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POST-CONSTRUCTION BIRD AND BAT STUDIES at the SHILOH III WIND PROJECT, LLC Solano County, California

Report on Year 1 Results

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Prepared for:

EDF Renewable Energy, Inc.
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Prepared by:
CURRY & KERLINGER, LLC

Paul Kerlinger, Ph.D.
Richard Curry, Ph.D.
Aaron Hasch
John Guarnaccia
Daniel Riser-Espinoza

Curry and Kerlinger, LLC
1734 Susquehannock Drive
McLean, VA. 22101
703-821-1404, fax-703-821-1366
RCA1817@aol.com

Executive Summary

This interim report details the first-year results of a three-year (January 2012-January 2016) study of post-construction bird and bat fatalities and avian use (abundance and behavior) at the Shiloh III Wind Project, LLC (hereafter, Shiloh III). Shiloh III is located in the Montezuma Hills Wind Resource Area (MHWRA) in Solano County, California. Managed and leased by EDF Renewable Energy, Inc., (f.k.a enXco) and operating since December 2011, Shiloh III has 50 wind turbines, each with a nameplate capacity of 2.05 MW.

Standardized carcass searches were conducted weekly beneath 25 turbines of the 50 turbines (50%), and all turbines will be searched, some in more than one year, during the three-year study period. Each turbine was searched out to 105 m. Weekly observations at four observation points (OPs) distributed across the Shiloh III footprint were also conducted to determine abundance and examine how birds were distributed and used the airspace while turbines were operating. In addition, a raptor nesting survey was conducted.

In the first year of the study, a total of 1,300 standardized turbine searches were conducted (52 weekly searches at each of 25 turbines). These searches found 74 carcasses of which 7 (9%) were of bats and 67 (91%) were of birds. Mexican Free-tailed Bat (four carcasses) and Hoary Bat (three carcasses) were the only bat species recorded. Bird fatalities were distributed among 21 species. Forty-seven (70%) of the bird carcasses were landbirds, 19 (28%) were raptors, and one (2%) was a waterbird. Western Meadowlark was by far the most commonly recorded bird species (18 carcasses – 27% of all bird carcasses), followed by American Kestrel (7 carcasses – 10%) and Mourning Dove (5 carcasses – 8%). More than half of the species recorded were represented by one or two carcasses.

Special-status species recorded in Shiloh III searches included four California special-concern species: Loggerhead Shrike (two carcasses), Northern Harrier (one carcass), Yellow Warbler (one carcass), and Savannah Sparrow (four carcasses), but the dates for Yellow Warbler and Savannah Sparrow appear to indicate that the individuals were not from special-concern populations that breed in California.

When adjusted for searcher efficiency (Se) and scavenger removal (Sr), bat mortality at Shiloh III averaged 0.4 bats/MW/year, while bird mortality was about eight times greater, averaging 3.3 birds/MW/year. Adjusted bird mortality was distributed as follows: small birds, 36%; medium birds, 55%; and large birds, 6%. When raptor mortality was considered separately, it was found to be 0.7 raptors/MW/year.

When the rate of fatalities at individual turbines was examined for outliers using Grubb's test, none was found. In other words, there was no evidence that particular turbines killed many more bats or birds than others. When it could be tested statistically, aviation obstruction lighting was found to have no effect on fatalities.

In comparison with the results from other MHWRA wind farms, the first year of study at Shiloh III found that bird mortality – estimated at 3.3 birds/MW/year – was not significantly different from the mean of eight years of estimates at High Winds, Shiloh I, and Shiloh II (4.2 ± 1.3

birds/MW/year; $p = 0.5103$). Bat mortality – estimated at 0.4 bats/MW/year – was significantly lower than the mean of eight years of estimates at those wind farms (3.4 ± 0.5 bats/MW/year; $p = 0.0006$). It should be pointed out, however, that mean mortality at High Winds, Shiloh I, and Shiloh II may be somewhat lower, because year 1 results at Shiloh I were anomalously high, a result of limited Se and Sr testing in that year.

Turbine characteristics may explain the lower bat mortality. At Shiloh III, 24 of the 25 turbines were tall, with the rotor-swept zone (RSZ) beginning at 32.5 m above ground level (agl). The RSZ for the short turbine extended to ~22.5 m agl. At Shiloh II, where the "short-turbine effect" on bat mortality came to light, 42 turbines were tall and 33 were short, allowing an analysis of the height effect. In the western areas of Shiloh II (adjacent to the western areas of Shiloh III), short turbines killed nearly four times as many bats as tall turbines.

In other words, we hypothesize that Mexican Free-tailed Bat and Hoary Bat – the two species most often recorded in mortality monitoring studies in the MHWRA – generally forage below 32.5 m agl. When the RSZ extends lower, collision risk for bats increases. Bat abundance, as measured in the number of carcasses observed under tall turbines in the western areas of Shiloh III relative to the numbers observed in previous years under the same type of turbine in adjacent areas of Shiloh II, was not significantly different between years.

Studies at ridgeline wind farms in Pennsylvania have demonstrated that bat mortality decreases as wind velocity increases above 5.5-6.0 m/s. Thus, greater wind speeds may also explain the lower bat mortality at Shiloh III, but wind data at turbines would need to be analyzed.

There was no indication in the Shiloh III data that mortality was likely to cause a population decrease for any species or potentially reduce the conservation prospects of any special-status species. Bird mortality, for example, was distributed among dozens of species, and the species that were killed most are relatively abundant both continentally and in California. As noted, bat mortality was significantly lower than at other MHWRA wind farms that Curry & Kerlinger has studied.

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Figure 1. Location of the Shiloh III Wind Power Project in the Montezuma Hills Wind Resource Area (MHWRA).

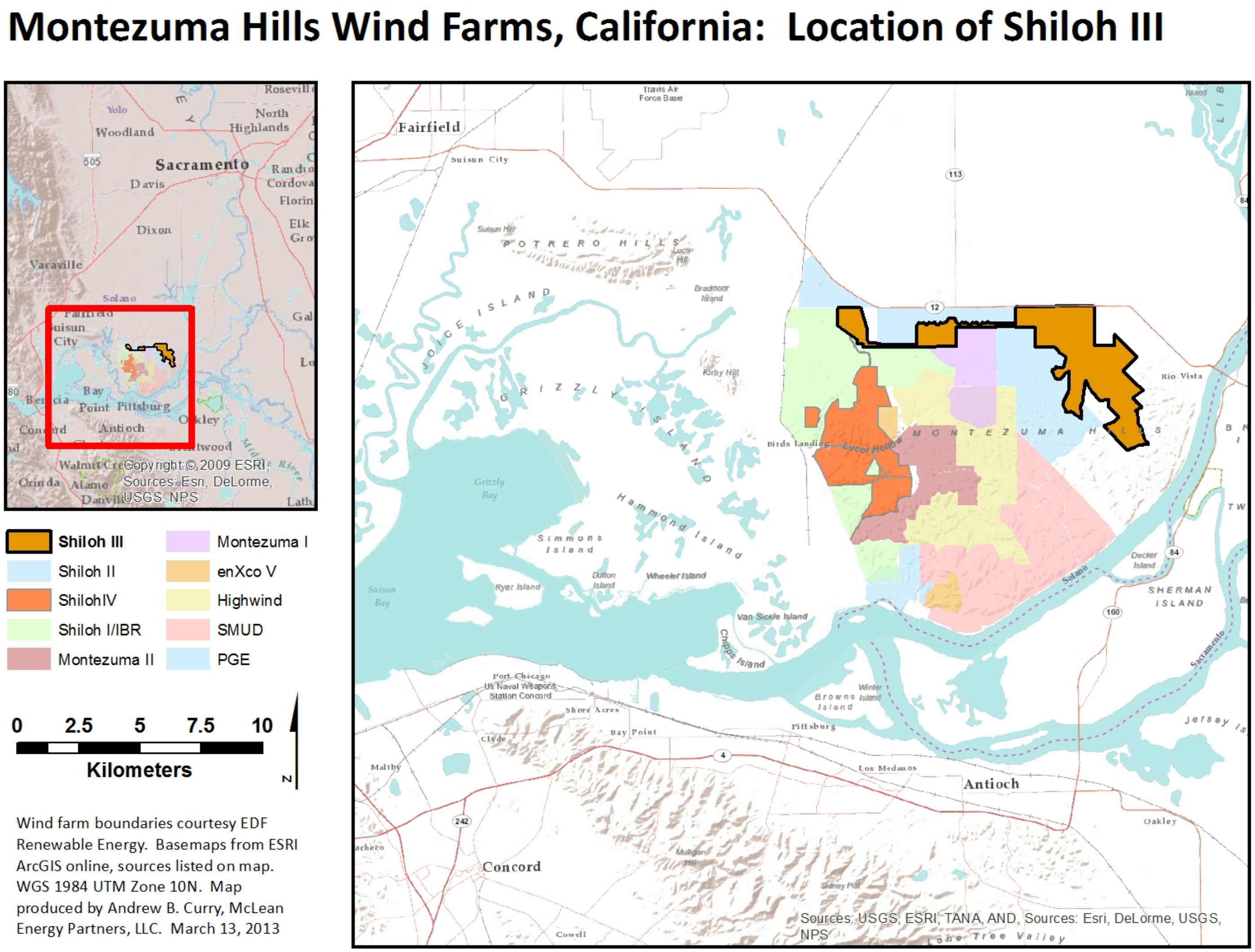
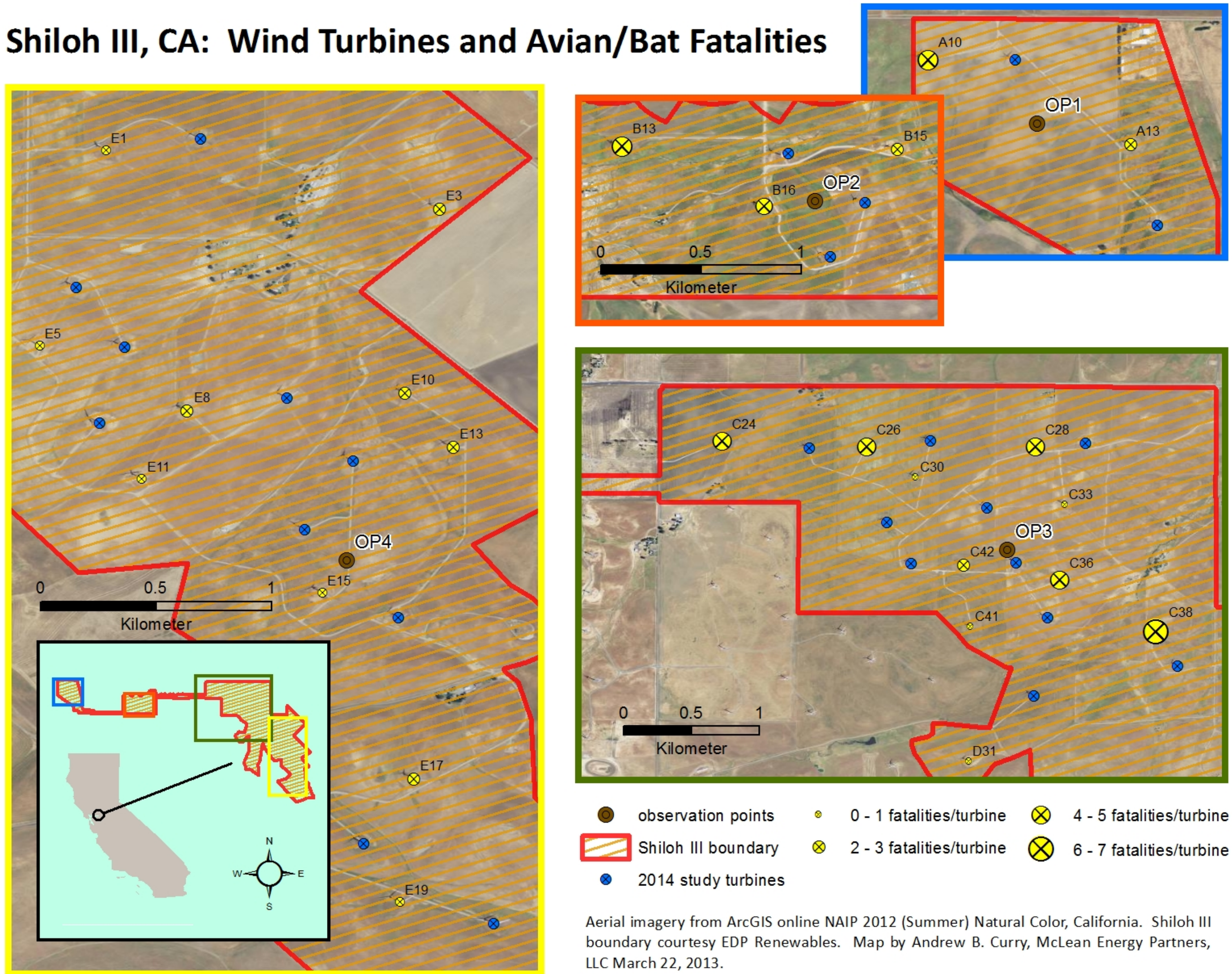


Figure 2. Shiloh III turbine layout with fatalities recorded in searches and observation points (OPs) in avian abundance and use study.



Introduction

This interim report details the first year's results of a three-year (January 2012-January 2016) study of post-construction fatalities and avian use (abundance and behavior) at the Shiloh III Wind Project, LLC (hereafter, Shiloh III). The Shiloh III project is located in the Montezuma Hills Wind Resource Area (MHWRA) in Solano County, California (Fig. 1). Shiloh III is leased, managed and operated by EDF Renewable Energy, Inc. (f.k.a enXco).

Operating wind farms in the MHWRA have been well studied, including pre-construction avian monitoring studies and risk assessments at High Winds (Kerlinger et al. 2001), Shiloh I (Kerlinger et al. 2005), Shiloh II (Kerlinger et al. 2006a), and Shiloh III (Kerlinger et al. 2009a). Post-construction avian and bat fatality monitoring studies, as well as post-construction avian abundance and use studies, have been conducted over two years at High Winds (Kerlinger et al. 2006b), over three years at Shiloh I (Kerlinger et al. 2009b), and over three years at Shiloh II (Kerlinger et al. 2012). Such studies in the MHWRA date back to the late 1980s (Orloff and Flannery 1992, Howell et al. 1988, Jones and Stokes Associates 1987).

The present study at Shiloh III provides additional fatality monitoring and use data, making the MHWRA one of the most thoroughly studied wind resource areas in the United States. In this interim report, we examine the species composition of fatalities, estimate the overall numbers of bird and bat fatalities, examine the incidence of rare species, and quantify the abundance and behavior of birds observed during the study period. We also examine whether individual turbines accounted for disproportionate numbers of fatalities, and whether there were areas within Shiloh III in which fatalities were statistically greater. Finally, we compare the fatalities found at Shiloh III with those found in fatality studies of other MHWRA wind farms and consider the biological significance of the mortality indicated.

Shiloh III dimensions and habitats

As of the end of 2012, 607 wind turbines with a total generating capacity of 1,024 MW were operating in the MHWRA (Solano County Department of Resource Management 2012). Shiloh III represented 50 (~8%) of those turbines and 102.5 MW (~10%) of the total generating capacity. Its turbines began to produce electricity in December 2011.

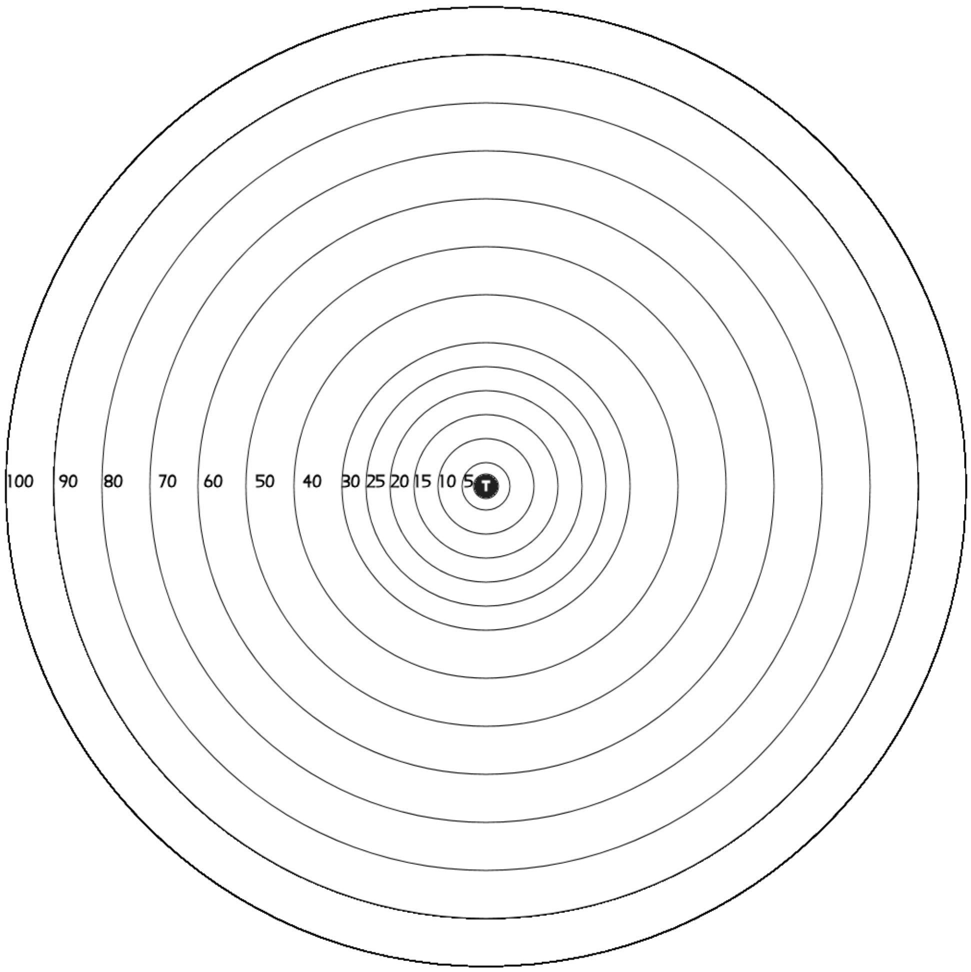
Twenty-five (50%) of Shiloh III's 50 turbines were searched during the first year of the study. These turbines had rotor diameters of 92 m and hub heights of 78.5 m, except for one turbine (A13) that had a hub height of 68.5 m (Appendix A). Thus, the rotor-swept zone (RSZ) of the tall turbines was located at 32.5 to 124.5 m above ground level (agl), while that of the short turbine was located at 22.5 to 114.5 m agl. Eleven (44%) of the 25 turbines had aviation obstruction lighting (Appendix A). Turbines were distributed in five areas (A-E; Fig. 2 and Appendix A).

Topography and land use at Shiloh III are similar to those of other wind farms in the MHWRA, with rolling hills predominating, some reaching about 70 m in elevation above mean sea level. Land use is entirely agricultural. Fields are left fallow and then are grazed by cattle or sheep once crops such as wheat, barley, and hay have been harvested. Other habitats within the project's footprint are minimal by comparison, including eucalyptus groves, patches of native oaks and junipers, and small cattail wetlands. Farms, some abandoned, are found throughout the site. Suisun Marsh, an extensive wetland complex, is located as close as about 4 km west of turbines in area A, and the Sacramento River Deep Water Ship Channel is located as close as about 3 km southeast of turbines in area E (Fig. 1).

Methods

Field methods for fatality monitoring study

Figure 3. Concentric search transects (distance from turbine base in m)



Trained observers were enlisted to search 25 (50%) of the 50 turbines at Shiloh III. They did so in groups of two to four searchers by walking concentric circular transects around the base of each wind turbine. A qualified field biologists and expert in identification of bats and birds, Aaron Hasch directed fieldwork. He trained a number of searchers, who included George Henry, Sam Hill, Phil Jenkins, and Chris Mueller.

The circular transects that searchers walked were 10 m apart from 100 m to 30 m from turbine bases and 5 m apart between 30 m and 5 m from turbine bases (Fig. 3). Searchers used range finders to estimate distances from turbines and recheck them periodically.

When searchers arrived at a turbine, they searched from the outer transects inward. First, they positioned themselves in a line in adjacent transects and walked slowly as they scanned 5 m on each side of their transects for bat and bird carcasses. Thus, search areas extended to 105 m from the turbines. Searchers in outer transects walked somewhat faster than searchers walking transects closer to the turbines, but their pace was slow, allowing a careful search. When outer transects were completed, the group of searchers moved to the next inward set of transects. When they reached transects within 30 m of turbines, the search area on each side of transects was reduced to 2.5 m since those transects were only 5 m apart. This was the same sampling method as employed at Shiloh II. It should be noted that transects were 15 m apart within 30 m of turbines at High Winds and in the first two years of Shiloh I, but at the request of the Technical Advisory Committee, more inner transects were added beginning with the third year of Shiloh I.

The entire search area out to 105 m from a turbine covered 3.5 ha. The total distance of the 13 concentric transects was 3.7 km. It should be noted that all turbine sites were completely searchable; in other words, there was no need to adjust mortality data for partial searches.

When a carcass or injured bat or bird was found, a standardized data-collection protocol was followed. Each carcass was assigned a date and a unique identification number, and its location was recorded two ways: (1) in UTM coordinates using a handheld geographical positioning system (GPS) device, and (2) by distance and bearing from the tower using a rangefinder and compass. The carcass was also photographed as it was found.

Carcasses were then identified to the species level, and age and sex were determined if possible. In all but a very few cases, carcasses were identified to species. The next step was to determine the nature and extent of injuries, and record whether scavenging or insect infestation had occurred and the degree to which carcasses were damaged or consumed. The time elapsed since death was also estimated. In the case of dismemberment, observers searched the vicinity for all body parts. Loose feathers were considered fatalities only if enough feathers were found to represent a dead bird. All loose feathers were collected to avoid counting them again in future searches.

Vegetation cover and its height where carcasses were found were also recorded, as were cover type and height generally within the 105-m search area surrounding a turbine. Vegetation height was categorized as follows: Short, <6 inches; Medium, 6-12 inches; and Tall, >12 inches. The dominant vegetation type and height that was assigned to each tower were those that covered more than 50%. Height differences at search sites were not common, only an issue at four sites (16%) that were bisected by fence lines, where vegetation height differed during a portion of the year. At a few other sites with fence lines, vegetation height did not differ.

In the case of raptors, prey species that were present during searches were noted.

Finally, carcasses were placed in plastic bags labeled with the date, species identification, tower number, and identification number. They were then deposited in a freezer on site for storage in accordance with U.S. Fish and Wildlife Service (FWS) requirements. When carcasses were found outside of standardized searches, such as during clean sweep surveys (see below), during other fieldwork, at other turbines, or when moving between sites, they were processed as above but classified as incidental finds, i.e., carcasses found outside of searches. Data from "incidental" carcasses have been included in this report, but they were not used for estimating total numbers of fatalities because they were not found during scheduled sampling or in many cases within designated search areas.

When an injured animal was found, searchers recorded the same data, categorizing the find as an injured animal. Searchers then captured or restrained the animal in a manner that avoided either further injury to the animal or to searchers. Once the animal was secured, it was transported to a wildlife rehabilitator or veterinarian. The hospital accession number and the final disposition of the animal were recorded on the report form.

Clean sweep surveys were conducted the week before weekly searches commenced at each turbine to be surveyed. Their purpose was to increase the likelihood that all carcasses found during subsequent searches occurred during the study period and not before.

The number of carcasses found beneath towers did not reflect all of the bats and birds that collided with them, because searchers did not find all carcasses and scavengers removed some of them before they could be found[1]. Thus, trials were conducted to estimate searcher efficiency (Se) and scavenger removal (Sr) rates.

A trial consisted of placing a carcass at a predetermined distance and bearing from a specific turbine early in the morning before a scheduled search. A team member, other than the searchers, determined the placement location using a random number table, and all searchers were tested. Trial carcasses were marked with black filament tied to a leg so that the marking did not make the carcass more visible, yet it could be determined upon examination that the find was a trial carcass and not a fatality. All trial carcasses were left in the field for up to 14 days to determine the Sr rate. Trial carcasses were dispersed throughout the wind farm in small numbers so as not to encourage scavenging.

Each trial carcass was used to measure the Se and Sr rates. The first morning's search was the Se trial, graded on whether searchers found the carcass or not. At the end of fieldwork that day, searchers reported results to the field leader. The field leader then checked each carcass that was not found to determine whether it had been missed or whether a scavenger had removed it before the search commenced. If he could not find the carcass, then the trial was thrown out with respect to determining the Se rate, but it was used to calibrate the Sr rate.

Each carcass was then checked daily for up to 14 days to determine if and when it disappeared or could no longer be found. On day 14, all remains of the trial carcass were removed.

[1] Given that all searches covered entire search areas, there was no need to account for partial searches.

Because bats were different in texture, shape, and coloration than small birds, and because large birds were more easily found than smaller birds, trials were conducted with carcasses of bats and different sized birds to determine Se and Sr rates for those categories. Following methods in Kerlinger et al. 2012, size classes for birds were large (e.g., Turkey Vulture, Red-tailed Hawk, and California Gull), medium (e.g., American Kestrel, Mourning Dove, and Western Meadowlark), and small (e.g., Horned Lark, European Starling, and Red-winged Blackbird). In other words, large carcasses exceeded 50 cm in length, small carcasses were less than 25 cm in length, and medium carcasses were in between. There was only one size class for bats: small.

Statistical methods for estimating overall fatalities of birds and bats

Estimates for the total number of tower-related fatalities were based on the searcher efficiency (Se) rate, scavenger removal (Sr) rate, and the observed number of carcasses found during standardized searches. They were calculated with an estimator published by Huso (2011). The average Se, Sr, adjusted fatalities, and corresponding standard error and 95% CI were derived using bootstrapping in R for birds of three size classes (large, medium, and small), as well as for birds of all size classes pooled and for bats (Canty and Ripley 2010, Davidson and Hinkley 1997, R Development Core Team 2010). Five thousand bootstrap iterations were used for each statistic.

The Se rate, expressed as *p*, was the average probability that a searcher would find a carcass during a given search (ratio of carcasses found to the number placed). Sr, the rate of carcass removal by scavengers before they could be detected, was calculated using the mean carcass removal time $\bar{t}$, that is, the average length of time (in days) that a carcass was expected to remain detectable in the search area. $\bar{t}$ was calculated from a maximum likelihood estimator assuming carcass removal times followed an exponential distribution with right-censoring of data (Young et al. 2009). In this study, carcasses were collected once they had been in the field for 14 consecutive days; thus, data were censored at 14 days. The maximum likelihood estimator was

$$\bar{t} = \frac{\sum_{i=1}^{S} t_i}{S - S_c}$$

where S was the number of carcasses placed in Sr trials and S_c was the number of carcasses censored.

The observed number of fatalities, $\bar{c}$, found per turbine per year was

$$\bar{c} = \frac{\sum_{j=1}^{n} c_j}{n \cdot \left(\frac{\mu}{12}\right)}$$

where c_j was the number of fatalities found at the *jth* turbine during weekly searches for the duration of the study period, *n* is the number of turbines, and μ is the length of the study period in months.

The final fatality estimate, $\bar{m}$, was found by dividing the observed number of fatalities, $\bar{c}$, by $\hat{r}$, p, and $\hat{v}$; these were factors that accounted for the probability of carcass persistence, probability of detection given persistence (i.e., *p*, as above), and the effective search interval, respectively (Huso 2011). Thus,

$$\bar{m} = \frac{\sum_{j=1}^{n} c_j}{\hat{r} \cdot p \cdot \hat{v}}$$

where

$$\hat{r} = \frac{\bar{t}\left(1 - exp\left(-min(\tilde{I}, I)/\bar{t}\right)\right)}{min(\tilde{I}, I)},$$

$$\hat{v} = \min\left(1, (\tilde{I}/I)\right),$$

$$\tilde{I} = -\log(0.01) \cdot \bar{t},$$

and I =7 since towers were searched weekly. $\bar{m}$, standard error, and the 95% CI were calculated by bootstrapping $\bar{c}$ 5000 times and applying the persistence, detection, and effective interval adjustment factors.

In previous reports that Kerlinger et al. (2006b, 2009b) have issued for post-construction studies in the MHWRA, a different estimator, one developed by Jain, was used. For details on that estimator, see those reports. Given that the Huso (2011) estimator is now most widely used in studies of this nature, we feature it here. When the two estimators were compared using the Shiloh II data (Kerlinger et al. 2012), it showed that there was no statistical difference in mean fatality rates, but with narrower 95% confidence intervals, the Huso estimate appeared to be more precise.

Means are reported with Standard Errors (mean ± SE), except when data were bootstrapped, when they are reported with 95% confidence intervals. This is because the bootstrap confidence interval is not centered on the mean, but takes into account some of the skew of the empirical distribution generated by the bootstrap procedure.

Avian abundance and behavior study

This study examined how birds were distributed and used the airspace at Shiloh III while turbines were operating. It also allowed comparison with pre-construction data to examine if any differences in abundance and use could be detected.

Four observation points (OPs) were selected to survey the Shiloh III site during the post-construction period (Fig. 2). They were located on hilltops in agricultural land and allowed good visibility out to 1.6 km. They were distributed in areas A (OP1), B (OP2), C (OP3), and E (OP4).

Observations were conducted twice weekly during August-November and March-June and once weekly during July and December-February. In the first year of the study, 91 rounds of observations were conducted.

On a normal day, observations began at about 8:00 and ended at about 15:00, a time span chosen because it corresponded to the hours when raptors were most active. Thirty minutes of observation were conducted at each point, and an equal amount of time was allotted for the observer to move between points. Thus, on a normal observation day, three hours of observations were conducted. If visibility decreased to less than 1.6 km because of precipitation, then the round of observations was completed on the next day after visibility had improved. The sampling order of OPs was also rotated so that each OP was sampled at different hours of the day.

An observation period began with recording weather conditions, such as temperature, wind velocity and direction, percent cloud cover, precipitation if any, and distance of visibility. Then, the observer scanned the observation area with naked eye and binoculars. When one or more birds were seen, he recorded the following information:

- Species
- Number of individuals
- Start and stop time when bird(s) were observed
- Age of bird(s) if it could be determined (e.g., adult, subadult, and immature)
- Flight height relative to the rotor swept zone (RSZ), namely, low (below the RSZ, 0-30 m in altitude above the ground), medium (at an altitude equivalent to the RSZ, 30-120 m), and high (above the RSZ, >120 m). Nearby wind turbines helped to gauge flight height.
- Direction of flight
- Flight behavior (e.g., soaring, hunting, etc.)

Raptor nesting study

Searches were conducted during the raptor-nesting season to locate raptor nests. Trees, groves, and abandoned buildings were checked in May, and a special effort was made to check the status of nests that had been found in 2007, during pre-construction surveys. Care was taken not to disturb nesting raptors, so most observations were made from a distance. Particular attention was given to behaviors that indicated nesting, such as birds soaring together in pairs, territorial displays, birds with nesting material, copulations, birds carrying food, etc. When those behaviors were noted, nearby trees and groves were examined more closely.

Throughout this report, special-status species are highlighted or indicated when they appear in the text or tables. In order of priority, these are California threatened and endangered (T&E) species (CDFG 2009), California Bird Species of Special Concern (SSC, Shuford and Gardali 2008, CDFG 2011), and species that CDFG lists as Fully Protected (CDFG 2011). There were no federally listed T&E species observed on this site.

Results

Fatality monitoring study

Observed fatalities

A total of 1,300 scheduled turbine searches were conducted during first year of the study, plus 25 clean sweep searches (Appendices A and B). A total of 235 field days were invested (Appendix B, Table 1). The average turbine search involving 2-4 searchers took 69.5 minutes.

In year 1, 74 carcasses were found during standardized searches (Appendix B, Table 2) and three as incidental finds (Appendix B, Table 3). No carcasses were found in clean-sweep searches, which were conducted on 16-18 January 2012, the week before standardized searches commenced.

Of the 74 carcasses found in standardized searches, seven (9%) were of bats (Table 1) and 67 (91%) were of birds (Table 2).

Two bat species were recorded: Mexican Free-tailed Bat and Hoary Bat (Table 1). One bat fatality was recorded in each of the following months: February, April, May, June, August, September, and October (Appendix B, Table 2).

Table 1. Bats carcasses recorded during standardized searches

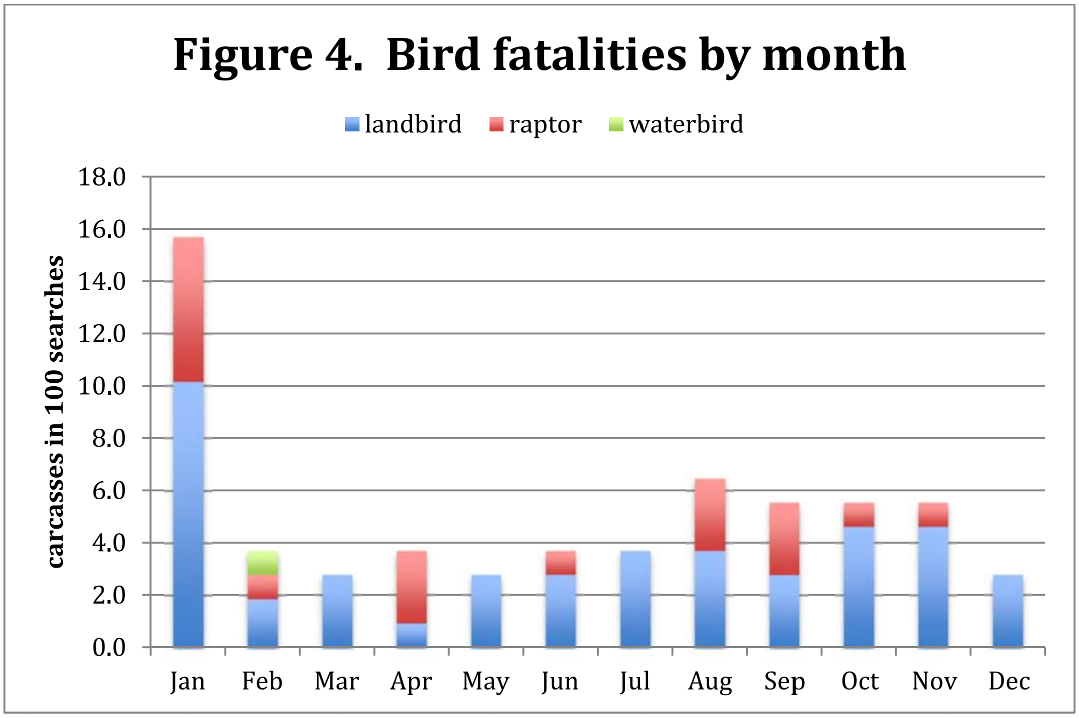
Species	N	Rate per 100 searches
Mexican Free-tailed Bat	4	0.3
Hoary Bat	3	0.2
2 species	7	0.5

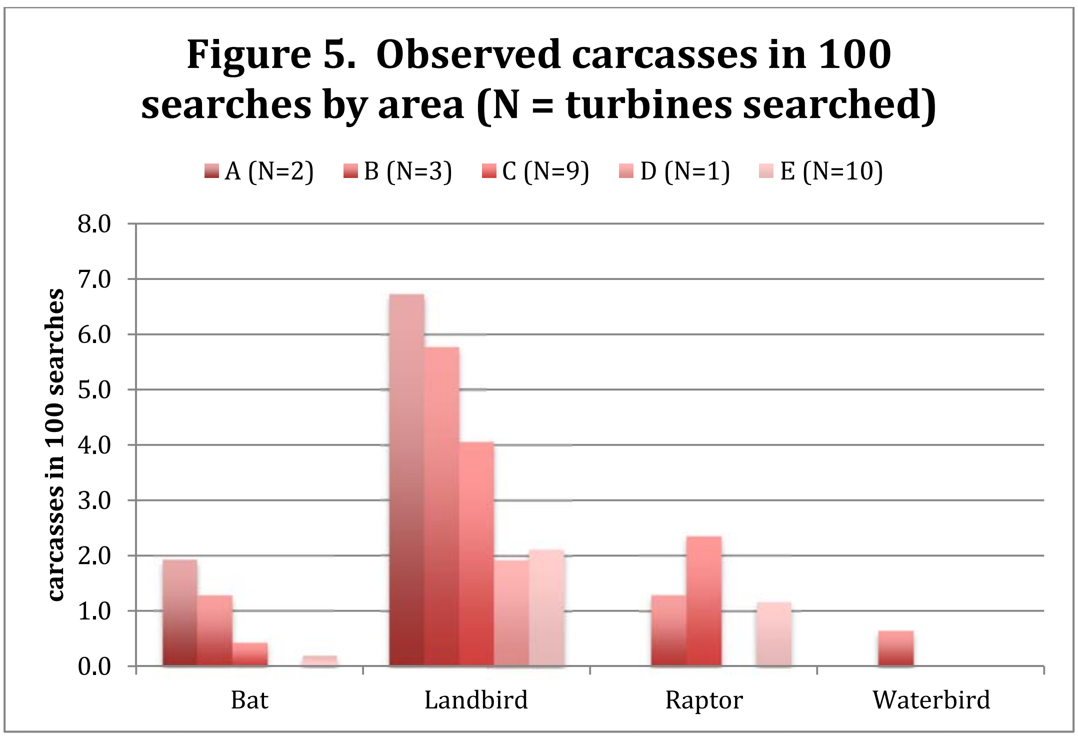
The 67 bird carcasses recorded during standardized searches were distributed among 21 species (Table 2). Of those carcasses, 47 (70%) were landbirds, 19 (28%) were raptors, and 1 (2%) was a waterbird. Western Meadowlark was by far the most commonly recorded species (18 carcasses), followed by American Kestrel (7 carcasses) and Mourning Dove (5 carcasses). More than half of the species recorded were represented by one or two carcasses (Table 2).

Bird fatalities were recorded in every month of the year, but the fatality rate peaked in January, when it was more than double that of the second highest month (Fig. 4). The fatality rate in August-November was slightly greater than that in February-July (Fig. 4).

Table 2. Bird carcasses recorded during standardized searches

Species	Class	N	Rate per 100 searches
Western Meadowlark	Landbird	18	1.4
Mourning Dove	Landbird	5	0.4
Brewer's Blackbird	Landbird	4	0.3
Red-winged Blackbird	Landbird	4	0.3
Savannah Sparrow	Landbird	4	0.3
Cliff Swallow	Landbird	2	0.2
European Starling	Landbird	2	0.2
Loggerhead Shrike (CA Special Concern)	Landbird	2	0.2
Rock Pigeon	Landbird	2	0.2
American Goldfinch	Landbird	1	0.1
Common Raven	Landbird	1	0.1
Horned Lark	Landbird	1	0.1
Yellow Warbler	Landbird	1	0.1
13 species		47	3.6
American Kestrel	Raptor	7	0.5
Red-tailed Hawk	Raptor	4	0.3
Barn Owl	Raptor	3	0.2
Turkey Vulture	Raptor	2	0.2
Great Horned Owl	Raptor	1	0.1
Northern Harrier (CA Special Concern)	Raptor	1	0.1
Rough-legged Hawk	Raptor	1	0.1
7 species		19	1.5
American Coot	Waterbird	1	0.1
1 species		1	0.1
21 species		67	5.2





In bats and landbirds, there appeared to be a gradient of decreasing fatalities from area A in the west to area E in the east (Fig. 5). This may have been related to the proximity of the Suisun marsh complex to the westernmost areas.

When the rate of fatalities at individual turbines was examined for outliers using Grubb's test, none was found at 0.05 significance. In other words, there was no evidence that any particular turbine killed significantly more bats or birds than others. For bats, mean observed mortality at 25 turbines during the study period was 0.28 ± 0.11 bats per turbine (median of 0). For raptors, it was 0.76 ± 0.23 raptors per turbine (median of 0). And for all birds, it was 2.68 ± 0.41 birds (median of 2).

Concerns have been raised that aviation obstruction lighting, which flashes visibly at night, may attract night-migrating songbirds or insects on which bats feed. Such attraction would increase fatality rates. Nonetheless, in a review of fatality monitoring studies at 30 wind farms across North American, Kerlinger et al. (2010) found that night-migrating songbirds were not attracted to flashing lights on wind turbines. In a review of bat mortality studies in North America, Kunz et al. (2007) found that preliminary evidence suggested that bats were not attracted to the lighting attached to wind turbines.

In the case of Shiloh III, the two carcasses of night-migrating songbirds (Yellow Warbler and Savannah Sparrow found during the months of fall migration) constituted too small a sample to analyze. Of the seven bat carcasses found, three were at the 11 lighted turbines and four were at the 14 unlighted turbines. This difference was not statistically significant (p = 0.9514).

At Shiloh II (Kerlinger et al. 2012), bat fatality was found to be greater at short turbines, which had the rotor-swept zone (RSZ) 10 m closer to ground level. This could not be tested at Shiloh III because there was only one short turbine, and the sample of bat fatalities was too small.

Fatalities of special-status species

With respect to endangered, threatened, special-concern, and other special-status species, carcasses of the following species were found during the first year of study:

- **Loggerhead Shrike,** listed as California Special Concern (Shuford and Gardali 2008), was recorded twice in searches, in October-November 2012.
- **Northern Harrier**, listed as California Special Concern (Shuford and Gardali 2008), was recorded once in searches, on 4/9/12. This raptor was known to nest locally (see Raptor Nesting Study)
- **Yellow Warbler**, listed as California Special Concern (Shuford and Gardali 2008), was recorded once on 9/12/13. Given that the date coincides with fall migration, we believe the bird was migrant from a northern population, not a local nester from a California special-concern population.
- **Savannah Sparrow**, listed as California Special Concern (Shuford and Gardali 2008), was recorded four times, in fall and winter months. Those individuals were likely migrants and wintering birds from northern populations, not local nesters from a California special-concern population.

Adjusted fatalities

During the first year of the study, 59 carcasses were distributed within the study area for searcher efficiency (Se) and scavenger removal (Sr) trials (Table 3 and Appendix C). There were no instances in which scavengers removed carcasses before searchers could search for them. In those instances, those carcasses would have been thrown out as Se trials (see Methods), but they would have been maintained as Sr trials (with persistence recorded as zero days).

Table 3. Searcher efficiency (Se) and scavenger removal (Sr) rates by taxa and size (mean and 95% CI)

Category	# Se trials	mean efficiency	# Sr trials	mean persistence (days)
Bats (all small)	21	0.57 (0.38, 0.76)	21	6.1 (4.1, 8.3)
Small birds	17	0.58 (0.29, 0.76)	17	5.5 (3.3, 7.9)
Medium birds	12	0.58 (0.33, 0.83)	12	8.1 (5.6, 10.5)
Large birds	9	1.00 (1.00, 1.00)	9	13.8 (12.9, 14.0)
	59		59	

Se rates ranged from slightly less than 60% for bats and small and medium birds to 100% for large birds (Table 3). Scavengers removed bats and small bird carcasses at about 6 days on average, but large bird carcasses were much more persistent, averaging nearly 14 days in tests that were terminated at 14 days (see Methods).

Table 4. Adjusted mortality (mean and 95% CI) for bats and different size classes of birds

Group	# carcasses	per MW	per turbine	All turbines
Bats	7	0.4 (0.3, 0.7)	0.8 (0.5, 1.5)	41 (27, 77)
Small birds	21	1.2 (0.8, 3.4)	2.5 (1.7, 6.9)	127 (83, 345)
Medium birds	36	1.8 (1.2, 3.7)	3.7 (2.4, 7.6)	185 (118, 379)
Large birds	10	0.2 (0.2, 0.3)	0.5 (0.5, 0.5)	26 (25, 26)
All birds	74	3.3 (2.2, 7.3)	6.7 (4.5, 15.0)	337 (226, 750)

Se/Sr data from year 1 of this study were used to calculate adjusted mortality at Shiloh III (Table 4). Bat mortality averaged 0.4 bats/MW/year, while bird mortality was over eight times greater, averaging 3.3 birds/MW/year. Adjusted bird mortality was distributed as follows: small birds, 36%; medium birds, 55%; and large birds, 6%.

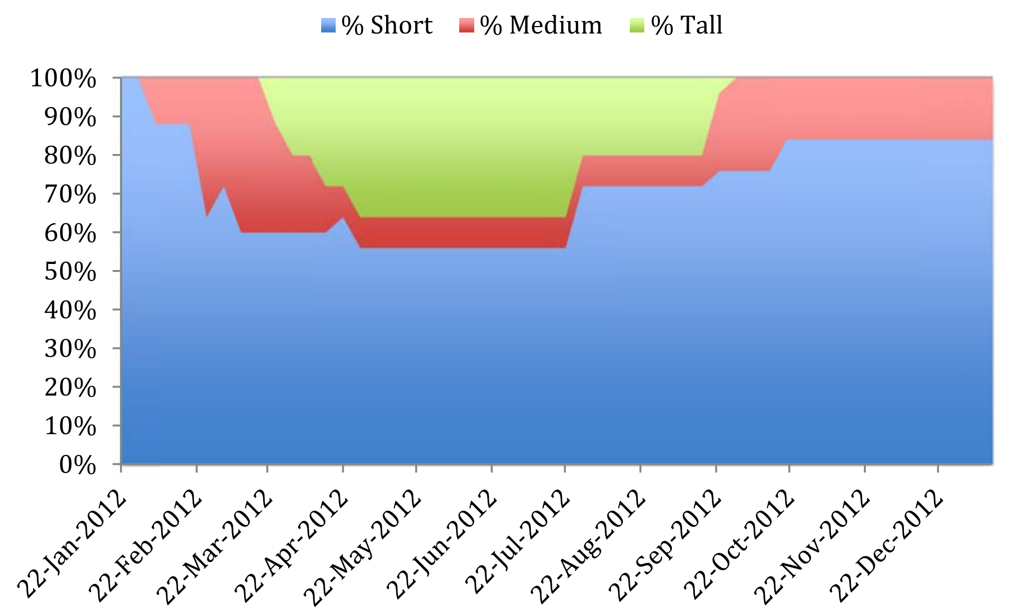
When all 50 turbines at Shiloh III were considered, bat mortality slightly more than 40 bats per year, while bird mortality averaged nearly 340 birds per year (Table 4).

Table 5. Adjusted mortality (mean and 95% CI) for raptors

Group	# carcasses	per MW	per turbine	All turbines
Year 1	19	0.7 (0.5, 1.3)	1.5 (1.1, 2.6)	74 (56, 128)

Of the 19 raptor carcasses found during searches, 10 were medium and size and nine were large in size (Appendix B, Table 2). When raptor mortality was calculated based on this size distribution, it was found to be 0.7 birds/MW/year, or 74 raptors at Shiloh III's 50 turbines (Table 5).

Figure 6. Phenology of vegetation height at Shiloh III



When each turbine was searched, the dominant vegetation height was assessed as short, medium, or tall. When the weekly percentages of turbines with short, medium, and tall vegetation were plotted, short vegetation was found to predominate, generally exceeding 60% of turbines each week (Fig. 6). Tall vegetation was only recorded between 25 March and 23 September 2012. Mean weekly percentages were 71.6% ± 1.8% for short vegetation, 14.2% ± 1.2% for medium vegetation, and 14.2% ± 2.1% for tall vegetation.

We assessed vegetation height because it affected Se and Sr rates in some cases (Table 6). With respect to searcher efficiency (Se), searchers were 46%-63% less efficient at finding test carcasses of bats and small and medium birds in taller vegetation, but they were able to find all large bird carcasses irrespective of vegetation height.

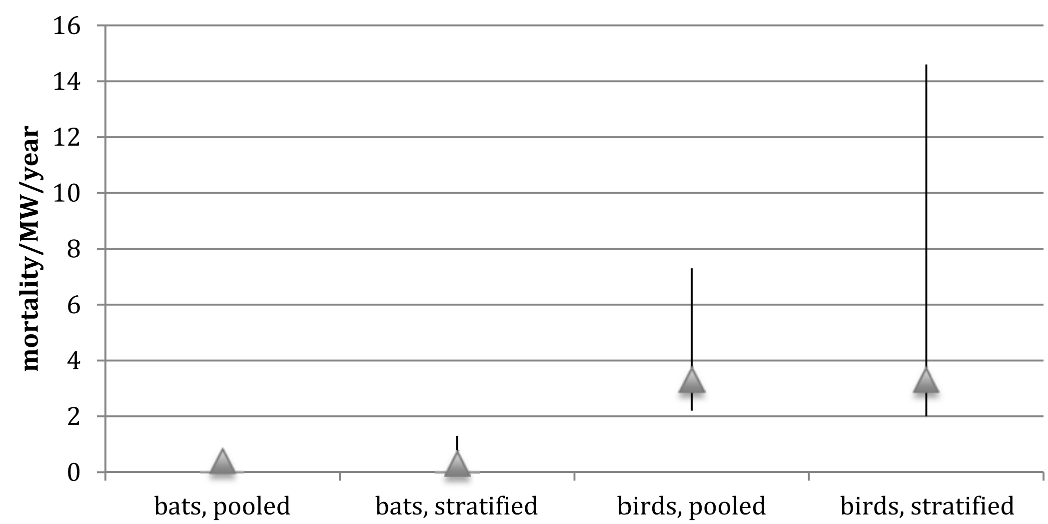
With respect to scavenger removal (Sr), the number of days that test carcasses persisted in taller vegetation decreased slightly for large birds and decreased 36%-41% for bats and medium birds (Table 6). For small birds, however, carcass persistence nearly doubled in taller vegetation. The data are confusing with respect to scavenger removal. Much larger samples are probably required to attempt to explain a relationship between scavenger removal rates and vegetation height, if a relationship indeed exists.

Table 6. Effect of vegetation height on Se and Sr

Vegetation height	Carcass size	N	Se	Se % change	Sr	Sr % change
short	bat	11	0.8 (0.4, 0.9)		7.4 (4.4, 10.3)	
short	small	9	0.8 (0.2, 0.9)		3.8 (0.9, 7.3)	
short	medium	5	0.8 (0.4, 1.0)		10.6 (7.4, 13.6)	
short	large	5	1.0 (1.0, 1.0)		14 .0 (14.0, 14.0)	
medium/tall	bat	10	0.3 (0.1, 0.5)	-63% ($p <0.0001$)	4.7 (2.3, 7.5)	-36% ($p = 0.0004$)
medium/tall	small	8	0.4 (0.1, 0.8)	-52% ($p < 0.0001$)	7.4 (4.9, 12.5)	95% ($p = 0.0003$)
medium/tall	medium	7	0.4 (0.1, 0.9)	-46% ($p = 0.0062$)	6.3 (3.4, 9.7)	-41% ($p = 0.0009$)
medium/tall	large	4	1.0 (1.0, 1.0)	0%	13.5 (12.5, 14.0)	-4% ($p = 0.0330$)
		59				

Estimated mortality reported above (Table 4) was calculated by pooling vegetation-height data, which effectively averaged out the variation due to vegetation height. When estimated mortality was calculated by stratifying vegetation-height data (i.e., when carcasses found in short vegetation were calculated separately from those found in medium/tall vegetation), mean mortality essentially did not change, but confidence intervals were much broader (Fig. 7).

Figure 7. Comparison of adjusted mortality (mean and 95% CI) with data pooled or stratified by vegetation height



It should be noted that, to calculate adjusted mortality (Table 4), we pooled all Se and Sr trials, not taking into account differences in vegetation height. However, as noted above, 71.6% of turbine searches were classified as having been conducted in short vegetation, yet only 50.8% of Se and Sr trials were conducted in short vegetation (Table 6). In short vegetation, the Se rate for bats, small birds, and medium birds was 0.8 (Table 6), but in medium/tall vegetation, it was about half that rate. Vegetation height had a questionable effect on the Sr rate. Thus, if we were to apply the Se averages to the proportion of turbine searches in different vegetation height classes, our pooled adjusted mortality estimate would decrease by a small amount. Nonetheless, there are statistical considerations. As noted (Fig. 7), introducing vegetation height as a variable spreads the confidence intervals. In years 2 and 3, we will attempt to improve our sampling so that pooling the results better matches the different vegetation height classes present.

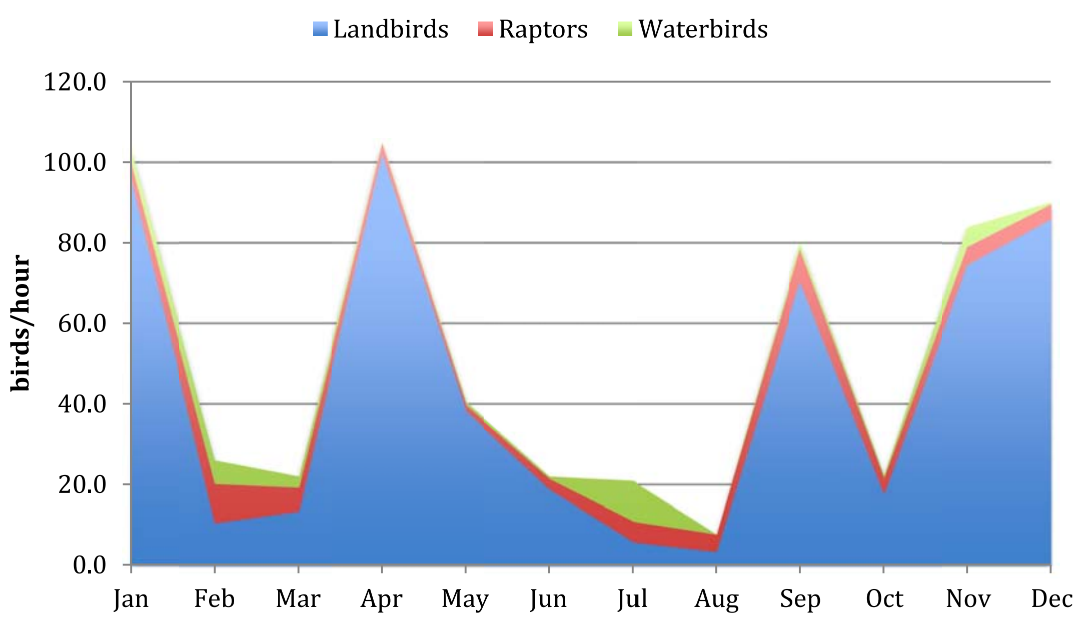
Avian abundance and behavior study

Abundance and flight behavior of raptors, landbirds, and waterbirds were measured at four observation points (OPs) distributed throughout the Shiloh III area (Fig. 2). In the first year of this study, 182 hours of observation were conducted, or 45.5 hours at each OP.

A total of 9,138 individual birds of 45 species of birds were recorded. This represented an overall avian abundance of 50.2 birds/hour (Table 7). Blackbirds (icterids), including Western Meadowlark, Red-winged Blackbird, Brewer's Blackbird, and mixed blackbird flocks (i.e., flocks composed of more than one species of blackbird) made up 66% of the overall abundance.

Red-tailed Hawk (1.49 birds/hour) was the most abundant raptor, followed by Turkey Vulture (1.30 birds/hour), American Kestrel (0.85 birds/hour), and Northern Harrier (CA Special Concern; 0.46 birds/hour). All other raptors were relatively scarce (recorded at <0.10 birds/hour), including the California-threatened Swainson's Hawk (0.05 birds/hour), special-concern Burrowing Owl (0.01 birds/hour), and Golden Eagle (0.09 birds/hour) and White-tailed Kite (0.07 birds/hour), both of which are California Special Animals.

Figure 8. Avian abundance (birds/hour) by month and class



Landbirds were the most abundant class of birds, making up 87% of all individuals recorded, versus 9% for raptors and 4% for waterbirds. When monthly abundances were plotted (Fig. 8), there were three peaks when abundance exceeded 80 birds/hour, in April, September, and November-January. These peaks represented the months during which large numbers of blackbirds were present at the site. Avian abundance was least (<25 birds/hour) in February-March and June-August.

Table 7. Avian abundance (birds/hour) at Shiloh III OPs in year 1

Species[1]	**OP1**	**OP2**	**OP3**	**OP4**	**Overall abundance**
Mixed blackbirds	43.25	18.02	25.23	12.04	24.64
Western Meadowlark	7.25	2.51	2.73	1.91	3.60
Red-winged Blackbird	4.75	3.56	2.37	1.67	3.09
Brewer's Blackbird	1.98	1.36	2.00	1.80	1.79
American Goldfinch	4.44	1.76			1.55
Horned Lark	0.44	0.70	0.31	4.73	1.54
Red-tailed Hawk	1.23	2.15	1.12	1.45	1.49
Cliff Swallow	0.09	2.68	2.11	0.75	1.41
Turkey Vulture	0.99	1.21	1.19	1.82	1.30
Savannah Sparrow	1.10	0.44		2.77	1.08
American Pipit	0.62	1.41	1.32	0.88	1.05
American Kestrel	1.01	0.62	0.88	0.88	0.85
Rock Pigeon	0.86	0.53	1.54		0.73
Killdeer	0.13	0.04	1.58	1.14	0.73
Common Raven	0.70	1.14	0.48	0.42	0.69
American White Pelican (CA Special Concern)	0.26	0.00		1.98	0.56
Snow Goose	0.00	2.20			0.55
House Finch	1.58	0.26			0.46
Northern Harrier (CA Special Concern)	0.48	0.84	0.35	0.18	0.46
Loggerhead Shrike (CA Special Concern)	0.62	0.57	0.44	0.11	0.43
Tree Swallow			1.32	0.22	0.38
Barn Swallow	0.26	0.88	0.13		0.32
Mourning Dove	0.20	0.44	0.09	0.13	0.21
American Crow	0.53	0.04	0.00	0.04	0.15
Mallard		0.02	0.59		0.15
European Starling				0.57	0.14
Unidentified gull			0.57		0.14
White-crowned Sparrow		0.40			0.10
Golden Eagle (CDFG Fully Protected)	0.11	0.18	0.04	0.02	0.09
Dark-eyed Junco		0.31			0.08
White-tailed Kite (CDFG Fully Protected)	0.04	0.18	0.02	0.02	0.07
Ring-necked Pheasant		0.18	0.02		0.05
Say's Phoebe		0.07		0.13	0.05
Swainson's Hawk (CA Threatened)	0.04	0.09	0.04	0.02	0.05
Prairie Falcon	0.04	0.04		0.07	0.04
Great Egret	0.04		0.02	0.07	0.03
Northern Flicker		0.09		0.04	0.03
Yellow-rumped Warbler			0.13		0.03
Great Horned Owl		0.09			0.02
Canada Goose			0.07		0.02
Burrowing Owl (CA Special Concern)	0.02			0.02	0.01

Rough-legged Hawk	0.02		0.02		0.01
Red-shouldered Hawk		0.02	0.02		0.01
Western Kingbird	0.04				0.01
American Robin	0.02				0.01
Northern Mockingbird				0.02	0.01
45 species	**73.16**	**45.01**	**46.75**	**35.91**	**50.21**

[1] Special-status species are designated in boldface.

OP locations sampled avian abundance across Shiloh III, from area A in the west (OP1) to area E in the east (OP4). When abundance was plotted by area (Fig. 9), there appeared to be a pattern of decreasing abundance from west to east. Most of the difference, however, was attributable to landbirds, which, as noted above, were mostly blackbirds (icterids).

The overall abundance pattern for landbirds resembled the fatality distribution (Fig. 5) in that both decreased from west to east. When this was examined in a linear regression, overall abundance explained nearly two-thirds of the observed fatality, but the observed relationship may have been a coincidence (R^2 = 0.6436, p = 0.1978). For raptors, overall abundance explained very little of the fatality pattern, and that pattern was likely a coincidence (R^2 = 0.0141, p = 0.8812).

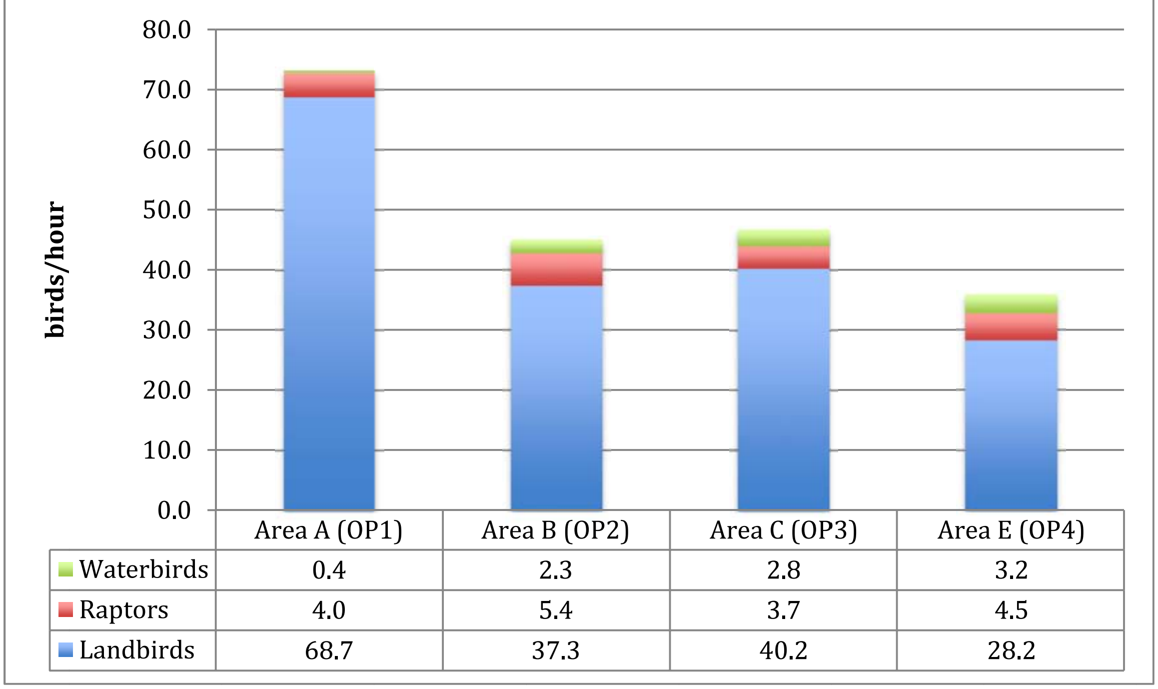


Figure 9. Avian abundance by area

Prey species observations were recorded when they occurred during searches (Table 7A). There were 27 observations in total. Excluding Area D, where abundance and use was not measured, the correlation in a linear regression between prey observations per turbine and raptor use in the different areas (Table 7B) was not strong (R^2 = 0.62706, p = 0.20813), while that between prey observations per turbine and raptor fatalities per turbine in the different areas (Table B) was weak (R^2 = 0.24272, p = 0.50734).

Table 8. Raptor prey species recorded during year 1 searches at Shiloh III

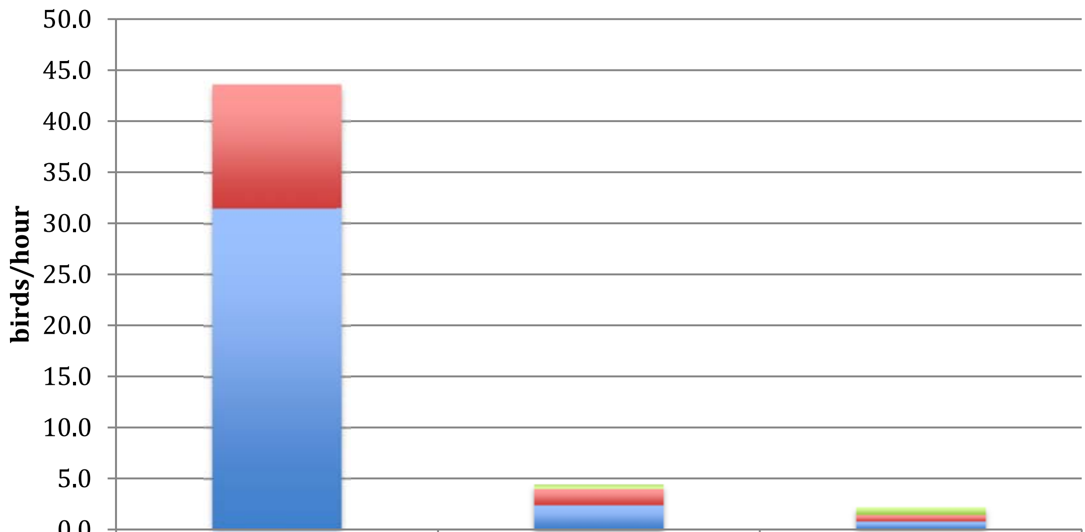
Area (# turbines)	Black-tailed Jackrabbit	Domestic Cat	Gopher Snake	Western Racer	Alligator Lizard
A (2)	3		1		
B (3)	6	1	1	1	
C (9)	2		2		
D (1)					
E (10)	7		1		2
	18	1	5	1	2

Table 9. Comparison of prey observations with observed fatalities and raptor use

Area (# turbines)	Prey observations per turbine	Observed raptor fatalities per turbine	Raptor use recorded (birds/hour)
A (2)	2.0	0.0	4.0
B (3)	3.0	0.7	5.4
C (9)	0.4	1.2	3.7
D (1)	0.0	0.0	N/A
E (10)	1.0	0.6	4.5
	1.1	0.8	4.5

Area B had the greatest recorded raptor abundance of all areas (Fig. 9). Aaron Hasch, who manages the study for Curry & Kerlinger, believes that the principal difference is that Area B is all pasture, most of which is continuously grazed. In his experience, which dates back to 2003, this is one of the few areas in the MHWRA that has never been used for anything other than grazing. He believes that the greater raptor activity recorded may be the result of easier foraging, as the overall vegetation is short.

Figure 10. Flight height by avian class



	Landbirds	Raptors	Waterbirds
H	0.0	0.4	0.8
M	12.1	1.6	0.6
L	31.5	2.4	0.8

Many more landbirds were observed using the Shiloh III airspace in one of the three height classes than raptors or waterbirds (Fig. 10). Overall, landbirds were recorded in flight at a rate of 43.6 birds/hour, compared with 4.4 birds/hour for raptors, and 2.2 birds/hour for waterbirds. The proportion of each flying at altitudes equivalent to the rotor-swept zone (RSZ; i.e., M height) was 28% for landbirds, 36% for raptors, and 27% for waterbirds.

Six special-status species were recorded in the abundance and use study (Table 8). One was listed as threatened in California (CDFG 2009): Swainson's Hawk. Four were California Special Concern (Shuford and Gardali 2008): American White Pelican, Northern Harrier, Burrowing Owl, and Loggerhead Shrike. Two were listed by CDFG as fully protected (CDFG 2011): Golden Eagle and White-tailed Kite.

Table 10. Abundance (birds/hour) of special-status species at Shiloh III

Month	AWPE	BUOW	GOEA	LOSH	NOHA	SWHA	WTKI
Jan		0.1		0.9	0.5		0.1
Feb			0.1	0.8	1.8		0.3
Mar			0.1	0.8	1.4		0.1
Apr			0.1		0.3		
May	0.6			0.1	0.1		
Jun			0.2	0.4	0.2	0.3	
Jul	9.0			0.5	0.5	0.1	
Aug				0.3	0.7	0.1	0.1
Sep				0.5	0.2		0.1
Oct			0.2	0.5	0.3	0.1	0.1
Nov		0.1	0.3	0.4	0.2	0.1	0.1
Dec			0.0	0.8	0.0		0.2
Annual	**0.56**	**0.01**	**0.09**	**0.43**	**0.46**	**0.05**	**0.07**

When monthly abundance of special-status species was considered (Table 8), two species were found to be year-round residents (recorded in nearly all months): Loggerhead Shrike (LOSH) and Northern Harrier (NOHA). Both were more abundant during winter months than during summer months. With respect to special-status species recorded at >1.0 birds/hour in any month, Northern Harrier was recorded at 1.4-1.8 birds/hour in February-March, and American White Pelican was recorded at 9.0 birds/hour in July.

Swainson's Hawk (SWHA) was uncommon during June-November. The summer records indicated that it bred locally in the MHWRA and vicinity. Golden Eagle (GOEA) and White-tailed Kite (WTKI) were mostly recorded outside of the nesting season, but the eagle was also recorded in June. It is known to nest in the MHWRA. White-tailed Kite (WTKI) was scarce during August-March. Burrowing Owl (BUOW) was a scarce winter visitor. There were two observations of American White Pelican (AWPE) flying over Shiloh III: a flock of 12 birds in May and a flock of 90 birds in July.

Of these species, Loggerhead Shrike (two carcasses) and Northern Harrier (one carcass) were recorded among fatalities (Table 2).

Pre-construction observations were conducted in April 2007-April 2008 (Kerlinger et al. 2009a), but because the wind farm layout changed, only two of the post-construction OPs (OPs 3 and 4 in the eastern portion of the wind farm) were located in the vicinity of 2007-2008 OPs (OPs 9 and 8 respectively). Thus, there is more pre-construction abundance and use data to consider other than the raptor nest results (see below).

When we extracted pre-construction raptor data, we found that overall raptor use in 2007-2008 was less than that recorded in 2012-2103. In Area C, overall raptor use was 2.1 birds/hour in 2007-2008 and 3.7 birds/hour in 2012-2013 (76% increase). In Area E, it was 3.4 birds/hour in 2007-2008 and 4.5 birds/hour in 2012-2013 (32% increase). This does not necessarily mean that raptors benefited from the wind farm. It is most likely an indication of the inter-year variation that may be expected in raptor abundance.

Raptor nesting study

Surveys conducted in early May 2012 located five raptor nests within the Shiloh III footprint (Table 9): two nests of American Kestrel (AMKE), two nests of Great Horned Owl (GHOW), and one nest of Red-tailed Hawk (RTHA).

The Shiloh III area had been previously surveyed in 2007, when 10 nests were found, including two nests of the California-threatened Swainson’s Hawk and one nest of the California special-concern Northern Harrier (Table 10).

Note that the greatest decrease in number of nests from 2007 to 2012 was for American Kestrel and Swainson's Hawk. One possible explanation is that there were several large storms since 2007 that resulted in broken limbs and a few blown down trees. One of the Swainson's Hawk nests was lost to such storm damage (see Table 9). Given that kestrels nest in tree holes, which compromise the structural integrity of trees, some nesting sites may have also been lost to storm damage. Kestrel nests are usually confirmed by territorial/courtship displays and by birds bringing prey items back to trees. Fewer such behaviors were observed in 2012 relative to 2007.

Given that Shiloh III has an area of about 1,800 ha (4,500 acres; Solano County Department of Resource Management 2012), nesting densities in 2012 were 9.1 km^2/nest for American Kestrel and Great Horned Owl, 18.2 km^2/nest for Red-tailed Hawk.

Table 11. Results of raptor nesting survey

Nest ID	Date discovered	Lat./Long.	Substrate	Breeding season 2007	Breeding season 2012	Notes
AMKE-1	5/3/12	38 08 36.81, -121 43 30.77	grove	No	Yes	
AMKE-2	4/1/07	38 10 17.97, -121 49 59.78	grove	Yes	Yes	Found again on 5/5/12
AMKE-3	4/1/07	38 10 46.42, -121 46 42.31	grove	Yes	No	
AMKE-4	4/1/07	38 10 24.82, -121 46 42.31	grove	Yes	No	
AMKE-5	4/1/07	38 10 31.30, -121 48 18.95	grove	Yes	No	
				4	2	
GHOW-1	5/1/12	38 09 53.59, -121 44 59.25	transmission line	No	Yes	
GHOW-2	5/1/12	38 10 24.47, -121 44 53.56	transmission line	No	Yes	
GHOW-3	4/1/07	38 11 26.27, -121 51 39.16	grove	Yes	No	
				1	2	
NOHA-1	4/1/07	38 10 25.70, -121 50 36.97	ground	Yes	No	
				1	0	
RTHA-1	4/1/07	38 11 27.59, -121 51 37.60	grove	Yes	Yes	Found again on 5/6/12
RTHA-2	4/1/07	38 10 17.26, -121 50 01.90	grove	Yes	No	
				2	1	
SWHA-1	4/1/07	38 10 58.57, -121 47 33.99	grove	Yes	No	Part of tree with nest blew down in 2008, killing nestings; nest never rebuilt.
SWHA-2	4/1/07	38 10 59.20, -121 46 06.48	grove	Yes	No	
				2	0	

Discussion

Mortality comparison with other MHWRA studies

This study includes the ninth year of mortality monitoring by Curry & Kerlinger at MHWRA wind farms. Studies included two years at High Winds (Kerlinger et al. 2006b), three years at Shiloh I (Kerlinger et al. 2009b), three years at Shiloh II (Kerlinger et al. 2012), and the first year at Shiloh III (this report).

These studies differed slightly with respect to turbine characteristics and search methodologies (Table 10). For example, 1.8-MW turbines at High Winds were searched at 15-day intervals and out to a distance of 75 m, whereas 1.5-MW turbines at Shiloh I and 2.0 and 2.05-MW turbines at Shiloh II and Shiloh III were searched on 7-day intervals out to a distance of 105 m. There were also differences in search intensity within 30 m of turbines, which increased beginning in the third year of Shiloh I at the recommendation of the Technical Advisory Committee (TAC).

Methods also differed with respect to estimators used to adjust mortality for searcher efficiency and scavenger removal. At High Winds and Shiloh I, we used the Jain estimator, but at Shiloh II and Shiloh III, we commenced using the Huso (2011) estimator, because it had been peer-reviewed and published recently. The Huso (2011) estimator is now the most widely used for estimating mortality at wind turbines.

When the outputs from both estimators were compared using the Shiloh II data (see Kerlinger et al. 2012: 37), the means were not significantly different, but the Huso estimates appeared to be more precise, providing narrower confidence intervals. This demonstrated that improvements in estimating mortality did not appreciably change results regarding fatality rates.

How did bird and bat mortality during the first year of Shiloh III compare with previous studies conducted by Curry & Kerlinger[2]? In a one-sample *t* test that compared the year-1 estimates at Shiloh III with those of the eight previous years, the estimate for bird mortality – 3.3 birds/MW/year – was not significantly different from the mean of previous years' estimates (4.2 ± 1.3 birds/MW/year; $p = 0.5103$), but the estimate for bat mortality – 0.4 bats/MW/year – was significantly lower than the mean of the previous years' estimates (3.4 ± 0.5 bats/MW/year; $p = 0.0006$)[3].

The difference in the bat estimate does not appear to have been a consequence of searchers not finding bat carcasses, or of scavengers removing them at greater rates. This is likely to be a result of searcher efficiency and scavenger removal rates not being significantly different from those determined for previous years.

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[2] We chose not to include the Montezuma I and Solano Wind projects in comparisons because Curry & Kerlinger had not conducted those studies.

[3] It should be pointed out that mean mortality at High Winds, Shiloh I, and Shiloh II may be somewhat lower, because year 1 results at Shiloh I were anomalously high, a result of limited Se and Sr testing in that year.

Shiloh II data, however, strongly suggested that the location of turbines in the MHWRA and the altitude range of the rotor-swept zone (RSZ) affected bat mortality (Kerlinger et al. 2012). At Shiloh II, more bats were killed in areas A and B (the western areas) than in C and D (the eastern areas), but all turbines in areas A and B had short hub heights, with the RSZ nearly 10 m closer to the ground. Thus, RSZ and proximity to Suisun Marsh are confounding variables that make it difficult to determine whether the height of the rotor or proximity to a larger marsh are responsible for the difference in fatality rates.

When bat fatalities at short turbines versus tall turbines were examined in areas C and D of Shiloh II, the rate of bat carcasses found in searches was nearly four times greater at the shorter turbines. Thus, it appeared that shorter turbines killed more bats, presumably because their RSZ extended into lower altitudes where bats foraged (Kerlinger et al. 2012).

Table 12. Comparison of results of MHWRA studies

Turbine characteristics	High Winds[1]	Shiloh I[2]	Shiloh II[3]	Shiloh III[4]
Turbine capacity	1.8 MW	1.5 MW	2.0 MW	2.05 MW
Turbine height	100 m	104 m	116-125 m	115-125 m
Search interval	15 days	7 days	7 days	7 days
Search radius	75 m	105 m	105 m	105 m
Average searcher efficiency				
Small birds	0.50	0.35	0.58	0.58
Medium birds	1.00	0.69	0.85	0.58
Large birds	1.00	1.00	0.97	1.00
Bats	0.50	0.35	0.41	0.57
Average scavenger removal				
Small birds	0.60	0.40	6.6 days (0.47)	5.5 days (0.39)
Medium birds	0.70	0.62	8.9 days (0.64)	8.1 days (0.58)
Large birds	0.43	0.91	13.0 days (0.93)	13.8 days (0.99)
Bats	0.38	0.43	6.1 days (0.44)	6.1 days (0.44)
Estimated birds/MW/year				
Year 1	1.6	12.0	1.9	3.3
Year 2	1.1	8.6	2.8	
Year 3		2.8	2.8	
Average	1.4	7.8	2.5	3.3
Estimated bats/MW/year				
Year 1	2.5	5.2	2.6	0.4
Year 2	1.5	5.8	3.8	
Year 3		2.1	3.4	
Average	2.0	3.9	3.3	0.4

[1] See Kerlinger et al. 2006b; estimates derived using Jain estimator.
[2] See Kerlinger et al. 2009b; estimates derived using Jain estimator.
[3] See Kerlinger et al. 2012; estimates derived using Huso (2011) estimator.
[4] This report; estimates derived using Huso (2011) estimator.

Among the 25 turbines studied at Shiloh III, only one (A13) had a short hub height. Thus, the lower bat mortality rate at Shiloh III may have been the result of taller turbines. Another possible explanation – that fewer bats were present in the MHWRA in 2012 – can apparently be discounted because, when the annual rates of observed fatalities of Mexican Free-tailed Bat and Hoary Bat at tall turbines in the western sections (areas C-E) of Shiloh II and Shiloh III were compared, the 0.3 bats in 100 searches recorded at Shiloh III was not significantly different (p = 0.2096) from the mean of 1.4 ± 0.6 bats in 100 searches recorded in three years at Shiloh II. We await data from years 2 and 3 at Shiloh III to determine how much observed fatalities and mortality estimates vary for bats.

Studies at ridgeline wind farms in Pennsylvania (Arnett et al. 2011) have demonstrated that bat mortality decreases as wind velocity increases above 5.5-6.0 m/s. Thus, greater wind speeds may also explain the lower bat mortality at Shiloh III, but wind data would need to be analyzed.

The raptor mortality estimate at Shiloh III was 0.7 raptors/MW/year (Table 6). Although seemingly greater, this estimate was not significantly different (p = 0.5209) from the mean of 0.51 ± 0.25 raptors/MW/year during three years of study at Shiloh II. The Shiloh II data showed considerable variation in annual mortality, ranging from 0.11 to 0.97 raptors/MW/year. In addition, the mortality rate seemed to be correlated positively with cyclical raptor abundance (Kerlinger et al. 2012: 30).

The Environmental Impact Report (EIR; Ecology and Environment 2010) prepared for Shiloh III projected possibly one Golden Eagle fatality per year and 210-360 bat fatalities per year. We believe these projections were based on results from High Winds and Shiloh I. In year 1 of the Shiloh III study, no Golden Eagle fatalities were recorded, and the adjusted mortality rate for bats was 41 bats at the entire wind farm (95% confidence ranging from 27 to 77).

Biological significance of mortality

There was no indication in the Shiloh III data that mortality was likely to cause a population decrease for any species or potentially decrease the conservation prospects of any special-status species. Bird mortality, for example, was distributed among dozens of species, and the species that were killed most are relatively abundant both continentally and in California. As noted, bat mortality was significantly lower than at other MHWRA wind farms that Curry & Kerlinger had studied.

Western Meadowlark, for example, had the highest observed fatality of any bird at Shiloh III. The 18 carcasses found in searches (Table 2) constituted 27% of all bird carcasses recorded and suggested an annual mortality rate of about 90. Fatalities occurred throughout the year, suggesting that fatalities were not limited to a resident population, but also occurred among migrants and winter visitors from a wide geographic area. The continental population of Western Meadowlark is estimated to be 30 million birds, of which 3% (~ 1 million) are estimated to breed in California (Blancher et al. 2007). Thus, given that Western Meadowlarks killed at Shiloh III come from various source populations, this additive mortality is an insignificant percentage of total annual mortality for the species.

Recently, Arnold and Zink (2011) assessed the relative vulnerability of landbird populations in eastern North America to collisions with buildings and towers. Analyzing 243,103 collision records of 188 species, they found no correlation between relative collision mortality among species, which varied over four orders of magnitude, and long-term population trends. They concluded that, although million of birds are killed annually by collisions with manmade structures in North America, this source of mortality has no discernible effect on populations. Thus, the relatively small numbers of birds that collide with wind turbines, as compared to those killed by other structures, is unlikely to have a biologically significant impact on the species involved.

Based on best available estimates, Erickson et al. (2005) estimated that annual bird mortality from human-caused sources (including building collisions, electrocutions, cat predation, pesticide poisoning, etc.) easily approached one billion birds in the U.S. alone, of which <0.01% was attributable to collisions with wind turbines. They also figured that human-caused mortality took approximately 5% to 10% of the U.S. landbird population each year. Of importance for these statistics is the fact that federally funded and permitted projects, such as communication towers (both publicly and privately owned) and highways, are subject to review under the National Environmental Protection Act (NEPA) prior to construction. What this means is that the millions of fatalities at federally funded or permitted facilities have in theory been subjected to review by federal and other wildlife agencies and have not been found to result in biologically significant impacts.

It is also noteworthy that the best wildlife management practices routinely allow harvests at or above 5% to 10% for waterfowl and gamebird populations, including some species of conservation concern. Using a common species as an example, about 1.1 million hunters harvested 20.5 million Mourning Doves in 2007 (Richkus et al. 2008). This accounted for 19% of the total population of about 110 million individuals (Blancher et al. 2007) and was additive to the other human-caused mortality of Mourning Doves.

The five carcasses of Mourning Doves found in searches at Shiloh III represented 7.5% of all bird carcasses found and pointed toward annual mortality on the order of about 25 Mourning Doves. This number is clearly insignificant.

With respect to Red-tailed Hawk and American Kestrel, the 2012 raptor nesting survey found reductions in nest numbers in both species, as well as in the threatened Swainson's Hawk and special-concern Northern Harrier, relative to a survey conducted in 2007 (Table 9). Storm damage of nesting trees appeared to be a factor in this decline, but since 2007, the Shiloh II, Shiloh III, and Montezuma Winds (Nextera Energy project) had also been constructed in the area. Thus, construction and operation of three wind farms may have had an effect on numbers of locally nesting raptors. Nonetheless, a study of Golden Eagles nesting in the Altamont Pass Wind Resource Area (APWRA) showed that, despite considerable mortality, a sample of 58 territories occupied by eagle pairs in 2000 were also occupied in 2005, most likely because of immigration from outside areas (Hunt and Hunt 2006). This demonstrates considerable resilience among raptor populations.

Special-status species require special consideration, because their populations are relatively small or decreasing. Six special-status species were recorded in the abundance and use study, of which two were recorded in the mortality study: Loggerhead Shrike and Northern Harrier, both special-concern species in California (Table 2). California ranks the global (G) and state (S) populations of special-status species as follows (CDFG 2011):

- G/S5: Secure; common and widespread
- G/S4: Apparently secure; uncommon but not rare
- G/S3: Vulnerable; at moderate risk of extinction due to a restricted range, relatively few populations (often 80 or fewer), recent and widespread declines, or other factors
- G/S2: Imperiled: at high risk of extinction due to very restricted range, very few populations (often 20 or fewer), steep declines, or other factors
- G/S1: Critically imperiled: at very high risk of extinction due to extreme rarity (often five or fewer populations), very steep declines, or other factors

Special-status birds recorded in the Shiloh III study were relatively secure globally (G4 or above), except American White Pelican, which was ranked as G3 (CDFG 2011). At a state level, however, the special-concern American White Pelican was ranked S1 (critically imperiled), and the threatened Swainson's Hawk and special-concern Burrowing Owl were ranked S2 (imperiled). Three other species were ranked S3 (vulnerable; Table 11).

Data indicated small annual losses of Loggerhead Shrike and Northern Harrier at Shiloh III. The two shrikes fatalities were found in October and November. Thus, there were probably drawn from wintering/migratory populations that covered a broad geographic area. The continental population of Loggerhead Shrike is estimated at 3.7 million, while the California population is estimated at 230,000 (Blancher et al. 2007). The harrier fatality was recorded in April and may have been a resident breeder or spring migrant. The continental population of Northern Harrier is estimated at about 400,000 birds, with roughly 19,000 birds in California (Blancher et al. 2007).

Other special-status species recorded in the abundance study were not recorded among fatalities, but they may occur, especially those species that have numbered among fatalities at other MHWRA wind farms. In this regard, Golden Eagle deserves special consideration given protection afforded under the Federal Bald and Golden Eagle Protection Act (BGEPA). Its continental population is estimated at 80,000 birds, of which 2,000 (2.5%) are estimated to breed in California (Blancher et al. 2007). Single Golden Eagle carcasses were recorded in searches both at High Winds and Shiloh I, plus two were recorded outside of search areas at Shiloh I (Kerlinger et al. 2006b, 2009b). These data indicate the possibility of Golden Eagle fatalities at Shiloh III. In any event, this rate of loss appears unlikely to cause a discernible population effect, given the above-mentioned finding of Hunt and Hunt (2006) in the APWRA.

The California-threatened Swainson's Hawk also deserves special consideration, given its heightened protection status in California and that it has bred within the Shiloh III footprint. That it was not recorded among fatalities at High Winds, Shiloh I, and Shiloh II would indicate less frequent mortality than Golden Eagle. Its California breeding population is estimated at 4,000 birds (Blancher et al. 2007). Given that it appears less susceptible to collision and has a larger California population than Golden Eagle, discernible population effects from collisions with Shiloh III turbines appear unlikely.

Conclusions

The first year of study at Shiloh III found that bird mortality – estimated at 3.3 birds/MW/year – was not significantly different from the mean of eight years of estimates at High Winds, Shiloh I, and Shiloh II (4.2 ± 1.3 birds/MW/year; $p = 0.5103$). Bat mortality – estimated at 0.4 bats/MW/year – was significantly lower than the mean of eight years of estimates at those wind farms (3.4 ± 0.5 bats/MW/year; $p = 0.0006$).

Turbine characteristics may explain the lower bat mortality. At Shiloh III, 24 of the 25 turbines were tall, with the rotor-swept zone (RSZ) beginning at 32.5 m above ground level (agl). The short turbine had the RSZ extending down to 22.5 m agl. At Shiloh II, where the "short-turbine effect" on bat mortality came to light, 42 turbines were tall and 33 were short, allowing an analysis of the height effect. In the western areas of Shiloh II (adjacent to the western areas of Shiloh III), short turbines killed nearly four times as many bats as tall turbines.

In other words, we hypothesize that Mexican Free-tailed Bat and Hoary Bat – the two species most often recorded in mortality monitoring studies in the MHWRA – generally forage below 32.5 m agl. When the RSZ extends lower, collision risk for bats apparently increases at turbines in the MHWRA. Bat abundance, as measured in the number of carcasses observed under tall turbines in the western areas of Shiloh III relative to the numbers observed in previous years under the same type of turbine in adjacent areas of Shiloh II, was not significantly different between years.

Studies at ridgeline wind farms in Pennsylvania (Arnett et al. 2010, 2011) have demonstrated that bat mortality decreases as wind velocity increases above 5.5-6.0 m/s. Thus, greater wind speeds may also explain the lower bat mortality at Shiloh III, but wind data would need to be analyzed in relation to fatality timing.

There was no indication in the Shiloh III data that mortality was likely to cause a population decrease of any species or potentially reduce the conservation prospects of any special-status species. Bird mortality, for example, was distributed among dozens of species, and the species that were killed most are relatively abundant both continentally and in California. As noted, bat mortality was significantly lower than at other MHWRA wind farms that Curry & Kerlinger has studied.

Table 13. Abundance and observed carcasses of special-status species recorded at Shiloh III

Special-status species	Status	Global population[1]	California population[1]	Average abundance, Shiloh III (birds/hour)[2]	Greatest monthly abundance (birds/hour)[2]	Observed carcasses, Shiloh III[3]	Observed carcasses at High Winds. Shiloh I, and Shiloh II (N)[4]
Swainson's Hawk	CA Threatened	G5	S2	0.05	0.3	0	No
American White Pelican	CA Special Concern	G3	S1	0.56	9.0	0	No
Northern Harrier	CA Special Concern	G5	S3	0.46	1.8	1	Yes (4)
Burrowing Owl	CA Special Concern	G4	S2	0.01	0.1	0	No
Loggerhead Shrike	CA Special Concern	G4	S4	0.43	0.9	2	No
Golden Eagle	CDFG Fully Protected	G5	S3	0.09	0.3	0	Yes (2)
White-tailed Kite	CDFG Fully Protected	G5	S3	0.07	0.3	0	Yes (3)

[1] From CDFG 2007, 2011
[2] See Table 8
[3] See Tables 1 and 2
[4] From Kerlinger et al. 2006b, 2009b, 2012

Literature cited

Arnett, E. B., M. M. P. Huso, M. R. Schirmacher, and J. P. Hayes. 2011. Altering turbine speed reduces bat mortality at wind-energy facilities. *Front Ecol Environ* 2010; doi: 10.1890/100103.

Arnold, T.W., and R.M. Zink. 2011. Collision mortality has no discernible effect on population trends of North American birds. PLoS ONE 6(9): e24708.

Blancher, P. J., K. V. Rosenberg, A. O. Panjabi, B. Altman, J. Bart, C. J. Beardmore, G. S. Butcher, D. Demarest, R. Dettmers, E. H. Dunn, W. Easton, W. C. Hunter, E. E. Iñigo-Elias, D. N. Pashley, C. J. Ralph, T. D. Rich, C. M. Rustay, J. M. Ruth, and T. C. Will. 2007. Guide to the Partners in Flight Population Estimates Database. Version: North American Landbird Conservation Plan 2004. Partners in Flight Technical Series No 5. http://www.partnersinflight.org/

Canty, A. and B. Ripley. 2010. boot: Bootstrap R (S-Plus) Functions. R package version 1.2-43.

California Department of Fish and Game (CDFG). 2007. California Wildlife: Conservatiom Challenges, California's Wildlife Action Plan. Sacramento, California. 624 pp.

California Department of Fish and Game (CDFG). 2009. State & Federally Endangered & Threatened Species of California. Sacramento, California. 12 pp.

California Department of Fish and Game (CDFG). 2011. Special Animals (898 taxa). Sacramento, California. 60 pp.

Davidson, A. C., and D. V. Hinkley. 1997. Bootstrap Methods and Their Applications. Cambridge University Press, Cambridge.

Ecology and Environment, Inc. 2010. Draft Environmental Impact Report, Shiloh III Wind Energy Project. Prepared for Solano County Department of Resource Management.

Erickson, W.P., G.D. Johnson, and D.P. Young. 2005. A Summary and Comparison of Bird Mortality from Anthropogenic Causes with an Emphasis on Collisions. USDA Forest Service General Technical Report PSW-GTR-191.

Howell, J.A., and J.E. DiDonato. 1988. Raptor nesting survey related to wind turbine siting, Montezuma Hills, Solano County, California, Spring, 1988. Prepared for Solano County Dept. of Environ. Mgt., Fairfield, CA.

Hunt G., and T. Hunt. 2006. The trend of golden eagle territory occupancy in the vicinity of the Altamont Pass Wind Resource Area: 205 survey. Pier Final Project Report, CEC-500-2006-056. 17pp.

Huso, M. M. P. 2011. An estimator of wildlife fatality from observed carcasses. Environmetrics 22: 318–329.

Jones and Stokes Associates. 1987. Bird abundance and movements in the Potrero Hills Wind Turbine Site, Solano County, California. Prepared for Solano County Dept. of Environ. Mgt., Fairfield, CA.

Kerlinger, P., R. Curry, and L. Culp. 2001. Avian Monitoring Study and Risk Assessment for the High Winds Wind Power Project, Solano County, California. Prepared for FPL Energy.

Kerlinger, P., R. Curry, and A. Hasch. 2005. Avian Monitoring Study and Risk Assessment for the Shiloh Wind Power Project, Solano County, California. Prepared for enXco.

Kerlinger, P., R. Curry, C. Wilkerson, L. Culp, A. Hasch, and A. Jain. 2006a. Avian Monitoring Study and Risk Assessment for the Shiloh Wind Power Project, Solano County, California. Prepared for enXco.

Kerlinger, P., R. Curry, L. Culp, A. Jain, C. Wilkerson, B. Fischer, and A. Hasch. 2006b. Post-Construction Avian and Bat Fatality Monitoring Study for the High Winds Wind Power Project, Solano County, California: Two Year Report. Prepared for High Winds, LLC, and FPL Energy.

Kerlinger, P., R. Curry, C. Wilkerson, L. Culp, A. Hasch, and A. Jain. 2009a. Avian Monitoring Study and Risk Assessment for the Shiloh III Wind Power Project, Solano County, California. Prepared for enXco.

Kerlinger, P., R. Curry, L. Culp, A. Hasch, and A. Jain. 2009b. Post-Construction Avian Monitoring Study for the Shiloh I Wind Energy Project, Solano County, California: Final Report. Prepared for Iberdrola Renewables.

Kerlinger, P., J. Gehring, W.P. Erickson, R. Curry, A. Jain, and J. Guarnaccia. 2010. Night migrant fatalities and obstruction lighting at wind turbines in North America. Wilson Journal 122(4):744-754.

Kerlinger, P., R. Curry, A. Hasch, J. Guarnaccia, and D. Riser-Espinoza. 2012. Post-construction bird and bat studies at the Shiloh II Wind Power Project, Solano County, California. Report prepared for EDF Renewables, USA.

Kunz T. H., E. B. Arnett, W. P. Erickson, *et al*. 2007. Ecological impacts of wind energy development on bats: questions, hypotheses, and research needs. *Front Ecol Environ* **5**: 315–24

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. Work performed by BioSystems Analysis, Inc., Tiburon, CA. Sacramento, CA: California Energy Commission.

R Development Core Team. 2010. R: A language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria.

Richkus, K.D., K.A. Wilkins, R.V. Raftovich, S.S. Williams, and H.L. Spriggs. 2008. Migratory bird hunting and harvest during the 2006 and 2007 hunting seasons: preliminary estimates. U.S. Fish and Wildlife Service, Division of Migratory Bird Management, Branch of Harvest Surveys, Laurel, Maryland. 65pp.

Shuford, W.D., and T. Gardali, editors. 2008. California Bird Species of Special Concern: A ranked assessment of species, subspecies, and distinct populations of birds of immediate conservation concern in California. Studies of Western Birds 1. Western Field Ornithologists, Camarillo, California, and California Department of Fish and Game, Sacramento, California.

Solano County Department of Resource Management. 2012. Commercial Wind Energy Facilities, Montezuma Hills Area. Fairfield, CA. 3 pp.

Young, D. P., Jr., W. P. Erickson, K. Bay, S. Nomani, and W. Tidhar. 2009. Mount Storm Wind Energy Facility, Phase 1 Post-Construction Avian and Bat Monitoring, July-October 2008. Prepared for NedPower Mount Storm, LLC. Prepared by Western EcoSystems Technology, Inc., Cheyenne, Wyoming. 54pp.

Appendix A. Turbine characteristics and searches conducted

Turbine	Hub height (m)	Lighting	Year(s) studied	# scheduled searches conducted
A10	78.5	Yes	1	52
A13	68.5	No	1	52
B13	78.5	Yes	1	52
B15	78.5	No	1	52
B16	78.5	No	1	52
C24	78.5	Yes	1	52
C26	78.5	Yes	1	52
C28	78.5	No	1	52
C30	78.5	No	1	52
C33	78.5	Yes	1	52
C42	78.5	No	1	52
C36	78.5	No	1	52
C41	78.5	Yes	1	52
C38	78.5	No	1	52
D31	78.5	No	1	52
E1	78.5	No	1	52
E3	78.5	Yes	1	52
E5	78.5	Yes	1	52
E8	78.5	No	1	52
E10	78.5	Yes	1	52
E11	78.5	Yes	1	52
E13	78.5	Yes	1	52
E15	78.5	No	1	52
E17	78.5	No	1	52
E19	78.5	No	1	52
				1300

Appendix B, Table 1. Search rounds in year 1

Project year	Calendar year	Dates	Search days	Search type	Round #	# scheduled turbine searches	# other turbine searches
1	2012	16-18 Jan	3	Clean Sweep			25
1	2012	24-26 Jan	3	Scheduled	1	25	
1	2012	31 Jan-2 Feb	3	Scheduled	2	25	
1	2012	6-10 Feb	4	Scheduled	3	25	
1	2012	14-16 Feb	3	Scheduled	4	25	
1	2012	21-23 Feb	3	Scheduled	5	25	
1	2012	28 Feb-2 Mar	4	Scheduled	6	25	
1	2012	6-10 Mar	5	Scheduled	7	25	
1	2012	13-16 Mar	4	Scheduled	8	25	
1	2012	21-23 Mar	3	Scheduled	9	25	
1	2012	28-30 Mar	3	Scheduled	10	25	
1	2012	3-6 Apr	4	Scheduled	11	25	
1	2012	9-12 Apr	4	Scheduled	12	25	
1	2012	17-20 Apr	4	Scheduled	13	25	
1	2012	23-27 Apr	5	Scheduled	14	25	
1	2012	1-5 May	5	Scheduled	15	25	
1	2012	7-11 May	5	Scheduled	16	25	
1	2012	14-17 May	4	Scheduled	17	25	
1	2012	21-23 May	3	Scheduled	18	25	
1	2012	29 May-1-Jun	4	Scheduled	19	25	
1	2012	4-8 Jun	5	Scheduled	20	25	
1	2012	11-15 Jun	5	Scheduled	21	25	
1	2012	19-22 Jun	4	Scheduled	22	25	
1	2012	25-27 Jun	3	Scheduled	23	25	
1	2012	3-7 Jul	4	Scheduled	24	25	
1	2012	9-13 Jul	5	Scheduled	25	25	
1	2012	16-20 Jul	5	Scheduled	26	25	
1	2012	25-28 Jul	4	Scheduled	27	25	
1	2012	31 Jul-4 Aug	5	Scheduled	28	25	
1	2012	6-11 Aug	5	Scheduled	29	25	
1	2012	14-18 Aug	5	Scheduled	30	25	
1	2012	21-24 Aug	4	Scheduled	31	25	
1	2012	27 Aug 1 Sep	5	Scheduled	32	25	
1	2012	4-7 Sep	4	Scheduled	33	25	
1	2012	10-13 Sep	4	Scheduled	34	25	
1	2012	17-22 Sep	6	Scheduled	35	25	
1	2012	24-28 Sep	5	Scheduled	36	25	
1	2012	1-4 Oct	4	Scheduled	37	25	
1	2012	7-12 Oct	6	Scheduled	38	25	
1	2012	14-20 Oct	6	Scheduled	39	25	

1	2012	22-25 Oct	4	Scheduled	40	25	
1	2012	29 Oct-3 Nov	5	Scheduled	41	25	
1	2012	5-10 Nov	6	Scheduled	42	25	
1	2012	12-16 Nov	5	Scheduled	43	25	
1	2012	19-24 Nov	6	Scheduled	44	25	
1	2012	26 Nov-1 Dec	6	Scheduled	45	25	
1	2012	3-8 Dec	6	Scheduled	46	25	
1	2012	11-14 Dec	4	Scheduled	47	25	
1	2012	19-24 Dec	6	Scheduled	48	25	
1	2012	26-30 Dec	5	Scheduled	49	25	
1	2013	2-4 Jan	3	Scheduled	50	25	
1	2013	8-12 Jan	5	Scheduled	51	25	
1	2013	15-18 Jan	4	Scheduled	52	25	
			235			1300	25

Appendix B, Table 2. Carcasses found in searches in year 1

Project year	Date found	ID #	Species	Class	Size	Turbine	Lighting	Veg. height	Distance (m)
Y1	2/2/12	SH3Y1-003-12	Mexican Free-tailed Bat	bat	bat	C24	Yes	short	15
Y1	4/24/12	SH3Y1-015-12	Hoary Bat	bat	bat	B16	No	short	52
Y1	5/14/12	SH3Y1-020-12	Mexican Free-tailed Bat	bat	bat	B16	No	short	19
Y1	6/14/12	SH3Y1-023-12	Mexican Free-tailed Bat	bat	bat	A13	No	short	30
Y1	8/22/12	SH3Y1-035-12	Hoary Bat	bat	bat	C42	No	medium	58
Y1	9/4/12	SH3Y1-039-12	Hoary Bat	bat	bat	A10	Yes	short	82
Y1	10/3/12	SH3Y1-048-12	Mexican Free-tailed Bat	bat	bat	E10	Yes	short	19
Y1	1/26/12	SH3Y1-001-12	Brewer's Blackbird	landbird	S	E8	No	short	18
Y1	1/31/12	SH3Y1-002-12	Western Meadowlark	landbird	M	C36	No	short	82
Y1	2/6/12	SH3Y1-004-12	Western Meadowlark	landbird	M	C38	No	short	2
Y1	2/15/12	SH3Y1-006-12	Brewer's Blackbird	landbird	S	A10	Yes	short	30
Y1	3/21/12	SH3Y1-010-12	European Starling	landbird	S	C24	Yes	short	40
Y1	3/21/12	SH3Y1-009-12	Red-winged Blackbird	landbird	S	B16	No	short	49
Y1	3/21/12	SH3Y1-011-12	Red-winged Blackbird	landbird	S	C28	No	short	5
Y1	4/27/12	SH3Y1-017-12	Red-winged Blackbird	landbird	S	D31	No	tall	8
Y1	5/2/12	SH3Y1-018-12	Rock Pigeon	landbird	M	B13	Yes	short	95
Y1	5/2/12	SH3Y1-019-12	Rock Pigeon	landbird	M	B13	Yes	short	45
Y1	5/23/12	SH3Y1-021-12	Red-winged Blackbird	landbird	S	C36	No	short	11
Y1	6/4/12	SH3Y1-018B-12	Brewer's Blackbird	landbird	S	E11	Yes	short	66
Y1	6/14/12	SH3Y1-024-12	Western Meadowlark	landbird	M	A10	Yes	short	48
Y1	6/21/12	SH3Y1-026-12	Mourning Dove	landbird	M	C26	Yes	high	7
Y1	7/3/12	SH3Y1-027-12	Western Meadowlark	landbird	M	C36	No	short	60
Y1	7/12/12	SH3Y1-028-12	Western Meadowlark	landbird	M	C33	Yes	high	74
Y1	7/13/12	SH3Y1-029-12	Western Meadowlark	landbird	M	E17	No	medium	35
Y1	7/28/12	SH3Y1-030-12	Horned Lark	landbird	S	C36	No	short	33
Y1	8/10/12	SH3Y1-032-12	Savannah Sparrow	landbird	S	C41	Yes	short	7
Y1	8/21/12	SH3Y1-033-12	Mourning Dove	landbird	M	B13	Yes	high	95
Y1	8/24/12	SH3Y1-036-12	Mourning Dove	landbird	M	E8	No	medium	53
Y1	8/29/12	SH3Y1-037-12	Western Meadowlark	landbird	M	C38	No	medium	73
Y1	9/10/12	SH3Y1-042-12	Western Meadowlark	landbird	M	C42	No	medium	50
Y1	9/17/12	SH3Y1-044-12	Western Meadowlark	landbird	M	C28	No	medium	51
Y1	9/17/12	SH3Y1-045-12	Yellow Warbler	landbird	S	E3	Yes	short	100
Y1	10/9/12	SH3Y1-049-12	Western Meadowlark	landbird	M	E5	Yes	short	88

Project year	Date found	ID #	Species	Class	Size	Turbine	Lighting	Veg. height	Distance (m)
Y1	10/10/12	SH3Y1-051-12	European Starling	landbird	S	A10	Yes	short	80
Y1	10/10/12	SH3Y1-050-12	Loggerhead Shrike	landbird	S	E13	Yes	short	14
Y1	10/10/12	SH3Y1-050B-12	Western Meadowlark	landbird	M	E17	No	short	98
Y1	10/16/12	SH3Y1-052-12	Mourning Dove	landbird	M	B13	Yes	medium	95
Y1	11/12/12	SH3Y1-053-12	Loggerhead Shrike	landbird	S	A10	Yes	short	94
Y1	11/19/12	SH3Y1-054-12	American Goldfinch	landbird	S	A13	No	short	30
Y1	11/19/12	SH3Y1-055-12	Western Meadowlark	landbird	M	B13	Yes	short	60
Y1	11/21/12	SH3Y1-056-12	Savannah Sparrow	landbird	S	C26	Yes	short	3
Y1	11/27/12	SH3Y1-058-12	Western Meadowlark	landbird	M	C36	No	short	85
Y1	12/18/12	SH3Y1-059-12	Western Meadowlark	landbird	M	E1	No	short	39
Y1	12/20/12	SH3Y1-060-12	Savannah Sparrow	landbird	S	B13	Yes	medium	51
Y1	12/27/12	SH3Y1-061-12	Mourning Dove	landbird	M	E15	No	medium	82
Y1	1/2/13	SH3Y1-062-13	Western Meadowlark	landbird	M	E3	Yes	short	82
Y1	1/3/13	SH3Y1-064-13	Common Raven	landbird	L	A13	No	short	35
Y1	1/3/13	SH3Y1-063-13	Western Meadowlark	landbird	M	A10	Yes	short	82
Y1	1/3/13	SH3Y1-066-13	Western Meadowlark	landbird	M	B15	No	medium	68
Y1	1/10/13	SH3Y1-069-12	Cliff Swallow	landbird	S	C28	No	short	40
Y1	1/10/13	SH3Y1-068-13	Savannah Sparrow	landbird	S	B15	No	medium	98
Y1	1/11/13	SH3Y1-072-13	Cliff Swallow	landbird	S	C26	Yes	short	37
Y1	1/11/13	SH3Y1-071-13	Western Meadowlark	landbird	M	C36	No	short	78
Y1	1/16/13	SH3Y1-074-13	Brewer's Blackbird	landbird	S	C38	No	short	92
Y1	2/6/12	SH3Y1-005-12	American Kestrel	raptor	M	E3	Yes	short	65
Y1	4/9/12	SH3Y1-014-12	Northern Harrier	raptor	L	E3	Yes	short	45
Y1	4/9/12	SH3Y1-013-12	Red-tailed Hawk	raptor	L	C38	No	short	105
Y1	4/24/12	SH3Y1-016-12	Red-tailed Hawk	raptor	L	C24	Yes	short	72
Y1	6/1/12	SH3Y1-022-12	Turkey Vulture	raptor	L	B16	No	short	17
Y1	8/6/12	SH3Y1-031-12	Red-tailed Hawk	raptor	L	C38	No	short	34
Y1	8/22/12	SH3Y1-034-12	Barn Owl	raptor	M	C24	Yes	medium	105
Y1	8/29/12	SH3Y1-038-12	American Kestrel	raptor	M	C38	No	medium	30
Y1	9/6/12	SH3Y1-041-12	Barn Owl	raptor	M	E8	No	short	24
Y1	9/12/12	SH3Y1-043-12	Turkey Vulture	raptor	L	E3	Yes	short	41
Y1	9/26/12	SH3Y1-046-12	American Kestrel	raptor	M	E10	Yes	medium	10
Y1	10/2/12	SH3Y1-047-12	American Kestrel	raptor	M	C38	No	short	66
Y1	11/21/12	SH3Y1-057-12	American Kestrel	raptor	M	C30	No	short	29
Y1	1/3/13	SH3Y1-065-13	Red-tailed Hawk	raptor	L	B16	No	medium	58
Y1	1/4/13	SH3Y1-067-13	Rough-legged Hawk	raptor	L	C26	Yes	short	44

Project year	Date found	ID #	Species	Class	Size	Turbine	Lighting	Veg. height	Distance (m)
Y1	1/10/13	SH3Y1-070-13	American Kestrel	raptor	M	C28	No	short	50
Y1	1/15/13	SH3Y1-073-13	American Kestrel	raptor	M	E13	Yes	short	50
Y1	1/16/13	SH3Y1-075-13	Barn Owl	raptor	M	C26	Yes	short	96
Y1	1/16/13	SH3Y1-076-13	Great Horned Owl	raptor	L	C28	No	short	103
Y1	2/16/12	SH3Y1-007-12	American Coot	waterbird	M	B15	No	short	72

Appendix B, Table 3. Carcasses found outside of searches in year 1

Project year	Date found	ID #	Species	Class	Size	Turbine	Distance (m)	Comments
Y1	3/8/12	SH3Y1-008-12	American Coot	waterbird	M	C38	133	Incidental find
Y1	8/3/12	SH3Y1-INC-12	Turkey Vulture	raptor	L	B5	50	Incidental find
Y1	1/3/13	SH3Y1-063-12	Rough-legged Hawk	raptor	L	A11	41	Incidental find

Appendix C. Searcher efficiency (Se) and scavanger removal trials (Sr)

Date	Turbine	Species	Class	Size	Vegetation Height	Se (1/0)	Sr (days)
Mar-12	A10	Hoary Bat	Bat	Bat	short	1	8
Mar-12	A13	Hoary Bat	Bat	Bat	short	1	2
Mar-12	C41	Hoary Bat	Bat	Bat	short	0	5
Mar-12	B15	Mexican Free-tailed Bat	Bat	Bat	short	1	14
Mar-12	B16	Mexican Free-tailed Bat	Bat	Bat	short	1	14
Mar-12	C36	Mexican Free-tailed Bat	Bat	Bat	short	1	3
Mar-12	B15	American Crow	Landbird	M	short	1	14
Mar-12	C28	American Crow	Landbird	M	short	1	14
Mar-12	C36	American Crow	Landbird	M	short	0	12
Mar-12	B13	American Goldfinch	Landbird	S	short	1	12
Mar-12	D31	European Starling	Landbird	S	short	1	0
Mar-12	C28	Horned Lark	Landbird	S	short	0	0
Mar-12	B15	Savannah Sparrow	Landbird	S	short	1	13
Mar-12	C36	Red-tailed Hawk	Raptor	L	short	1	14
Sep-12	D31	Bat	Bat	Bat	short	1	9
Sep-12	E3	Bat	Bat	Bat	short	1	1
Sep-12	E5	Bat	Bat	Bat	medium	0	4
Sep-12	E8	Bat	Bat	Bat	medium	0	4
Sep-12	E15	Bat	Bat	Bat	tall	0	0
Sep-12	E15	Bat	Bat	Bat	tall	0	0
Sep-12	E8	Mourning Dove	Landbird	M	medium	1	4
Sep-12	E5	European Starling	Landbird	S	medium	0	6
Sep-12	E8	European Starling	Landbird	S	medium	0	3
Sep-12	E15	European Starling	Landbird	S	tall	1	13
Sep-12	D31	Turkey Vulture	Raptor	L	short	1	14
Sep-12	E5	Turkey Vulture	Raptor	L	medium	1	14
Sep-12	E15	Turkey Vulture	Raptor	L	tall	1	14
Sep-12	E15	American Coot	Waterbird	M	tall	1	13
Dec-12	E19	Hoary Bat	Bat	Bat	short	1	1
Dec-12	B15	Hoary Bat	Bat	Bat	tall	1	1
Dec-12	B15	Hoary Bat	Bat	Bat	tall	1	12
Dec-12	E17	Mexican Free-tailed Bat	Bat	Bat	short	1	10
Dec-12	B13	Mexican Free-tailed Bat	Bat	Bat	medium	1	11
Dec-12	E17	Mourning Dove	Landbird	M	short	1	5
Dec-12	E13	European Starling	Landbird	S	short	1	0
Dec-12	A10	European Starling	Landbird	S	short	0	3
Dec-12	B13	European Starling	Landbird	S	medium	1	14
Dec-12	B16	European Starling	Landbird	S	tall	0	5
Dec-12	C24	European Starling	Landbird	S	short	1	1
Dec-12	C24	European Starling	Landbird	S	short	1	1
Dec-12	E13	Red-tailed Hawk	Raptor	L	short	1	14
Dec-12	A13	Red-tailed Hawk	Raptor	L	short	1	14
Dec-12	B15	Red-tailed Hawk	Raptor	L	tall	1	12
Dec-12	B16	American Coot	Waterbird	M	tall	1	11
Jan-13	B16	Hoary Bat	Bat	Bat	medium	0	7
Jan-13	B15	Hoary Bat	Bat	Bat	tall	0	1
Jan-13	B15	Mexican Free-tailed Bat	Bat	Bat	tall	0	7
Jan-13	C36	Mexican Free-tailed Bat	Bat	Bat	short	0	14
Jan-13	B16	Mourning Dove	Landbird	M	medium	0	6

Jan-13	C42	Mourning Dove	Landbird	M	short	1	8
Jan-13	B16	European Starling	Landbird	S	medium	0	4
Jan-13	B15	European Starling	Landbird	S	tall	0	10
Jan-13	C24	European Starling	Landbird	S	short	1	4
Jan-13	B13	Tree Swallow	Landbird	S	medium	1	4
Jan-13	C36	Red-tailed Hawk	Raptor	L	short	1	14
Jan-13	B13	Turkey Vulture	Raptor	L	medium	1	14
Jan-13	B13	American Kestrel	Raptor	M	medium	0	2
Jan-13	B16	American Kestrel	Raptor	M	medium	0	1
Jan-13	B15	American Coot	Waterbird	M	tall	0	7