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Final

2012-2013 Annual Report
Avian and Bat Monitoring Project
Vasco Winds, LLC

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September 2013

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1.0 INTRODUCTION

The Vasco Winds area of the Altamont Pass Wind Resource Area (APWRA), hereafter referred to as Vasco Winds, was repowered in 2011 by Vasco Winds LLC, a subsidiary of NextEra Energy Resources (NextEra). The prior 80MW project in 1985 originally consisted of 800 KCS56 100-KW turbines. In 1992 20 KVS33 400-KW turbines were added. The original project was located near the Los Vaqueros Reservoir (that was not present until construction was initiated in 1994) in southern Contra Costa County. This project was part of the northern aspect of the APWRA. Over time, the number of turbines in the area declined due to attrition, mitigation efforts and removal projects (e.g. building of the current Vasco Road through the original project). In 2011 the 438 remaining wind turbines were removed and replaced by 34 Siemens 2.3MW wind turbines (Table 1). The 78.2 MW repowered project commenced operations in February 2012. On behalf of NextEra, Ventus Environmental Solutions (Ventus) initiated avian and bat fatality and use monitoring in May 2012. The monitoring program consists of site specific avian and bat carcass surveys, searcher detection trials, carcass persistence trials, avian use and behavior surveys, and bat acoustical monitoring. The following report summarizes the preliminary results from the first year of a three year monitoring program.

Table 1. Attributes of turbines present during the pre- (1992) and post- (2011) repowering periods in the Vasco Winds Area.

Attribute	Old turbines As of 1992		New turbines 2011-present
Model	KCS-56	KVS-33	Siemens
MW rating	100 KW	400 KW	2.3 MW
Number in project	726	20	34
Rotor diameter (m)	17.8	33.2	101
Tower height (m)	18.5	24.6	80
Height above ground at highest blade reach (m)	27.4	41.2	131
Height above ground at lowest blade reach (m)	9.6	8	29
Rotor-swept area (m2)	248.8	865.7	8,000
RPM	73.4	28.8	6-16
Cut-in speed (m/s)	5	4	3-4
Cut-out speed (m/s)	20	21	25
Tower	Lattice	Lattice	Tubular

1.1 Background

The APWRA, including the Vasco Winds area, has a long association with bird fatalities, and especially raptor fatalities (Orloff and Flannery 1992; Hunt et al. 1998; Hunt 2002; Smallwood and Thelander 2004, 2005, 2009; Smallwood and Karas 2009; Smallwood et al. 2010). Four bat fatalities were found between 1998 and 2003, and bat fatalities have been found in increasing numbers since 2007 (Leslie et al. 2012), mostly at larger, repowered wind turbines (Smallwood and Karas 2009). Fatality searches were performed at the Vasco Winds area twice during 2002-2003 (Smallwood and Karas 2009), and routine fatality monitoring commenced at the Vasco Winds area in spring 2005 and continued until the old-generation wind turbines were removed as part of repowering in 2010 and 2011.

Following the release of a 2004 report that was funded by California's Public Interest Energy Research program (PIER) (Smallwood and Thelander 2004), regulatory agencies and members of the public rallied for action to reduce raptor fatality rates in the APWRA. An Altamont Working Group met repeatedly to address the issues during 2004-2005. These meetings culminated in an Alameda County Board of Supervisors Resolution No. R-2005-453 (22 September 2005), which renewed the wind companies' conditional use permits but also required a suite of mitigation measures intended to reduce avian fatality rates. These measures were collectively referred to as the Avian Wildlife Protection Program & Schedule (AWPPS). Although wind companies had already contracted with a consulting firm to perform fatality and utilization monitoring beginning in spring 2005, the Board Resolution expanded the monitoring effort to a team of three organizations. A Scientific Review Committee (SRC) was also established to review the monitoring team's monitoring design and data, to analyze the data, to assess the effectiveness of mitigation measures, and to recommend additional management actions, as needed. Required mitigation measures included shutdowns of most of the wind turbines over the winter months, removals of wind turbines rated by Smallwood and Spiegel (2005a,b,c) as disproportionately hazardous, removal of vacant towers ("derelict turbines"), phased repowering over a specified schedule, and a suite of optional measures the SRC was to consider.

Californians for Renewable Energy and several chapters of Audubon Society filed petitions for writ of mandate under the California Environmental Quality Act (CEQA), arguing that the Board Resolution did not go far enough to reduce fatalities. A Settlement Agreement was reached by Parties to the CEQA action, and it was certified by the Alameda County Board of Supervisors on 11 January 2007. The revised measures included a 50% raptor fatality reduction target, which was refined later into a reduction target for four species: golden eagle (*Haliaeetus leucocphalus*), red-tailed hawk (*Buteo jamaicensis*), burrowing owl (*Athene cunicularia*), and American kestrel (*Falco sparverius*), otherwise known as "target or focal species." The new plan was otherwise similar, although the phased repowering was eliminated and included an expanded effort to identify and relocate or remove wind turbines deemed by the SRC to pose excessive collision risk to the target raptor species.

Since it first met in August 2006, the SRC struggled to understand the effectiveness of the required mitigation measures, including the effects of the winter shutdown and hazardous turbines removals. The reasons for this struggle were multiple and complex. However, the SRC never wavered in its priority recommendation for reducing fatalities in the APWRA, and that recommendation was repowering as soon as possible. One of its former members, K. S. Smallwood, helped develop map-based collision hazard models to guide the siting of repowered wind turbines at Vasco Winds (Smallwood and Neher 2010b). The models were intended to help guide the siting of new wind turbines to minimize the risk of collision by target raptor species. Specifically, hazard classes 3 and 4 – the most hazardous classes -- were avoided to the maximum extent feasible. The effort was inspired by the results of focused behavior surveys that had been performed on the neighboring Vasco Caves Regional Preserve, owned by East Bay Regional Park District (Smallwood et al. 2010), which themselves were inspired by strong relationships between fatality rates and specific flight behaviors (Smallwood et al. 2009).

The repowering of Vasco Winds was facilitated by an agreement reached in late 2010 between the California Attorney General's Office, Audubon Society, Californians for Renewable Energy and NextEra (hereafter referred to as the AG agreement). This agreement was for three phases of repowering of all of NextEra's wind turbines in the APWRA, beginning with Vasco Winds as Phase I. The AG Agreement stipulated that the new wind turbines would be sited based on best available scientific methods, and it referenced the approach that appeared in Smallwood and Neher (2010a,b). The AG Agreement also established compensatory mitigation measures and post-construction fatality monitoring standards, the details of which were to be developed in consultation with a newly formed Contra Costa County Technical Advisory Committee (TAC). The monitoring methodology resulting from the AG Agreement and TAC consultation was summarized in the request for proposals and implemented by Ventus.

The AG agreement also stipulated that fatality monitoring at Vasco Winds would be used to validate the map-based collision hazard maps of Smallwood and Neher (2010b), and that all new data collected would be used to inform the siting of new turbines in two additional phases of repowering planned by NextEra in other parts of the APWRA. It stipulated that the TAC would review the final three-year Monitoring Report for each repowering phase to evaluate whether any repowered turbines are causing significantly disproportionate target raptor and or bat fatalities relative to other turbines within that particular phase of repowering. If warranted the TAC then could recommend to the Planning Director of the applicable county, that additional focused monitoring and/or management measures be directed to these turbines to reduce fatalities.

This report presents the results of the first year of avian and bat fatality and utilization monitoring at Vasco Winds. The acoustic monitoring results are presented in Attachment A. To interpret the fatality estimates it was essential to compare fatality estimates in years before and after repowering. This before and after comparison necessitated the use of fatality rate adjustments that were common to both time periods, as well as an adjustment for the difference in maximum search radius of 50 m before repowering and 105 m after repowering. For the purpose of comparing fatality rates before and after repowering, the fatality rate adjustments for carcass persistence and searcher detection consisted of national averages of trial results in grassland environments with high or very high ground visibility, consistent with conditions at Vasco Winds most of the time. On-site trials were also performed for birds, and these yielded on-site carcass persistence and searcher detection rates, which we also were able to combine into overall detection rates so that we could avoid the complex interactions and potential biases associated with relying on separate adjustments for carcass persistence and searcher detection rates. In summary, we compared post-construction fatality rates that were adjusted all three ways just described – (1) National averages for carcass persistence and searcher detection, (2) On-site carcass persistence and searcher detection rates, and (3) On-site trials for overall detection rates, including comparisons of the magnitudes of both the estimates and their associated uncertainty ranges. We also provided a table of what we regarded as the best estimates for bat and bird fatalities found at Vasco Winds.

The report's objectives based on the first year of monitoring were the following:

1) Accurately estimate fatalities of bird and bat species during the first year of post-construction monitoring;
2) Compare fatality rates before and after repowering to assess the relative impacts of repowering;
3) Compare fatality rates among wind turbines to (a) validate the map-based collision hazard models used to site the turbines, (b) inform turbine siting in repowering Phases II and III, and (c) assist the TAC with determining whether any of the wind turbine caused significantly disproportionate numbers of fatalities;
4) Compare adjustments for carcass persistence and searcher detection rates based on (a) national averages from trial results across the USA, (b) on-site trial results applied to small and large bird categories, (c) on-site trial results combining carcass persistence and searcher detection rates in an overall detection rate applied to small and large bird categories, and (d) on-site trial results combining carcass persistence and searcher detection rates in an overall detection rate applied to a wider range of body sizes;
5) Estimate avian use rates that will later be used to (a) eventually compare use rates before and after repowering (an adequate sample size will be needed before convincing comparisons can be made), and (b) validate the map-based collision hazard models; and
6) Estimate bat use rates (Attachment A).

1.2 Study Area

Vasco Winds is situated within the northwestern section of the APWRA in southern Contra Costa County, California, and encompasses 4,234 acres (Figure 1). It lies approximately 4.5 miles south-southwest of the unincorporated community of Byron, approximately 5 miles north of the City of Livermore and approximately 2 miles west-southwest of the Byron Airport. It is bounded to the south by the Alameda County line, bounded to the west by Los Vaqueros Road and transected north-south by Vasco Road. The northwest portion of the study area overlooks the Los Vaqueros Reservoir.

The climate of the site is classified as Mediterranean, with dry, hot summers and cool, wet winters. The area consists of rolling hills covered mostly by annual grassland and interspersed with a few small wetlands. The dominant land use is livestock grazing.

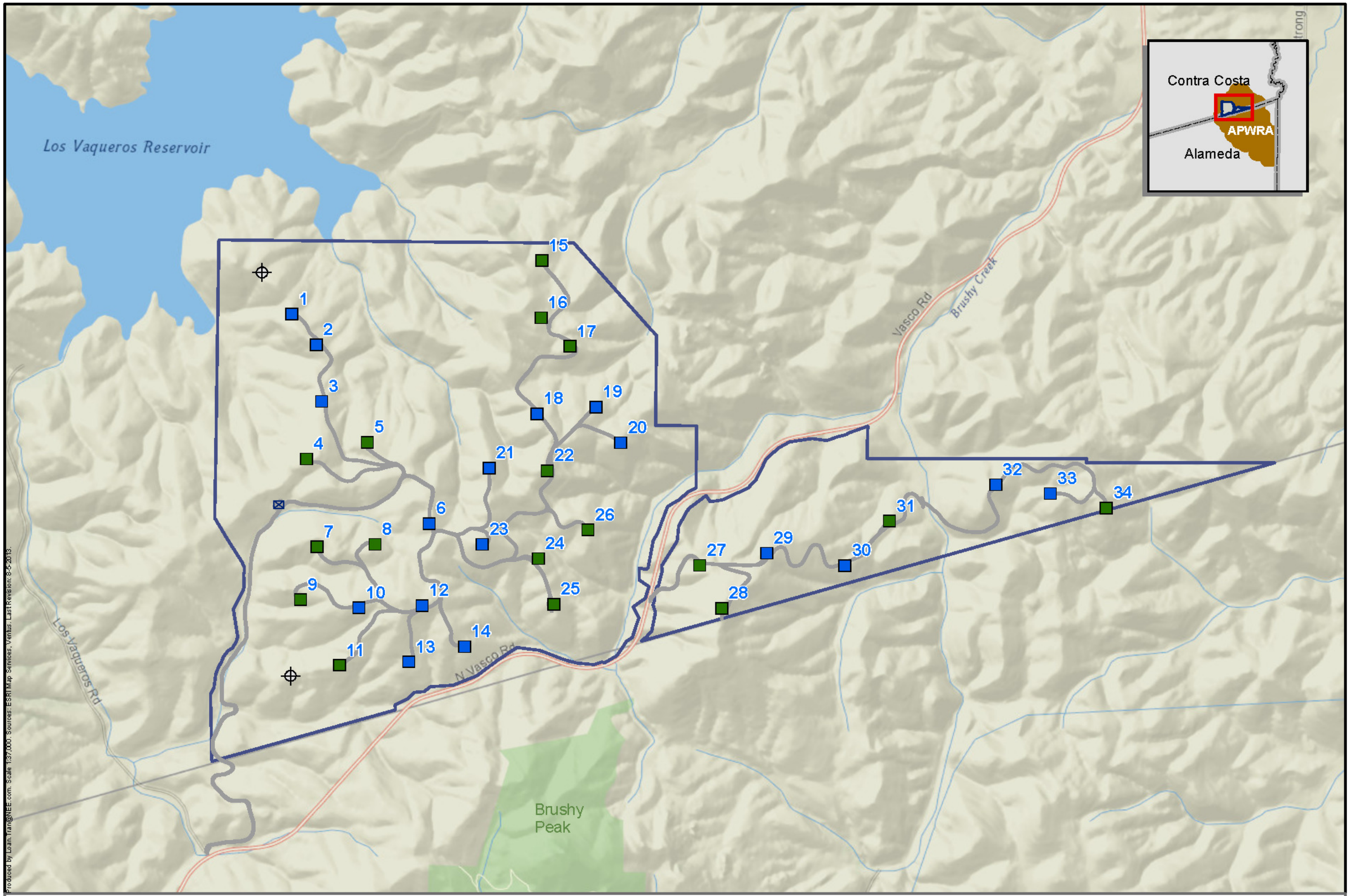

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Figure 1. General Overview Map of the Vasco Winds Energy Center Study Area within the APWRA May 2012 - May 2013

2.0 METHODOLOGY

2.1 Study Design

The Vasco Winds monitoring design included searches once every 7 days at 17 of the 34 turbines and once every 28 days at the other 17 turbines (Table 2). Turbines were randomly assigned to search intervals within six geographic areas, each area including 4-8 turbines. This stratified random design was intended to ensure interspersion of the search intervals, because randomization of a small number of study units can result in pseudoreplication (Hurlbert 1984). For years two and three, the turbines assigned to the two search intervals were again randomly selected, except for a randomly selected core of 5 turbines to be searched once every 7 days all 3 years. Each of the remaining 29 turbines will be searched on a 7 day cycle for at least one year of the three monitoring years.

2.2 Field Methods

2.2.1 Avian Use Surveys

The ultimate objective of the avian use surveys was to compare use rates before and after repowering and to help validate the map-based collision hazard models that were used to site the turbines. Monthly avian use surveys were conducted during the morning hours at eight sites across Vasco Winds. The surveys were performed at the same eight observation points used in monitoring prior to repowering (Figure 2). These observation points were originally selected as part of APWRA-wide monitoring, so they are not evenly spread across Vasco Winds. Their distribution was not intended for comparison of use rates to fatality rates across the project, but could prove useful for comparing use rates before and after repowering.

Surveys lasted 10 minutes at each observation point and consisted of a 360-degree visual scans of the visible airspace out to 500 meters from the center of each point. Prior to each survey, biologists recorded the observation point number, observer's initials, date, start time, cloud cover (%), wind speed (km/hr) and which turbines are operating within the surveyed area. Surveys were not conducted in winds averaging >55 km/hr (33 mph).

During surveys, biologists recorded all birds the size of American kestrels or larger. Individuals or flocks were assigned unique alphanumeric identifiers, with alphabetical characters representing the sequence of observations among individuals and flocks, and numbers representing the minute into the session. Locations were plotted on orthographic maps. On-the minute observations were made of all qualifying birds until the bird or flock left the survey area or the session ended. Observations were recorded to

Table 2. Fatality monitoring design involving the assignment of 7-day or 28-day search intervals to wind turbines in the Vasco Winds Area. This resulted in 5 core 7- day search interval turbines searched over all three study years.

Wind turbine	Stratum	Assigned search interval (days)		
		Year 1	Year 2	Year 3
WTG-01	West 1	7	7	7
WTG-02	West 1	7	7	28
WTG-03	West 1	7	28	7
WTG-04	West 1	28	7	28
WTG-05	West 1	28	28	7
WTG-06	West 3	7	28	28
WTG-07	West 2	28	28	7
WTG-08	West 2	28	28	7
WTG-09	West 2	28	7	28
WTG-10	West 2	7	28	28
WTG-11	West 2	28	28	7
WTG-12	West 2	7	7	28
WTG-13	West 2	7	28	28
WTG-14	West 2	7	7	7
WTG-15	West 4	28	28	7
WTG-16	West 4	28	28	7
WTG-17	West 4	28	7	28
WTG-18	West 4	7	7	28
WTG-19	West 4	7	28	28
WTG-20	West 4	7	7	28
WTG-21	West 3	7	7	7
WTG-22	West 3	28	28	7
WTG-23	West 3	7	7	28
WTG-24	West 3	28	7	28
WTG-25	West 3	28	7	28
WTG-26	West 3	28	28	7
WTG-27	East 5	28	28	7
WTG-28	East 5	28	7	28
WTG-29	East 5	7	7	7
WTG-30	East 5	7	28	28
WTG-31	East 6	28	7	28
WTG-32	East 6	7	28	7
WTG-33	East 6	7	7	7
WTG-34	East 6	28	28	7

Shaded entries represent turbines selected as “core” turbines.

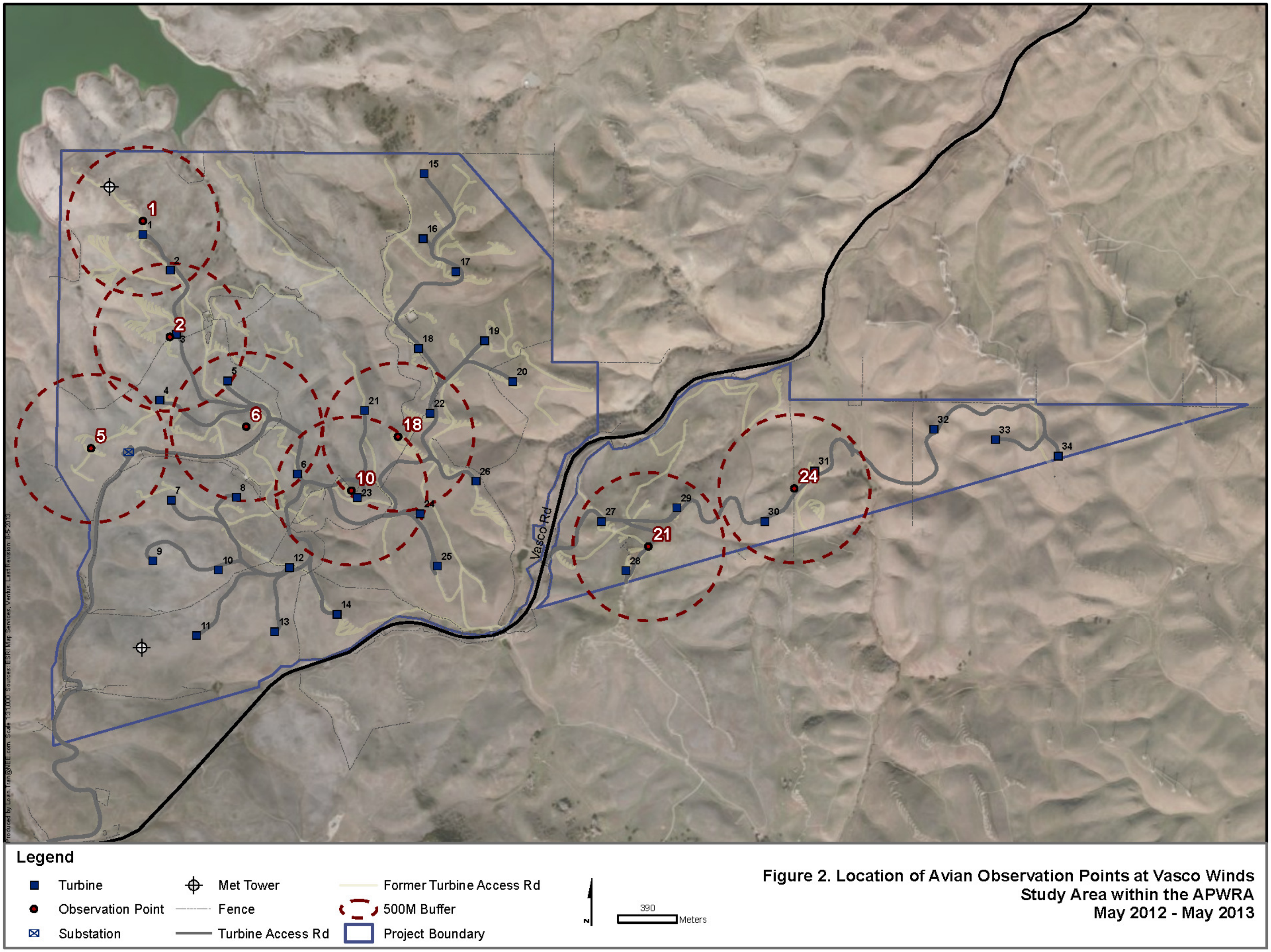

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Figure 2. Location of Avian Observation Points at Vasco Winds Study Area within the APWRA May 2012 - May 2013

electronic spreadsheets, including species, number of individuals, estimated flight height, and behavior (e.g., soaring, contouring, kiting, hovering, gliding, flying through, perching). All mapped locations are intended for digitization and use in a geographic information system (GIS). Because the maximum survey radius implemented in past avian use surveys was reduced from 800 m to 500 m in 2007, detection rates likely changed with the shifts in distance from the observer and the visible airspace. These changes in detection rates need to be characterized and used to adjust the use rates for comparison. This step has not been done yet, so there is no value in comparing use rates before and after repowering at this time.

Another survey effort focused on flight behavior was performed in Vasco Winds. This effort was intended to complement the APWRA-wide golden eagle behavior surveys that were funded by the mitigation stemming from the AG Agreement. These surveys were performed at 8 behavior stations in Vasco Winds, a few of which were at the same observation points used in the utilization surveys. The behavior surveys lasted 30 minutes each and involved a different methodology. The results of these surveys will be analyzed later and separately from the monitoring results that are reported herein.

2.2.2 Fatality Monitoring

Periodic searches were conducted to find bird and bat fatalities associated with wind turbines. The numbers of fatalities found needed to be adjusted for the numbers not found due to searcher error, scavenger removal, and carcasses located beyond the maximum search radius. To produce two of these adjustments, carcasses are volitionally placed in searcher detection and carcass persistence trials. The third adjustment was made based on patterns of fatalities found with increasing distance from the wind turbines searched in projects across North America (Smallwood 2013a).

2.2.2.1 Standardized Carcass Searches

All 34 Siemens turbines were searched for fatalities from 21 May 2012 through 20 May 2013. During this first year of monitoring, half were searched every 7 days and half were searched every 28 days (Table 2). Searchers walked 10 concentric, parallel transects spaced 10 meters apart, while alternately scanning 5 meters to either side of transects. Thus, the maximum search radius of the search area was 105 m. Even though the maximum search radius was 105 m, searchers could still detect carcasses outside the search radius while walking within the search radius. We termed the areas visible to the searchers outside the search area as the additional monitored areas. Fatalities found within additional monitored areas were included in fatality rate estimates so long as they were found within 150% of the maximum search radius (262 meters). This percentage expansion of the monitored area was chosen to be consistent with the Alameda County

SRC's recommended percentage expansion the 50-m maximum search radius applied to the old generation turbines.

To be considered a fatality, each find must have included body parts, bones or feathers. If only feathers were discovered, a minimum of 5 tail feathers or 2 primaries from the same wing had to be found within 5 m of each other, or a minimum of 10 body feathers must have been found to qualify as a fatality, consistent with the protocol used in monitoring prior to repowering.

Each fatality find was assigned a unique number, photographed, and described on an incident report form, then bagged for freezing. (All State or Federally Threatened or Endangered species were left in the field and its location reported to the NextEra Wildlife Program Coordinator for collection.) Data recorded included date and time found, species, age, sex, GPS location, surrounding vegetation, distance and bearing to the nearest turbine, estimated time of death, notes on possible cause of death, and other data. The condition of each carcass was classified as intact, scavenged, or feather spot (>10 feathers).

Fatalities for which cause of death could not be determined were treated as wind turbine-caused fatalities, even though they could have been caused by other factors including predation. Partial remains were checked against previous fatality finds to minimize risk of double counting the same fatality. Collected carcasses were stored at a facility freezer in accordance with Federal collection and salvage permits. Incidental finds within wind turbine search areas were processed in the same manner as routine fatality finds and left in place to possibly be detected during routine searches.

Consistent with practice at most wind projects, including in the APWRA, carcasses found incidental to routine fatality searches within monitored areas were included in fatality rate estimates to minimize bias caused by premature carcass detections at monitored turbines. During routine study activities, such as driving between wind turbines and performing use surveys, incidental finds are inevitable. Excluding incidental finds can generate systematic bias. There is no perfect solution to this form of contamination in routine fatality monitoring, but erring on the side of caution is the standard that applies to resources of high conservation value assessed in the face of high uncertainty (National Research Council 1986).

As detection trials were integrated into routine fatality monitoring, meaning that placed carcasses were left in the search areas to quantify detection rates, biologists discovering carcasses would first ascertain whether the carcass was placed in a trial by inspecting the carcass for clipped flight feathers or taped legs. Trial carcasses were simply recorded as found, and left in the field for the remainder of the trial.

Because a portion of the search area around turbine WTG-34 overlapped with the search area of a row of 120 KW Bonus old generation wind turbines just across the Alameda County border to the south, fatalities found within this area of overlap could have been caused by either WTG-34 or one of the Bonus turbines. These fatalities were recorded as usual, but left in place for the Alameda County monitoring team to find. These fatalities were reported to the NextEra Wildlife Program Coordinator. The Alameda County Monitoring Team implemented the identical protocol for this area of overlap. We estimated fatality rates with and without the fatalities found in this area of overlap.

Fatalities not used for fatality rate estimation employing distance adjustments included remains found outside monitored areas (262 meters), determined to have died due to non-turbine related reasons, estimated to have been in the field >90 days since death, or estimated to have died prior to 7 days preceding the first search at the turbines searched every 7 days and prior to 28 days preceding the first search at the turbines searched every 28 days.

2.2.2.2 Detection Trials

Investigators intending to estimate fatality rates at wind projects typically perform two separate trials to estimate searcher detection rates and carcass persistence rates -- the converse of carcass removal rates. More recently, trial birds used for searcher detection are often left in the field for measurement of carcass persistence, but after the searchers were given only one chance to detect the carcasses. The results of these latter trials were treated in the same analytical manner, either way, with estimates of carcass persistence and searcher detection serving as separate adjustment terms in the fatality estimator.

Beginning in June 2012, we implemented a new method to estimate the proportion of fatalities not detected by fatality searches, while at the same time maintaining the typical methodology. Each season we placed at least 10 carcasses of small birds, i.e., <280 g (e.g., mourning dove, European starling, horned lark), and 10 carcasses of large birds, i.e., ≥280 g (e.g., rock pigeon, mallard, red-tailed hawk), at randomly selected locations within the search areas of wind turbines searched every 7 days and of wind turbines searched every 28 days. Placements were randomized because it remains unknown whether there is any spatial pattern to carcass deposition around wind turbines, whether scavengers remove carcasses non-randomly, or whether searchers find carcasses non-randomly. Placed carcasses were marked by affixing black electrical tape to each leg and clipping flight feathers. Placed birds were tossed over the shoulder to vary the carcasses' dispositions on the ground, and they were mapped using a GPS to help prevent counting the carcass as a collision casualty.

In June 2012 we placed European starlings (*Sturnus vulgaris*) as small birds and mallards (*Anas platyrhynchos*) as large birds, but in later trials we expanded the species and the range of body sizes representing small and large birds. Extra-large birds, such as Canada goose (*Branta canadensis*) and turkey (*Meleagris gallopavo*) were also deployed when available to simulate species such as golden eagles. A designated investigator performed status checks on the following schedule, starting with day 0 as the placement date: 1, 2, 3, 4, 5, 6, 7, 10, 13, 20, 27, 34, 46, and 60 days since placement. Some changes were made to the schedule to accommodate weekends, holidays, and travel constraints.

In fall we placed bat carcasses that had been found on-site during routine fatality searches (we were unable to obtain frozen fresh bat carcasses for use in the trial). These bat carcasses were unsuitable for estimating carcass persistence rates due to unknown time since death-were not likely fresh- (Smallwood 2013a, Smallwood et al. 2013), but were useful for estimating searcher detection rates. The same few bat carcasses were placed repeatedly at randomized locations within turbine search areas scheduled to be searched within the next 24 hours, yielding 14 search detection trial placements.

We measured searcher detection rates, *p*, in the typical manner, where the first search of each area including a placed carcass was used to measure a detection or miss of each carcass, the accumulation of which leads to the estimate of the proportion of placed carcasses that were detected, *p*. This measurement was made only on the carcasses that were available to be found, i.e., not yet removed, thus requiring status checks by a designated investigator. We termed this rate as the initial search-specific detection rate, *p*, in order to distinguish it from our overall detection rate, *D*, which can include multiple searches and incorporates carcass persistence (see below). Our approach differed from the typical approach to measuring the initial search-specific detection rate in one detail. The typical trial involves searches as placed carcasses on the same day of the placements, so as to minimize the number of carcasses being removed by scavenges before the searchers arrive. The carcasses we placed in the trials could have been in the field for 0-7 days at turbines searched every 7 days, or for 0-28 days at turbines searched every 28 days. Carcass condition in our trial likely varied more than it did in typical trials performed across the USA, but we believe that our trial was more realistic in that way.

We measured carcass removal rates (carcass persistence) by leaving trial bird carcasses in the field for at least 90 days, even those that were already detected by fatality searchers. We also measured the overall detection rate, *D*, as the proportion of placed carcasses that were ever found between the date of placement and 90 days since placement. This latter rate, *D*, accounted for both searcher detection, *p*, and carcass persistence rates, *R*, and all the complicated interactions between these two rates, including (1) carcasses persisting longer than the periodic search interval, otherwise known locally as “bleed-through;” (2) changes in carcass detection through time due to environmental exposure, i.e., arthropods, bacteria, sun, wind, rain; and, (3) increased probability of detection of persisting carcasses that were placed where fatality monitoring involves shorter search intervals and thus more opportunities for the searchers to find the carcass.

Beginning in March 2013, we placed additional birds with a greater size range (very small birds such as lesser goldfinch to very large carcasses such as wild turkey and Canada goose) to derive more accurate estimates of *D*, but these placements did not require carcass checks and so no carcass checks were made. Some of these trial birds were placed too late in spring 2013 for use in this report because insufficient fatality searches had been conducted by the end of the first year of monitoring. All of these birds remain in the study and will eventually be used to estimate *D*.

2.3 Analytical Methods

2.3.1 Avian Use

Data collected from the utilization surveys were summarized as the number of first detections of each bird per 10-minute survey. To be comparable to use rates before repowering, an adjustment is needed for the decrease in maximum survey radius from 800 m to 500 m in 2007. This adjustment will be derived from models fit to detection rates of each species as functions of distance from the observer. That work is ongoing.

2.3.2 Avian and Bat Fatality

We placed bird carcasses for simultaneous measurements of searcher detection rates (*p*) and carcass persistence rates (*R*), but we also used these and other carcasses to measure overall detection rates (*D*). The adjustment terms *R* and *p* were used in the following fatality estimation equations derived from Horvitz and Thompson (1952):

$$\mathrm{F}_A = \frac{\mathrm{F}_U}{p \times R_c \times d}, \qquad \text{eqn 1}$$

where F_A and F_U were adjusted and unadjusted fatality rate estimates, respectively, *d* was the proportion of carcasses predicted to be found within the maximum search radius, given the combination of the search radius and the tower height, and based on patterns of fatalities found with increasing distance from the turbines (Smallwood 2013a), *p* was the initial search-specific detection rate expressed as the proportion of available carcasses that were found, and R_c was the carcass persistence rate expressed as the proportion of carcasses remaining at the time of the search:

$$R_c = \frac{\sum_{i=1}^{I} R_i}{I} \quad ,$$

where R_i was the predicted proportion of carcasses remaining at the *i*th day into the trial, based on nonlinear regression used to fit a predictive model to the data, and I was the day into the trial which corresponded with the average search interval of the fatality monitoring (7 days or 28 days). In this study, R_c values based on national averages were doubled for birds weighing >1 kg, because monitors at wind projects across North America often placed rock pigeons, ducks, and other birds that were much smaller than 1 kg to represent “large birds” the size of red-tailed hawks and golden eagles. Also, an ongoing, integrated trial intended to estimate an overall detection rate in the avian safety test of a new wind turbine design in the APWRA found high persistence rates of bird carcasses of species >1 kg in size (This study). National average Rc values >0.5 were converted to 1.0 for bird species >1 kg because R_c values cannot exceed 1.0. The doubling yielded persistence rates of large birds that were consistent with the values obtained in our expanded carcass placements to estimate D.

We also predicted D across a greater number of body size categories than the small and large categories often used in wind projects. We recorded the typical body mass of each bird species we placed in the trials, and aggregated these body masses into the following initial categories: 1-12, 13-24, 25-48, 49-96, 97-192, 193-384, 385-768, 769-1536, 1537-3072, and 3073-6,144 g. We calculated the proportion of carcasses found within each of these size categories that included a sufficient number of trials to make the calculation, and we related these calculated values of D to the mean species’ body mass included in each size-range category. For example, if one bird was detected among four weighing 6, 8, 10, and 12 g, then a D of 0.25 would be related to an average body mass of 9 g ((6+8+10+12) ÷ 4). These comparisons were used to derive predictions of D as a logistic function of body mass, using least-squares regression and the simplex method to iteratively search parameter space for the best-fit model parameters. We used the root mean square error (RMSE) of the nonlinear regression models to serve as standard error.

2.3.2.1 Search Radius and Carcass Distance from the Turbine

Fatality rates are not comparable between wind projects unless one accounts for variation in combinations of tower heights and maximum fatality search radius (Smallwood 2009, 2013a). These combinations partly determine the proportion of fatalities that are found, because turbines on taller towers can throw some birds and bats outside the search area, and search areas that have been implemented at projects have been decided somewhat arbitrarily. The adjustment factor, d, represents the proportion of carcasses likely to be found from within the maximum search radius around wind turbines on given tower heights. To obtain d in fatality rate equation 1, Smallwood (2013a) reviewed tables and appendices in available reports to obtain distances of fatalities from wind turbines. Fatality finds were summed within 1-m intervals of distance from the turbines for each group of tower heights and each group of maximum search radii, and least-squares regression analysis was used to fit logistic functions to the cumulative sum fatalities with increasing distance from the turbine. The regressions were restricted to the distance of the maximum search radius plus 5 m to account for the area likely searched as the searcher reached the search boundary. In all cases, a logistic function was fit to the data, iteratively changing the upper bound value of the dependent variable in the model until the minimum root mean square error (RMSE) was obtained:

$$Y = \frac{1}{\left(\frac{1}{u} + a \times b^X\right)},$$

where u was the upper bound value of the dependent variable, Y, X was meters from wind turbine where nearest fatality remains were located, and a and b were fitted coefficients.

The regression models were used to predict cumulative sum fatalities as functions of distance from the turbine, which were then extended to distances beyond the maximum search radii that were reported at wind-energy projects (Smallwood 2013a). These model predictions were extended to greater distances to identify asymptotic values, which were then divided into predicted values at each 1-m interval to represent the predicted value as a proportion of the asymptotic value. The result was a predicted cumulative proportion of fatalities relative to the predicted maximum (1.0) that would have been found had the searches extended well beyond the search boundary. For tower heights of 18.5-24.6 m among the old-generation turbines preceding repowering, and for the 80 m towers of the new turbines, asymptotes of cumulative carcasses found were obtained from wind projects with maximum search radii of 50 m and 105 m, corresponding with the methodology used in the Altamont Pass before and after repowering. Most of the data representing the shorter towers and search radius were from the Altamont Pass. For bats, however, insufficient data were available from projects with tower heights as short as those of the old-generation turbines in the Altamont Pass, so data were used from projects with tower heights of 50 m and maximum search radius of 50 m.

The distances to which carcasses are deposited by wind turbines remain unknown, but it is known that carcasses are often detected beyond the maximum search radius. The adjustment for search radius is necessary because wind turbine sizes and maximum search radii have varied greatly, resulting in variation in the proportion of fatalities occurring outside the maximum search radius that are found. There was no empirical foundation for deciding on maximum search radius, so it has been decided by following the examples of other monitoring programs and by budgets. Until directed research can better establish detection rates as functions of distance from turbines, Smallwood's (2013a) approach is the only one available at this time. Many factors could affect the proportions of fatalities detected beyond the maximum search radius at wind projects, such as slope and vegetation cover, but these factors have yet to be adequately quantified.

2.3.2.2 New Estimator

We performed our trial in a manner that allowed us to replace $p \times R_c$ in equation 1 with an overall detection rate, D:

$$F_A = \frac{F_U}{D \times d}, \qquad \text{eqn 2}$$

where *D* was the proportion of placed carcasses that was detected by searchers performing periodic fatality searches throughout the duration of monitoring. The advantages of the latter approach would be to avoid biases caused by interactions between searcher detection and scavenger removal rates, when estimated separately, and to carry less error through the calculations due to one fewer adjustment terms. Another advantage would be much lower cost of implementation, because it does not require carcass checks.

2.3.2.3 Carrying Error Terms through Calculations

We carried the error through the equations using the Delta Method (Goodman 1960), shown here applied to the adjustment factors, p, R_c, and d:

$$SE(F_A) = \sqrt{\left(\left(\left(\frac{1}{p \times R_C \times d}\right) \times SE(F_U)\right)^2 + \left(\left(\frac{F_U}{p \times d} \times \left(\frac{-1}{{R_C}^2}\right)\right) \times SE(R_C)\right)^2 + \left(\left(\frac{F_U}{R_C \times d} \times \left(\frac{-1}{p^2}\right)\right) \times SE(p)\right)^2 + \left(\left(\frac{F_U}{R_C \times p} \times \left(\frac{-1}{d^2}\right)\right) \times SE(d)\right)^2\right)}$$

The adjustment for searcher detection, *p*, was a proportion of carcasses found. This proportion is a single measured outcome rather than a statistical outcome with measured variation. A common problem with using proportions of carcasses found in a trial is sacrificial pseudoreplication (Smallwood et al. 2013), because no estimate of the variation in outcomes accompanies the calculated proportion. To partly overcome this problem, we obtained standard error estimates for both *p* and *D* by performing 1,000 iterations of Monte Carlo simulation on Binomial distributions fit to the data for small birds and large birds in trials involving 7 day and 28 day average search intervals.

In the cases of two broad size categories (small and large), the SE (standard error) values obtained from the Monte Carlo simulations will tend to be small, due to sacrificial pseudoreplication. The SE values from the nonlinear functions of *D* with species' body mass will tend to be large for now, due to small sample sizes in some size range categories. As the trials for *D* continue, the range of body size categories will increase, as will the sample sizes of trials within each category, so the SE estimates will lessen substantially.

2.3.2.4 Comparing Fatalities before and after Repowering

Prior to repowering, fatality rates were dynamic due to natural fluctuations in relative abundance of species in the APWRA, and due to management actions. Fatality monitoring in the APWRA revealed multi-year cycles of fatalities among raptor species from 1999 through 2012. Species-specific cycles largely occurred in parallel, so there were peaks and troughs in combined raptor fatality rates (Smallwood 2013b). A peak in fatalities occurred in 2006, followed by a decline through 2009 (Leslie et al. 2012), and the pattern of fatality rates over the long term would lead to a prediction of the next peak in fatalities occurring in 2012 and 2013 – a prediction that was supported by patterns in the data, e.g., at wind turbines searched over long periods (Smallwood 2013b). The declining trend from 2006 through 2009 was only part of a larger cycle, and was also evident in the fatality monitoring at the Diablo Winds Energy Project, where no management actions were taken, i.e., where management actions could not confound interpretation of the trend. At Vasco Winds, management actions were taken, and those actions contributed to more substantial declines in raptor fatalities than would have happened as a result of natural cycles (Smallwood 2013b). Therefore, comparing fatality rates before and after repowering must be done very carefully, keeping in mind the natural cycles of fatality rates that occur in the APWRA.

To compare fatality rates before and after repowering, we obtained and processed the fatality data maintained by Smallwood and the Alameda County Monitor (currently ICF International). These data were then used to estimate fatality rates for comparison to the first year of fatality monitoring following repowering. The only adjustment factors commonly available to both sets of data were national averages of p and R_c obtained from wind projects in grasslands where ground visibility was high or very high. Using D as the adjustment factor would be preferable to using p and R_c, but D has not been estimated for search intervals of 30 to 50 days used by the Alameda County Monitor. Fatality rates were also adjusted for differences in tower height and maximum search radius, as discussed above.

2.3.2.5 Comparing Fatality Rates among Repowered Turbines

To assess the effectiveness of the map-based collision hazard models and to learn from the patterns of fatalities so that wind turbines can be more effectively sited in future phases of repowering, we compared fatality rates among the repowered turbines during the first year of monitoring. To compare fatality rates among the 34 repowered wind turbines, we adjusted the fatality rates by values of D that were predicted from measured values of D as a logistic function of species-specific body mass (g). Because the logistic function was less reliable for predicting small birds found in the 28-day search interval due to small sample size, we doubled the predicted values of D for all birds smaller than 80 g to be consistent with values of D predicted in this study. No such adjustment was made for the birds found in the 7 day search interval.

Adjusted fatality rates were compared to the area (m^2) of species-specific collision hazard classes 3 and 4 within 150 m of each wind turbine. Collision hazard classes 3 and 4 – the most hazardous classes -- were the classes to be avoided when siting the Vasco Winds turbines (Smallwood and Neher 2010b). We also compared fatality rates to measured terrain variables, including elevation, slope, aspect, distance to the nearest ridge crest, distance to the nearest major ridge or hill peak, slope size, and many other measures. All measurements were made in GIS. These comparisons will be made in future years as average search intervals are rotated among the wind turbines.

2.3.2.6 Summary of Fatality Adjustments

To summarize, we used the following approaches to adjust fatality rate estimates based on searches at 7 day and 28 day intervals, depending on the comparison of fatality rates being made and the availability of data needed to make the adjustments:

1. To compare fatality rates before and after repowering, we used national averages of p and R_c from hundreds of searcher detection and carcass persistence trials performed across North America, taking the averages only from grasslands with high and very high ground visibility (Smallwood 2013a) and applying them to bats and two body-size classes of birds – small and large;

2. To compare the efficacy of detection trial methodology, we compared fatality rate estimates derived from 7 and 28 day search intervals and adjusted by $p \times R_c$ and adjusted by D, all of which were derived from on-site trials and applied to small and large body-size classes of birds;

3. To compare fatality rates among the 34 repowered wind turbines, we adjusted the fatality rates by predicted values of D, the model of which consisted of measured values of D as a logistic function of species-specific body mass (g), and where D was measured in on-site trials.

We did not use the adjustment trial data developed by the Alameda County Monitoring Team because (1) most of its placed carcasses were of unknown times since death and (2) the complexity of the data structure has required considerable post-processing, which is ongoing.

All three of the approaches above are useful for comparing methodology, such as determining whether on-site trial results were anomalous, but each also meets specific needs. We needed national averages to compare pre- and post-repowering fatality estimates because we lacked on-site detection trials prior to repowering, and because the fatality searches preceding repowering were at much longer intervals. We also needed national averages to fill in carcass persistence rates for bats, which we did not have available for on-site trials. The third approach should prove to be the most effective, but our sample sizes need to be larger for certain size classes, especially at the turbines searched every 28 days.

We used what we regarded as the most appropriate adjustment factors that were applied to the data derived from two search intervals – 7 days and 28 days -- to compile our best fatality estimates at Vasco Winds during the first year of monitoring after repowering.

3.0 RESULTS

3.1 Avian Use

After 8 plots were surveyed 12 times, totaling 960 minutes of survey (96 surveys × 10 min), 122 groups of birds were observed, including 803 individual birds representing at least 14 species (Table 3). Overall avian use was 8.36 birds/10 minute survey, ranging from 0 to 6.72 birds/10 min. The five most abundant taxa were gulls with a mean use of 6.72 birds/survey followed by common raven (0.86 birds/survey), red-tailed hawk (0.23 birds/survey), turkey vulture (0.15 birds/survey), and mallard (0.10 birds/survey). Of all observations, raptors composed 6% and target species (red-tailed hawk, golden eagle, American kestrel) composed 4%. No burrowing owls were observed during the surveys. Although gulls exhibited the highest mean use, they were observed in only 10% of surveys, because they were observed in large groups. Common ravens were observed in 27% of all surveys.

Red-tailed hawks were the most common raptor, with 22 individuals observed in 19% of surveys, followed by 14 turkey vultures in 11% of surveys, 6 golden eagles and 7 American kestrels in 6% of surveys, and 1 northern harrier (*Circus cyaneus*) and 1 merlin (*Falco columbarius*) in 1% of surveys.

Table 3. Avian use after one year of monthly 10-minute surveys at 8 stations (960 minutes total) at the Vasco Winds Area.

Species*	Number of Individuals	Number of Groups	Use (individuals/ 10 min survey)	Frequency (% surveys detected)	% composition	
					Group	Overall
Great blue heron	1	1	0.01	1.04	0.82	0.12
Merlin	1	1	0.01	1.04	0.82	0.12
Mourning dove	1	1	0.01	1.04	0.82	0.12
Northern harrier	1	1	0.01	1.04	0.82	0.12
American white pelican	3	1	0.03	1.04	0.82	0.37
American crow	4	2	0.04	2.08	1.64	0.50
Bufflehead	45	2	0.05	2.08	1.64	0.62
Golden eagle	6	6	0.06	6.25	4.92	0.75
American kestrel	7	7	0.07	6.25	5.74	0.87
Mallard	10	5	0.10	5.21	4.10	1.25
Turkey vulture	14	12	0.15	11.46	9.84	1.74
Red-tailed hawk	22	21	0.23	18.75	17.21	2.74
Common raven	83	40	0.86	27.08	32.79	10.34
Unknown gull species	645	22	6.72	10.42	18.03	80.32
All species	**803**	**122**	**8.36**	--	**100**	**100**
Raptors	51	48	0.53	32.29	39.34	6.35
Target species	35	34	0.36	27.08	27.87	4.36

Species in **bold** are target raptor species as defined in the AG Agreement.

3.2 Avian and Bat Fatalities

A total of 84 fatalities, 65 birds and 19 bats, were discovered during the first year of fatality searches (Table 4, Appendix A). These included three avian fatalities that were determined to be >90 days since death, and excluded from fatality estimates. Five fatalities were found incidentally to routine searches, three of which were found within search areas and two that were beyond the maximum search radius. Incidental finds included in fatality estimates included a swallow and a Mexican free-tail bat. One red-tailed hawk found at 137 m from a turbine was used in fatality estimation adjusting for distance because it was within 150% of the maximum search radius.

Thirty-three fatalities were raptors, including 16 red-tailed hawks, 9 American kestrels, and 3 burrowing owls. No golden eagles were found during the monitoring period, but one was found in late February 2012 and could have been available for searchers to find had the carcass not been removed per protocol. It was also possible that had searchers found this golden eagle, its death would have been estimated within 28 days of the first search at the turbine, which was searched every 28 days beginning in mid-May 2012. A golden eagle fatality rate was calculated so that readers can either include or exclude the rate, depending on whether the reader believes the eagle carcass would have been counted as a recent fatality had it not been removed.

Of the 19 bat fatalities, 10 (53%) were hoary bats (*Lasiurus cinereus*), 7 (37%) were Mexican free-tail bats (*Tadarida brasiliensis*), 1 was a western red bat (*Lasiurus blossevillii*), and 1 could not be identified to species.

The locations of all fatalities, including those found beyond the search area and the golden eagle found before the beginning of the monitoring period are mapped in Figure 3. Locations of bat and target raptor species are presented in Figure 4.

Table 4. Avian and bat fatalities found during the first monitoring year at the Vasco Winds Area used in estimates (total number found).

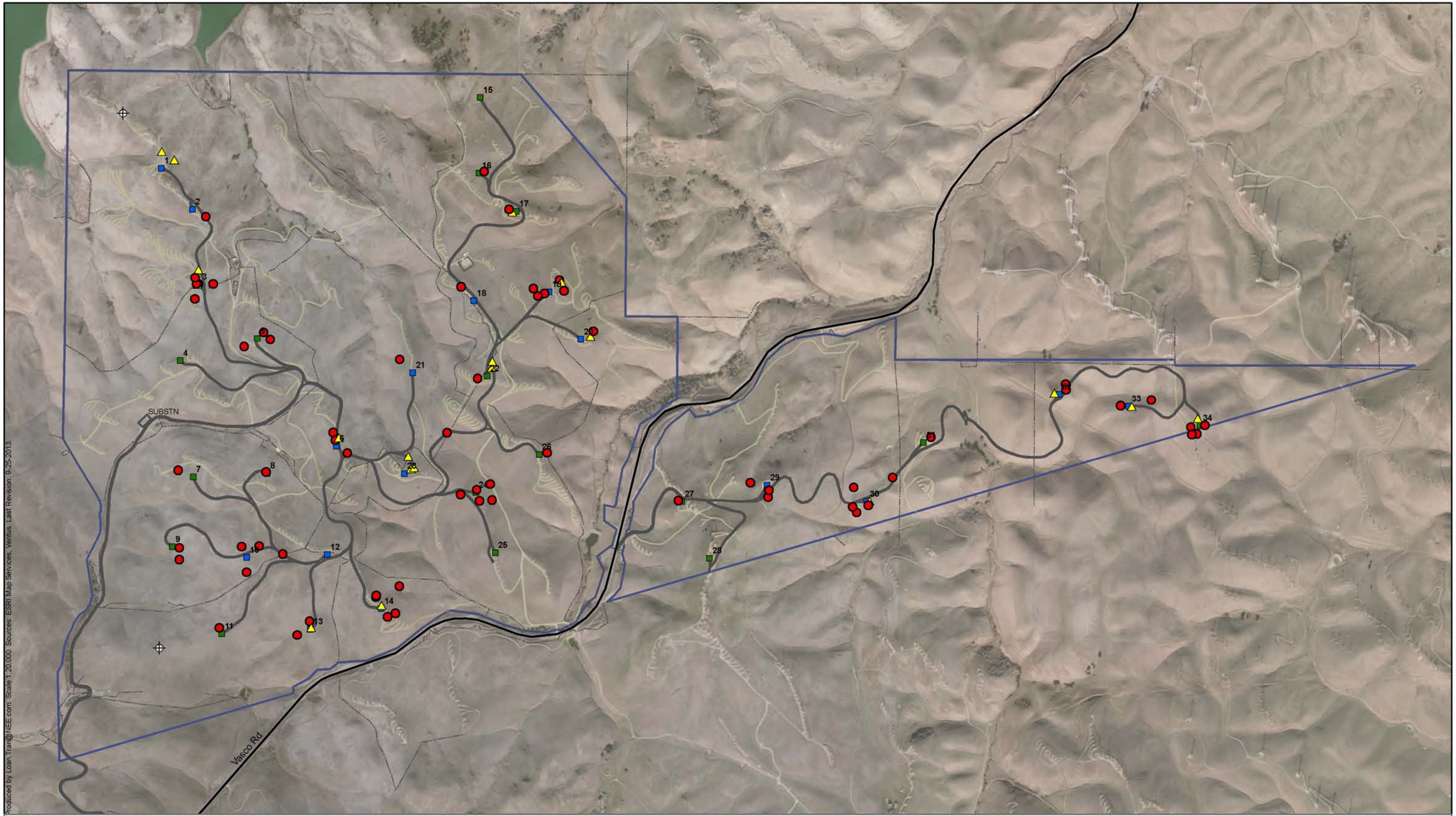
Species/Group	Species name	28 day search interval	7 day search interval	Total, including incidentals
American kestrel	*Falco americanus*	3[a] (3)[a]	5 (5)	8[a] (9)[a, b]
Barn owl	*Tyto alba*	0 (0)	2 (3)	2 (3)
Brewer's blackbird	*Euphagus cyanocephalus*	0 (0)	1 (1)	1 (1)
Burrowing owl	*Athene cunicularia*	2 (2)	1 (1)	3 (3)
Double-crested cormorant	*Phalocrocorax auritus*	1 (1)	0 (0)	1 (1)
Golden eagle [c]	*Aquila chrysaetos*	1 (1)	0 (0)	1 (1)
Hoary bat	*Lasiurus cinereus*	2 (2)	8 (8)	10 (10)
Mexican free-tailed bat	*Tadarida brasiliensis*	2[d] (2)	5 (5)	7 (7)
Mourning dove	*Zenaida macroura*	1 (1)	2 (2)	3 (3)
Red-tailed hawk	*Buteo jamaicensis*	6[a] (7)[a]	9 (10)	15[a] (17)[a]
Rough-winged swallow	*Stelgidopteryx serripennis*	0 (0)	1 (1)	1 (1)
Ruby-crowned kinglet	*Regulus calendula*	0 (0)	1 (1)	1 (1)
Tree swallow	*Tachycineta bicolor*	0 (0)	1 (1)	1 (1)
Bat sp.		0 (0)	1 (1)	1 (1)
Duck sp.		1 (1)	0 (0)	1 (1)
Gull sp.		3 (3)	1 (1)	4 (4)
Large bird		1 (2)	0 (1)	1 (4)[b]
Raptor sp.		0 (0)	1 (1)	1 (1)
Small bird		0 (0)	4 (5)	4 (5)
Swallow sp.		0 (0)	1 [d] (1)	1 (1)
Virginia rail	*Rallus limicola*	1 (1)	0 (0)	1 (1)
Western meadowlark	*Sturnella neglecta*	0 (1)	6 (6)	6 (7)
Western red bat	*Lasiurus blossevillii*	0 (0)	1 (1)	1 (1)
Total		**24 (27)**	**51 (55)**	**75 (84)**
All bats		**4 (4)**	**14 (15)**	**18 (19)**
All raptors		**12 (13)**	**18 (20)**	**30 (34)**
All birds		**20 (23)**	**36 (40)**	**56 (65)**
Target raptors		**12 (13)**	**15 (16)**	**27 (30)**

[a] One American kestrel and 2 red-tailed hawk fatalities found in search area that overlapped with the area searched by the Alameda County Monitoring Team at the 120 KW Bonus old generation turbines.

[b] One large bird found and American kestrel were found incidentally on site far from wind turbine search areas, and excluded.

[c] Golden eagle was found in February 2012, prior to fatality monitoring.

[d] Found on plot incidentally to routine searches, but included in adjusted fatality estimates.



Legend

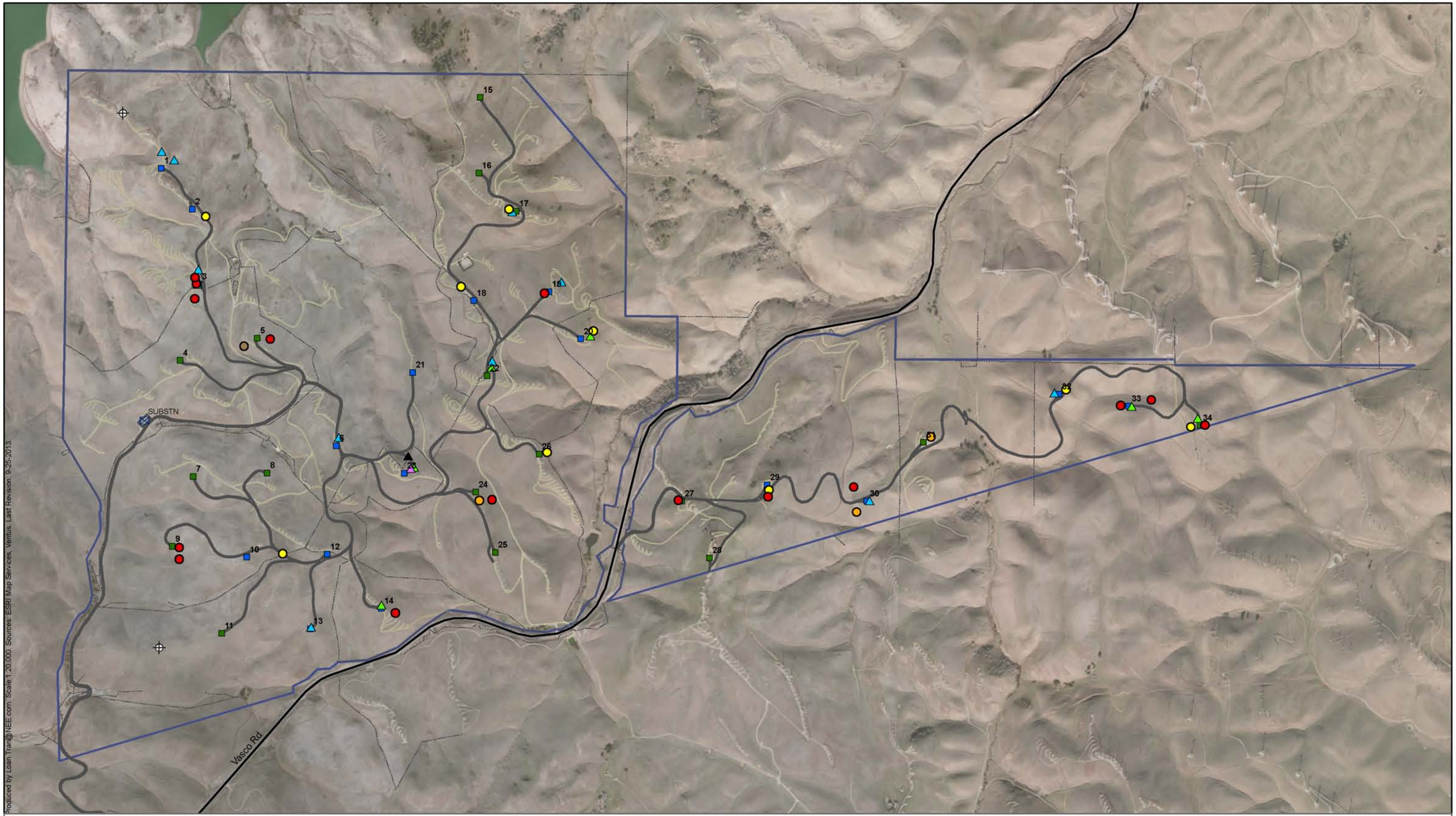
🟦 Turbine (7 day search)	● Avian Fatality	⌖ Met Tower	Former Turbine Access Rd
🟩 Turbine (28 day search)	△ Bat Fatality	Turbine Access Rd	☐ Project Boundary

N

400 Meters

Figure 3. Distribution of All Avian and Bat Fatalities Documented at Vasco Winds Study Area within the APWRA
May 2012 - May 2013

Note: Includes incidentals (carcasses found within plots outside of routine searches or beyond search plots), aged carcasses and one golden eagle found in February 2012 prior to fatality monitoring.



Produced by Loan.Tran@NEE.com. Scale 1:20,000. Sources: ESRI Map Services, Ventus. Last Revision: 9-25-2013.

Legend

- ■ Turbine (7 day search)
- ■ Turbine (28 day search)

Target Species

- ● American kestrel
- ● Burrowing owl
- ● Golden eagle
- ● Red-tailed hawk

Bat Species

- ▲ Hoary bat
- ▲ Mexican free-tailed bat
- ▲ Unknown Bat
- ▲ Western red bat

N

400 Meters

Figure 4. Distribution of All Target Species and Bat Fatalities Documented at Vasco Winds Study Area within the APWRA May 2012 - May 2013

Note: Includes incidentals (carcasses found within plots outside of routine searches or beyond search plots), aged carcasses and one golden eagle found in February 2012 prior to fatality monitoring.

3.2.1 Adjustment Factors

3.2.1.1 Search radius/Tower height

Available data from monitoring reports at wind projects across North American, including 2,345 bird carcasses found within 50 m of 18.6-m towers, 45 bat carcasses within 50 m of 50-m towers, and 408 bird carcasses and 97 bat carcasses within 105 m of 80-m towers (Figure 5), showed patterns of distribution suggesting that few if any bats would have been found beyond the fatality search radii used before and after repowering at Vasco Winds. The patterns in the data also suggest that about 9% of the birds available to be found would have been beyond the 50 m search radius prior to repowering, and about 22% would have been beyond the maximum search radius used after repowering (Figure 6). We adjusted our fatality rate estimates accordingly. Pre-repowering bird estimates were divided by 0.91 (SE = 0.186) and post-repowering bird estimates were divided by 0.78 (SE = 0.226). Pre-repowering bat estimates were divided by 1.0 (SE = 0.359), and post-repowering bat estimates were divided by 0.98 (SE = 0.229).

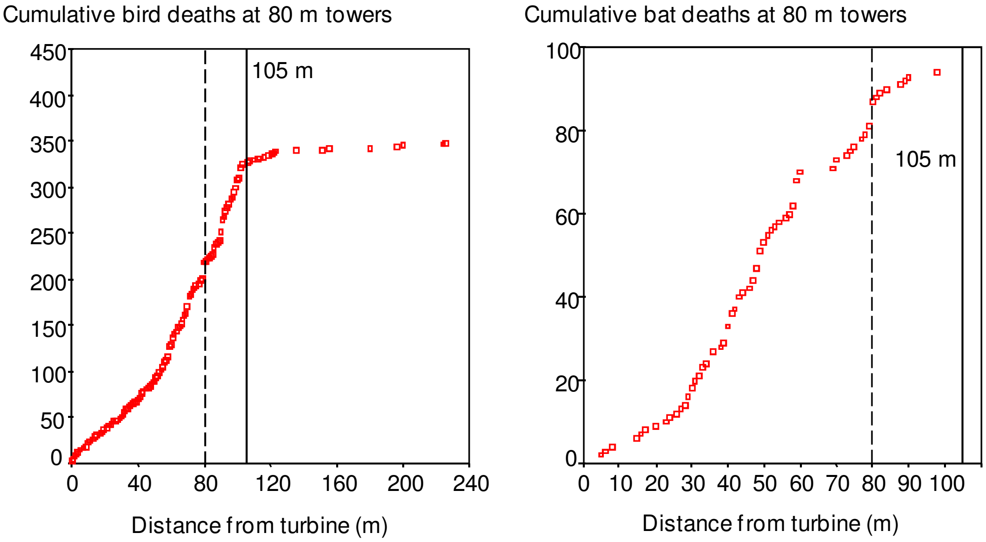


Figure 5. Cumulative sum carcasses of birds (left graph) and bats (right graph) found at North American wind projects with 105-m maximum search radius (solid vertical line) around turbines on 80-m towers (dashed vertical lines) (Smallwood 2013).

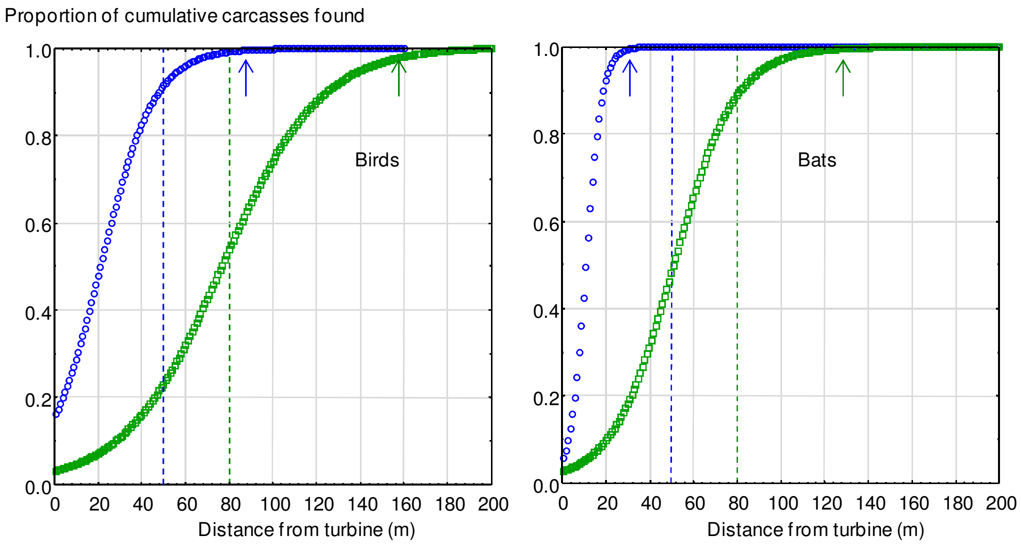


Figure 6. Proportions of cumulative sum carcasses of birds (left graph) and bats (right graph) at 19-m towers and 50 m maximum search radius (blue circles) and at 80-m towers and 105 m maximum search radius (green squares). The dashed vertical lines represent the tower heights, and the arrows show the asymptotes of cumulative sum carcasses predicted by linear regression models (Smallwood 2013).

3.2.1.2 Searcher Detection

Of the carcasses remaining upon the first fatality search, the proportion found by searchers was similar to proportions reported in hundreds of detection trials performed at wind projects across the USA (Smallwood 2013a), including 28% of bats, 34% of small birds and 70% of large birds (Table 5). Searcher detection rates used to estimate fatality rates in this study appear in Table 6, along with their SE estimates derived from Monte Carlo simulation.

Table 5. Summary of searcher detection trials at the Vasco Winds Area, June 2012 through April 2013, for each combination of size class, season, and search interval (top panel), for combined search intervals (second panel), for combined seasons (third panel), and for combined seasons and search intervals (bottom panel).

Size class	Season	Search interval (days)	Total placed	Available to be found on first search	Percent available to be found	Found during initial search	Proportion found during first search of available carcasses
Small	Fall	7	8	8	100	2	0.250
Small	Spring	7	9	6	67	2	0.333
Small	Summer	7	8	4	50	2	0.500
Small	Winter	7	8	6	75	1	0.167
Small	Fall	28	8	2	25	1	0.500
Small	Spring	28	9	4	44	2	0.500
Small	Summer	28	7	3	43	1	0.333
Small	Winter	28	10	2	20	1	0.500
Large	Fall	7	8	8	100	8	1.000
Large	Spring	7	9	9	100	7	0.778
Large	Summer	7	8	5	63	3	0.600
Large	Winter	7	8	8	100	5	0.625
Large	Fall	28	8	5	63	3	0.600
Large	Spring	28	9	5	56	4	0.800
Large	Summer	28	5	3	60	2	0.667
Large	Winter	28	7	4	57	1	0.250
Extra large	Fall	7	1	1	100	1	1.000
Extra large	Fall	28	4	4	100	4	1.000
Small	Fall		15	10	67	3	0.300
Small	Spring		18	10	56	4	0.400
Small	Summer		15	7	47	3	0.429
Small	Winter		18	8	44	2	0.250
Large	Fall		16	13	81	11	0.846
Large	Spring		18	14	78	11	0.786
Large	Summer		13	8	62	5	0.625
Large	Winter		15	12	80	6	0.500
Small	Annual	7	33	24	73	7	0.292
Small	Annual	28	34	11	32	5	0.455
Large	Annual	7	33	30	91	23	0.767
Large	Annual	28	29	17	59	10	0.588
Small	Annual		67	35	52	12	0.343
Large	Annual		62	47	76	33	0.702

Table 6. Searcher detection rates used to adjust fatality rates after the first year of post-repowering monitoring at the Vasco Winds Area, where SE was estimated from 1000 iterations of Monte Carlo simulation on Binomial distributions fit to the data.

Size class	Search interval (days)	No. carcasses placed	No. available to be found upon first search	Proportion found	SE
Bats		17	14	0.286	0.014
Small	7	33	24	0.292	0.014
Small	28	34	11	0.455	0.016
Large	7	33	30	0.767	0.013
Large	28	29	17	0.588	0.016
Extra large	7	1	1	1.000	0.000
Extra large	28	4	4	1.000	0.000

3.2.1.3 Carcass Persistence

Most of the carcass removals happened within the first few days after placement, resulting in nearly identical removal curves between small and large birds over the first few days. All extra large birds persisted and were found by searchers (Figure 7). As has been typical, the removal rate of large carcasses slowed sooner than did the removal rate of small carcasses. Persistence rates did not vary much by season among small-bodied carcasses, but was lowest in fall for large-bodied carcasses (Figure 3, top graphs). With only one seasonal difference for one size-class (fall, large birds), we decided to combine all of the trial data across seasons. The following regression models were fit to the data and used to predict the persistence rates corresponding with 7-day and 28-day search intervals, R_c:

Small birds ($r^2 = 0.94$, RMSE = 0.084, $P < 0.0001$),

$$R_i = 1.047 - 0.895 \times \log_{10}(\text{Days} + 1) + 0.177 \times \log_{10}(\text{Days} + 1)^2$$

Large birds ($r^2 = 0.98$, RMSE = 0.117, $P < 0.0001$),

$$R_i = 0.961 - 0.134 \times \log_{10}(\text{Days} + 1)$$

Predicted average persistence rates appear in Table 7. Because we only had bat carcasses found during fatality searches, we were unaware of how long the bats had been dead. Our bat carcasses were therefore unusable in a carcass persistence trial. We placed these bats only for estimating an initial search-specific detection rate. To adjust bat fatalities for carcass persistence, we used national averages in grassland environments with high to very high ground visibility.

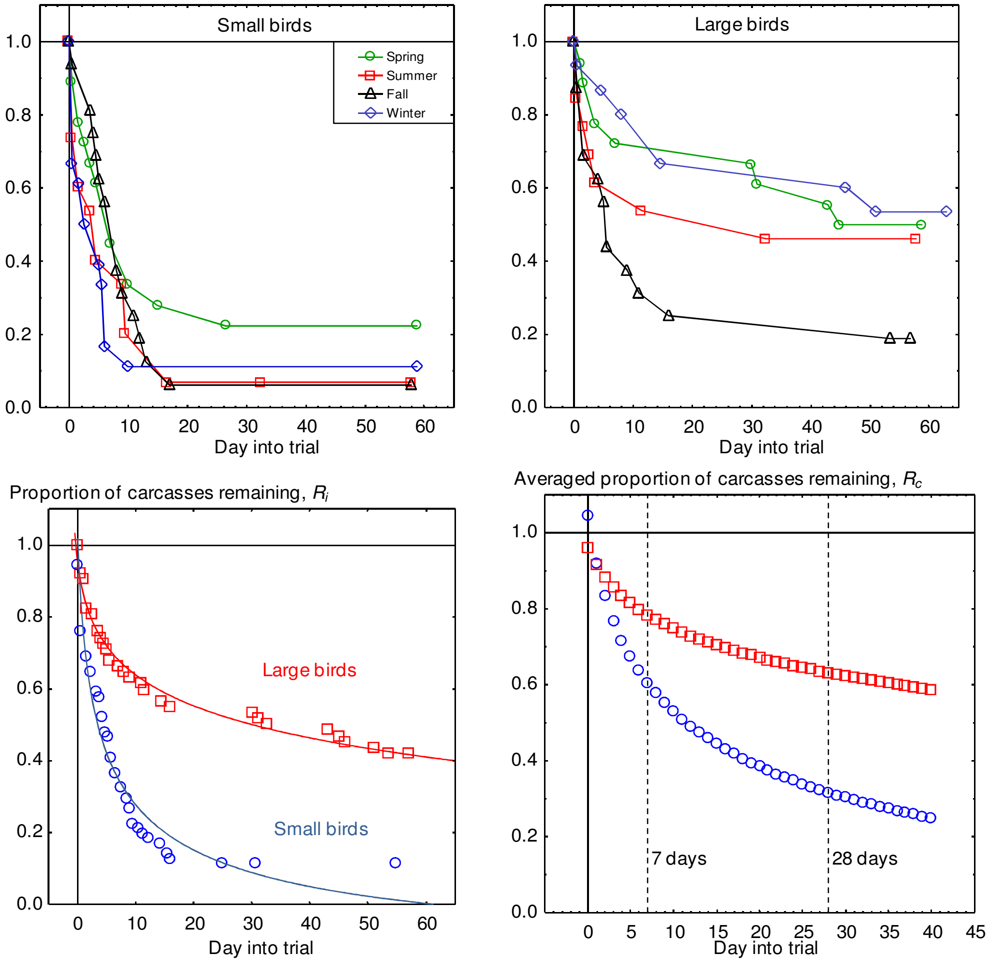


Figure 7. Seasonal carcass persistence curves for small birds (top left graph) and large birds (top right graph), and season-free persistence rates fit by non-linear regression models (bottom left graph) to predict the average proportion of carcasses remaining at 7 days and 28 days (bottom right graph), based on trial data from the Vasco Winds Energy Project during its first year of post-repowering monitoring.

Table 7. Average avian carcass persistence rates predicted at 7 and 28 day periods corresponding with average search intervals at Vasco Winds Area.

Size class	Search interval (days)	No. carcasses placed	Proportion remaining, R_c	SE
Small	7	67	0.636	0.084
Small	28	67	0.323	0.084
Large	7	62	0.797	0.117
Large	28	62	0.635	0.117
Extra large	7	5	1.000	0.000
Extra large	28	5	1.000	0.000

3.2.1.4 Overall Detection Rates

Small and large size classes.--Except for small birds and 28-day search intervals, the combined adjustment terms, $p \times R_c$, were lower values than the overall detection rates, *D*, more so at the turbines searched weekly than at those searched every 28 days (Table 8). Therefore, compared to the conventional adjustments applied to the Horvitz-Thompson estimator, fatality rates based on *D* will be lower on average within the two size classes, small and large.

Table 8. Overall detection rate (D) during detection trials performed during monitoring of the Vasco Winds Area from June 2012 through April 2013, where SE was estimated from 1000 iterations of Monte Carlo simulation on Binomial distributions fit to the data.

Size class	Search interval (days)	No. carcasses placed	Typical combined adjustment $p \times R_c$	Proportion found, D	SE
Small	7	33	0.186	0.333	0.018
Small	28	34	0.147	0.147	0.011
Large	7	33	0.611	0.879	0.010
Large	28	29	0.373	0.414	0.016
Extra large	7	1	1.000	1.000	0.000
Extra large	28	4	1.000	1.000	0.000

As functions of species' body mass.—Overall detection rates, *D*, increased with increasing body mass of the species placed in trials until an asymptote of 1.0 was reached (Figure 8). The asymptote was reached at smaller a body mass at the wind turbines searched with a 7 day interval. At turbines searched with a 7 day interval, the asymptote was reached when the size of the bird was at least as big as about 450 g, and at turbines searched with a 28 day interval, the asymptote was reached when the size of the bird was at least 720 g.

The trials in the 28 day search interval were unbalanced, because by the end of the year too few carcasses were placed for robust results representing a few of the carcass size ranges (these trials are ongoing, and additional carcasses beyond those required for this program are being placed). For example, too few very small birds were placed in the 28-day search areas. Therefore, we decided not to report fatality rates of bats and small birds that were adjusted from extrapolated values of *D* in the 28-day search interval.

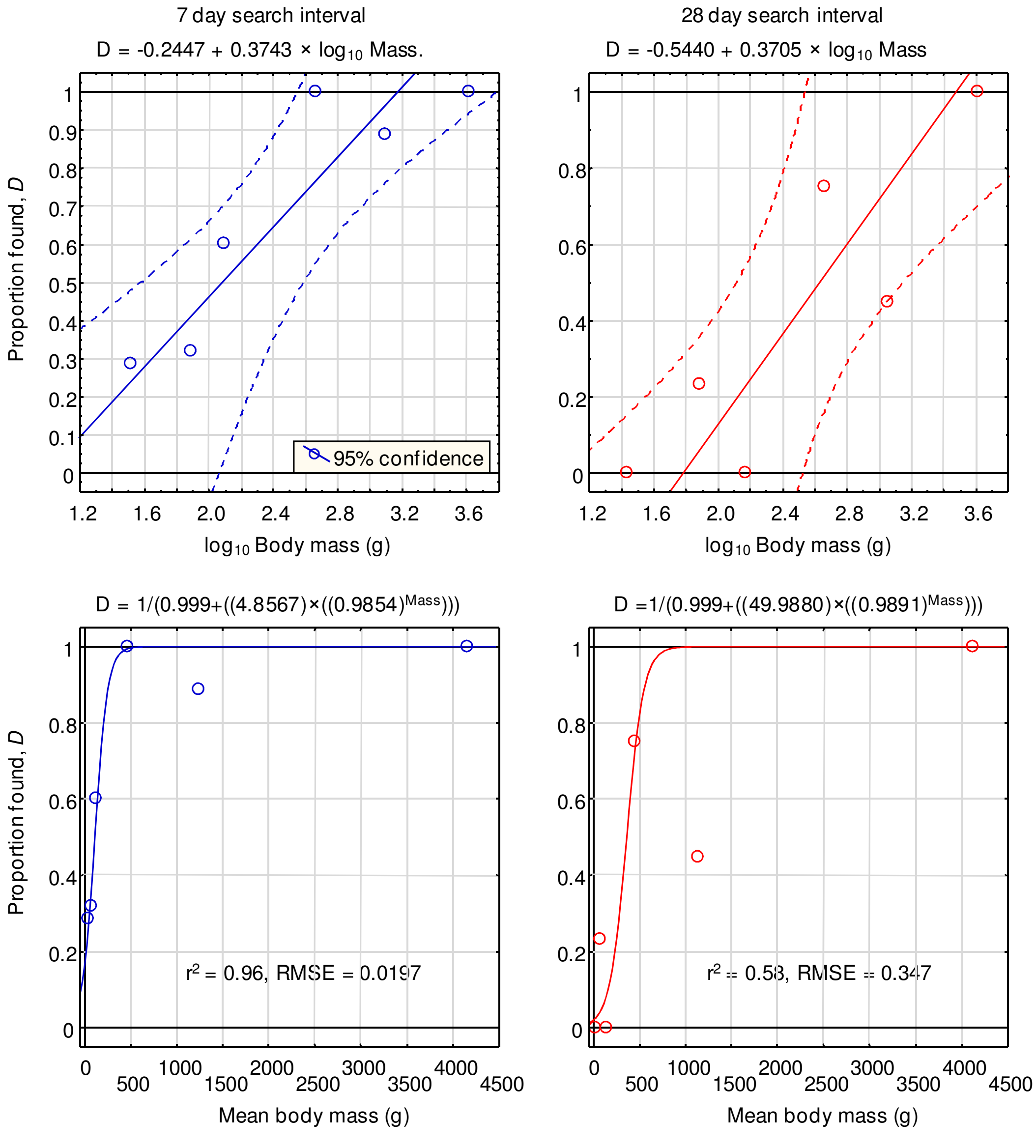


Figure 8. Overall carcass detection, D, increased quickly with increasing body mass until reaching an asymptote of 1.0 at turbines searched with average search intervals of 7 days (left graphs) and 28 days (right graphs) in trials sufficiently completed by the end of the first year of monitoring (each trial is a placed bird). The top graphs show best fits of D to log10 body mass, and the bottom graphs show D as logistic functions of body mass. The models fitting the data in the lower graphs were used to adjust fatality rates.

3.2.2 Fatality Estimates

One golden eagle fatality was found incidentally prior to the initiation of monitoring (February, 2012). We included this eagle in the overall fatality tables because due to its large size and location within a search plot it likely would have been detected had the eagle not been removed after discovery, and it could have been estimated to have died within 28 days of the first search. One could argue that this eagle should not be included in fatality rate estimates because it was found prior to monitoring, so we give the reader the option to include it or exclude it.

Another optional inclusion applies to a red-tailed hawk and an American kestrel fatality found within the search area of a row of 120 KW Bonus turbines occurring nearby Vasco Winds turbine 34. We calculated fatality rate estimates with and without these two fatalities.

Most of the bats and small birds were found at turbines searched with a 7 day interval, whereas an equal number of large birds were found at turbines searched with 7 and 28 day intervals (Table 9). In the 28 day search interval, 1 of the 3 bat species was not found, but all 3 species were found in the 7 day search interval. Also in the 28 day search interval, and excluding golden eagle, 7 of 16 bird species were not found. Therefore, there was a bias in fatality rates that could not be adjusted by estimates of carcass persistence or searcher detection error due to left-censored fatality data in the 28-day interval (Smallwood 2007). Comparisons of fatality rates between turbines or through time should be cautiously interpreted, because the longer the search interval, the fewer small bird species and bat species will be included in fatality rate estimates.

Table 9. Summary of fatalities found by search interval implemented at Vasco Winds Area turbines during the first year of monitoring.

Group	Fatalities found	
	7 day interval	28 day interval
All bats	14	4
All birds <150 g	22	5
All birds >450 g	13	13

No matter the source of the adjustment factors, fatality rate estimates tended to be higher among bats and small birds when based on 7 day search intervals as compared to 28 day search intervals (Tables 10 and 11). When adjustments were applied to small and large size categories based on national averages or on-site trials, the 7-day interval yielded fatality rate estimates that were twice as high among bats, 50% higher for red-tailed hawks, and 40-80% higher for all birds as a group (Table 10). The higher fatality rates at turbines searched with a shorter search interval resulted from higher carcass detection rates.

When adjustments were based on on-site trials to obtain *D*, the 7-day interval yielded fatality rate estimates that were only 10% higher than the 28-day interval for all birds as a group, and 30% lower for red-tailed hawks (Table 10). When *D* was applied to a broader range of body size categories, the 7 day interval yielded nearly the same 50% higher fatality rate estimate for red-tailed hawks as did the national averages used for adjustment factors (Table 10), but this was because the national average persistence rate was doubled for use in this analysis. After *D* is based on a wider range of body size categories, we expect smaller differences in fatality rates between 7 and 28 day search intervals.

Estimates averaged between the two search intervals are summarized in Table 12. Mean fatality estimates with and without the adjustment for search radius bias, *d*, appear in Table 13. Our best estimates appear in Table 14. The latter estimates were selected from the on-site trial data applied to values of *D* predicted by 6 body size categories, and consisted of bats and small birds found in the 7 day interval and large birds found in both the 7 and 28 day intervals.[1]

Based on the same trial birds, the use of overall detection adjustments, *D*, resulted in lower fatality estimates than did the use of R_c and *p* in separate trials (Table 10). Using *D* instead of R_c and *p* in the 7-day interval yielded fatality rate estimates that were 52% lower for all bats as a group, 39% lower for all raptors, 42% lower for all birds, 44% lower for American kestrel, 45% lower for burrowing owl, and 33% lower for red-tailed hawk.

Total estimated fatalities during the first year of monitoring of the 34 2.3-MW turbines after repowering included 0-1 golden eagles, depending on whether one includes the eagle found prior to fatality monitoring, 17 to 19 red-tailed hawks, depending on whether one includes the fatalities found between Turbine 34 and the 120 KW Bonus turbines, 23 American kestrels, 4 burrowing owls, 48-50 raptors of all species, 214 birds of all species, and 131 bats of all species (Table 14).

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[1] The bat fatality estimates were adjusted by national averages of *p*, R_c, and *d*, because we lacked on-site trial data. We also made a special adjustment for Virginia rail, which was the only small bird found at a turbine in the 28-day search interval. For Virginia rail, we used the differences in fatality rates of mourning dove to scale the rate in the 28-day interval to the rate in the 7-day interval. We used mourning dove for this scaling because the sample size was larger and the body mass was similar.

Table 10. Vasco Winds Area fatality rates adjusted several ways at wind turbines searched with a 7 day interval.

Species/Group	Deaths/MW		Deaths/MW adjusted by:							
	Unadjusted		National means of R_c & *p*, 2 sizes		On-site trials for R_c & *p*, 2 sizes		On-site trials for *D*, 2 size classes		On-site trials for *D*, 6 size classes	
	Mean	SE	Mean	SE	Mean	SE	Mean	SE	Mean	SE
Mexican free-tail bat	0.128	0.050	0.474	0.222	0.815	0.371	0.392	0.178	0.662	0.306
Western red bat	0.026	0.026	0.095	0.098	0.163	0.168	0.078	0.081	0.131	0.135
Hoary bat	0.205	0.066	0.758	0.315	1.304	0.522	0.627	0.251	0.886	0.360
American kestrel	0.128	0.050	0.494	0.241	0.883	0.445	0.492	0.240	0.297	0.144
Burrowing owl	0.026	0.026	0.099	0.103	0.177	0.185	0.098	0.103	0.050	0.052
Barn owl	0.051	0.035	0.107	0.080	0.107	0.081	0.075	0.055	0.066	0.049
Red-tailed hawk[a]	0.230	0.113	0.333	0.190	0.483	0.284	0.336	0.191	0.295	0.168
Golden eagle	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Ruby-crowned kinglet	0.026	0.026	0.099	0.103	0.177	0.185	0.098	0.103	0.175	0.184
Rough-winged swallow	0.026	0.026	0.099	0.103	0.177	0.185	0.098	0.103	0.162	0.170
Tree swallow	0.026	0.026	0.099	0.103	0.177	0.185	0.098	0.103	0.151	0.157
Swallow sp. [b]	0.026	0.026	0.099	0.103	0.177	0.185	0.098	0.103	0.148	0.155
Small bird	0.102	0.059	0.395	0.257	0.706	0.468	0.394	0.256	0.529	0.346
Brewer's blackbird	0.026	0.026	0.099	0.103	0.177	0.185	0.098	0.103	0.093	0.097
Western meadowlark	0.153	0.064	0.593	0.303	1.059	0.558	0.591	0.302	0.411	0.209
Mourning dove	0.051	0.035	0.198	0.148	0.353	0.267	0.197	0.147	0.111	0.082
Duck	0.026	0.026	0.056	0.058	0.054	0.056	0.037	0.039	0.033	0.034
Gull	0.026	0.026	0.056	0.058	0.054	0.056	0.037	0.039	0.033	0.034
All bats	0.358	0.141	1.326	0.635	2.281	1.060	1.097	0.510	1.679	0.801
All raptors	0.435	0.223	1.034	0.614	1.649	0.995	1.001	0.589	0.708	0.413
All birds	0.921	0.560	2.826	1.954	4.758	3.329	2.750	1.884	2.554	1.882

[a] One red-tailed hawk found 137 m from wind turbine.

[b] One fatality found incidentally within monitored area.

Table 11. Vasco Winds Area fatality rates adjusted several ways at wind turbines searched with a 28 day interval.

Species/Group	**Deaths/MW**		**Deaths/MW adjusted by:**							
	Unadjusted		**National means of R_c & p, 2 sizes**		**On-site trials for R_c & p, 2 sizes**		**On-site trials for D, 2 size classes**		**On-site trials for D, 6 size classes**	
	Mean	**SE**	**Mean**	**SE**	**Mean**	**SE**	**Mean**	**SE**	**Mean**	**SE**
Mexican free-tail bat [a]	0.051	0.035	0.332	0.243	0.570	0.413	0.355	0.370		
Hoary bat	0.051	0.035	0.332	0.243	0.570	0.413	0.355	0.370		
American kestrel	0.077	0.041	0.526	0.324	0.669	0.446	0.669	0.647		
American kestrel [b]	0.051	0.035	0.351	0.262	0.446	0.352	0.446	0.471		
Burrowing owl	0.051	0.035	0.351	0.262	0.446	0.352	0.446	0.471		
Red-tailed hawk	0.153	0.074	0.222	0.125	0.527	0.312	0.475	0.268	0.197	0.130
Red-tailed hawk [b]	0.102	0.059	0.148	0.096	0.351	0.237	0.317	0.206	0.131	0.096
Golden eagle [c]	0.026	0.026	0.037	0.039	0.052	0.055	0.033	0.034	0.033	0.036
Virginia rail	0.026	0.026	0.175	0.183	0.223	0.240	0.223	0.286		
Mourning dove	0.026	0.026	0.175	0.183	0.223	0.240	0.223	0.286		
Duck	0.026	0.026	0.076	0.079	0.088	0.093	0.079	0.083	0.033	0.036
Gull	0.077	0.041	0.227	0.140	0.263	0.169	0.238	0.146	0.099	0.070
Large bird	0.026	0.026	0.073	0.076	0.088	0.093	0.079	0.083	0.033	0.036
Double-crested cormorant	0.026	0.026	0.037	0.039	0.052	0.055	0.033	0.034	0.033	0.036
All bats	**0.102**	**0.070**	**0.663**	**0.486**	**1.141**	**0.827**	**0.710**	**0.739**		
All raptors	**0.307**	**0.176**	**1.136**	**0.750**	**1.694**	**1.165**	**1.623**	**1.420**		
All raptors [b]	**0.230**	**0.155**	**0.887**	**0.658**	**1.295**	**0.995**	**1.242**	**1.181**		
All birds	**0.512**	**0.345**	**1.900**	**1.448**	**2.631**	**2.053**	**2.498**	**2.337**		
All birds [b]	**0.435**	**0.324**	**1.650**	**1.357**	**2.232**	**1.883**	**2.117**	**2.098**		

[a] One fatality found incidentally to routine searches.

[b] Omitted 1 American kestrel and 2 red-tailed hawk fatalities that were found in search area that overlapped with the area searched by the Alameda County Monitoring Team at the nearby 120 KW Bonus turbines.

[c] Golden eagle was found in February 2012, prior to fatality monitoring.

Table 12. Vasco Winds Area project-wide annual fatality estimates from various adjustments.

Species/Group	Annual project-wide fatalities & 80% CI											
	National means of Rc & p, 2 size classes			On-site trials for Rc & p, 2 size classes			On-site trials for D, 2 size classes			On-site trials for D, 6 size classes		
	Mean	LCL	UCL	Mean	LCL	UCL	Mean	LCL	UCL	Mean	LCL	UCL
Mexican free-tail bat [a]	31.5	8.2	54.8	54.2	14.9	93.5	29.2	1.7	56.7			
Western red bat	3.7	-1.2	8.6	6.4	-2.0	14.8	3.1	-1.0	7.1			
Hoary bat	42.6	14.6	70.6	73.3	26.4	120.2	38.4	7.3	69.5			
American kestrel	39.9	11.6	68.2	60.7	16.0	105.3	45.4	1.0	89.9			
American kestrel [b]	33.0	7.8	58.2	52.0	12.0	91.9	36.7	1.1	72.3			
Burrowing owl	17.6	-0.7	35.9	24.4	-2.6	51.3	21.3	-7.4	50.0			
Barn owl	4.2	0.2	8.2	4.2	0.1	8.3	2.9	0.1	5.7	2.6	0.1	5.0
Red-tailed hawk [c]	21.7	5.9	37.5	39.5	9.6	69.3	31.7	8.7	54.7	19.2	4.3	34.2
Red-tailed hawk [b]	18.8	4.5	33.1	32.6	6.5	58.7	25.5	5.6	45.4	16.7	3.4	29.9
Golden eagle [d]	1.4	-0.5	3.4	2.0	-0.7	4.8	1.3	-0.4	3.0	1.3	-0.5	3.1
Ruby-crowned kinglet	3.9	-1.3	9.0	6.9	-2.4	16.2	3.9	-1.3	9.0			
Rough-winged swallow	3.9	-1.3	9.0	6.9	-2.4	16.2	3.9	-1.3	9.0			
Tree swallow	3.9	-1.3	9.0	6.9	-2.4	16.2	3.9	-1.3	9.0			
Swallow sp. [a]	3.9	-1.3	9.0	6.9	-2.4	16.2	3.9	-1.3	9.0			
Small bird	15.5	2.6	28.4	27.6	4.1	51.1	15.4	2.6	28.2			
Brewer's blackbird	3.9	-1.3	9.0	6.9	-2.4	16.2	3.9	-1.3	9.0			
Virginia rail	6.9	-2.3	16.0	8.7	-3.3	20.7	8.7	-5.6	23.1			
Western meadowlark	23.2	8.0	38.4	41.4	13.5	69.4	23.1	8.0	38.2			
Mourning dove	14.6	-2.0	31.2	22.5	-2.9	47.9	16.4	-5.3	38.1			
Duck	5.2	-1.7	12.0	5.5	-2.0	13.0	4.6	-1.5	10.6	2.6	-1.0	6.1
Gull	11.1	1.2	21.0	12.4	1.1	23.7	10.7	1.5	20.0	5.2	-0.1	10.4
Large bird	2.8	-1.0	6.6	3.4	-1.2	8.1	3.1	-1.0	7.2	1.3	-0.5	3.1
Double-crested cormorant	1.4	-0.5	3.4	2.0	-0.7	4.8	1.3	-0.4	3.0	1.3	-0.5	3.1
All bats	77.8	21.6	134.0	133.8	39.2	228.4	70.7	8.0	133.3			
All raptors	84.8	16.5	153.2	130.7	22.5	239.0	102.6	1.9	203.3			
All raptors [b]	75.1	11.3	138.8	115.1	15.4	214.9	87.7	-1.0	176.4			
All birds	184.8	14.2	355.3	288.9	19.2	558.7	205.2	-6.4	416.8			
All birds [b]	175.0	9.1	341.0	273.3	12.1	534.6	190.3	-9.3	389.9			

[a] One carcass found incidentally to routine fatality searches.

[b] Omitted 1 American kestrel and 2 red-tailed hawk fatalities that were found in search area that overlapped with the area searched by the Alameda County Monitoring Team at the nearby 120 KW Bonus turbines.

[c] One fatality found 137 m from wind turbine

[d] Found in February 2012, prior to fatality monitoring.

Table 13. Comparison of Vasco Winds fatality rate estimates with and without the search radius adjustment, *d*.

	Annual project-wide fatalities adjusted by							
Species/Group	**National means for $R_c \times p \times d$ on 2 sizes**	**National means for $R_c \times p$ on 2 sizes**	**On-site trials for $R_c \times p \times d$ on 2 sizes**	**On-site trials for $R_c \times p \times d$ on 2 sizes**	**On-site trials for $D \times d$ on 2 sizes**	**On-site trials for D on 2 sizes**	**On-site trials for $D \times d$ on 6 sizes**	**On-site trials for D on 6 sizes**
Mexican free-tail bat [a]	31.5	30.9	54.2	53.1	29.2	28.6		
Western red bat	3.7	3.6	6.4	6.3	3.1	3.0		
Hoary bat	42.6	41.7	73.3	71.8	38.4	37.6		
American kestrel	39.9	31.1	60.7	47.3	45.4	35.4		
American kestrel [b]	33.0	25.7	52.0	40.6	36.7	28.6		
Burrowing owl	17.6	13.7	24.4	19.0	21.3	16.6		
Barn owl	4.2	3.3	4.2	3.3	2.9	2.3	2.6	2.0
Red-tailed hawk [c]	21.7	16.9	39.5	30.8	31.7	24.7	19.2	15.0
Red-tailed hawk [b]	18.8	14.7	32.6	25.4	25.5	19.9	16.7	13.0
Golden eagle [d]	1.4	1.1	2.0	1.6	1.3	1.0	1.3	1.0
Ruby-crowned kinglet	3.9	3.0	6.9	5.4	3.9	3.0		
Rough-winged swallow	3.9	3.0	6.9	5.4	3.9	3.0		
Tree swallow	3.9	3.0	6.9	5.4	3.9	3.0		
Swallow sp. [a]	3.9	3.0	6.9	5.4	3.9	3.0		
Small bird	15.5	12.1	27.6	21.5	15.4	12.0		
Brewer's blackbird	3.9	3.0	6.9	5.4	3.9	3.0		
Virginia rail	6.9	5.4	8.7	6.8	8.7	6.8		
Western meadowlark	23.2	18.1	41.4	32.3	23.1	18.0		
Mourning dove	14.6	11.4	22.5	17.6	16.4	12.8		
Duck	5.2	4.1	5.5	4.3	4.6	3.6	2.6	2.0
Gull	11.1	8.7	12.4	9.7	10.7	8.3	5.2	4.1
Large bird	2.8	2.2	3.4	2.7	3.1	2.4	1.3	1.0
Double-crested cormorant	1.4	1.1	2.0	1.6	1.3	1.0	1.3	1.0
All bats	77.8	60.7	133.8	104.4	70.7	55.1		
All raptors	84.8	66.1	130.7	101.9	102.6	80.0		
All raptors [b]	75.1	58.6	115.1	89.8	87.7	68.4		
All birds	184.8	144.1	288.9	225.3	205.2	160.1		
All birds [b]	175.0	136.5	273.3	213.2	190.3	148.4		

[a] One carcass found incidentally to routine fatality searches.

[b] Omitted 1 American kestrel and 2 red-tailed hawk fatalities that were found in search area that overlapped with the area searched by the Alameda County Monitoring Team at the nearby 120 KW Bonus turbines.

[c] One fatality found 137 m from wind turbine.

[d] Found in February 2012, prior to fatality monitoring.

Table 14. Best estimates of Vasco Winds Area fatality rates based on overall detection rates (D) predicted by body mass and search radius adjustment (d) applied to monitoring results at wind turbines searched with 7 and 28 day intervals.

Species/Group	Adjusted fatalities/MW		Annual project-wide fatalities & 80% CI		
	Mean	SE	Mean	LCL	UCL
Mexican free-tail bat [a]	0.662	0.306	51.8	21.0	82.5
Western red bat	0.131	0.135	10.2	-3.3	23.8
Hoary bat	0.886	0.360	69.3	33.2	105.4
American kestrel	0.297	0.144	23.2	8.8	37.6
American kestrel [b]	0.297	0.144	23.2	8.8	37.6
Burrowing owl	0.050	0.052	3.9	-1.3	9.2
Barn owl	0.033	0.025	2.6	0.1	5.0
Red-tailed hawk [c]	0.246	0.149	19.2	4.3	34.2
Red-tailed hawk [b]	0.213	0.132	16.7	3.4	29.9
Golden eagle [d]	0.016	0.018	1.3	-0.5	3.1
Ruby-crowned kinglet	0.175	0.184	13.7	-4.7	32.1
Rough-winged swallow	0.162	0.170	12.7	-4.3	29.7
Tree swallow	0.151	0.157	11.8	-4.0	27.6
Swallow sp. [a]	0.148	0.155	11.6	-3.9	27.1
Small bird	0.529	0.346	41.4	6.8	76.1
Brewer's blackbird	0.093	0.097	7.3	-2.5	17.0
Virginia rail	0.182	0.399	14.2	-25.8	54.3
Western meadowlark	0.411	0.209	32.1	11.1	53.1
Mourning dove	0.111	0.082	8.7	0.4	16.9
Duck	0.033	0.035	2.6	-1.0	6.1
Gull	0.066	0.052	5.2	-0.1	10.4
Large bird	0.017	0.018	1.3	-0.5	3.1
Double-crested cormorant	0.016	0.018	1.3	-0.5	3.1
All bats	1.679	0.801	131.3	50.9	211.7
All raptors	0.642	0.388	50.2	11.4	89.1
All raptors [b]	0.609	0.371	47.7	10.5	84.8
All birds	2.554	1.911	214.1	-17.6	445.7
All birds [b]	2.521	1.894	211.6	-18.5	441.4

[a] One carcass found incidentally to routine fatality searches.

[b] Omitted 1 American kestrel and 2 red-tailed hawk fatalities that were found in search area that overlapped with the area searched by the Alameda County Monitoring Team at the nearby 120 KW Bonus turbines.

[c] One fatality found 137 m from wind turbine

[d] Found in February 2012, prior to fatality monitoring.

3.2.3 Comparison of Fatalities Before and After Repowering

Fatality rates based on national average searcher detection rates and carcass persistence rates in grassland environments were compared before and after repowering, focusing on 2006 and 2012 as peak years in what appears to be a multi-annual cycle of raptor fatalities in the Altamont Pass, (Smallwood 2013b). Between the peak fatality years of 2006 and 2012 that were evident in the Altamont Pass, golden eagle fatalities were greatly reduced at Vasco Winds – by as much as 97% (Figure 10). The fatality rate of red-tailed hawk might have declined about 68% compared to 2006, and American kestrel fatalities declined about 59%. Burrowing owl fatalities did not change. The combined fatality rate of all raptors declined about 65%, and the combined fatality rate of all birds declined about 78%.

Bat fatalities appear to have increased a great deal since repowering (Figure 9). However, ground visibility also increased due to project construction, so multiple years of monitoring will be needed to more completely understand bat impacts. Bat fatality rates have usually been highest during the first year of multi-year monitoring efforts at wind projects across North American, possibly due to the increased ground visibility during the first year following project construction (Smallwood 2013a).

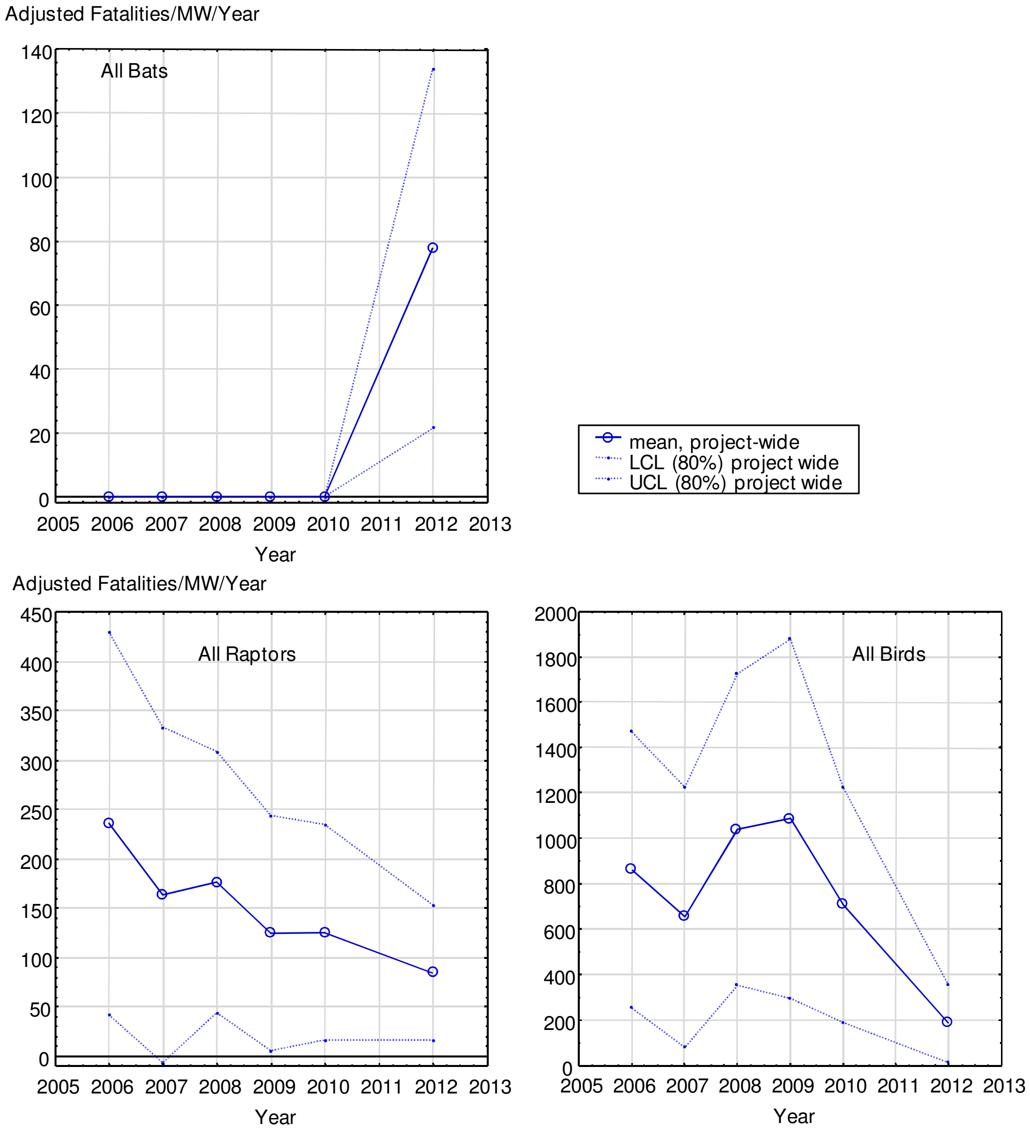

Figure 9. Comparison of annual fatality estimates (and 80% CI) in Vasco Winds before (2006-2010) and after (2012-2013) repowering.

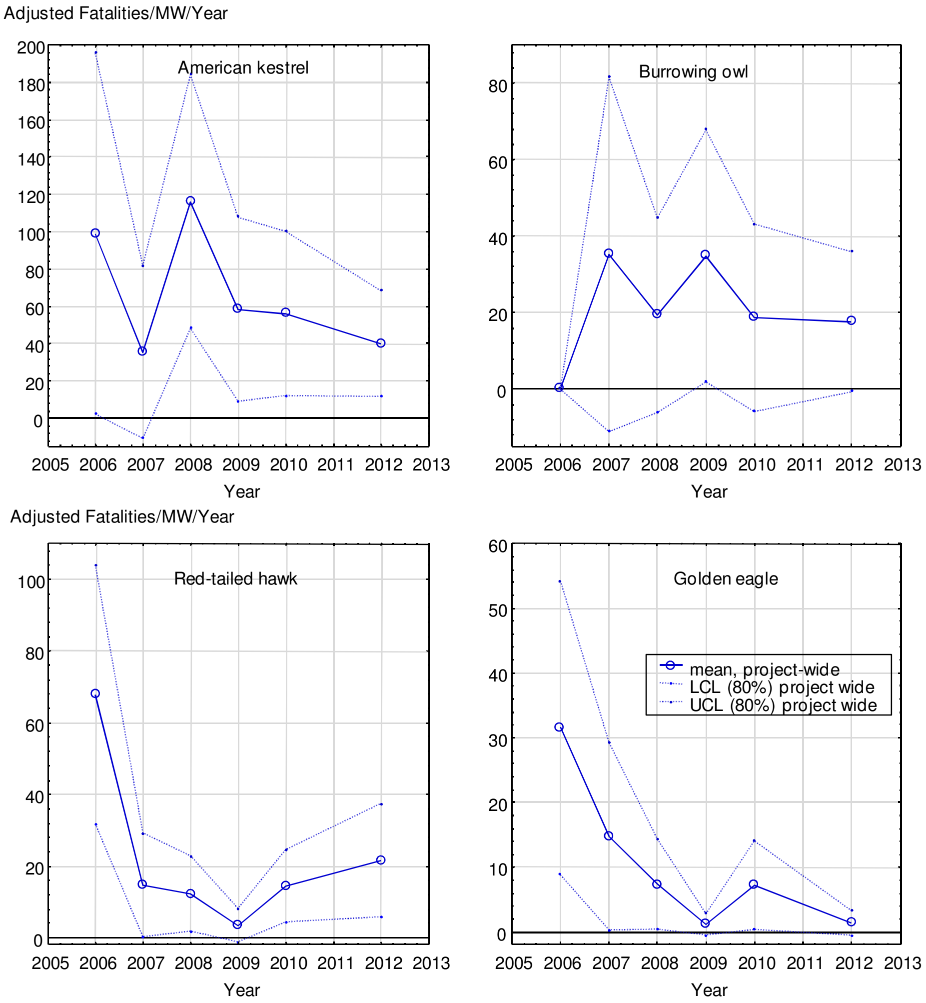

Figure 10. Comparison of annual fatality estimates (and 80% CI) of target species in Vasco Winds before (2006-2010) and after (2012-2013) repowering.

3.2.4 Comparing Fatality Rates among Repowered Turbines

Among the wind turbines where red-tailed hawk fatalities were found, fatality rates increased (n=9) with the area of Smallwood and Neher's (2010b) collision hazard classes 3 and 4 within 150 m of the turbines (Figure 11). The highest fatality rates were at turbines 3, 33, 34, and 9 (Figure 12). However, it must be remembered that this comparison was based on data from only the first year of monitoring; as search intervals are shifted among the turbines, variation in fatality rate estimates might also change.

American kestrel fatalities did not relate with the area of collision hazard class 4 occurring within 150 of the turbine, but they occurred at wind turbines with about twice the area of hazard class 3 within 150 m as compared to turbines where American kestrel fatalities have yet to be found. Turbines that killed American kestrels tended to be toward the tops of slopes, especially the most prominent hills and ridges in the project area. They were on southwest slopes (average 208°), whereas the other turbines occurred on slopes averaging 148°. Turbine with American kestrel fatalities averaged 10 m from the nearest ridge crest, whereas the others averaged 27 m. Turbines with American kestrel fatalities averaged 97.3% up the slope (90% CI: 95.4-99.2%), whereas the others averaged 83% up the slope (90% CI: 76.6-89.4%). The highest fatality rates were at turbines 17, 26, and 34 (Figure 13).

The single golden eagle fatality was found at turbine 5, where very little area of collision hazard classes 3 and 4 occurred within 150 m. However, this turbine was installed on a pad that was cut deeply into the hill. The grading for this turbine created a break in slope that Smallwood and Neher (2010b) did not anticipate. Such grading effects need to be considered in collision hazard models developed for future phases of repowering.

The highest raptor fatalities were at turbines 17, 26, 34, 3 and 24 (Figure 14). The highest bird fatality rates were at turbines 3, 5, 14, 24, and 34 (Figure 15). The highest bat fatality rates were at turbines 22, 34, and 17 (Figure 16).

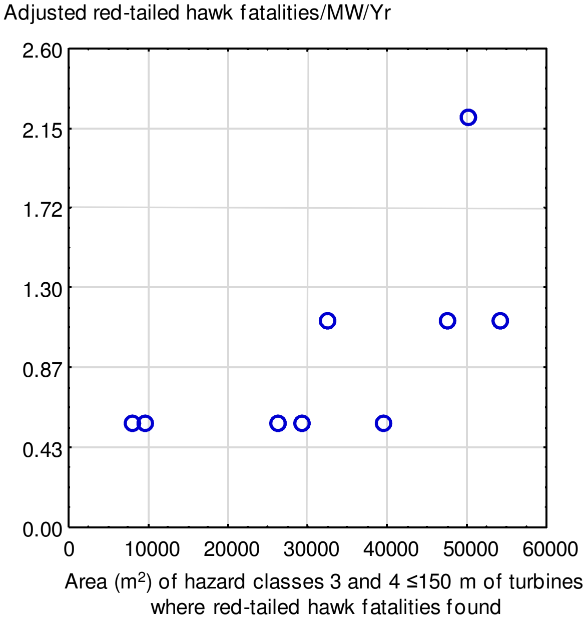

Figure 11. Red-tailed hawk fatality rates increased at wind turbines with greater areas of collision hazard classes 3 and 4 within 150 m of the turbines.

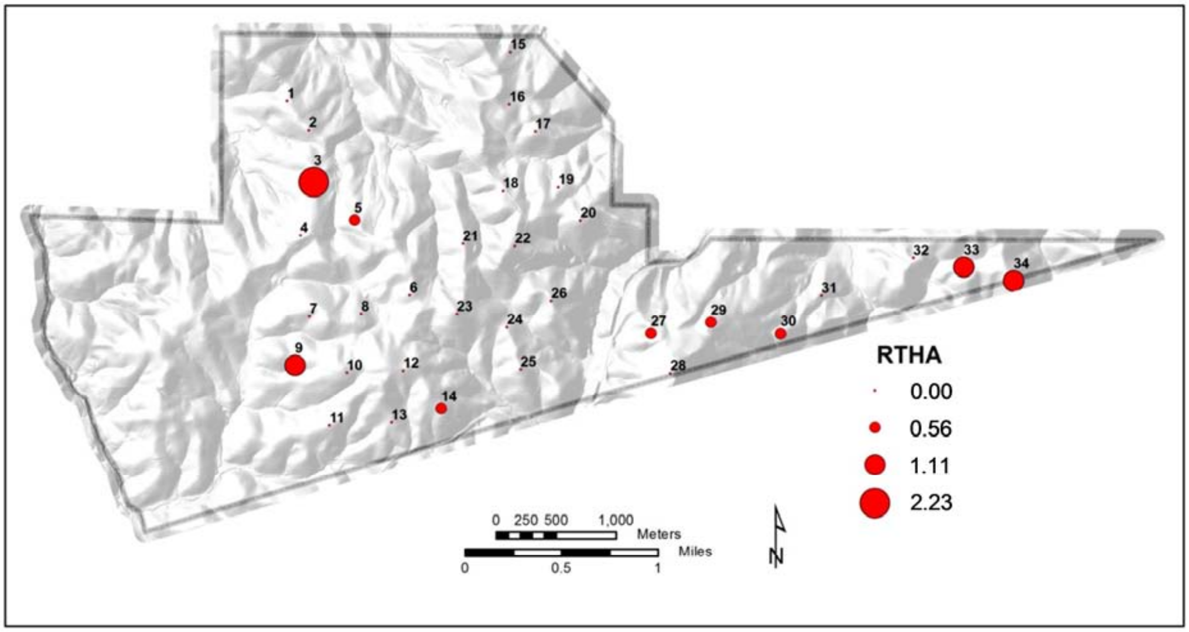

Figure 12. Adjusted red-tailed hawk fatality rates among 34 wind turbines during the first year of monitoring in the Vasco Winds Energy Project.

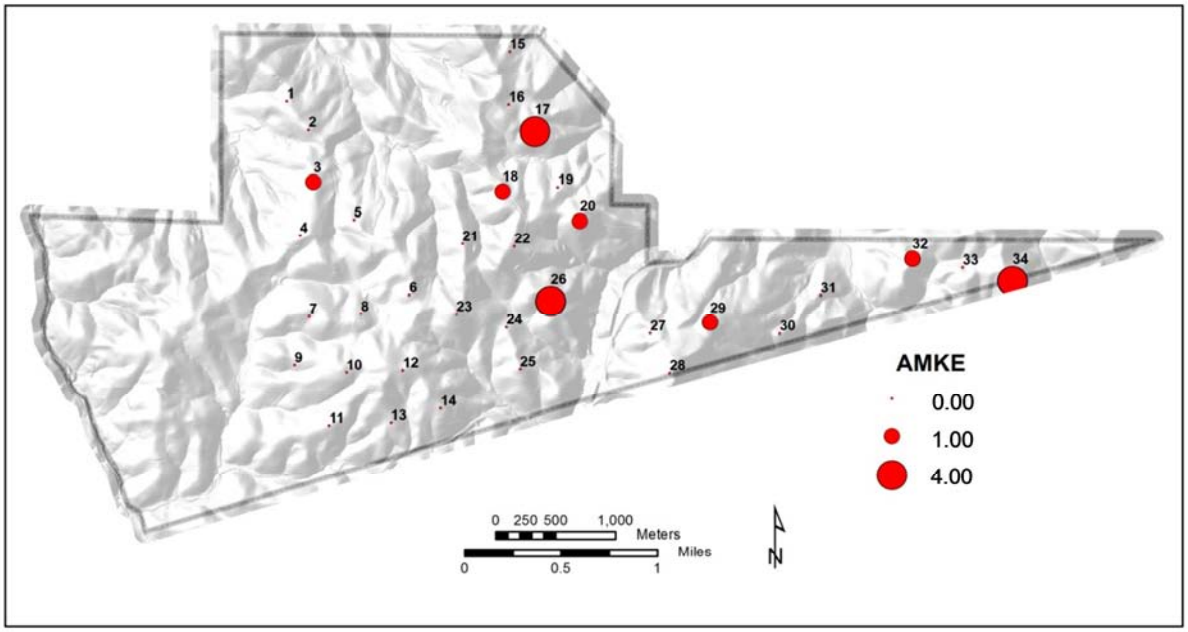

Figure 13. Adjusted American kestrel fatality rates among 34 wind turbines during the first year of monitoring in the Vasco Winds Energy Project.

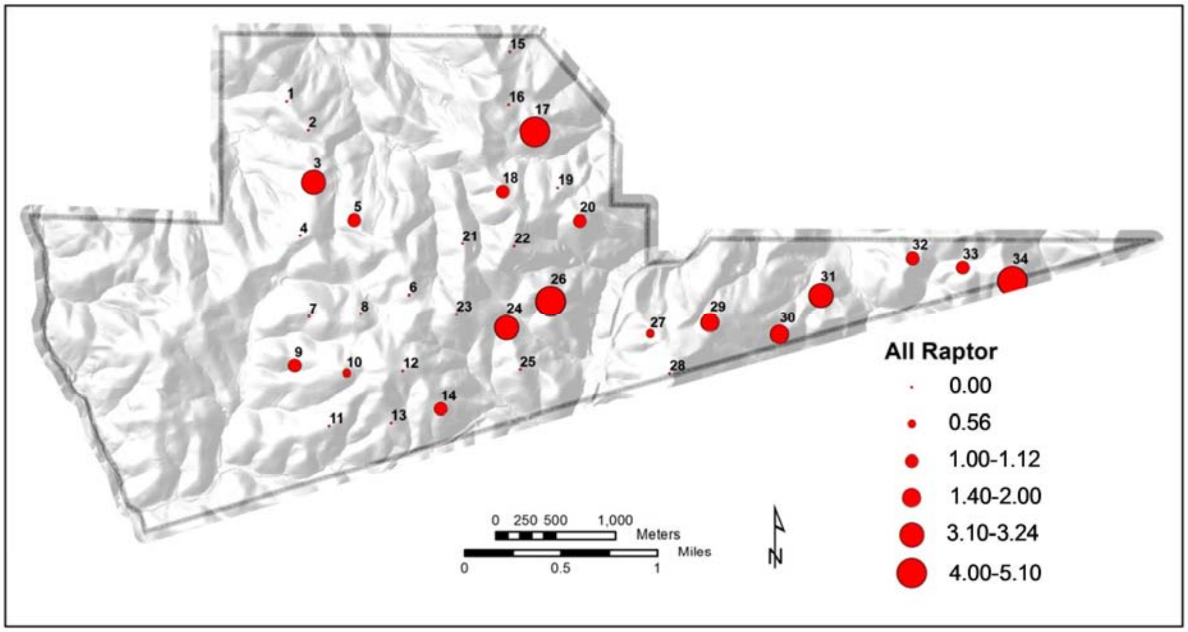

Figure 14. Adjusted raptor fatality rates among 34 wind turbines during the first year of monitoring in the Vasco Winds Energy Project.

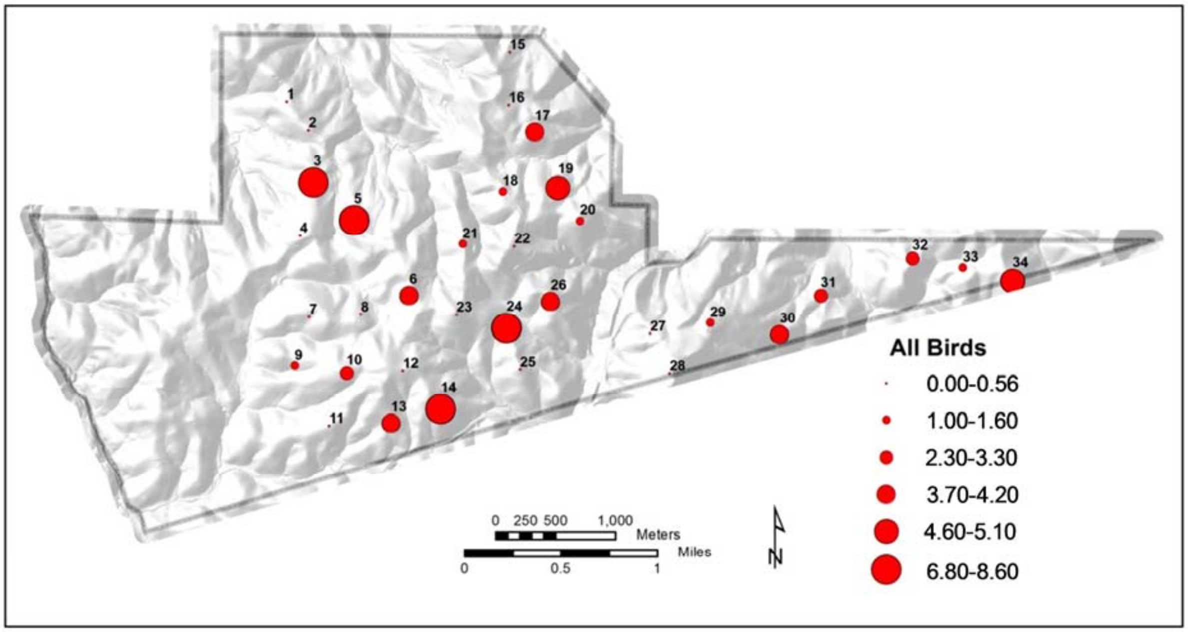

Figure 15. Adjusted bird fatality rates among 34 wind turbines during the first year of monitoring in the Vasco Winds Energy Project.

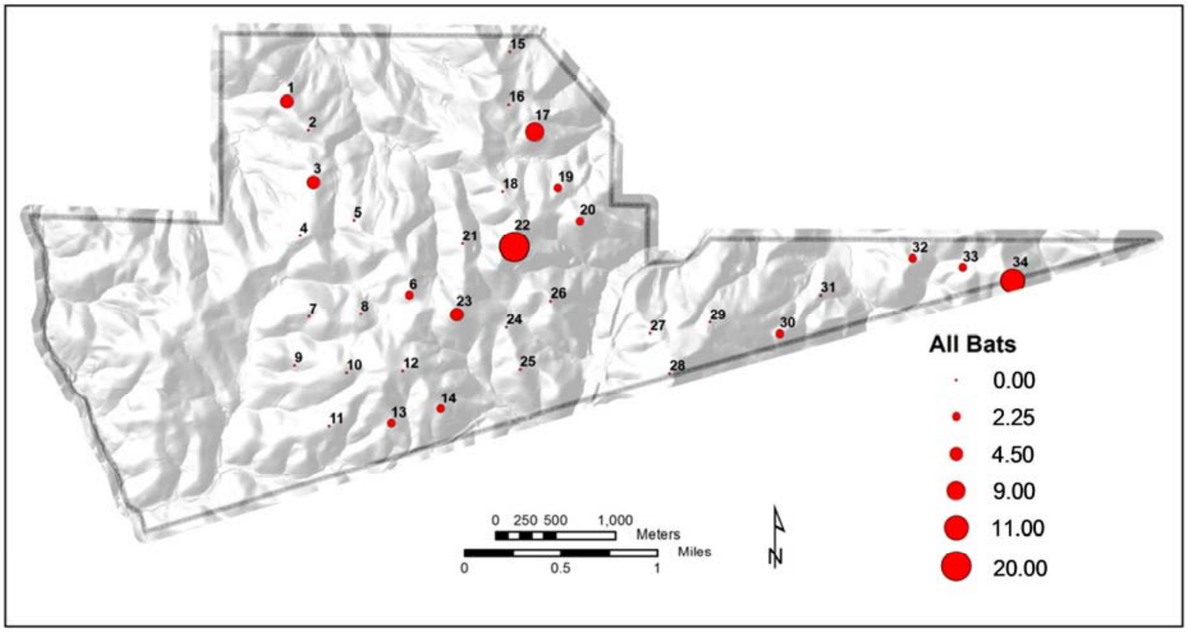

Figure 16. Adjusted bat fatality rates among 34 wind turbines during the first year of monitoring in the Vasco Winds Energy Project.

4.0 DISCUSSION AND CONCLUSIONS

4.1 Avian Use

Use surveys were designed for comparing relative abundance through time. Differences in relative abundance before and after repowering should be tested after multiple years of data have been collected after repowering, due to inter-annual variation in abundance, including likely population cycles. To achieve comparability, adjustments must be made to use rates because the maximum survey radius was reduced from 800 m to 500 m in 2007. This adjustment will be made from species' use rates as functions of distance between the bird and the observer. The analysis is ongoing.

That gulls exhibited the highest use rates was not very surprising because there is a great deal of gull traffic between Los Vaqueros Reservoir and the Altamont Landfill, and Vasco Winds is located between these features of the landscape.

4.2 Fatality Rates

Interpreting fatality rate estimates at Vasco Winds Energy Project requires careful consideration of an apparent multi-annual cycle of raptor fatalities. The last major cycle peak was in 2006, and it appears from the data herein, as well as from the data from the rest of the Altamont Pass (Smallwood, unpublished data), that 2012-2013 was another peak period. Additionally, management actions to reduce raptor fatalities were implemented at Vasco Winds during 2008-2010, and likely contributed to reduced fatality rates prior to repowering. The only non-comparable periods that were not confounded by management actions and a cyclic pattern of fatalities were 2006 and 2012-2013 but even these two years were comparable only if it was true that 2012 was the next peak year of raptor fatalities in the APWRA.

The most obvious fatality reduction following repowering was for golden eagles (Figure 10). Golden eagle fatalities declined by as much as 97%. Overall raptor fatalities declined about 65% (Figure 9).

Bat fatalities at wind energy facilities emerged as an issue in 2003 following unexpected numbers of bat carcasses recovered at the Mountaineer Wind Energy Center in West Virginia operating newer, taller MW scale turbines (Arnett et al. 2008). Bat fatalities apparently increased (Figure 9) at the Vasco site since repowering. However, other data from the Altamont Pass's old-generation wind turbines suggest that bat fatalities Altamont-wide also steadily increased since 2006 (Smallwood 2013b). A likely explanation for this increase at the older turbines was either (1) increased vigilance of the fatality searchers, or (2) increased areas of cleared turbine pads as repowering projects introduced progressively larger wind turbines. Repowering might have increased bat mortality in the Altamont Pass, but the apparent increase might reflect nothing more than methodological bias. During nocturnal surveys using a thermal camera since October 2012, Smallwood (Unpublished data) has witnessed many bats go out of their way to fly in and out of the active rotor planes of old-generation wind turbines, suggesting that the old turbines pose considerable collision risk to bats. It might be that bats are more difficult to find at old-generation turbines simply because cleared pads are usually very small or non-existent.

Although only one year of data are available, the patterns of fatalities are encouraging in their potential to help guide siting of wind turbines in future phases of repowering. The siting of the wind turbines at Vasco Winds appears to have worked very well to minimize golden eagle fatalities, especially considering that golden eagle fatalities showed no relationship with wind turbine size in the APWRA (Smallwood 2013b). It appears that red tailed hawk mortality is associated with proximity to hazard classes 3 and 4.

American kestrel fatalities at Vasco Winds tended to occur at turbines surrounded by more collision hazard class 3 than class 4, so the collision hazard model for American kestrels can probably be improved. The relationships between American kestrel fatalities and measured slope variables indicate that improved models can be developed.

Bat fatalities also showed patterns that can lead to effective collision hazard models, if the patterns remain consistent through monitoring years two and three. More bat fatalities were found at turbines on the most prominent landscape features, i.e., the tallest hills, except for at turbine 28, which is on a tall hill but where no bat fatalities were found. Bat fatalities also overlapped with American kestrel fatalities, so siting to minimize kestrel fatalities might also minimize bat fatalities. However, it must be cautioned that no adjustment has yet been made for variation in detection rates among wind turbines, so bats might be more difficult to find or more quickly removed at certain turbines. This potential bias could have affected our interpretation of the distribution of bat fatalities.

One potential source of bias that we could not adjust was the difference in inter-transect distance in the fatality searches. The post-repowering spacing was wider than before repowering, and we lack a means to adjust for the difference. Another source of bias that was only poorly adjusted was the maximum search radius, which changed between monitoring periods. We used the adjustment factors reported in Smallwood (2013), but these adjustments were inferred from patterns of found fatalities. If there is a detection bias in the distance of carcasses from turbines, such as lower searcher detection rates farther from turbines, or higher carcass persistence rates farther from turbines, then the patterns of found fatalities used by Smallwood (2013) could have been the products of those biases.

Another bias in comparing fatality rates among the 34 new wind turbines was left-censoring of data in the 28-day search interval. Not detecting birds or bats due to too few searches results in a bias that cannot be adjusted. Detection of at least one bird or bat is needed before the fatality rate of a species can be adjusted. The fundamental problem is 0 values being reported where fatalities actually occurred. The longer search interval is attractive for monitoring, but the left-censoring bias jeopardizes its credibility.

Our new adjustment trial methodology revealed that carcass checks in conventional trials do not achieve 100% accuracy when monitoring carcass persistence and availability to be found by fatality searchers. Of 134 carcasses placed in standard trials, 20 were not detected in carcass checks. These undetected carcasses would normally be characterized as removed, presumably by scavengers. However, of these 20 carcasses that went undetected during carcass checks, 3 were found by searchers. In other words, 3 of the carcasses that would have been determined “removed” at the outset of typical scavenger trials were instead present and found by the fatality searchers. This error rate of 15% applies to the most critical time period of scavenger trials, when the likelihood is greatest that a carcass will be removed in whole. One of these 3 birds missed by carcass checks was small, and the other two were large.

To overcome a large suite of sources of error and bias in conventional adjustment trials (Smallwood 2007, 2013; Smallwood et al. 2010, 2013; Warren-Hicks et al. 2013), more effort needs to be directed toward trials that are integrated with routine fatality monitoring and intended for estimating an overall detection rate. Only frozen fresh carcasses should be used. Priority should be given to obtaining and placing fresh bat carcasses. As more carcasses are placed in this type of trial, standard errors will lessen and so will the confidence ranges around point estimates.

5.0 List of Preparers

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K. Shawn Smallwood, PhD

6.0 Acknowledgements

We heartedly acknowledge the hard work and devotion that Travis Poitras and Theresa Rettinghouse have contributed to the work on this project. Kristen Taylor is appreciated for providing her technical editing skills.

We thank NextEra Energy for logistical support and for providing staff to assist with bat acoustical monitoring efforts. Special thank you to Renee Culver and Joanie Stewart for project guidance, insightful comments and careful review of the report and to Loan Tran for day-to-day logistics, support and GIS assistance.

We also thank the Contra Costa County Technical Advisory Committee composed of Doug Bell of East Bay Regional Park District, Abigail Fateman of Contra Costa County, Heather Beeler of U.S. Fish and Wildlife Service, and Brenda Blinn of California Department of Fish and Wildlife, for their in depth review of the report, questions and comments. Special thank you to Ruben Hernandez of Contra Costa County for directing the Committee.

7.0 References

Arnett, Edward B., W. Brown, Wallace P. Erickson, Jenny K. Fiedler, Brenda L. Hamilton, Travis H. Henry, Aaftab Jain et al. 2008. Patterns of bat fatalities at wind energy facilities in North America. *The Journal of Wildlife Management* 72, no. 1: 61-78.

Goodman, L. A. 1960. On the exact variance of products. Journal American Statistical Association 55:708-713.

Horvitz, D. G. and D. J. Thompson. 1952. A generalization of sampling without replacement from a finite universe. Journal of American Statistical Association 47:663-685.

Hunt, W. G. 2002. Golden eagles in a perilous landscape: Predicting the effects of mitigation for wind turbine blade-strike mortality. Consultant Report to California Energy Commission, Sacramento, California.

Hunt, W. G., R. E. Jackman, T. L. Hunt, D. E. Driscoll, and L. Culp. 1998. A population study of golden eagles in the Altamont Pass Wind Resource Area: population trend analysis 1997. Report to National Renewable Energy Laboratory, Subcontract XAT-6-16459-01. National Technical Information Service, U. S. Department of Commerce, Springfield, Virginia.

Hurlbert, S.H. 1984. Pseudoreplication and the design of ecological field experiments. Ecological Monographs 54:187-211.

Leslie, D., J. Schwartz, and B. Karas. 2012. Altamont Pass Wind Resource Area bird fatality study, bird years 2005–2010. ICF International report to Alameda County Community Development Agency, Hayward, California.

National Research Council. 1986. Ecological knowledge and environmental problem-solving: concepts and case studies, National Academy Press, Washington, D.C.

Orloff, S., and A. Flannery. 1992. Wind turbine effects on avian activity, habitat use, and mortality in Altamont Pass and Solano County Wind Resource Areas: 1989-1991. Report to California Energy Commission, Sacramento, California.

Smallwood, K. S. 2007. Estimating wind turbine-caused bird mortality. Journal of Wildlife Management 71:2781-2791.

Smallwood, K. S. 2009. Methods manual for assessing wind farm impacts to birds. Bird Conservation Series 26, Wild Bird Society of Japan, Tokyo. T. Ura, ed., in English with Japanese translation by T. Kurosawa.

Smallwood, K. S. 2013a. Comparing bird and bat fatality-rate estimates among North American wind-energy projects. Wildlife Society Bulletin 37: 19-33.

Smallwood, K. S. 2013b. Long-term trends in fatality rates of birds and bats in the Altamont Pass Wind Resource Area, California. Alameda County Scientific Review Committee document R68, http://www.altamontsrc.org/alt_rl.php.

Smallwood, K. S. and B. Karas. 2009. Avian and Bat Fatality Rates at Old-Generation and Repowered Wind Turbines in California. Journal of Wildlife Management 73:1062-1071.

Smallwood, K. S. and L. Neher. 2010a. Siting Repowered Wind Turbines to Minimize Raptor Collisions at the Tres Vaqueros Wind Project, Contra Costa County, California. Draft Report to the East Bay Regional Park District, Oakland, California.

Smallwood, K. S. and L. Neher. 2010b. Siting Repowered Wind Turbines to Minimize Raptor Collisions at Vasco Winds. Unpublished report to NextEra Energy Resources, LLC, Livermore, California. 32 pp.

Smallwood, K. S. and L. Spiegel. 2005a. Assessment To Support An Adaptive Management Plan For The APWRA. Unpublished CEC staff report, January 19. 19 pp.

Smallwood, K. S. and L. Spiegel. 2005b. Partial Re-assessment of An Adaptive Management Plan For The APWRA. Unpublished CEC staff report, March 25. 48 pp.

Smallwood, K. S. and L. Spiegel. 2005c. Combining biology-based and policy-based tiers of priority for determining wind turbine relocation/shutdown to reduce bird fatalities in the APWRA. Unpublished CEC staff report, June 1. 9 pp.

Smallwood, K. S. and C. Thelander. 2004. Developing methods to reduce bird mortality in the Altamont Pass Wind Resource Area. Final Report to the California Energy Commission, Public Interest Energy Research – Environmental Area, Contract No. 500-01-019. Sacramento, California.

Smallwood, K. S. and C. Thelander. 2005. Bird mortality in the Altamont Pass Wind Resource Area, March 1998 – September 2001 Final Report. National Renewable Energy Laboratory, NREL/SR-500-36973. Golden, Colorado.

Smallwood, K. S., L. Rugge, and M. L. Morrison. 2009. Influence of Behavior on Bird Mortality in Wind Energy Developments: The Altamont Pass Wind Resource Area, California. Journal of Wildlife Management 73:1082-1098.

Smallwood, K. S., D. A. Bell, S. A. Snyder, and J. E. DiDonato. 2010. Novel scavenger removal trials increase estimates of wind turbine-caused avian fatality rates. Journal of Wildlife Management 74: 1089-1097 + Online Supplemental Material.

Smallwood, K. S., D. A. Bell, B. Karas, and S. A. Snyder. 2013. Response to Huso and Erickson Comments on Novel Scavenger Removal Trials. Journal of Wildlife Management 77: 216-225.

Warren-Hicks, W., J. Newman, R. Wolpert, B. Karas, L. Tran. (California Wind Energy Association.) 2013. Improving Methods for Estimating Fatality of Birds and Bats at Wind Energy Facilities. California Energy Commission. Publication Number: CEC-500-2012-086.

APPENDICES

Appendix A. Fatalities recorded during the first year of monitoring at Vasco Winds Area (May 2012 through May 2013).

Date found	Species/Taxa	Turbine	Bearing from turbine	Distance from turbine (m)	Finding	Whether contributed to various fatality estimates
05/22/12	Red-tailed hawk	WTG-19	234	29	Standard search	Too old
05/22/12	Barn owl	WTG-19	245	65	Standard search	Too old
05/22/12	Gull	WTG-06	335	72	Standard search	Included
05/22/12	Small bird	WTG-30	49	208	Incidental	Too old
05/29/12	Western meadowlark	WTG-34	177	56	Standard search	Too old
05/30/12	Large bird				Incidental	Too old
05/31/12	Bat	WTG-23	2	97	Standard search	Too old
06/07/12	Western meadowlark	WTG-14	130	66	Standard search	Included
06/13/12	Red-tailed hawk	WTG-24	102	116	Standard search	Too old
06/19/12	Western meadowlark	WTG-19	266	81	Standard search	Included
07/09/12	Red-tailed hawk	WTG-30	297	99	Standard search	Included
07/26/12	Tree swallow	WTG-13	340	41	Standard search	Included
08/09/12	Large bird	WTG-24	26	15	Standard search	Too old
08/09/12	Virginia rail	WTG-24	48	100	Standard search	Included
08/15/12	Western meadowlark	WTG-10	33	103	Standard search	Included
08/16/12	Hoary bat	WTG-30	85	23	Standard search	Included
08/27/12	Hoary bat	WTG-01	346	90	Standard search	Included
08/28/12	Small bird	WTG-19	38	96	Standard search	Included
08/28/12	Mexican free-tailed bat	WTG-20	50	63	Standard search	Included
08/30/12	Small bird	WTG-14	360	67	Standard search	Included
09/04/12	Mourning dove	WTG-03	254	92	Standard search	Included
09/04/12	Burrowing owl	WTG-31	47	59	Standard search	Included
09/05/12	Barn owl	WTG-10	160	94	Standard search	Included
09/06/12	Mourning dove	WTG-24	240	83	Standard search	Included
09/11/12	Hoary bat	WTG-17	257	20	Standard search	Included
09/12/12	Mexican free-tailed bat	WTG-23	50	64	Standard search	Included
09/12/12	Western red bat	WTG-23	50	44	Standard search	Included
09/13/12	Hoary bat	WTG-13	45	7	Standard search	Included
09/17/12	American kestrel	WTG-34	240	50	Standard search	Included
09/18/12	Hoary bat	WTG-03	347	85	Standard search	Included
09/20/12	Red-tailed hawk	WTG-27	255	10	Standard search	Included
09/20/12	Rough-winged swallow	WTG-30	136	27	Standard search	Included
09/20/12	Swallow	WTG-06	347	32	Incidental	Included
09/24/12	Hoary bat	WTG-01	44	94	Standard search	Included
09/24/12	Mexican free-tailed bat	WTG-33	90	19	Standard search	Included
09/27/12	Small bird	WTG-14	260	74	Standard search	Included
10/02/12	Mexican free-tailed bat	WTG-22	64	200	Incidental	Included
10/02/12	Ruby-crowned kinglet	WTG-03	89	1	Standard search	Included
10/04/12	Burrowing owl	WTG-30	204	89	Standard search	Included

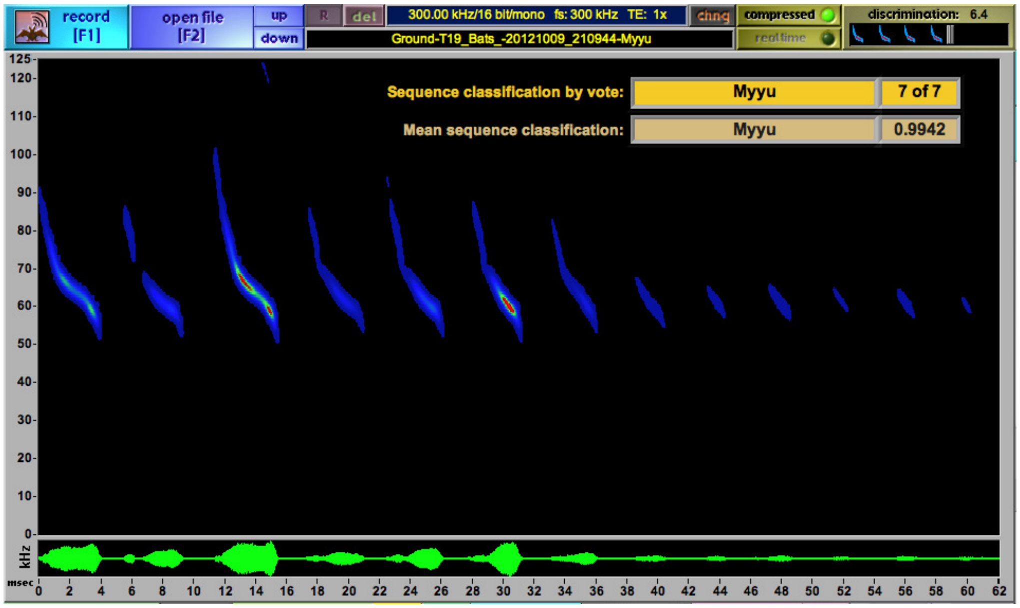
10/09/12	Mourning dove	WTG-06	111	85	Standard search	Included
10/11/12	American kestrel	WTG-17	288	36	Standard search	Included
10/15/12	Mexican free-tailed bat	WTG-34	332	38	Standard search	Included
10/17/12	Western meadowlark	WTG-21	296	99	Standard search	Included
10/18/12	Red-tailed hawk	WTG-29	158	73	Standard search	Included
10/18/12	Mexican free-tailed bat	WTG-14	352	16	Standard search	Included
10/22/12	Small bird	WTG-32	24	79	Standard search	Included
10/25/12	American kestrel	WTG-29	138	38	Standard search	Included
10/29/12	Red-tailed hawk	WTG-33	68	137	Standard search	Included
10/29/12	American kestrel	WTG-03	107	97	Standard search	Included
10/30/12	American kestrel	WTG-26	64	59	Standard search	Included
10/31/12	Burrowing owl	WTG-24	132	67	Standard search	Included
11/06/12	Hoary bat	WTG-06	4	52	Standard search	Included
11/12/12	Red-tailed hawk	WTG-34	208	71	Standard search	Included
11/27/12	American kestrel	WTG-20	44	88	Standard search	Included
12/06/12	American kestrel				Incidental	Too far
12/11/12	Mexican free-tail bat	WTG-03	264	7	Standard search	Included
12/12/12	Large bird	WTG-10	325	62	Standard search	Included
12/12/12	Duck	WTG-22	240	54	Standard search	Included
12/28/12	Western meadowlark	WTG-13	256	86	Standard search	Included
12/31/12	Red-tailed hawk	WTG-03	258	9	Standard search	Included
01/02/13	Red-tailed hawk	WTG-03	248	6	Standard search	Included
01/03/13	Gull	WTG-11	328	31	Standard search	Included
01/04/13	Barn owl	WTG-14	166	30	Standard search	Included
01/04/13	Raptor	WTG-30	288	85	Standard search	Too old
01/17/13	Gull	WTG-08	0	8	Standard search	Included
01/22/13	American kestrel	WTG-32	46	52	Standard search	Included
01/25/13	Red-tailed hawk	WTG-14	94	92	Standard search	Included
01/29/13	Western meadowlark	WTG-19	70	96	Standard search	Included
01/31/13	Red-tailed hawk	WTG-09	137	96	Standard search	Included
01/31/13	American kestrel	WTG-18	282	90	Standard search	Included
02/13/13	Gull	WTG-07	278	88	Standard search	Included
02/25/13	Red-tailed hawk	WTG-33	257	46	Standard search	Included
02/27/13	Large bird	WTG-16	38	33	Standard search	Included
03/06/13	Red-tailed hawk	WTG-05	80	75	Standard search	Included
03/06/13	Double-crested cormorant	WTG-05	32	55	Standard search	Included
03/19/13	Hoary bat	WTG-19	46	98	Standard search	Included
03/26/13	Red-tailed hawk	WTG-03	177	90	Standard search	Included
03/28/13	Red-tailed hawk	WTG-09	74	53	Standard search	Included
04/29/13	Red-tailed hawk	WTG-34	100	33	Standard search	Included
05/01/13	Hoary bat	WTG-22	12	100	Standard search	Included
05/06/13	Red-tailed hawk	WTG-03	76	32	Standard search	Included
05/06/13	Hoary bat	WTG-32	280	22	Standard search	Included
05/09/13	Brewer's blackbird	WTG-29	259	92	Standard search	Included
02/27/12	Golden eagle[a]	WTG-5	90	32	Incidental	Included

[a] Found in February 2012, prior to fatality monitoring.

ATTACHMENTS

Acoustic Bat Survey
at Vasco Winds, LLC Wind Area
2012

Prepared for:
Ventus Environmental Solutions
3522 SW Kanan Dr. Portland OR 97221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Ground-T19_Bats_-20121009_210944-Myyu
discrimination: 6.4
Sequence classification by vote: Myyu 7 of 7
Mean sequence classification: Myyu 0.9942

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Arcata, CA 95521

September 2013

Table of Contents

1.0 Vasco Acoustic Bat Survey

This document reports the findings of ultrasonic acoustic monitoring of bats on the Vasco Winds LLC, Wind Area (Vasco Winds Area) from 27 August 2012 through 3 December 2012. This effort focused on the anticipated fall migratory season with recording from two representative locations on the Vasco Wind Area, each with an ultrasound recording unit with a microphone on the lee side of a turbine nacelle and an associated ground station (four ultrasound recording units in total).

Non-invasive ultrasonic detection and recording of the echolocation pulses that bats emit as they fly can document species presence and provide an index of bat use activity. Acoustic monitoring provides information about bat presence and activity, as well as seasonal changes in species composition, but does not measure the number of individual bats or population density (i.e., acoustic detectors can detect and record individual bat passes within the range of the detector, but cannot differentiate whether there is one bat flying over the detector multiple times, or several bats flying over the detector one time).

1.1 Introduction/Study Area

The Vasco Winds study area is situated within the northwestern section of the Altamont Pass Wind Resource Area (APWRA) Contra Costa County, California, and encompasses 4,234 acres. It lies approximately 4.5 miles south-southwest of the unincorporated community of Byron, approximately 5 miles north of the City of Livermore and approximately 2 miles west-southwest of the Byron Airport. It is bounded to the south by the Alameda County line, bounded to the west by Los Vaqueros Road and transected north-south by Vasco Road. The northwest portion of the study area overlooks the Los Vaqueros Reservoir to the northwest.

Vasco Winds LLC, a subsidiary of NextEra Energy Resources (NextEra), repowered the Vasco Winds area (hereafter referred to as Vasco Winds) in 2011. The original project operated 800 KCS56-100, 100-KW turbines and then later added 20 KVS33, 400-KW turbines. The original project installation occurred in 1985-1986 near the Los Vaqueros Reservoir site (construction of the reservoir was initiated later in 1994) in southern Contra Costa County. Over time attrition, mitigation efforts, and removal projects (e.g., building of the current Vasco Road through the original project) reduced the number of turbines in the area. In 2011 NextEra removed and replaced the original wind turbines with 34 Siemens 2.3-MW wind turbines. The 78.2 MW repowered project commenced operations in February 2012. Permitting requirements mandated bat acoustical monitoring of the Vasco Winds repowered site. To satisfy these requirements Dr. Joseph M. Szewczak and Ventus Environmental Solutions (hereafter Ventus) conducted species-level bat acoustic monitoring during the late summer and early autumn 2012. This monitoring will continue during the same period in 2013 and 2014.

2.0 Methods

In August and September 2012 Ventus Environmental Solutions and NextEra Energy Resources installed and began operating four Pettersson D500X acoustic bat detector stations with remotely mounted microphones at the Vasco Winds project site. These bat detector systems automatically trigger to record sound events nightly from dusk through dawn. The analysis of recorded echolocation calls from passing bats enabled the assessment of species composition, relative bat activity from the total bat passes, and temporal activity changes from mean passes per night over time. In consultation with Siemens engineers, NextEra wind technicians installed one detector and remote boom-mounted microphone on the lee side of nacelles on Turbine 4 and Turbine 19 on 23 August with usable data from Turbine 19 beginning on 16 September 2012 (Fig. 1).

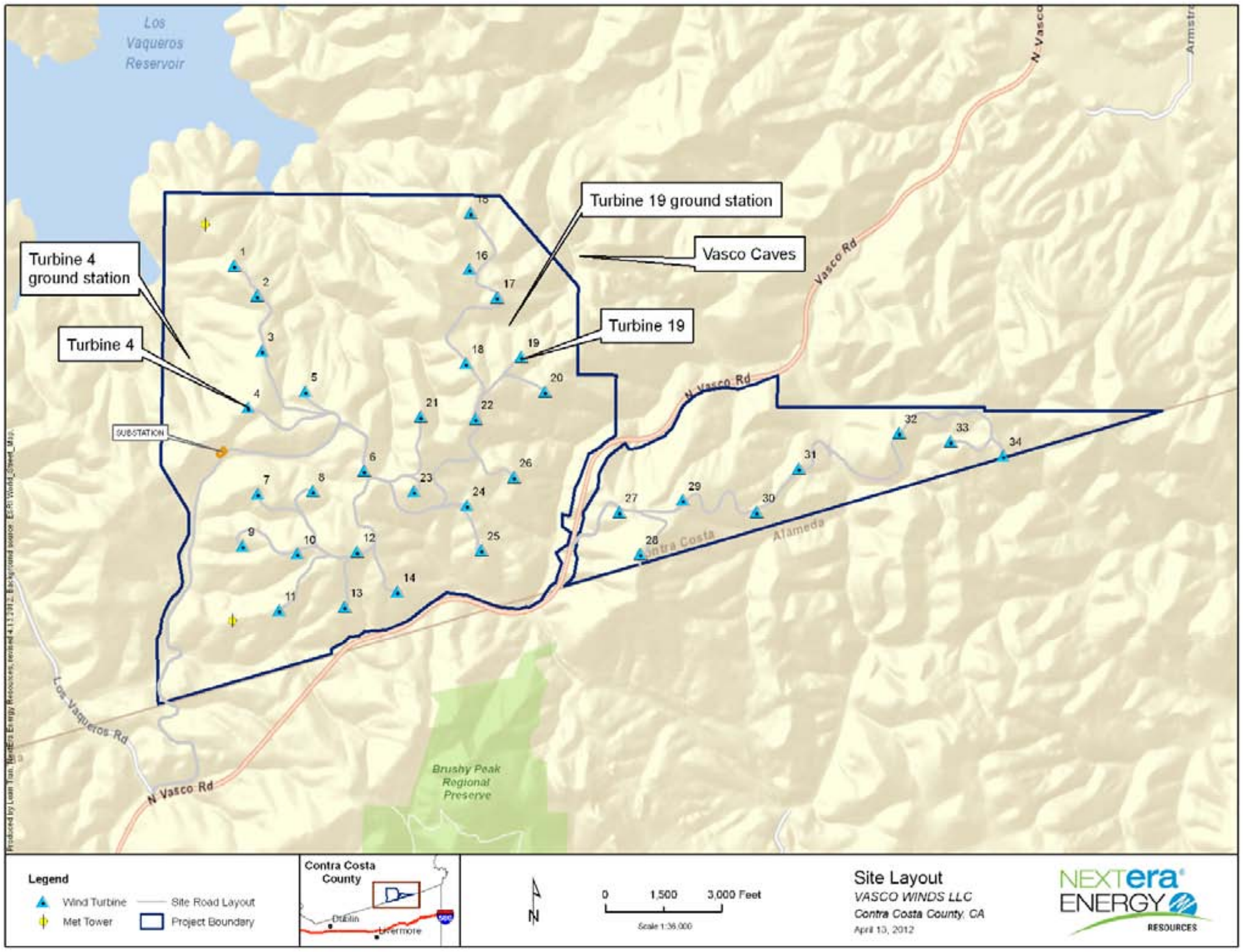


Figure 1. Site map with callouts indicating locations of acoustic monitoring stations at Vasco Winds Area.

2.1 Selection of monitoring site locations

This survey selected two representative acoustic monitoring sites with the objective of detecting bats that may pass through the Vasco Wind Area during fall seasonal movements. Although not fully understood, the fall migratory movements of bats are presumed to follow landscape features in a general north to south movement (Cryan and Diehl 2009, Cryan and Barclay 2009). Bats may thus move along the eastward lee side of the north-south trending ridge of the Morgan Territory Regional Preserve, cross the Los Vaqueros Reservoir and then proceed up the drainage to cross the saddle near the Vasco Wind Area Turbine 4 (Figs. 1 and 2). The forested slopes and topography of the Morgan Territory Regional Preserve also may provide more attractive roosting resources than those available on the Vasco Wind Area and the Turbine 4 acoustic monitoring stations would also record bats that may commute from those roosts.

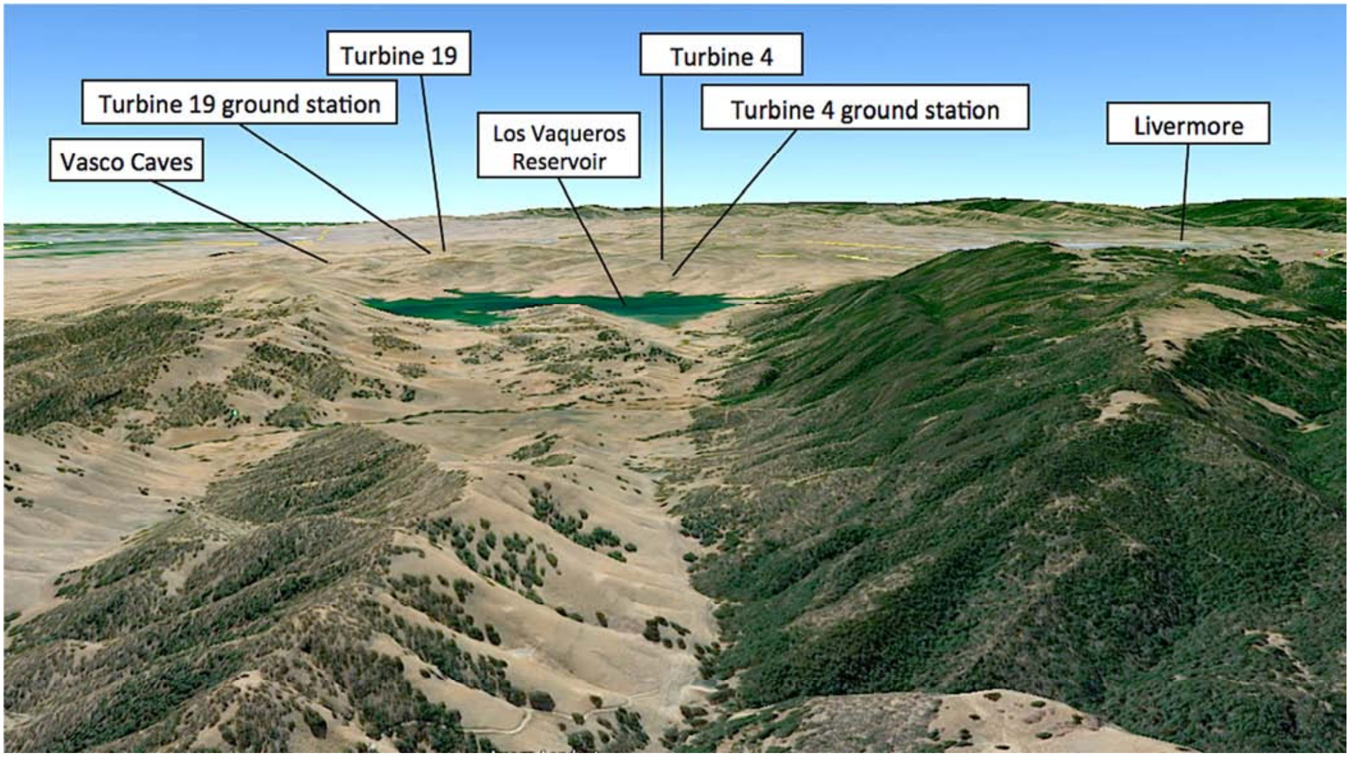


Figure 2. Aerial view looking south of possible migratory flight corridor. This corridor would direct migrating bats onto the Vasco Wind Area. The forested slope of the Morgan Territory Regional Preserve on the right leads to the Los Vaqueros Reservoir and across that to the Vasco Wind Area. The Turbine 4 and associated ground acoustic monitoring stations were placed to detect bats flying along this potential corridor.

Migrating bats may also occupy interim migratory stopover roosts during the day (Cryan and Diehl 2009, Cryan and Barclay 2009). The acoustic monitoring stations on Turbine 19 and its associated ground station were placed to detect bats that may use the roosting resources of nearby Vasco Caves and then move into the Vasco Wind Area either to forage or migrate (Fig. 3).

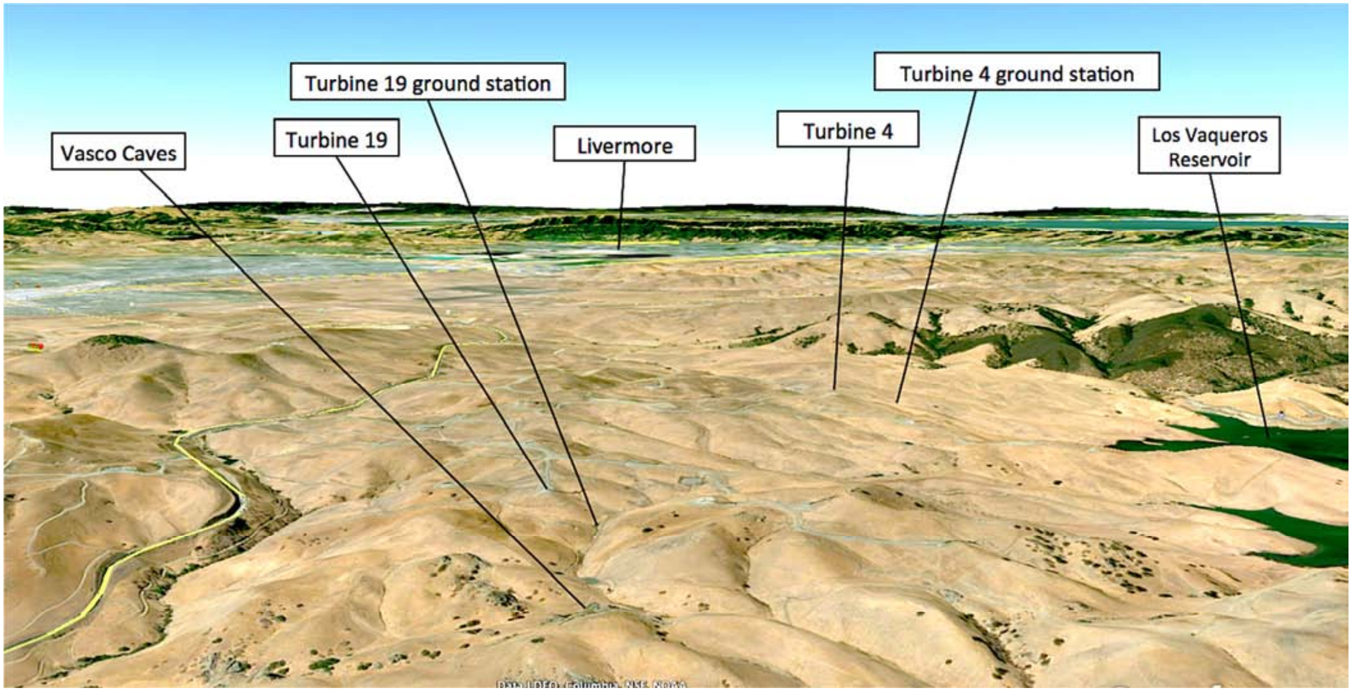


Figure 3. Aerial view of acoustical monitoring sites. View looking west showing relative position of the Vasco Caves and the Vasco Wind Area, the Los Vaqueros Reservoir, and the forested slope of the Morgan Territory Regional Preserve past the Los Vaqueros Reservoir. The Turbine 19 and associated ground acoustic monitoring stations were placed to detect bats that may fly into the Vasco Wind Area from roosts at Vasco Caves, or during migratory movements.

2.2 Turbine monitoring stations

Bats operate in a vertical stratigraphy from near-ground gleaning and aerial hawking foraging to above ground open air aerial hawking foraging (Kunz and Fenton 2003). We paired acoustic ground stations with microphones deployed from turbine nacelles to enable sampling bats across this vertical stratigraphy and with the intent to distinguish species operating near the ground versus those higher up and with the potential to enter the rotor swept area. We elevated the ground station microphones approximately 3–4 m from the ground on poles to eliminate distortion and interference from ground clutter echoes. This height also enabled sampling the airspace from the microphone to the ground and from the microphone height and above. We anticipated the near ground monitoring to more likely document local resident foraging bats and provide an accounting of species presence, while the nacelle mounted monitoring units would provide a record of bats further aloft moving through the site, in addition to resident bats that forage more aloft in open air spaces (Fig. 4). Installation of the turbine nacelle mounted microphone booms required design and specification consultation with Siemens engineers. This novel arrangement enabled placement of the microphone in the center of the rotor swept area, and out and away from the nacelle surfaces to avoid echo distortion. By placing the boom on the nacelle's lee side, and with the directionality of the microphone, this placement also minimized wind and turbine noise that would conflict with the acoustic sensitivity needed to acquire high quality, clean recordings that facilitate accurate species classification.

Figure 4. Configuration of nacelle mounted microphones at Vasco Winds Area. A boom mounted from the top of the nacelle extended out and down to place the microphone in the lee side of the nacelle (left). As bats tend to forage in the lee side of natural structures such as trees and cliffs, the directional microphone was positioned to listen outward from the lee side of the nacelle. This also minimized recording distorting sound from the wind and turbine operation.

2.3 Ground monitoring stations

A Ventus crew installed two detector ground stations downslope from Turbines 4 and 19 on 27 August 2012 (Figs. 5 and 6). The Turbine 4 ground station recorded from a microphone secured to a bracket mounted on a pole extending above a California buckeye (*Aesculus californica*) tree (Fig.5). The selection of this site intended to use a naturally occurring feature (the buckeye stand) to sample bats foraging near the ground and those potentially en route from the reservoir to the ridge saddle (see text and map in previous section).

Figure 5. Setting and mounting arrangement of microphone at Turbine 4 ground station at Vasco Winds Area. Placed in a drainage leading down to Los Vaqueros Reservoir to the north (left). Turbine 4 can be seen upslope above the station (right).

The Turbine 19 ground station recorded from a microphone secured to a bracket mounted on a pole extending above a preexisting post in the drainage down the north side slope below Turbine 19 (Fig. 6). The selection of this site intended to sample bats foraging near the ground and those that potentially roost in cavities and crevices at Vasco Caves, and to sample bats en route from the east (see text and map in previous section).

Figure 6. Setting and mounting arrangement of microphone at Turbine 19 ground station at Vasco Winds Area. Turbine 19 can be seen upslope above the station.

2.4 Acoustic data analysis

The data and power arrangements of the recording units enabled data retrieval on two week intervals. Raw data was offloaded and metadata tagged using a SonoBat Attributer utility as part of the transfer procedure to hard drive archives for processing. The data was next run through the SonoBat Scrubber utility to eliminate noise files (i.e., non-bat files) generated by the recording units. The scrubbed data was then batch processed using SonoBat v3.2 using the US west classifier to recognize bat passes and determine species when possible. The output results of the automated processing were then manually vetted to confirm passes and species identifications for quality control. Discrimination to species enables correlation with foraging behavior and ecology and presumptive migratory or non-migratory species. Together with temporal analysis of events this data can support the determination of bat presence in relation to observed bat fatalities and allow assessment of the project's potential impacts to bats.

3.0 Results

Technical issues and outages were encountered for all recording units that resulted in gaps in data acquisition. Excess noise and subsequent unit setting refinements were required during the initial portion of the periods for all units. Damage to recording equipment at Turbine 4 also resulted in delayed data procurement. As turbine units were ultimately connected to direct power, a week-long, non-facility related power outage in Mid-October shut both units down during that period. Ground unit functionality was also affected by a battery failure and one unit was damaged by wildlife near the end of the recording period.

3.1 Turbine 4 – Following a series of technical issues associated with establishing this unprecedented method of recording bats from a turbine nacelle, usable data collection commenced from Turbine 4 on 25 October 2012 following the Vasco site power outage. The bat pass data collected from Turbine 4 during its operational period ending on the morning of 4 December 2012 was consistent with that from Turbine 19 (below). During the 41 operational nights from 25 October 2012 through 4 December 2012 the Turbine 4 recording station detected 10 bat passes (mean 0.244 passes per detector night) consisting of 8 free-tailed bats *(Tadarida brasiliensis)* and 2 hoary bats (*Lasiurus cinereus*) (Fig. 7, Tables 1 and 2).

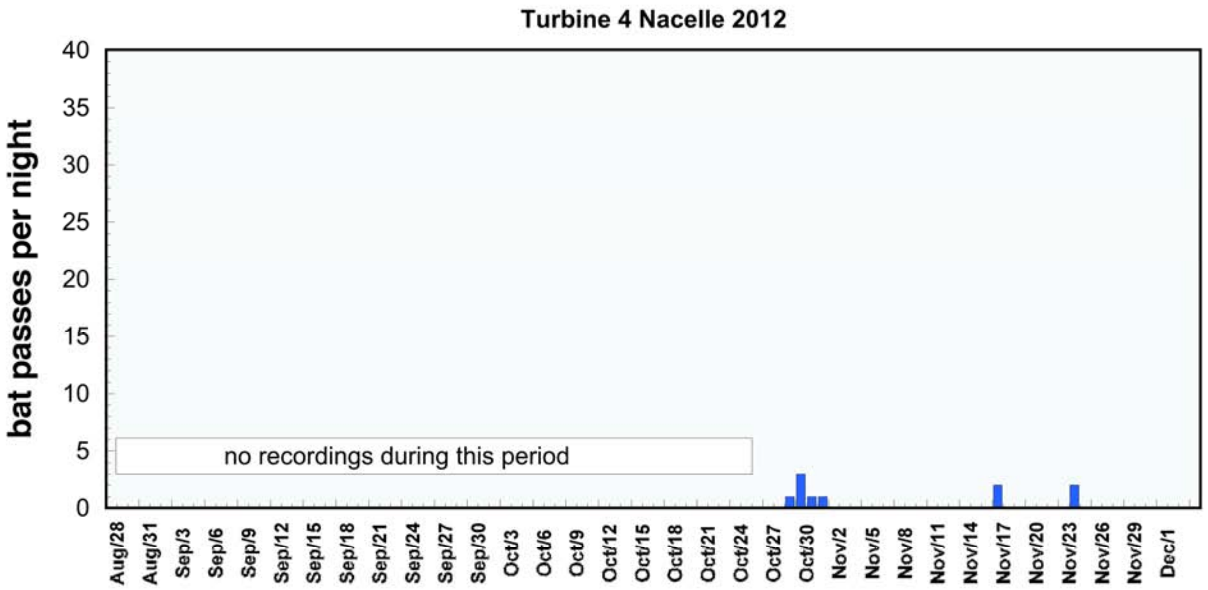


Figure 7. Bat passes per night recorded from the nacelle of Turbine 4 at Vasco Winds Area, 2012. In this and other plots, the periods indicated as having "no recordings" resulted from technical difficulties and to display all plots with the same time period despite different deployment schedules.

3.2 Turbine 19 – Usable data collection from the Turbine 19 nacelle began on 29 August 2012 for one night, then resumed 12 September 2012 until the Vasco site power outage on 15 October 2012, shut the unit down through 25 October 2012, when the unit then continued functioning through the morning of 4 December 2012 when recordings were terminated. During its 74 operational nights the Turbine 19 recording station detected 185 bat passes (mean of 2.50 passes per detector night) consisting of 168 free-tailed bats *(T. brasiliensis)*, 13 hoary bats (*L. cinereus*), and 4 passes indiscernible between these two species (Fig. 8, Tables 1 and 2). The number of bats detected passing Turbine 19 peaked in mid-September, although with interspersed days having few or no passes. Removing the top two active days of 22 and 26 September having 38 and 27 passes, respectively, would adjust the mean passes to 1.67 per detector night. Removing the next two most active days of 12 and 16 September having 19 and 16 passes, respectively, would adjust the mean passes to 1.21 per detector night.

One pass on 17 October 2012 displayed a rapid sequence of short "inspection" calls consistent with the bat making a close approach to the microphone boom, perhaps to investigate it as a potential roost, consistent with this species' habit of daytime roosting in trees (Cryan and Diehl 2009, Cryan and Barclay 2009) (Fig. 9).

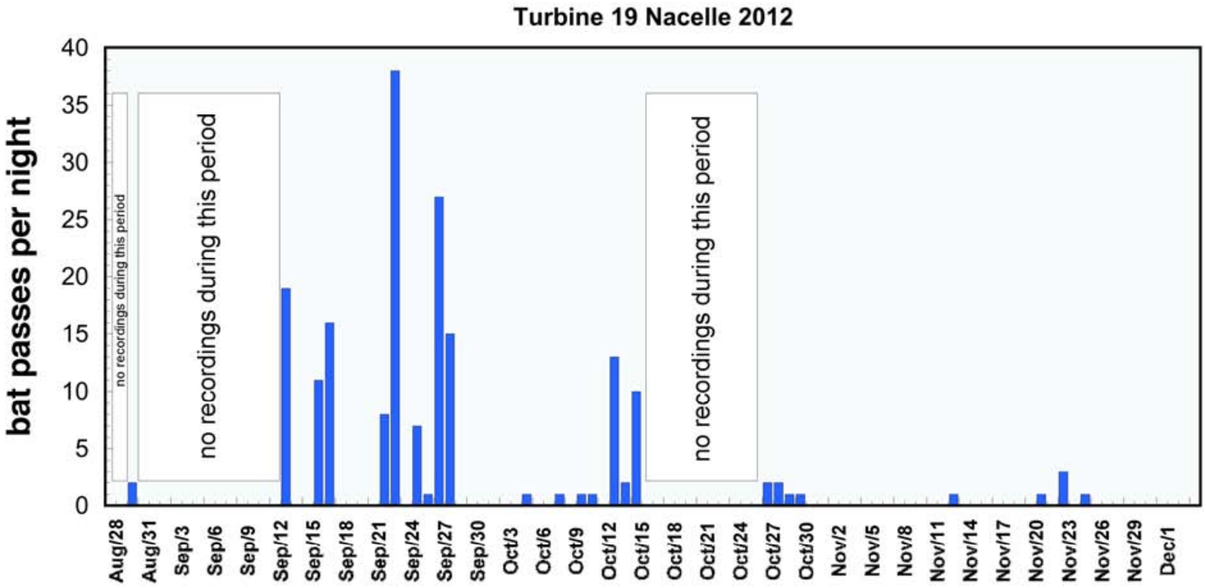
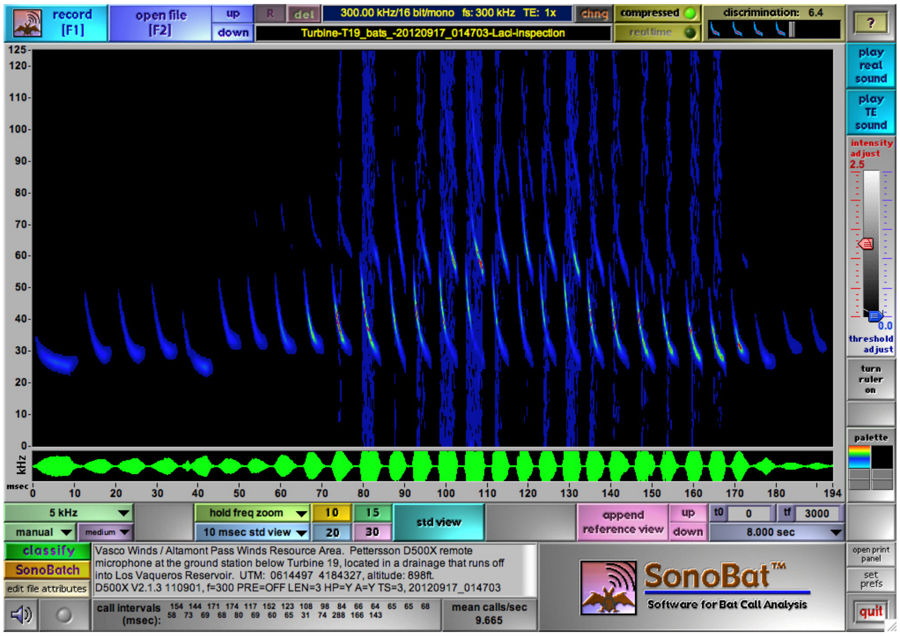


Figure 8. Bat passes per night recorded from the nacelle of Turbine 19 at Vasco Winds Area, 2012.



300.00 kHz/16 bit/mono fs: 300 kHz TE: 1x

Turbine-T19_bats_-20120917_014703-Laci-Inspection

discrimination: 6.4

5 kHz

manual

medium

hold freq zoom

10 msec std view

t0 0

tf 3000

8.000 sec

Vasco Winds / Altamont Pass Winds Resource Area. Pettersson D500X remote microphone at the ground station below Turbine 19, located in a drainage that runs off into Los Vaqueros Reservoir. UTM: 0614497 4184327, altitude: 898ft.
D500X V2.1.3 110901, f=300 PRE=OFF LEN=3 HP=Y A=Y TS=3, 20120917_014703

call intervals (msec): 154 144 171 174 117 152 123 108 98 84 66 64 65 65 68
58 73 69 68 80 69 60 65 31 74 288 166 143

mean calls/sec 9.665

Figure 9. Inspection sequence recorded from nacelle at Vasco Winds Area. A bat pass sequence recorded on 17 September 2012 displaying calls of shorter duration, higher frequency, greater overall frequency bandwidth, and more calls per second than that of typical search phase calls of hoary bats. Such a sequence of calls indicates a close up investigation. The vertical bars result from signal strength overloading the detector's maximum amplitude resolution also indicate a close approach to the boom-mounted microphone for inspection. (Note: this and other sonogram images in this report display call sequences in SonoBat compressed view mode that compresses the actual spacing between the calls in the sequence to render the overall progression of call structure through the bat pass sequence more visible. In reality the calls have greater temporal separation than shown in these displays.)

3.3 Turbine 4 ground station – Data collection from the Turbine 4 ground station began on 28 August 2012 for one night, then resumed 12 September 2012 and continued through 16 November 2012. This station detected a total of 197 bat pass events over 66 operational detector nights (mean of 2.98 passes per detector night) (Fig. 10, Tables 1 and 2). The night of 26 October 2012 exceeded all other nights with 104 passes, all of free-tailed bats (*T. brasiliensis*). Excluding that night from the data set leaves a mean pass rate of 1.43 per detector night for the remaining 65 operational nights.

The Turbine 4 ground station detected four species: 18 California myotis (*Myotis californicus*), 14 Yuma myotis (*M. yumanensis*), 5 western red bats (*L. blossevillii*), 7 passes indistinguishable between these high frequency species, 142 free-tailed bats (*T. brasiliensis*), and 11 indistinguishable low frequency bats (most likely free-tail or hoary bats).

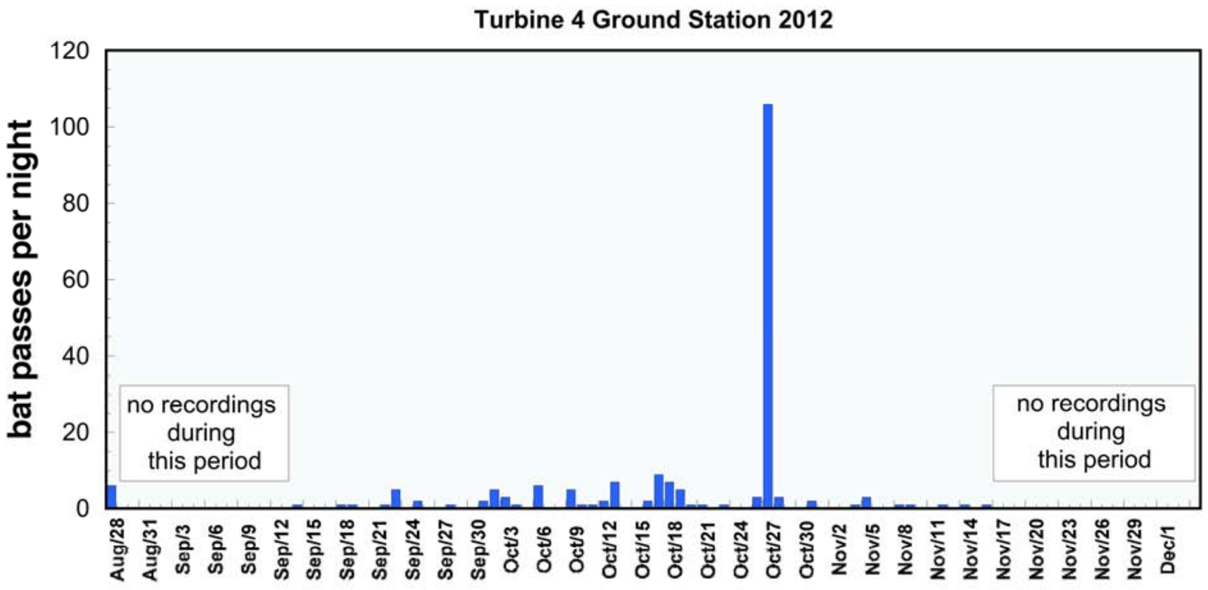


Figure 10. Bat passes per night recorded from the Turbine 4 ground station at Vasco Winds Area, 2012.

3.4 Turbine 19 ground station – Data collection from the Turbine 19 ground station began on 6 September 2012 and continued through the morning of 4 December 2012. This station detected a total of 234 bat pass events over 88 operational detector nights (mean of 2.66 passes per detector night) (Fig. 11, Tables 1 and 2). The night of 18 October 2012 exceeded all other nights with 91 passes, all of free-tailed bats (*T. brasiliensis*). Excluding that night from the data set leaves a mean pass rate of 1.64 per detector night for the remaining 87 operational nights.

The Turbine 19 ground station detected six species: 2 California myotis (*M. californicus*), 6 Yuma myotis (*M. yumanensis*), 3 canyon bats (*Parastrellus hesperus*), 1 western red bats (*L. blossevillii*), 3 passes indistinguishable between these high frequency species, 2 big brown bats (*Eptesicus fuscus*), 11 hoary bats (*L. cinereus*), 190 free-tailed bats (*T. brasiliensis*), and 16 indistinguishable low frequency bats (most likely free-tail or hoary bats).

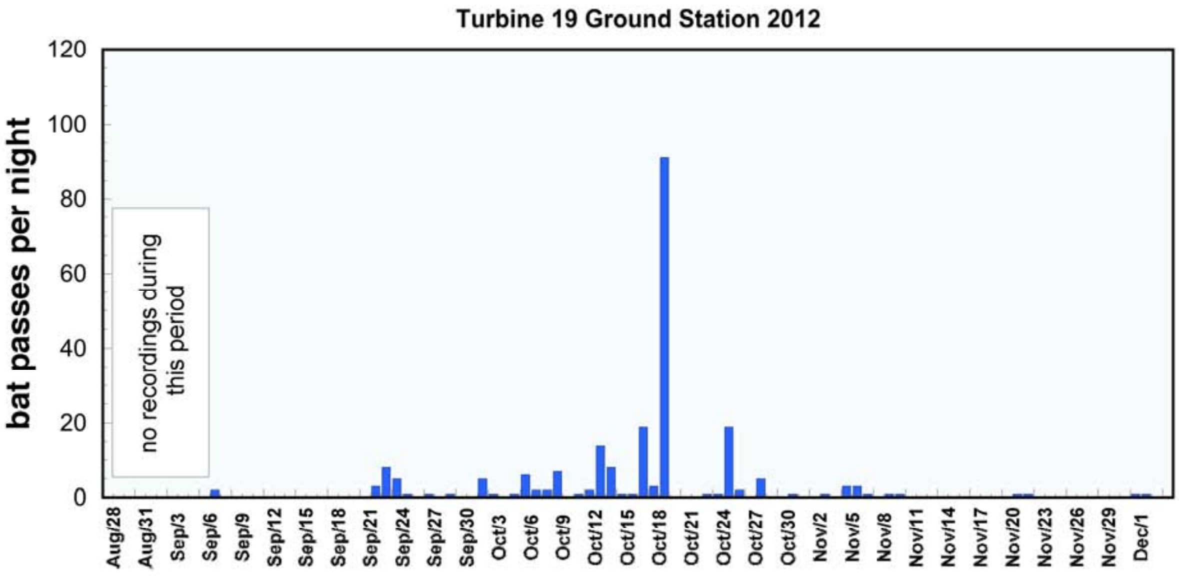


Figure 11. Bat passes per night recorded from the Turbine 19 ground station at Vasco Winds Area, 2012.

Table 1. Total bat passes by species and recording location, 27 August through 4 December 2012.

	Yuma myotis	California myotis	Canyon bat	Western red bat	Big brown bat	Free-tailed bat	Hoary bat	Unknown HiF	Unknown LoF	Totals
Turbine 4 (41 nights)						8*	2*			10*
Turbine 19 (74 nights)						168	13		4	185
Totals						176	15		4	195
Turbine 4 ground (66 nights)	14	18		5		142		7	11	197
Turbine 19 ground (88 nights)	6	2	3	1	2	190	11	3	16	234
Totals	20	20	3	6	2	332	11	10	27	431

* The operational period of the Turbine 4 recording unit missed the peak of activity from September through mid-October consistent across the other three recording stations.

Table 2. Mean bat passes per detector night by species and recording location, 27 August to 4 December 2012.

	Yuma myotis	California myotis	Canyon bat	Western red bat	Big brown bat	Free-tailed bat	Hoary bat	Unknown HiF	Unknown LoF	Totals
Turbine 4 (41 nights)						0.195*	0.049*			0.25*
Turbine 19 (74 nights)						2.270	0.176		0.054	2.50
Totals						1.530	0.130		0.035	1.70

	Yuma myotis	California myotis	Canyon bat	Western red bat	Big brown bat	Free-tailed bat	Hoary bat	Unknown HiF	Unknown LoF	Totals
Turbine 4 ground (66 nights)	0.212	0.273		0.076		2.152		0.106	0.167	2.99
Turbine 19 ground (88 nights)	0.068	0.023	0.034	0.011	0.023	2.159	0.125	0.034	0.182	2.66
Totals	0.130	0.130	0.019	0.039	0.013	2.156	0.071	0.065	0.175	2.80

* The operational period of the Turbine 4 recording unit missed the peak of activity from September through mid-October consistent across the other three recording stations.

4.0 Discussion

The Vasco Wind Area consists mostly of rolling grassland hills. Compared to other local landscape features within a nightly flight for a bat (~10–50 km or more, depending on species), the site has relatively limited foraging resources to attract bats. The richest sites lay at the lower drainages leading to the Los Vaqueros Reservoir at the northwest edge of the site, and an intermittent riparian corridor paralleling North Vasco Road where it bisects the site. This situation leads to an expectation of a low level of resident bat foraging activity, and the data supports this expectation. For survey period, this study found low activity of less than 0.2 bat passes per detector night for small, near ground foraging high frequency echolocating non-migratory bats (e.g., Myotis spp., Canyon bats).

The Vasco Wind Area does lie within the potential range for summer resident populations of the migratory species free-tailed bats and hoary bats. However, if residents were present throughout, the data should have exhibited more consistent recorded activity levels over the course of the survey period. Instead, this survey observed a pulse of activity from all three monitoring stations operational during September through mid-October. Consistent with the low level of non-migratory bat activity, this pulse of activity likely indicates these bats are non-resident and only passing through the Vasco Wind Area during their fall migratory movement. Both ground and turbine recording stations showed the September through mid-October pulse of free-tailed and hoary bat activity. Although open air flying free-tailed and hoary bats both echolocate with loud intensity (Surlykke and Kalko 2008) bats must typically pass within about 30 m for the recorders to trigger and record a detection. Detection by the ground stations would indicate that these bats may follow the landscape slopes and corridors as they pass through the Vasco Wind Area in addition to higher flight as indicated by the detections from the turbine stations.

Hein et al. (2012) compiled 242 studies to relate pre-construction bat activity and post-construction fatality to predict risk at wind energy facilities. Although Hein et al. (2012, 2013) found considerable variability across sites and regions, and between pre-construction acoustic activity and post-construction fatality findings, a general trend emerged of approximately an average of one bat pass per detector night predicted a post-construction fatality rate of 1 bat/MW-yr. Fatality estimates adjusted for carcass persistence and searcher detection rates ranged between 5 and 19 bat fatalities per MW per year in the eastern forest and Midwest regions, between 2 and 4 bat fatalities per MW per year, and between 1 and 2 bat fatalities per MW per year for 43 post-construction monitoring sites in the Great Basin region (Note: previous range values not exacted as they were estimated from the graphics presented in the webinar of preliminary results). The range of 0.66 to 2.28 bat fatalities per MW-yr calculated for the Vasco Wind Area during the first year of acoustical monitoring shows consistency with the nearby Great Basin results and do not indicate an unusual or unexpected high concentration of bat activity at the Vasco site.

The data from this first year of acoustic surveys conducted during the autumn 2013 found an overall 1.70 bat passes per detector night at turbine height compared with the overall bat fatality result of 1.68 per MW-yr of this study, a finding consistent with the trend of Hein et al. (2012, 2013). This study recorded only two species acoustically at turbine height, free-tailed bats (*Tadarida brasiliensis*) and hoary bats (*Lasiurus cinereus*). Although the overall acoustic and fatality results compare favorably to the Hein et al. (2012, 2013) trend, the individual species results do not. This study detected 1.53 bat passes per detector night for free-tailed bats compared to 0.66 bat fatalities per MW-yr, and just 0.13 bat passes per detector night for hoary bats compared to 0.89 bat fatalities per MW-yr. This disproportional number of hoary bat fatalities relative to their rate of acoustic detection may indicate different flight dynamics or behavior when passing through the rotor-swept zone, consistent with the hypothesis that hoary bats may slow or investigate the turbine towers as an element of the social behavior as tree-roosting bats (Cryan and Diehl 2009, Cryan and Barclay 2009). In support of this we found some recordings that indicated investigatory behavior by hoary bats near the turbine nacelles (Figure 9).

Further evaluation may enable some fatality predictive power using a model based on temporal and meteorological data, site-specific historic bat pass activity trends, and perhaps real-time monitoring of bat pass activity. Continued acoustic monitoring and carcass surveys at the Vasco Wind Area will contribute further to such an initiative.

5.0 Literature Cited

Cryan, P. M., & Barclay, R. M. 2009. Causes of bat fatalities at wind turbines: hypotheses and predictions. *Journal of Mammalogy*, *90*(6), 1330-1340.

Cryan, P. M., Diehl, R. 2009. Analyzing bat migration. Pp. 476–488 in Ecological and behavioral methods for the study of bats (T. H. Kunz and S. Parsons, eds.). Johns Hopkins University Press, Baltimore, Maryland. 476-488.

Hein, C., W. Erickson, J. Gruver, K. Bay, and E. B. Arnett. 2012. Relating pre-construction bat activity and post-construction fatality to predict risk at wind energy facilities. PNWWRM IX. 2013. Proceedings of the Wind-Wildlife Research Meeting IX. Broomfield, CO. November 28-30, 2012. Prepared for the Wildlife Workgroup of the National Wind Coordinating Collaborative by the American Wind Wildlife Institute, Washington, DC, Susan Savitt Schwartz, ed. 175 pp.

Kunz, T. H., & Fenton, M. B. (Eds.). (2003). *Bat ecology*. University of Chicago Press.

Surlykke, A., and Kalko, E. K. V. (2008). "Echolocating bats cry out loud to detect their prey," PLoS ONE 3(4):e2036.

Appendix A: Potential Bat Species

Species positively identified through ultrasonic acoustic monitoring of the Vasco Wind site during the Bat Acoustical Survey conducted in 2012.

Table 1. Potential and Confirmed Presence of Sensitive Bat Species within the Study Site.

Species	Status	Habitat associations	Presence
western mastiff bat *(Eumops perotis)*	DFG:SSC USFS:S BLM:S WBWG:H	associated with open, semi-arid to arid habitats, including conifer and deciduous woodlands, coastal scrub, annual and perennial grasslands, chaparral, and urban; requires high rock faces or similar feature for roosting	no
fringed myotis (*Myotis thysanodes*)	BLM:S WBWG:H IUCN:LC	found in mixed deciduous/coniferous forest	no
long-eared myotis (*Myotis evotis*)	BLM:S WBWG:M IUCN:LC	more often found in coniferous forests but also known to occur in desert scrub	no
Townsend's big-eared bat (*Corynorhinus townsendii*)	DFG:SSC USFS:S BLM:S WBWG:H IUCN:LC	lives in a wide variety of habitats but most common in mesic sites; typically roosts in caves, mines, and analogous structures	no
pallid bat (*Antrozous pallidus*)	DFG:SSC USFS:S BLM:S WBWG:H IUCN:LC	resides in deserts, grasslands, shrublands; most common in open, dry habitats with rock areas	no
hairy-winged myotis, long-legged myotis (*Myotis volans*)	WBWG:H IUCN:LC	often found in coniferous forests and in forested habitats along the coast	no
Yuma myotis (*Myotis yumanensis*)	BLM:S WBWG:H IUCN:LC	prefers to forage over open water; often roosts in buildings	**yes**
western red bat *(Lasiurus blossevillii)*	DFG:SSC USFS:S WBWG:H IUCN:LC	associated with riparian and wooded habitats, including orchards; day roosts in trees, within the foliage, prefers broadleaf trees	**yes**
hoary bat (*Lasiurus cinereus*)	WBWG:M IUCN:LC	tree-associated species; found primarily in forested habitats; day roosts in trees, within foliage, 3-12 m above the ground, in both coniferous and deciduous trees; may on rare occasions roost in caves, beneath ledges, in woodpecker holes, and in squirrels nests	**yes**

DFG:SSC	California Department of Fish and Wildlife Species of Special Concern; species as designated by the Department of Fish and Wildlife due to declining population levels, limited ranges, and/or continuing threats that have made the species vulnerable to extinction
USFS:S	U.S. Forest Service Sensitive Species
BLM:S	Bureau of Land Management Sensitive Species
WBWG:M	Medium Priority Status as listed by the Western Bat Working Group
WBWG:H	High Priority Status as listed by the Western Bat Working Group

Table 2. Presence of Potential Non-sensitive Bat Species in the study site.

Species	**Habitat associations**	**Presence**
free-tailed bat *(Tadarida brasiliensis)*	found throughout California; roosts may vary considerably, from cliff faces, bridges, building, mines, and caves	**yes**
big brown bat (*Eptesicus fuscus*)	known to a variety of habitats; roosts include, but are not limited to mines, caves, buildings, bridges, and trees (e.g., ponderosa, aspen, oaks, and sycamores)	**yes**
California myotis *(Myotis californicus)*	variety of habitats from lower Sonoran desert scrub to forests; wide variety of day roosts including mines, caves, buildings, rock crevices, hollow trees, and under exfoliating bark; crevice roosting	**yes**
canyon bat (*Parastrellus hesperus*)	lower and Upper Sonoran desert and coastal sage scrub, usually in association with rock features such as granite boulders and canyons; roosts primarily in rock crevices, but may include mines, caves, or rarely buildings	**yes**

Species descriptions

Western mastiff bat (*Eumops perotis*)

The largest bat species in North America. Mostly know to the Central Valley and south, and the canyons of the western Sierra. This bat is severely limited by available drinking water. Its long, narrow wings preclude it from drinking at ponds less than 100 feet long.

Townsend's big-eared bat (*Corynorhinus townsendii*)

These bats typically venture out to forage only after dark, and fly with great agility to hunt moths and other insects. In the spring and summer, females form maternity colonies in mines, caves, or buildings, while males roost individually. In winter, these bats hibernate in caves and abandoned mines. Compared with other species, they are considered to be extremely sensitive to disturbance at their roosting sites and have suffered severe population declines throughout much of the U.S.

Free-tailed bat (*Tadarida brasiliensis*)

Free-tailed bats consume enormous quantities of insects over woodlands and forests, likely including many pest species. Free-tailed bats fly fast and high on narrow wings like swallows. They typically forage in open air, well above vegetation.

Pallid bat (*Antrozous pallidus*)

Pallid bats often glean large insect prey, i.e., feeding from the ground. Unlike most other North American bats, this species captures little, if any, prey while in flight. Using its huge ears, it often detects insects by passive listening and vision rather than using echolocation. After capturing its prey, pallid bats will carry it to a convenient perch to consume its meal, e.g., in the basal hollows of sequoias. The insect parts left behind reveal pallid bat presence. Its most common prey include crickets, beetles, grasshoppers, and even scorpions. Pallid bats typically roost in rock crevices, buildings, and bridges.

Big brown bat (*Eptesicus fuscus*)
Found in virtually every North American habitat ranging from timberline meadows to lowland deserts, though it is most abundant in deciduous forest areas. This bat is often abundant in suburban areas of mixed agricultural use, where it often roosts in buildings. Historically, these bats formed maternity colonies beneath loose bark and in small cavities of trees. Common maternity roosts today can be found in buildings, barns, bridges, and even bat houses. Small beetles are their most frequent prey, yet big brown bats will consume prodigious quantities of a wide variety of night-flying insects, and have been demonstrated to consume significant agricultural pest species. They are generalists in their foraging behavior and habitat selections, seemingly showing little preference for feeding over water vs. land, or in forests vs. clearings.

Western red bat (*Lasiurus blossevillii*)
The red bat is a typical tree bat, roosting amid the foliage, and is closely associated with cottonwoods in riparian areas. Especially favored roosts are found in broadleaf trees where leaves form a dense canopy above and branches do not obstruct the bats' flyway below. Red bats are also known to roost in orchards. Despite their bright amber color, these bats are actually rather cryptic, resembling dead leaves when they curl up in their furry tail membranes to sleep. As with other tree bats, this species is solitary, coming together only to mate and to migrate. Red bats often give birth to twins, and can have litters of up to four pups, though three is the average. These bats typically feed along forest edges, in small clearings, or around street-lights where they prefer moths. It is known that red bats in the Pacific Northwest move to milder coastal areas during the winter.

Hoary bat (*Lasiurus cinereus*)
These bats roost in canopy foliage throughout the day. They typically roost 10-15 feet up in tree foliage along forest borders. In the summer, they don't emerge to feed until after dark, but during migration, they may be seen soon after sundown. They can make round trips of up to 24 miles on the first foraging flight of the night, then make several shorter trips, returning to the day roost about an hour before sunrise. Hoary bats migrate annually from subtropical and possibly even tropical areas where they spend the winter northward to as far as Canada. Traveling in waves, they have been observed in the company of birds, who also migrate in groups. For the rest of the year, however, hoary bats remain solitary.

California myotis (*Myotis californicus*)
Ubiquitous in California, this bat roosts beneath loose bark and in crevices of old snags, as well as crevices in trees and cliffs, and in buildings and bridges. Like many species, this bat switches roosts on a regular basis, from within a few feet or up to a mile apart. Roost switching may be in response to following available insects or aid in finding ideal roost temperatures as well as in avoiding predators and parasites. These bats are among North America's smallest, enabling them to feed on especially tiny insect prey.

Long-eared myotis (*Myotis evotis*)
Predominantly associated with coniferous forests, they usually roost in tree cavities and beneath exfoliating bark in both living trees and dead snags. Pregnant long-eared myotis often roost at ground level in rock crevices, fallen logs, and even in the crevices of sawed-off stumps, but do not rear young in such vulnerable locations. Like pallid bats, long-eared myotis capture prey in flight, but also glean stationary insects from foliage or the ground. Their main diet appears to consist of moths, and their relatively quiet echolocation calls are well suited for sneaking up on prey undetected as well as for maneuvering through cluttered habitats.

Fringed myotis (*Myotis thysanodes*)

Known from low desert scrub to high elevation coniferous forest. Found in mixed deciduous/coniferous forest. Maternity roosts are comprised of adult females and may include several hundred individuals. Males roost individually. Hibernating groups can contain both sexes. Often roosts in buildings or mines. Forages on a variety of small beetles and a variety of other taxa including moths. Forages among vegetation, along forest edges and over the forest canopy with some gleaning activity.

Yuma myotis (*Myotis yumanensis*)

Found throughout western North America, and often found in buildings or bridges. A colonial species, but single males also sometimes roost in abandoned cliff swallow nests. These bats typically forage over open water in forested areas, but will occur anywhere in California near open water. Although this bat feeds predominantly over water on emergent aquatic insects, they eat a variety of insects that includes moths, froghoppers, leafhoppers, June beetles, ground beetles, midges, mosquitoes, muscid flies, caddisflies, and crane flies.

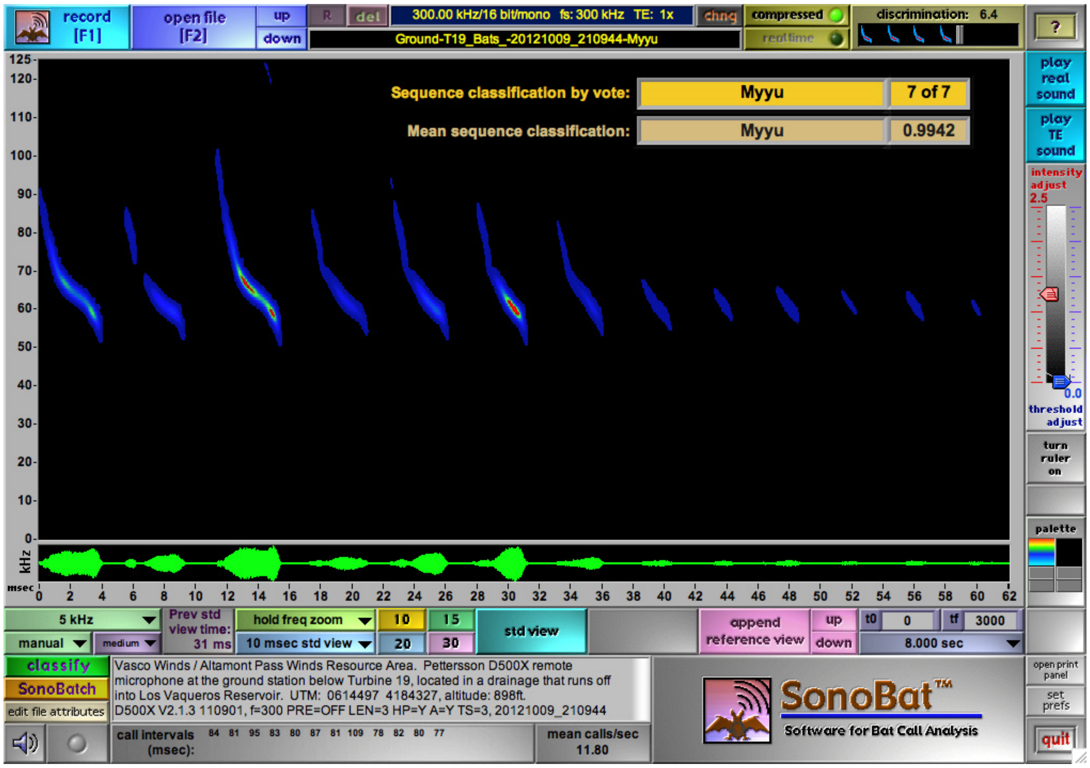
Hairy-winged myotis, long-legged myotis (*Myotis volans*)

Associated with wooded habitats from pinyon-juniper to coniferous forests. Radio-tracking studies have identified maternity roosts beneath bark and in other cavities. Most maternity colonies have been located in at least 100 year-old trees that provide crevices or exfoliating bark. Though maternity colonies are most often formed in tree cavities or under loose bark, they also are found in rock crevices, cliffs, and buildings. These bats forage over ponds, streams, water tanks, and in forest clearings, often on moths.

Canyon bat (*Parastrellus hesperus)*

Concentrated in desert areas, but associated anywhere in its range near rocky outcrops. The smallest North American bat, it prefers desert and coastal sage scrub, and is usually associated with rock features such as granite boulders and canyons. Females may form small maternity colonies, but usually fewer than 12 individuals, including both females and young. Primarily day roosts in rock crevices, or rarely buildings. Generally roost singly or in small groups. Mostly feeds on small moths, leafhoppers, mosquitoes, and flying ants. Foraging is characterized by slow, erratic flight patterns and usually occurs in the open.

Appendix B: Sample Recording Vouchers



300.00 kHz/16 bit/mono fs: 300 kHz TE: 1x

Ground-T19_Bats_-20121009_210944-Myyu

Sequence classification by vote: Myyu 7 of 7

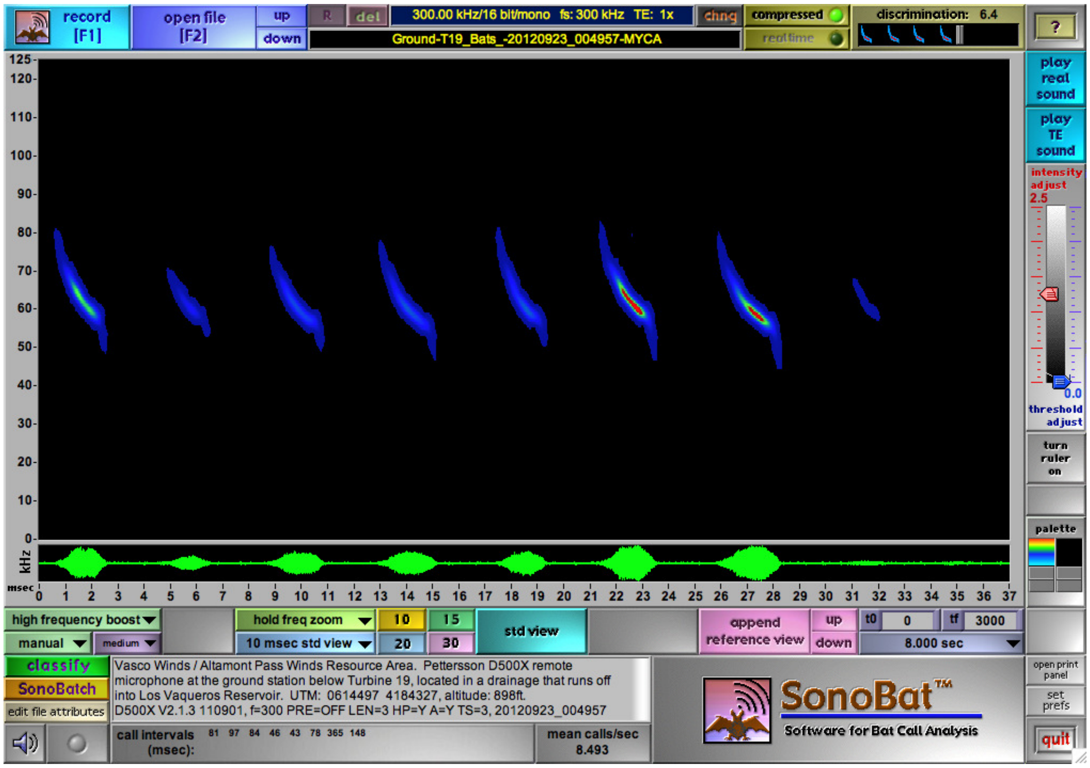
Mean sequence classification: Myyu 0.9942

Vasco Winds / Altamont Pass Winds Resource Area. Pettersson D500X remote microphone at the ground station below Turbine 19, located in a drainage that runs off into Los Vaqueros Reservoir. UTM: 0614497 4184327, altitude: 898ft.
D500X V2.1.3 110901, f=300 PRE=OFF LEN=3 HP=Y A=Y TS=3, 20121009_210944

call intervals (msec): 84 81 95 83 80 87 81 109 78 82 80 77

mean calls/sec 11.80

Yuma myotis (*Myotis yumanensis*).



300.00 kHz/16 bit/mono fs: 300 kHz TE: 1x

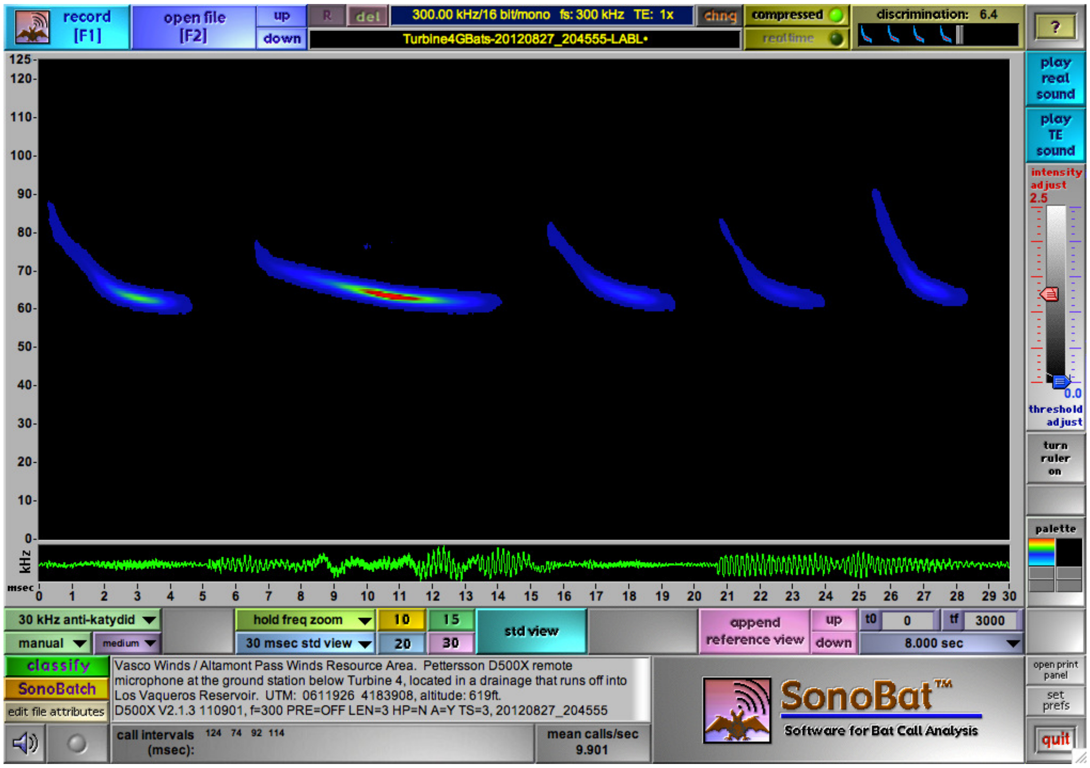
Ground-T19_Bats_-20120923_004957-MYCA

Vasco Winds / Altamont Pass Winds Resource Area. Pettersson D500X remote microphone at the ground station below Turbine 19, located in a drainage that runs off into Los Vaqueros Reservoir. UTM: 0614497 4184327, altitude: 898ft.
D500X V2.1.3 110901, f=300 PRE=OFF LEN=3 HP=Y A=Y TS=3, 20120923_004957

call intervals (msec): 81 97 84 46 43 78 365 148

mean calls/sec 8.493

California myotis (*Myotis californicus*).



300.00 kHz/16 bit/mono fs: 300 kHz TE: 1x

Turbine4GBats-20120827_204555-LABL•

discrimination: 6.4

30 kHz anti-katydid

manual

medium

hold freq zoom

30 msec std view

t0 0

tf 3000

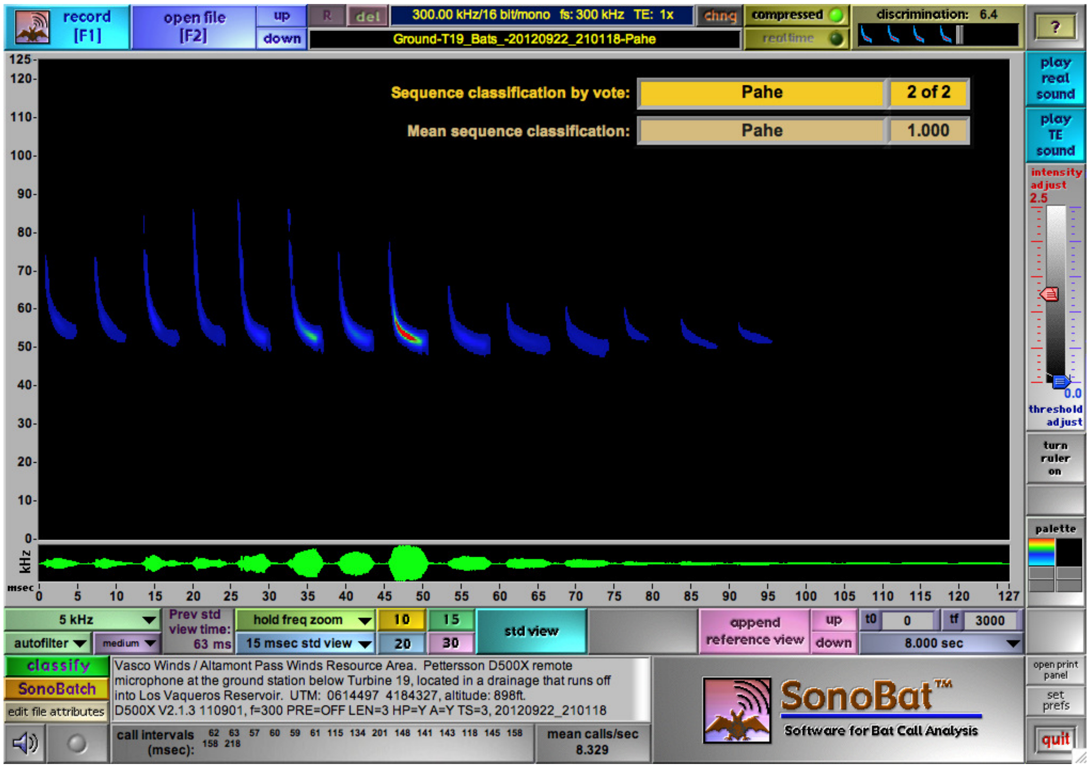
8.000 sec

Vasco Winds / Altamont Pass Winds Resource Area. Pettersson D500X remote microphone at the ground station below Turbine 4, located in a drainage that runs off into Los Vaqueros Reservoir. UTM: 0611926 4183908, altitude: 619ft.
D500X V2.1.3 110901, f=300 PRE=OFF LEN=3 HP=N A=Y TS=3, 20120827_204555

call intervals (msec): 124 74 92 114

mean calls/sec 9.901

Western red bat (*Lasiurus blossevillii*).



300.00 kHz/16 bit/mono fs: 300 kHz TE: 1x

Ground-T19_Bats_-20120922_210118-Pahe

discrimination: 6.4

Sequence classification by vote: Pahe 2 of 2

Mean sequence classification: Pahe 1.000

5 kHz

autofilter

medium

Prev std view time: 63 ms

hold freq zoom

15 msec std view

t0 0

tf 3000

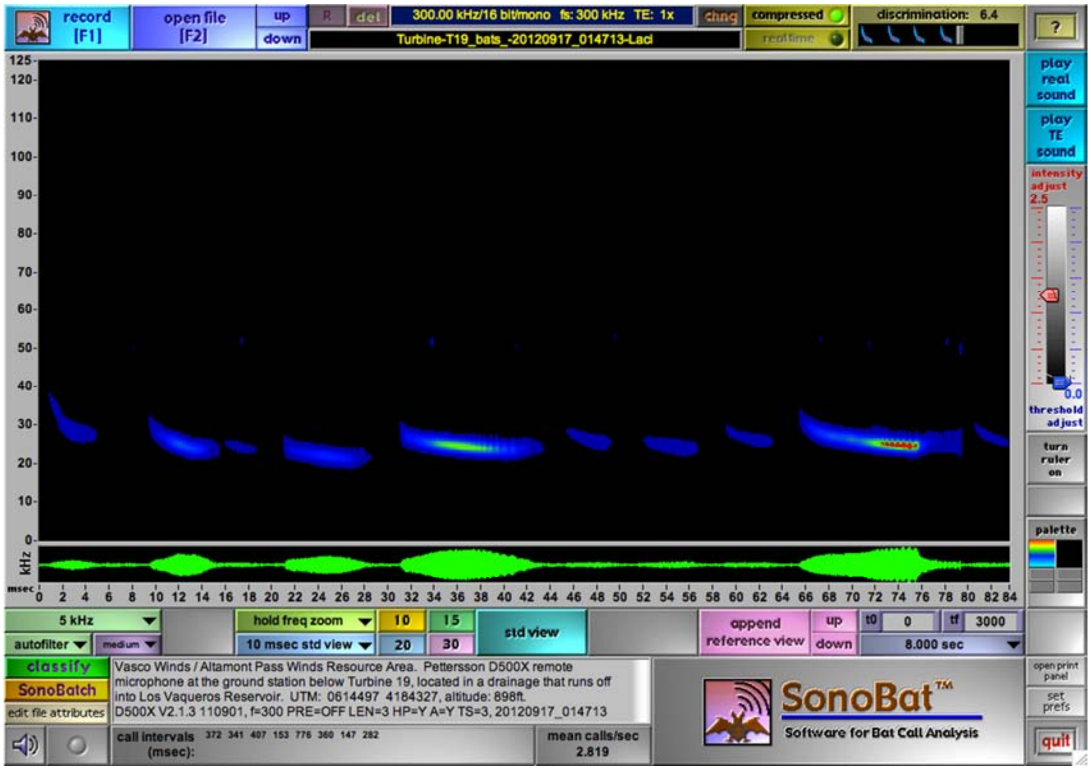
8.000 sec

Vasco Winds / Altamont Pass Winds Resource Area. Pettersson D500X remote microphone at the ground station below Turbine 19, located in a drainage that runs off into Los Vaqueros Reservoir. UTM: 0614497 4184327, altitude: 898ft.
D500X V2.1.3 110901, f=300 PRE=OFF LEN=3 HP=Y A=Y TS=3, 20120922_210118

call intervals (msec): 62 63 57 60 59 61 115 134 201 148 141 143 118 145 158 158 218

mean calls/sec 8.329

Canyon bat (formerly western pipistrelle) (*Parastrellus hesperus*).



300.00 kHz/16 bit/mono fs: 300 kHz TE: 1x

Turbine-T19_bats_-20120917_014713-Laci

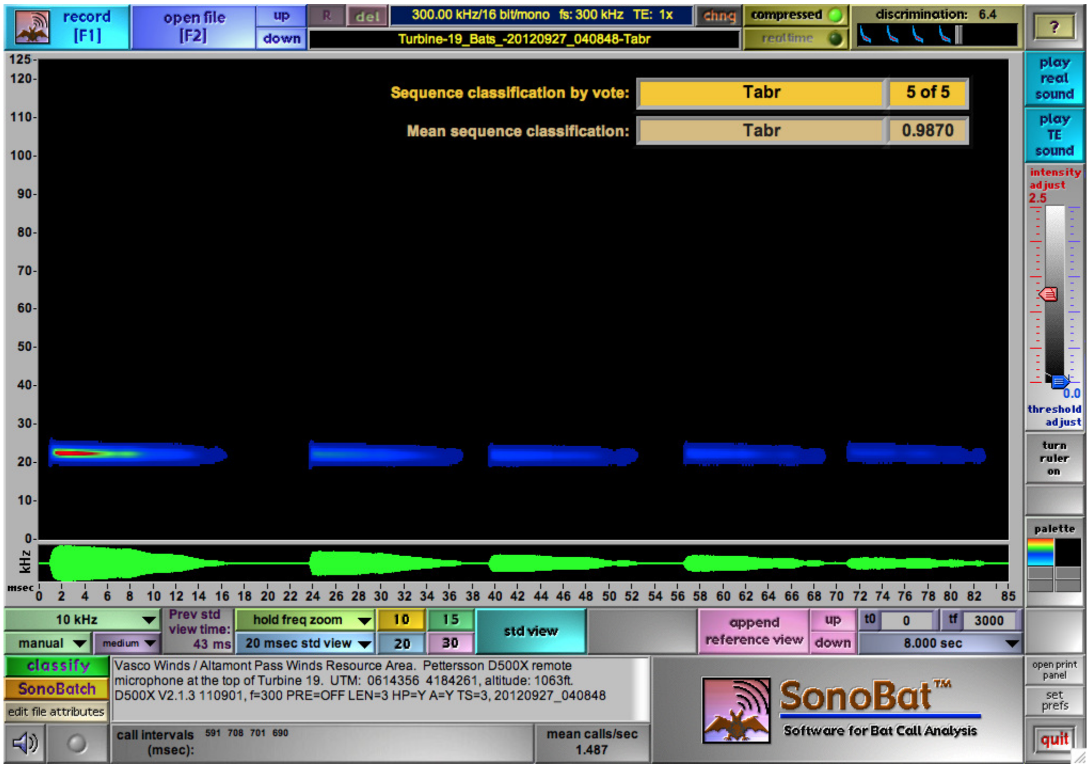
discrimination: 6.4

Vasco Winds / Altamont Pass Winds Resource Area. Pettersson D500X remote microphone at the ground station below Turbine 19, located in a drainage that runs off into Los Vaqueros Reservoir. UTM: 0614497 4184327, altitude: 898ft. D500X V2.1.3 110901, f=300 PRE=OFF LEN=3 HP=Y A=Y TS=3, 20120917_014713

call intervals (msec): 372 341 407 153 776 360 147 282

mean calls/sec 2.819

Hoary bat (*Lasiurus cinereus*).



300.00 kHz/16 bit/mono fs: 300 kHz TE: 1x

Turbine-19_Bats_-20120927_040848-Tabr

discrimination: 6.4

Sequence classification by vote: Tabr 5 of 5

Mean sequence classification: Tabr 0.9870

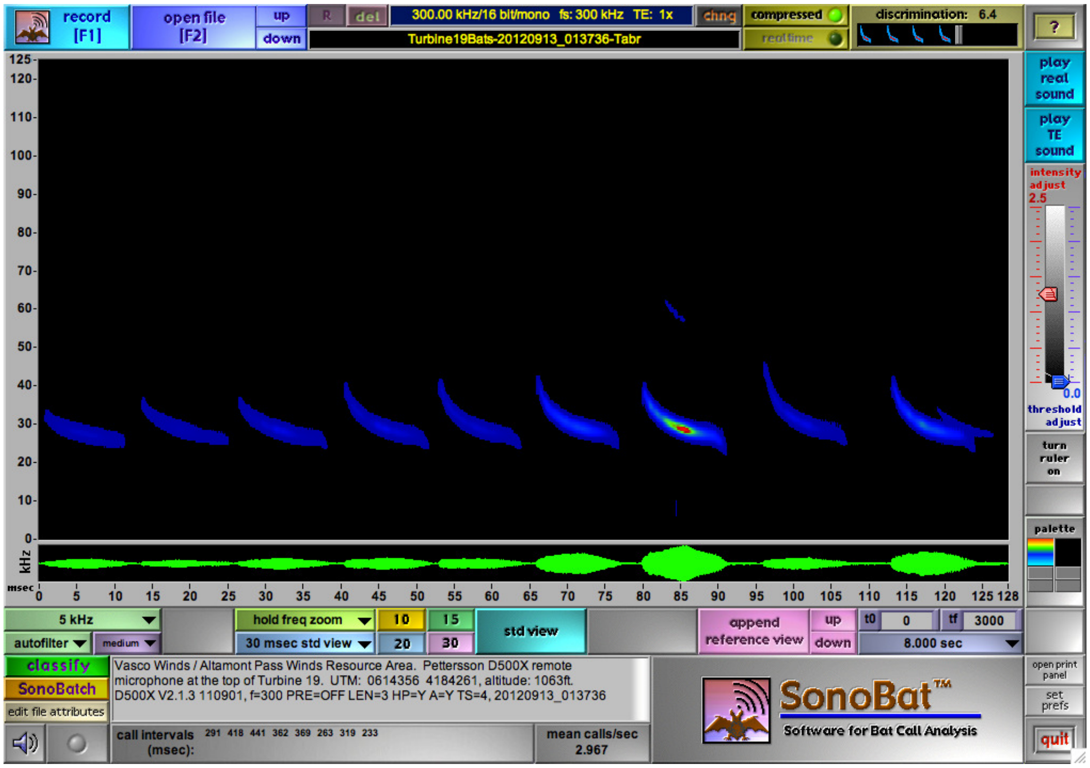
Prev std view time: 43 ms

Vasco Winds / Altamont Pass Winds Resource Area. Pettersson D500X remote microphone at the top of Turbine 19. UTM: 0614356 4184261, altitude: 1063ft. D500X V2.1.3 110901, f=300 PRE=OFF LEN=3 HP=Y A=Y TS=3, 20120927_040848

call intervals (msec): 591 708 701 690

mean calls/sec 1.487

Free-tailed bat (*Tadarida brasiliensis*).



300.00 kHz/16 bit/mono fs: 300 kHz TE: 1x

Turbine19Bats-20120913_013736-Tabr

discrimination: 6.4

5 kHz

autofilter

medium

30 msec std view

t0 0

tf 3000

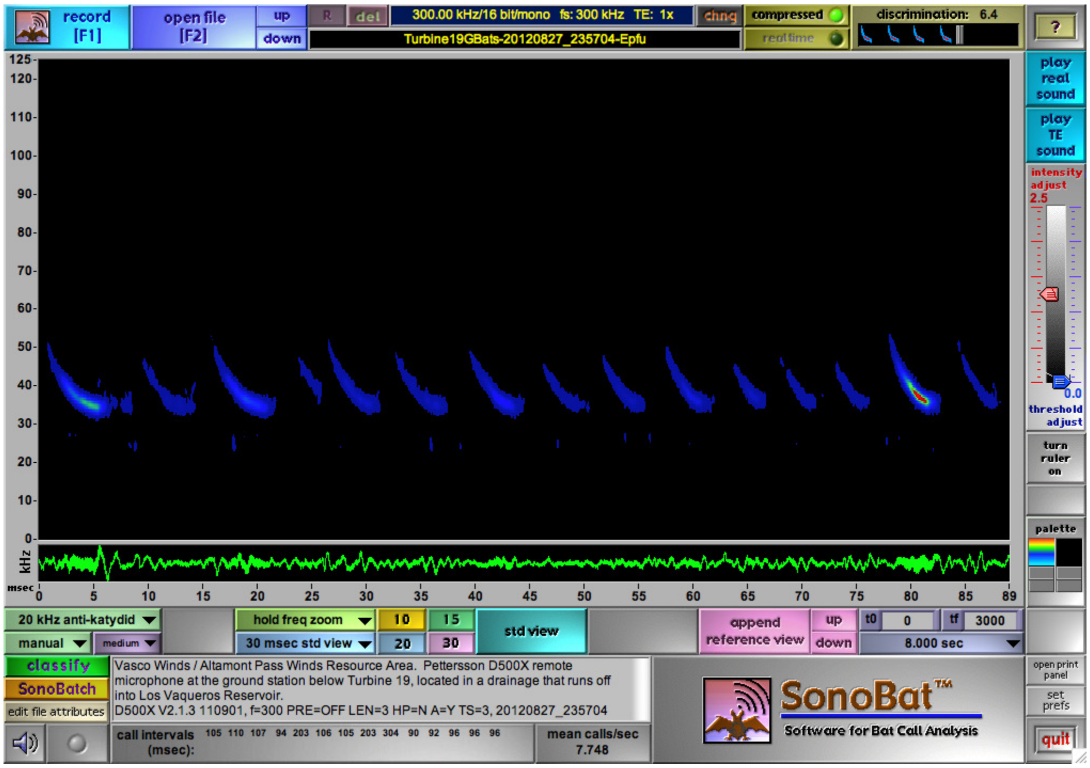
8.000 sec

Vasco Winds / Altamont Pass Winds Resource Area. Pettersson D500X remote microphone at the top of Turbine 19. UTM: 0614356 4184261, altitude: 1063ft.
D500X V2.1.3 110901, f=300 PRE=OFF LEN=3 HP=Y A=Y TS=4, 20120913_013736

call intervals (msec): 291 418 441 362 369 263 319 233

mean calls/sec 2.967

Free-tailed bat (*Tadarida brasiliensis*).



300.00 kHz/16 bit/mono fs: 300 kHz TE: 1x

Turbine19GBats-20120827_235704-Epfu

discrimination: 6.4

20 kHz anti-katydid

manual

medium

30 msec std view

t0 0

tf 3000

8.000 sec

Vasco Winds / Altamont Pass Winds Resource Area. Pettersson D500X remote microphone at the ground station below Turbine 19, located in a drainage that runs off into Los Vaqueros Reservoir.
D500X V2.1.3 110901, f=300 PRE=OFF LEN=3 HP=N A=Y TS=3, 20120827_235704

call intervals (msec): 105 110 107 94 203 106 105 203 304 90 92 96 96 96

mean calls/sec 7.748

Big brown bat (*Eptesicus fuscus*).