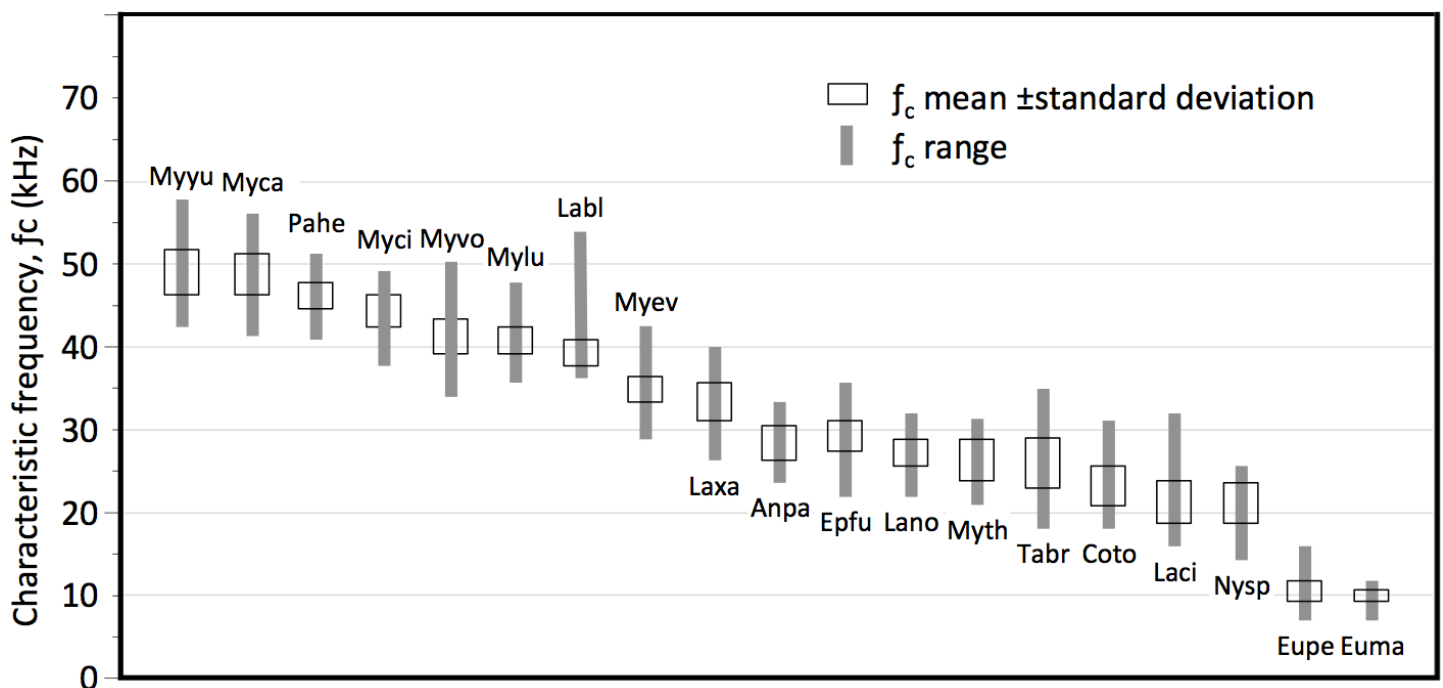


# Echolocation Call Characteristics of California Bats

## How to use this table

This table presents the echolocation call characteristics commonly used to identify species. The **boldface** numbers display the **mean** and **± standard deviation** of selected parameter measures from the subset of calls with discriminating characteristics that support confident automated classification, i.e., the subset of each species' call repertoire having the most species-discriminating characteristics. The lower, smaller text numbers display the total range of values documented by the approximately 43,000 calls in the western library of species-known, tracked bats used to prepare the SonoBat classifiers. The quantitative parameters in this table present just a subset of the more than 90 time-frequency and time-amplitude that SonoBat uses for call and sequence classification.

Because of *intraspecific* call variability and *interspecific* call similarity, the parameters presented here do not typically foster confident species identification anymore than would overlapping physical characteristics such as fur color or body weight. Use the parameter data to guide initial sorting of which species to consider when evaluating unknown sequences. Begin by assessing the characteristic frequency to narrow the candidates. The **special characteristics** describe features that may allow discrimination between species, with the **boldface** text indicating the most discriminating features.



## General recommendations for species identification

Analyze **1)** Well formed calls, i.e., search-phase calls recorded from bats in a steady mode of flight. Be aware that bats just leaving a roost, accelerating or performing other maneuvers often emit rapid, short calls that subvert species identification. **2)** Calls with little distortion or echo and with a strong signal that clearly rises above the background noise. It is preferable to avoid analyzing calls that saturate (overload), the detector or recorder, although saturated calls will still provide usable time-frequency characteristics despite having unreliable time-amplitude characteristics.

**Caveats:** Please note that call characteristics overlap among many species. Although more than 43,000 selected calls contributed to the data in this table, it still represents a finite, noninclusive data set. Any individual bat may emit calls outside the typical ranges and characteristics listed in this table (and thereby mimic another species). These realities, along with the inevitability of recording weak, noisy, and distorted calls, all render acoustic classification of bats a probabilistic process, relatively inexact compared to a process like genotyping. For most species, only a subset of call types within the repertoire enable confident species classification. As a result, many recordings will remain ambiguous. Expect this outcome and seek the most species-discriminating call types from which to determine species presence.

# Echolocation Call Characteristics of California Bats

|   | Species                                     | $f_c$                   | hi $f$                   | lo $f$                  | $f_{maxE}$              | dur                      | uppr slp                 | lwr slp                  | slp @ $f_c$               | total slp                | special characteristics   |
|---|---|-------------------------|--------------------------|-------------------------|-------------------------|--------------------------|--------------------------|--------------------------|---------------------------|--------------------------|---|
| 50  | <b>Myyu</b><br><i>Myotis yumanensis</i>     | <b>49.2</b><br>52<br>47 | <b>90</b><br>103<br>77   | <b>45.6</b><br>47<br>44 | <b>55.2</b><br>67<br>46 | <b>5.5</b><br>6.7<br>4.4 | <b>16.6</b><br>22<br>11  | <b>4.4</b><br>6.9<br>1.8 | <b>5.5</b><br>8.3<br>2.7  | <b>8.1</b><br>13<br>3.2  | Power focused around $f_c$ ; gradually builds up to peak and attenuates rapidly. Typically exhibit only a hint of a tail. Pronounced knee, dur>6, upprSlp<16, lwrSlp<3 diagnostic. Sometimes insert longer duration calls within sequence of short duration calls.  |
|   | <i>Yuma myotis</i>                          | 43-58                   | 58-117                   | 37-56                   | 46-91                   | 1.8-8.4                  | 3.1-55                   | 1.6-17                   | 0-20                      | 2.2-25                   |   |
|   | <b>Myca</b><br><i>Myotis californicus</i>   | <b>49.1</b><br>51<br>47 | <b>99.6</b><br>111<br>89 | <b>45.3</b><br>47<br>43 | <b>52.8</b><br>59<br>47 | <b>3.8</b><br>4.7<br>2.9 | <b>28.0</b><br>35<br>21  | <b>7.4</b><br>10<br>4.9  | <b>6.7</b><br>11<br>2.7   | <b>15.1</b><br>21<br>9.5 |   |
| <i>California myotis</i>                        | 43-56                                       | 58-126                  | 34-56                    | 45-95                   | 1.8-6.9                 | 5.5-144                  | 1.6-24                   | 0-24                     | 2.7-41                    |                          |   |
|   | <b>Pahe</b><br><i>Parastrellus hesperus</i> | <b>45.9</b><br>47<br>44 | <b>60.6</b><br>71<br>50  | <b>45.4</b><br>47<br>44 | <b>48.3</b><br>52<br>45 | <b>5.5</b><br>6.6<br>4.3 | <b>9.6</b><br>19<br>0.2  | <b>1.2</b><br>2.0<br>0.4 | <b>0.2</b><br>0.8<br>-0.3 | <b>2.6</b><br>4.7<br>0.6 | Strongly inflected, almost vertical FM changing to low slope below 47 kHz for the majority of the call. Calls generally consistent across a sequence. Appear hockey stick-shaped in sonogram when FM sweep is present. Some calls exhibit "squiggles."  |
| <i>canyon bat formerly: western pipistrelle</i> | 41-51                                       | 44-101                  | 28-51                    | 41-70                   | 2.7-11                  | 0.1-131                  | 0-6.9                    | 0-4.1                    | 0.2-17                    |                          |   |
| 40  | <b>Myci</b><br><i>Myotis ciliolabrum</i>    | <b>44.3</b><br>46<br>42 | <b>95.1</b><br>104<br>86 | <b>40.6</b><br>42<br>39 | <b>49.1</b><br>52<br>46 | <b>3.2</b><br>3.9<br>2.5 | <b>33.5</b><br>40<br>27  | <b>9.6</b><br>12<br>7.0  | <b>8.9</b><br>12<br>5.5   | <b>16.9</b><br>22<br>12  | FM sweep a smooth curve (no inflection), beginning steeply and then increasing in curvature*. Often a well-defined downward tail. Peak power of call typically persists for at least 1 msec on non-saturated calls.<br><br>*some calls may have an inflection, but the smoothly curved variant is diagnostic. |
|   | <i>small-footed myotis</i>                  | 38-48                   | 55-115                   | 31-44                   | 40-71                   | 1.7-5.3                  | 6.9-48                   | 2.5-22                   | 0-28                      | 4.6-36                   |   |
|   | <b>Myvo</b><br><i>Myotis volans</i>         | <b>41.6</b><br>44<br>39 | <b>89.6</b><br>101<br>78 | <b>36.9</b><br>40<br>34 | <b>48.0</b><br>54<br>42 | <b>4.8</b><br>5.9<br>3.6 | <b>15.1</b><br>19<br>11  | <b>7.7</b><br>11<br>4.1  | <b>8.7</b><br>13<br>4.3   | <b>12.0</b><br>17<br>7.5 | May exhibit an upward sweep into the call; uncommon, but diagnostic when present. =>note at end   |
|   | <i>hairy-winged myotis</i>                  | 34-50                   | 52-120                   | 27-44                   | 39-89                   | 1.1-8.8                  | 4.9-35                   | 1.1-25                   | 0-25                      | 4.0-32                   |   |
|   | <b>Mylu</b><br><i>Myotis lucifugus</i>      | <b>40.8</b><br>42<br>39 | <b>74.5</b><br>86<br>63  | <b>38.1</b><br>40<br>36 | <b>44.5</b><br>49<br>40 | <b>6.0</b><br>7.3<br>4.6 | <b>13.1</b><br>20<br>6.5 | <b>3.9</b><br>6.5<br>1.3 | <b>4.2</b><br>7.7<br>0.8  | <b>6.2</b><br>10<br>2.2  | Sometimes with multiple power centers making calls look clumpy. Can make the longest duration and lowest slope of all <i>Myotis</i> . Dur>6 & lwrSlp<3 diagnostic. =>note at end  |
| <i>little brown bat</i>                         | 35-48                                       | 48-103                  | 28-44                    | 36-74                   | 2.0-9.0                 | 2.7-38                   | 0.8-15                   | 0-19                     | 1.6-23                    |                          |   |
|   | <b>Labl</b><br><i>Lasiurus blossevillii</i> | <b>38.9</b><br>41<br>37 | <b>54.6</b><br>60<br>49  | <b>38.8</b><br>41<br>37 | <b>41.6</b><br>44<br>39 | <b>10.7</b><br>13<br>8.9 | <b>4.0</b><br>5.4<br>2.7 | <b>0.7</b><br>0.9<br>0.6 | <b>0</b><br>0.1<br>0      | <b>1.5</b><br>1.9<br>1.2 | U-shaped calls; upturn at end of call; may exhibit variable $f_c$ across sequence (randomly variable $f_c$ and call duration diagnostic, as opposed to progressive change across a sqnc). Power smoothly centered in call. Dur>10 diagnostic among 40kHz bats.  |
|   | <i>western red bat</i>                      | 36-53                   | 44-102                   | 36-52                   | 37-61                   | 2.9-14                   | 1.9-30                   | 0.3-10                   | 0-8.6                     | 0.6-19                   |   |

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|   | species                   | $f_c$       | hi $f$      | lo $f$      | $f_{maxE}$  | dur        | uppr slp    | lwr slp    | slp @ $f_c$ | total slp   | special characteristics  |
|---|---------------------------|-------------|-------------|-------------|-------------|------------|-------------|------------|-------------|---|--|
| 30  | <b>Myev</b>               | <b>34.3</b> | <b>78.5</b> | <b>28.1</b> | <b>39.1</b> | <b>3.7</b> | <b>20.5</b> | <b>8.7</b> | <b>10</b>   | <b>13.5</b>   | Calls may have up to 100 kHz of bandwidth. Shaped like Myth but distinguished by $f_c$ . FM sweep may be nearly linear making $f_c$ difficult to recognize.  |
|   | <i>Myotis evotis</i>      | 36<br>33    | 93<br>64    | 31<br>26    | 43<br>35    | 4.5<br>2.9 | 28<br>13    | 12<br>5.0  | 14<br>6.0   | 19<br>7.9   |  |
|   | long-eared myotis         | 29-43       | 46-119      | 23-43       | 31-71       | 1.1-6.5    | 6.1-58      | 2.3-34     | 0.1-34      | 4.9-42  |  |
|   | <b>Laxa</b>               | <b>33.9</b> | <b>54.0</b> | <b>33.0</b> | <b>36.5</b> | <b>7.0</b> | <b>8.6</b>  | <b>1.8</b> | <b>0.4</b>  | <b>3.6</b>  | U-shaped calls; upturn at end of call; may exhibit <b>variable <math>f_c</math> and call duration across sequence</b> ( <i>randomly</i> variable $f_c$ and call duration diagnostic, as opposed to progressive change across a sqnc). Power smoothly centered in call. Dur>10 diagnostic among 30kHz bats.   |
|   | <i>Lasiurus xanthinus</i> | 36<br>31    | 65<br>43    | 35<br>30    | 41<br>32    | 9.6<br>4.4 | 14<br>3     | 3.0<br>0.7 | 1.2<br>0    | 6<br>1.4  |  |
|   | western yellow bat        | 27-40       | 30-81       | 26-40       | 28-56       | 3-22       | 0.3-26      | 0.1-6      | 4-0         | 0.1-2.2   |  |
|   | <b>Anpa</b>               | <b>28.8</b> | <b>56.0</b> | <b>26.5</b> | <b>31.8</b> | <b>7.1</b> | <b>8.6</b>  | <b>2.9</b> | <b>1.2</b>  | <b>4.5</b>  | Often simple curved FM; sometimes with knee in ctr, or a "dog paw" ledge near $f_c$ . Distinguish from Epfu when <6 calls/sec. No tail. <b>Presence of social calls diagnostic.</b>  |
|   | <i>Antrozous pallidus</i> | 31<br>26    | 64<br>47    | 29<br>24    | 36<br>28    | 8.9<br>5.4 | 13<br>4.3   | 4.1<br>1.7 | 2.5<br>0    | 13<br>4.3   |  |
|   | pallid bat                | 23-34       | 39-86       | 21-32       | 25-52       | 2.3-12     | 2.1-31      | 0.6-8.3    | 0-9.2       | 2.1-31  |  |
|   | <b>Epfu</b>               | <b>28.8</b> | <b>55.5</b> | <b>27.1</b> | <b>31.8</b> | <b>8.1</b> | <b>8.6</b>  | <b>2.3</b> | <b>0.9</b>  | <b>4.1</b>  | Variable; calls with high $f$ below 60 kHz can be confused with Lano and/or Tabr. <b>Calls with high <math>f</math> above 65 kHz distinguish from Lano</b> , even long calls have some FM component, i.e., never flat. The end of calls may hook upward. Even in search phase sequences with consistent calls, may vary call intervals to have 2 or 3 calls more closely spaced, followed by a longer interval, then 2 or 3 more closely spaced again, etc. (view in realtime to see). |
|   | <i>Eptesicus fuscus</i>   | 31<br>27    | 65<br>46    | 29<br>25    | 36<br>28    | 11<br>5.6  | 13<br>4.6   | 3.7<br>0.9 | 2.2<br>0    | 6.4<br>1.8  |  |
|   | big brown bat             | 23-37       | 27-84       | 21-33       | 23-53       | 2.3-18     | 0.5-27      | 0.2-10     | 0-10        | 0.2-15  |  |
| * Shorter calls (<7) recorded with full detail, i.e., ones that closely approached the microphone, as indicated by the presence of harmonics, exceed 65-70 kHz.                     |                           |             |             |             |             |            |             |            |             |   |  |
| <b>Lano</b>   | <b>27.0</b>               | <b>39.6</b> | <b>25.5</b> | <b>28.7</b> | <b>10.1</b> | <b>4.6</b> | <b>0.5</b>  | <b>1.2</b> | <b>0.6</b>  | Shorter calls reverse J-shaped; often with a distinct inflection. Some call variants can be confused with Epfu and/or Tabr. <b>Flat calls <math>\geq 26</math> kHz diagnostic.</b> Flat Laci calls are lower in $f$ . Low slope calls in the 25-26 kHz range may be distinguished from Laci by the presence of an inflection. Epfu has more FM, typically with smooth curvature (no inflection). Will sometimes vary call intervals in consistent search phase, but with gaps ~twice that of other intervals (call skipping). |  |
| <i>Lasionycteris noctivagans</i>  | 28<br>26                  | 49<br>31    | 27<br>24    | 31<br>26    | 14<br>6.0   | 8.6<br>0.7 | 0.8<br>0.2  | 2.5<br>0   | 4.5<br>0    |   |  |
| silver-haired bat   | 23-32                     | 25-63       | 17-30       | 23-44       | 2.3-24      | 0-19       | 0-2         | 0-9.4      | 0-12        |   |  |
| * Shorter calls (<7) recorded with full detail, i.e., ones that closely approached the microphone, as indicated by the presence of harmonics, still do <i>not</i> exceed 50-55 kHz. |                           |             |             |             |             |            |             |            |             |   |  |

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|                                | species                  | $f_c$       | hi $f$      | lo $f$      | $f_{maxE}$  | dur         | uppr slp    | lwr slp    | slp @ $f_c$ | total slp   | special characteristics   |
|--------------------------------|--------------------------|-------------|-------------|-------------|-------------|-------------|-------------|------------|-------------|-------------|---|
| <b>20</b>                      | <b>Myth</b>              | <b>25.5</b> | <b>65.9</b> | <b>20.2</b> | <b>29.7</b> | <b>4.0</b>  | <b>16.6</b> | <b>8.3</b> | <b>7.5</b>  | <b>10.9</b> | <p><b>Calls may have up to 100 kHz of bandwidth.</b> Shaped like Myev but distinguished by <math>f_c</math>. FM sweep may be nearly linear making <math>f_c</math> difficult to recognize; fragments of these type of calls may mimic Coto - look for presence of harmonics to distinguish each with confidence.</p>  |
|                                | <i>Myotis thysanodes</i> | 28<br>23    | 84<br>48    | 22<br>18    | 36<br>24    | 5.0<br>3.0  | 24<br>9.0   | 14<br>3.1  | 13<br>2.3   | 18<br>3.6   |   |
|                                | fringed myotis           | 21-32       | 35-118      | 12-28       | 22-63       | 1.4-6.7     | 4.9-48      | 2.0-36     | 0.1-39      | 2.1-47      |   |
|                                |                          |             |             |             |             |             |             |            |             |             |   |
|                                | <b>Tabr</b>              | <b>26.3</b> | <b>34.0</b> | <b>24.3</b> | <b>28.1</b> | <b>11.5</b> | <b>2.0</b>  | <b>0.5</b> | <b>0.3</b>  | <b>1.0</b>  | <p>Variable, even within a sequence; FM to flat; can be confused with Epfu, Lano, or Laci. <b>Long calls that "turn on" power rapidly with high energy at beginning (oscillogram carrot-shaped).</b> Diagnostic calls have <b>upswing</b> into call and <b>downswing</b> out of call.</p> <p>Fragments from out of range flat Laci calls can mimic Tabr.</p>  |
| <i>Tadarida brasiliensis</i>   | 29<br>23                 | 43<br>25    | 27<br>22    | 32<br>24    | 14<br>8.8   | 4.3<br>0    | 0.8<br>0.1  | 0.8<br>0   | 2.1<br>0    |             |   |
| free-tailed bat                | 18-36                    | 19-64       | 13-35       | 18-47       | 3.5-24      | 0-15        | 0-4.5       | 0-0.8      | 0-4.8       |             |   |
|                                | <b>Coto</b>              | <b>23.4</b> | <b>42.5</b> | <b>21.4</b> | <b>31.1</b> | <b>4.6</b>  | <b>7.1</b>  | <b>4.9</b> | <b>4.2</b>  | <b>5.0</b>  | <p>Low intensity, difficult to detect; harmonics often present. Call shape <b>simple linear FM sweep, (sometimes with upsweep at onset).</b> <math>f_{maxE}</math> may alternate between fundamental and second harmonic.</p> <p>Tabr approach &amp; terminal phase calls can mimic Coto- use full sqnc to confirm search phase. Myth fragments can mimic Coto- use presence of harmonics to confirm/reject.</p>  |
| <i>Corynorhinus townsendii</i> | 26<br>21                 | 45<br>40    | 23<br>19    | 34<br>28    | 6.3<br>3.0  | 13<br>1.2   | 6.6<br>3.2  | 6.5<br>1.9 | 6.5<br>3.5  |             |   |
| Townsend's big-eared bat       | 18-32                    | 36-51       | 17-30       | 22-41       | 1.7-11      | 0.2-70      | 1.1-13      | 0-13       | 1.0-11      |             |   |
|                                | <b>Laci</b>              | <b>21.2</b> | <b>27.5</b> | <b>20.6</b> | <b>22.1</b> | <b>10.1</b> | <b>2.2</b>  | <b>0.6</b> | <b>0.1</b>  | <b>1.0</b>  | <p><b>Pronounced or subtle U-shape;</b> very flat calls may have slight downturn into call or upturn at end. may exhibit <b>variable <math>f_c</math> and call duration across sequence (randomly variable <math>f_c</math> and call duration diagnostic, as opposed to progressive change across a sqnc).</b> <b>Power builds toward center then gradually declines.</b> Short calls can be confused with Lano, Epfu, or Tabr.</p> <p>Fragments from out of range low bndwidth calls can lack beginning and ending details and mimic Tabr.</p> |
| <i>Lasiurus cinereus</i>       | 24<br>18                 | 36<br>19    | 23<br>18    | 26<br>18    | 15<br>6     | 4.8<br>0    | 1.2<br>0    | 0.5<br>0   | 2.3<br>0    |             |   |
| hoary bat                      | 16-32                    | 16-61       | 15-31       | 16-44       | 2-27        | 0-22        | 0-2         | 0-4.7      | 0-8.3       |             |   |

# Echolocation Call Characteristics of California Bats

|                | species                                       | $f_c$       | hi $f$      | lo $f$      | $f_{maxE}$  | dur         | uppr slp   | lwr slp    | slp @ $f_c$ | total slp  | special characteristics  |
|----------------|---|-------------|-------------|-------------|-------------|-------------|------------|------------|-------------|------------|--|
| 20 and 1 e s s | <b>Nysp</b>                                   |             |             |             |             |             |            |            |             |            | Similar call shapes as Tabr and Eupe, but of intermediate $f_c$ . Similar call shape as Tabr and Eupe, i.e., <b>upswing</b> into call and <b>downswing</b> out of call. Variable, even within a sequence; FM to flat; higher freq calls confusable with Tabr; lower freq calls confusable with Eupe. <b>Long calls that "turn on" power rapidly with high energy at beginning (oscillogram carrot-shaped).</b> |
|                | <i>Nyctinomops spp.</i>                       | <b>21.1</b> | <b>35.3</b> | <b>18.5</b> | <b>25.0</b> | <b>8.6</b>  | <b>3.9</b> | <b>1.2</b> | <b>0.8</b>  | <b>2.0</b> |  |
|                |   | 23          | 41          | 22          | 29          | 10          | 5.5        | 1.8        | 1.6         | 2.8        |  |
|                | Big free-tailed and pocketed free-tailed bats | 18          | 29          | 16          | 21          | 7.2         | 2.2        | 0.7        | 0.1         | 1.2        |  |
|                |   | 14-25       | 17-47       | 12-21       | 15-38       | 3.5-16      | 0.2-9.7    | 0.1-3.5    | 0-3.8       | 0.4-4.5    |  |
|                |   |             |             |             |             |             |            |            |             |            |  |
|                |   |             |             |             |             |             |            |            |             |            |  |
|                |   |             |             |             |             |             |            |            |             |            |  |
|                |   |             |             |             |             |             |            |            |             |            |  |
|                |   |             |             |             |             |             |            |            |             |            |  |
|                | <b>Eupe</b>                                   |             |             |             |             |             |            |            |             |            | Often simple sweeps with slight curvature; long, low; often similar call shape as Tabr and Nysp, i.e., <b>upswing</b> into call and <b>downswing</b> out of call. Variable, even within a sequence; FM to flat; higher freq calls confusable with Nysp. <b>Longer duration than Euma.</b>  |
|                | <i>Eumops perotis</i>                         | <b>10.4</b> | <b>19.8</b> | <b>9.4</b>  | <b>13.2</b> | <b>15.4</b> | <b>1.0</b> | <b>0.5</b> | <b>0.8</b>  | <b>0.7</b> |  |
|                |   | 12          | 22          | 11          | 15          | 20          | 1.3        | 0.7        | 1.3         | 0.9        |  |
|                | mastiff bat                                   | 9           | 18          | 8           | 12          | 11          | 0.7        | 0.2        | 0.2         | 0.4        |  |
|                |   | 7.7-16      | 12-25       | 7.3-14      | 10-19       | 7.4-25      | 0.3-1.8    | 0.1-1.4    | 0-2.1       | 0.2-1.4    |  |
|                | <b>Euma</b>                                   |             |             |             |             |             |            |            |             |            | <b>Simple linear FM sweep</b> , sometimes with a mild inflection. Short calls at low frequency. Harmonics often present, with 2nd harmonic persisting beyond 1st (artifact).   |
|                | <i>Euderma maculatum</i>                      | <b>10</b>   | <b>14.5</b> | <b>9.6</b>  | <b>12.5</b> | <b>3.2</b>  | <b>2.2</b> | <b>1.5</b> | <b>0.6</b>  | <b>1.7</b> |  |
|                |   | 11          | 16          | 10          | 14          | 3.9         | 3.7        | 2.3        | 1.4         | 2.2        |  |
|                | spotted bat                                   | 9.3         | 13          | 8.9         | 11          | 2.4         | 0.6        | 0.8        | -0.1        | 1.1        |  |
|                |   | 7.5-12      | 12-22       | 7.2-12      | 10-17       | 1.6-7.0     | 0.1-10     | 0-4.4      | 0-4.2       | 0.9-5.5    |  |

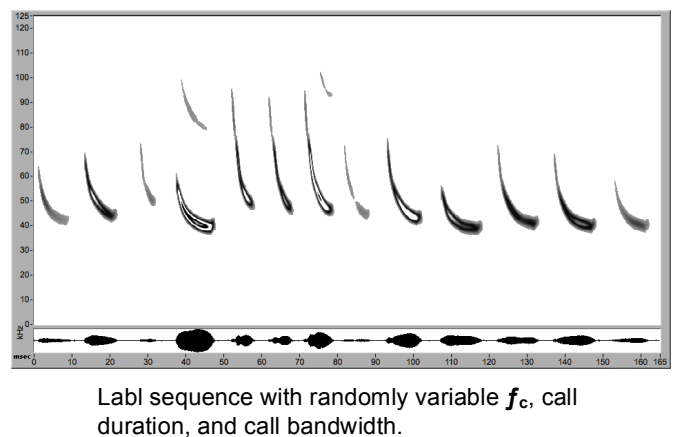
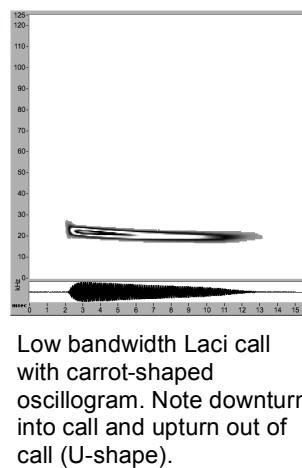
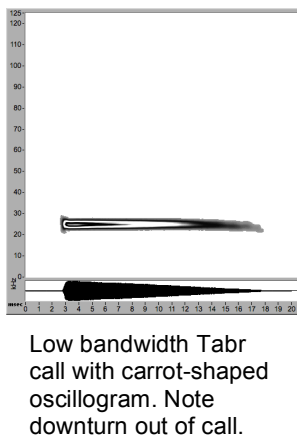
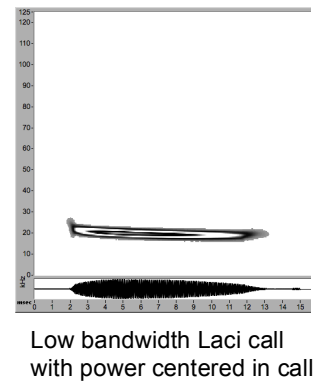
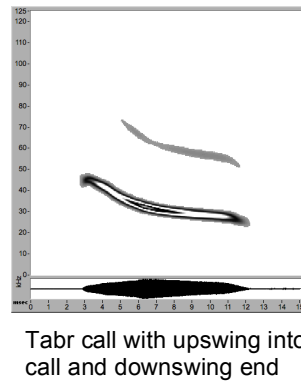
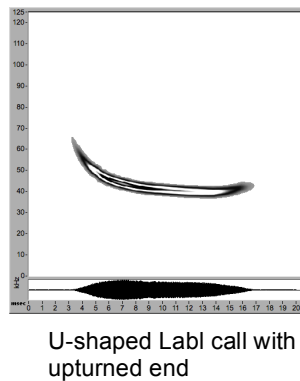
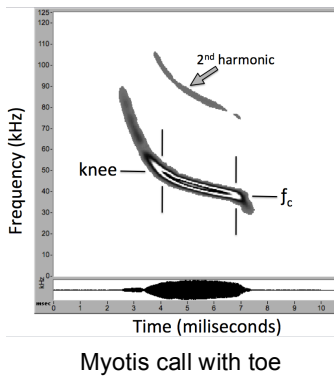
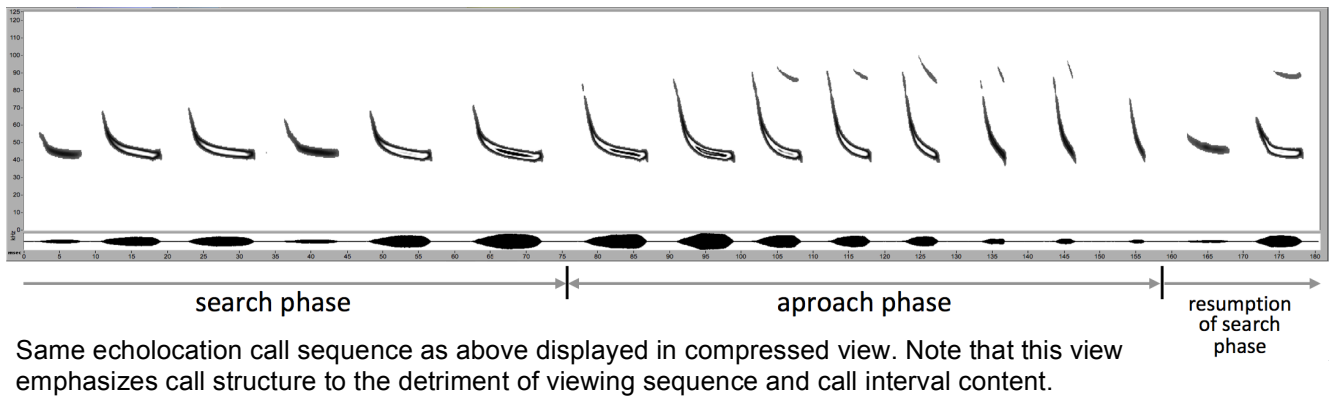
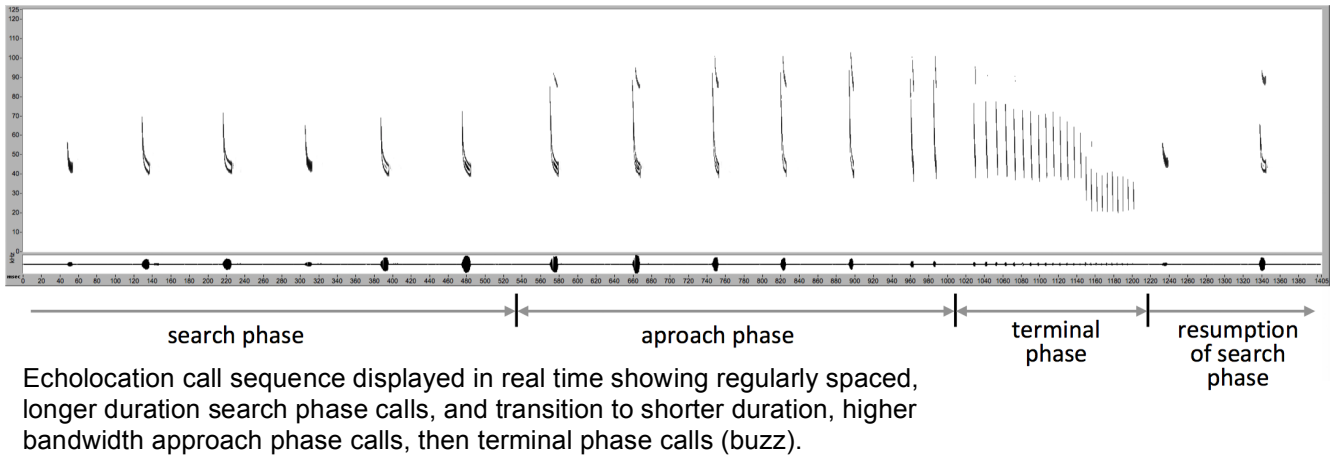
## Note regarding *Myotis spp* and distinguishing *M. volans* and *M. lucifugus*

All *Myotis spp* of similar  $f_c$  produce nearly indistinguishable short, steep calls. Confident species classification of *Myotis spp* increases with longer duration call variants. This is particularly so for Mylu and Myvo. To increase the likelihood of obtaining the most species-diagnostic calls, record in open, uncluttered airspace. There, Mylu will tend to emit longer calls relative to Myvo, whereas Myvo will tend to still emit shorter, steeper calls with greater bandwidth than Mylu.

## Sources:

Characteristics based from recordings acquired by Joseph M. Szewczak (SonoBat), Humboldt State University Bat Lab (J.M. Szewczak, Aaron Corcoran, and Jean-Paul Kennedy), Patricia C. Ormsbee, USFS Pacific Northwest Research Station, and various contributors to the Pacific Northwest Bat Grid, Theodore J. Weller, USFS Redwood Sciences Lab, and numerous other generous contributors that have assisted with fieldwork.

# Echolocation Call Characteristics of California Bats



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## Glossary

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**approach phase:** shorter, more closely spaced calls that bats transition into to pursue and evaluate a target after detecting it from echoes gleaned from **search phase** calls

**bandwidth:** the total change in frequency through the call (kHz)

**body:** the section of the call from the knee to the characteristic frequency ( $f_c$ )

**dur:** call duration (msec), from the beginning to the end of the call

**$f_c$ :** characteristic frequency, i.e., the frequency of the call at its lowest slope toward the end of the call, or the lowest frequency for consistent FM sweeps (kHz)

**flat:** a call or portion of a call with a very low slope or no slope (horizontal); low bandwidth

**FM:** frequency modulation, i.e., a change in frequency with time

**$f_{maxE}$ :** the frequency (kHz) with the greatest amplitude (power, energy)

**lo  $f$ :** lowest apparent frequency (kHz); an unreliable call descriptor as the distance to the bat strongly influences the observed value

**harmonic:** Higher frequency components of the same signal, appearing at integral multiples of the fundamental component (first harmonic)

**hi  $f$ :** highest apparent frequency (kHz); an unreliable call descriptor as the distance to the bat strongly influences the observed value

**inflection:** a pronounced change in the slope of a call, sometimes called a “**knee**”

**knee:** a break in the downward FM sweep of a call with a discernable change in slope between the initial part and lower section of the call (body) leading to the characteristic frequency ( $f_c$ )

**lwr slp:** lower slope, **knee** to  $f_c$  slope (kHz/msec); the slope of the lower portion or body of the call from the knee to the  $f_c$  (listed as KnToFcSlope on SonoBat output)

**power:** the amplitude or sound energy of a call or portions of a call

**saturated:** portion of a signal in which the amplitude of the signal exceeded the maximum recordable amplitude of the recording hardware, resulting in a flat-topped waveform; such a signal will not faithfully render the time-amplitude trend of a call, a useful feature for disambiguating some species

**search phase:** the (mostly) regularly spaced calls of (mostly) regular duration that bats use in routine flight to detect and avoid obstacles and search for prey

**slp@  $f_c$ :** slope at characteristic frequency,  $f_c$ , (kHz)

**sqnc, sequence:** “bat pass;” a temporal series of calls from a passing bat; begins with the bat entering the detection volume of the microphone and ends with the bat leaving the detection volume

**squiggle:** an S-shaped variation in frequency (per time) over a portion of the call

**tail, aka toe:** a downward turn in the call trend at the end of the call

**total slp:** total slope (kHz/msec); overall change in frequency per change in msec (time) from the start of the call to the end of the call

**uppr slp:** upper slope, **hi  $f_c$  to knee** slope (kHz/msec); the slope of the upper portion or onset of the call from the highest frequency at the start of the downward sweep to the knee (listed as HiFtoKnSlope on SonoBat output)