Final Report

Acoustic Inventory and Monitoring of Bats at National Parks in the San Francisco Bay Area

Gary M. Fellers
Western Ecological Research Center, USGS
Point Reyes National Seashore
Point Reyes, CA 94956

August 2007

The bat monitoring program is designed to collect data on the presence of bats in National Park Service (NPS) areas in the San Francisco Bay Area. In 2002 and 2003, this included Point Reyes National Seashore, Golden Gate National Recreation Area, Eugene O'Neill National Historic Park, and John Muir National Historic Site. In addition to creating a species list, data will be analyzed to evaluate bat activity throughout each night, as well as on each night throughout the year. By comparing data from several monitoring stations, it will be possible to look for trends related to habitat, location within a park, and regional patterns throughout the bay area parks.

Acoustic Monitoring Stations

The first long-term bat monitoring station was setup in December 1999 at the Bear Valley headquarters of Point Reyes National Seashore. It has been in continual operation ever since. In 2002, nine additional bat monitoring stations were installed. One monitoring station was setup in each of three additional park areas: Eugene O'Neill NHS, John Muir NHS, and the northern lands of Golden Gate NRA (Wilkins Ranch). Six new monitoring stations were

added to Point Reyes NS. The location of all stations is shown in Appendix 1, and the UTM coordinates are given in Appendix 2.

All monitoring stations were setup in buildings with 110v power. This power supply allowed for more reliable operation of the monitoring equipment, and the buildings provided a secure location. Whenever possible, bat monitoring stations were chosen so they were near apparently good bat habitat, and also near a source of water that bats might use (e.g. pond, small stream).

Bat vocalizations are detected using an Anabat bat detector (Fig. 1). Each bat detector is adjusted to a standardized signal so sensitivity between detectors is identical. Vocalizations are stored on a portable computer hard drive. Figures 2-6 show some of the monitoring stations, illustrating typical placements of bat detectors and the surrounding habitat.

There were some continuing problems of operation. The Dell computers have a power plug that is easily dislodged, thus allowing the computer to run down the battery and quit functioning. Steps were taken to tape the plugs in place, and the computers subsequently worked more reliably. The IBM portable computers tended to run hot. This was probably caused by the power management software. This software runs under Windows and controls the cooling fans. The bat monitoring software requires that the computers run in DOS mode. Hence, the cooling fans did not operate normally and the computers periodically shut down due to overheating. While this did not damage any equipment, it did result in less data from certain sites. Ways to alleviate the cooling problem are being explored.

Identification of Calls

The Anabat bat detector records ultrasonic sounds and lowers them into a frequency range that can 1) be heard by the human ear, and 2) can be conveniently stored on a computer hard drive. The Analook software displays these sounds in a graphic format that is similar to a sonogram that is typically used for analysis of bird vocalizations (e.g. frequency versus time). The typical

call of a Mexican free-tailed bat is shown in Figure 7. Typical of most bat calls, each vocalization sweeps down in frequency (pitch). The slope of this sweep, and the lowest frequency are important features that assist in identification of bat vocalizations.

Since each call is separated by a longer period of silence (during which time the bat is listening for echoes), it is convenient to display bat vocalizations with the intervening "dead space" removed so that the display is a closely spaced series of calls. Figure 8 shows the same bat call with the time between each vocalization removed; this also results in more calls in the sequence being displayed. The calls of this species are characterized by a relatively low frequency and a fairly flat slope.

The calls of silver-haired bats (Fig. 9) and big brown bat (Fig. 10) are quite different. The figure legends point out some of the diagnostic features. Not all bat calls are so distinct, and the characteristics of a call can change a great deal, depending on what the bat is doing. For example, an individual bat will tend to produce lower pitched calls that sweep through a small range of frequencies when the bat is flying in the open. If the bat flies through the more cluttered understory of a forest, the calls increase in pitch, tend to sweep through a wider range of frequencies, and occur more frequently. All these changes function to provide the bat with more information about the environment in which it is flying. Calls also change when a bat detects a flying insect.

Search phase call, feeding buzzes, and social vocalizations can be played from the Western Ecological Research Center, USGS, web site. Visit: http://www.werc.usgs.gov/bats/batstudiesnorth.html.

The variability in vocalizations within each species means that not all calls are easily assignable to one species. The prototype software, being developed by Chris Corben (http://users.lmi.net/corben/) as part of this project, examines 8-10 features of each call and compares the characteristics to those of calls from known species of bats. Calls that are a close match are assigned to a particular species. We use fairly conservative criteria so that we

have a high level of confidence that a call assigned to a given species is correct. As we refine our species-specific filters, we should be able to assign more calls to particular bat species.

Results

Table 1 shows the number of calls recorded at each of the 11 bat monitoring stations during 2002, and Figure 11 shows the same results graphically. Figures 12 – 16 show similar data for several species of bats.

Table 2 shows the number of calls recorded at each of the 11 bat monitoring stations during 2003, and Figure 17 shows the same results graphically. Figures 18 – 22 show similar data for several species of bats.

There are some large differences between monitoring sites. These differences are likely due to 1) the number of individual bats in the vicinity of the detector, and 2) the activity of a few bats that might be foraging (e.g. flying back and forth) in the vicinity of the detector. There are known bat roosts in the vicinity of the detector at the Environmental Education Center, the Point Reyes Bird Observatory (PRBO), and the Wilkins Ranch. Interestingly, there is almost certainly not a roost in the vicinity of the detector at Olema Marsh, one of the sites where a fairly large number of bats were detected.

The fewest calls/day were recorded at the North District Office Center (NDOC) and at Eugene O'Neill NHS. The low number of bats at NDOC would be expected since it is out on the Point Reyes Peninsula in an area where there is more wind and cooler temperatures compared with the other Point Reyes monitoring sites. The low numbers of bats recorded at Eugene O'Neill is surprising since the detector is only about 100 yards from a large pond on the adjacent open space property.

Tables 3 and 4 show the species of bats detected at each of the 11 monitoring sites in 2002 and 2003, respectively. Some bats were detected at all stations, e.g. Mexican free-tailed bat, red bat, hoary bat. Two of the most common bats in the San Francisco area (California myotis and Yuma myotis) are somewhat difficult to distinguish acoustically, so they are lumped together

in the first column. This species pair was detected at all 11 sites. It is likely that we will be able to sort out the calls of these two species as we further develop and refine our call filters.

One moderately uncommon bat (long-eared myotis) that we thought might be in the area was not detected anywhere. The other species listed in the table were found in some, but not all sites. It is likely that the number of species detected at each site will increase as monitoring continues.

Table 1. Number of bat calls detected at each of the 11 monitoring sites in 2002.

	Days	**Calls**	**Calls/Day**
Bear Valley	354	277,989	785.3
Ed Center	141	1,065,861	7,559.3
Eugene O'Neill	86	18,104	210.5
John Muir	166	126,652	763.0
Learning Center	159	49,340	310.3
NDOC	147	30,536	207.7
Olema Marsh	107	219,707	2,053.3
PRBO	228	608,249	2,667.8
PRNSA	48	15,645	325.9
Shallow Beach	121	91,865	759.2
Wilkins Ranch	186	330,302	1,775.8

Table 2. Number of bat calls detected at each of the 11 monitoring sites in 2003.

	Days	**Calls**	**Calls/Day**
Bear Valley	360	274,378	72.9
Ed Center	331	784,062	154.9
Eugene O'Neill	300	309,536	51.4
John Muir	257	97,308	40.0
Learning Center	140	43,683	21.2
NDOC	186	34,354	13.3
Olema Marsh	317	459,052	73.6
PRBO	317	749,260	64.2
PRNSA	345	158,567	35.2
Shallow Beach	262	116,863	36.2
Wilkins Ranch	294	290,328	56.2

Table 3. Species of bats detected at each of 11 sites monitored during 2002.

	California or Yuma Myotis	Yuma Myotis	Little Brown Myotis	Long-eared Myotis	Fringed Myotis	Big Brown Bat	Siler-haired Bat	Red Bat	Hoary Bat	Mexican Free-tailed bat
	Myotis californicus or *Myotis yumanensis*	*Myotis yumanensis*	*Myotis lucifugus*	*Myotis evotis*	*Myotis thysanodes*	*Eptesicus fuscus*	*Lasionycteris noctivagans*	*Lasiurus blossevillii*	*Lasiurus cinereus*	*Tadarida brasiliensis*
Bear Valley	Y	Y	Y	N	Y	Y	Y	Y	Y	Y
Ed Center	Y	Y	Y	N	Y	Y	Y	Y	Y	Y
Eugene O'Neill	Y	Y	Y	N	Y	N	N	Y	Y	Y
John Muir	Y	Y	Y	N	Y	Y	Y	Y	Y	Y
Learning Center	Y	Y	N	N	Y	Y	Y	Y	Y	Y
NDOC	Y	Y	Y	N	Y	Y	Y	Y	Y	Y
Olema Marsh	Y	Y	Y	N	Y	Y	Y	Y	Y	Y
PRBO	Y	Y	Y	N	N	Y	Y	Y	Y	Y
PRNSA	Y	N	N	N	N	Y	Y	Y	Y	Y
Shallow Beach	Y	Y	Y	N	Y	Y	Y	Y	Y	Y
Wilkins Ranch	Y	Y	Y	N	Y	Y	Y	Y	Y	Y

Table 4. Species of bats detected at each of 11 sites monitored during 2003.

	California or Yuma Myotis	Yuma Myotis	Little Brown Myotis	Long-eared Myotis	Fringed Myotis	Big Brown Bat	Siler-haired Bat	Red Bat	Hoary Bat	Mexican Free-tailed bat
	Myotis californicus or *Myotis yumanensis*	*Myotis yumanensis*	*Myotis lucifugus*	*Myotis evotis*	*Myotis thysanodes*	*Eptesicus fuscus*	*Lasionycteris noctivagans*	*Lasiurus blossevillii*	*Lasiurus cinereus*	*Tadarida brasiliensis*
Bear Valley	Y	Y	Y	N	Y	Y	Y	Y	Y	Y
Ed Center	Y	Y	Y	N	Y	Y	Y	Y	Y	Y
Eugene O'Neill	Y	Y	N	N	Y	Y	Y	Y	Y	Y
John Muir	Y	Y	N	N	N	N	N	Y	Y	Y
Learning Center	Y	Y	N	N	Y	Y	Y	Y	Y	Y
NDOC	Y	Y	Y	N	Y	Y	Y	Y	Y	Y
Olema Marsh	Y	Y	Y	N	Y	Y	Y	Y	Y	Y
PRBO	Y	Y	Y	N	Y	Y	Y	Y	Y	Y
PRNSA	Y	Y	Y	N	Y	Y	Y	Y	Y	Y
Shallow Beach	Y	Y	Y	N	Y	Y	N	Y	Y	Y
Wilkins Ranch	Y	Y	Y	N	Y	Y	Y	Y	Y	Y

Figure 1. Anabat bat detector inside a waterproof box, ready to mount. A multistrand wire is used to power to the detector and to bring the signal back to a computer inside the building.



Figure 2. Location of the bat detector at Bear Valley, Point Reyes National Seashore. The bat detector is located adjacent to the lower eve that covers the steps at the far end of the building. Habitat is Douglas fir forest edge with nearby riparian along a small creek draining into Tomales Bay.



Figure 3. Location of bat detector at the North District Operations Center (NDOC), Point Reyes National Seashore. The detector is mounted at the lower edge of the second floor window on the far right. Habitat is predominantly non-native cypress, Mediterranean grasslands, and nearby cultivated fields.



Figure 4. Location of the bat detector at the Education Center, Point Reyes National Seashore. The detector is located under the eve near the far window. Habitat is Mediterranean grassland with nearby coyote brush/ceanothus thickets on adjacent hillsides.



Figure 5. Location of the bat detector at Olema Marsh, Point Reyes National Seashore. The detector is located on the eve at the near corner of the house, just above the gate. Habitat is Mediterranean grassland with nearby riparian associated with Olema Marsh.



Figure 6. Location of the bat detector at Shallow Beach, adjacent to Point Reyes National Seashore. The detector is clearly visible near the bottom of the far right side of the deck. Habitat is mixed hardwood conifer adjacent to Tomales Bay.



Figure 7. Sample recording of a Mexican free-tailed bat showing two vocalizations from a series of calls. The Y-axis is frequency (pitch) in kilohertz (kHz), and the X-axis along the bottom is time with each major mark denoting 25 milliseconds.

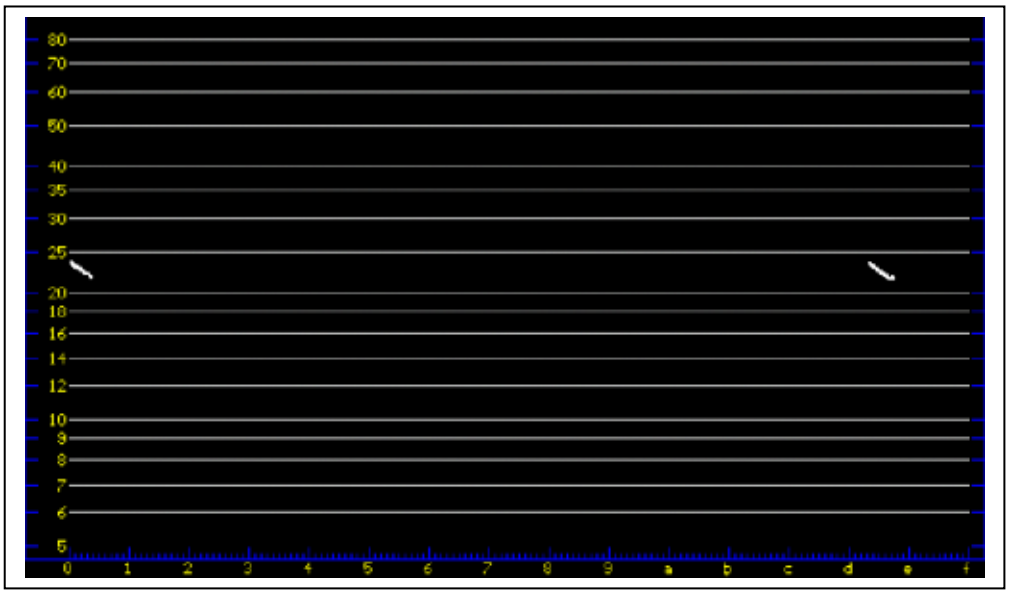


Figure 8. Sample recording of a Mexican free-tailed bat showing a series of vocalizations with the time between each call removed.

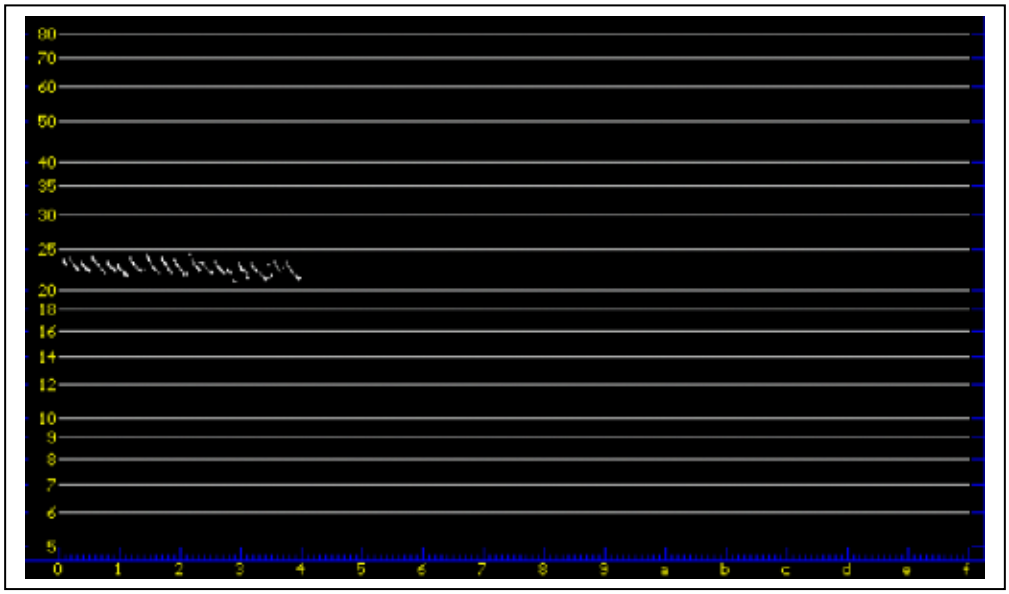


Figure 9. Sample vocalization of a silver-haired bat showing a series of vocalizations with the time between each call removed. Note that each vocalization sweeps down to about 20-25 kHz, but that the lowest frequency is quite variable.

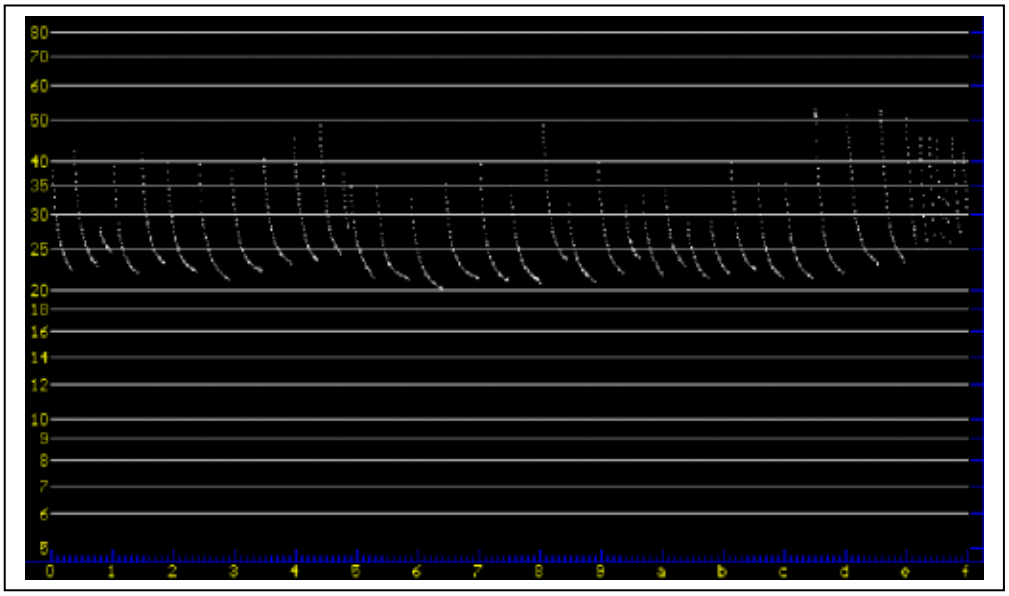


Figure 10. Sample vocalization of a big brown bat showing a series of vocalizations with the time between each call removed. Note that each vocalization sweeps down to about 25-30 kHz and the lowest frequency is fairly consistent from one call to another.

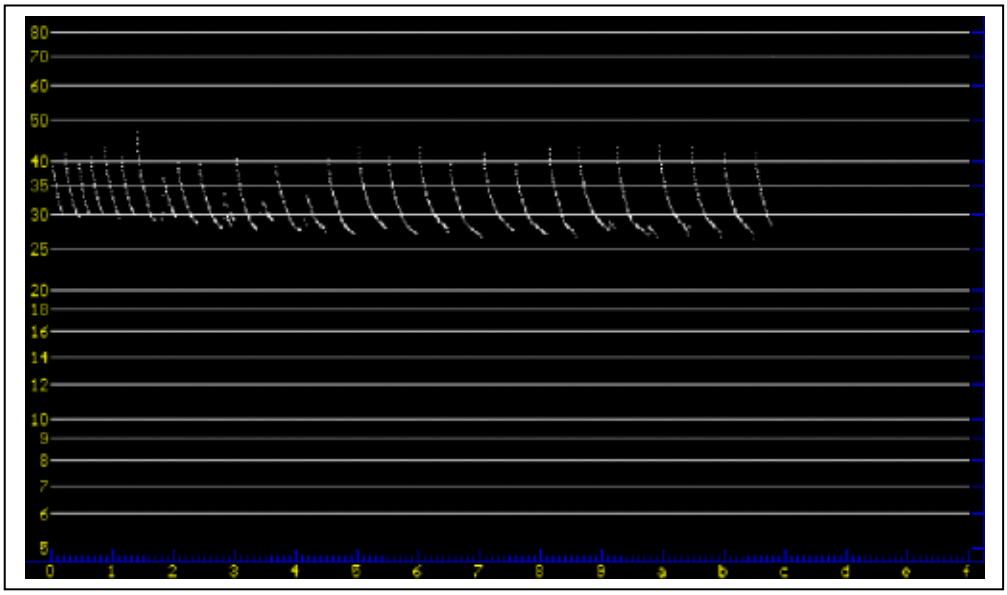


Figure 11. Number of calls detected per day at each of the 11 bat monitoring stations in 2002. Note that the Y-axis is limited to 3,000 and the number of calls at the Ed Center was more than double that number at 7,559.

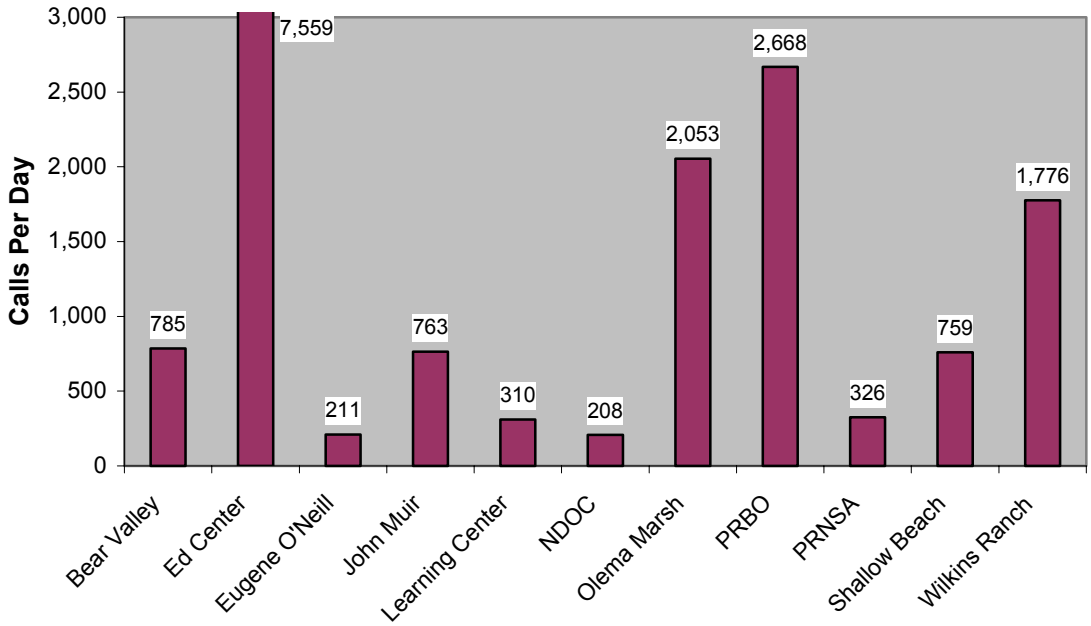


Figure 12. Number of red bat calls per day at each of the 11 monitoring sites in 2002.

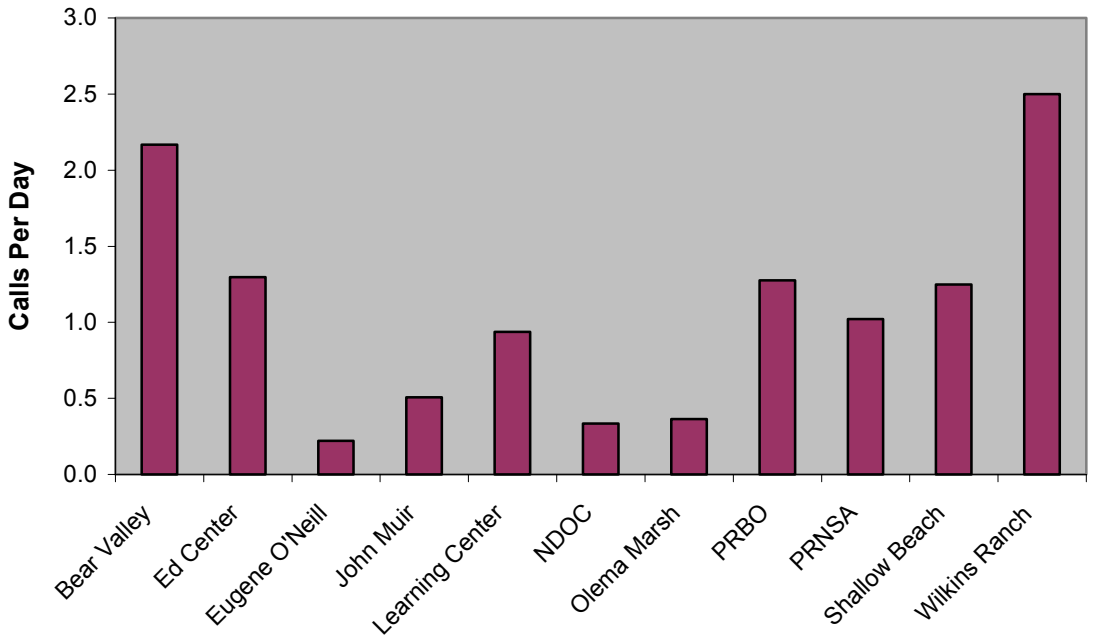


Figure 13. Number of hoary bat calls per day at each of the 11 monitoring sites in 2002.

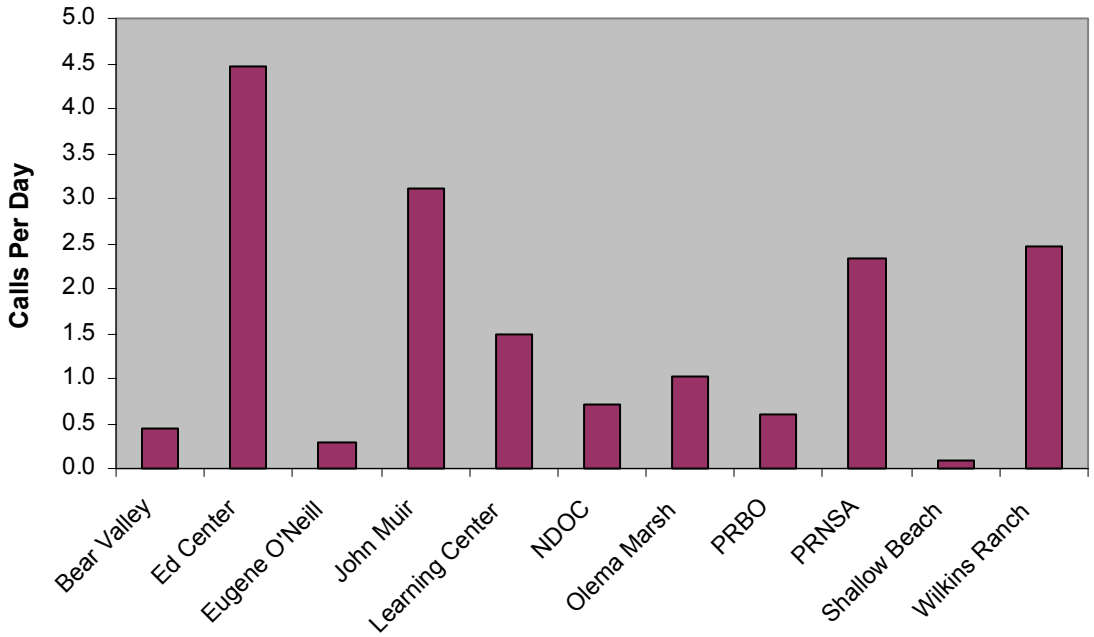


Figure 14. Number of big brown bat calls per day at each of the 11 monitoring sites in 2002.

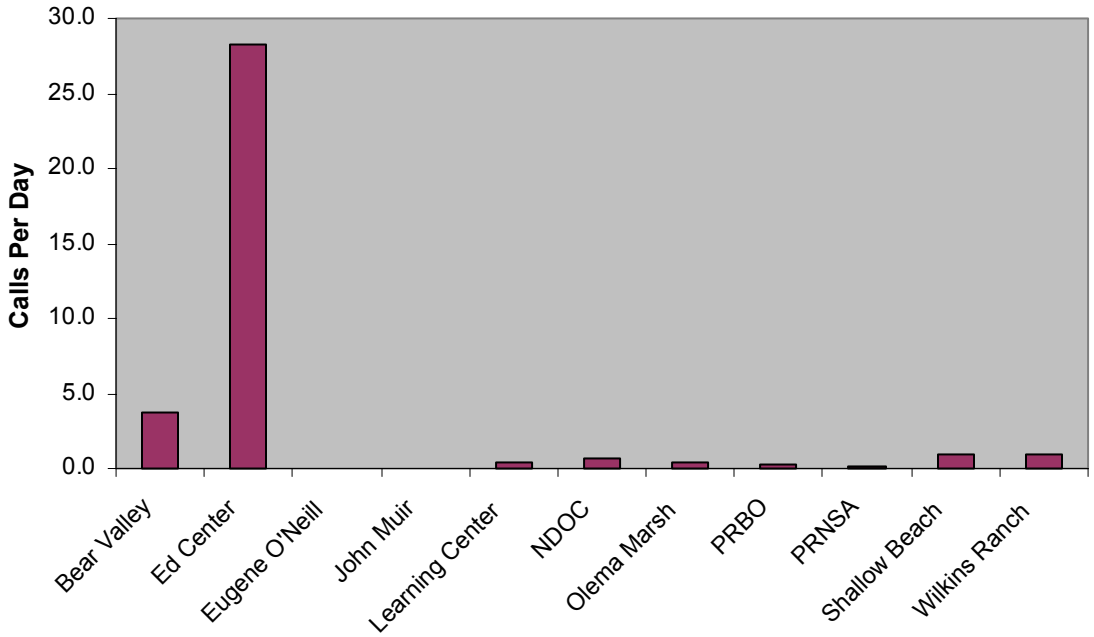


Figure 15. Number of silver-haired bat calls per day at each of the 11 monitoring sites in 2002.

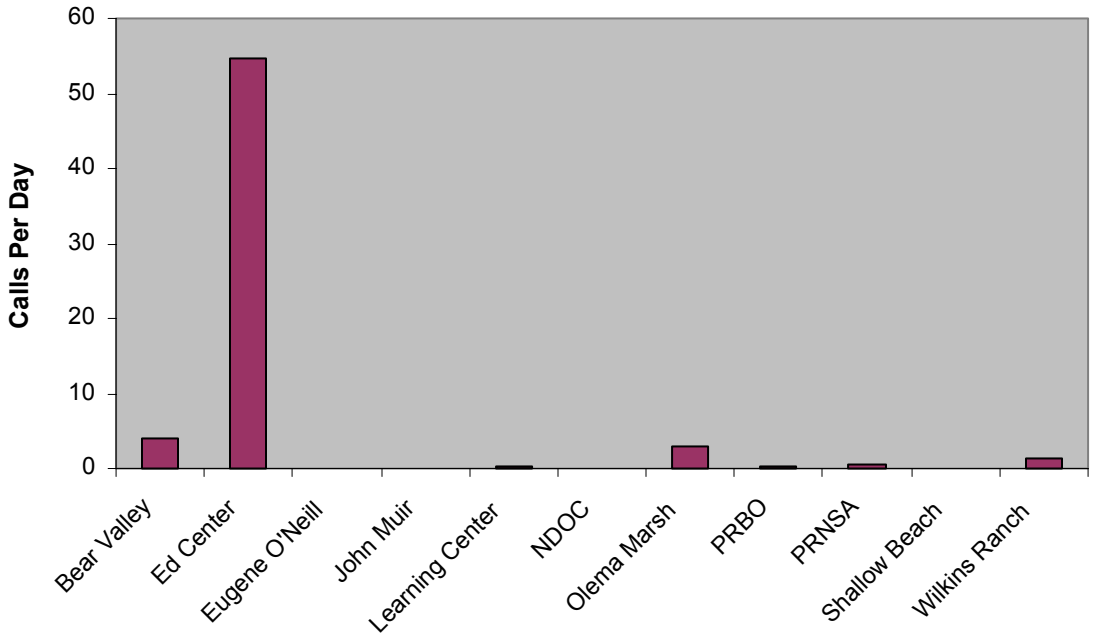


Figure 16. Number of Mexican free-tailed bat calls per day at each of the 11 monitoring sites in 2002.

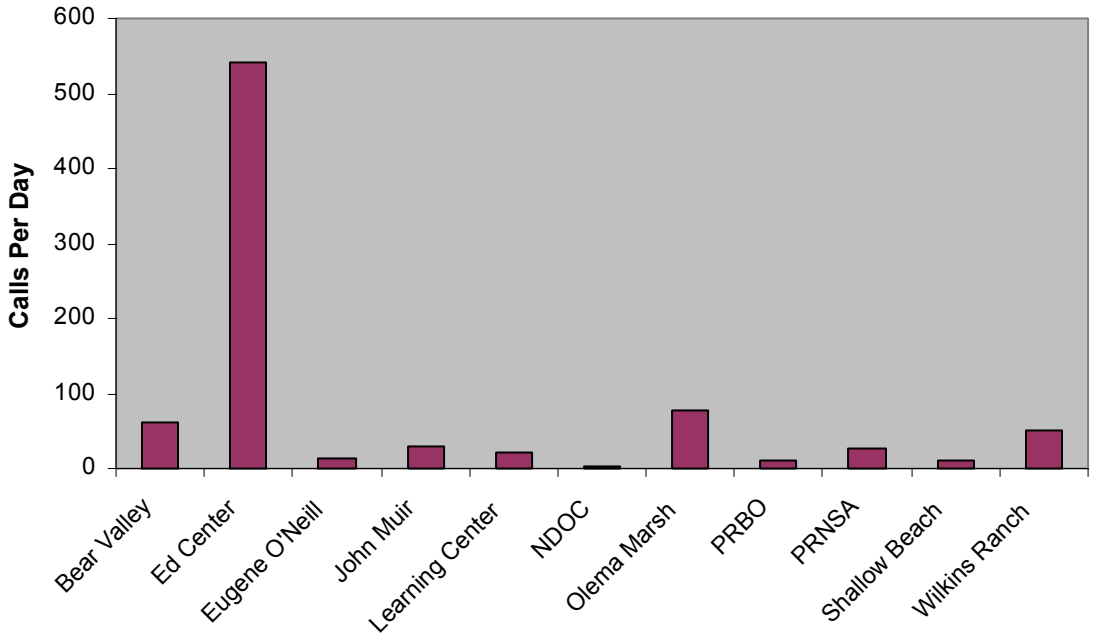


Figure 17. Average number of calls detected per day at each of the 11 bat monitoring stations in 2003.

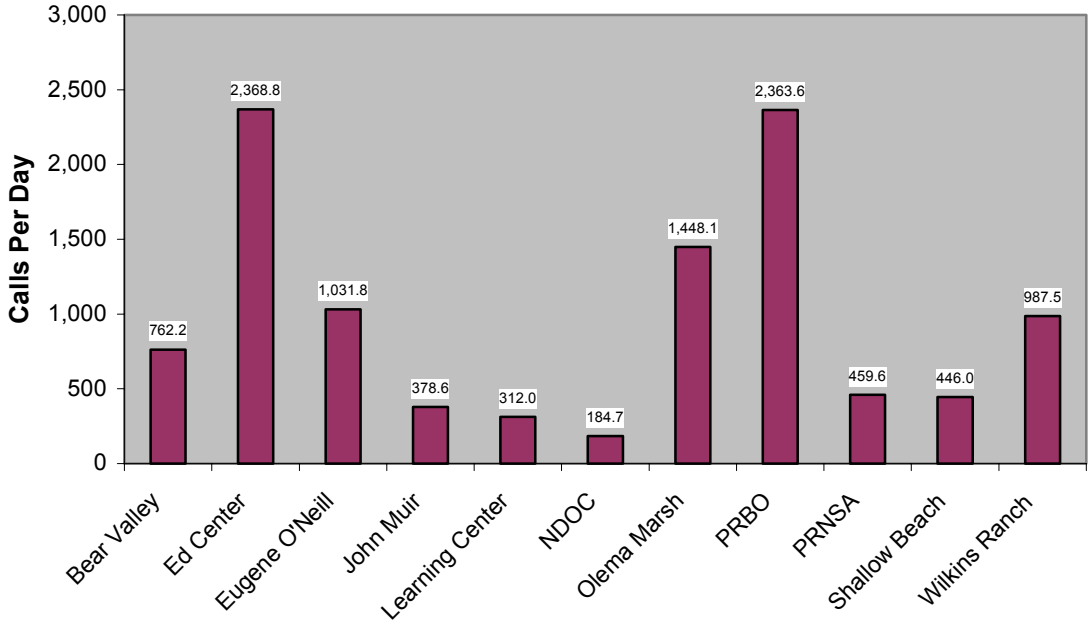


Figure 18. Average number of red bat calls per day at each of the 11 monitoring sites in 2003.

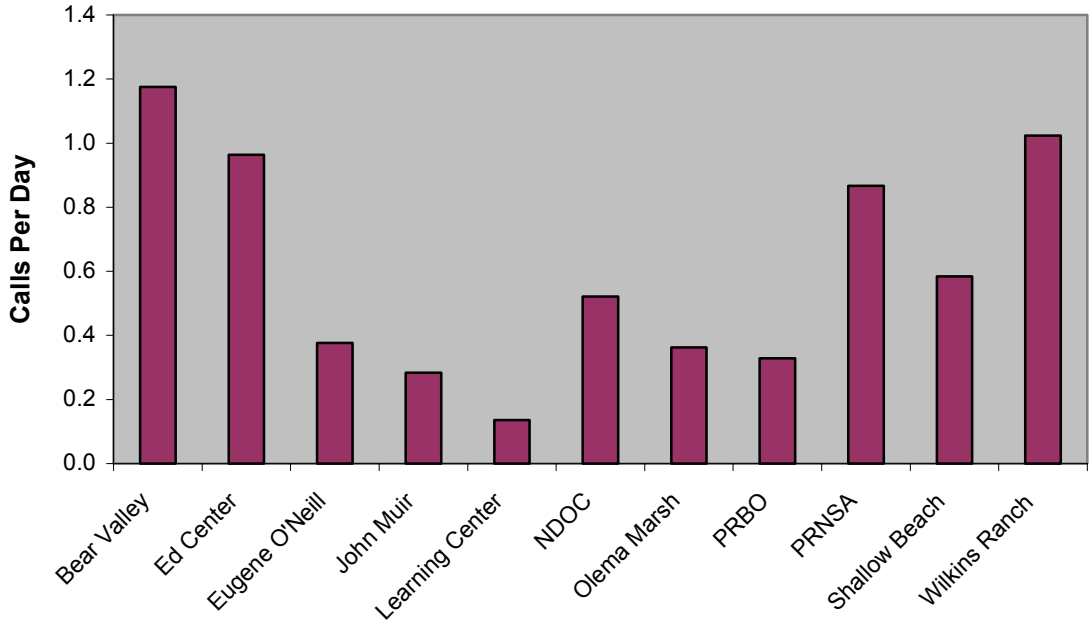


Figure 19. Average number of hoary bat calls per day at each of the 11 monitoring sites in 2003.

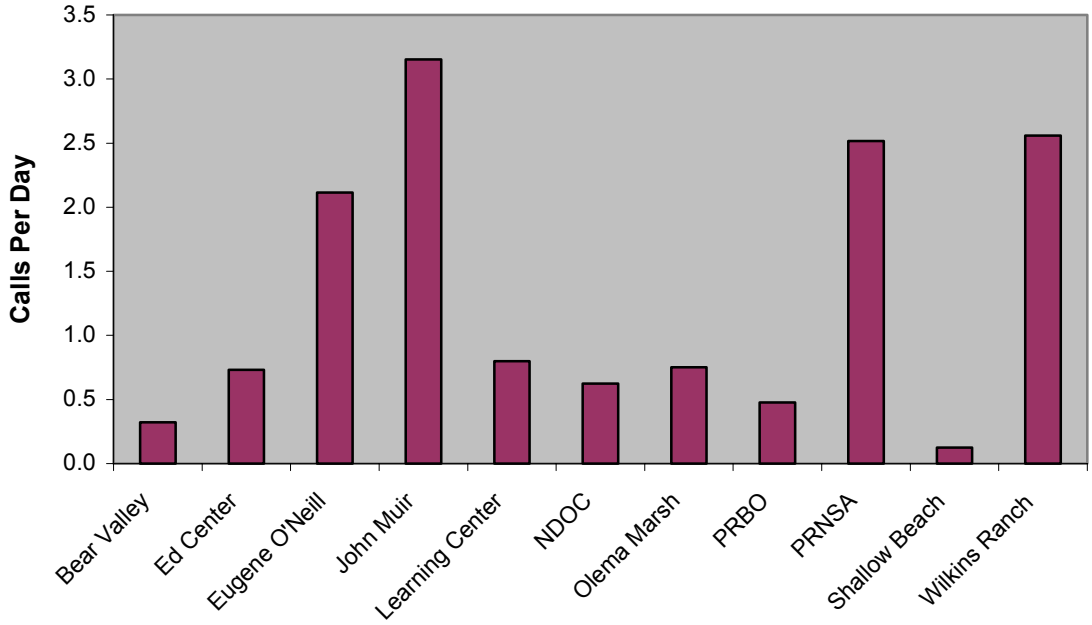


Figure 20. Average number of big brown bat calls per day at each of the 11 monitoring sites in 2003.

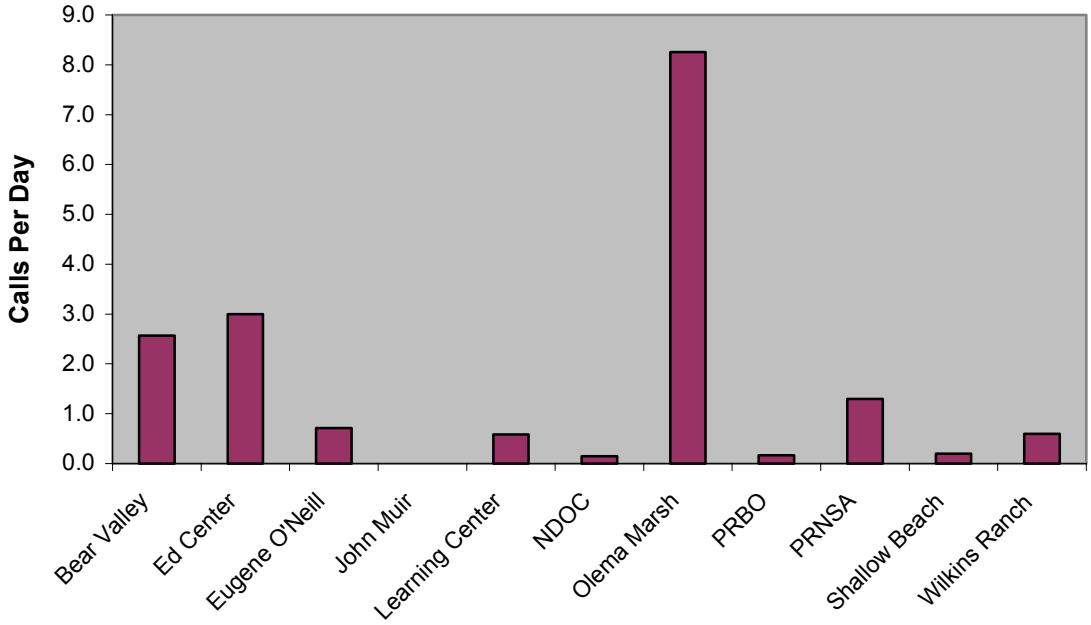


Figure 21. Average number of silver-haired bat calls per day at each of the 11 monitoring sites in 2003.

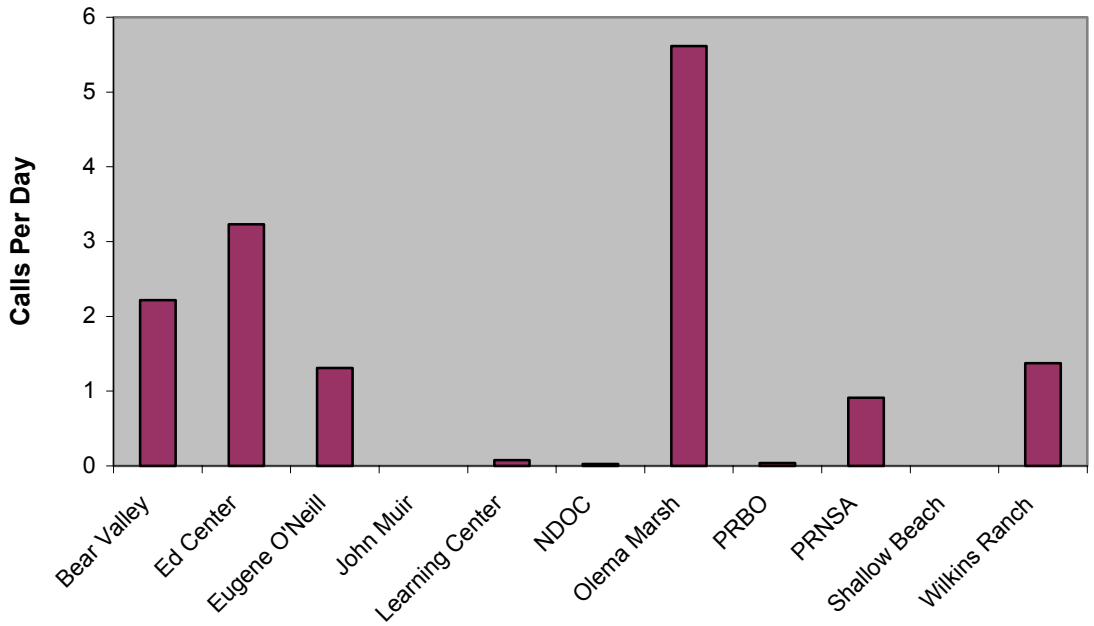
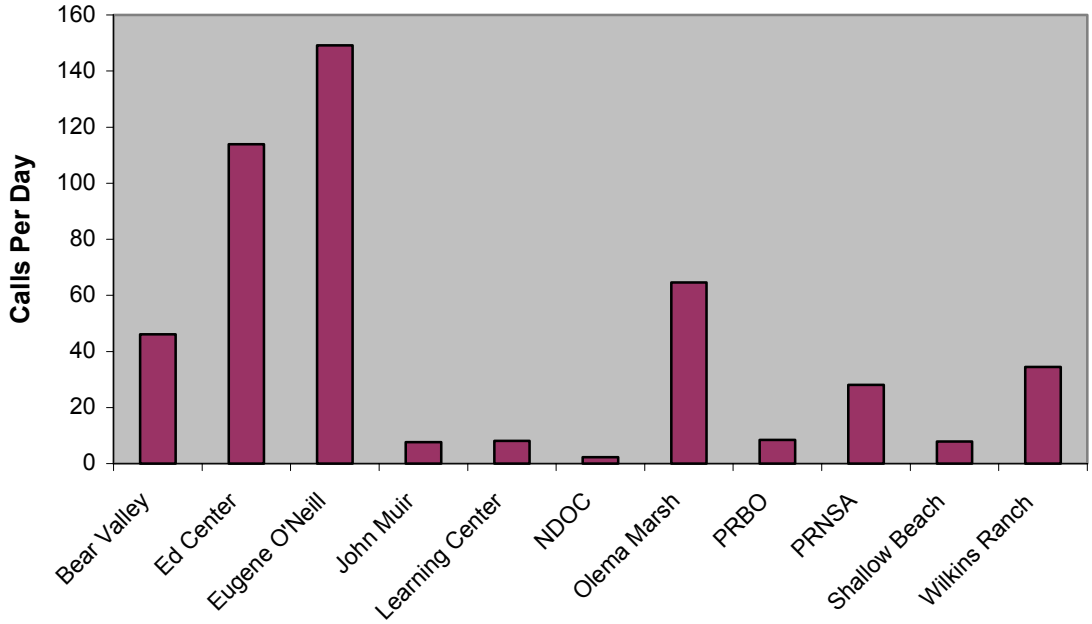
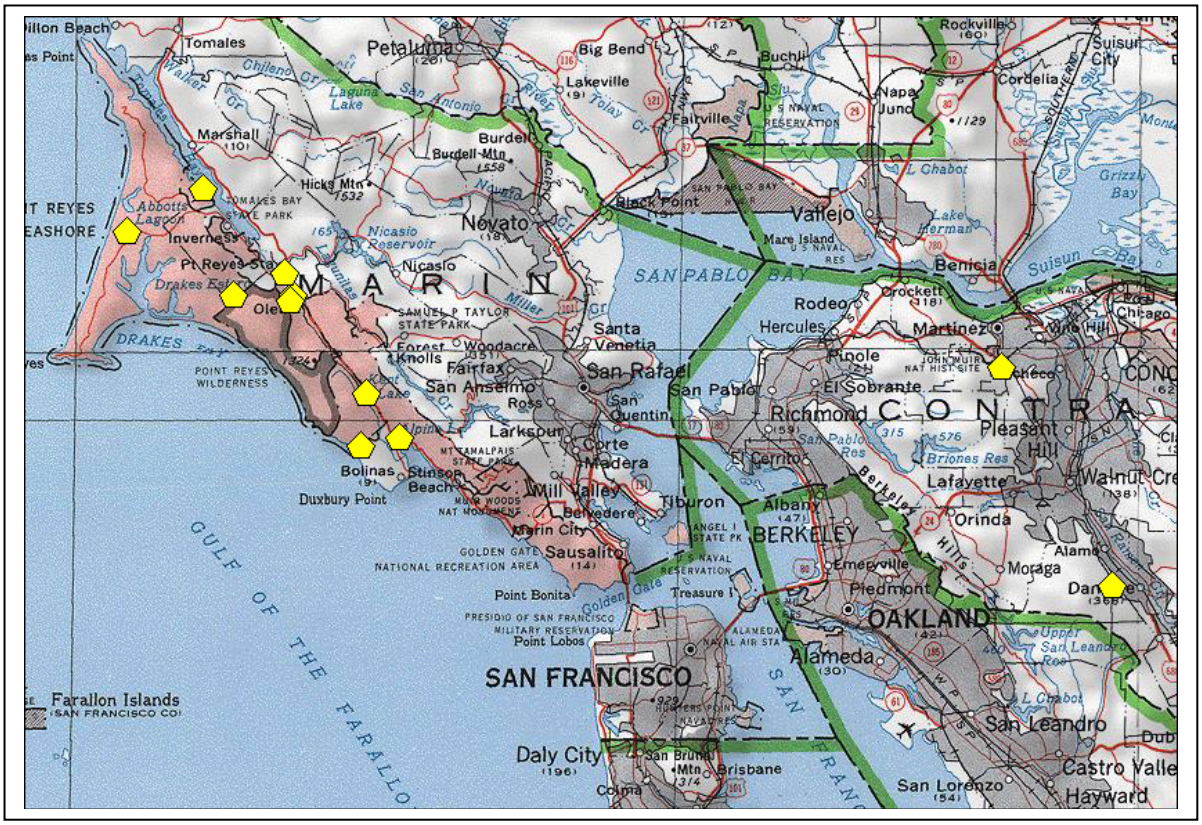


Figure 22. Average number of Mexican free-tailed bat calls per day at each of the 11 monitoring sites in 2003.



Appendix 1. Location of bat monitoring stations.



Appendix 2. Coordinates for bat monitoring stations based on NAD27 projection.

	UTM Easting	**UTM Northing**
Bear Valley	517717	4208924
Ed Center	512615	4210403
Eugene O'Neill	585623	4186708
John Muir	576219	4204793
Learning Center	523781	4202325
NDOC	503994	4215812
Olema Marsh	516940	4212401
PRBO	523317	4197892
PRNSA	517513	4210132
Shallow Beach	510363	4219431
Wilkins Ranch	526521	4198595