07, for each region.
Category 2 – Relatively Common Bats Along the Lower Colorado River

*Canyon Bat*

Canyon bats are a ubiquitous and abundant species. They were detected at all sites for all years (figure 10). There were activity peaks at both the Bill Williams River NWR and Imperial NWR, ranging from approximately 1,000 bat minutes to nearly 1,700 bat minutes.

![Canyon Bat Total Bat Minutes by Year for Each Region and General Area](image)

*Figure 10.*—Canyon bat total bat minutes, 2002–07, for each region.
**Yuma Myotis**

The Yuma myotis is a common species, and it was recorded throughout all of the regions (figure 11) at fairly low bat minute numbers with the exception of Region 3 in the Lake Havasu area. This is a bat that prefers to forage over large ponds or lakes. Activity peaked in Region 3 (Lake Havasu area) in 2003 at 243 bat minutes of activity and a modest level of activity in 2004 with 101 bat minutes of activity, although this could be an indicator of sampling level. Other regions with modest numbers of bat minutes included Region 4 (Bill Williams River NWR) in 2005, with 96 bat minutes, and Region 8 (Imperial NWR) in 2003, with 54 bat minutes of activity.

![Figure 11. Yuma myotis total bat minutes, 2002–07, for each region.](image-url)
California Myotis

Although recorded in all regions, the overall bat activity for California myotis (figure 12) as measured by total bat minutes was relatively low with the exception of Region 5 in 2002, with 172 bat minutes, and Region 3 in 2003, with 68 bat minutes.

Mexican Free-tailed Bat

Mexican free-tailed bats were well represented throughout all nine regions. There was some year-to-year variability largely due to the differences in sampling intensity. Peak activity was recorded in Regions 1, 2, 3, 5, 8, and 9, with total bat minutes ranging from 300 to 425. Several large roosts of this species occur near Lake Havasu (Region 3). This species prefers to roost in caves, some mines, and areas with cliff faces.
Category 3 – Less Abundant Bats Along Lower Colorado River

**Big Brown Bat**

Big brown bats were detected in all regions in all years sampled. Peak activity occurred in Region 7 (Cibola NWR) in 2006, with 186 bat minutes. Another moderate peak occurred in 2003 in Region 8 (Imperial NWR), with 96 bat minutes. Most other regions and years were less than 20 bat minutes. No roost has yet been identified in Region 7, but a mine roost occurs along the LCR near the gauging station at the Imperial NWR.

![Figure 14](image)

**Pallid Bat**

Pallid bats were detected in all regions in all years (figure 15). Peak activity as measured by total bat minutes was observed at two regions. Region 4 (Bill Williams River NWR) had peaks ranging from 51 to 68 bat minutes. These bats prefer to roost in rock crevices and mines. A mine roost occurs in the Planet Ranch area of the Bill Williams River (Region 4).

![Figure 15](image)
Pocketed Free-tailed Bat

While pocketed free-tailed bats were detected in all regions in nearly every year (figure 16), Region 4 (Bill Williams River NWR) had an overwhelmingly large amount of total bat minutes for 2003 through 2005, ranging from 378 to 535 bat minutes. Recordings were often made near a cliff roost for this species. Region 7 (Cibola NWR) and Region 8 (Imperial NWR) also had total bat minutes exceeding 100.

Figure 16.—Pocketed free-tailed bat minutes, 2002–07, for each region.
Western Mastiff Bat
Western mastiff bats were detected in all regions in all years (figure 17), with peak total bat minutes found in Region 8 (Imperial NWR) ranging from 178 to 181. Moderate activity was also observed in Region 4, with 80 bat minutes, and in Region 9 with 83 bat minutes. This large cliff-roosting species usually forages over wide areas while emitting an echolocation signal in the human audible range. They are often heard by people and not recorded on the bat detectors because the calls are below the frequency threshold of the standard microphones used for high-frequency bats.

Figure 17.—Western mastiff bat total bat minutes, 2002–07, for each region.
California Leaf-nosed Bat
California leaf-nosed bats are “whispering” bats that rely on vision and prey-produced sounds while foraging, which makes recording calls problematic. However, this species was recorded at all nine regions (figure 18). Peak activity was recorded at Region 9 (below Imperial Dam), with 42 bat minutes recorded. This is due to the detectors being deployed near the 3C Mine, which is a year-round roost for this species. Other regions with relative high numbers of bat minutes included Region 3 (Lake Havasu), with a peak of 24 bat minutes; Region 4, with peaks of 20 to 29 bat minutes; Region 5, with a peak of 19 bat minutes; Region 6, with peak of 14 bat minutes; Region 7, with peak of 18 bat minutes; and Region 8, with a peak of 13 bat minutes. For a whispering bat species, these are phenomenal numbers of bat minutes recorded with an acoustic detector. There is a California leaf-nosed bat mine roost in each region, and recording was usually conducted during exit counts in winter or spring. This species is currently a LCR MSCP evaluation species.

Category 4 – Bats Occurring Sporadically Along the Lower Colorado River or with Very Restricted Habitat Requirements

Spotted Bat
Spotted bats were not detected during acoustic monitoring surveys between 2002 and 2007. (Note: They are still included in this grouping because a museum specimen for this species exists from east of Yuma, Arizona.)
**Hoary Bat**

Hoary bats were recorded in all nine regions at low levels ranging from 1 to 7 bat minutes (figure 19). The exception is Region 4 (Bill Williams River NWR), with 17 bat minutes, which is an area that has historically large cottonwoods for roosting and foraging habitat.

![Figure 19. Hoary bat total bat minutes, 2002–07, for each region.](image)
Western Yellow Bat

A small number of western yellow bat minutes were recorded across all nine regions, with the exception of 2004 in Region 5 (Parker Strip), where high values ranging from 119 to 294 (figure 20) bat minutes were recorded. Proctor Palms and Cienega Springs in Region 5 provide abundant habitat for this palm-roosting species. Western yellow bats are a LCR MSCP covered species.

Figure 20.—Western yellow bat total bat minutes, 2002–07, for each region.
Western Red Bat

Western red bats were recorded throughout the nine regions, with large peaks in bat minutes occurring in Region 4 (Bill Williams River NWR) (figure 21). The Bill Williams River was where the first specimen for the LCR was captured in a mist net in January 2003 (Brown and Berry 2003). Bat minute numbers during the survey ranged from 47 to 87 and are considered very large numbers of bat minutes for this relatively scarce species. Western red bats are a LCR MSCP covered species.

Figure 21.—Western red bat total bat minutes. 2002–07, for each region.
Big Free-tailed Bat

Big free-tailed bats were detected in all regions, except Region 6, in surprisingly large numbers of bat minutes in some cases. Peak activity was recorded in Region 2 (Havasu NWR) in 2005, with 38 bat minutes, and in Region 1 (Lake Mohave), with 27 bat minutes. These rare bats have not been captured along the LCR.

![Big Free-tailed Bat Total Bat Minutes by Year for Each Region and General Area](image)

Figure 22.—Big free-tailed bat total bat minutes, 2002–07, for each region.

Category 5 – Bats with No Confirmed Records on the Lower Colorado River

Allen’s big-eared bats, Mexican long-tongued bats, and lesser long-nosed bats were not detected during acoustic monitoring surveys between 2002 and 2007.

DISCUSSION

Along the LCR, Arizona myotis and cave myotis are riparian specialists (Arizona Game and Fish Department 2016; Reid 1997; Calvert and Neiswenter 2012; Brown and Berry 2003). Arizona myotis are primarily found over water, near water, or in riparian forests in desert areas. This species, long thought to be extirpated from the LCR, was captured during mist netting during 2007–10 (Calvert and Neiswenter 2012). The 2002–07 acoustic data show that the Arizona myotis was present at the Bill Williams River NWR and possibly along the Parker Strip (see figure 4) prior to the advent of sampling activities under the LCR MSCP. The cave myotis is found in riparian habitats near desert scrub in lower elevations (Reid 1997). Cave myotis activity was relatively high through
the sample areas, especially the recordings conducted near mine roosts. Acoustic results for the Arizona myotis presented in figure 7 are exciting, showing that this elusive species was present along the LCR in the complex habitats at the Havasu NWR and Bill Williams River NWR in addition to the cave myotis, which was also recorded along the Parker Strip.

The three lasurine tree-roosting bats (western yellow, western red, and hoary) were documented along the LCR during the acoustic surveys of 2002–07 presented here. The western red bat was particularly active in the Bill Williams River NWR and was present throughout the sample areas. The western yellow bat was also recorded throughout the sample areas, with high levels of activity in the Parker Strip area where non-native Mexican fan palms (*Washingtonia robusta*) are abundant. Hoary bats were present throughout the sample areas at low levels of activity. Broderick (2016) reports that hoary bat activity has increased markedly in riparian restoration areas created under the LCR MSCP in recent years (2010–14). The spotted bat was not detected during acoustic monitoring surveys between 2002 and 2007. It also was not mist netted along the LCR or recorded in other extensive bat monitoring efforts between 2002 and 2016.

There are four molossid bat species in California and Arizona: western mastiff bat, pocketed free-tailed bat, Mexican free-tailed bat, and the big free-tailed bat. Molossids have long, slender wings adapted for rapid, prolonged flight in open areas and are the fastest flying bat species in North America (Best et al. 1996; Western Bat Working Group 2016). They usually prefer cliff-roosting habitat, but Mexican free-tailed bats occasionally roost in mines. There is some controversy about the identification of big free-tailed bat calls in the exploratory acoustic surveys of 2000–02. While the calls meet species identification criteria, it is possible that the big free-tailed bat calls overlap with the similar pocketed free-tailed bat calls. To the authors’ knowledge, no one working along the LCR has reported capturing a big free-tailed bat. However, Hinman and Snow (2003) show suitable big free-tailed bat habitat throughout the State, including areas along the LCR. Caution should be taken in interpreting big free-tailed bat calls until an actual bat is captured in a mist net. While the call identification was based on strict minimum frequency criteria, it is also possible that the mastiff bat’s calls may overlap those of the big free-tailed bat. Based on the call identification used, the western mastiff bat was consistently present across all regions, and big free-tailed bats and Mexican free-tailed bats were particularly active throughout the sampling areas. Apparent decreases in bat detections in 2006 and 2007 were a function of a lower sampling effort during those years (see attachment 1 for a description of sample sites and dates of sampling).

Allen’s big-eared bats, Mexican long-tongued bats, and lesser long-nosed bats were not detected during acoustic monitoring surveys between 2002 and 2007. They also were not mist netted along the LCR or recorded in other extensive bat monitoring efforts between 2007 and 2016.
LITERATURE CITED


Acoustic Monitoring for Lower Colorado River Bat Species
September 2002 to May 2007


ATTACHMENT 1

Acoustic Sample Sites and Dates by Region
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