BAT ACOUSTIC SURVEYS ON LOPEZ ISLAND, WASHINGTON

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Bats are important members of ecosystems worldwide and have received increased attention in recent years due to the discovery of White-nose Syndrome in the United States. Habitat loss and degradation, wind energy-related mortalities, and White-nose Syndrome are some of the urgent issues warranting increased surveillance, monitoring and research on bat populations. Within Washington, wildlife managers lack sufficient information to adequately evaluate and manage bat populations. A few of the information deficiencies include knowledge of species distributions across seasons, population estimates, migration routes, and hibernation sites.

The *San Juan County Best Available Science Synthesis* (Adamas Resource Assessment Inc. and others 2011), which is used by city and county land managers to inform decisions, lists the presence of most local bat species as probable rather than confirmed. The only published research pertaining to bat observations in San Juan County was performed in the late 1930's (Dalquest 1940); although, numerous additional observations are noted in government databases and additional research is underway. Lopez Island is one of the largest and most inhabited islands within the San Juan Archipelago and newly established National Monument of San Juan County, Washington. The island is known to harbor one maternity colony of *Corynorhinus townsendii* (Townsend's Big-eared Bat) and may also be used by *Myotis keenii* (Keen's Myotis); both of these species are candidates for listing as state species of special concern. Lopez Island has experienced an increase in human and livestock populations along with agriculture and timber harvesting over the past one hundred years, and currently is a popular island for tourism and vacation-home construction. Less than 12% of land on Lopez Island is protected for conservation (Adamas Resource Assessment Inc, and others 2011); therefore, concerns over habitat loss and anticipated human population growth necessitate identifying local bat species and their critical resources. We performed a 3 night, mid-summer, acoustic survey for bats on Lopez Island during 2013 to identify species present and activity levels in different habitat types. This brief survey will help inform future research, surveillance, and management projects.

Study Area and Site Selection

We performed acoustic bat surveys on Lopez Island, located within the San Juan Archipelago of San Juan County, Washington, USA. The 76 km^2 island is a mixture of residential, business, public, agriculture, and forest resource lands, with approximately 36% of the land area comprising resource lands, open spaces and parks (San Juan County Board of Commissioners 2005). The island has a maritime climate characterized by mild, wet winters, and cool, dry summers. Predominant native ecosystem types include: North Pacific Maritime Dry-Mesic Douglas-Fir Western Hemlock Forest, North Pacific Dry Douglas-Fir-(Madrone) Forest and Woodland, Temperate Pacific Freshwater Emergent Marsh, and North Pacific Herbaceous Bald and Bluff (Johnson and O'Neil 2001, NatureServe Explorer 2007). Island elevation ranges between 0 m and 163 m above sea level.

Eighteen sites were selected for acoustic surveys, evenly divided among 3 habitat types including open field sites (n=6), water sites (n=6), and forest-edge sites (n=6). Thirteen sites were located on private land and 5 were on public land. The island was split into northern, central, and southern regions, with 6 sites in each region. Each habitat category had 2 sites within each region, except for the southern region (3 edge sites) and the northern region (3 open sites). Water sites were located within 3 m of a pond's edge (n=5) or saltmarsh channel (n=1) and contained calm water. Forest-edge sites were located 3 m from the forest canopy at an edge-open field interface where trees and shrubs exceeding 3 m in height were adjacent to open fields with vegetation less than 1 m in height. Open sites were located in vegetated fields at least 10 m from trees and shrubs over 1 m in height. Precise property locations are not provided in this report to protect landowner privacy.

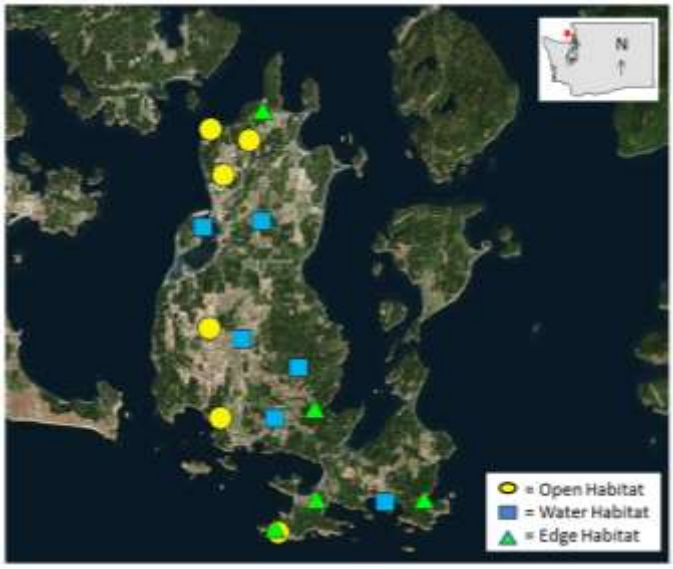

Figure 1. Lopez Island acoustic survey locations and their habitat categories; Lopez Island, Washington, mid-summer 2013.

Survey Methods

Acoustic surveys were performed on July 29th, 30th, and August 3rd of 2013 when there was no precipitation, low wind conditions (<9 km/hr), and moon phase was between 10% and 52% illumination. Temperatures were not taken at individual survey sites, although local island temperatures averaged 14˚C at dusk and ranged between a low of 11˚C and a high of 17˚C during the 9 hours of survey time across the 3 sampling nights. One Pettersson D240X bat detector (Pettersson Elektronic, Uppsala, Sweden) with an iRiver recorder (iRiver Inc, Irvine, CA) was used to collect and record echolocation calls of bats at each of 6 different sites each of the 3 survey nights (18 detector nights). The detectors ran for 3 continuous hours beginning 10 minutes prior to sunset, and were mounted on 1 m posts aimed vertically upwards except at ponds where they were aimed at an approximate 30˚ angle below vertical over the center of the water body.

Data Analysis

Echolocation calls of bats were recorded as REC files, converted to MP3 files with iRiver Music Manager (iRiver Inc, Seoul, Korea), and lastly converted to WAV files with Winamp (Nullsoft Inc, www.nullsoft.com). Sound files were limited to 1.7 seconds duration during recording, with each WAV file being considered one bat "pass" for analysis regardless of the number of echolocation pulses within the file. If two or more bats were evident in one WAV file, each bat's sequence of pulses was considered a separate pass. SonoBat (SonoBat, Arcata, CA) was used for call analyses. All WAV files were first run through SonoBat's AutoID function with all filters turned off, then every file was manually examined by experienced biologists and assigned a final species identification using bat call characteristics guidelines developed by Humboldt State University Bat Lab (version March 2011). We utilized search phase call sequences with ≥ 2 pulses of content to identify bats to species, recognizing bats are flexible within their call repertoires and may change call structure to aid in obstacle avoidance, for communication, or other purposes (Fenton 1990; Schnitzler and Kalko 2001; Broders and others 2004). We were conservative with analyses and required high quality and consistent calls for species determination. Only WAV files containing at least one bat pass (a pass defined as at least 2 pulses of echolocation activity) were used for species identification to document presence. Microsoft Excel (Microsoft, Bellevue, WA) was used to manage data, ArcGIS (ESRI, Redlands, CA) was used to create the map figure, and R was used to create boxplots (R Core Team, Vienna, Austria).

Results

Problems encountered during this survey included one detector malfunction at an edge site (central region), reducing the number of sites to 17; one potential iRiver recorder malfunction at one water site

(southern region), which may have reduced the total number of possible files; and one detector at an open site (southern region) having been set to record 3.4 second files rather than 1.7 second files, which may have reduced the total number of possible REC files and hence number of bat calls recorded.

A total of 793 REC files were recorded on Lopez Island, with 358 files possessing more than one bat call recorded in a file, equating to 1306 separate bat calls across 17 sites over 3 nights of surveys (water = 812 calls, open = 280 calls, edge = 214 calls). Many calls recorded in water sites were impossible to identify to species due to overlapping calls or insufficient quality. We identified 9 bat species on Lopez Island through evaluating acoustic data, including *C. townsendii, Eptesicus fuscus* (Big brown Bat), *Lasionycteris noctivagans* (Silver-haired Bat), *Lasiurus cinereus* (Hoary Bat), *M. californicus* (California Myotis), *M. evotis* (Western Long-eared Myotis) */M. keenii*, *M. lucifugus* (Little Brown Myotis), *M. volans* (Long-legged Myotis), and *M. yumanensis* (Yuma Myotis). Eight species were recorded at least once in each habitat category; *C. townsendii* was not recorded in open sites. Two species, *M. evotis* and *M. keenii*, cannot be differentiated through acoustic analysis at this time; although, we recorded calls that represent one or both of these species. Activity levels based upon total number of calls and number of calls by species in each habitat category are illustrated in Appendix A; however, we remind readers a large percentage of calls recorded at the water sites were not identifiable to species and one edge site lacked data.

Discussion

Numerous studies and observations of bats have been made within the San Juan Archipelago over the past 75 years. Dalquest (1940) collected *M. californicus* and *M. yumanensis* specimens on Lopez Island, although collected or captured an additional 5 species (*C. townsendii, E. fuscus, L. noctivagans, M. lucifugus* and *M. volans*) on other islands in the archipelago. Downes (unpublished senior thesis, 1999) documented *E. fuscus, L. noctivagans, L. cinereus, M. californicus, M.evotis, M. volans,* and *M. yumanensis* on Lopez Island through the use of frequency division acoustic detectors and live captures; however, the software type, explicit methods used for call analysis, and explicit methods used to differentiate captured *M. yumanensis* from *M. lucifugus* were not documented. Unpublished senior theses on bats from two additional students reported finding some of the same species as Downes on San Juan Island through the use of acoustic detectors; although, these theses did not document explicit methods used for acoustic differentiation between species which we now understand have nearly identical echolocation sonograms (Sweeney 1997, Hulscher 2003). Kwiaht biologists have documented the presence of *C. townsendii, M. californicus, M. yumanensis/lucifugus, M. evotis/keenii, E. fuscus,* and *L. noctivagans* across numerous islands through visual observations in roosts or through examining mortalities (Kwiaht Database, unpub. data). WDFW and BLM database records indicate *E. fuscus, M.*

californicus, M. lucifugus, M. volans, and *M. yumanensis* have been documented in the archipelago outside of the formerly described undergraduate research efforts through captures, acoustic recordings, and examining external characteristics of mortalities (Washington Department of Fish and Wildlife, WSDM Database; USDI Bureau of Land Management, GeoBOB database); although, methods did not include the use of combined measurements and acoustics to refine differentiation between *M. yumanensis* and *M. lucifugus* during live captures, nor did WDFW records always indicate explicit acoustic methods used to identify species. Appendix B includes a table of species documented on islands in the San Juan Archipelago through previous research and observations, along with documented methods.

Some former species observation records for Lopez Island may be unreliable based upon new information available in recent years. Morphometrics on live bats have at times been found unreliable to differentiate *M. yumanensis* from *M. lucifugus* (Rodhouse and others 2008), and some long-eared bats from one another morphometrically or acoustically (e.g. *M. keenii* from *M. evotis;* Lausen and Hill 2010). Current scientific research indicates we can use spectral analysis combined with morphometrics to differentiate captured *M. yumanensis* from *M. lucifugus* with a high degree of reliability (Weller and others 2007), although DNA analysis may offer the least fallible method of differentiation between live *M. keenii* and *M. evotis* at this time (Nagorsen and Lausen 2008; Lausen and Hill 2010). Acoustic analysis of bat echolocation calls has been an evolving process, with many refinements having taken place over the past few decades and surely more to come. The collection of many thousands of reference calls from bats, equipment and software improvements, and a better understanding of species repertoires have helped to refine our analysis capabilities. These advances in our understanding and capabilities for acoustic and morphometric analysis unfortunately imply some species were likely incorrectly assigned in decades past. Future surveys will continue to modify species lists as additional technological and analytical improvements are made in the coming decades.

We identified 9 bat species on Lopez Island through evaluating acoustic data recorded during a 3-night mid-summer survey, including *C. townsendii, Eptesicus fuscus, Lasionycteris noctivagans, Lasiurus cinereus, M. californicus, M. evotis/keenii, M. lucifugus, M. volans,* and *M. yumanensis*. Eight species were recorded at least once in each of open, forest-edge and water habitat sites, with *C. townsendii* not recorded in open sites. We found the majority of bat activity took place near fresh-water, although forest-edge and open habitats also experienced bat activity. The small and short-term nature of our survey prohibits drawing conclusions about bat habitat use and activity across and between seasons and years; although offers preliminary data for future studies to expand upon. Our results support predictions made by the US Geological Survey Washington Gap Analysis Project (GAP), which developed distribution models of various species by using current habitat conditions, topography, known records of observations, and expert opinions. The GAP exercise predicted 10 bat species could be found in the San

Juan Archipelago, including each species we identified as well as *Myotis keenii* (Johnson and Cassidy 1997).

Freshwater, trees and snags are important landscape characteristics for many bat species, providing drinking sources, roosting habitat, and locations that provide invertebrate prey. Loss or degradation of these habitat features on Lopez Island may prohibit use by bats if they cannot find these essential resources within a reasonable distance. Energy expenditures for inter-island flights for females and their pups during gestation and pup-rearing could be cost-prohibitive. The extent to which bats move between islands in this archipelago is unknown, as are the movements between islands and the mainland. Questions abound related to island biogeography and the impacts of habitat loss or degradation in this archipelago for bats and other wildlife species, which will hopefully be addressed by future research. Acoustic "bioblitzes" cannot replace multi-season and multi-year formal inventories or long-term scientific studies; however, they can provide rapid, low-cost information to resource managers and inform development of research, surveillance and monitoring projects for bat populations.

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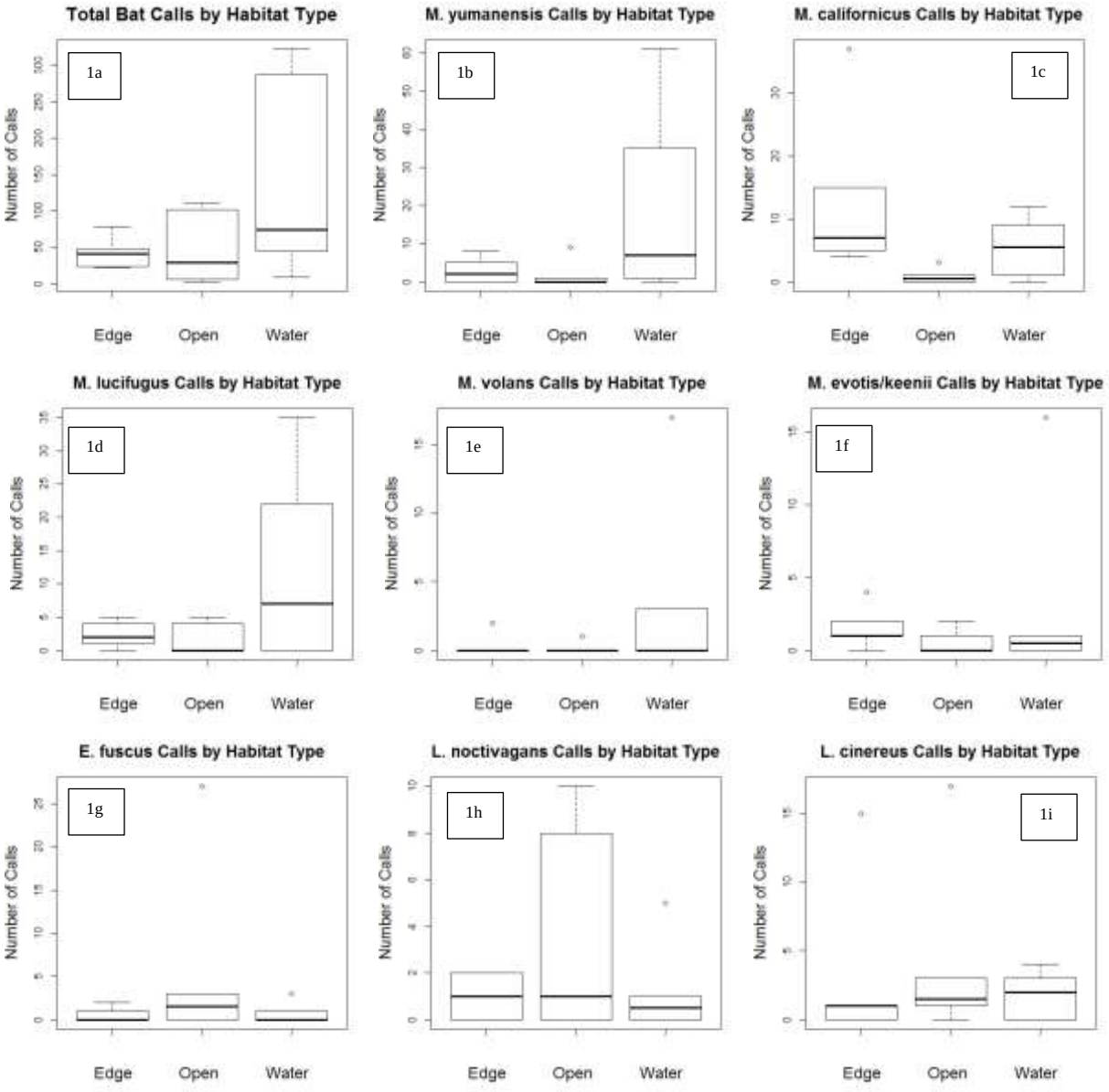
Appendix A. Boxplots demonstrating means and interquartile ranges for total number of bat calls (also known as "passes"; 1a), and the number of bat calls by species (1b-1i) within 3 different habitat types during a 3-day mid-summer inventory on Lopez Island, Washington in 2013. Habitat types included forest-edge (n = 5), open field (n = 6), and open water (n = 6).



Appendix B. Bat species documented present on islands within the San Juan Islands Archipelago and National Monument through published and unpublished records as of August 2013; methods utilized are also indicated if they were provided.

Species	Blakeley Island	Cypress Island	Decatur Island	Johns Island	Jones Island	Lopez Island	Orcas Island	Patos Island	San Juan Island	Spieden Island	Waldron Island
Corynorhinus townsendii	A		A			F,G	F		A,F		F
Eptesicus fuscus	A		A		A	C,E,F,G	E,F	E	A,B,F		F
Lasionycteris noctivagans	A					C,F,G	E		A,B,F		
Lasiurus cinereus						C,G					
Myotis californicus	A	A		A		A,C,E,F, G		E	A,D	A	
M. evotis (or M. keenii)						C,E,F,G	F		F		
M. lucifugus			A			E,G	E		A		
M. volans	A					C,E,G					
M. yumanensis	A					A,C,E,F, G	E		A,B,D		

A = Dalquest 1940; collected specimens and visual observations

B = Sweeney 1997; unknown type acoustic detectors; unpublished

C = Downes 1999; Anabat II frequency division acoustic detectors and captures; unpublished

D = Hulscher 2003; Anabat II frequency division acoustic detectors; ambiguous species calls; unpublished

E = WDFW WSDM and USDI BLM GeoBOB databases; acoustic detectors, captures, visual observations

F = Kwiaht Database; visual observations

G = Rowan and others (this report); Pettersson D240X acoustic detectors; SonoBat software

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