BAT RISK ASSESSMENT

Project Icebreaker in Lake Erie

Cuyahoga County, Ohio

Report Prepared for:

Lake Erie Energy Development Corporation (LEEDCo)

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Executive summary

This report analyzes the potential risk to bats from the six-turbine Project Icebreaker, a demonstration wind-energy project proposed for the waters 11-16 kilometers (km) (7-10 miles) off of Cleveland, Ohio. Turbines would have an 87.5-meter (m) (287-foot) tubular steel tower on which a rotor of 120 m (394 feet) in diameter would be mounted. Rotors would sweep from a maximum height of 147.5 m (484 feet) to a minimum height of 27.5 m (90 feet) above the lake, making a rotor swept area of 11,310 m^2. Each turbine would generate a nameplate capacity of 3.0 megawatts (MW). Lighting on turbines has not yet been determined, but this analysis is based on L-864, red-strobe obstruction lights mounted on nacelles, as generally required by the Federal Aviation Administration (FAA) for wind turbines. A docking platform would be constructed at the base of each turbine to allow maintenance crews to access the turbines.

This risk assessment is based on a bat acoustic study conducted at a the Cleveland Crib (the "Crib"), an offshore structure located close to the Project Icebreaker site, reviews of numerous studies in North America on the impacts of onshore wind turbines on bats, studies of bat interactions with offshore wind turbines in Europe, and a recent synthesis on the potential for bat interactions with offshore wind farms produced for the Bureau of Ocean Energy Management (BOEM).

Relatively small numbers (as compared to onshore turbines) of mainly migratory bats are likely to encounter the Project Icebreaker turbines when they migrate across Lake Erie, mostly on calm or low-wind nights in August-September, when bat activity offshore was found to peak at the Crib. Those bats will be at risk of collision (or related barotrauma) if they forage around, or roost at, the turbines. In other words, from a population perspective, very few bats will encounter the Project Icebreaker turbines, but those that fly around the rotors in pursuit of insects or attempt to roost at the turbines may be at higher risk of mortality.

It is also conceivable that small numbers of bats residing along the lakeshore in summer may forage at the Project Icebreaker turbines when weather conditions permit, but their abundance and frequency of occurrence among the turbines is likely to be low given that bat activity offshore at the Crib in summer was relatively low, and better foraging opportunities are likely to be found along the lakeshore, where insects are known to concentrate. Thus, it is unlikely that many bats will fly 11+ km (7+ miles) offshore to forage when there is ample or greater forage close to the shoreline, and where lower winds would be more conducive to foraging than offshore.

Given that Project Icebreaker is a pilot project, post-construction studies will provide a valuable opportunity to study bat interactions with offshore turbines, thereby helping to ensure responsible development of offshore wind energy on large inland lakes, and perhaps ocean-based sites, in North America.

Introduction

This report analyzes the potential risk to bats from Project Icebreaker, a demonstration wind-energy project proposed for the waters off of Cleveland, Ohio. This risk assessment is based on a bat acoustic study conducted offshore near the Project Icebreaker site (Svedlow et al. 2012), reviews of numerous studies in North America on the effects of onshore wind farms on bats (Kunz et al. 2007, Arnett et al. 2008, Hein et al. 2013), a landmark study of bat interactions with offshore wind turbines in Europe (Ahlén et al. 2007, 2009), and a recent synthesis on the potential for bat interactions with offshore wind farms (Pelletier et al. 2013) produced for BOEM.

Our method was to: (1) profile the bat community that is expected to occur at the Project Icebreaker site, (2) summarize the literature on bat interactions with onshore projects in North America and offshore projects in Europe, where offshore wind-energy development continues to be centered, and (3) overlay the bat profile with the literature's findings on likely effects. These data and information sources are the basis for the risk assessment for Project Icebreaker and for recommendations for minimizing impacts at Project Icebreaker and other potential offshore wind projects in the Great Lakes.

Offshore wind-energy development is still almost entirely a European phenomenon. Presently, 96% of the world's 5,600 MW of installed generating capacity in offshore environments is located in ten European countries[1]. In addition, many more offshore projects have been approved or are under consideration in Europe, Asia, and North America. To date, only two projects have been permitted in North America: Cape Wind off of Cape Cod, Massachusetts, and Fishermen's Energy off of New Jersey.

Project specifications

Project Icebreaker proposes to construct six turbines approximately 11-16 km (7-10 miles) from the lakeshore (Fig. 1) in waters averaging about 20 m in depth. Turbines would have an 87.5-m (287-foot) tubular steel tower on which a rotor of 120 m (394 feet) in diameter would be mounted. Rotors would sweep from a maximum height of 147.5 m (484 feet) to a minimum height of 27.5 m (90 feet) above the lake, making a rotor swept area of 11,310 m^2. Each turbine would generate a nameplate capacity of 3.0 megawatts (MW), giving Project Icebreaker a capacity of 18 MW at peak production.

Lighting on turbines has not yet been determined, but this analysis is based on L-864, red-strobe obstruction lights mounted on nacelles, as generally required by the Federal Aviation Administration (FAA) for wind turbines. A docking platform would be constructed at the base of each turbine to allow maintenance crews to access the turbines. BOEM is presently developing best practices for lighting at offshore wind plants. The authors of this report, John Guarnaccia and Paul Kerlinger of Curry & Kerlinger, LLC, conducted the literature search for BOEM and recommended best avian and bat safety practices vis-à-vis lighting. The best practices to be published by BOEM should be evaluated for adoption for Project Icebreaker. As

[1] http://www.lorc.dk/offshore-wind-farms-map/statistics/installed-capacity/countries.

will be noted below, aviation obstruction lighting on wind turbines has been found not to influence bat mortality (Arnett et al. 2008).

Figure 1. Proposed turbine locations (provided by LEEDCo)

Profile of bat use of Project Icebreaker site

Harvey et al. (2011) show the ranges of ten species of bats as extending into northern Ohio (Table 1). Three of those species – Eastern Red Bat, Hoary Bat, and Silver-haired Bat – are considered migratory, because they are known to migrate relatively long distances between summer and winter habitats (Harvey et al. 2011). This is an important consideration, because bat fatalities at wind turbines appear to be heavily skewed to these and other migratory species (Kunz et al. 2007, Arnett et al. 2008). The other species are mostly considered hibernating species, because they spend the winter in caves and abandoned mines, where they reduce their metabolism to survive the winter without food (Harvey et al. 2011).

Table 1. Status and abundance of bats with ranges that include northern Ohio[1]

Species[1]	Hibernating or migratory?[1]	Federal status[1]	Ohio status[2]	Reported in Atlas of Mammals of Ontario (number of records near Lake Erie)[3]	Recorded at Cleveland lakeshore[4]	Recorded offshore at Cleveland Crib[4]
Big Brown Bat (*Eptesicus fuscus*)	Hibernating		SC	Yes (140)	Yes	Yes
Eastern Red Bat (*Lasiurus borealis*)	Migratory		SC	Yes (63)	Yes	Yes
Hoary Bat (*Lasiurus cinereus*)	Migratory		SC	Yes (53)	Yes	Yes
Evening Bat (*Nycticeius humeralis*)	Some Migrate		SI	Yes (1)		
Tricolored Bat (*Perimyotis subflavus*)	Hibernating		SC	Yes (7)	Yes	Yes
Silver-haired Bat (*Lasionycteria noctivagens*)	Migratory		SC	Yes (31)	Yes	Yes
Eastern Small-footed Bat (*Myotis leibii*)	Hibernating	SC	SC	Yes (9)		
Little Brown Bat (*Myotis lucifugus*)	Hibernating		SC	Yes (52)	Yes	Yes
Northern Long-eared Bat (*Myotis septentrionalis*)	Hibernating		SC	Yes (8)		
Indiana Bat (*Myotis sodalis*)	Hibernating	END	END	No		

[1] Ranges, type (hibernating or migratory), and federal status from Harvey et al. 2011; END = Endangered, SC = Special Concern.
[2] http://www.dnr.state.oh.us; END = Endangered, SC = Special Concern, and SI = Special Interest.
[3] Dobbyn 1994
[4] Svedlow et al. 2012

Indiana Bat is federally listed as endangered, and Eastern Small-footed Bat is federally listed as special concern (Harvey et al 2011). Indiana Bat is also listed as endangered in Ohio. The other bat species are listed as special concern in Ohio, except for Evening Bat, which is listed as special interest (Table 1).

Across Lake Erie to the north in Ontario, Dobbyn (1994) in the Atlas of Mammals of Ontario showed all of the bats listed in Table 1 as occurring in the province, except Indiana Bat. Bat abundance in Ontario is an important consideration because the frequency in which Lake Erie is crossed in migration may be directly related to that abundance. The Atlas indicated the abundance of the various species of bats by the number of 10-km by 10-km squares in which each species was recorded in the seven 100-km by 100-km atlas blocks that included Lake Erie. These data showed that Big Brown Bat, Eastern Red Bat, Hoary Bat, Silver-haired Bat, and Little Brown Bat were relatively abundant in southern Ontario, while Evening Bat, Tricolored Bat, Eastern Small-footed Bat, and Northern Long-eared Bat were relatively scarce (Table 1).

A similar atlas project has not been conducted in Ohio. Thus, the literature does not indicate the relative abundance of bat species occurring in northern Ohio for the bat species that occur in that part of the state (for Indiana Bat, see below). The section that follows, however, details a study conducted specifically for Project Icebreaker that quantified bat abundance above the waters off of Cleveland as well as along the lakeshore.

Bat acoustic study

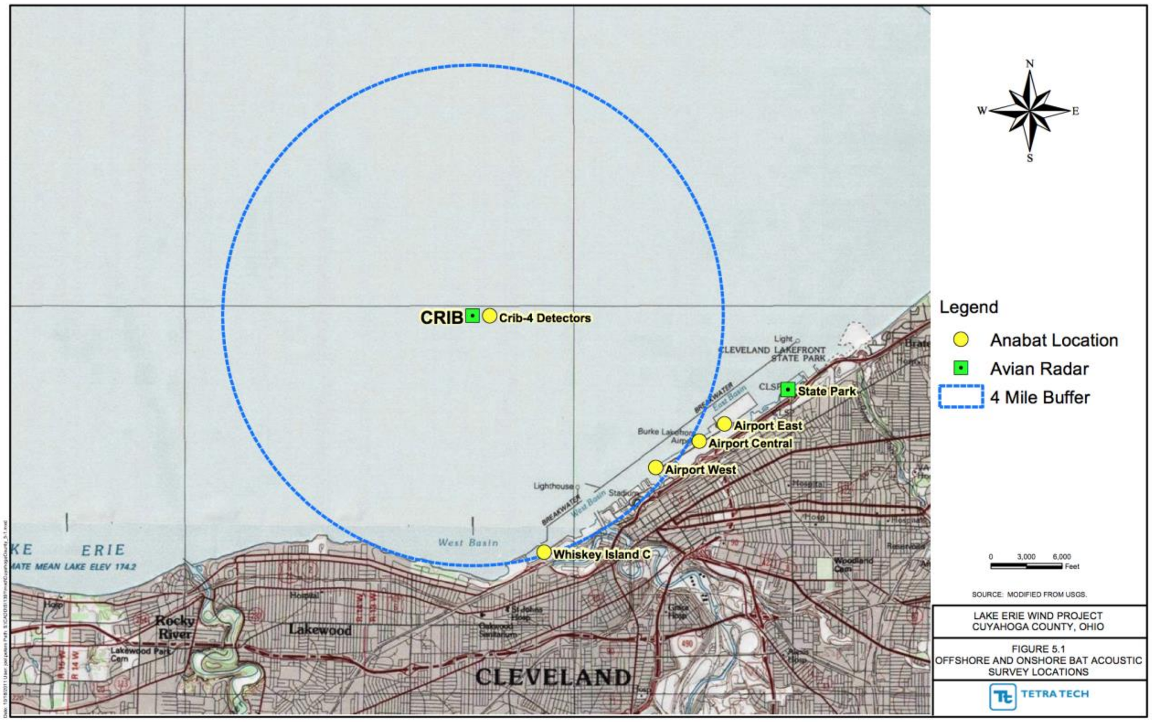
Tetra Tech (Svedlow et al. 2012) used Anabat SD-1 acoustic bat detectors to quantify bat use of the waters off of Cleveland as well as along the lakeshore. Detectors were deployed on 225 nights from 1 April to 10 November 2010. They operated from about 45 minutes before sunset to about 45 minutes after sunrise each day.

Four detectors were placed on the Cleveland Crib, located about 6.4 km (4 miles) from the lakeshore (Fig. 2). Thus, the bat acoustic study did not specifically include the waters where Project Icebreaker would be located (which would be slightly farther offshore and to the east of the Crib), but it did provide general data on the bat use that would be expected to occur within the Project Icebreaker area.

Options for locating acoustic detectors on the Crib were limited, and as a result, two acoustic detectors were placed at 50 m above the surface of the lake and two at 35 m above the surface of the lake. Four detectors were also placed along the lakeshore in separate locations at Whiskey Island, Burke Lakefront Airport, and Cleveland Lakefront State Park (Fig. 2).

Specialized software categorized recorded call sequences, in many cases to species (Table 2). In its report, Tetra Tech (Svedlow et al. 2012) reported relative abundance of bat species according to an Index of Activity (the number of minutes in which call sequences were recorded divided by the number of detector-nights times 100). Data was provided, however, to calculate another metric, bat passes/detector-night. In the discussion that follows, we report Tetra Tech's results as bat passes/detector-night (Table 2) because it allows comparison with a recent analysis (Hein et al. 2013) discussed below that explored the correlation between pre-construction bat activity and post-construction bat fatalities.

Figure 2. Locations of Anabat bat detectors in Tetra Tech study (from Svedlow et al. 2012)



Bat activity offshore at the Crib (mean of 3.7 passes/detector-night) was one tenth of that along the lakeshore (mean of 38.0 passes/detector-night). The same six species were recorded at the Crib and along the lakeshore (Table 1), but two migratory species, Hoary Bat and Eastern Red Bat, were better represented in offshore sampling than in onshore sampling. Svedlow et al. (2012) surmised that the majority of calls recorded offshore in the frequency range shared by Silver-haired Bat and Big Brown Bat were attributable to the migratory Silver-haired Bat. In fact, they classified calls in that frequency range recorded during 1 April-3 May 2010 offshore to Silver-haired Bat.

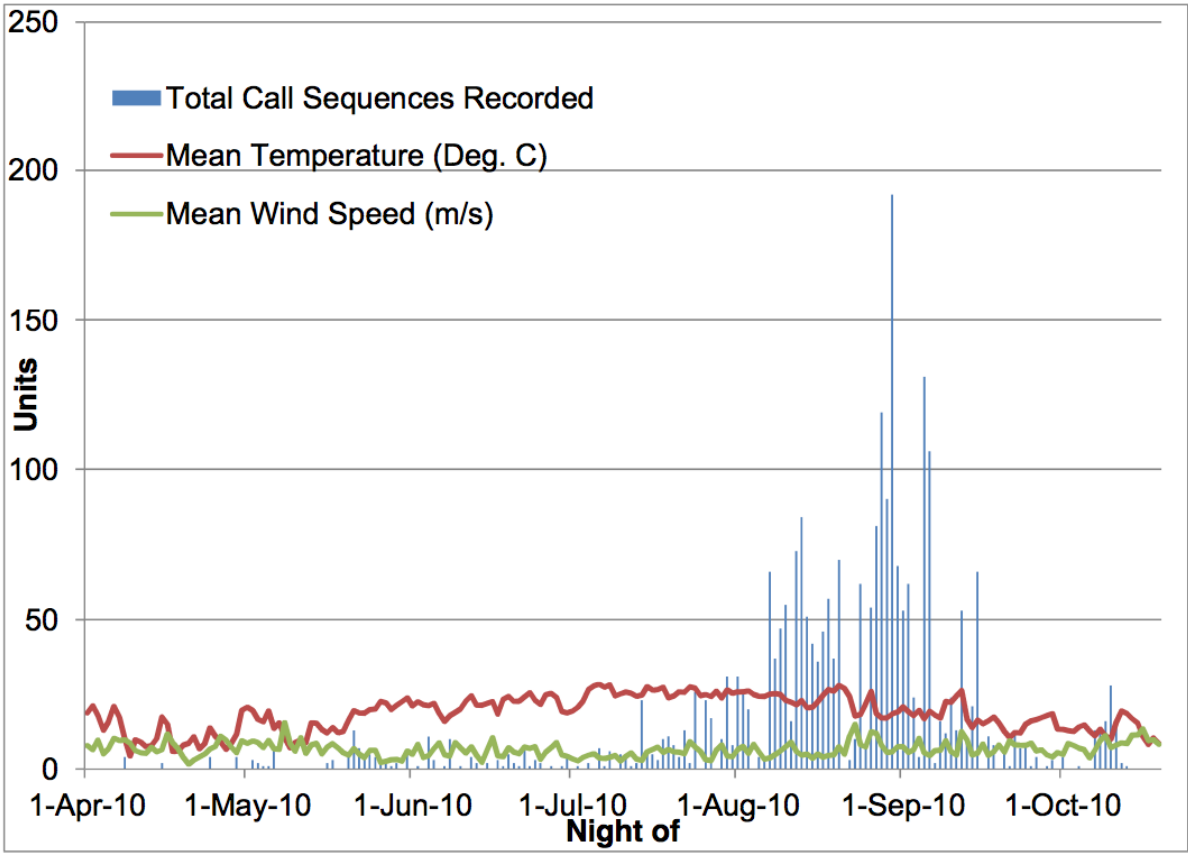
Calls attributable to *Myotis* bats made up a very small percentage of calls recorded offshore or along the lakeshore (Table 2). We concur with Svedlow et al. (2012) that Indiana Bat (*Myotis sodalis*) is unlikely to occur in the vicinity of Project Icebreaker. Suitable forested habitat for maternity colonies does not occur in Cleveland, and no hibernaculum is known in Cuyahoga County. Indiana Bat was not recorded in the Atlas of Mammals of Ontario (Dobbyn 1994), and it appears to be scarce in Michigan, where the U.S. Fish and Wildlife Service (hereafter, Service) showed only one hibernaculum with 20 individuals in 2001-2005 (Service 2007). Thus, the likelihood of Indiana Bats occurring north of Project Icebreaker and attempting lake crossings to migrate to a hibernaculum is nil. Thus, it is highly unlikely that Indiana bats are found offshore in Lake Erie near the Project Icebreaker site.

Table 2. Results of bat acoustic study at Crib (offshore) and along lakeshore (onshore) (from Svedlow et al. 2012)

Metrics	**Offshore**	**Onshore**
# call sequences (i.e., passes)	2,627	32,693
# detector-nights	714	860
Mean bat passes/detector-night	3.7	38.0
Call sequence categorization and probable species	**Offshore**	**Onshore**
Hoary Bat	18.9%	5.0%
Big Brown Bat		0.1%
Silver-haired Bat	1.8%	2.5%
Silver-haired Bat/Big Brown Bat	15.0%	75.8%
Unknown middle frequency call sequence	0.3%	0.1%
Eastern Red Bat	60.1%	14.2%
Tricolored Bat	0.3%	0.3%
Little Brown Bat/*Myotis* sp.	3.4%	2.0%
Unknown high frequency call sequence	0.1%	0.1%
	100.0%	100.0%

Bat activity at the Crib was generally very low from 1 April to mid July, when detections began to increase. However, there was a marked peak in bat activity from early August to mid September, when >50 call sequences were recorded on 20 nights (Fig. 3). This level of calling is minimal as compared to the Cleveland and other onshore sites. Svedlow et al. (2012) reported no significant correlations between weather variables and nightly call rates, which is what would be expected given the small number of calls recorded.

Figure 3. Total number of offshore call sequences, mean temperature, and mean wind speed during date range sampled at Crib by Tetra Tech (from Svedlow et al. 2012)



Other bat studies in the Lake Erie Basin

Long Point is a peninsula in Ontario that extends about 30 km (18.6 miles) into Lake Erie. It is located about 170 km (106 miles) northeast of Project Icebreaker. In their literature review on the potential for bat interactions with offshore turbines, Pelletier et al. (2013) highlighted anecdotal and survey evidence of bat presence at Long Point as an indication of the propensity of bats to migrate over water barriers.

Seven of the ten species with ranges that extended into northern Ohio (Table 1) were recorded at Long Point in June and August by Dzal et al. (2009, cited by Pelletier et al. 2013). These were the six species recorded in the Tetra Tech study (Svedlow et al. 2012; see above) plus Northern Long-eared Bat, a relatively scarce species based on data presented by Dobbyn (1994).

That bats migrate across Lake Erie was confirmed in a study that McGuire et al. (2012, cited by Pelletier et al. 2013) conducted at Long Point. They placed radio transmitters on 30 Silver-haired Bats in August-September. Migration was found to occur in two waves, in late August and in mid September, and stopover duration was only 1-2 days. Departure directions from Long Point were recorded for 24 of the individuals under study. Eight (30%) departed along the lakeshore in a westerly direction, four (20%) along the lakeshore in an easterly direction, and 12 (50%) over the lake, where the minimum crossing distance was 38 km (23.6 miles).

Summary of bat profile at Project Icebreaker site

Bat activity at the Project Icebreaker site is expected to be low as an acoustic study at the Cleveland Crib showed activity to be one tenth that of activity along the lakeshore (Svedlow et al. 2012). In this regard, offshore bat activity at the Project Icebreaker site itself may be lower still as aviation and ship warning lights on the Crib probably attracted insects that in turn attracted bats to feed on them. Insect attraction was also suggested in a marine radar study that Tetra Tech (Svedlow et al. 2012) conducted at the Crib to assess nocturnal bird and bat migration (see Kerlinger and Guarnaccia 2013).

Six species of bats are likely to occur at the Project Icebreaker site. Acoustic data (Svedlow et al. 2012) showed that the migratory species (Eastern Red Bat, Hoary Bat, and Silver-haired Bat) were much more abundant in the offshore environment than the hibernating species (Big Brown Bat, Tricolored Bat, and Little Brown Bat), with as much as 95% of calls attributable to the migratory species (Table 2). Of the migratory species, Eastern Red Bat was particularly abundant at the Crib, with about 60% of calls attributable to it (Table 2).

Bats were present at the Crib from early April to mid October (Fig. 2). Their abundance was generally low in spring, summer, and late fall, but it peaked from early August to mid September. This peak coincided with the period when bat migration is known to occur both generally (Kunz et al. 2007, Arnett et al. 2008) and across Lake Erie (McGuire et al. 2012). Outside of the migration season, bats recorded at the Crib may have been lakeshore residents that foraged offshore. Data indicated, however, that relatively few bats foraged as far offshore as the Crib, which is closer to shore than the proposed Project Icebreaker.

There is no evidence that the endangered Indiana Bat migrates across Lake Erie or is likely to forage in the offshore waters near Project Icebreaker. The species is not as migratory and does not generally migrate as far as the various tree bats, such as Red and Hoary. Indiana Bat was not known in Ontario when Dobbyn (1994) produced the mammal atlas for that province, and it is scarce in Michigan (Service 2007). Thus, there appear to be no Indiana Bats breeding north of Lake Erie, and as a consequence, no biological reason to cross the lake. There is a record of one maternal colony in Cuyahoga County (Service 2007), but mature forest of enough quality for a maternal colony appears to be entirely absent from the lakeshore region near Project Icebreaker. Thus, it appears unlikely that Indiana Bats breed close enough to the lake near Project Icebreaker to forage offshore with any frequency, and they were not identified in the acoustic survey in 2010 (Svedlow et al. 2012). They are, in all likelihood, absent from the Project Icebreaker site.

The six bat species recorded in the acoustic study are listed as special-concern in Ohio (Table 1), however. Of them, the three migratory species appear the most likely to come into contact with the Project Icebreaker turbines.

Literature review of risk to bats at wind-energy projects

In this section, first we summarize what is known about bat risk at onshore wind-energy projects in North America. Our primary sources are comprehensive reviews (Kunz et al. 2007, Arnett et al. 2008, Hein et al. 2013). Then we examine what has been learned about bat risk at offshore projects in Europe, where offshore wind energy has had the longest track record and has been studied in detail (Ahlén et al. 2007, 2009).

Onshore studies in North America

In their review of the ecological impacts of wind energy development on bats, Kunz et al. (2007) focused exclusively on collision mortality. This was because bat mortality estimates were much greater than bird mortality estimates at some sites, particularly where turbines were constructed along the tops of forested ridgelines in the eastern U.S. At those sites, bat mortality was found to range between 15.3 and 41.1 bats/MW/year (Kunz et al. 2007). In comparison, bird mortality at ridgeline wind farms in Appalachia was found to range between 2.7 and 7.2 birds/MW/year (National Research Council 2007).

Kunz et al. (2007) did not examine displacement impacts (such as loss of breeding habitat as a result of turbine construction or presence), which have been a focus of avian research at wind farms. Displacement impacts have recently received attention in a draft Habitat Conservation Plan (Stantec 2012) for the Indiana Bat at the Buckeye Wind Power Project in Champaign County, Ohio. We do not examine displacement impacts in this risk assessment, because there is no existing breeding, maternity, roosting, or hibernating habitat at or in the vicinity of the offshore Project Icebreaker.

In their review and analysis of patterns of bat fatalities at wind-energy facilities in North America, Arnett et al. (2008: 69) identified what they considered to be five unifying patterns in the 21 post-construction fatality studies that they reviewed (verbatim text follows):

> 1) Fatalities were heavily skewed toward migratory bats and were dominated by lasiurine species in most studies, 2) studies consistently reported peak of turbine collision fatality in midsummer through fall from all studies in North America, 3) fatalities were not concentrated at individual turbines (i.e., fatalities were distributed among turbines at facilities), and current studies have not identified consistent relationships with habitat variables (e.g., distance to water), 4) red-strobe lights recommended by the FAA did not influence bat fatality, and 5) bat fatalities were highest during periods of low wind speed, and they were related to weather variables associated with the passage of weather fronts. These patterns generally were consistent with findings reported from [onshore] wind facilities in Europe (Dürr and Bach 2004, Brinkmann 2006).

Kunz et al. (2007: 321) formulated 11 hypotheses to explain "where, when, how, and why insectivorous bats are killed at wind energy facilities" (verbatim text follows):

- **Linear corridor hypothesis.** Wind energy facilities constructed along forested ridgetops create clearings with linear landscapes that are attractive to bats.
- **Roost attraction hypothesis.** Wind turbines attract bats because they are perceived as potential roosts.
- **Landscape attraction hypothesis.** Bats feed on insects that are attracted to the altered landscapes that commonly surround wind turbines.
- **Low wind velocity hypothesis.** Fatalities of feeding and migrating bats are highest during periods of low wind velocity.
- **Heat attraction hypothesis.** Flying insects upon which bats feed are attracted to the heat produced by nacelles of wind turbines.
- **Acoustic attraction hypothesis.** Bats are attracted to audible and/or ultrasonic sound produced by wind turbines.
- **Visual attraction hypothesis.** Nocturnal insects are visually attracted to wind turbines.
- **Echolocation failure hypothesis.** Bats cannot acoustically detect moving turbine blades or miscalculate rotor velocity.
- **Electromagnetic field disorientation hypothesis.** Wind turbines produce complex electromagnetic fields, causing bats to become disoriented.
- **Decompression hypothesis.** Rapid pressure changes cause internal injuries and/or disorient bats while foraging or migrating in proximity to wind turbines.
- **Thermal inversion hypothesis.** Thermal inversions create dense fog in cool valleys, concentrating both bats and insects on ridgetops.

The linear corridor, landscape attraction, and thermal inversion hypotheses are not applicable to Project Icebreaker, because they are specific to ridgetops or landscapes. The other hypotheses may apply in some instances in offshore environments. Of particular interest is the roost attraction hypothesis, which was confirmed offshore in Europe, when service technicians found bats roosting in the nacelles of wind turbines located 5.8 km (3.6 miles) offshore (Ahlén et al. 2009).

With respect to the heat attraction and visual attraction hypotheses, midges (*Chironomus plumosus*) are famous for their invasions of the shores of Lake Erie, including being credited for beating the New York Yankees in the playoffs, when a Yankee pitcher was distracted enough by midges to throw two wild pitches in the deciding game[2]. They are among many insects that

[2] http://cleveland.about.com/od/livingincleveland/f/midges.htm.

emerge from the lake during different seasons. When there are large emergences of insects, it is reasonable to expect that bats would find food everywhere and not be attracted to turbines specifically.

Hein et al. (2013) recently examined the correlation between pre-construction bat activity and post-construction bat fatalities in an attempt to predict risk at onshore wind-energy facilities. They reviewed pre-construction bat activity studies at 92 sites and post-construction bat fatality studies at 75 sites, limiting studies to the United States and Canada and analyzing them by four regions, including the Midwest (Table 3). The post-construction studies used by Hein et al. included carcass removal and searcher efficiency trials in their estimates.

Overall mean activity was 10.52 bat passes/detector-night (95% CI: 5.98-15.07), but at most of the 92 sites, activity rates were below this mean (Hein et al. 2013). The highest activity rates occurred in the Eastern Forest Region, with 141.70 passes/detector-night recorded at one site (Table 3). Activity rates in 31 Midwest sites averaged 7.29 passes/detector-night and ranged from 0.73 to 33.88 passes/detector-night (Table 3).

Overall mean bat mortality at 75 sites was 5.71 bats/MW (95% CI: 3.91-7.52), and the distribution of fatalities was more varied among the Eastern Forest and Midwest regions, with fatalities >15 bats/MW at several sites (Hein et al. 2013). The Midwest region had a slightly greater mean fatality rate than the Eastern Forest region, but both regions showed similar high and variable fatality estimates compared with other regions (Hein et al. 2013).

Twelve sites had paired data (i.e., both pre-construction activity and post-construction fatality studies). When Hein et al. (2013) examined them in a linear regression, the slope of the regression line was not significantly different from zero ($F1,10 = 4.06$; $p = 0.072$). Only a small portion of the variation in fatalities was explained by activity (adj. $R^2 = 21.8\%$). The 95% prediction intervals for this relationship indicated that, given currently available data, acoustic data gathered prior to construction does not accurately predict bat fatality.

Table 3. Summary statistics for pre-construction activity and post-construction mortality studies reported by Hein et al. (2013)

		Bat activity (passes/detector-night)				Bat fatality (bats/MW)		
Region	**# Pre-construction Sites**	**Mean**	**Median**	**Minimum-Maximum**	**# Post-construction Sites**	**Mean**	**Median**	**Minimum-Maximum**
Great Basin/Southwest Open Range-Desert (Basin-Desert)	22	10.69	4.49	0.02-77.14	28	1.29	1.17	0.12-3.92
Great Plains (Great Plains)	24	4.19	2.22	0.15-17.45	15	3.07	2.15	0.12-10.85
Northeastern Deciduous Forest (Eastern Forest)	15	25.20	6.40	1.24-141.70	19	9.49	4.67	1.11-35.62
Midwestern Deciduous Forest-Agricultural (Midwest)	31	7.29	5.15	0.73-33.88	13	12.75	8.72	2.46-32.00

Offshore studies in Europe and North America

Despite the large number of offshore wind farms in Europe, there have been few studies of bat interactions with offshore wind turbines (Pelletier et al. 2013). The most comprehensive study has been that of Ahlén et al. (2007, 2009), who used radar, visual (using spotlights and thermal imaging cameras at night), and acoustic surveys to study activity patterns of bats at the seven-turbine Utgrunden wind farm and nearby lighthouse. Utgrunden is situated in the middle of the southern Kalmar Sound off of Sweden. It is 8 km (5 miles) from the island of Öland and 12 km (7.5 miles) from the mainland. Ahlén et al. (2009) also used boats to study bat use of seascapes up to 14 km (8.7 miles) from shore.

Of the 18 bat species recorded in Sweden and 17 recorded in Denmark, Ahlén et al. (2007, 2009) observed 11 species out at sea and 14 at coastal take-off points. Few species were relatively abundant at sea, but one of them (*Pipistrellus pygmaeus*) was not known to be migratory before Ahlén et al. began their observations. It is worth noting that observations at sea in Kalmar Sound were about 10% of observations on land, which was the approximate proportion when offshore and onshore observations were compared between the Crib and Cleveland lakeshore (Svedlow et al. 2012; Table 2).

The findings of Ahlén et al. (2007, 2009) were as follows:

<u>Bats used consistent take-off points for over-water migration</u>: Bats concentrated at known take-off points on their southern (fall) migration and became less concentrated as they flew over the sea on different southerly headings or as they drifted with the wind. Not all bats departed departure points, however, and some species recorded at departure points were never found at sea. The northern (spring) migration, on the other hand, was much more dispersed, with landfall occurring anywhere.

<u>Patchy insect concentrations attracted bats to forage</u>: Wind turbines, boats, bridges, and lighthouses were found to concentrate insects. As a result, when weather conditions permitted (see below), migrating bats would sometimes pause to forage before continuing their migration, and resident, non-migrating bats would travel several kilometers over the sea to forage in specific areas and then return to land. In the Kalmar Sound, insects appeared to concentrate consistently in some sea areas, which were regularly used as feeding grounds by bats, but in many other areas, insect abundance was too low to attract foraging bats. Marine chironomids was one insect group singled out by Ahlén et al. Chironomids (i.e., midges) are a regularly superabundant species group in Lake Erie (see above).

<u>Calm or light winds were required for most bats to fly across the sea or forage at sea</u>: The majority of bats flew across the sea only in calm or light winds. Larger species were more wind tolerant, but all species preferred relatively calm conditions. Bats seldom departed coasts when winds exceeded 10 meters per second (m/s) (22.4 miles per hour [mph]), and most activity at sea was found to occur with winds under 5 m/s (11.2 mph). The most intense hunting was observed with winds close to 0 m/s (0 mph) and no waves, when insects were more abundant around the higher parts of the wind turbines.

Bats flew at low altitudes when migrating over the sea: All migrating bats observed over the sea with spotlights, thermal imaging cameras, and radar (only the large *Nyctalus noctula* could be observed with radar) flew at relatively low altitudes, generally <10 m (33 feet), including the normally high-flying *N. noctula*. Nonetheless, a few *N. noctula* were recorded at >40 m (131 feet) above the sea surface. One of the authors of this report (P. Kerlinger) has anecdotally observed Eastern Red Bats flying low over the surface of the Atlantic Ocean during the day when far from land.

Bats changed altitude rapidly near vertical structures: Observations made at night with spotlights, thermal imaging cameras, and radar showed that bats changed altitude quickly when near ships, bridges, lighthouses, and wind turbines. *N. noctula* was found to move from low over the water surface to the top of a nearby wind turbine within minutes. Observations at the Cleveland Crib, where acoustic detectors were affixed at 35 m and 50 m above the lake surface (Svedlow et al. 2012), are consistent with this finding.

At Utgrunden lighthouse, bats avoided the area around the lighthouse when marine surveillance (navigation) radar was turned on, supporting a similar finding of Nicholls and Racey (2007), but the extent of this avoidance was not mentioned nor studied empirically. It should be noted that, during the bat acoustic study at the Crib, Svedlow et al. (2012) were also using marine surveillance radar to study nocturnal bird migration.

Bats roosted on structures at sea, including wind turbines: Bats were found to roost at wind turbines and on ships, and Ahlén et al. also surmised that they probably also roosted on bridges and lighthouses. Wind turbine technicians found bats roosting in the nacelles of wind turbines located 5.8 km (3.6 miles) offshore, where they were present for several days and foraged around the turbines. Some of the bats that flew around turbines were recorded emitting territorial or mating calls.

Based on these findings, Ahlén et al. (2007, 2009) concluded that bats were at greatest risk of collision with wind turbines at low wind speeds, when insects would gather around turbines and attract bats to feed. Another potential risk was electrocution of bats roosting inside nacelles.

The findings and conclusions of Ahlén et al. (2007, 2009) cover most of those of Pelletier et al. (2013), who conducted a literature review on the potential for bat interactions with offshore wind turbines for BOEM. Pelletier et al. (2013) posited that the attraction of bats to wind turbines that has been suggested onshore (see the hypotheses of Kunz et al. 2007 above) might be exaggerated offshore, where turbines would present a considerable contrast to the surrounding water. The concern over long-distance visual attraction that Pelletier et al. (2013: 4) voiced is possible for bats over the ocean far from land, where bats moving during the day might see wind turbines in the distance and be attracted to them. However, visual attraction is probably negated to a large extent in Lake Erie, where the distance across the lake can easily be traversed in a few hours and land can be seen at great distances from the altitudes at which bats likely migrate. In other words, bats departing the north shore of Lake Erie at night are likely to have crossed the lake and be in terrestrial habitats on the south shore before dawn and before wind turbines would become readily apparent at long distances as roosting sites.

Pelletier et al. (2013) also compared acoustic studies conducted at inland, coastal, and offshore locations primarily in Maine. They found that bats were active offshore at least as far out at their most remote detector was deployed, which was 28 km (17 miles) from the coast. They also found that migratory bats were about equally likely to be recorded offshore as at coastal and inland sites, but non-migratory bats were substantially less likely to be recorded at offshore sites relative to observed levels of activity at coastal and inland sites. Nonetheless, both migratory and non-migratory bats had a 20% likelihood of detection at offshore acoustic recorders. This means that the risk of collisions with offshore wind is not limited to migratory bats. Data were not sufficient to compare activity levels in the inland, coastal, and offshore zones.

Bat and bird collisions at offshore wind turbines are difficult to document, but Desholm (2006) experimented with a Thermal Animal Detection System (TADS) to detect bird and bat collisions at the Nysted wind farm in Denmark. The TADS unit consisted of a thermal video camera housed in weatherproof, corrosion-resistant box fastened to the base of a turbine. Given the low resolution of thermal images, a telephoto lens was required to capture passerine migrants and bats. This, however, limited the field of view to one third of the rotor-swept area (RSA). Images were recorded on a computer inside the turbine only when a thermal image (bird or bat) passed within camera view, thereby saving countless hours of review of empty video. The system was connected via optic fiber cables to the mainland, where via the Internet, researchers could review the data.

Desholm may have documented a bat collision with one of the offshore turbines at Nysted. In 2,000 hours (83 days, or 0.23 years) of collision monitoring using TADS, 16 thermal-video sequences triggered by passing animals (many of them distant from the RSA) were recorded. Only one sequence proved to show a collision event involving a small bird or bat. The 15 non-collision sequences were ascribed to 10 birds or flocks of birds, two bats (based on flight style), one moth, and two birds or bats. The bat observations were considered noteworthy at the time, because bats were considered rare at sea (i.e., the work of Ahlén et al. had not yet been published). Desholm did not calculate the mortality rate implied by the single collision event recorded by TADS, but based on what he reported, it would calculate to approximately 1.5 birds or bats per turbine per year.

Bat risk assessment for Project Icebreaker

In this section, we overlay the bat profile developed for the Project Icebreaker site with the known risks to bats at onshore and offshore wind-energy facilities.

A study by Tetra Tech (Svedlow et al. 2012), conducted at the Crib, 3-4 miles closer to shore than the Project Icebreaker turbines would be located, demonstrated that bats occurred offshore from April until November, but abundance peaked in August and September. Six species occurred offshore (Table 1), with abundance greatest among the three species of migratory bats, particularly Eastern Red Bat (Table 2). Hibernating bats were relatively scarce offshore, but some species were detected. The most common of hibernating bats, Little Brown, was detected in only very small numbers offshore at the Crib.

Offshore bat activity at the Cleveland Crib (3.7 bat passes/detector-night) was one tenth of lakeshore activity (38.0 bat passes/detector-night) (Table 2). In the context of the review by Hein et al. (2013), Cleveland lakeshore activity exceeded the highest value reported for Midwest sites, but the Cleveland offshore activity was below the median and the mean for Midwest sites (Table 3). Offshore activity may have been inflated by insect attraction to lights on the Crib, but a concurrent marine radar study of nocturnal bird migration at the Crib may have also caused some bats to avoid the Crib. This is suggested by the finding of Ahlén et al. (2007), that bats avoided the area around Utgrunden lighthouse when navigation radar was in use, and by the research of Nicholls and Racey (2007). Nonetheless, the 1:10 activity ratio between offshore and onshore activity in Cleveland was similar to that found by Ahlén et al. (2007, 2009) in Sweden.

Ahlén et al. (2007, 2009) found migrating bats to concentrate at regularly used departure points, from which they dispersed over the water as bats took different southerly headings and drifted with the wind. This suggested flyways originating from departure points, but not well defined migration corridors across expanses of water. Not all bats departed departure points, however. This was also noted in a radio telemetry study at Long Point, Ontario, which found that half of a sample of 24 Silver-haired Bats departed to cross the lake in August-September, while the other half flew along the lakeshore to the east and west (McGuire et al. 2012).

Based on the topography of Lake Erie, northern departure points to cross the lake during fall migration would be, from west to east, Point Pelee, Rondeau Peninsula, and Long Point. Of them, Rondeau is the closest to the Project Icebreaker site, located about 80 km (50 miles) north. Thus, some migration across the lake in the vicinity of Project Icebreaker may be expected, but it would be scattered by the different headings that bats would fly on and by wind drift. As with any animals that fly slowly, lateral wind components that exceed air speeds can act to push them off course or make them follow different pathways (Kerlinger 1984, 1985, 1989). Nothing is known about orientation in relation to wind for bats, but we do know air speeds for bats are similar to those for small birds and, therefore, they would be no more able to correct for wind drift with higher wind speeds than birds.

With respect to spring migration, there are no funneling peninsulas along the southern lakeshore in the vicinity of Project Icebreaker. The closest would be Catawba Island and Marblehead, about 80 km (50 miles) to the west. Nonetheless, the acoustic study showed no increase in bat abundance during the spring period. It is also possible that some or most bats fly around Lake Erie in spring, rather than cross the lake.

When crossing Lake Erie, most bats may be expected to fly at relatively low altitudes. This is strongly suggested by research in the Kalmar Sound of Sweden, where most bats flew at altitudes of <10 m (<33 feet), including species that normally flew higher (Ahlén et al. 2007, 2009). That bats were recorded by acoustic detectors mounted at 35 m and 50 m above the lake surface at the Crib does not negate the expectation of low-altitude flight over the lake, because Swedish research also found that bats increased altitude when they came into contact with vertical structures.

Based on the Swedish research, the greatest frequency of lake crossings may be expected in low wind and calm conditions. Given the distance across Lake Erie, bats should easily make the crossing in one night – or in a few hours. Therefore, visual attraction of migrating bats to roost at turbines at Project Icebreaker is unlikely, given that bats will likely not be over the lake during daylight hours. Furthermore, red-flashing, aviation obstruction lighting on turbines has not been found to influence bat mortality at onshore turbines (Kerns and Kerlinger 2004, Arnett et al. 2008), probably because it does not attract bats.

On the other hand, migrating bats that happen to fly close to the Project Icebreaker turbines at night may forage near the turbines on insects that have been attracted to the turbines. This is strongly suggested by the research of Ahlén et al. (2007, 2009), who found that, when bats at sea encountered vertical structures, they increased their flight altitude rapidly, and in the case of wind turbines, foraged around nacelles and rotors. However, this attraction behavior may prove to be species or turbine-specific and may not occur at the Project Icebreaker turbines.

Based on the Swedish research, most migrating bats are likely to resume their migration after foraging at the Project Icebreaker turbines, but a small number may attempt to roost at the turbines. As noted above, bats were found to roost in the nacelles of offshore turbines in Sweden and could do so at Project Icebreaker, if they can gain access to the inside of the nacelles.

Small numbers of resident bats along the Cleveland lakeshore may forage at times at the Project Icebreaker turbines when weather conditions (i.e., calm or low winds) permit, but this would occur only if the turbines are found to be insect hotspots and bats discover them. Traveling 11 km (7 miles) to forage around offshore turbines does not seem likely, because the bat acoustic study at the Crib showed relatively little bat activity at the Crib during the summer months, as compared with shoreline activity, when bats would be in residence. Most importantly, bats are likely to find sufficient insects along the lakeshore and not need to travel farther, as chironomid invasions of the lakeshore would indicate. Also, there are other insects in abundance at the edge of Lake Erie, where there is shallow water and terrestrial habitat available for insects, as well as bat roosting/resting sites.

It appears improbable that Project Icebreaker would displace bats, given that the lake does not provide habitat for roosting or hibernating, and foraging habitat is abundant onshore. If anything, wind turbines at sea may attract bats either to forage on insects attracted to turbines or to roost at turbines, a behavior that has been documented at offshore turbines in Europe (Ahlén et al. 2009).

With respect to the endangered Indiana Bat, no collision impacts will likely occur as there is no evidence of migration across Lake Erie or of a resident population in the lakeshore region in the vicinity of Project Icebreaker. The likelihood of a collision is *de minimis*.

Conclusions and recommendations

Small numbers of mainly migratory bats are likely to encounter the Project Icebreaker turbines when they migrate across Lake Erie on calm or low-wind nights mainly in August-September, when bat activity offshore was found to peak. Those bats will be at some level of risk of collision or related barotrauma if they forage around, or roost at, the turbines.

It is also conceivable that small numbers of bats residing along the lakeshore in summer may forage at the Project Icebreaker turbines when weather conditions permit, but their abundance and frequency of occurrence among the turbines is likely to be low given that bat activity offshore in summer was relatively low, and better foraging opportunities are likely to be found along the lakeshore, where insects are known to concentrate. Thus, it is unlikely that many bats will fly 11+ km (7+ miles) offshore to forage when there is ample or greater forage close to the shoreline, and where the wind is likely to be less than offshore.

Given that it is a pilot project, Project Icebreaker provides a valuable opportunity to study bat interactions with offshore turbines, thereby helping to ensure responsible development of offshore wind energy on large inland lakes, and perhaps ocean-based sites, in North America.

Recommendations are as follows:

Pre-construction

- Summarized above, the Tetra Tech bat acoustic study conducted at the Cleveland Crib allows the bat activity there to be compared with dozens of onshore studies. In the context of other studies, bat activity at the Crib was low and indicative of low mortality levels. Nonetheless, Hein et al. (2013) have found that acoustic data gathered prior to construction is not an accurate predictor of bat fatality. Given that finding, further pre-construction study of offshore bat activity will not improve the assessment of potential risk at this demonstration project and is not recommended.

Construction

- Lighting of construction equipment (including work vessels), with exception of safety and FAA obstruction lights, should be kept to a minimum and extinguished at night to avoid attracting insects and bats if turbines are operating. If FAA lights are needed for turbines or cranes, they should be limited to red-flashing lights. Other safety lights should be used judiciously.

- Other lighting on turbines and other infrastructure should be minimal. Safety lights on turbines, the substation, and other infrastructure should be extinguished at night and only used when human safety is in question. U.S. Coast Guard navigation lights should be minimal and down-shielded to avoid attracting bats flying in the vicinity of the Project Icebreaker site. If work lights are needed on turbines or the substation, some consideration should be given to green or blue lights rather than white lighting.

Post-construction

- Project Icebreaker provides a valuable opportunity to study bat interactions with offshore turbines, advancing knowledge to assess cumulative impacts of multiple projects in the Great Lakes. In this regard, appropriate post-construction study methods and technologies should be evaluated.

- Nacelles should be regularly checked for roosting bats and secured so that bats cannot enter them and risk mortality or injury.

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