Avian and Bat Assessment at the Lewes Wind Turbine
University of Delaware College of Earth, Ocean and Environment

March 1, 2013

A conference call was held with the advisory committee on February 14, 2013. On the call were Genevieve LaRouche (US Fish & Wildlife Service-USFWS), Julie Thompson (USFWS), Holly Niederriter (Delaware Department of Natural Resources and Environmental Control-DNREC), and William Fintel, (President of the Sussex Bird Club), Nancy Targett (Dean, College of Earth, Ocean, and Environment, University of Delaware-UD CEOE), and Jeremy Firestone, Professor, UD CEOE.

The Advisory Committee was presented with the results of March – October of year 2 of the study and related recommendations (see attachments 1 and 2). Last year, on June 7, 2012, UD CEOE provided the Advisory Committee with updated year 1 study report that included information on species presence (on the basis of acoustic devices and thermal images, etc.). This document can be found at www.ceoe.udel.edu/lewesturbine/documents/lewes_turbine_interim_report_2012.pdf.

Most of the discussion centered around bats with the Advisory Committee concurring with CEOE's recommendation that no further action be taken regarding avian species. Because no further action was recommended regarding birds and there was no take of a threatened or endangered species, USFWS indicated that it had no further regulatory jurisdiction in this matter and that as far as it understood, our obligations to DOE had been discharged.

As for bats, UD CEOE and the Advisory Committee discussed the relative merits of (a) studying the effects of tall structures, rotating blades and wind speed on bat movement, attraction and collision; and (b) adjustments to the cut-in speed during times of peak bat migration. USFWS expressed a strong preference for making adjustments to the cut-in speed this summer. Cut-in speeds of 4.5m/s, 5m/s and 6.5m/s were mentioned during the discussion. USFWS indicated that 5m/s was typically what was being employed during the evenings between July 15-October 15.

UD CEOE (subject to concurrence by its partner, Gamesa a joint owner of the wind turbine, obtained later that day and conveyed to the Steering Committee) committed to voluntarily raise the cut-in speed to 5m/s during periods of peak bat migration. Because UD through its researchers have collected presence data (acoustic and thermal imaging), we may be able to refine somewhat the period during which cut-ins speed adjustments will be made. UD CEOE is exploring with researchers the possibility of collecting data during July 1-October 31, 2013. UD CEOE, like USFWS, is interested in calculations of bat collisions avoided/MWh lost and the related bat collisions avoided/$1000 in lost revenue. UD values the expertise and advice of the Steering Committee and intends to consult informally with the Advisory Committee going forward.

In conclusion, UD CEOE intends to take actions consistent with this document.

UD LEWES WIND TURBINE AVIAN AND BAT ASSESSMENT

University of Delaware College of Earth, Ocean and Environment (CEOE) Recommendations to Advisory Committee regarding Activities after the Completion of the Second Year of Study

Based on a review of the 2013 Report (attached) detailing post-construction avian and bat assessment activities during 2012 at the University of Delaware (UD) Wind Turbine by Dr. Jeffrey Buler, Kyle Horton and Dr. Greg Shriver, as well as the earlier report detailing the 2011 investigation and an earlier Assessment of Bat Carcasses found in 2011 prepared by Dr. Kevina Vulinc, et al. from Delaware State University, as well as other relevant information, UD's College of Earth, Ocean and Environment (CEOE) recommends that:

1. No further action be taken regarding migratory birds

2. With regard to bats, CEOE and the Advisory Committee discuss the potential benefits and efficacy of undertaking a scientific study in 2013 of the relationship among wind speed, the wind turbine and rotor operation during periods of peak bat movement (those hours during July, August and September when based on existing data are at the greatest risk of fatality).

POST-CONSTRUCTION AVIAN AND BAT IMPACT ASSESSMENT OF THE UNIVERSITY OF DELAWARE WIND TURBINE IN LEWES, DE:

Fatal Collisions Spring 2012 – Fall 2012

Interim report

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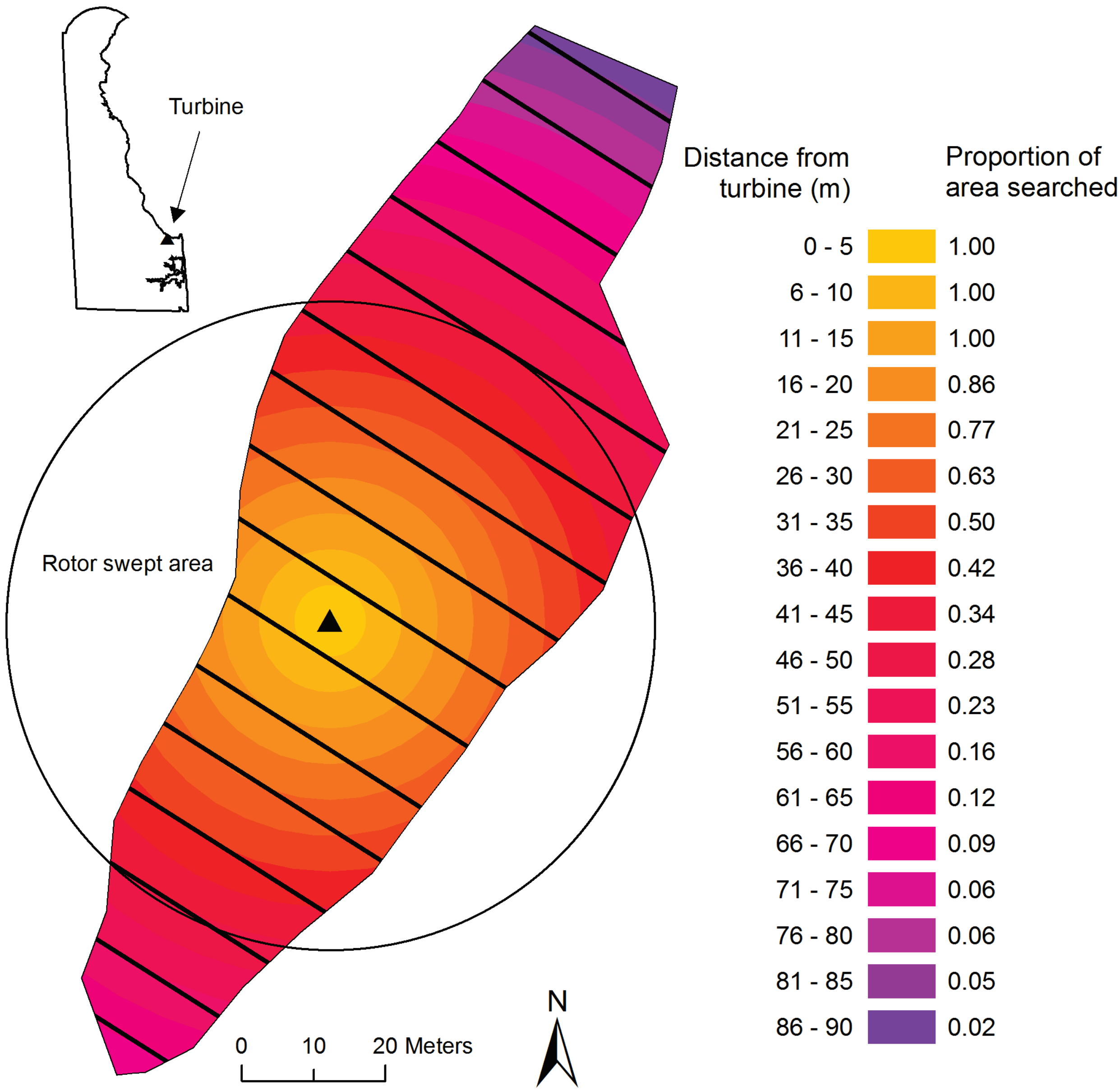
This report supplements the previous interim project report submitted in May 2012 (see attached) of our larger project to assess the post-construction wildlife impacts of the University of Delaware wind turbine in Lewes, DE. For this report, we present the results from March 2012 through October 2012 carcass search effort component that documents the number and identity of bird and bat species that fatally collide with the wind turbine and estimates collision fatality rate of flying birds and bats during 2012. We've included text from the May 2012 report where necessary to describe general methods. However, to reduce redundancy, we refer the reader to the May 2012 report for complete details about methodology and for results from the first year of carcass monitoring (March 2011 through February 2012).

METHODS

Study Site

The University of Delaware wind turbine is located in Lewes, DE (38°46'58.53"N, - 75° 9'53.41"W) on the campus of The College of Earth, Ocean, and Environment (Fig. 1).

Figure 1. Location of the University of Delaware wind turbine (triangle) in Lewes, DE. Transects (lines) within the carcass search area, colored according to distance from the turbine, are depicted. The proportion of distance band area searched is reported.



Carcass Searches

The carcass search area encompassed a total area of 0.57 ha (1.41 acres) centered on the base of the turbine and was restricted to areas with no vegetation (bare gravel) or with sparse vegetation under 1m in height. We split the search area into individually labeled, parallel transects that searchers walked in a serpentine pattern. Transect lines were 10 m apart and were of varying length due to the irregular shape of the search area. Each had a search width of 5 m on either side of each line, so as not to overlap search effort but also to provide complete coverage.

We conducted daily carcass searches shortly after sunrise from 1 March - 31 October. We did not conduct searches during inclement weather. For each carcass found, searchers would record date, time found, observer name, species, identification number of carcass, habitat, perpendicular distance from the transect line to the carcass, distance from turbine, bearing from turbine, condition of carcass, probable scavenger of carcass, cause of death/visible injuries, and estimated time of death (e.g., <1day, <2 days). Searchers photographed each carcass before collecting it in a plastic bag while wearing rubber gloves. Dr. Kevina Vulinec at Delaware State University identified and took possession of bat carcasses.

Searcher Efficiency

We estimated searcher efficiency rates by randomly placing frozen bird and bat carcasses within the search area for searchers to find. We randomly selected the date, location and number of trial carcasses placed (i.e., 1 or 2 carcasses at a time) within the search area for each trial. Searchers were unaware of when and where trial carcasses were being deployed. During the deployment of trial carcasses, the senior researcher would record the date, time of placement (generally in the afternoon or evening), species, condition and location of each carcass in relation to the turbine and nearest transect line. When a trial carcass was found, the searcher would record the same data as an actual carcass. However, trial carcasses were left out for use in the scavenging trials. Any trial carcass that was not found would be monitored by the senior researcher until it was removed or discovered during a formal search.

Scavenging and Carcass Removal

We monitored animal carcasses used for the searcher efficiency trials to estimate carcasses removal rates by scavengers. Once a carcass was deployed, it was monitored daily by the senior researcher until it was found by the searcher. The searcher then continued monitoring until the carcass was removed.

Data Analysis

We estimated mean number of fatalities per day (f_s) separately for each sampling season, s, according to the following equation:

$$f_s = A\frac{o_s}{rD}$$

where o_s is the observed fatality rate (number of carcasses found during formal searches / number of days that turbine was operational during search season), r is the observed probability a carcass is not removed by a scavenger during one day, D is the carcass detection rate, and A is the search area adjustment factor. We determined carcass detection rate D by multiplying the observed searcher efficiency rate by the modeled detection probability of carcasses within 5 m of the transect line. We calculated the searcher efficiency rate by dividing the total number of trial carcasses found by the total number of carcasses that were placed. We used program Distance (http://www.ruwpa.st-and.ac.uk/distance/) to model the probability of carcass detection within 5 m of the transect line as a function of distance from the transect line.

We determined the adjustment factor (A) for the distribution of carcasses relative to the turbine and the differential search effort at varying distances from the turbine using the following equation:

$$A = \sum_{j=1}^{18} \frac{c_j}{s_j}$$

where c_j is the proportion of observed carcasses found in the jth distance band from the turbine in 5 m increments, and s_j is the proportion of the jth distance band area that was searched.

RESULTS

From March through October 2012, we found 30 carcasses during formal searches and 10 carcasses incidentally (Table 1). Of the 40 total carcasses, 37 of them were bats and 3 were birds. Bat carcasses were comprised of 5 species: Eastern red bat (77.5%), hoary bat (5.0%), big brown bat (5.0%), tri-colored bat (2.5%), and silver-haired bat (2.5%). Out of the 3 bird fatalities, we observed a total of 3 species: Osprey (2.5%), Chipping Sparrow (2.5%), and Swamp Sparrow (2.5%). Necropsies of birds were not performed. Most bird specimens had visible external trauma and were located within the rotor swept area of the turbine, leading us to believe that they fatally collided with the turbine rather than other causes of death. We have not yet received information on necropsies of bats performed by researchers from Delaware State University.

We placed 19 trial bird and 13 bat carcasses between 3m and 85m away from the turbine for estimating carcass removal rate and searcher efficiency during 2011 and 2012. Scavengers removed 22% of trial carcasses within one day (r = 0.78; Fig. 2). All carcasses were removed by 27 days. The mean number of days a trial carcass persisted before being scavenged was 6.07 days. Searchers found 22 trial carcasses during formal searches. This yielded an overall searcher efficiency rate of 65%. Of the trial carcasses that were found, 52% of them were found within one day of deployment and 71% within two days of deployment. Since the detection of carcasses declined with distance from the search transect (Fig. 2), we used program DISTANCE (Thomas 2005) to estimate detection probability of carcasses within 5 m of the transect line. Detection probability was estimated at 0.78, yielding a carcass detection rate (*D*) of 0.51.

Table 1. Bird (bold) and bat carcasses found at the University of Delaware wind turbine in Lewes, DE during 2012 based on searches conducted within a 0.56 ha area around the turbine. Winter searches were conducted weekly from 5 Jan – 21 Feb (n=8) and 1 Nov – 1 Dec (n=4). Searches were conducted daily from 2 March – 31 October (n=210).

Season	Species		Date collected	Current location
Spring	**Chipping Sparrow**	***Spizella passerina***	**4/11/2012**	**UD**
	Osprey	***Pandion haliaetus***	**4/12/2012**	**UD**
	Big Brown Bat	*Eptesicus fuscus*	5/17/2012	Del State
Early Summer	Eastern Red Bat	*Lasiurus borealis*	6/1/2012	Del State
Late Summer – Fall	Eastern Red Bat	*Lasiurus borealis*	8/3/2012	Del State
	Eastern Red Bat	*Lasiurus borealis*	8/6/2012	Del State
	Eastern Red Bat	*Lasiurus borealis*	8/9/2012	Del State
	Eastern Red Bat	*Lasiurus borealis*	8/9/2012	Del State
	Eastern Red Bat	*Lasiurus borealis*	8/10/2012	Del State
	Eastern Red Bat	*Lasiurus borealis*	8/11/2012	Del State
	Eastern Red Bat	*Lasiurus borealis*	8/11/2012	Del State
	Eastern Red Bat*	*Lasiurus borealis*	8/11/2012	n/a
	Eastern Red Bat*	*Lasiurus borealis*	8/12/2012	n/a
	Eastern Red Bat	*Lasiurus borealis*	8/12/2012	Del State
	Eastern Red Bat	*Lasiurus borealis*	8/12/2012	Del State
	Eastern Red Bat	*Lasiurus borealis*	8/12/2012	Del State
	Eastern Red Bat	*Lasiurus borealis*	8/12/2012	Del State
	Eastern Red Bat	*Lasiurus borealis*	8/14/2012	Del State
	Eastern Red Bat	*Lasiurus borealis*	8/15/2012	Del State
	Eastern Red Bat	*Lasiurus borealis*	8/16/2012	Del State
	Eastern Red Bat	*Lasiurus borealis*	8/16/2012	Del State
	Eastern Red Bat	*Lasiurus borealis*	8/16/2012	Del State
	Eastern Red Bat	*Lasiurus borealis*	8/17/2012	Del State
	Eastern Red Bat	*Lasiurus borealis*	8/17/2012	Del State
	Eastern Red Bat	*Lasiurus borealis*	8/22/2012	Del State
	Eastern Red Bat	*Lasiurus borealis*	8/31/2012	Del State
	Eastern Red Bat	*Lasiurus borealis*	8/31/2012	Del State
	Big Brown Bat	*Eptesicus fuscus*	8/31/2012	Del State
	Eastern Red Bat	*Lasiurus borealis*	9/2/2012	Del State
	Tri-colored Bat	*Perimyotis subflavus*	9/7/2012	Del State
	Eastern Red Bat	*Lasiurus borealis*	9/8/2012	Del State
	Eastern Red Bat	*Lasiurus borealis*	9/10/2012	Del State
	Hoary Bat	*Lasiurus cinereus*	9/12/2012	Del State
	Eastern Red Bat	*Lasiurus borealis*	9/17/2012	Del State
	Hoary Bat	*Lasiurus cinereus*	9/28/2012	Del State
	Eastern Red Bat	*Lasiurus borealis*	9/28/2012	Del State
	Eastern Red Bat	*Lasiurus borealis*	10/02/2012	Del State
	Eastern Red Bat	*Lasiurus borealis*	10/05/2012	Del State
	Swamp Sparrow	***Melospiza georgiana***	**10/17/2012**	**UD**
	Silver-haired Bat	*Lasionycteris noctivagans*	10/18/2012	Del State

* Found alive but injured and not collected

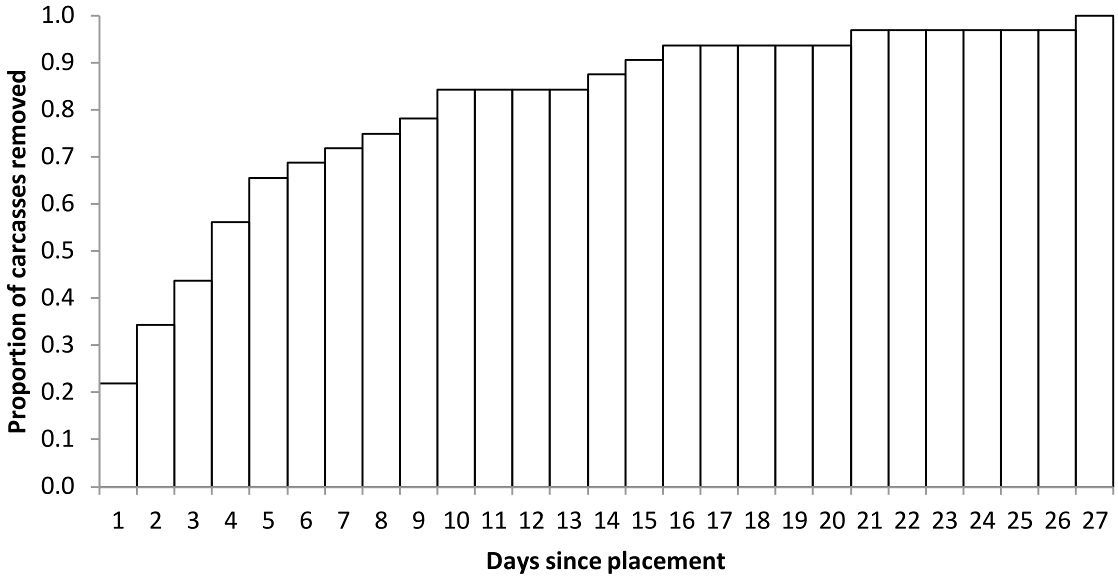


Figure 2. The proportion of trial carcasses removed by scavengers relative to the number of days since placement (n=32).

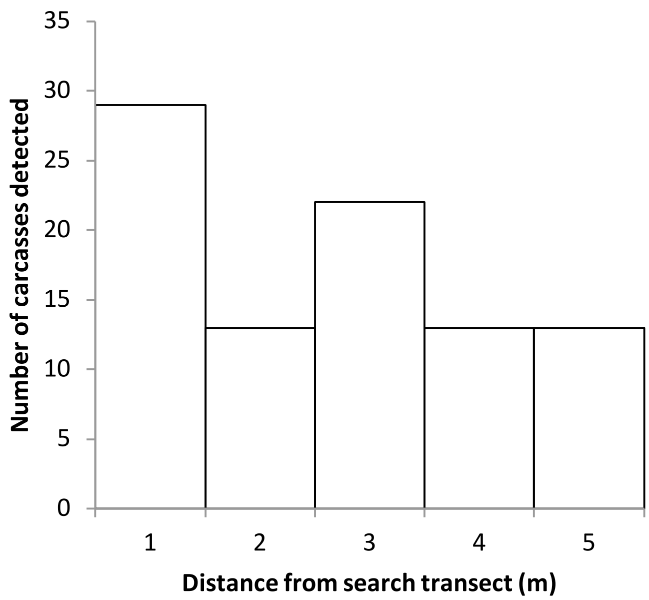


Figure 3. Distribution of observed and trial carcasses relative to distance from the search transect found during formal searches (n = 90).

The distribution of observed carcasses, expressed as the proportion of carcasses found within each distance band after adjusting for the amount of the distance band searched, generally increased with distance from the turbine and peaked at the 45-50 m distance band (Fig. 4). We found all carcasses within 55m of the turbine. The adjustment factor (*A*) accounting for carcass location and search area with respect to distance from the turbine was 1.70.

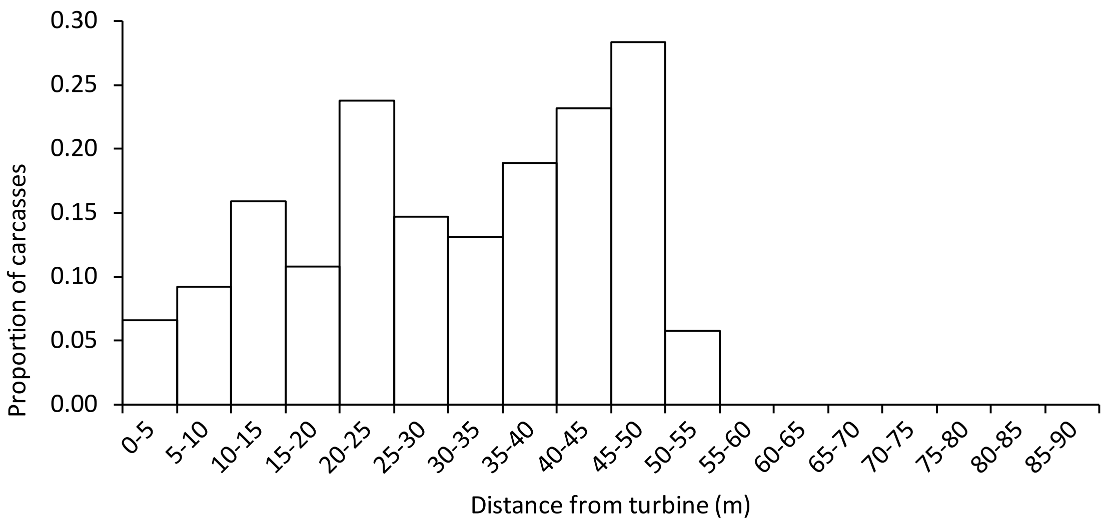


Figure 4. The distribution of observed carcasses relative to distance from the turbine. Proportions are adjusted for the amount of area searched at each distance band.

Fatality Estimates

We estimate that 123.9 fatal collisions by birds and bats occurred between March and October 2012 after adjusting observed fatality rates for search effort, search efficiency, and carcass removal by scavengers (Table 2). See Appendix A for a summary of all parameter values used for adjusting fatality rates. Most collisions of birds and bats occurred during the late summer and fall. Bats comprised 91% of estimated fatalities, and had an overall adjusted fatality rate of 0.56 bats/day; 8.6 times greater than that of birds (0.065 birds/day).

We assessed monthly variability in bat fatality rates and found a peak in August (2.5 bats per day) followed by September (0.58 bats per day; Fig. 5). Bats were found during all months except March, April, and July. Among bat species, eastern red bats peaked during August, while patterns were not apparent for other species as few individuals were collected. It must also be noted that during the entire month of July the turbine was not operational due to weather related damage. In 2011, peak bat mortality occurred in July.

Table 2. Estimated number of bird and bat collision fatalities at the University of Delaware wind turbine in Lewes, DE from 1 March through 31 October 2012 (245 days).

Taxon	Season			Total
	Spring (March – May)	Early summer (June – 15 July)	Late summer/Fall (16 July – October)	
Birds	8.5	0	4.3	12.8
Bats	4.3	4.3	102.6	111.1
All	12.8	4.3	106.8	123.9

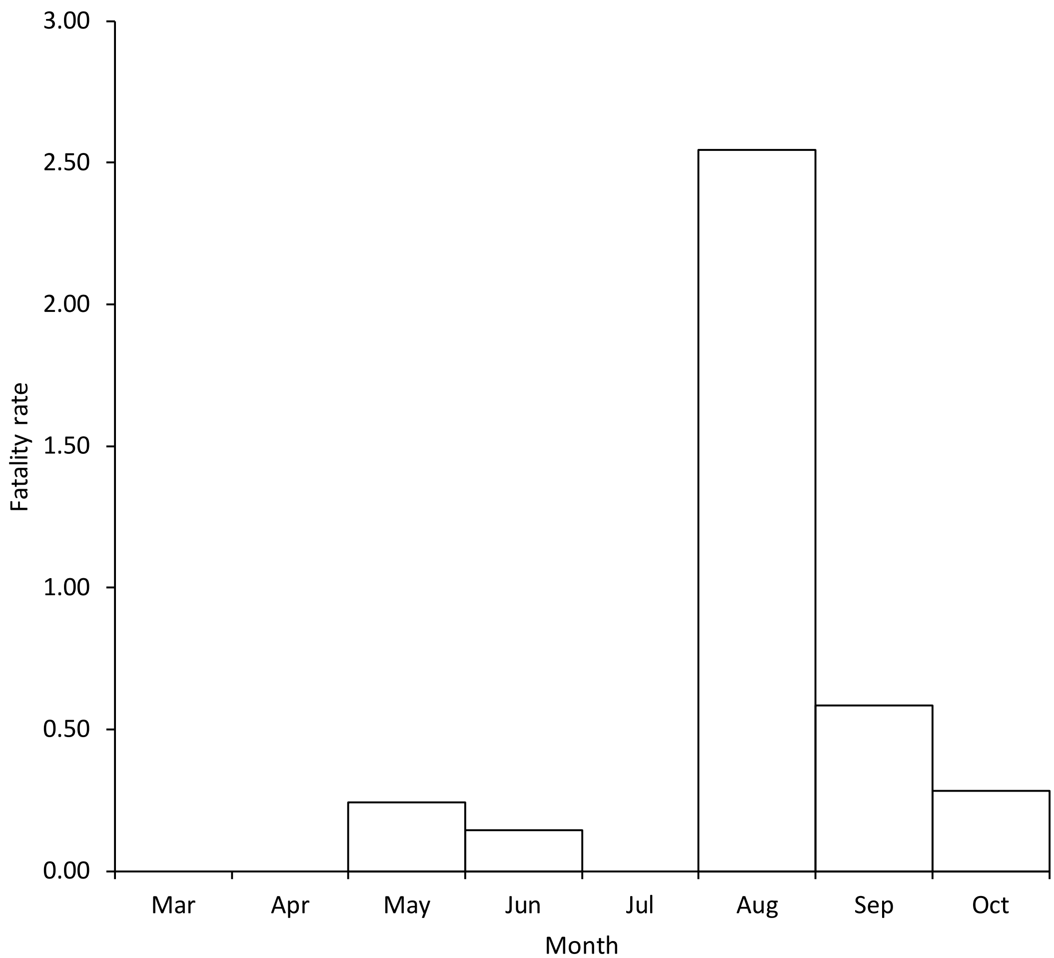


Figure 5. Estimated monthly bat fatality rate (number of bats per day) during 2012 at the University of Delaware wind turbine in Lewes, DE. Note: turbine was not operational during the entire month of July.

Table 3. Bat carcasses found during 2012 (formal and incidental) by species, season, and month.

Species	Spring			Summer		Fall		
	March	April	May	June	July	August	Sep	Oct
Eastern Red Bat	0	0	0	1	0	23	5	2
Big Brown Bat	0	0	1	0	0	1	0	0
Hoary Bat	0	0	0	0	0	0	2	0
Tri-colored Bat	0	0	0	0	0	0	1	0
Silver-haired Bat	0	0	0	0	0	0	0	1
Total	0	0	1	1	0	24	8	3

DISCUSSION

We estimate that few birds fatally collided with the University of Delaware wind turbine during the 2012 reporting period. Cast in terms of birds per megawatt of energy production capacity, the estimated fatality rate of birds at the UD turbine is 6.4 birds/MW during the 8-month reporting period. This is slightly lower than the 7.2 birds/MW we estimated during 2011 (updated for pooled parameter estimates across years) and much lower than the estimated rate of 20 birds/MW at the nearby five-turbine Jersey-Atlantic Wind Farm (JAWF) along the coast of Atlantic City, NJ (New Jersey Audubon Society, unpub. data). Our rate is much greater than the national average rate of 2.1 birds/MW/year (NWCC 2004). Pooling bird fatality estimates across 2011 and 2012 provides a mean of 6.8 birds/MW/year (assuming no bird fatalities for the remainder of the sampling period through February 2013, which is likely).

We found that passerine birds comprised only 5% of the wildlife (66% of birds) that fatally collided with the turbine, despite a review that reports passerine birds are among the most frequently (78%) reported wildlife fatalities at wind-energy facilities in the eastern United States (Erickson et al. 2001). However, since Erickson et al. (2001) was published, monitoring of bat fatalities at wind turbine facilities has garnered more attention and evidence indicates that bats comprise the majority of wildlife colliding with wind turbines (Kunz et al. 2007b). For example, when bat carcasses are also monitored, passerine birds comprise only 11% of the wildlife fatalities (33% of bird) based on three years of monitoring at the JAWF. Thus, the mortality of migratory passerine birds in particular is relatively low compared to other wildlife.

All of the birds observed colliding with the turbine or carcasses we found were of migratory species. However, there is considerable uncertainty as to whether birds were actively migrating at the time of collision. We are uncertain as to whether the Osprey collision we detected was a migrating or breeding individual because it occurred during April; a time when both breeding and migrating individuals co-occur in the area (Poole et al. 2002). Similarly, both sparrow species collisions temporally overlapped with migration and breeding, or wintering periods.

Consistent with 2011 results, we identified 4 key findings that are similar to other bat fatality studies at wind-energy facilities reviewed by Arnett et al. (2008): 1) estimated fatality rates were relatively-high compared to other facilities, 2) fatalities were heavily skewed toward migratory foliage-roosting lasiurine species, 3) the peak of collisions occurred in midsummer through fall, and 4) the distribution of fatalities declined as a function of distance from the turbine and was largely restricted to the rotor swept area. Our estimate of 55.6 bats/MW during the 8-month study period in 2012 is similar to our revised 2011 estimate of 55.0 bats/MW/year, yet almost twice that of the average ± SD estimate of 30.1 ± 13.5 bats/MW/year among six other wind-energy facilities in the eastern U.S. (Arnett et al. 2008), and the rate of 30.7 bats/MW/year at the JAWF. Our 2012 estimate precludes potential mortalities that would have likely occurred had the turbine been in operation during July, the peak month for bat mortalities during 2011. Eastern red bat, which is a migratory foliage-roosting species, was the dominant bat species;

consistent with Arnett et al. (2008) and one of the only two bat species found at the JAWF. We found that the resident tree-roosting big brown bat (5.4%) and tri-colored bat (2.7%) made up for a small proportion of bat fatalities. The majority of bat fatalities occurred during the mid-summer to mid-fall period corresponding with the southward post-breeding migratory movements of bats (Arnett et al. 2008, Johnson 2004). We estimate that 91% of bat fatalities occurred during this same time period. Similarly, 87% of bat fatalities occurred during August and September at the JAWF. Finally, the distribution of fatalities as a function of distance from turbines suggests that nearly all bat fatalities occur within the radius of the turbine blades (Arnett et al. 2008). Similarly, all bats that we found were within the radius of the rotor swept area.

By pooling data across years, our average detection probability within 5 m of the search transect is 78%, which leads to an overall carcass detection rate of 51% across years. This is greater than the regional average of 36% ± 8% reported by Arnett et al. (2008). This is likely because we restricted our search area to more open strata (i.e., bare ground and low grass) where detection of carcasses is better. We also had a shorter search interval (i.e., daily) throughout most of the study period compared to other studies (i.e., weekly or greater search intervals) and were therefore able to find carcasses before scavengers removed them.

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Appendix A. Parameter values used in estimation of fatality rates.

Parameter	Value		
	Birds	Bats	Combined
Observed fatality rate (fatalities/day)			
$o_{overall}$	0.015	0.131	0.146
o_{spring}	0.026	0.013	0.039
o_{summer}	0	0.033	0.033
o_{fall}	0.011	0.261	0.272
Daily carcass survival rate (proportion of carcasses remaining for one day)			
r			0.78
Carcass detection rate (proportion of available carcasses found)			
D			0.51
Search area adjustment			
A			1.70