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March 22, 2018

Ms. Barcy F. McNeal, Secretary
Ohio Power Siting Board
Docketing Division
180 East Broad Street, 11th Floor
Columbus, Ohio 43215-3793

Re: Case No. 16-1871-EL-BGN, In the Matter of the Application of Icebreaker Windpower Inc. for a Certificate to Construct a Wind-Powered Electric Generation Facility in Cuyahoga County, Ohio.

Fourth Supplement to Application

Dear Ms. McNeal:

On February 1, 2017, as supplemented on March 13, July 20 and 24, and August 18, 2017, Icebreaker Windpower, Inc. ("Applicant") filed an application with the Ohio Power Siting Board ("Board") for a certificate of public convenience and necessity ("Application") to construct a six-turbine demonstration wind-powered electric generation facility in Lake Erie, off the shore of Cleveland, in Cuyahoga County, Ohio ("Project"). The Application was prepared in accordance with the requirements set forth in Ohio Administrative Code Chapter 4906-4.

As discussed below, the purpose of this Fourth Supplement to the Application is to provide information pertaining to wildlife in the Project area. **Attachment 1** to this Fourth Supplement is a table showing the information the Applicant has filed to date regarding avian and bat wildlife in the Project area, as well as the information the Applicant is providing today.

<u>Background</u>

As a preliminary matter, we note that nearly fourteen months have passed since the Applicant filed this Application. During that time, the Applicant has responded in a timely manner to requests for additional information. The Board found that the Application was in compliance with applicable laws and regulations in late July 2017, and the procedural schedule was established. Subsequently, the procedural process was suspended, pending the submission of additional information, which information has been provided by the Applicant. To date, the application process remains suspended and the Applicant's January 24, 2018 Motion to Reestablish the Procedural Schedule remains pending.

We note that the federal permitting process is proceeding on schedule. The Ohio Department of Natural Resources ("ODNR") and the Applicant have agreed to baseline radar and other monitoring studies,[1] and the United States Fish and Wildlife Service ("USFWS") has

[1] Avian and Bat Memorandum of Understanding ("MOU") (July 12, 2017). See Second Supp. to App. (July 20 and 24, 2017).

now concurred with the Applicant's approach to pre-construction radar and has stated that the Project's size and location minimize its risk.[2] Continued prolonged delays could irreparably harm the feasibility of the Project. Therefore, the Applicant respectfully requests that the Board grant the Applicant's January 24, 2018 Motion to Reestablish the Procedural Schedule as expeditiously as possible.

The Applicant is committed to safeguarding any wildlife in the Project area. To that end, the Applicant has provided thorough risk assessments based on both site-specific surveys and literature review that support a determination that the facility will have the minimum adverse environmental impact on birds, bats, fisheries, and aquatic resources "considering the state of available technology and the nature and economics of the various alternatives" in accordance with Ohio Revised Code Section 4906.10(A)(3). In addition, the Applicant has signed two Memoranda of Understanding with ODNR in which the Applicant has agreed to complete extensive baseline monitoring studies prior to construction, the results of which will be used for comparison with robust post-construction monitoring to determine any Project impacts on fish and wildlife.[3] These results will be used to inform any additional mitigation and/or adaptive management measures called for, in consultation with wildlife agencies and Project stakeholders.

<u>Fourth Supplemental Filing</u>

The purpose of this <u>Fourth Supplement</u> to the Application is threefold:

1. <u>Summary of Avian and Bat Risk Assessment</u>: **Attachment 2** to this Fourth Supplement is the March 20, 2018 Risk Assessment Summary ("Summary") by Western EcoSystems Technology, Inc. ("WEST"), which summarizes the information currently in the record that can be relied on to support a determination by the Board that the facility will have minimal adverse environmental impact on wildlife resources. The Summary identifies and lists the site-specific surveys referenced in WEST's November 29, 2016 Assessment of Risk to Birds and Bats ("Risk Assessment"), which supports the finding that this Project poses low risk of adverse impact to birds and bats (See Att. 2, Table 1.1 for a list of the surveys).[4]

2. <u>Baseline Pre-Construction Studies</u>: Unlike the studies cited in the Application, which were conducted to inform the question of Project risk to fish and wildlife, the Applicant has also signed the Avian and Bat and Aquatic MOUs with ODNR setting forth the Applicant's commitments to perform extensive pre- and post-construction monitoring to assess *actual* Project impacts. Specifically, as stated in the Avian and Bat MOU, the

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2 USFWS March 12, 2018 Letter to ODNR. See Fourth Supp. to App. (Mar. 22, 2018) at Att. 6.

3 Avian and Bat MOU (July 12, 2017) and Aquatic MOU (June 8, 2017). See Second Supp. to App. (July 20 and 24, 2017)

4 The information that has previously been provided in the record supporting a finding of minimal adverse impact includes: the February 1, 2017 Application Narrative (pages 90-125); Exhibit J to the February 1, 2017 Application, which includes WEST's November 29, 2016 Risk Assessment and WEST's January 23, 2017 NEXRAD Assessment of Nocturnal Bird Migration Activity from Weather Radar Data for the Project ("NEXRAD Analysis"), which was a site-specific survey.

purpose of the MOU was "to set forth the monitoring protocols for avian and bat resources" and the purpose of the monitoring protocols was *not to assess risk*, but to "assess, in a scientifically rigorous manner, any impacts that Project construction and operation may have on avian and bat species and resources…."[5] Extensive baseline studies are currently being performed to collect information prior to construction on fisheries, aquatic resources, and birds and bats. Survey results will be used to inform any mitigation and adaptive management measures that can be taken to further minimize any adverse impacts.[6]

Both the Avian and Bat MOU and the Aquatic MOU require the Applicant to submit annual pre-construction baseline monitoring reports, including preliminary analyses and summaries of all data collected for the preceding year to ODNR. In compliance with the MOUs, the Applicant submitted the following reports to ODNR for the 2017 monitoring year. The Applicant is now providing the reports as attachments to this Fourth Supplement to the Application:

a. Results of 2017 Aquatic Sampling, February 8, 2018, LimnoTech (**Attachment 3).**

b. Icebreaker Wind Bird and Bat Monitoring Annual Report, February 20, 2018, WEST (**Attachment 4**).

3. Update on Baseline Radar Survey and USFWS: The Avian and Bat MOU calls for the Applicant to undertake a baseline radar survey. As noted above, during the extensive discussions the Applicant engaged in with USFWS and ODNR, commencing in August 2016, the wildlife agencies have agreed that any pre-construction radar would be used to collect baseline data, and were not needed to inform the question of risk.

In response to the October 23, 2017 request from the Board's Staff ("Staff") that the Applicant file the "recommendation on the viability and precise design of any pre-construction radar" from a large four-point anchor vessel, which was to be provided by Dr. Robb Diehl ("Diehl Report"), and the Administrative Law Judge's entry issued that same day, the Applicant filed the December 2017 Diehl Report on January 24, 2018.[7] In its request, the Staff stated that it anticipated that, once the Diehl Report was provided, the Staff Report could be filed "shortly thereafter . . . [and] a new procedural schedule would be quickly issued. . . ." Based on the conclusions in the Diehl Report and with the

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5 Second Supp. to App. (July 20 and 24, 2017), Avian and Bat MOU at ¶ 2.

6 The information that has previously been provided in the record documenting the MOUs and plans for pre- and post-construction monitoring studies and the information obtained to date that will provide the baseline for post-construction monitoring includes: 1) the July 20 and 24, 2017 Second Supplement to the Application, which includes the Avian and Bat MOU, the Avian and Bat Monitoring Plan dated July 17, 2017, the Aquatic MOU, and the Aquatic Monitoring Plan dated January 25, 2017; and 2) the August 18, 2017 Third Supplement to the Application, which included the Aerial Waterfowl & Waterbird Study Plan dated August 8, 2017.

7 In its October 23, 2017 request, Staff noted that the Avian and Bat Monitoring Plan makes reference to the fact that the Diehl Report would be provided to the Staff in the fall of 2017.

support of the state and federal wildlife agencies, the Applicant is submitting the Diehl Report in support of its determination to commence radar monitoring prior to construction in order to provide a baseline for the post-construction monitoring as **Attachment 5** to this supplemental filing.

On March 12, 2018, USFWS sent a letter to ODNR that acknowledged that the Project is a "relatively small-scale demonstration project consisting of six turbines and as such *has limited direct risk* to migratory birds and bats." (Emphasis added). In addition, in the March letter, USFWS stated that both vessel-based radar, with the incorporation of recommendations from Dr. Diehl and USFWS, and radar at the water intake crib a few miles offshore "have the potential to contribute meaningfully to migratory bird and bat exposure data for the project." (**Attachment 6**).

Conclusion

In conclusion, the Applicant has provided more than sufficient information upon which the Board can base a conclusion that the Project poses low risk to fish and wildlife, and meets the statutory minimal adverse environmental impact standard. Accordingly, we respectfully request that the Board grant the Applicant's January 24, 2018 Motion to Reestablish the Procedural Schedule as expeditiously as possible.

We are available, at your convenience, to answer any questions you may have.

Respectfully submitted,

/s/ *Christine M.T. Pirik*____

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CERTIFICATE OF SERVICE

The Ohio Power Siting Board's e-filing system will electronically serve notice of the filing of this document on the parties referenced in the service list of the docket card who have electronically subscribed to these cases. In addition, the undersigned certifies that a copy of the foregoing document is also being served upon the persons below this 22nd day of March, 2018.

/s/ Christine M.T. Pirik
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COLUMBUS 63172-1 85885v10

Icebreaker Windpower, Inc.
Case No. 16-1871-EL-BGN
Fourth Supplement to Application
March 22, 2018

Attachment 1

Avian and Bat Wildlife Information Filed March 22, 2018

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ICEBREAKER FOURTH SUPPLEMENT
ATTACHMENT 1

To date, the information that has been included in the Application in regard to avian and bat information includes:

Filing	Date	Contents	Purpose	Comments
Application	2/1/17	Narrative (pgs. 90-125)	Demonstrate that the Project poses the "minimum adverse environmental impact" and low risk to birds and bats	Site-specific surveys and literature review cited to show Project poses low risk of adverse impacts to birds and bats
		Ex. J: WEST Risk Assessment; WEST NEXRAD Analysis	Same as previous	Same as previous
First Supplement	3/13/17	USFWS comments on Applicant's options matrix for pre- and post-construction monitoring options (2/28/17)	Update the Board on discussions with wildlife agencies on bird and bat monitoring plan development	Avian and Bat Monitoring Plan being developed with wildlife agencies to identify baseline (pre-construction) survey requirements and post-construction survey requirements to be used for comparison purposes to assess any actual Project impacts
		Applicant's response to USFWS comments (3/6/17)	Same as previous	Same as previous
Second Supplement	7/20/17 & 7/24/17	Avian and Bat MOU between Applicant and ODNR (7/12/17)	Sets forth agreement between ODNR and Applicant for monitoring studies pre- and post-construction, reporting requirements, etc.	Voluntary agreement between ODNR and Applicant setting forth Applicant's commitments
		Avian and Bat Monitoring Plan	Details pre- and post-construction monitoring to help assess actual Project impacts	Identifies pre-construction surveys that will be undertaken to collect baseline data, to be compared to post-construction surveys to identify any Project impacts
		Timeline of Reporting Requirements, Pre- and Post-Construction	Sets forth Applicant reporting requirements and schedule	
Third Supplement	8/18/17	Aerial Waterfowl & Waterbird Study Plan (8/8/17)	Submitted pursuant to MOU and Avian and Bat Monitoring Plan	Details baseline pre-construction aerial survey study plan, agreed to by ODNR with input from USFWS; results to be compared to post-construction aerial surveys to determine if Project has any impact on waterfowl and waterbirds

Filing	Date	Contents	Purpose	Comments
Fourth Supplement	3/21/18	Summary of Avian and Bat Risk Assessment	Condensed summary of the original WEST Risk Assessment filed with Application; identifies site-specific studies relied upon for determination that Project poses minimal risk of adverse impacts to birds and bats and other materials supporting finding of low risk	Describes studies and basis supporting conclusion that Project poses low risk of adverse impact to birds and bats
		Diehl Report (12/2017)	Referenced in Avian and Bat Monitoring Plan and requested by Board when it suspended permitting on 10/23/17	Dr. Diehl recommends a vendor and study design parameters for vessel based radar at the Project site prior to construction
		USFWS Letter (3/12/18)	USFWS accepts conclusions of Diehl Report and agrees to either vessel-based radar or radar on the crib for baseline survey	USFWS acknowledges Project poses “limited direct risk” to migratory birds and bats
		Annual Bird and Bat Report (2/20/18)	Submitted to ODNR pursuant to Avian and Bat MOU	Provides results of 2017 bat acoustic monitoring and aerial surveys to date, updates research into collision monitoring technologies; surveys conducted for purposes of comparison to post-construction monitoring to determine any impact on avian and bat resources

Icebreaker Windpower, Inc.
Case No. 16-1871-EL-BGN
Fourth Supplement to Application
March 22, 2018

Attachment 2

Summary of November 2016 Avian and Bat Risk Assessment for the Icebreaker Wind Project
March 20, 2018
Western EcoSystems Technology, Inc.

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Summary of November 2016 Avian and Bat Risk Assessment for the Icebreaker Wind Project

March 20, 2018

Prepared for:

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1 INTRODUCTION

Icebreaker Windpower, Inc. (IWP) has filed an application with the Ohio Power Siting Board (OPSB) to construct the Icebreaker Wind Project (Project), a small, six-turbine, 20.7-megawatt (MW) demonstration offshore wind energy facility eight to 10 miles (mi; 13 to 21 kilometers [km]) from the shore of Cleveland, Ohio. Among other findings, the OPSB must determine that the Project poses the "minimum adverse environmental impact." To this end, in the fall of 2016, Dr. Caleb Gordon and Wally Erickson of Western EcoSystems Technology, Inc. (WEST) completed a risk assessment (RA) to evaluate the likely adverse impact posed by the proposed Project on birds and bats. The RA was submitted with the application for the Project as Exhibit J.

The RA consisted of a review and summary of baseline data and other publicly available data on bird and bat use within, or in the vicinity of the Project area, as well as other information relevant to the assessment of risk, including technical literature on taxon-specific collision susceptibility patterns, and past studies of bird and bat fatality rates conducted at existing wind energy facilities within the Great Lakes region. The surveys that were reviewed are summarized within Table 1.1, and the aerial coverage of these surveys is illustrated in Figure 1.1. A NEXRAD analysis was completed by WEST after submission of the RA; aerial coverage of the WEST NEXRAD analysis is shown in Figure 1.2.

The Risk Assessment concluded that the Project poses low risk of adverse impacts to birds and bats. This conclusion stemmed largely from two principal observations: 1) the Project is small in scale, consisting of six turbines; and 2) site-specific and other studies have documented that the level of use of this area by birds and bats is low compared to bird and bat use of terrestrial or nearshore environments. The RA also relied on previously published studies of bird and bat fatality rates at onshore wind energy facilities in the Great Lakes region to bracket the range of fatality rates likely to be generated by the Project.

Following are summaries of: 1) the RA; 2) a site-specific analysis of NEXRAD radar data completed by WEST in January, 2017; 3) WEST's 2017 Annual Report; and, 4) WEST's Draft Bird and Bat Conservation Strategy (BBCS). The first item was filed with the OPSB; the second was completed several months after the RA was completed and was filed as part of the OPSB application; the third has been shared with the Ohio Department of Natural Resources (ODNR) and US Fish and Wildlife Service (USFWS) and is being filed with OPSB; and, the final item is under discussion with the USFWS.

Table 1.1. Surveys reviewed during the development of the Risk Assessment.

A summary of the surveys reviewed, the type of information obtained, the entities who performed the work, and the geographic scope of the survey elements during the development of the WEST Bird and Bat Risk Assessment (Gordon and Erickson 2016).

Survey Technique (years of survey data analyzed)	Entity Who Performed Survey	Species Identification	Spatial Distribution	Temporal Distribution	Flight Ecology	Site-specific Data?
NEXRAD radar analysis (2003-2007)	Geo-Marine	no	yes	yes	yes	yes
NEXRAD radar analysis (2013-2016)	WEST	no	yes	yes	yes	yes*
Bird Acoustic Survey (2010)	Tetra Tech	yes	yes	yes	no	near (Crib)**
Bat Acoustic Survey (2010)	Tetra Tech	yes	yes	yes	no	near (Crib)
Merlin Radar Survey (2010)	Tetra Tech	no	yes	yes	yes	partial***
Boat-based Bird Surveys (2010)	Tetra Tech	yes	yes	yes	yes	near
Bird and Bat Fatality Surveys at 42 (birds) and 55 (bats) Wind Energy Facilities in the Great Lakes Region (years vary by project)	Various	yes	yes	yes	no	no
Aerial Bird Survey (2009-2011)	ODNR	yes	yes	yes	no	yes

*Finalized after the RA was completed

**Survey results successfully collected for spring migration period

***The maximum extent of the radar range overlapped with the southern end of the current turbine layout.

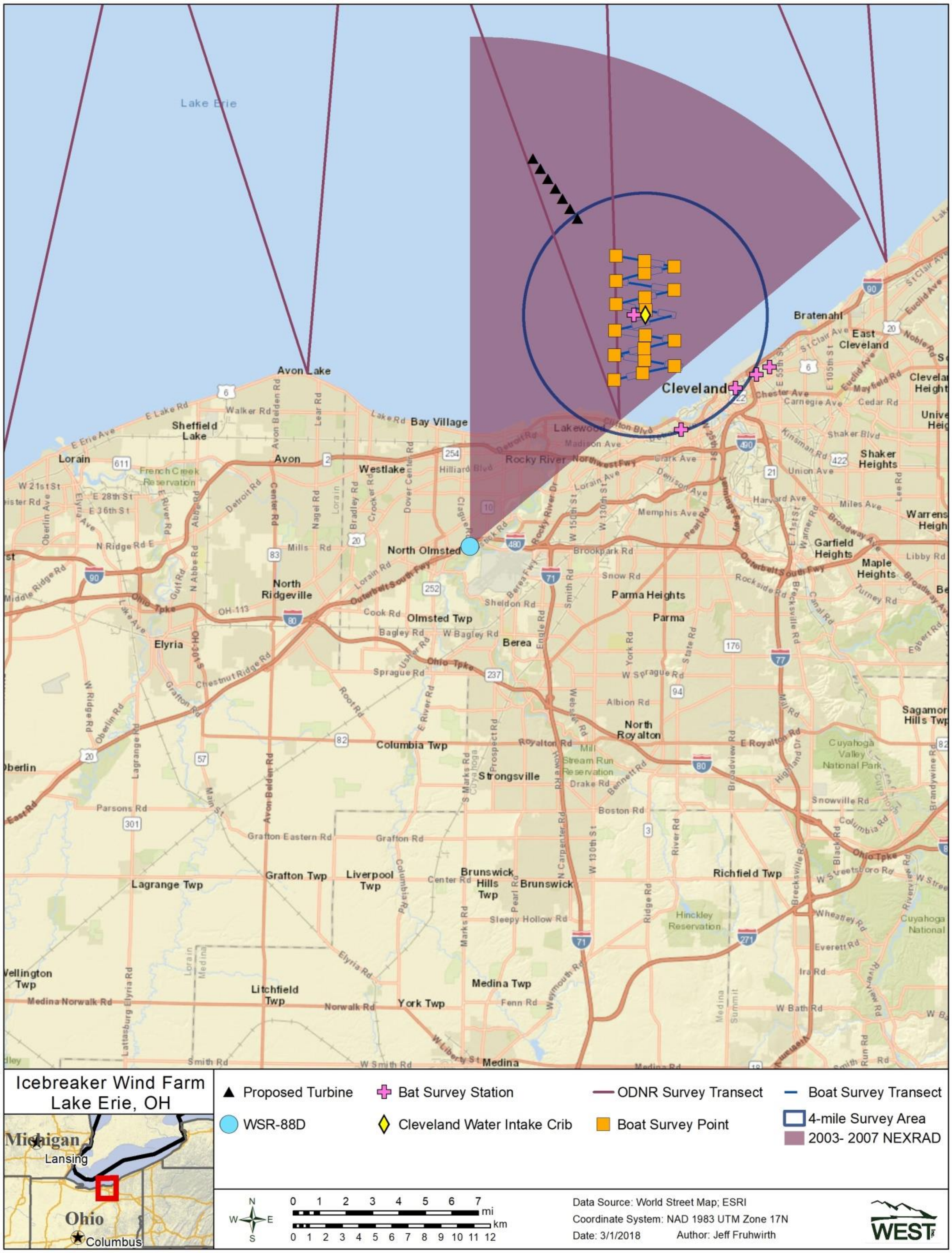

Figure 1.1. A map showing the coverage of the field surveys used to inform the risk assessment.

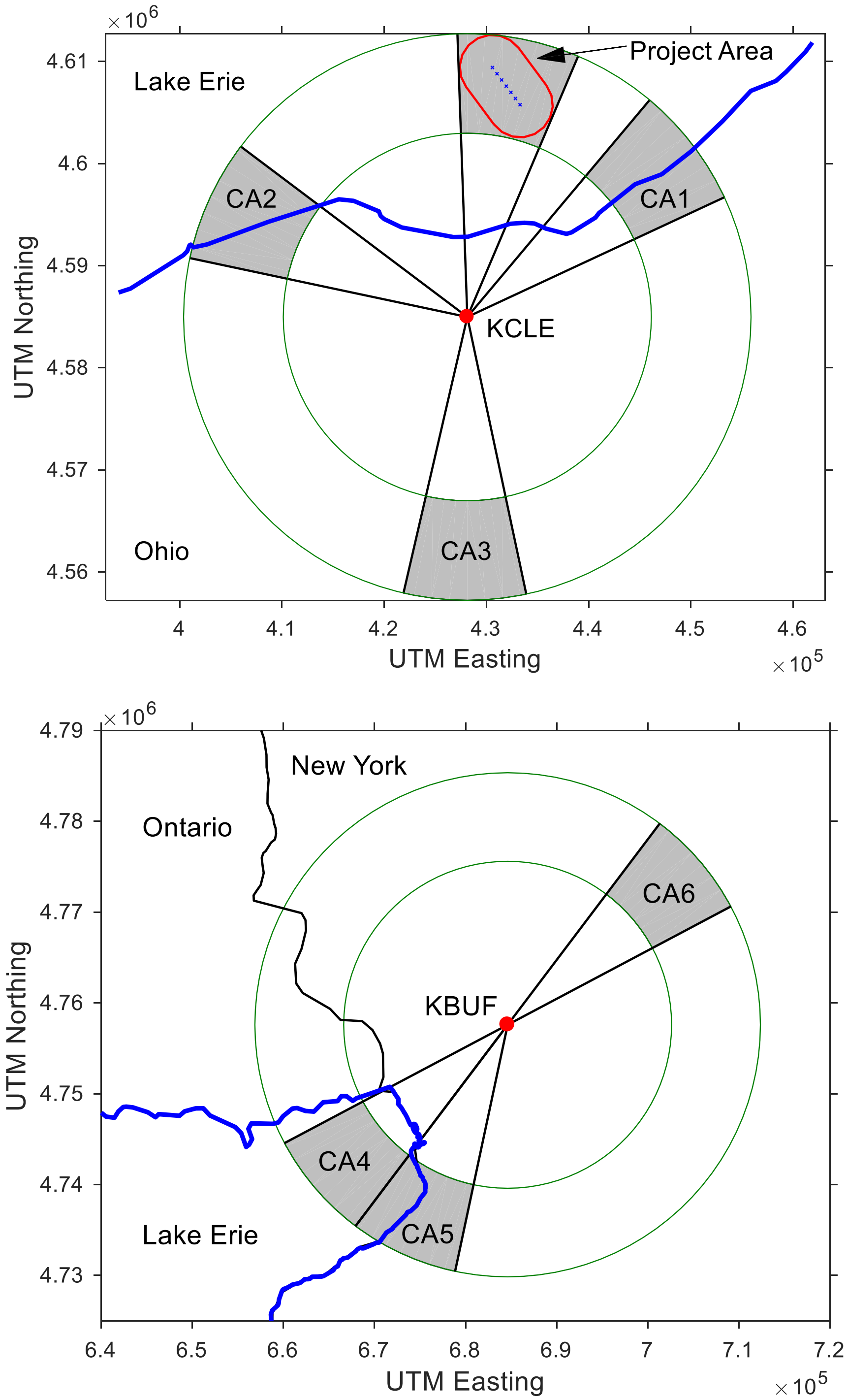

Figure 1.2. A map showing the coverage of the 2017 WEST NEXRAD analysis.

2 DOCUMENT SUMMARIES

2.1 WEST Risk Assessment

The WEST RA examined the potential project impacts on bird and bat species, including displacement, behavioral attraction and avoidance, and collisions.

2.1.1 Displacement Effects

A displacement effect is defined as the transformation of the Project area from suitable habitat to less suitable habitat by virtue of Project construction or operation.

Results of Aerial Surveys

Baseline data gathered by the ODNR in 2009-2011 indicated very low use of the offshore environment of Lake Erie in the vicinity of the Project area by diurnal waterbirds (Figure 2.1). Only six species of birds (including ring-billed gull (*Larus delawarensis*), herring gull (*Larus argentatus*), Bonaparte's gull (*Chroicocephalus philadelphia*), common loon (*Gavia immer*), horned grebe (*Podiceps auritus*), red-breasted merganser (*Mergus serrator*)) were documented regularly within the vicinity of the Project area, all of them in very low abundance.[1]

Conclusion (Displacement Effect)

Displacement effects are not likely because there are very few waterbird species or individuals to displace, as waterbirds do not regularly occur within the Project area. If any displacement effect were to occur, it would have minimal adverse impact on waterbird species, as very few individuals of waterbird species would be affected.

[1] IWP is currently conducting Aerial Waterbird/Waterfowl Surveys. Survey results to date confirm the ODNR survey results showing low usage of the Project area by waterbirds and waterfowl. An Interim Aerial Waterbird Survey Report was provided to ODNR and USFWS as part of the IWP's 2017 Annual Report.

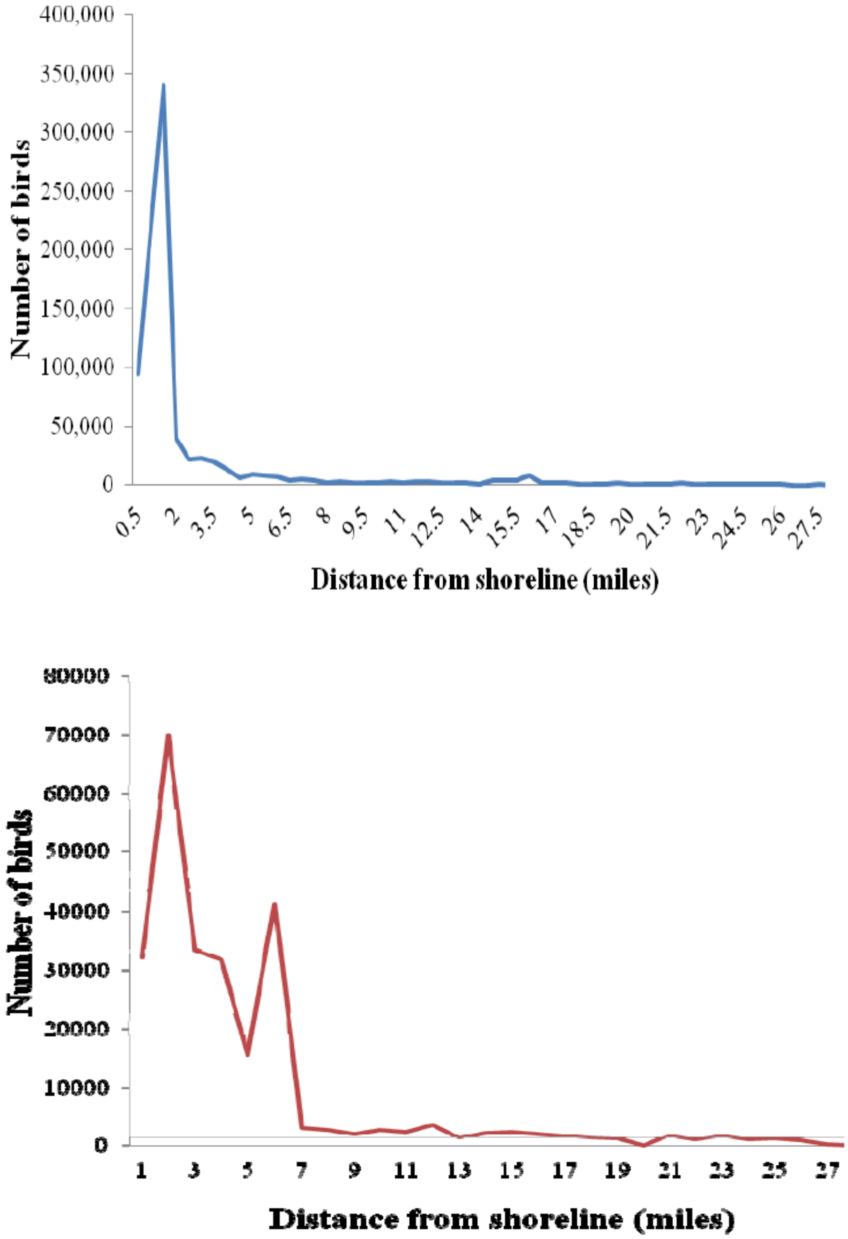

Figure 2.1. Number of birds as a function of distance from shoreline. The nearest proposed Icebreaker wind turbine is located 8 miles from the shoreline ODNR 2009-11.

2.1.2 Behavioral Avoidance or Attraction Effects

Behavioral attraction is defined as attraction to the Project area by bird or bat species that would otherwise utilize the area less frequently or not at all. Behavioral avoidance is defined as the avoidance of the Project area by species using the area strictly for transit. Researchers have shown that tree bats are attracted to on-shore wind turbines. Bird response to turbines has been more variable.

Aerial Surveys, NEXRAD; Acoustic and Boat-Based Surveys

Very few bird species or individuals currently utilize the Project area for foraging, feeding, or roosting. It is possible that some species may be attracted to the site for such activities after Project construction. Data from NEXRAD radar analysis (birds) and offshore acoustic studies (birds and bats) indicate that some bats and many nocturnally migrating birds regularly transit the Project area during migratory periods, though in both cases, exposure data indicate that the volume of such activity is lower than over terrestrial nearshore areas.[2] The extent to which nocturnally transiting bird and bat migrants may exhibit either avoidance or attraction to the facility is impossible to predict with pre-construction data.

Studies from European offshore wind facilities have shown that certain bird species tend to avoid flying through offshore wind farms or turbine strings, most notably migrating sea ducks, for whom the additional energy expenditure of flying around the facilities has been shown to be negligible. Certain other species have demonstrated attraction to European offshore wind facilities, most notably certain cormorants and gulls that may benefit from the availability of perching structures and/or the attraction of prey species by virtue of “artificial reef” effects. It is not known whether such effects are adverse or beneficial to the affected species.

Conclusion (Avoidance/Attraction Effects)

The Project has the potential to generate both behavioral avoidance and attraction effects in some groups of birds or bats, which may be either adverse or beneficial, but *are not expected to be substantial for any species*. The pre- and post-construction monitoring outlined in the Memorandum of Understanding (MOU) between the Ohio Department of Natural Resources (ODNR) and IWP, and the associated Monitoring Plan (MP), will allow evaluation of whether behavioral avoidance and/or attraction effects are evidenced at the Project.

2.1.3 Collision Effects

Birds and bats are known to collide with wind turbine blades causing injury or death. Collision rates and taxonomic patterns have been well-characterized for birds and bats at land-based wind energy facilities in the Great Lakes region and elsewhere in the US using bias-corrected carcass searching studies conducted during projects’ operational phases. Less is known about collision rates at offshore wind energy facilities. The Great Lakes are distinct from marine

[2] WEST’s Bat Activity Monitoring Report concludes that the 2017 survey effort results are consistent with the RA conclusions

environments, and some uncertainty exists in the expected per turbine rate of bird and bat fatalities; however the small size of the project, and lower expected exposure limits the total impact of the project compared to on-shore facilities. In Table 2.1, below, evidence from technical literature and site-specific information are integrated into the risk summaries for each of the major taxonomic or functional groups of birds and bats potentially exposed to wind turbine collision risk from the Project.

Conclusion (Collision Effects)

The collision risk from the Project is expected to be low. This conclusion is based both on the small size of the Project as well as the lower expected rate of exposure of birds and bats at the Project relative to on-shore facilities, as documented through the two NEXRAD radar analyses and the acoustic monitoring.

Table 2.1. Summary of collision risk assessment for specific bird and bat taxa or functional groups

Bird or Bat Group	Primary Evidence	Collision Risk Conclusion
Eagles and other raptors	• the Project **does not contain suitable nesting habitat** or substrate for any eagle or other raptor species • the Project **does not contain suitable foraging or feeding habitat** for any species in any season • the Project **is likely to receive very little raptor migratory passage**, as it is located in one of the widest sections of Lake Erie, and not in the vicinity of any islands or peninsulas that could attract migrating raptors, which are known to concentrate along shorelines and to minimize over water flight distances during migration in the region • **No eagles or other raptor species have been observed within the Project area** or vicinity in any of the surveys that were reviewed for the RA	**Low risk for all species during all seasons**
Waterfowl and other waterbirds	• **Very few (six) species occur regularly within the Project area** or immediate vicinity • **All of the species that do occur regularly** within the Project area or immediate vicinity **occur there in very low abundance** • An extensive aerial survey effort in Lake Erie documented a pattern of extreme bird concentration within the first several (up to seven) miles from shore; **bird abundance in the zone where the Project is located (eight to 10 miles from shore) is consistently several orders of magnitude lower than it is closer to shore** • **European studies have documented a strong tendency for waterfowl to avoid collisions** with offshore wind turbines • **US studies have documented low waterfowl collision rates** at land-based wind energy facilities located in close proximity to large waterfowl concentration areas	**Low risk for all species during all seasons**
Nocturnally migrating songbirds and similar birds	• The Project **does not contain suitable breeding, wintering, or migratory stopover habitat** for any species of bird in this category • **>100 species** of songbirds and other similar birds (e.g. cuckoos) **migrate at night in a broad-front pattern** over most of the US, including the Great Lakes region, including over the open water environment of Lake Erie and the Project area • In spite of this nearly ubiquitous exposure, **collision fatality rates for this group are consistently low across the country and within the region, and not likely to impact the population of any species.** A survey of 42 publicly available, bias-corrected bird fatality studies at wind farms in the Great Lakes region revealed that **bird fatality rates ranged from less than one to roughly seven birds/MW/year for all species combined, most of which are nocturnal migrants**	**Low risk for all species during spring and fall migrations. No risk at other times.**

Table 2.1. Summary of collision risk assessment for specific bird and bat taxa or functional groups

Bird or Bat Group	Primary Evidence	Collision Risk Conclusion
Bats	• Using the range of bird fatality rates within the region, and the installed capacity of the Project (20.7 MW), **the total predicted bird fatality rate for the Project is likely to be between 20 and 150 bird fatalities per year** • Site-specific NEXRAD analysis[3] revealed that nocturnal migrant **passage rates over the Project area are one third to one half of what they are in comparable areas along the central Lake Erie shoreline** or over land in the vicinity of Cleveland, and **one eighth of what they are over the eastern Lake Erie basin and shoreline**. • **If this site-specific exposure data for nocturnal bird migration is applied to the bird fatality rate prediction, it would suggest that the Project's bird fatality rate is likely to be on the low end of the spectrum of what has been observed elsewhere in the region (e.g. from 10 to 70 total bird fatalities/year)** • The Project **does not provide suitable roosting habitat for any species of bat**. • Several migratory bat species are known to sometimes transit, and possibly forage over open water environments of the Great Lakes and may encounter the Project area • A baseline bat acoustic study showed that bat acoustic **activity was substantially (roughly 10x) lower offshore than in terrestrial environments** near Cleveland • In spite of the availability of this information on exposure from the acoustic baseline study, it was not considered to provide a strong indication of site-specific bat risk, as the **relationship between pre-construction bat acoustic activity and post-construction bat fatality is known to be complex**, and dependent on behaviors that are not well characterized in the offshore environment • A survey of 55 publicly available, bias-corrected bat fatality studies at wind farms in the Great Lakes region revealed that bat fatality rates ranged from less than one to roughly 30 bats/MW/year for all species combined • Using the range of bat fatality rates within the region, and the installed capacity of the Project (20.7 MW), **the total predicted bat fatality rate for the Project is likely to be between 20 and 600 bat fatalities per year**	**Low-moderate risk for migratory species**

[3] This statement refers to the conclusion from the WEST 2017 NEXRAD analysis, which was completed subsequent to the WEST RA. In the RA, a similar conclusion was reached regarding exposure of nocturnal migrant birds from NEXRAD data based on a study by Diehl et al. (2003). The WEST NEXRAD analysis was similar to Diehl et al.'s but it was based on more data, more recent data, and the study area was selected specifically to encompass the Project site and directly comparable areas.

2.2 WEST 2017 NEXRAD Analysis

WEST's January 2017 NEXRAD Analysis presents the results of an analysis of nocturnal migrant bird patterns inferred from NEXRAD weather radar data, intended to provide a robust comparison of nocturnal migrant bird passage rates over the Project area compared with nearby shoreline, terrestrial, and other open water environments (Figure 1.2). Data from peak spring and fall migration periods were analyzed for a three year period (2013 – 2016) for the Project area and six comparable sites, using analytical techniques that have been developed and refined over five decades of NEXRAD radar ornithology designed to identify and isolate migratory bird signals. Due to the nature of NEXRAD radar beams, and the distance of the study sites to the radar stations (roughly 23 km; 14 mi), the altitudinal ranges sampled at the study sites ranged from 114 to 963 meters above ground level, overlapping the upper portion of the rotor swept zone of the turbines that would be installed (146 meter maximum blade tip height), and encompassing the altitudes at which most of nocturnal songbird migration is known to occur.

Conclusion:

For the seven sites analyzed, the Project area contained the lowest migratory bird passage rate in each year, in each season, and at both beam angles (altitudes) analyzed (Figure 2.2). Overall, averaging all years and seasons, the migratory bird passage rate at the Project area was roughly one third that of the comparison site over land south of Cleveland, less than half that of the two shoreline comparison sites in the central Lake Erie basin, and roughly one eighth that of the shoreline and over water sites in the eastern Lake Erie basin. The conclusion of this study was that the Project area had consistently lower densities of nocturnal migratory bird passage compared to shoreline or terrestrial sites within the region.

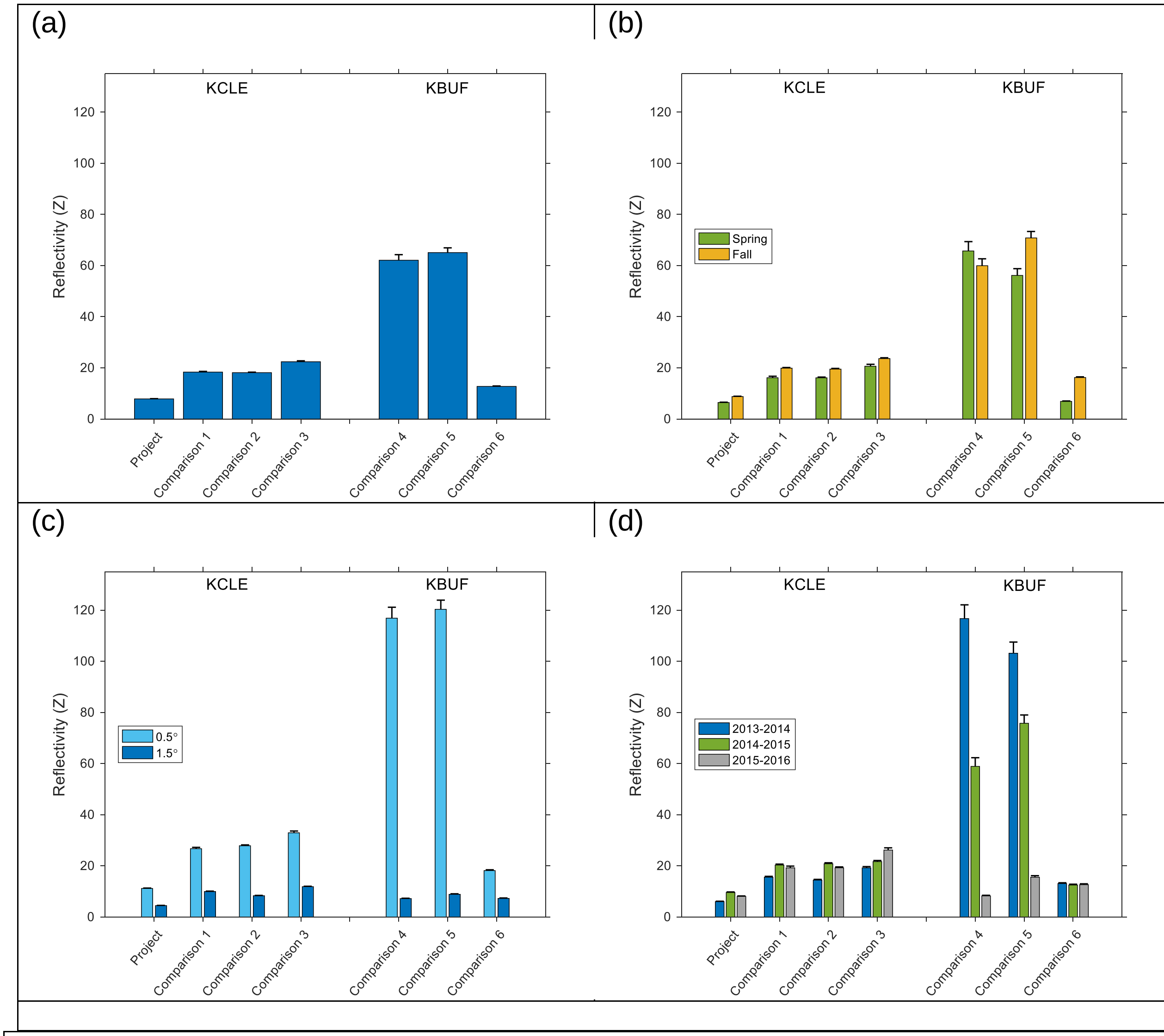

Figure 2.2. Mean reflectivity (bar heights) plus 1 standard error (error bars) at the seven sample areas:
(a) degrees overall – averaged across season, year, and elevation
(b) by season – averaged across year and elevation
(c) by elevation – averaged across season and year
(d) by year – averaged across season and elevation.

2.3 WEST Annual Report

WEST's Bird and Bat Monitoring Annual Report, dated February 20, 2018, presents the results of the Bat Acoustic Monitoring conducted in 2017; the Aerial Waterbird Survey results to date; the ongoing research into collision monitoring technologies in preparation for selection of the best and most practical technology available at the time the selection decision must be made; and results of the evaluation of vessel based radar to collect baseline data prior to construction for comparison to post-construction data to assess any actual avoidance/attraction and behavioral effects. **While not presented as the basis for making a determination regarding**

the Project's environmental risk, the survey results to date are consistent with the conclusions of the RA.

2.4 Draft Bird and Bat Conservation Strategy

The BBCS is currently being prepared to ensure that the Project avoids, minimizes, and mitigates any adverse environmental impacts that could result from the Project. The BBCS draft contains complete, or near-complete, versions of most of the typical elements of a BBCS (a summary of the Project and bird and bat risk assessment, description of the impact avoidance/minimization/mitigation measures to which the Project team has already committed, and a record of agency coordination). It will also include adaptive management strategies to further reduce any unforeseen adverse environmental impacts to birds and bats. **As such, a BBCS that has been approved by wildlife agencies will provide a mechanism to ensure that the Project poses the "minimum adverse environmental impact."**

During the fall of 2017, WEST completed the first draft of the BBCS for the Project. IWP submitted this draft to the USFWS for its review, and received emailed comments back from the USFWS on November 21, 2017. The IWP team held a teleconference with USFWS in early December to discuss comments on the draft BBCS. The BBCS is a living document, and will be continually updated, as specific impact thresholds and adaptive management measures will be dependent upon the precise nature of the post-construction monitoring methods and data. A final BBCS that has been agreed to by the Applicant and wildlife agencies can be made a condition of the Project's permit, to be submitted prior to construction

3 CONCLUSION

The Risk Assessment concluded that the Project poses low risk of adverse impacts to birds and bats based on 1) the Project is small in scale, consisting of six turbines; and 2) site-specific and other studies have documented that the level of use of this area by birds and bats is low compared to bird and bat use of terrestrial or nearshore environments. Subsequent studies completed for Icebreaker further support this assessment.

Icebreaker Windpower, Inc.
Case No. 16-1871-EL-BGN
Fourth Supplement to Application
March 22, 2018

Attachment 3

Results of 2017 Aquatic Sampling
February 8, 2018
LimnoTech

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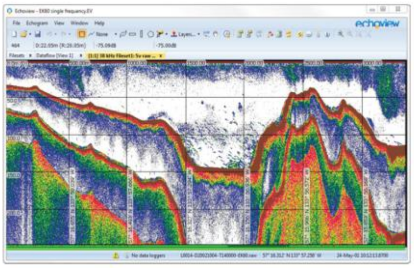







Report: Results of 2017 Aquatic Sampling

Icebreaker Wind

Prepared for:

Icebreaker Windpower, Inc.

February 8, 2018

LimnoTech

Water Environment | Scientists Engineers

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Report: Results of 2017 Aquatic Sampling

Prepared for:
Icebreaker Wind

Under Contract to:
Icebreaker Windpower, Inc.

February 8, 2018

Prepared by:
LimnoTech
Ann Arbor, Michigan

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1 Introduction

The purpose of this report is to document the field methods, results, and analysis carried out in 2017 to support the Icebreaker Wind project. LimnoTech, under contract to Icebreaker Windpower, Inc., led a multi-disciplinary team of researchers to collect site specific data at the site of and in the vicinity of the proposed Offshore Wind (OSW) demonstration project in Lake Erie.

The report includes the following major sections:

- Project introduction (Section 1)
- Sampling methods (Section 2)
- Results and discussion (Section 3)
- Conclusion (Section 4)
- References (Section 5)
- Appendices

1.1 Project Description

The proposed Icebreaker Wind demonstration project will include installation of six wind turbines, 8 to 10 miles offshore of Cleveland, Ohio in the Central Basin of Lake Erie. The turbines will be placed in water depths ranging from 58 feet to 63 feet, each with a nameplate capacity of 3.45 megawatts (MW) for a total generating capacity of 20.7 MW. A 2.3-mile buried electric cable will connect the six turbines, and an approximate 9.3-mile buried electric cable will connect the turbines to the Cleveland Public Power Lake Road substation. Figure 1 shows the project location within the Central Basin of Lake Erie offshore of Cleveland and the bathymetric contours.

1.2 Project Team

This section describes the project team in further detail. The project team is led by LimnoTech, an environmental engineering and science firm headquartered in Ann Arbor, MI. As a leader in environmental science and water quality management for nearly three decades, LimnoTech has helped clients assess, create and implement workable strategies for identifying and addressing aquatic impacts on scales both large and small. Our experts offer diverse technical skills, experience, and expertise that enable us to provide a full range of services for monitoring and evaluating these complex environments. The LimnoTech team is led by Ed Verhamme with support from Greg Peterson, Jen Daley, Cathy Whiting, John Bratton, and Greg Cutrell. Additional staff from the Ann Arbor office supported the fieldwork as needed. LimnoTech is responsible for all project deliverables, communication with Icebreaker Windpower, and management of additional team members.

The Ohio State University (OSU) – Stone Lab was established in 1895, and is the oldest freshwater biological field station in the United States. It is the center of Ohio State University's teaching and research on Lake Erie. The lab serves as a base for more than 65 researchers from 12 agencies and academic institutions, all working year-round to solve the most pressing problems facing the Great Lakes.

Justin Chaffin, Chris Winslow and other team members supported the collection of juvenile fish and also process the nutrient and water samples.

The Cornell University Bioacoustics Research Program develops and uses digital technology, including equipment and software, to record and analyze the sounds of fish and wildlife. By listening to wildlife, their research advances the understanding of animal communication and monitors the health of wildlife populations. Policy makers, industries, and governments use this information to minimize the impact of human activities on fish and wildlife and natural environments. Aaron Rice assists with the development of the underwater soundscape/noise survey as well as with data processing and interpretation.

BSA Environmental Services, Inc. is an environmental consulting firm specializing in aquatic plankton and larval taxonomy. John Beaver of BSA assists LimnoTech with processing and identifying organisms from the phytoplankton, zooplankton, and larval fish surveys.

Biosonics is an environmental company that specializes in hydroacoustics. They offer a wide range of scientific equipment for fisheries research and aquatic habitat assessments. They are experts in understanding and post-processing acoustics data and have a wide range of experience throughout the country.

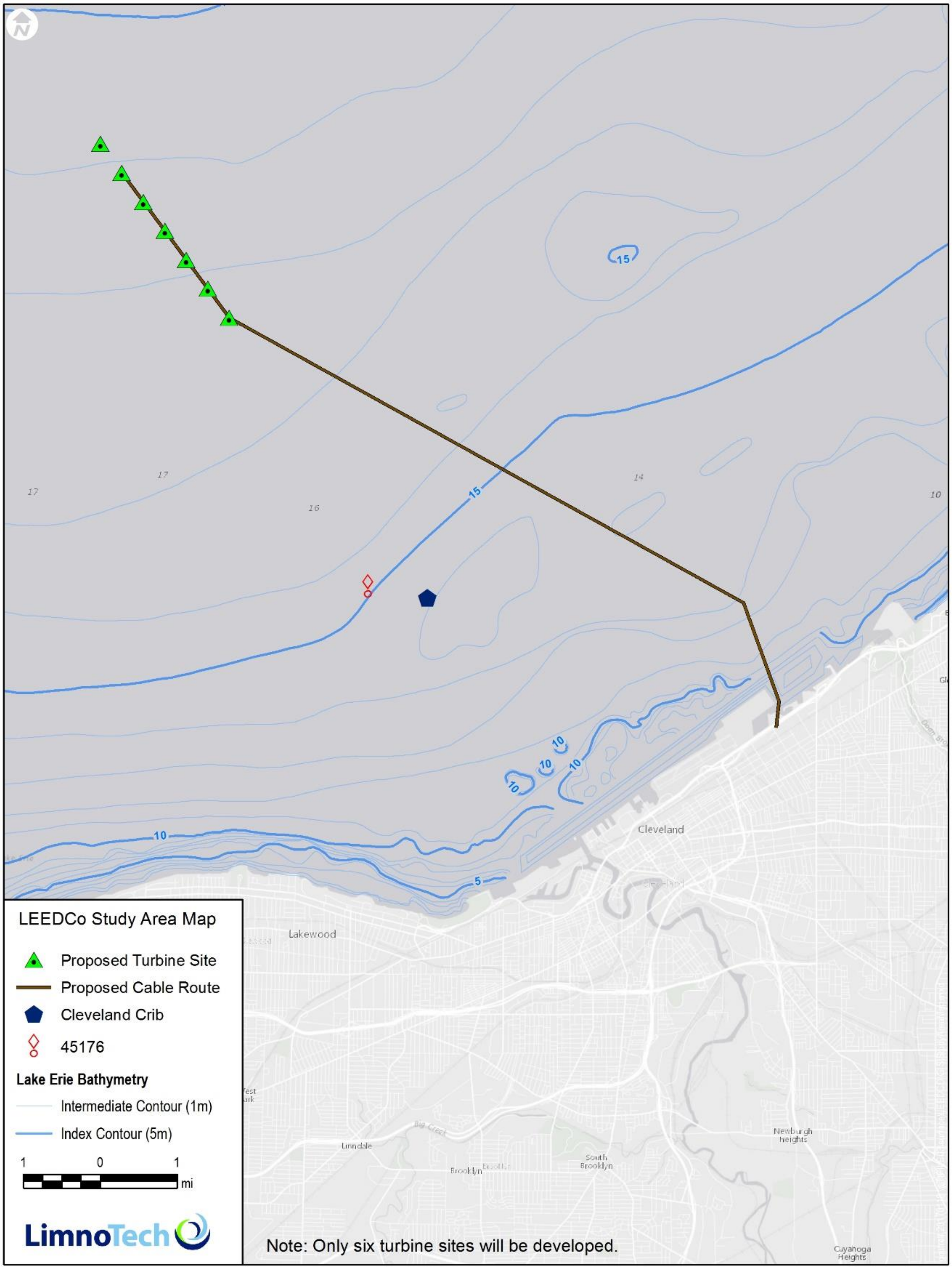


Figure 1. Project location map showing 7 turbine sites (only 6 will be developed).

1.3 Agency Coordination

Since April 2016, Icebreaker Windpower Inc. with support from LimnoTech has collaborated with the Ohio Department of Natural Resources (ODNR) and U.S. Fish and Wildlife Service (USFWS) to develop a monitoring program to assess ecological resources at the proposed project site and initiate the baseline characterization monitoring.

LimnoTech prepared The Lake Erie Monitoring Plan (LEMP), dated January 25, 2017, to serve as the basis for the aquatic resources and fisheries pre, during, and post-construction monitoring effort by Icebreaker Windpower Inc. By letter dated February 1, 2017, the ODNR Division of Wildlife indicated that all of its comments were addressed in the LEMP (Appendix A). The USFWS participated in discussions to design the study protocol and 2016 Monitoring Plan. The LEMP is considered a living document that will serve as a template for future aquatic monitoring work related to the Project.

On June 8, 2017 Icebreaker Windpower and the ODNR formally entered into a Memorandum of Understanding (MOU), which set forth that an agreement had been reached on the monitoring protocols for fisheries and aquatic resources. The MOU includes provisions for an annual performance review, and an option to adjust the monitoring plan based on changes in project design and/or results-driven knowledge gained from the monitoring work. The monitoring conducted in 2016 and 2017 forms the basis for the pre-construction monitoring program.

1.4 Reports and Memorandum

The following reports were completed in 2017. Copies of each item were emailed to ODNR and USFWS throughout the season. The list is presented here to document the deliverables completed as part of the 2017 sampling season.

- Report: Lake Erie Monitoring Plan –January 25, 2017
- Report: Annual Aquatic Data Report for 2016 Sampling Season - March 9 2017
- Report: Quarterly Status Report #1 – August 7, 2017
- Report: Quarterly Status Report #2 – December 8, 2017
- Report: Annual Data Report for 2017 Sampling Season (this document)

2
Sampling Methods

This section reviews the sampling methods for each major monitoring category. The methods presented in this section were included in the Lake Erie Monitoring Plan (LimnoTech, 2017) and approved by ODNR. A copy of the approval letter from ODNR is included in Appendix A. Any deviation from the sampling plan is noted in each section.

2.1 Stations

Sampling stations are listed below in Table 1 and a graphical depiction of the stations is shown in Figure 2. Table 2 lays out, by category, which stations or transects were sampled for each type of monitoring. The GPS coordinates for each sampling station are included in Table 2. The transects are located down the center (C) of the project grid, and to the east (E), and west (W) in adjacent Reference areas. The transects have a southeast to northwest orientation, and are aligned down the axis and parallel to the proposed turbines. Transect C extends from stations ICE1 to ICE7, transect W extends from stations REF2 to REF3, and transect E extends from stations REF4 to REF6.

Table 1. Sampling stations by sample type.

Task Description		Reference Stations (REF)						Turbine Stations (ICE)							Transects		
		1	2	3	4	5	6	1	2	3	4	5	6	7	C	E	W
Fish Community	Mobile Acoustic														x	x	x
Fish Community	Larval Fish	x							x				x				
Fish Community	Juvenile	x							x				x				
Fish Community	Zooplankton	x	x	x	x	x	x		x		x		x				
Fish Community	Phytoplankton	x	x	x	x	x	x		x		x		x				
Fish Community	Benthos	x							x				x				
Physical	Chemistry (discrete)	x	x	x	x	x	x		x		x		x				
Physical	Chemistry (discrete sonde profiles)	x	x	x	x	x	x	x	x	x	x	x	x	x			
Physical	Chemistry (continuous)	x						x (DO)	x (DO)		x			x (DO)			
Physical	Substrate Mapping	See substrate mapping section															
Physical	Hydrodynamic	x									x						
Fish Behavior	Acoustic telemetry	See acoustic telemetry section for map															
Fish Behavior	Fixed Acoustic	x								x							
Fish Behavior	Noise	x									x						
Fish Behavior	Aerial Surveys	See aerial survey section for description of locations															

Table 2. Table of sampling stations and latitude and longitude.

Turbine Station	Latitude	Longitude	Depth (feet)	Reference Station	Latitude	Longitude	Depth (feet)
ICE1	41.60072	-81.80055	58	REF1	41.60867	-81.8255	61
ICE2	41.60616	-81.80602	59	REF2	41.62539	-81.8421	63
ICE3	41.61159	-81.8115	60	REF3	41.59184	-81.8089	58
ICE4	41.61702	-81.81697	61	REF4	41.60899	-81.7915	58
ICE5	41.62246	-81.82245	61	REF5	41.62493	-81.8081	61
ICE6	41.62789	-81.82793	62	REF6	41.6399	-81.8237	63
ICE7	41.63333	-81.8334	63	Nearshore*	41.55016	-81.76528	53

*Nearshore station was selectively sampled in 2017. See notes in each section.

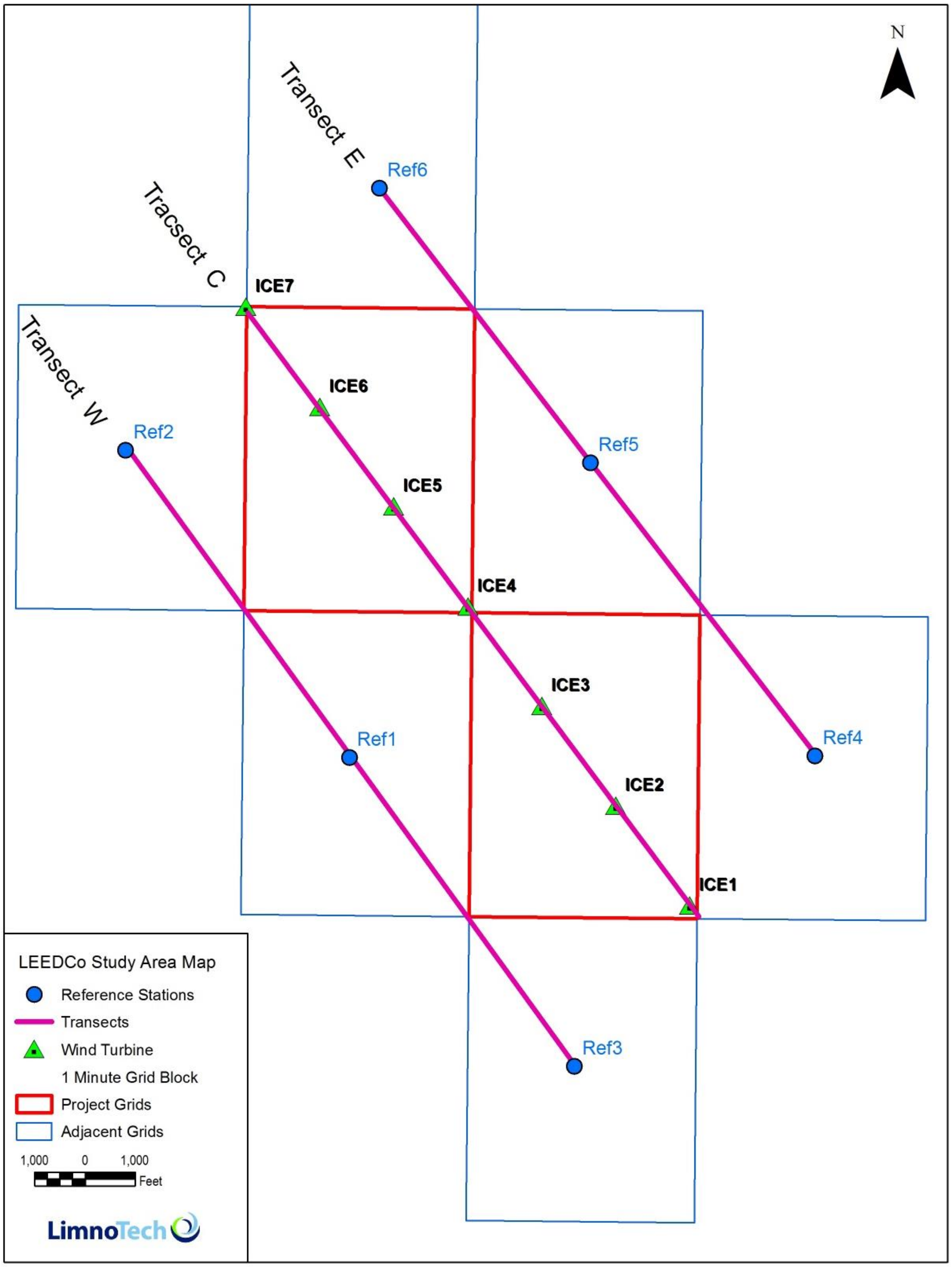


Figure 2. Map of project area, proposed turbine locations, sampling stations, and transects.

2.2 Field Events Summary

Table 3 provides a listing of the exact dates that each of the field tasks were completed for each month. Copies of field notes for each date are included in Appendix B.

Table 3. Dates of field main activities performed in 2017 by sample type

Sampling Category		May	June	July	August	September	October
Fish Community							
	Hydroacoustic	25-May	21-Jun	18-Jul	20-Aug	18-Sep	20-Oct
	Larval Fish	9-May	21-Jun	19-Jul			
	Juvenile	13-May			7-Aug		10-Oct
	Zooplankton	10-May	8-Jun	12-Jul	2-Aug	6-Sep	3-Oct
	Phytoplankton	10-May	8-Jun	12-Jul	2-Aug	6-Sep	3-Oct
	Benthos	9-May					2-Oct
Physical							
	Chemistry (discrete)	10-May	8-Jun	12-Jul	2-Aug	6-Sep	3-Oct
	Chemistry (continuous)	3-May	9-Jun	11-Jul	1-Aug	7-Sep	2-Oct, 20-Oct
	Substrate Mapping						
	Hydrodynamic	10-May	8-Jun	11-Jul	1-Aug	6-Sep	2-Oct, 20-Oct
Fish Behavior							
	Fixed acoustics	25-May	21-Jun	18-Jul	20-Aug	18-Sep	20-Oct
	Noise	3-May	8-Jun	11-Jul	1-Aug	7-Sep	2-Oct, 20-Oct
	Acoustic Telemetry	Deployed and recording			15-Aug	Deployed and recording	
	Aerial Surveys	29-May	2-Jun, 20-Jun, 24-Jun	15-Jul, 19-Jul	3-Aug, 6-Aug, 21-Aug, 27-Aug	14-Sep, 17-Sep	6-Oct, 8-Oct, 20-Oct, 29-Oct

2.3 Fish Community/Lower Trophic

LimnoTech undertook sampling of the fish and lower trophic community (zooplankton, phytoplankton, benthos) throughout the spring, summer and fall of 2017 to gain a second year of baseline data on existing conditions. This data can be compared to sampling conducted during and post construction project phases to determine if the project is having any potential impacts on the fish and lower trophic communities in the project area.

2.3.1 Hydroacoustic

Hydroacoustic monitoring was conducted monthly from May to October 2017 to assess the density and seasonal abundance of juvenile and adult fish. Sampling was completed on three transects, one down the center of the project grid and turbine locations, and two transects in adjacent grid cells to serve as reference areas. The map in Figure 2 shows the location of the acoustic transects (Transects W, C and E). Collection methods and sampling design followed the Standard Operating Procedure for Fisheries Acoustic Surveys in the Great Lakes (FASGL; Parker-Stetter et al., 2009). A BioSonics DT-X portable echo sounder surface unit with an emitting frequency of 120kHz with a 6º split beam transducer was pole-mounted and towed along the sampling transects at appropriate speeds (~4-5 mph). Equipment was calibrated prior to each survey following manufacturer protocols. Whenever possible the event was completed in calm conditions, a half hour after sunset and within five days of the new moon. A detailed analysis of acoustic data was performed in 2016 to ensure correct sampling methods were used. The 2017 data will be archived for comparison with during and post-construction data. All raw data files will be submitted in Appendix C.

Photo 1. Hydroacoustic data collection.

Photo 2. Biosonics DT-X instrument.

2.3.2 Larval Fish

Larval fish sampling was conducted once per month during 2017, in May, June and July. Three replicate 5-minute tows were completed at two Turbine Stations (ICE2 and ICE6) and one Reference Station (REF1). A 1X2m frame, 500 micron neuston net was used to collect the fish according to the ODNR ichthyoplankton sampling protocols. Following collection, samples were concentrated and preserved in 95% ethanol. Samples were brought to the BSA Environmental lab, where they were separated for total count but the taxonomic identification was not completed due to the low numbers. The main output from this task was an assessment of the density within the project area and the adjacent areas.

Photo 3. Larval fish monitoring using the neuston net.

2.3.3 Juvenile Fish

Juvenile fish sampling was conducted once per month in May, August and October. Three replicate 10 minutes tows were conducted at two Turbine Stations (ICE2, ICE6) and one Reference Station (REF1). A flat-bottom otter trawl with a 10.7 meter head rope and 12-mm bar mesh in the cod end was used to complete the bottom trawls according to ODNR bottom trawl techniques. Trawl catches were sorted by species and where appropriate age-category (AC 0-3, based on the ODNR Age Break protocol) and enumerated. A subsample of 30 individuals per species and age category were measured for total length (nearest mm) and weight (nearest 0.1 g). During days with larger waves, weights were estimated in the field and a subset of species, preserved in formalin, were brought back to the lab for more precise measurements.

Photo 4. Juvenile fish trawling.

2.3.4 Zooplankton

Zooplankton sampling was conducted monthly from May to October 2017. Samples were collected at six Reference Stations and three Turbine Stations. Sampling protocols followed the Lake Erie Coordinated Lower Trophic Level Assessment. Briefly, a weighted zooplankton net (0.5 m in diameter, 64 micron mesh), with a flow meter was used to complete the sampling. The net was lowered to the lake bottom and then pulled up so the plankton were collected along the way down and up. The net was washed with filtered water so all plankton were within the collection jar. Samples were concentrated through a 64 micron screen and preserved with 5% Lugols's Iodine solution, which was the preservative recommended by BSA Environmental. Samples were stored in 200 mL jars and three 2 to 5 mL sub-samples were removed for plankton identification to taxonomic genus and enumerated. Any exotic species were identified to species level. Laboratory protocols for identification, enumeration and biomass estimates followed the methods that BSA Environmental Services has been using for several years.

Photo 5. Sample of fish collected during juvenile trawling.

2.3.5 Phytoplankton

Phytoplankton sampling was conducted monthly from May to October 2017. Samples were collected at six Reference stations and three Turbine stations. Sampling and laboratory protocols followed the Lake Erie Coordinated Lower Trophic Level Assessment. An integrated tube sampler at two times the Secchi depth was used to complete the sampling. Samples were concentrated and preserved with 4% Lugols solution. Samples were processed according to the BSA Environmental Services Laboratory method, which follows the (OSU) Aquatic Ecological Lab processing protocols.

2.3.6 Benthos

Sampling was conducted at one Reference Station and two Turbine Stations, in May and October of 2017. Sampling and laboratory protocols followed the Lake Erie Coordinated Lower Trophic Level Assessment. Three replicate grabs of bottom sediment were collected using a PONAR grab sampler. Benthos were removed, preserved, sorted to the nearest taxonomic order or aquatic functional group and enumerated.

Photo 6. Samples of benthos collected in project area.

2.4 Physical Habitat

Physical habitat sampling included characterizing bottom sediments, water currents, nutrients, and trends of light attenuation, temperature, and dissolved oxygen. These parameters are being monitored to track changes in environmental conditions to assist with interpretation of trends that might be occurring in other biological data collected as part of this study. The trends reflect the dynamic nature of Lake Erie and not necessarily the impact from the Icebreaker Wind project.

2.4.1 Water Chemistry: Discrete

Discrete water sampling was conducted simultaneously with the collection of zooplankton and phytoplankton by three researchers. During each sampling event one researcher recorded and took integrated samples of water chemistry while another researcher prepped bottles for water samples, made notes, and measured photosynthetic active radiation (PAR). PAR measures the intensity of light in the band that are used by phototrophs (e.g. can excite chlorophyll). The third researcher measured Secchi depth and collected zooplankton.

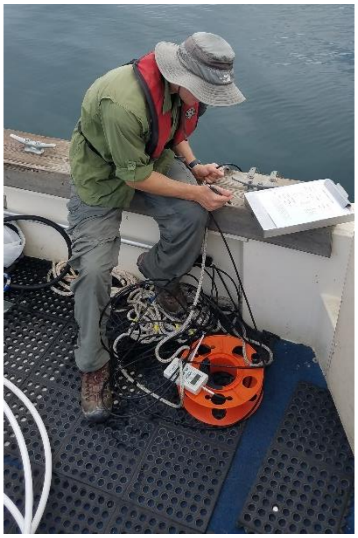


Photo 7. Water quality sampling.

Sampling was conducted using a crosslinked polyethylene pipe sampler lowered to the lake bottom to obtain an integrated water column sample. The tube was lowered to the lake bottom and emptied into a stainless steel bucket to sub-sample water for two-1L bottles for chlorophyll-*a* and two-250 mL bottles for total phosphorus (TP) and total nitrogen (TN). Samples were collected at six reference stations (Ref 1 to 6) and three turbines stations (ICE2, ICE4, ICE6). The samples were collected monthly from May to October 2017. Sampling and laboratory protocols followed the Lake Erie Coordinated Lower Trophic Level Assessment. Samples were bottled and placed in an iced cooler along with a chain of custody form before sending the coolers overnight to the OSU's Stone Laboratory. Once the samples arrived at Stone Laboratory chlorophyll-*a* was immediately filtered through a Whatman GF-C filter using low vacuum pressure and initially measured using a fluoroprobe. Final chlorophyll-*a* concentrations were determined by placing the filtered samples into dimethyl sulfoxide "DMSO", heated, centrifuged, with absorbance being measured at 665, 649, and 580.

Each water chemistry sampling station was supplemented with water clarity measurements using a Secchi disk and PAR. A Secchi disk was lowered into the water column until it was not visible to measure water transparency. A LI-COR LI-193 spherical submersible light meter was lowered on a LI-2009S lowering mount from the water surface at 0.5 -1.0 meters increments. PAR was displayed on a LI-250A and written in the field form to calculate light extinction.

From May through October, profiles of temperature, dissolved oxygen, pH, conductivity, turbidity, chlorophyll-a, and blue-green algae were measured from the lake surface to the bottom by using an YSI EXO2 sonde at every sampling station. The only exception was on May 10, when the sonde did not log at REF1, REF3, REF4, REF6, ICE2, and ICE6 (Table 12).

All field probes were calibrated prior to the first measurement of each sampling day. All sampling containers were new or cleaned in a five percent diluted acid bath and rinsed thoroughly with deionized water prior to each collection.

2.4.2 Water Chemistry: Continuous

Replicated stations were installed at ICE4 and REF1 in May to measure continuous dissolved oxygen, PAR, and water temperature.

HOBO water temperature Pro V2's were deployed at stations ICE4 and REF1 to measure temperature at the water surface and one meter from the lake bottom once every ten minutes. Paired with the bottom water temperature both stations were equipped with YSI 600 OMS loggers with a DO sensor to record once every hour. To measure PAR at ICE4 and REF1 a submersible Odyssey logger was deployed approximately 14.3 meters above the lake bottom at both stations and recorded measurements every ten minutes. MiniDO$_2$T sensors deployed at ICE1, ICE2, and ICE7 measured and recorded temperature and DO every ten minutes one meter from the lake bottom.

All field probes were calibrated prior to the first measurement and maintained throughout the field season.

The REF1 dissolved oxygen sensor (YSI 600 OMS) sonde began to exhibit mechanical problems during 2017 that resulted in intermittent loss of data. Gaps in DO data exist in May, from June 1 to June 9, and between June 26 to July 2. A brand new unit (PME miniDOT) was placed at this site on July 12, 2017. As discussed further in section 3.2.2 other nearby dissolved oxygen sensors showed values between 11 mg/L and 2 mg/L, which are above the threshold for hypoxic conditions. Data from the other functioning sensors as well as the trend in values recovered from the faulty sensor provide adequate information to describe DO conditions at the reference site.

The mooring of the PAR sensors were also modified between 2016 and 2017. During 2016 each PAR sensor was installed on a rope between a surface buoy and its anchor at a depth of approximately 14.3 meters. For 2017 a small underwater float was used to suspend the PAR sensors on a rope that only attached to anchor and not a surface buoy.

2.4.3 Substrate Mapping

There was no additional substrate mapping completed for the 2017 field season.

2.4.4 Hydrodynamic

Two ADCPs were deployed from October 31st 2016 to October 20th 2017. One ADCP (Nortek AWAC AST 1MHz Aquadopp Z-cell) was deployed at the center turbine location (ICE4) and the second ADCP (RDI Workhorse Sentinel 1200kHz) was deployed at REF 1. Both ADCPs were attached to an anchor and placed in a cage mount with buoys attached to keep the ADCP vertical. The ADCPs measured lake currents on an hourly basis in one meter increments from the surface to the bottom of the lake. On July 11 the ADCP deployed at ICE4 stopped recording due to water egress in the battery canister. This failure was the result of a bad o-ring seal. The failure was discovered in early August during the routine maintenance event. A replaced was immediately ordered from the manufacturer and was redeployed on August 20. This gap in data is not significant as the instrument collected current data for the months of November 14, 2016 to July 11, 2017 and from August 20, 2017 to October 20, 2017. This is a significant amount of data to compare against current data collected at the reference site. Both ADCPs were re-deployed November 14th, 2017 for the winter to sample water movement prior to and during the presence of ice, once every three hours.

Photo 8. REF1 ADCP mooring.

2.5 Fish Behavior

Fish behavior and movements are driven by several factors. Fish often make daily movements between feeding and resting habitats, seasonal movements to summer and winter habitat and annual movements to spawning areas. Fish also respond to direction and rate of water movement by their lateral line which contains nerve endings and acts as radar, allowing the fish to detect the size, shape, direction and speed of objects. Fishes may trade-off food acquisition to decrease the risk of predation, so that a habitat with lower food availability may be used to reduce risk. Understanding normal fish behavior and movement is critical to being able to predict how a population may respond to variable environmental conditions. The purpose of the sampling in this case is to understand whether the turbines and associated structures have any impact on fish behavior and movement.

2.5.1 Acoustic Telemetry

In the fall of 2016 (October 31st 2016), 26 receivers were deployed along two transects beginning near the Cleveland shore out past the farthest turbine location (Figure 3). Each receiver was suspended above the bottom using a 75 pound anchor, underwater floats, and a 200 feet drag line placed on the lake bottom. The drag line is used for annual instrument retrieval and data downloading. To ensure ongoing testing and verification of the system, two acoustic (sentinel) tags were installed permanently within the receiver array, roughly 500 meters apart from the closest receiver. These tags will allow continual range testing to occur. The receiver array was designed to have two rows of hydrophones (26 total), one on each side of the turbine/transmission line. This configuration was designed to monitor the behavior of tagged fish in and around the turbine site and transmission line with sufficient density to capture fish moving through the project and transmission sites. This array configuration minimizes monitoring gaps within the study area and the double line of receivers array provides a better understanding of individual fish track as it moves from one side of the project site to the other. The distance between receivers along each transect is approximately 1,350 meters. The distance between the two parallel receiver lines is approximately 1,000-1,200 meters. Two additional real-time receivers were added to the two buoys (45176, 45169) and provided real-time fish tag information throughout the buoy deployment season (March-October).

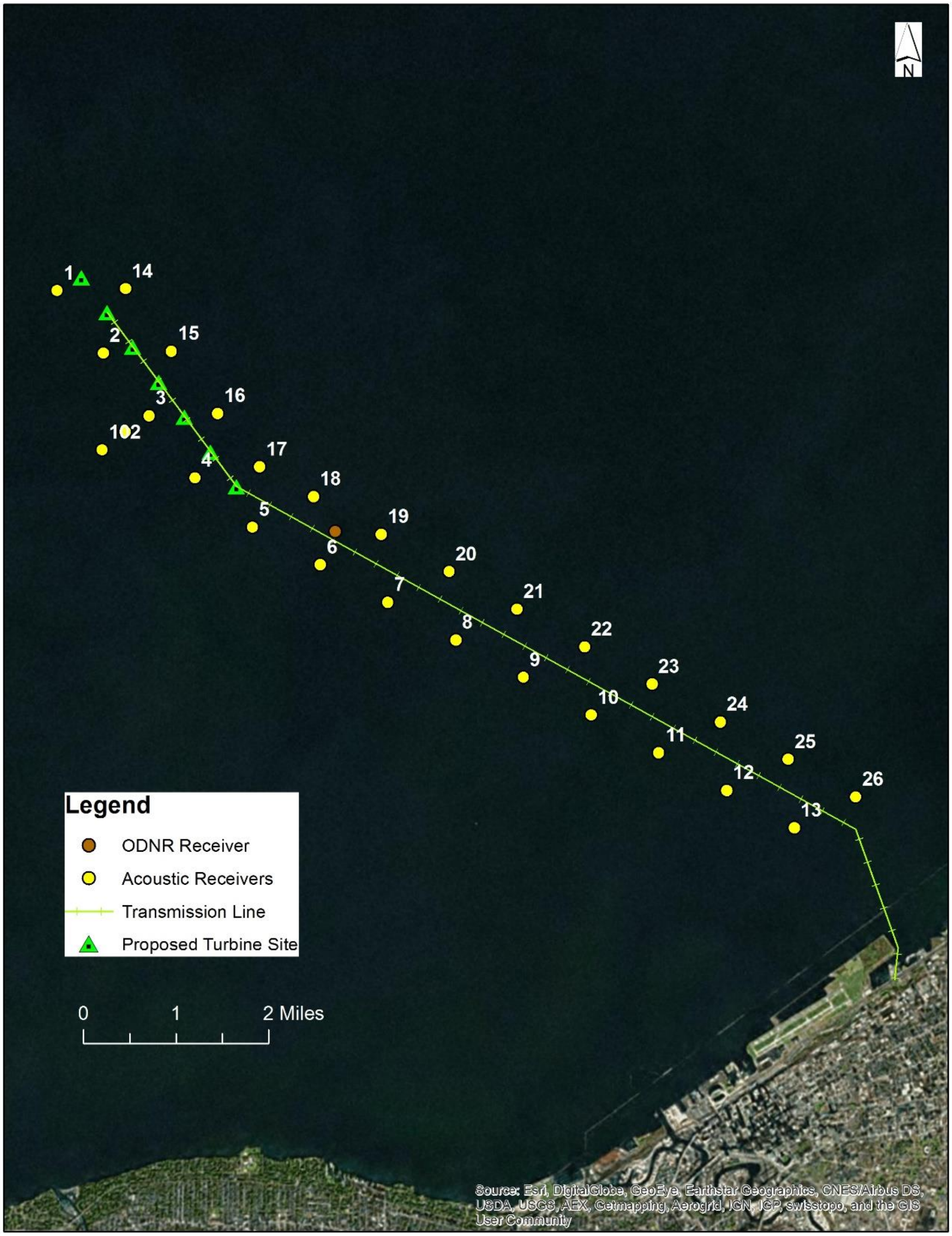


Figure 3. Map of the deployed array configuration. The yellow dots represent the receivers, the green triangles the turbines and the green line the transmission line. Receiver #102 is the location of the test transmitters.

The 26 receivers, plus the two real-time receivers, were retrieved, cleaned, downloaded, and batteries replaced on August 15, 2017. Data from each of the receiver units was uploaded to Great Lakes Acoustic Telemetry Observing System using their form system.

2.5.2 Fixed Acoustics

Fixed hydroacoustic sampling was conducted on the same nights the mobile acoustic surveys were conducted. Fixed surveys were completed by anchoring the boat for one hour at ICE3 and for one hour at REF1. The equipment and data settings remained the same as the mobile survey (section 2.3.1), with the exception that the collection ping rate was increased from five pings per second to 10 pings per second. Fixed acoustic data was collected monthly from May through October 2017. A detailed analysis of acoustic data was performed in 2016 to ensure correct sampling methods were used. The 2017 data will be archived for comparison with the during-construction and post-construction data. All raw data files will be submitted in Appendix C.

2.5.3 Noise Production

Two underwater sound recorders were deployed on May 11, 2016 two meters from the bottom of the lake using Ocean Instruments Smart Hydrophone Soundtraps at stations REF1 and ICE4. At the request of Aaron Rice of Cornell University the hydrophones recording frequency was change from 72 kHz to 24 kHz. The recording interval of 30 continuous minutes each hour was not changed. The hydrophones were attached to an anchored four meter suspended rope to limit sound from mooring hardware.

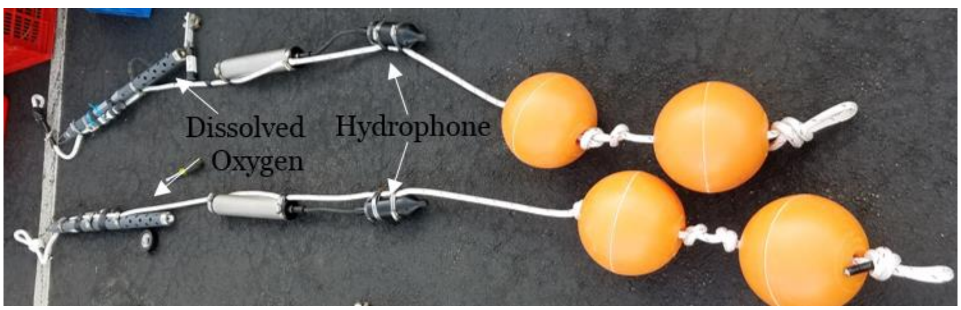


Photo 9. DO and hydrophone sensor setup.

Table 4 below shows each dataset that was collected from each site.

Table 4. Recording durations, recording unit and sensitivity of audio data collected in Lake Erie.

Recording Start	Recording Stop	Sound Trap Serial Number	Sensitivity
REF1			
5/2/17	6/8/17	671100952	171.3 dB re: 1 µPa
6/9/17	7/11/17	671100952	171.3 dB re: 1 µPa
7/12/17	8/1/17	671100952	171.3 dB re: 1 µPa
8/2/17	9/6/17	671100952	171.3 dB re: 1 µPa
9/6/17	10/20/17	671100952	171.8 dB re. 1 µPa
ICE4			
5/2/17	6/8/17	671117327	171.8 dB re: 1 µPa
6/9/17	7/11/17	671117327	171.8 dB re: 1 µPa
7/12/17	8/1/17	671117327	171.8 dB re: 1 µPa
8/2/17	10/2/17	671117327	171.8 dB re: 1 µPa
10/2/17	10/20/17	671117327	171.3 dB re: 1 µPa

A detailed analysis of acoustic data was performed in 2016 to ensure correct sampling methods were used. The 2017 data will be archived for comparison during and post-construction data.

2.5.4 Aerial Surveys of Boating

Aerial surveys were conducted to monitor use of the project site and surrounding areas by recreational boaters.

Aerial surveys were scheduled offshore of Cleveland two times a week (one weekday and one weekend day), roughly every three weeks from May 1 to November 1, 2017. Survey days were selected to coincide with days that ODNR was conducting creel surveys at area boat launches as well as when weather was adequate to fly safely, which generally were days suitable for boating. Aerial Associates Photography departed from Ann Arbor Municipal Airport to count commercial and recreational boats while taking high quality photographs to reference their location. Each 5-minute survey block has an ID and the numeric part of the ID (911 and 912) corresponds to the 10-minute size survey blocks that are used by ODNR to conduct boating surveys in Lake Erie. Boat activity was spatially grouped into 5-minute grids over Lake Erie with all Turbines falling within grid "911-NW" (Figure 44).

Photo 10. Photo taken from Aerial Associates Photography on August 6, 2017.

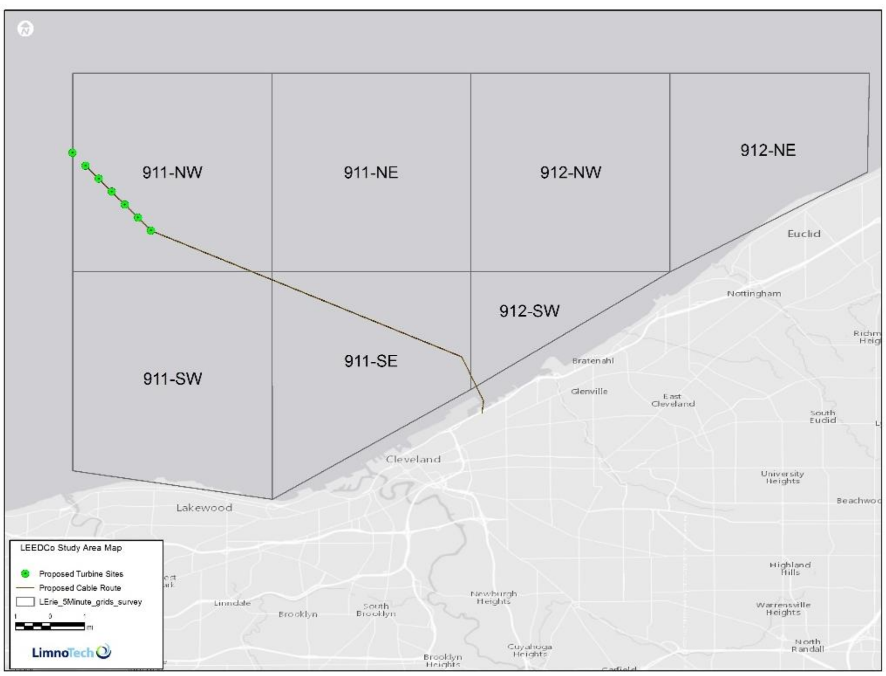


Figure 4. 5-minute grids offshore Cleveland for grouping boat activity.

2.6 Minor Sampling Plan Modifications

During 2017 there were several minor deviations from the environmental sampling plan that were caused by malfunctioning instrumentation and equipment. None of the following items represent significant loss of data that would prevent characterization of site conditions. The following list is a composite of changes that were addressed in greater detail in prior subsections.

- During the May 10 water quality sampling event, the profiling sonde did not record values at REF1, REF3, REF4, REF6, ICE2, and ICE6 (Section 2.4.1).
- Gaps in dissolved oxygen data exist at REF1 during May, from June 1 to June 9, and from June 26 to July 2 (Section 2.4.2).
- On July 11 the ICE4 ADCP stopped recording water current data and did not resume recording until August 20 (Section 2.4.4).

2.7 Other Activities

Bat Monitoring

LimnoTech worked with WEST to install two microphones and data loggers throughout 2017 on the Cleveland Crib and LEEDCo buoy, as well as on the lower portion of the Cleveland Crib and at the top of the crib tower. The buoys were deployed on March 21, 2017 and were retrieved November 14th 2017. Collaborating with AAron Godwin of Conserve First LLC and approval of the City of Cleveland the microphones and loggers were installed in March 2017. Every two to three weeks LimnoTech visited each logger to download data and ensure the logger and microphone was working directly. Additional backup recorders were added to the all stations in April, May, and June. LimnoTech also constructed and deployed a buoy at the project site on July 12th 2017 with a 10-meter pole mounted to the buoy base to allow a bat microphone to be installed 10-meters above the water surface. The 10-meter pole buoy was deployed until August 31st. After each visit to the bat monitoring equipment data was sent to WEST for processing. WEST was responsible for all data processing and reporting. The activities here are only mentioned for completeness to account for the coordination that occurred between the aquatics and bird/bat sampling teams.

Sediment Transport Memorandum

Electric transmission cable installation for the Icebreaker Wind Demonstration Project could resuspend sediments and temporarily increase water turbidity near the installation site. To assess the potential for increases in suspended sediment, LimnoTech reviewed existing modeling results from a similar project in Lake Erie as well as site specific sediment and water current data collected at the proposed project site. Icebreaker Wind expects the selected cable installation contractor will utilize a jet plow installation method, which should minimize the amount of resuspended material over traditional side-casting or open trench dredging. A memorandum was prepared (July 13, 2017) describing the major physical processes that can affect the fate and transport of suspended material.

City of Cleveland Water Department Letter

LimnoTech met with representatives from the City of Cleveland Water Department on August 24, 2017. The purpose of the meeting was to understand the water treatment process and what historical events Cleveland Water has encountered that might be similar to the LEEDCo construction activities. As a result of the meeting, Cleveland Water submitted a letter to LEEDCo (dated September 22, 2017) that lays out the specific communication and monitoring that will take place during installation of the electric cable, as well as describes how Cleveland Water is able to handle changes in turbidity with advance warning, similar to large storms. The Water Department did not think that project construction poses any significant risk to drinking water. A copy of the letter is attached in Appendix A.

3
Results and Discussion

3.1 Fish Community/Lower Trophic

3.1.1 Hydroacoustic

The hydroacoustic raw files for each survey are included in Appendix C. Bottom depth maps are presented in Figure 5 showing the transects completed near the project location (Transects W, C and E). The map in Figure 6 shows the location of the acoustic transects at the project location compared to the nearshore transect (sampled during select months).

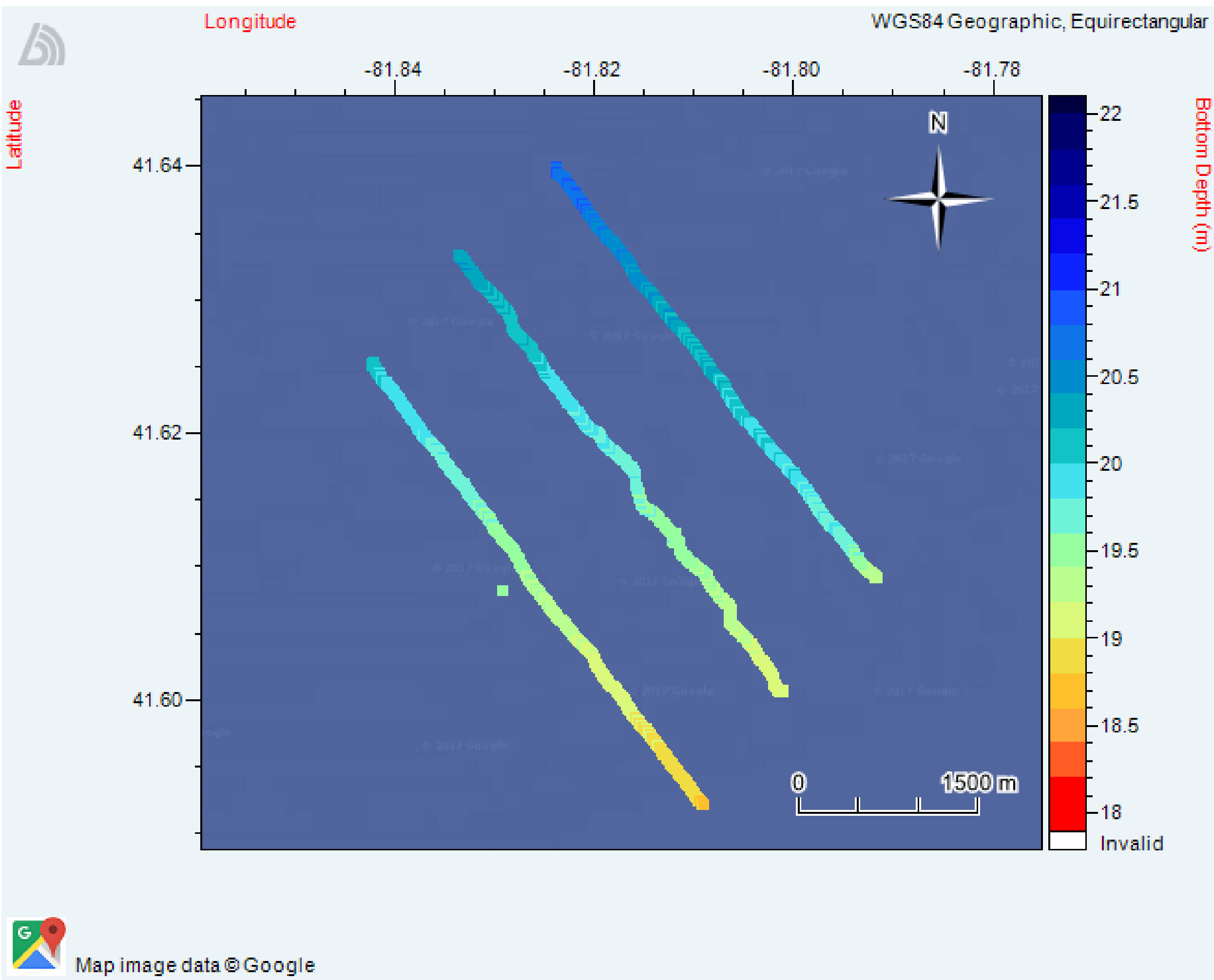


Figure 5.Bottom depth map of the project location transects.

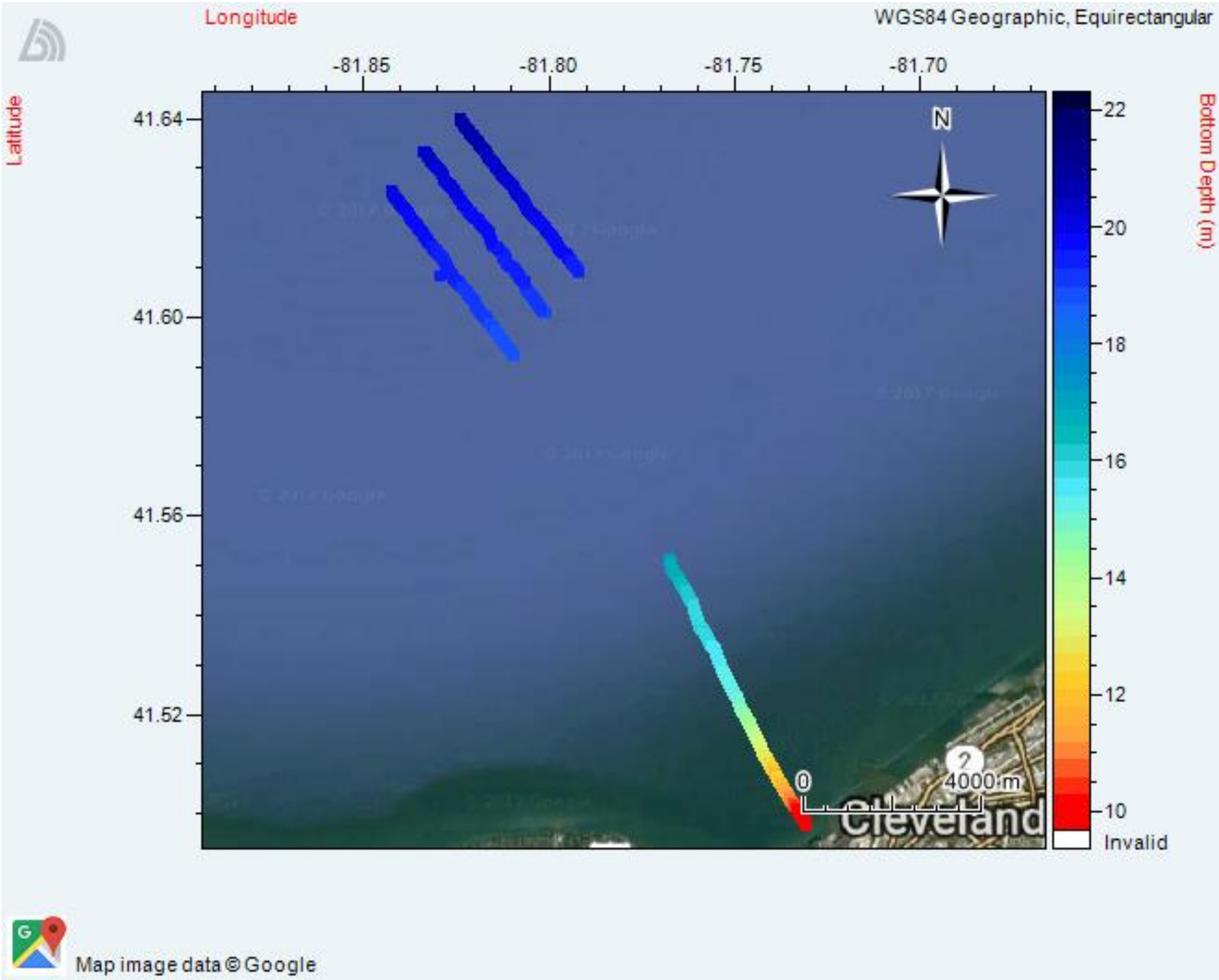


Figure 6. Bottom depth map of the project location compared to the nearshore transect.

Screenshots from each event are included in Figures 7 to 9. In 2016, adult and juvenile fish densities were similar between the three mobile transects, which included one transect down the center of the project location and two transects in nearby areas to serve as a reference. Although transects were similar within months, there was a significant decline in total density across months. The raw files for 2017 will be analyzed in the future to compare years when the turbines are deployed.

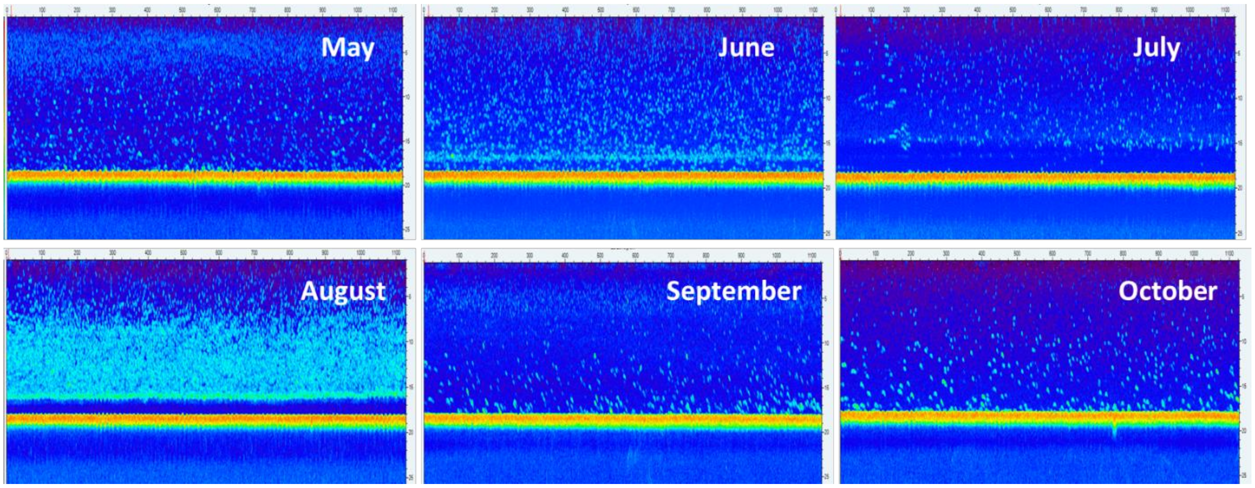


Figure 7. Screenshots of the Visual Acquisition software used for hydroacoustics across all sampling months in 2017 near the Turbine 1 location.

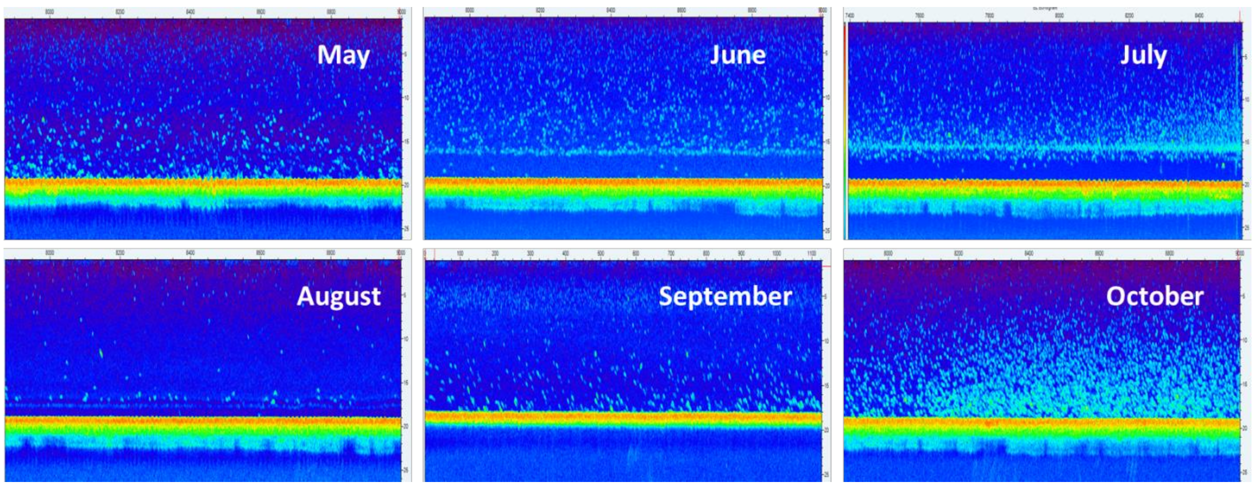


Figure 8. Screenshots of the Visual Acquisition software used for hydroacoustics across all sampling months in 2017 near the Turbine 7 location.

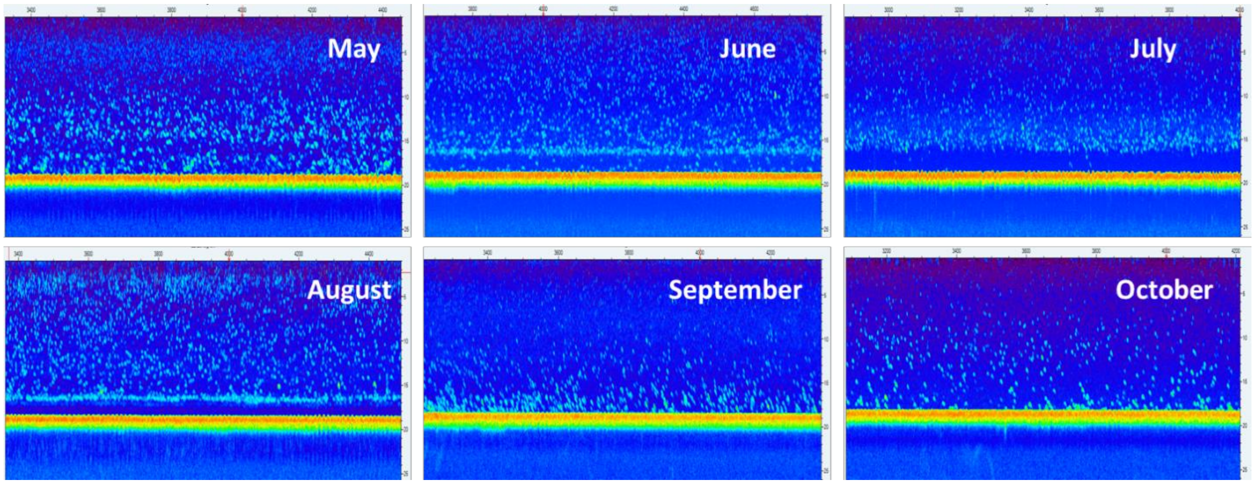


Figure 9. Screenshots of the Visual Acquisition software used for hydroacoustics across all sampling months in 2017 near the Turbine 4 location.

The thermocline was present in the June, July and August sampling events but had dissipated in September. These results are consistent with the temperature and dissolved oxygen profiles near the project location (Section 3.2.2). On June 21st, the thermocline was present but the bottom DO was still between 4-5 mg/L, which is why biota were present below the thermocline. Whereas, during the July 18th and August 20th events, DO was between 0-2mg/L. This coincides with fish physiology estimates, which state that fish become distressed between 2-4 mg/L and DO levels less than 2 mg/L may be lethal to many species. It is therefore not surprising that fish stayed above the thermocline or moved away from the location during the late summer-early fall due to the presence of hypoxic waters.

3.1.2 Larval Fish

The results from the larval fish collections are summarized in Table 5 below. There were no larval fish collected in May, four larval fish were collected in June and three in July. Overall, across all 27 trawls at the project location conducted in 2017, only seven fish were collected. This was similar to the 2016 trawling events where only five fish were collected. We also collected a sample near the Cleveland intake crib each month, which did not contain any larval fishes. This differed from the 2016 sampling where there were 16 fish collected nearshore in one trawl. The results suggest that larval fish densities are low at the project site due to its distance from shore.

Table 5. Ichthyoplankton results from the May, June and July 2017 sampling events.

Site	Rep	Date	Time	Tally
Nearshore	1a	5/9/2017	16:30	0
Nearshore	1b	5/9/2017	16:30	0
Turbine 2	1	5/9/2017	15:30	0
Turbine 2	2	5/9/2017	15:49	0
Turbine 2	3	5/9/2017	16:09	0
Reference 1	1	5/9/2017	14:30	0
Reference 1	2	5/9/2017	14:47	0
Reference 1	3	5/9/2017	15:07	0
Turbine 6	1	5/9/2017	12:35	0
Turbine 6	2	5/9/2017	12:56	0
Turbine 6	3	5/9/2017	13:20	0
Nearshore	1	6/21/2017	15:17	0
Turbine 2	1	6/21/2017	13:20	0
Turbine 2	2	6/21/2017	13:33	1
Turbine 2	3	6/21/2017	13:46	1
Reference 1	1	6/21/2017	12:31	1
Reference 1	2	6/21/2017	12:50	1
Reference 1	3	6/21/2017	13:04	0
Turbine 6	1	6/21/2017	14:27	0
Turbine 6	2	6/21/2017	14:39	0
Turbine 6	3	6/21/2017	14:50	0
Nearshore	1	7/19/2017	17:13	0
Turbine 2	1	7/19/2017	14:35	1
Turbine 2	2	7/19/2017	14:53	0
Turbine 2	3	7/19/2017	15:11	0
Reference 1	1	7/19/2017	13:39	0
Reference 1	2	7/19/2017	13:55	0
Reference 1	3	7/19/2017	14:13	0
Turbine 6	1	7/19/2017	12:50	0
Turbine 6	2	7/19/2017	12:55	1
Turbine 6	3	7/19/2017	13:15	1

3.1.3 Juvenile Fish

In total, across all nine replicate tows 240 fish were caught on May 13 2017, as compared to 1,716 fish caught in May 2016. The species composition was fairly consistent across all locations and replicates. Smelt dominated most trawls, followed by White Perch, Yellow Perch, Freshwater Drum and Round Goby. Lake Whitefish and White Sucker were collected in select trawls in low numbers (n=1). The thermocline did not appear to be present during the May event, and the results from this sampling event are summarized in Figure 1010.

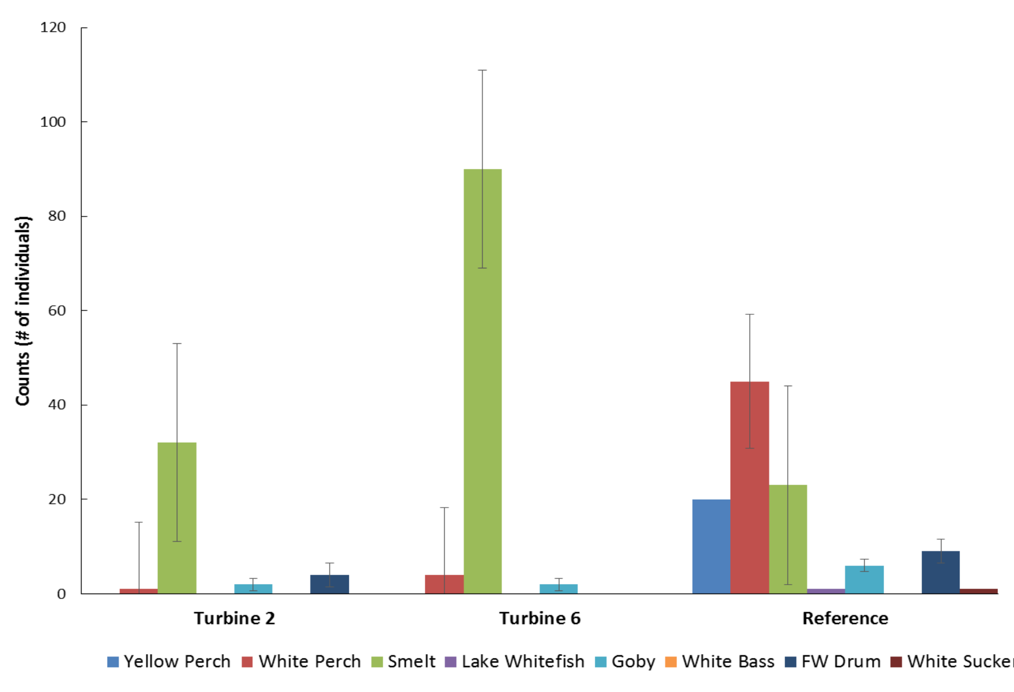


Figure 10. The mean (± SD) for each species collected at each location (n=3 replicate trawls) on the May 13, 2017 event.

The August event occurred when the thermocline was located roughly 1 meter off the bottom. Across all nine replicate tows 37 total fish were caught, compared to only 7 fish in August 2016. The increase in fish was likely due to the location and thickness of the thermocline, in 2016 it was 3-4 meters off the bottom compared to only one meter in 2017. Smelt made up most of the trawls (n=26) followed by Yellow Perch and White Perch, with a single Walleye caught at ICE2 (Replicate 3). The results from this sampling event are summarized in Figure 11.

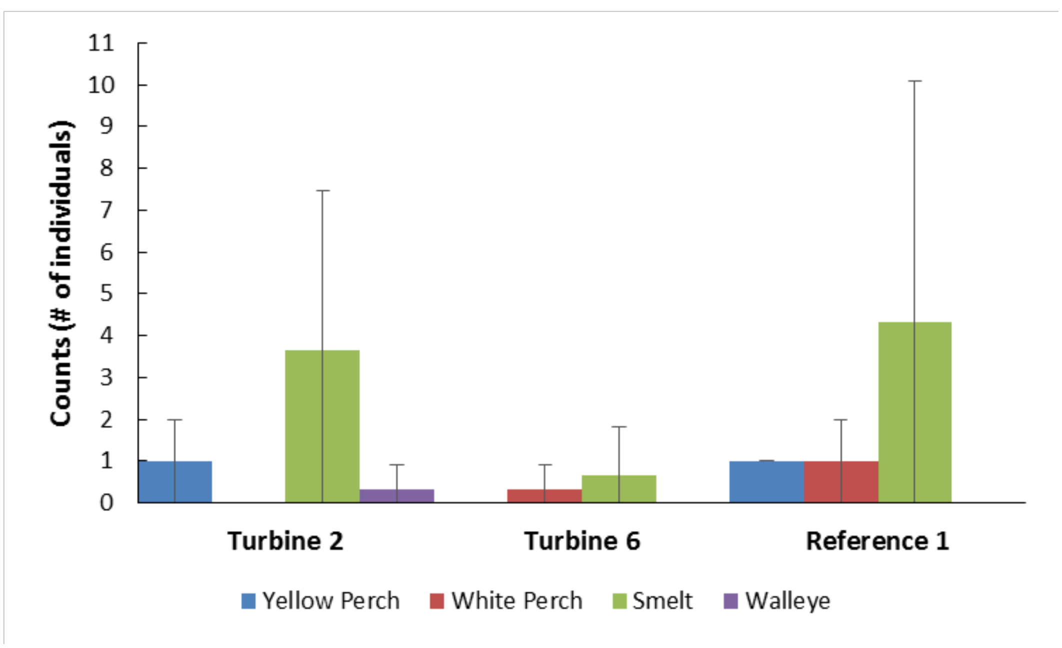


Figure 11. The mean (± SD) for each species collected at each location (n=3 replicate trawls) on the August 7, 2017 event.

The thermocline and associated bottom hypoxia had mostly dissipated for the October 10, 2017 event. The species composition for this last event was variable across locations, with a total of 1,770 fish collected across nine trawls. There was significantly less fish at Turbine 2 (n=50) compared to Turbine 6 (n=620), and Reference 1 (n= 1100). Variability in fish abundance is common, and could be due to a number of factors including, the time of the day, the presence of a large school, or a significant change in physical parameters etc. Smelt dominated all trawls, followed by white perch, and yellow perch. Freshwater drum, walleye, goby, ghost shiner and white bass were collected in select trawls in lower numbers. The abundance of smelt was higher in 2016 but the species composition was the same. The results from the three replicate surveys at each location are summarized in Figure 12.

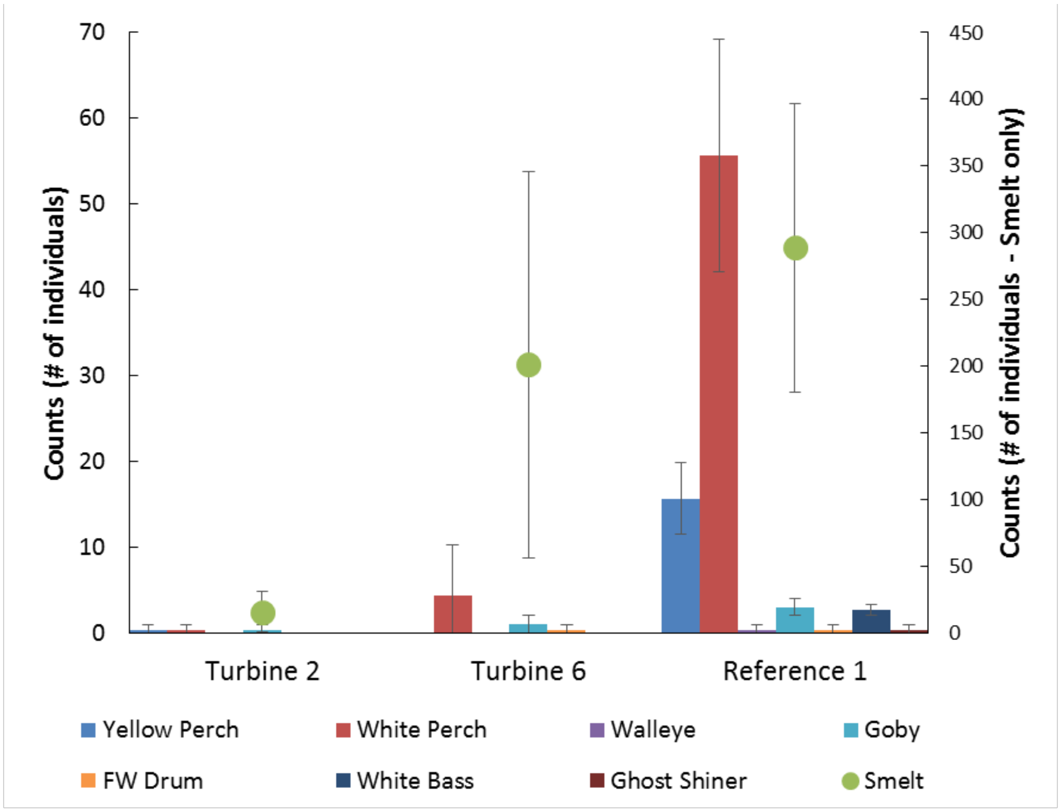


Figure 12. The mean (± SD) for each species collected at each location (n=3 replicate trawls) on the October 10, 2017 event. NOTE: Smelt values are on the right y-axis.

The combined results from the three replicate surveys at each location across the three events are summarized in Table 6 below.

Table 6. Summary of the juvenile fish sampling results from the 2017 spring, summer and fall events.

MAY, 2017	REPLICATE	Yellow Perch	White Perch	Smelt	Lake Whitefish	Goby	White Bass	FW Drum	White Sucker	Walleye	Ghost Shiner	Total
ICE2	1			27				2				29
	2			4		2						6
	3		1	1				2				4
ICE6	1			11								11
	2		1	49		1						51
	3		3	30		1						34
REF6	1	4	12	5		1		3				25
	2	9	21	2		2		4	1			39
	3	7	12	16	1	3		2				41
Total		20	50	145	1	10	0	13	1	0	0	240
AUGUST, 2017	REPLICATE	Yellow Perch	White Perch	Smelt	Lake Whitefish	Goby	White Bass	FW Drum	White Sucker	Walleye	Ghost Shiner	Total
ICE2	1	1	0	8						0		9
	2	0	0	1						0		1
	3	2	0	2						1		5
ICE6	1	0	0	0						0		0
	2	0	0	2						0		2
	3	0	1	0						0		1
REF6	1	1	0	1						0		2
	2	1	2	11						0		14
	3	1	1	1						0		3
Total		6	4	26	0	0	0	0	0	1	0	37
OCTOBER, 2017	REPLICATE	Yellow Perch	White Perch	Smelt	Lake Whitefish	Goby	White Bass	FW Drum	White Sucker	Walleye	Ghost Shiner	Total
ICE2	1	0	0	17		0	0	0		0	0	17
	2	0	0	30		0	0	0		0	0	30
	3	1	1	0		1	0	0		0	0	3
ICE6	1	0	0	114		0	0	0		0	0	114
	2	0	2	121		1	0	0		0	0	124
	3	0	11	368		2	0	1		0	0	382
REF6	1	17	56	215		2	3	0		0	0	293
	2	19	42	413		3	2	0		1	1	481
	3	11	69	238		4	3	1		0	0	326
Total		48	181	1516	0	13	8	2	0	1	1	1770

3.1.4 Zooplankton

The results from each event summarized, in Table 7, by common numerical metrics, including number of species, numbers/L and the biomass for each month and station. The results were variable across all sites for biomass and numbers/L; however, in general, the species composition remained similar.

Table 7. The number of species, number of organisms/L and the biomass for all zooplankton in each sample - May through October 2017.

	Turbine 2					
	May	June	July	August	September	October
Number/L	177	127	706	583	523	423
Biomass (ug d.w./L)	124	143	54	46	121	49
	Turbine 6					
	May	June	July	August	September	October
Number/L	151	364	2146	344	442	387
Biomass (ug d.w./L)	25	419	221	26	162	56
	Reference 2					
	May	June	July	August	September	October
Number/L	212	361	855	231	407	201
Biomass (ug d.w./L)	80	245	74	15	190	42
	Reference 4					
	May	June	July	August	September	October
Number/L	157	120	686	347	553	465
Biomass (ug d.w./L)	68	184	37	205	81	89
	Reference 6					
	May	June	July	August	September	October
Number/L	1089	262	666	367	480	145
Biomass (ug d.w./L)	496	451	28	32	41	85
	Turbine 4					
	May	June	July	August	September	October
Number/L	148	177	1361	252	343	418
Biomass (ug d.w./L)	27	199	442	34	76	68
	Reference 1					
	May	June	July	August	September	October
Number/L	155	181	1416	293	359	300
Biomass (ug d.w./L)	28	181	154	42	45	44
	Reference 3					
	May	June	July	August	September	October
Number/L	180	544	920	277	473	547
Biomass (ug d.w./L)	55	513	77	25	103	576
	Reference 5					
	May	June	July	August	September	October
Number/L	383	341	973	206	351	249
Biomass (ug d.w./L)	104	457	66	75	134	71
	Nearshore					
	May	June	July	August	September	October
Number/L	94	230	467	341	-	849
Biomass (ug d.w./L)	15	283	80	13	-	159

The species composition across each month is summarized in Table 8. The native predatory water flea (*Leptodora kindtii*) was present in select June, August, September October samples and the invasive, predatory spiny water flea (*Bythotrephes longimanus*) was present in select June samples and most July, August, September and October samples. This is consistent with the Forage Task Group's findings (FTG, 2016), which stated the densities of the invasive water flea are generally higher from July through September.

Table 8. Taxonomic groups present across all locations from the May through October 2017 sampling events are summarized.

Sub-class-Genus-Species	Sub-class-Genus-Species
Asplanchna priodonta	*Gastropoda stylifer*
Acanthocyclops robustus	*Hexarthra mira*
Alona guttata	*Kellicottia longispina*
Anuraeopsis fissa	*Keratella cochlearis*
Ascomorpha ecaudis	*Keratella cochlearis var.tecta*
Ascomorpha ovalis	*Keratella crassa*
Bosmina longirostris	*Keratella earlinae*
calanoid copepodid	*Keratella quadrata*
Ceriodaphnia lacustris	*Leptodiaptomus ashlandi*
Collotheca sp.	*Leptodora kindtii*
Colurella spp.	*Mesocyclops edax*
Conochilus unicornis	nauplii
cyclopoid copepodid	*Notholca laurentiae*
Daphnia galeata	*Ploespma lenticulare*
Daphnia retrocurva	*Ploespma truncatum*
Daphnia sp.	*Polyarthra eurptera*
Daphnia spp.	*Polyarthra vulgaris*
Diacyclops thomasi	*Pompholyx sulcata*
Diaphanosoma brachyurum	*Skistodiaptomus oregonenis*
Dreissena veliger	*Skistodiaptomus oregonensis*
Epischura nevadensis	*Synchaeta spp.*
Eubosmina maritima	*Synchaeta spp.*
Eubosmina coregoni	*Trichocerca multicrinus*
Euchlanis spp.	*Trichocerca similus*
Eurytemora affinis	*Tropocyclops prasinus*

In 2017, we identified an error in the formulation of the Number/L and Biomass in the 2016 raw and reported files in 2016 for zooplankton. The trends across months and locations, as well as the species specific information did not change but the raw numbers did change. These updated numbers are included in Appendix D.

Overall, zooplankton biomass and composition in the project area is consistent with the ongoing Great Lakes Fisheries Commission (GLFC) monitoring across the basin, suggesting there is no unique zooplankton structure at the project site. Alterations to zooplankton community composition and structure are not anticipated as part of the construction or operation of the Icebreaker Wind project. An ongoing monitoring program will continue to monitor zooplankton populations through all phases of the project.

3.1.5 Phytoplankton

The results from each event are summarized in Table 9, including the numerical metrics, including number of cells/L and the total biovolume for each month and station.

Table 9. The number of cells per liter and the total biovolume for all phytoplankton in each sample are summarized from May through October 2017.

	Turbine 2					
	May	June	July	August	September	October
Cells/L	5.92E+07	3.95E+07	7.36E+07	9.51E+07	1.60E+08	1.40E+08
Total Biovolume (um^3/L)	5.02E+09	3.75E+08	5.35E+09	1.14E+10	5.39E+09	6.45E+09
	Turbine 6					
	May	June	July	August	September	October
Cells/L	9.12E+07	4.69E+07	6.95E+07	9.46E+07	1.67E+08	1.19E+08
Total Biovolume (um^3/L)	5.68E+09	1.01E+09	4.08E+09	7.02E+09	1.49E+09	9.81E+09
	Reference 2					
	May	June	July	August	September	October
Cells/L	5.63E+07	3.66E+07	1.15E+08	7.86E+07	8.63E+07	1.95E+08
Total Biovolume (um^3/L)	1.28E+10	7.29E+09	9.95E+09	6.06E+09	8.39E+09	7.06E+09
	Reference 4					
	May	June	July	August	September	October
Cells/L	2.00E+08	4.48E+07	7.06E+07	9.02E+07	2.22E+08	7.91E+07
Total Biovolume (um^3/L)	7.97E+08	3.76E+08	7.23E+08	1.38E+09	1.01E+10	2.54E+09
	Reference 6					
	May	June	July	August	September	October
Cells/L	8.45E+07	5.13E+07	1.65E+08	1.14E+08	6.73E+07	8.86E+07
Total Biovolume (um^3/L)	8.32E+08	4.11E+08	8.71E+08	7.26E+09	2.35E+09	1.93E+09
	Turbine 4					
	May	June	July	August	September	October
Cells/L	4.25E+07	2.85E+07	3.24E+07	5.83E+07	1.75E+08	1.87E+08
Total Biovolume (um^3/L)	2.54E+09	2.23E+09	2.79E+09	2.89E+09	8.51E+09	7.20E+09
	Reference 1					
	May	June	July	August	September	October
Cells/L	1.09E+08	7.47E+07	1.44E+08	7.30E+07	1.62E+08	2.06E+08
Total Biovolume (um^3/L)	4.09E+09	4.17E+09	1.42E+09	3.85E+09	9.17E+09	8.14E+09
	Reference 3					
	May	June	July	August	September	October
Cells/L	6.45E+07	3.40E+07	2.83E+07	5.38E+07	1.43E+08	1.57E+08
Total Biovolume (um^3/L)	2.36E+09	2.74E+09	7.29E+08	4.48E+09	9.73E+09	5.85E+09
	Reference 5					
	May	June	July	August	September	October
Cells/L	8.53E+07	3.57E+07	4.04E+07	3.97E+07	1.67E+08	8.36E+07
Total Biovolume (um^3/L)	4.34E+08	2.21E+09	9.92E+08	8.59E+08	3.99E+09	3.99E+09
	Nearshore					
	May	June	July	August	September	October
Cells/L	1.68E+08	7.53E+07	5.02E+07	9.77E+07	-	1.61E+08
Total Biovolume (um^3/L)	2.11E+10	7.75E+08	5.73E+09	5.04E+09	-	5.14E+09

A summary of the composition of Genus across all months is found in Table 10. Across all months (May-October) cyanobacteria (blue-green algae) were the dominant (e.g. density) group. Microcystis were only present in August and September samples.

Table 10. The genera present across all locations from the May through October 2017.

Achnanthidium minutissimum	Aphanocapsa spp.	Aulacoseira spp.	Microcystis sp.
Achnanthidium sp.	Aphanothece sp.	Botryosphaerella sudetica	Monactinus simplex
Ankistrodesmus arcuatus	Ceratium sp.	Carteria sp.	Mougeotia sp.
Aphanizomenon sp.	cf. Aphanothece sp.	Ceratium cornutum	Nitzschia acicularis
Asterionella formosa	cf. Carteria sp.	Ceratium hirundinella	Nitzschia cf. acicularis
Aulacoseira sp.	cf. Chlamydomonas sp.	cf. Achnanthidium sp.	Nitzschia fruticosa
Chlamydomonas globosa	cf. Chlorella spp.	cf. Aphanocapsa sp.	Ochromonas spp.
Chlamydomonas sp.	cf. Chrysochromulina sp.	cf. Chlorella sp.	Pedinomonas sp.
Chlorella sp.	cf. Chrysochromulina spp.	cf. Cyanodictyon sp.	Peridiniopsis sp.
Chlorella vulgaris	cf. Crucigenia sp.	cf. Cyclotella sp.	Peridinium sp.
Chroococcus microscopicus	cf. Dictyosphaerium sp.	cf. Cylindrospermopsis sp.	Pseudanabaena endophytica
Chroococcus minimus	cf. Dolichospermum sp.	cf. Dinobryon sp.	Pseudanabaena spp.
cf. Chroomonas sp.	cf. Elakatothrix sp.	cf. Drepanochloris nannoselene	Romeria sp.
Coelastrum cf. microporum	cf. Gymnodinium sp.	cf. Eudorina sp.	Scenedesmus spp.
Cryptomonas erosa	cf. Klebsormidium sp.	cf. Fragilaria sp.	Selenastrum sp.
Cryptomonas ovata	cf. Leptosira sp.	cf. Glaucospira sp.	Staurastrum sp.
Cryptomonas sp.	cf. Melosira sp.	cf. Kephyrion sp.	Stephanodiscus cf. medius
Cyclotella sp.	cf. Ochromonas sp.	cf. Kirchneriella sp.	Stephanodiscus medius
Dinobryon sp.	cf. Ochromonas spp.	cf. Lagerheimia sp.	Stephanodiscus niagarae
Drepanochloris nannoselene	cf. Oocystis sp.	cf. Lagynion sp.	Stephanodiscus parvus
cf. Euglena sp.	cf. Planktolyngbya sp.	cf. Merismopedia sp.	Synura sp.
Fragilaria brevistriata	cf. Planktothrix sp.	cf. Microcystis sp.	Urosolenia sp.
Fragilaria capucina	cf. Pseudanabaena sp.	cf. Monoraphidium sp.	Woronichinia sp.
Fragilaria crotonensis	cf. Snowella sp.	cf. Pantocsekiella ocellata	Actinastrum hantzschii
Fragilaria sp.	cf. Tetrastrum sp.	cf. Peridinium sp.	Actinocyclus cf. normanii
cf. Geitlerinema sp.	Chlorella spp.	cf. Phormidium sp.	Asterionella sp.
Glaucospira sp.	Chroococcus minor	cf. Radiococcus sp.	cf. Aphanizomenon sp.
cf. Gloeocystis sp.	Chrysochromulina sp.	cf. Romeria sp.	cf. Chroococcus sp.
Gymnodinium sp.	Chrysococcus sp.	cf. Scenedesmus sp.	cf. Gloeoactinium limneticum
Kirchneriella sp.	Cocconeis sp.	cf. Sphaerocystis sp.	cf. Gloeocapsa sp.
Mallomonas sp.	Cyclotella meneghiniana	cf. Stephanodiscus sp.	cf. Kirchneriella spp.
Melosira varians	Cyclotella ocellata	cf. Synechococcus sp.	cf. Mougeotia sp.
Monoraphidium contortum	Diatoma sp.	cf. Woronichinia sp.	cf. Myxobaktron sp.
Monoraphidium minutum	Diatoma tenuis	Chroococcus cf. dispersus	cf. Ochromonas nana
Navicula sp.	Dinobryon spp.	Chroococcus cf. minimus	Chroococcus spp.
cf. Nitzschia sp.	Dolichospermum sp.	Chroococcus sp.	Crucigenia sp.
Ochromonas sp.	Dolichospermum spp.	Chroomonas sp.	Crucigenia tetrapedia
Oocystis sp.	Eudorina sp.	Coelastrum sp.	Desmodesmus cf. communis
cf. Pandorina sp.	Fragilaria spp.	Cosmarium sp.	Dichotomococcus curvatus
Pantocsekiella ocellata	Golenkinia sp.	Cryptomonas spp.	Dictyosphaerium pulchellum
Plagioselmis nannoplanctica	Golenkiniopsis sp.	Cuspidothrix sp.	Encyonema sp.
Plagioselmis sp.	Kephyrion sp.	Cyanodictyon	Lagerheimia genevensis
Planktolyngbya sp.	Lagynion sp.	Cyanodictyon sp.	Monoraphidium sp.
Planktothrix sp.	Melosira sp.	Cyclotella spp.	Myochloris sp.
cf. Pyramimonas sp.	Nephroselmis sp.	Cylindrospermopsis sp.	Nitzschia spp.
Quadrigula sp.	Nitzschia linearis	Dictyosphaerium sp.	Planktolyngbya spp.
Rhodomonas lacustris	Nitzschia sp.	Elakatothrix sp.	Skeletonema cf. potamos
Scenedesmus sp.	Oocystis spp.	Fragilaria cf. tenera	Skeletonema sp.
Scourfieldia sp.	Plagioselmis spp.	Fragilaria tenera	Surirella sp.
cf. Scourfieldia sp.	Planktolyngbya limnetica	Golenkiniopsis	Synechococcus spp.
cf. Skeletonema potamos	Planktosphaeria gelatinosa	Gyrosigma sp.	Tetraselmis sp.
Snowella sp.	Pseudanabaena limnetica	Kirchneriella cf. obesa	
Stephanodiscus sp.	Pseudanabaena sp.	Kirchneriella obesa	
Stephanodiscus binderanus	Sphaerocystis sp.	Kirchneriella spp.	
Stephanodiscus cf. niagarae	Tabellaria sp.	Lagerheimiella genevensis	
Synechococcus sp.	Tetrastrum sp.	Limnothrix sp.	
Tabellaria flocculosa	Achnanthidium catenatum	Lyngbya sp.	
Tetrastrum staurogeniaeforme	Actinocyclus normanii	Merismopedia cf. tenuissima	
Trachelomonas sp.	Aulacoseira cf. granulata	Merismopedia sp.	
Aphanocapsa sp.	Aulacoseira granulata	Merismopedia tenuissima	

3.1.6 Benthos

The counts (mean ±SD) for each genus are summarized in Table 11. Most of the benthos collected fell into three main groups, Bivalves, Insecta, and Oligochaeta, with a few crustaceans, mollusks and leeches. Their densities were relatively consistent across the three locations but densities in May were nearly double the density in October 2017. This difference was partially driven by Chironomid density. The May 9th, 2017 sampling event was likely just prior to the emergence of benthos (e.g. chironomids) from sediment, maximizing the size and number of individuals present.

Table 11. The mean density (#/m²) and standard deviation (in parentheses) are presented of each taxa across three replicate at each location for the May and October 2017 events.

Taxa	MAY		
	Turbine 2	Turbine 6	Reference 1
Oligochaeta	637.86 (612)	982.31 (437)	1001.44 (467)
*Pisidiidae sp.**	484.77 (130)	618.73 (228)	529.42 (72)
Chironomus sp.	401.85 (298)	267.90 (83)	223.25 (22)
Caecidotea sp.	6.38 (11)	0	0
Dreisseniidae sp.	0	6.38 (11)	0
Procladius sp.	121.19 (86)	19.14 (33)	19.14 (0)9.57 (11)
Glossiphoniidae sp.		0	6.38 (11)
Pleuroceridae sp.		0	28.70 (33)
Tanytarsini sp.		19.14 (19)	6.38 (11)
Valvata sp.		0	0
Total	1543.05	1913.6	1792.39
Taxa	October		
	Turbine 2	Turbine 6	Reference 1
Oligochaeta	478.40 (138)	459.26 (239)	223 (72)
*Pisidiidae sp.**	401.85 (282)	440.12 (191)	210.49 (116)
Chironomus sp.	165.84 (40)	140.33 (22)	165.84 (67)
Caecidotea sp.	76.54 (33)	0	63.79 (40)
Dreisseniidae sp.	12.76 (11)	19.14 (19)	6.38 (11)
Procladius sp.	0	0	0
Glossiphoniidae sp.	19.14 (33)	0	38.27 (38)
Pleuroceridae sp.	0	0	0
Tanytarsini sp.	0	0	0
Valvata sp.	6.38 (11)	6.38 (11)	6.38 (11)
Total	1160.91	1065.23	714.15

*Pisidiidae was previously listed as Sphaeriidae sp

Substrate type is often a key factor in controlling the composition and diversity of the benthic community. The offshore project site (~20 m) consists of primarily silty clay sediments and provides few natural, permanent structures for benthic invertebrates to attach to. While the featureless, silty bottom sediment is likely limiting taxa diversity, the absence of intolerant species (e.g., Mayflies) is also driven by the extended period of hypoxia. Dreissenids (e.g. zebra and quagga mussels) were found as part of this study in low numbers. These mussels can cause significant biofouling of structures, however low summer DO prevents permanent populations to accumulate below the thermocline.

3.2 Physical Habitat

3.2.1 Water Chemistry: Discrete

Discrete grab sampling for water chemistry and water clarity measurements were conducted on May 10, June 8, July 12, August 1, September 7, and October 3, 2017 at REF1-6 and ICE2, ICE4 and ICE6 (Table 12). Total Kjeldahl (TKN), TN, nitrate-nitrite, TP, and chlorophyll-*a* are summarized in Table 13. Water clarity results are summarized in Table 14. Unlike 2016 there were no yearly trends in chemistry parameters from May to October 2017. Average monthly water clarity was 7.6 feet in May before increasing to 18.8 feet in July and afterwards decreasing to 8.3 feet in October. An example of a water quality and photosynthetic active radiation profiles at REF 1 are shown in Figure 133 and Figure 144.

Table 12. Reference, Turbine, and Nearshore locations where discrete chemistry samples were taken from May to October 2017.

		Reference Stations 1 - 3																	
Task Description		1						2						3					
		May	June	July	Aug	Sep	Oct	May	June	July	Aug	Sep	Oct	May	June	July	Aug	Sep	Oct
Discrete Chemistry	Chlorophyll	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
	Nitrate+NO2	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
	Total P	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
	TKN	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
	PAR Extinction	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
	Secchi Depth	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
	DO/Temp Profile		x	x	x	x	x	x	x	x	x	x	x		x	x	x	x	x

		Reference Stations 4 - 6																	
Task Description		4						5						6					
		May	June	July	Aug	Sep	Oct	May	June	July	Aug	Sep	Oct	May	June	July	Aug	Sep	Oct
Discrete Chemistry	Chlorophyll	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
	Nitrate+NO2	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
	Total P	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
	TKN	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
	PAR Extinction	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
	Secchi Depth	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
	DO/Temp Profile		x	x	x	x	x	x	x	x	x	x			x	x	x	x	x

		Turbine Stations																		Nearshore					
Task Description		2						4						6											
		May	June	July	Aug	Sep	Oct	May	June	July	Aug	Sep	Oct	May	June	July	Aug	Sep	Oct	May	June	July	Aug	Sep	Oct
Discrete Chemistry	Chlorophyll	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	-	x
	Nitrate+NO2	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	-	x
	Total P	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	-	x
	TKN	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	-	x
	PAR Extinction	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x		x	x	x	-	x
	Secchi Depth	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x		x	x	x	-	x
	DO/Temp Profile		x	x	x	x	x		x	x	x	x	x		x	x	x	x	x		x	x	x	-	x

Table 13. 2017 monthly results for Total Kjedahl Nitrogen, Total Nitrogen, Chlorophyll-a, Nitrate+Nitrite, and Total Phosphorus.

2017 Water Chemistry Results

	Total Kjeldahl Nitrogen(mg/L)						Total Nitrogen (mg/L)					
Station ID	May	June	July	August	Sept	Oct	May	June	July	August	Sept	Oct
Ref 1	0.254	0.285	0.212	0.214	0.407*	0.342	0.326	0.627	0.390	0.308	0.506*	0.412
Ref 2	0.279	0.269	0.170	0.206	0.446	0.361	0.343	0.573	0.388	0.289	0.545	0.379
Ref 3	0.249*	0.308	0.238*	0.192*	0.391	0.338*	0.371*	0.656	0.409*	0.287*	0.456	0.417*
Ref 4	0.236	0.260	0.451	0.194	0.367	0.315	0.377	0.539	0.636	0.282	0.499	0.364
Ref 5	0.266	0.253	0.310	0.199	0.441	0.297	0.340	0.539	0.492	0.304	0.565	0.329
Ref 6	0.232	0.196*	0.393	0.218	0.397	0.344	0.322	0.454*	0.578	0.335	0.506	0.371
Ice 2	0.389	0.204	0.345	0.232	0.399	0.342	0.487	0.502	0.506	0.322	0.440	0.393
Ice 4	0.301	0.272	0.356	0.097	0.378	0.311	0.369	0.583	0.535	0.199	0.440	0.363
Ice 6	0.224	0.215	0.398	0.172	0.386	0.314	0.290	0.500	0.576	0.288	0.457	0.357
Near Shore	0.401	0.277	0.372	0.183		0.365	0.872	0.738	0.505	0.271		0.473
Field Blank	0.022	0.057	0.060	0.005	0.139	0.036	0.021	0.059	0.062	0.002	0.148	0.054
	MDL: 0.036 mg/L						MDL: 0.038					

	Chlorophyll-a (µg/L)						Nitrate+Nitrite (mg/L)					
Station ID	May	June	July	August	Sept	Oct	May	June	July	August	Sept	Oct
Ref 1	4.25	1.93	2.16	4.57	14.90*	10.61	0.072	0.342	0.177	0.094	0.099*	0.070
Ref 2	3.57	1.96	2.70	4.13	12.54	10.58	0.064	0.304	0.218	0.083	0.098	0.018
Ref 3	6.00*	1.95	2.57*	4.40*	24.39	8.42*	0.121*	0.348	0.171*	0.095*	0.064	0.078*
Ref 4	6.40	1.59	2.47	5.91	16.60	8.93	0.142	0.279	0.184	0.089	0.132	0.049
Ref 5	4.07	2.18	2.67	4.05	13.62	9.91	0.073	0.286	0.183	0.105	0.125	0.032
Ref 6	3.33	1.69*	2.30	3.93	23.59	9.47	0.090	0.258*	0.185	0.117	0.109	0.027
Ice 2	4.88	1.96	2.40	4.13	18.19	8.79	0.098	0.299	0.161	0.090	0.041	0.051
Ice 4	3.63	2.03	2.33	3.86	13.66	10.38	0.068	0.311	0.180	0.103	0.061	0.052
Ice 6	3.26	2.06	3.25	4.23	11.16	10.31	0.066	0.285	0.178	0.116	0.071	0.043
Near Shore	9.31	1.32	1.96	4.23		8.42	0.471	0.461	0.133	0.088		0.109
Field Blank	0.20	0.10	0.01	0.03	4.43	0.07	0.000	0.002	0.001	-0.002	0.009	0.019
	MDL: 1.00 µg/L						MDL: 0.002 mg/L					

	Total Phosphorus (µg/L)					
ID	May	June	July	August	Sept	Oct
Ref 1	11.60	8.32	6.94	8.42	21.17*	17.93
Ref 2	7.33	11.74	6.09	7.09	22.86	17.92
Ref 3	8.44*	9.11	7.20*	8.32*	24.27	16.23*
Ref 4	10.08	8.75	8.53	10.61	22.32	16.69
Ref 5	7.94	11.92	9.32	7.37	20.97	17.10
Ref 6	20.54	12.37*	5.59	8.67	30.06	18.89
Ice 2	14.25	8.27	6.40	7.28	24.41	16.15
Ice 4	9.28	9.52	5.98	7.65	23.23	19.11
Ice 6	7.82	8.64	5.78	8.61	25.55	19.68
Near Shore	27.26	6.26	6.72	7.65		17.52
Field Blank	-0.589	0.619	0.836	0.279	-0.108	1.394
	MDL: 3.15 µg/L					
	Values lower than the method detection level					
	* indicates sites with a dupulicate					

Table 14. 2017 water clarity and light extinction results.

2017 Water Clarity Results												
	Secchi Depth (m)						PAR Extinction Coeff. (m^{-1})					
Station ID	May	June	July	August	Sept	Oct	May	June	July	August	Sept	Oct
Ref 1	3.0	3.6	6.4	5.1	2.3	2.7	-0.157	-0.164	-0.079	-0.107	-0.206	-0.234
Ref 2	2.7	4.0	5.5	5.0	2.4	2.4	-0.136	-0.142	-0.095	-0.109	-0.206	-0.256
Ref 3	1.4	4.0	5.5	5.6	2.2	2.6	-0.315	-0.157	-0.087	-0.105	-0.240	-0.229
Ref 4	0.9	4.4	4.3	5.0	2.4	2.6	-0.374	-0.149	-0.094	-0.101	-0.242	-0.229
Ref 5	2.5	4.4	5.8	5.0	2.4	2.2	-0.185	-0.119	-0.090	-0.097	-0.218	-0.252
Ref 6	2.4	5.4	6.1	4.9	2.4	0.0	-0.121	-0.114	-0.091	-0.129	-0.193	-0.259
Ice 2	2.4	2.4	5.5	5.2	2.3	2.8	-0.210	-0.210	-0.078	-0.098	-0.221	-0.234
Ice 4	2.5	4.3	6.1	4.9	2.4	2.5	-0.133	-0.143	-0.081	-0.106	-0.223	-0.252
Ice 6	3.0	4.6	6.4	5.1	2.4	2.3	-0.154	-0.124	-0.073	-0.111	-0.200	-0.259
Near Shore	*	2.8	5.5	4.6	*	3.1	*	-0.181	-0.085	-0.115	*	-0.204

Note: * denotes no data taken.

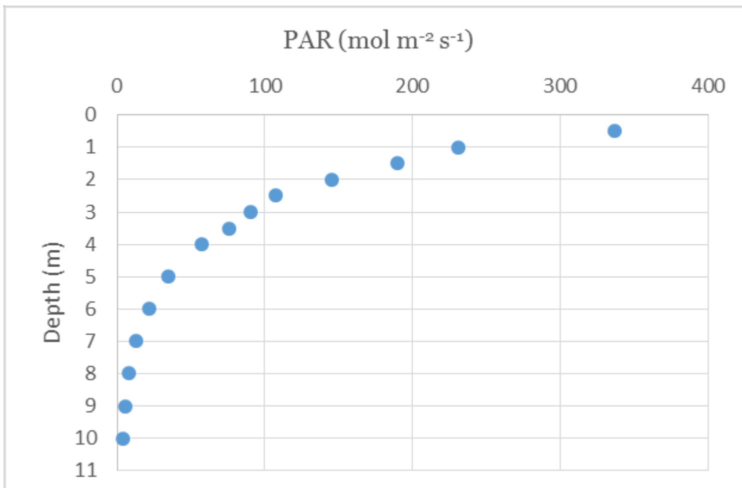


Figure 13. PAR measurements taken on 9/6/2017 at REF1.

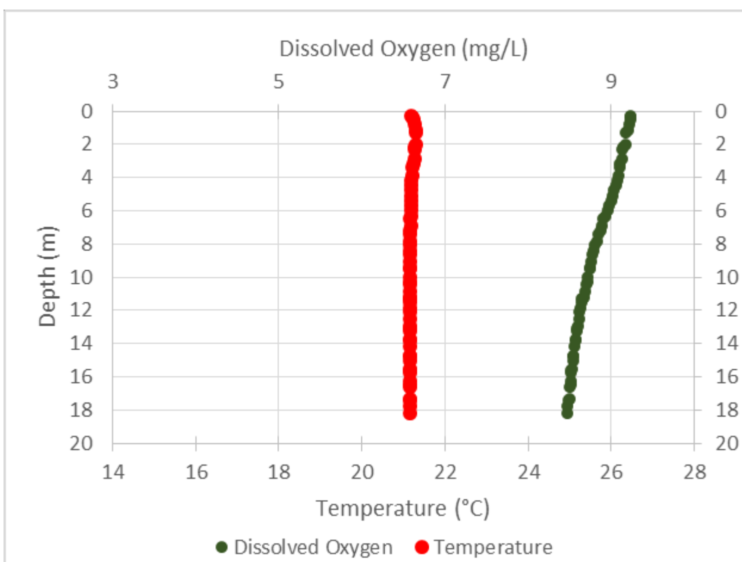


Figure 14. Water temperature and DO profile taken at REF1 on 8/2/2017.

3.2.2 Water Chemistry: Continuous

A summary of the number of days when data was collected by continuous sensors is provided in Table 5 and 16. DO and temperature data were also retrieved from nearby buoys 45164 and 45176 to provide additional data from nearshore and offshore locations. Buoy 45164 was deployed ten miles northeast of the central turbine location in 70 feet of water and provided hourly water temperature from the surface to 60 feet below the surface at two meter increments. Buoy 45176 was located six miles southeast of the central turbine and measured lake bottom DO and temperature every ten minutes.

PAR data for 2017 are shown in Figure 15. PAR was generally similar between the two sites (ICE4 and REF1), with PAR values slightly higher at the reference site. This may be due to differences in the exact positioning of the sensor in the water column resulting in a further distance and more light attention from the water surface. There was a 99% correlation between both sites, indicating PAR was influenced by the same physical dynamics.

Lake bottom DO and temperature from May 10, 2017 to November 7, 2017 are illustrated in Figure 166 and Figure 177. Bottom DO continually dropped until water became anoxic first in late-July and did not permanently oxygenate until October 1. Bottom lake temperature increased ten degrees Celsius at ICE4 and REF1 throughout the 2017 deployment with daily fluctuations due to strong wind events that mixed the water column. (Figure 177).

Deviations in temperature between the nearshore to offshore sites was a response to the location and of the thermocline and thickness of the hypolimnion. Throughout 2017 surface water temperatures from nearshore to offshore had little deviation (Figure 188). Figure 199 illustrates the increase in the thermoclines as the temperature gradient from June through August increases. While the hypolimnion still reached a depth of two meters in 2017, there was only a maximum temperature change over one meter of 8.5 °C in early-August compared to 11 °C from 2016.

Table 15. Number of days each month data was collected by continuous sensors at REF1 and ICE4.

	Reference 1						Turbine 4					
Task Description	May	June	July	August	Sept	Oct	May	June	July	August	Sept	Oct
Surface Water Temperature	29	30	31	31	30	20	29	30	31	31	30	20
Bottom Water Temperature	29	30	31	31	30	20	29	30	31	31	30	20
Bottom Dissolved Oxygen	0	17	30	31	30	20	29	30	31	31	30	20
Photosynthetic Active Radiation	29	30	31	31	30	20	29	30	31	31	30	20
Water Current Profile	29	30	31	31	30	20	29	30	30	21	30	20
Background Noise	29	30	31	31	30	20	29	30	31	31	30	20

Table 16. Number of days each month data was collected by continuous sensors at ICE1, ICE2, ICE7.

	Ice 1				Ice 2			Ice 7			
Task Description	July	August	Sept	Oct	August	Sept	Oct	July	August	Sept	Oct
Bottom Water Temp	11	31	30	31	13	30	31	11	30	30	19
Bottom DO	11	31	30	31	13	30	31	11	30	30	19

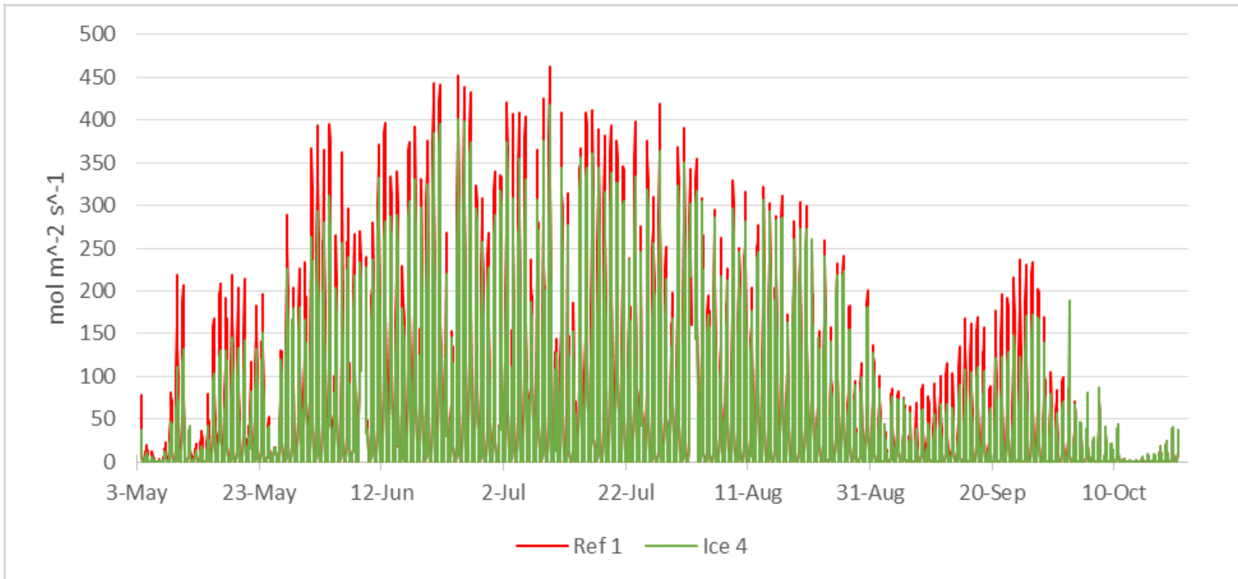


Figure 15. 2017 photosynthetic active radiation at ICE4 and REF1.

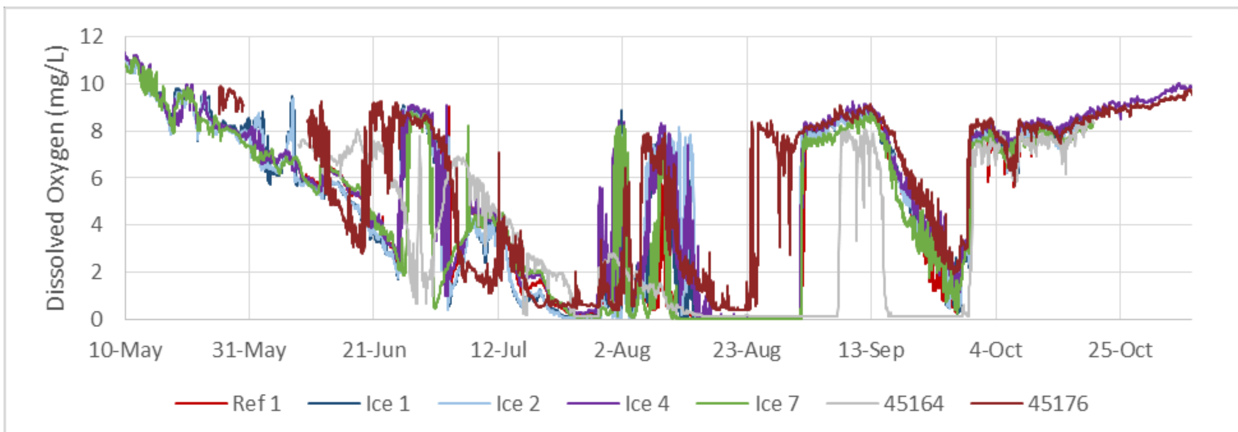


Figure 16. 2017 lake bottom DO at ICE1, ICE2, ICE4, ICE7, REF1, and buoy 45164 and 45176.

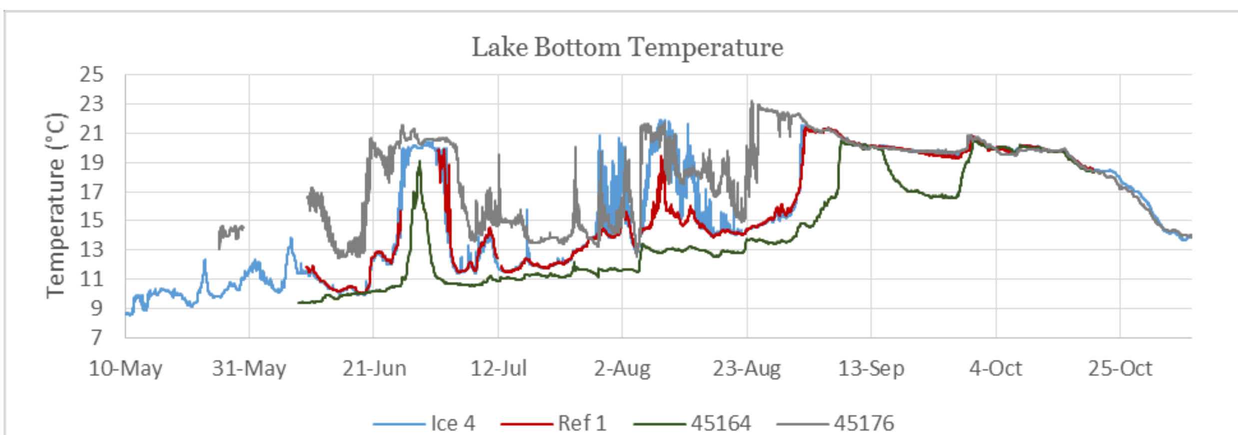


Figure 17. 2017 lake bottom temperature at ICE4, REF1, and buoys 45164 and 45176.

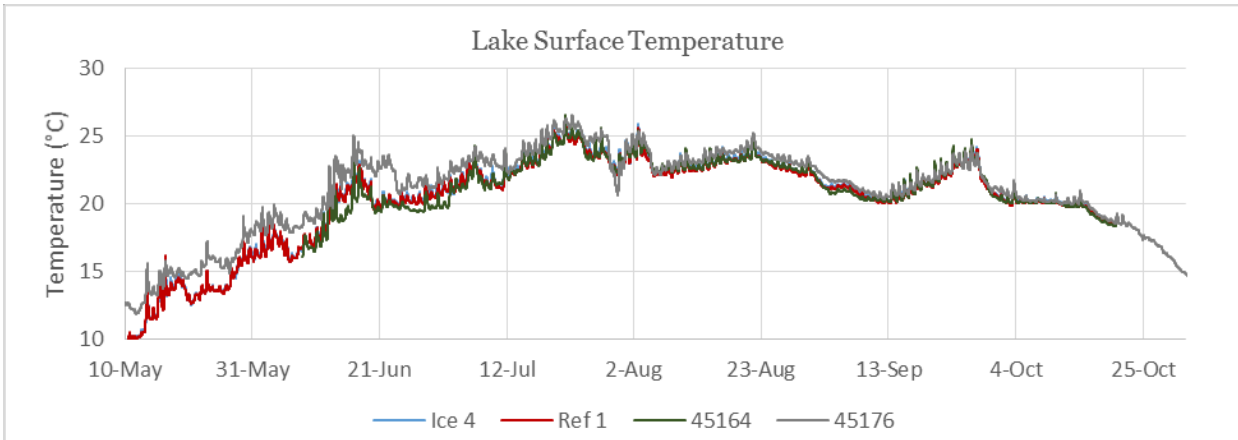


Figure 18. 2017 surface lake temperature at ICE4, REF1, and buoys 45164 and 45176.

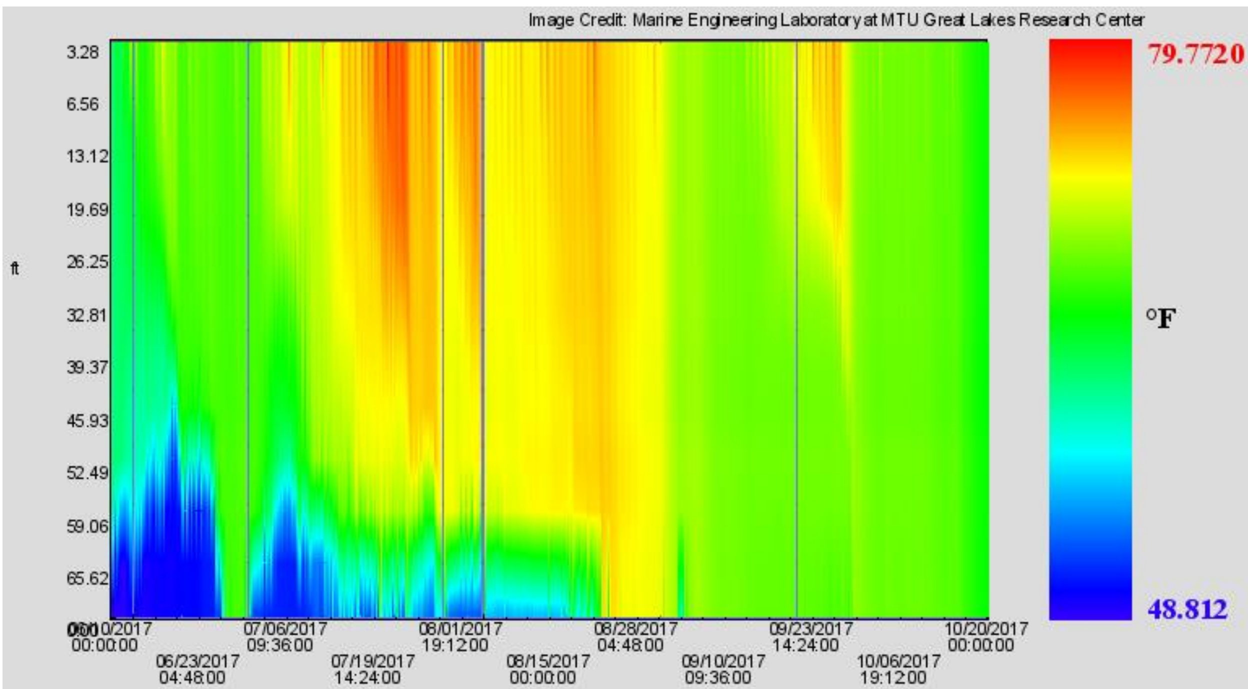


Figure 19. Buoy 45164 water temperature profile from June 1, 2017 to October 20, 2017.

3.2.3 Hydrodynamic

ICE4 exhibited small deviations between the top and bottom water velocity and direction throughout the year (Figure 20 and Figure 21). As summarized in Table 17, the average current velocity from April 1 to October 20, 2017 at the bottom of Lake Erie was 0.075 m/s while the surface was only slightly faster at 0.08 to 0.09 m/s. During the same period average significant wave height and mean wave period for 2017 was 0.38 meters and 2.6 seconds.

Winter data, defined as October 31, 2016 to March 31, 2017, exhibited average wave heights that were 52% higher than the warmer period from April 1 to October 20, 2017. While there was little change in water velocity between both periods at ICE4 and REF1 there was a significant increase in the percentage of water moving from west to east rather than east to west that was measured during the warm period.

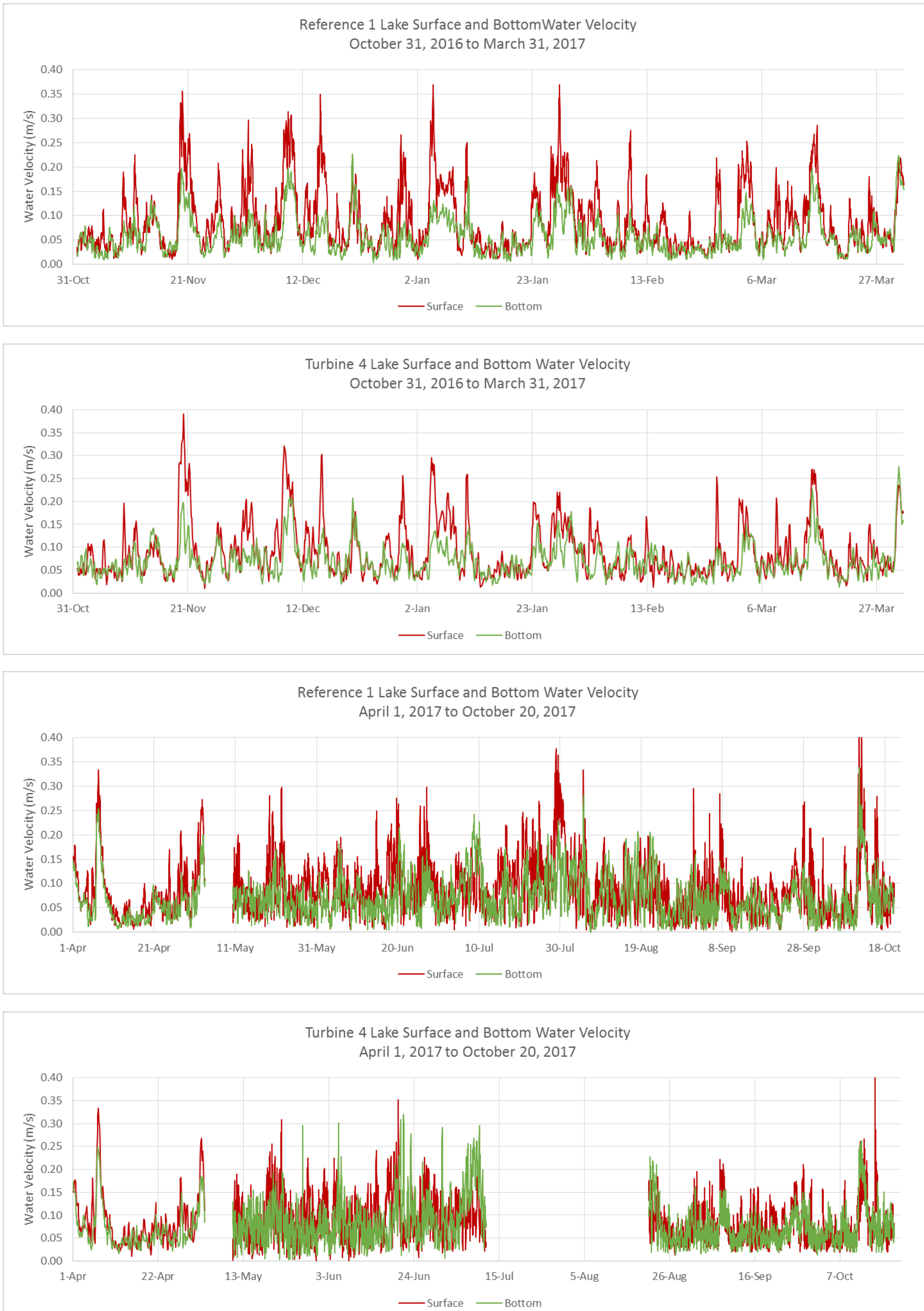
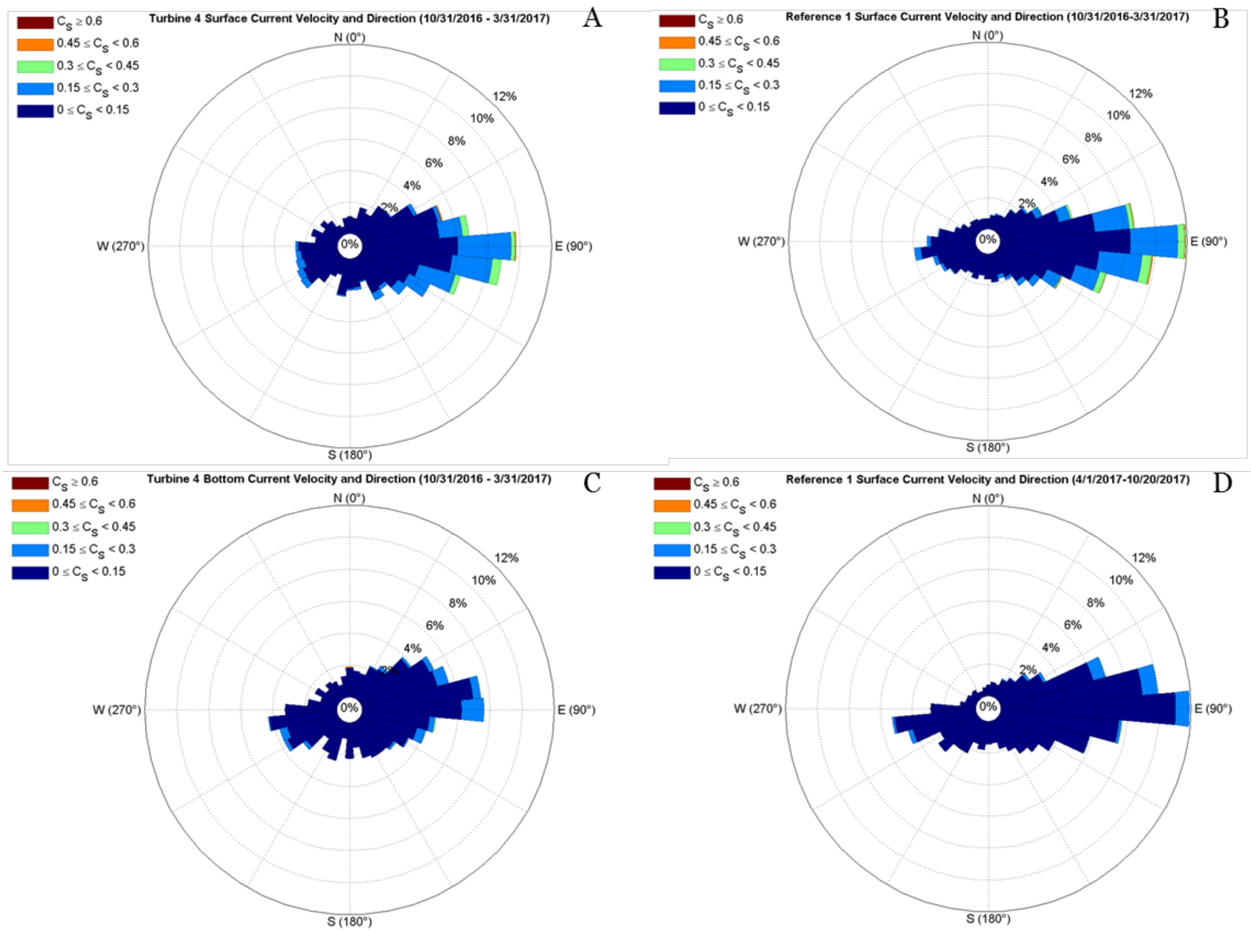


Figure 20. 2017 lake surface and bottom water velocity at ICE4 and REF1.


A
Turbine 4 Surface Current Velocity and Direction (10/31/2016 - 3/31/2017)
$C_s \geq 0.6$
$0.45 \leq C_s < 0.6$
$0.3 \leq C_s < 0.45$
$0.15 \leq C_s < 0.3$
$0 \leq C_s < 0.15$
N (0°)
E (90°)
S (180°)
W (270°)
0%
2%
4%
6%
8%
10%
12%
B
Reference 1 Surface Current Velocity and Direction (10/31/2016-3/31/2017)
$C_s \geq 0.6$
$0.45 \leq C_s < 0.6$
$0.3 \leq C_s < 0.45$
$0.15 \leq C_s < 0.3$
$0 \leq C_s < 0.15$
N (0°)
E (90°)
S (180°)
W (270°)
0%
2%
4%
6%
8%
10%
12%
C
Turbine 4 Bottom Current Velocity and Direction (10/31/2016 - 3/31/2017)
$C_s \geq 0.6$
$0.45 \leq C_s < 0.6$
$0.3 \leq C_s < 0.45$
$0.15 \leq C_s < 0.3$
$0 \leq C_s < 0.15$
N (0°)
E (90°)
S (180°)
W (270°)
0%
4%
6%
8%
10%
12%
D
Reference 1 Surface Current Velocity and Direction (4/1/2017-10/20/2017)
$C_s \geq 0.6$
$0.45 \leq C_s < 0.6$
$0.3 \leq C_s < 0.45$
$0.15 \leq C_s < 0.3$
$0 \leq C_s < 0.15$
N (0°)
E (90°)
S (180°)
W (270°)
0%
2%
4%
6%
8%
10%
12%

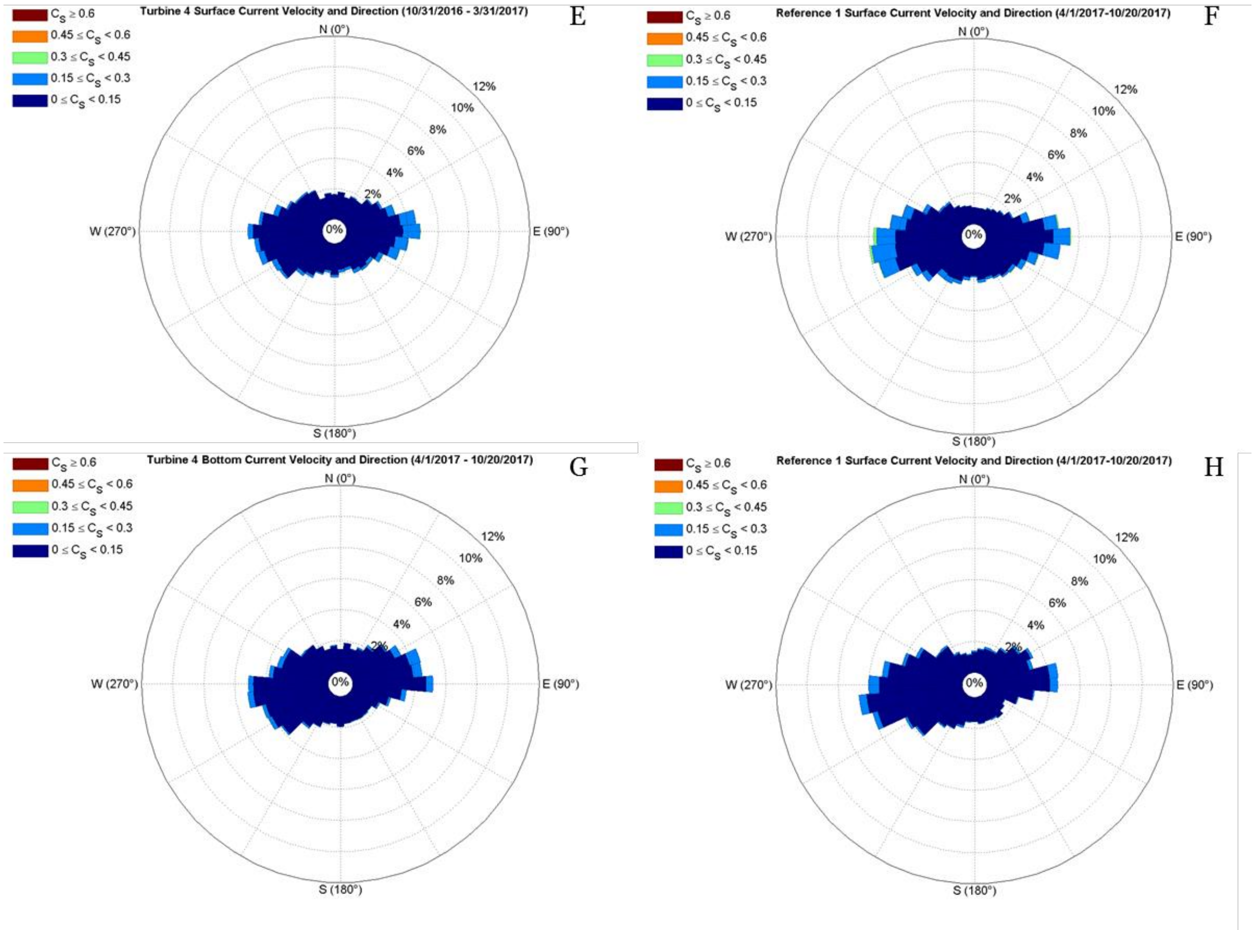


Figure 21. 2017 lake surface and bottom current velocity and direction at ICE4 (A, C) and REF1 (B, D). Spokes represent the frequency of currents moving towards a particular direction.

Table 17. 2017 average and maximum current velocity, wave height, and period at ICE4 and REF1 from October 31, 2016 to March 31, 2017 (top) and April 1 to October 20, 2017 (bottom).

October 31, 2016 to March 31, 2017								
	Current Velocity (m/s)				Wave Height (m)		Period (sec)	
	Bottom		Surface					
	Avg.	Max.	Avg.	Max.	Avg.	Max.	Avg.	Max.
Ice 4	0.070	0.302	0.085	0.414	0.65	3.26	2.93	33.11
Ref 1	0.058	0.245	0.089	0.518	*	*	*	*

April 1, 2017 to October 20, 2017								
	Current Velocity (m/s)				Wave Height (m)		Period (sec)	
	Bottom		Surface					
	Avg.	Max.	Avg.	Max.	Avg.	Max.	Avg.	Max.
Ice 4	0.074	0.444	0.079	0.510	0.38	2.87	2.58	42.7
Ref 1	0.073	0.339	0.093	0.494	*	*		*

Note: * denotes no data taken

3.3 Fish Behavior

3.3.1 Acoustic Telemetry

A brief summary of the detections for reach receiver location are shown below. The data presented were filtered by removing the unknown transmissions and any single detections for a single tag (Table 18).

Table 18. Summary of raw acoustic tag data from November 2016 to August 2017.

Station ID	Distance to Shore	Walleye	Lake Whitefish	Lake Sturgeon	Grass Carp
#	(km)	Unique fish count (total transmission received)			
26	2.96	54 (9493)	2 (119)	0 (0)	1 (4)
13	3.10	51 (9791)	1 (105)	0 (0)	1 (9)
25	4.10	52 (10256)	2 (21)	0 (0)	1 (9)
12	4.41	54 (11455)	2 (86)	0 (0)	1 (11)
24	5.34	64 (10958)	3 (31)	1 (6)	0 (0)
11	5.74	56 (8815)	4 (82)	0 (0)	0 (0)
23	6.63	57 (8823)	5 (123)	0 (0)	0 (0)
10	7.08	56 (8688)	7 (162)	0 (0)	0 (0)
22	7.92	59 (7658)	8 (202)	1 (3)	0 (0)
9	8.42	58 (11058)	8 (374)	1 (1)	0 (0)
21	9.24	55 (6645)	9 (485)	0 (0)	0 (0)
8	9.76	54 (6655)	10 (692)	1 (6)	0 (0)
20	10.57	49 (6859)	11 (904)	1 (7)	0 (0)
7	11.10	48 (6718)	9 (1627)	1 (46)	0 (0)
19	11.90	46 (5034)	10 (541)	1 (37)	0 (0)
6	12.44	52 (5968)	14 (778)	1 (73)	0 (0)
18	13.23	45 (4531)	14 (795)	1 (25)	0 (0)
5	13.79	51 (5211)	13 (1515)	1 (18)	0 (0)
17	14.29	45 (4614)	11 (1608)	1 (12)	0 (0)
4	15.10	49 (4426)	12 (2106)	1 (13)	0 (0)
16	15.43	47 (4702)	12 (1773)	1 (5)	0 (0)
3	16.37	42 (3964)	11 (1448)	1 (2)	0 (0)
15	16.74	33 (9944)	11 (1095)	0 (0)	0 (0)
2	17.66	39 (5279)	11 (1521)	0 (0)	0 (0)
14	18.05	41 (6702)	12 (2100)	0 (0)	0 (0)
1	18.95	34 (3264)	9 (1570)	0 (0)	0 (0)
45176	7.28	48 (2680)	8 (202)	0 (0)	0 (0)
45169	17.237	39 (1822)	10 (394)	0 (0)	0 (0)

Walleye were the most abundant species present within the array followed by Lake Whitefish. Walleye are the most commonly tagged species in Lake Erie, so it is not surprising that they appeared in the highest numbers around the array. The relationship between Walleye and Whitefish counts against the distance from shore is presented in Figure 22. Walleye were highest closest to shore whereas Whitefish decreased. Similarly, the relationship between the number of transmissions for both species is presented in Figure 23.

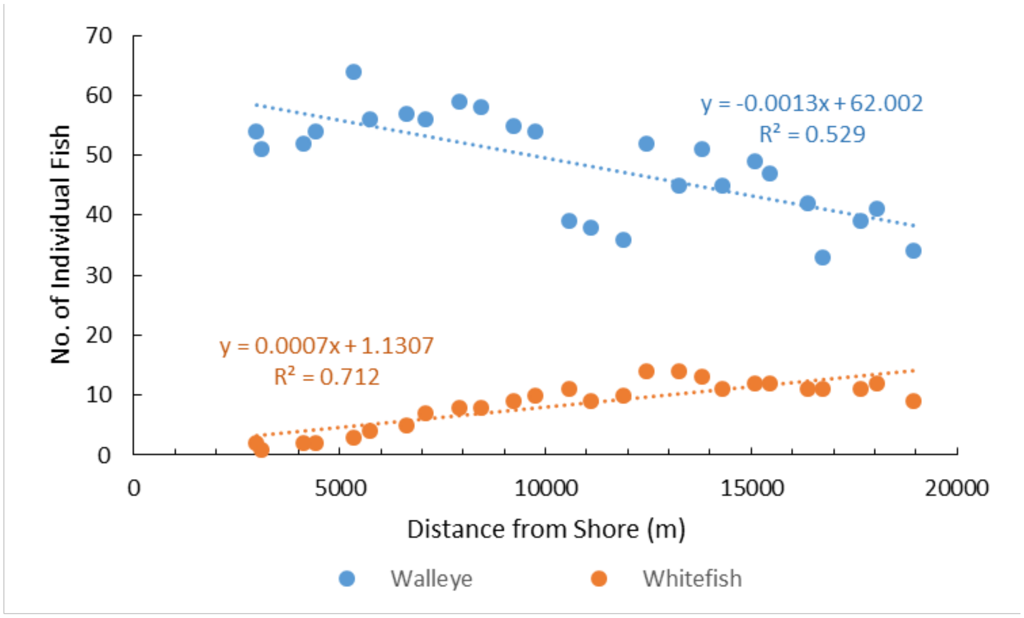


Figure 22. The number of Walleye and Whitefish plotted against distance from shore (m) from October 31 2016 through August 2017. (note: data has not been filtered for false positives)

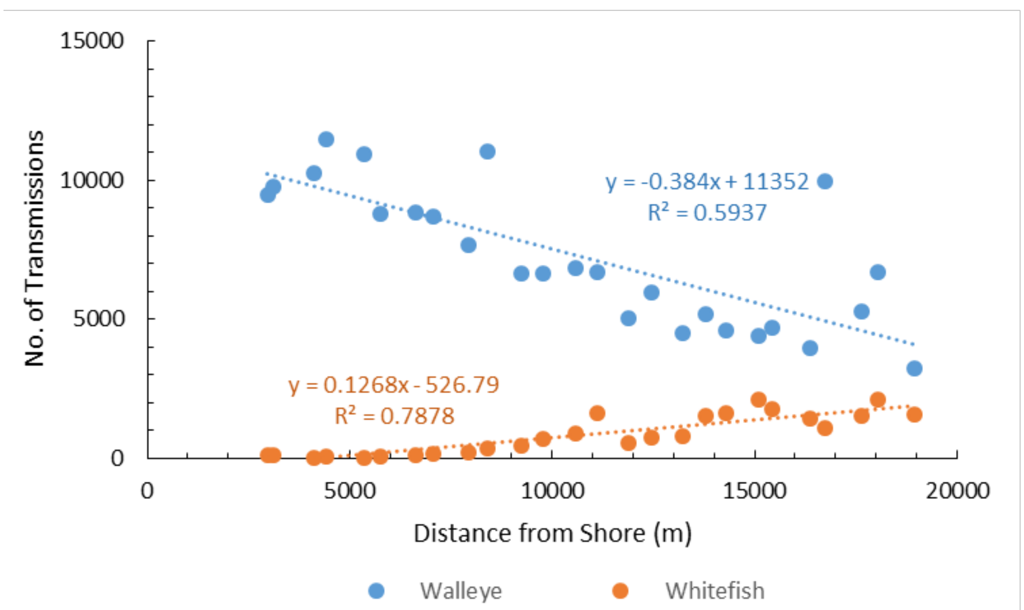


Figure 23. The number of total transmissions for Walleye and Whitefish plotted against distance from shore (m) from October 31 2016 through August 2017 (note: data has not been filtered for false positives)

3.3.2 Fixed Acoustics

The hydroacoustic raw files for each survey are included in Appendix C. In 2016, adult and juvenile fish densities were similar between the two fixed locations, which included one at the project location and one to serve as a reference. Although transects were similar within months in 2016, there was a significant decline in total density across months. The raw files will be analyzed in the future to compare years when the turbines are deployed.

3.3.3 Noise Production

The underwater sound was recorded at ICE4 and REF1 from 5/2/17 to 10/20/17 and was transformed into acoustic pressure (µP). The first standard deviation of acoustic pressure was derived from each 30-minute recording to illustrate sound fluctuations underwater (Figure 24). Noise fluctuations was then compared to LimnoTech's environmental monitoring activity to determine which significant sounds were produced by a single outboard motor, represented by arrows in Figure 24. The 2017 data will be further analyzed for comparison with during and post-construction data. Due to the large data storage for the recordings, the data will not be included in Appendix C. Noise data from 2017 can be obtained by contacting LimnoTech.

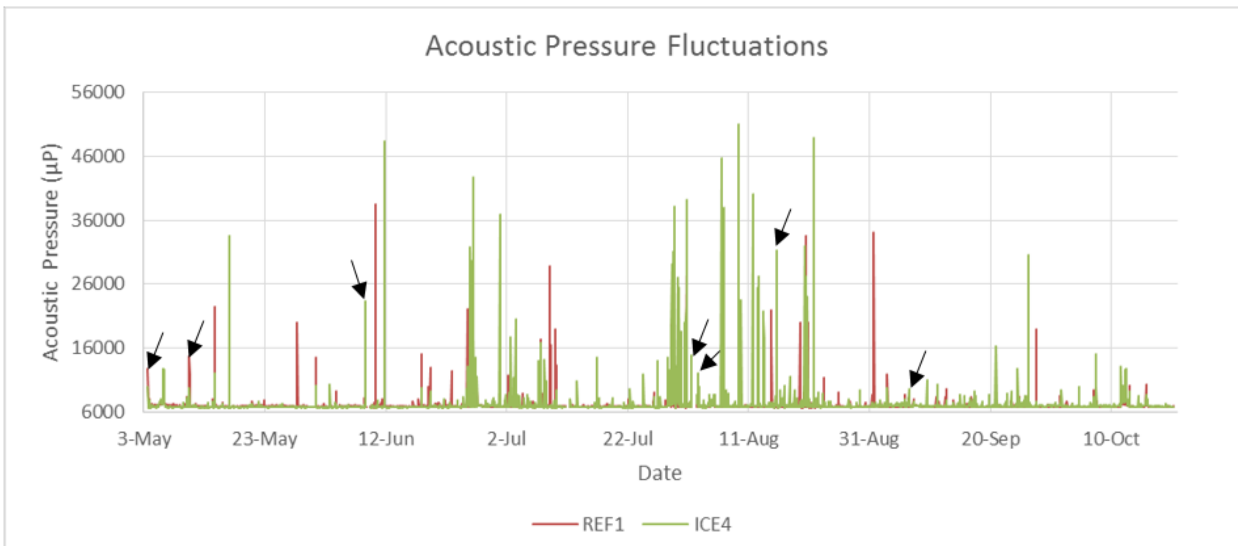


Figure 24. Acoustic pressure fluctuations (µP) at REF1 and ICE4 from 5/2/17 to 10/20/17. Arrows represent noise produced from LimnoTech during environmental monitoring.

3.3.4 Aerial Surveys of Boating

Results from all of the boat surveys by 5-minute survey block are summarized in Table 19 below. Data from the aerial survey shows that boating activity and recreational fishing effort occurs closer to shore than is depicted in the ODNR developed sport fishery maps shown in Figure 25. Each 5-minute survey block has an ID and the numeric part of the ID (911 and 912) corresponds to the 10-minute size survey blocks that are used by ODNR to conduct boating surveys in Lake Erie. Across all dates, only 3% of the total boats counted were in the 5-minute block covering the project area. This data shows that boating activity and recreational fishing effort occurs closer to shore and well away from the project site.

Table 19. Summary of all offshore boat counts from 2017 plane flyovers.

Date	911-NW	911-NE	912-NW	912-NE	911-SW	911-SE	912-SW	Total
5/29/2017	0	0	2	3	40	12	7	64
6/2/2017	0	0	3	2	7	5	8	25
6/22/2017	0	0	0	0	1	0	0	1
6/24/2017	0	0	3	3	84	3	12	105
7/15/2017	0	1	7	18	25	12	11	74
7/19/2017	4	2	8	10	23	5	11	63
8/3/2017	1	2	3	2	17	6	8	39
8/6/2017	0	4	10	7	92	26	23	162
8/21/2017	2	9	6	5	22	14	11	69
8/27/2017	4	6	12	7	49	5	12	95
9/14/2017	0	4	2	1	3	2	7	19
9/17/2017	11	24	14	17	12	16	10	104
10/5/2017	1	7	6	1	6	1	3	25
10/8/2017	1	0	0	1	14	24	0	40
10/26/2017	2	1	1	0	6	7	5	22
10/29/2017	0	0	1	0	5	1	0	7
Total	26	60	78	77	406	139	128	907
% of Total	3	7	9	8	45	15	14	100

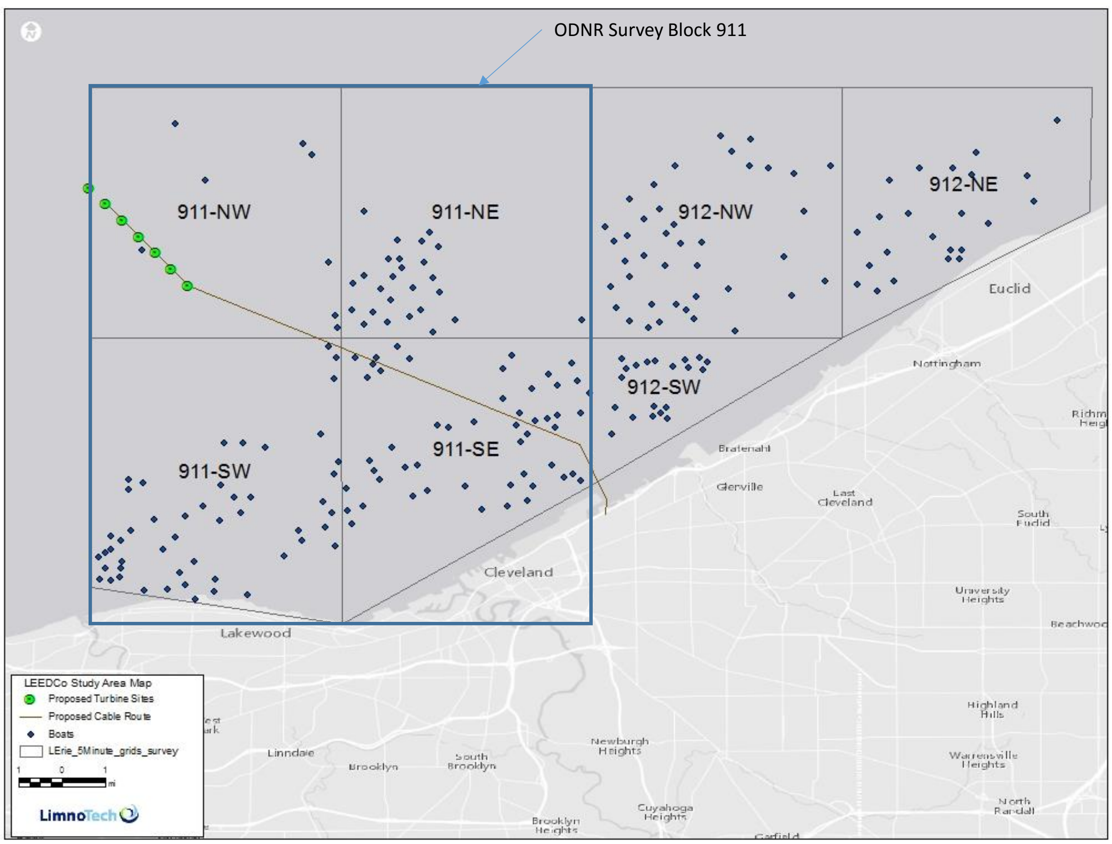


Figure 25. Example map of recreational boats (dots) as counted by plane and turbine location (green dots) on July 3, 2016.

4
Conclusion

The 2017 sampling program was the second year of data collection to support the characterization of the aquatic and biological environment at the proposed site of the nation's first freshwater offshore wind farm near Cleveland, OH in Lake Erie. The 2017 sampling results confirm what was found during the first year of sampling in 2016. These results do not reveal any unusual site conditions that differ from the previous understanding of the aquatic and biological make-up of this portion of Lake Erie. Observed trends in lake currents, temperature, dissolved oxygen, nutrients, water clarity, water quality conditions, sediments, benthic macroinvertebrates, phytoplankton, zooplankton, and larval and juvenile fish were all within ranges observed by others for this area of Lake Erie. Seasonal patterns were evident in almost every physical and biological parameter measured during the 2016 and 2017 field seasons. The data presented in this report do provide fine scale and specificity to the range of values observed at the project site in 2016 and 2017. These data can serve to represent baseline conditions that existed at these sites prior to the initiation of any construction activities. Comparisons can be made between the data collected in 2016/2017 with data collected during and after installation of wind turbines.

5 References

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6
Appendices

Appendix A
Attached Letters

Ohio Department of Natural Resources

JOHN R. KASICH, GOVERNOR

JAMES ZEHRINGER, DIRECTOR

Ohio Division of Wildlife
Raymond W. Petering, Chief
2045 Morse Road, Bldg. G
Columbus, OH 43229-6693
Phone: (614) 265-6300

February 1, 2017

Mr. Edward Verhamme
Project Engineer
LimnoTech
501 Avis Drive
Ann Arbor, MI 48108

Re: LimnoTech Lake Erie Monitoring Plan

Dear Mr. Verhamme:

The purpose of this letter is to formally acknowledge that the January 25, 2017 version of the *LimnoTech Lake Erie Monitoring Plan for the Offshore Wind Project: Icebreaker Wind* received via email on January 25, 2017 meets the requirements of the Ohio Department of Natural Resources (ODNR) Division of Wildlife (Division) Fish Management & Research Group. All Division comments have been addressed in this version of the plan.

The Division will work to develop adaptive language in a forthcoming Memorandum of Understanding (MOU) between ODNR, the United States Fish & Wildlife Service (USFWS), LEEDCo, and LimnoTech that obligates LEEDCo and LimnoTech to fully implement the agreed-to monitoring plan. The MOU will include provisions for an annual performance review, a comprehensive analysis of data, and an option to adjust the monitoring plan based on changes in project design and/or results-driven knowledge gained from the monitoring work.

Please feel free to contact me by email at rich.carter@dnr.state.oh.us or phone at (614) 265-6345 if you have any questions.

Sincerely,

Rich Carter
Executive Administrator
Fish Management and Research
ODNR-Division of Wildlife

cc: Robert Boyles, Deputy Director – ODNR
Raymond Petering, Chief, Division of Wildlife – ODNR
Scott Hale, Assistant Chief, Division of Wildlife - ODNR
Dr. Scudder Mackey, Chief, Office of Coastal Management – ODNR
Dave Kohler, Wildlife Administrator, Division of Wildlife - ODNR
Travis Hartman, Division of Wildlife - ODNR
Dr. Janice Kerns, Division of Wildlife - ODNR
Megan Seymour, Wildlife Biologist - USFWS

Office of the Director • 2045 Morse Rd • Columbus, OH 43229-6693 • ohiodnr.gov

City of Cleveland
Frank G. Jackson, Mayor
Department of Public Utilities
Division of Water
1201 Lakeside Avenue
Cleveland, Ohio 44114-1175
216/664-2444 Fax: 216/664-3330
www.clevelandwater.com

September 22, 2017

Ms. Beth A. Nagusky
Director of Sustainable Development
Lake Erie Energy Development Corporation
1938 Euclid Avenue, Suite 200
Cleveland, Ohio 44115

Dear Ms. Nagusky:

Cleveland Water offers this letter to summarize our meeting on August 24th, 2017 at your office. The meeting was between LEEDCo, CWD, and LimnoTech to discuss the planned construction of wind turbines located offshore from Cleveland and potential, if unlikely, impacts on raw water quality for two of our four plants, specifically the Morgan and Baldwin plants.

Construction of the 7-mile length of parallel lines is the portion of the project we are most interested in. Since it has been determined by LEEDCo that no known areas of toxic material or areas of open lake placement for dredging material exists in the construction corridor, turbidity is the contaminant of concern to Cleveland Water. While we believe this potential to be low, LEEDCo has agreed to the following to ensure the safety of the raw water:

- LEEDCo will provide Cleveland Water a minimum three-day notice before commencing construction of the export cable.
- LEEDCo will communicate with Cleveland Water on a daily basis during the cable laying operations. This construction is anticipated to last approximately one week in the area of concern.
- The cables will not be placed in any area of open lake placement.
- LEEDCo or their agent will monitor for turbidity during construction activities and will provide turbidity sensors for the Morgan buoy/sonde installation. The turbidity sensors will be located at the surface and at the bottom elevations.

Based upon our review of historical turbidity levels in Lake Erie, we have observed natural, storm-induced turbidity spikes up to 300 Nephelometric Turbidity Units

(NTU). Therefore, if turbidity is observed to exceed 300 NTU during construction-related activities, we would have to attribute this to LEEDCo activities. It is likely we would seek some type of relief if significant treatment adjustments are required to meet regulatory limits for potable water. For a number of reasons we discussed during the meeting, we do not anticipate this being a realistic concern.

Finally, as a matter of policy, we request LEEDCo refrain from identifying exact locations of key infrastructure near this project. While we understand much of this information is in the public realm, we try to protect this information at every opportunity. Specifically, we request you refrain from identifying the location of our submerged crib for the Morgan water plant and the locations/direction of the raw water intake tunnels extending from the Kirtland Crib and the Morgan Crib. These tunnels are inconsequential to the overall project and should not be identified.

We appreciate the opportunity to work with LEEDCo, LimnoTech, and your partners on this very important project. If you have any questions, please feel free to contact Maggie Rodgers at 216-664-2444 x75584 or Scott Moegling at 215-664-2444 x75583.

Sincerely,

Alex Margevicius, P.E.
Commissioner
Cleveland Water

ec: Maggie Rodgers, Plant Operations Manager
Scott Moegling, Water Quality Manager

Appendix B
Field Notes, Chain of Custodies, and Field Photos

This appendix will be transmitted to ODNR and USFWS via email.

Appendix C
Electronic Copy of Field Data

This appendix will be included on a thumb drive delivered to ODNR and USFWS.

Appendix D
2016 Zooplankton Correction

In 2017, we identified an error in the formulation of the Number/L and Biomass in the 2016 raw and reported files in 2016 for zooplankton. The trends across months and locations, as well as the species specific information did not change but the raw numbers did change. An updated table is shown below in Table D-1 of Appendix D. Additionally, the updated raw data files from the sampling year 2016 are being submitted with the 2017 data file submission (Appendix C).

Table D-1. 2016 Zooplankton Correction

	Turbine 2					
	May	June	July	August	September	October
Number/L	207.3	177.0	166.1	460.5	166.0	na
Biomass (ug d.w./L)	75.9	111.7	30.6	318.5	60.2	na
	Turbine 6					
	May	June	July	August	September	October
Number/L	509.7	63.2	499.6	485.9	356.3	149.2
Biomass (ug d.w./L)	237.5	132.7	113.1	86.3	141.5	68.1
	Reference 2					
	May	June	July	August	September	October
Number/L	304.5	480.0	180.5	390.8	274.1	na
Biomass (ug d.w./L)	164.8	241.2	22.7	72.0	48.8	na
	Reference 4					
	May	June	July	August	September	October
Number/L	182.5	95.9	279.1	315.0	182.2	na
Biomass (ug d.w./L)	77.7	90.0	35.1	53.4	142.6	na
	Reference 6					
	May	June	July	August	September	October
Number/L	286.8	180.6	155.7	450.1	422.9	189.1
Biomass (ug d.w./L)	110.0	184.7	29.9	61.3	8.9	74.3
	Turbine 4					
	May	June	July	August	September	October
Number/L	na	118.2	132.6	932.0	100.0	152.4
Biomass (ug d.w./L)	na	108.5	11.2	46.7	11.2	66.0
	Reference 1					
	May	June	July	August	September	October
Number/L	213.3	107.0	107.3	84.4	211.7	156.4
Biomass (ug d.w./L)	52.3	180.4	47.5	17.3	77.0	42.7
	Reference 3					
	May	June	July	August	September	October
Number/L	316.5	248.9	69.2	208.3	189.9	155.3
Biomass (ug d.w./L)	122.9	196.6	27.7	68.3	49.1	40.4
	Reference 5					
	May	June	July	August	September	October
Number/L	453.8	60.3	450.8	383.5	140.6	na
Biomass (ug d.w./L)	134.4	76.4	63.9	120.6	18.3	na

Icebreaker Windpower, Inc.
Case No. 16-1871-EL-BGN
Fourth Supplement to Application
March 22, 2018

Attachment 4

Icebreaker Wind Bird and Bat Monitoring Annual Report
February 20, 2018
Western EcoSystems Technology, Inc.

Christine M.T. Pirik (0029759)
Terrence O'Donnell (0074213)
William V. Vorys (0093479)
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wvorys@dickinsonwright.com

Attorneys for Icebreaker Windpower Inc.

Icebreaker Wind Bird and Bat Monitoring
Lake Erie, Ohio

Annual Report
February 20, 2018

Prepared for:

Icebreaker Windpower, Inc.

1938 Euclid Avenue, Suite 200
Cleveland, Ohio 44115

Prepared by:

Caleb Gordon, Ashley Matteson, Jennifer Stucker, and Rhett Good

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REPORT REFERENCE

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INTRODUCTION

This first annual status report is being provided by Western EcoSystems Technology Inc. (WEST) to the Ohio Department of Natural Resources (ODNR) pursuant to the Memorandum of Understanding (MOU) between ODNR and Icebreaker Windpower Inc. (IWP) dated July 12, 2017. The MOU sets forth the avian and bat monitoring protocols, reporting requirements and other commitments of the parties in regard to construction and operation of the Icebreaker Wind Project (Project), a 20.7 megawatt offshore wind demonstration project proposed 8 to 10 miles (mi) off the shore of Cleveland, Ohio. IWP currently has an application for a Certificate of Environmental Compatibility and Public Need pending at the Ohio Power Siting Board, which has been assigned case no. 16-1871-EL-BGN.

This first annual report covers all activities undertaken by the WEST team related to items described in the MOU and associated Monitoring Plan (MP) during 2017. It encompasses the activity reported in the first two quarterly reports, submitted in September and December of 2017 pursuant to the MOU, and additional activities undertaken during December, 2017 and January, 2018. The report includes a comprehensive summary of all MOU-specified activity on the Project by the WEST team that has occurred through early February, 2018. This report summarizes, but does not fully recapitulate all of the detail contained within the previously submitted quarterly reports. Activities covered in the current report include bat acoustic monitoring surveys, conducted between March and November, 2017, ongoing aerial waterfowl and waterbird surveys initiated in mid-October, 2017, and ongoing research, meetings, and deliberations aimed at finalizing several components of the MP that were contemplated in the MOU. These include collection of baseline data using surveillance radar, exploration into emerging technologies for collision fatality monitoring in the offshore environment, and the completion of an initial draft of the Bird and Bat Conservation Strategy (BBCS) which includes committed impact avoidance and minimization measures, as well as an adaptive management plan for the Project.

BAT ACOUSTIC MONITORING

WEST conducted acoustic bat call monitoring using protocols and sampling designs developed in coordination with ODNR and USFWS, and described in the MOU. This effort entailed gathering recordings at five offshore recording points (four “standard” and one “experimental” point[1]) during the 2017 potential bat activity season, defined by ODNR as extending from March 15 through November 15, using full spectrum bat recorders from Wildlife Acoustics (SM3 and SM4 models). The Final Bat Acoustic Monitoring Report was submitted to the ODNR and USFWS on February 15, 2018 and is attached as Appendix A.

In summary, this effort resulted in 469 successful detector-nights of recordings gathered and analyzed for the 2017 season, which included a total of 10,114 bat passes, including passes recorded by redundant detectors at each recording location. The number of bat passes per detector-night was used as the standard metric for measuring bat activity. A bat pass was defined as a sequence of at least two echolocation calls (pulses) produced by an individual bat with no pause between calls of more than one second (Fenton 1980). The same bat could be recorded echolocating during multiple passes at a given station; therefore, bat pass rates represent an index of bat activity, and do not represent numbers of individuals at each recording location. For example, 10 bats could echolocate near a detector once on a given night, or one bat could echolocate near a detector 10 times on a given night; both situations would result in 10 bat passes per detector-night.

The overall success of recording, defined as the percentage of the total nights between March 15 and November 15 for which recordings were successfully gathered at each of the four “standard” recording stations was 90.4%, with single-station success rates ranging from 82.5% to 96.8% for each of these stations. In addition, a fifth experimental station with microphones mounted at a 10m height on a carbon fiber pole resulted in 100% recording success during a smaller deployment period during the peak bat activity period (51 nights from July 11 through August 30). The overall average bat pass rate documented during this effort for all stations combined was 6.8 ± 0.7 bat passes per detector night, with single station averages ranging from 0.8 to 16.2 bat passes per detector night. Peak bat activity was recorded during the late summer/early fall period (roughly mid-July through early October), consistent with a well-documented pattern at terrestrial sites. Four common and widespread bat species accounted for the vast majority (<99.9%) of identified calls documented during this effort. The total numbers of passes unambiguously assigned to each bat species were as follows: *Lasiurus borealis* (eastern red bat) – 4097 passes; *Lasiurus cinereus* (hoary bat) – 2454 passes; *Lasionycteris noctivagans* (silver-haired bat) – 1545 passes; *Eptesicus fuscus* (big brown bat) – 1210 passes; *Perimyotis subflavus* (tri-colored bat) – 13 passes; *Myotis lucifugus* (little brown bat) – 1 pass. 1884 passes were classified as confirmed bat passes but could not be unambiguously identified to species. None of the calls recorded during this effort was classified

[1] WEST also performed a statistical analysis that demonstrated that the results from the “experimental” station (the 10 m pole at the Project site) were very similar to the results from the standard station at the project site. This analysis is included with the final bat acoustic survey report.

as potentially belonging to a federally listed species. Surveys completed at most on-shore wind facilities, and surveys previously completed for Icebreaker by Tetra Tech used Anabat detectors. Songmeter SMx units have more sensitive microphones than do Anabat units, and therefore record approximately 3x more bat passes than do Anabat units under conditions of identical bat activity (Adams et al. 2012). Therefore, bat pass rates collected with SMx detectors cannot be directly compared with data collected at on-shore projects using Anabat detectors to assess if rates of activity were low or high relative to other projects. Regarding the implications of these results for potential risk to bats from the development and operation of the Project, the patterns of bat activity recorded at the Project are consistent with the conclusions of the risk assessment, and suggest that the Project is likely to generate per turbine or per megawatt bat fatality rates within the range of those that have been documented at land-based wind energy facilities within the Great Lakes region, affecting primarily the four species documented at the site, and not likely to affect any federally listed species. Please see Appendix A for full detail on the sampling locations, methods, results, and interpretation.

AERIAL WATERBIRD SURVEY

WEST initiated aerial surveys for diurnal birds, primarily expected to include waterfowl and waterbirds, using protocols and sampling designs developed in coordination with ODNR and USFWS, and described in the MP and MOU. This effort entails conducting biweekly (every two weeks) bird surveys using live observers aboard a fixed wing aircraft. Surveys are conducted from October 15 through the end of May during the non-breeding season for most waterfowl and waterbirds. This seasonal sampling frame was recommended by USFWS because it is the season when the largest number of bird individuals and species occur in Lake Erie. After an observer training program was conducted on October 13-14, 2017, the first survey was flown on October 16, and surveys have been conducted every two weeks subsequently for a total of 9 regular surveys flown up to and including the latest data included in the present report, which is from the survey conducted on February 5, 2018. In addition to these 9 surveys, a supplemental survey was flown on January 4 to document patterns of bird use in association with ice formation on the Lake.

Each survey was performed using the prescribed double-observer approach identified in the study plan, with 3 observers aboard each survey flight. The survey vehicle was a Cessna 185 high-wing four-seat aircraft, and was flown at 76 meter elevation and 150 km/hour speed during surveys. The survey area covers 146 km^2, including all of the Project turbine locations plus a buffer of at least 5 km in all directions. The survey route flown within this area during each survey consisted of seven 10-km straight-line transects perpendicular to the turbine array, with transects spaced at 2.2 km intervals to minimize the likelihood of double counting. Beginning with the third survey effort (Mid-November), additional bird data was gathered from “off-transect” areas over the Lake during each survey flight. The off-transect flight paths over the Lake are the path taken by the aircraft in between the Lorain County airport and the survey area, when arriving and departing. While the off-transect area sampling effort encompasses substantially less transect length than the survey area, it is located closer to the south shore of Lake Erie and gives additional information about waterbird activity closer to shore.

In summary, after 9 regular surveys, this effort has resulted in 2098 total individual bird observations within the primary survey area during the regular surveys, representing at least 11 bird species, for an average of 233 individual birds observed within the primary survey area per survey (equivalent to an average bird observation rate of 3.3 bird observations per linear km of survey). In addition, 7 surveys closer-to-shore in the off-transect areas resulted in 3812 total individual bird observations, representing at least 10 bird species, for an average of 545 individuals birds per off-transect survey (equivalent to an average bird observation rate of 13.8 bird observations per linear km of survey). For each survey, abundance of birds per kilometer was greater at off-transect sites than within the project area. The supplemental ice survey conducted during freeze-up on January 4 documented 131 total observations of at least 6 bird species within the primary survey area, and 185 observations of at least 4 bird species in the off-transect survey. The total numbers of birds identified to species within the primary survey area during the regular and ice surveys through February 5, 2018 survey are as follows: *Larus argentatus* (Herring Gull) – 260 observations; *L. delawarensis* (Ring-billed Gull) – 253 observations; *L. marinus* (Great Black-backed Gull) – 38 observations; *Chroicocephalus philadelphia* (Bonaparte's Gull) – 35 observations; *Mergus serrator* (Red-breasted Merganser) – 30 observations; *Phalacrocorax auritus* (Double-crested Cormorant) – 17 observations; *Bucephala clangula* (Common Goldeneye) – 9 observations; *Gavia immer* (Common Loon) – 6 observations; *Clangula hyemalis* (Long-tailed Duck) – 2 observations; *Bucephala albeola* (Bufflehead) – 1 observation; *Mergus merganser* (Common Merganser) – 1 observation. Of the 2229 total individual bird observations recorded within the primary survey area (regular surveys plus one ice survey), 1577 (70.7%) were identified solely to genus (e.g. Scoter (*Melanitta spp*), Merganser (*Merganser spp*), loon (*Gavia spp*)), or a higher taxonomic or functional group (e.g. "waterfowl sp." or "gull sp."); unidentified gulls, most likely a mix of Herring/Ring-billed, accounted for 40.7% of all birds. Only 0.6% of bird observations in the primary survey area, and 0.2% of off-transect observations could not be identified to major group, and these individuals were classified as unidentified large birds.

The patterns of bird use of the Project area and nearby offshore environments is largely consistent with the patterns documented by the two-year waterbird aerial survey effort conducted by Norris and Lott (2011) and summarized within the Icebreaker Wind risk assessment, showing an overall pattern of low bird density and low species richness within the Project area relative to areas near the shoreline based on our preliminary review of data collected to date. Estimates of birds per linear kilometer within the Project area (0.2 – 13.4 birds/km) are on the low end of those observed previously by ODNR and FWS during 2009-2010 their surveys over Lake Erie (0.6 – 83.8 birds/km) (Lott et al. 2011). None of the birds recorded during this effort are protected by the Endangered Species Act (ESA) or BGEPA. Please see Appendix B for full detail on the survey areas, methods, and results obtained through February 5, 2018.

COLLISION MONITORING

Collision monitoring in the offshore environment presents a challenge that must be addressed to better understand the impacts of offshore wind on wildlife, as a basis for decision-making regarding potential future growth of the US offshore wind industry. Innovative technologies and methods are now being explored and proposed in Europe and the U.S. Ever since WEST was initially contracted to develop a bird and bat post-construction monitoring plan for the Project in August, 2016, WEST's biologists have been exploring options for collision monitoring technologies/methodologies with the objective of producing robust annual bird and bat fatality rate estimates for the Project once constructed. While such estimates are routinely gathered at land-based wind energy facilities using bias-corrected data from systematic carcass searching efforts, WEST and the IWP team recognize that no such estimates have ever been gathered at an offshore wind energy facility, as traditional carcass searching is not possible in open water.

Collision monitoring remains one of the most important objectives of this small demonstration project due to the importance of characterizing bird/bat turbine-related fatality rates in the offshore environment of Lake Erie, and in the spirit of generating the greatest scientific value as a U.S. Department of Energy funded demonstration project. The MP associated with the MOU specified that technologies for implementing a robust bird/bat collision monitoring program during the Project's operational phase would continue to be explored as the technologies continue to evolve, and that the most viable collision monitoring technology would be selected at the time such decision had to be made to ensure installation of the technology at the time of construction. Once this suitable technology/methodology was identified and selected, including any necessary validation, testing, algorithm development, or other associated methods necessary to obtain scientifically robust fatality rate estimates from the collected data, a fully developed collision monitoring protocol would be prepared and amended to the MP. In this report, we summarize the information that has been gathered to date on the various collision monitoring systems under consideration.

IDStat: This system is in an early stage of development by ecologist Bertrand Delprat, of the small French consultancy, Calidris, and was reviewed by Dirksen (2017). It relies on acoustic detection of collisions using microphones that listen for airborne sounds inside the blades (compare with blade-mounted vibration sensors in the WT-Bird and "thunk detector" systems, described below). At present, this is the only sensor within the system; there is no photographic sensor for obtaining images of colliding animals (in contrast to WT-Bird and "thunk detector" systems). This system has promise as the basis of a viable collision monitoring technology, but in order to be a stronger candidate for application to the Project, the sound-based detection must be demonstrated and validated, additional sensing capacity must be added to obtain images of colliding animals, and the system's development must progress to a more advanced stage, where viability and robust functional capability are demonstrated.

Batfinder: This is a system in a very early stage of development by Polish ecologist, Michal Przybycin, who presented the concept at the Conference on Wind and Wildlife held in Portugal in September, 2017, and who has a year of funding to advance the development of the system.

It was not covered in Dirksen's (2017) review, as it has only very recently been created and presented. Unlike other collision detection systems, it relies not on detecting the collisions, themselves, but on detecting animals falling from the rotors to the ground, which it does through a series of tower-mounted cameras that look out horizontally. When an animal is detected sequentially by the upper, and then lower systems, the system's signal processing software documents it as a collision. Though this system is being developed primarily for bats and for land-based application, in principle, it could work for both birds and bats in the offshore environment, as it does not rely on ground-based carcass searching. The principal limitations for applicability to the Project at present are twofold. First, it is in a very early stage of development. Second, the extent to which some collision victims are expected to blow away from the towers as they fall, particularly birds, may pose a substantial challenge for the system's tower-mounted cameras.

Exposure detection systems: Several remote sensing technologies that have been developed for the primary purpose of bird and bat exposure characterization have also sometimes been identified as promising systems for collision monitoring at wind energy facilities. The common element shared by these systems is that their sensors and signal processing software are focused on detecting animals flying within a certain airspace, usually encompassing at least a kilometer radius from the sensor, toward the primary objective of documenting the passage of flying animals through an airspace in which they may be exposed to collision risk from wind turbines (Dirksen 2017). The most advanced exposure monitoring systems include additional technology to obtain high resolution images of the detected animals in the interest of identifying the taxonomic identity of the animals. If an animal flying within a wind farm were to collide with a rotor while the sensors of this type of exposure monitoring system were tracking that animal, it is possible that the system would document the collision, hence it has been suggested that such systems could be useful for collision monitoring.

In order to explore whether or not such a system might be able to satisfy the collision monitoring objectives of the Project, WEST has investigated three of the most advanced exposure monitoring systems, pursuing conversations with the developers of each system. The exposure monitoring systems explored by WEST to date are the following:

- MUSE System: (DHI)
- Thermal Tracker System: (BRI-PNNL)
- Identiflight System: (RES-Boulder Imaging)

After investigating each of the above systems, WEST has concluded that, at this time, none are completely capable of satisfying the Project's collision monitoring objective of providing robust bird/bat annual fatality rate estimates. All of them are capable of characterizing the potential exposure of flying animals to wind turbines, as indicated by the passage of flying animals through a certain airspace, and all of them are capable of incidental documentation of some collisions of flying animals with wind turbine rotors if such a collision were to occur on an animal that was being tracked by the system's sensors at the time of the collision. However, the downside of these systems is that, at this time, none of them possess sensors or signal processing algorithms that are focused on wind turbine rotors or systematic detection of collisions. Therefore, with any of these systems, an unknown proportion of collisions of untracked flying animals would remain undetected, hence determination of robust annual collision fatality rates would not be possible. To a great degree, this reflects an inevitable tradeoff between having sensors and signal processing algorithms focused on detecting flying targets in an airspace rather than having sensors and algorithms focused on detecting collisions with rotors. In principle, it would be possible to develop a combined system, in which exposure detection was combined with collision detection, but none of the exposure monitoring systems investigated to date by the Project team have yet incorporated such a design.

OSU "Thunk Detector": With U.S. Department of Energy funding support, researchers at Oregon State University have developed a multisensor collision detection system that appears to hold promise for satisfying the collision monitoring objective of the Project. This system, referred to herein as the "thunk detector," (referred to by Dirksen 2017 as "wind turbine sensor unit for monitoring of avian and bat collisions") includes a combination of vibration sensors installed within the blades to detect the physical impacts of bird/bat collisions, combined with camera sensors focused on the blades to capture images of the animals upon collision, with signal processing software that enables the system to save image sequences from immediately before, to immediately after each collision, to allow for potential identification of the animals that collide. WEST has been discussing the applicability of the thunk detector to the collision monitoring objectives of Project with the system's chief designer, Dr. Roberto Albertani, since early 2017. Although the system's development and validation testing have advanced substantially since Dirksen's (2017) review, the discussions between Dr. Albertani and the Project team have identified the need to further improve, refine, and validate the system's function beyond that which has already been successfully demonstrated, in two principal areas. Specifically, to suit the monitoring needs of the Project, the system needs to be proven to successfully detect smaller animals, and it needs to function at night. Regarding the first need, the system has been shown to successfully detect collisions of objects as small as 50g tennis balls, roughly equivalent to the mass of a bird slightly heavier than a Northern Cardinal but lighter than an American Robin. However, for this Project, many of the birds and bats that may potentially be exposed to collisions weigh less than 50g. The very lightest of such species (e.g., *Myotis* bats and hummingbirds) may be 3-5g, and many potentially exposed species weigh on the order of 10-30g, including many species of warblers, vireos, flycatchers, and sparrows. Regarding the second need, the thunk detector has only been tested with visible light cameras to date. For IWP, as much of the potential collision exposure will occur at night (e.g. for bats or nocturnally migrating birds), the system needs to be adapted to use sensors capable of documenting collisions at night.

The previous two quarterly progress reports described the discussions between Dr. Albertani and the IWP team to seek new funding from the National Renewable Energy Laboratory (NREL) for Project-specific refinement and further testing of the thunk detector, along the lines of the two needs described above. The effort to obtain NREL funding was not successful. Icebreaker recently received and is currently reviewing a proposal from Dr. Albertani for additional refinement and testing of the thunk detector, intended to enable the system to satisfy the Project's collision monitoring objective.

WT Bird: This system, developed by ECN in the Netherlands, is similar in concept to the thunk detector, and was also covered in Dirksen's (2017) recent review. After some initial information gathering on this system, reported in the most recent quarterly report, WEST organized a teleconference, held in December, 2017, with a spokesperson for the system from ECN, Hans Verhoef, and the IWP team, to explore the suitability of the WT Bird system for satisfying the collision monitoring objectives of the Project. Similar to the thunk detector, the minimum mass of flying objects for which successful collision detection has been demonstrated to date is 50g, hence there is a need to further refine the system and demonstrate successful collision detection with flying animals of smaller mass for IWP's purposes. However unlike the thunk detector, the WT Bird system is already capable of nocturnal function, as it possesses night vision sensors to capture images of the collisions. A further advantage of WT Bird relative to the thunk detector is that it has already been deployed at an offshore wind farm; the Egmond Aan Zee offshore wind farm in the Netherlands, to monitor Vestas wind turbines very similar to the ones that have been selected for this Project. Subsequent to the December teleconference, the IWP team has been following up with Mr. Verhoef in order to gather additional information about the WT Bird system, including a request for information documenting the validation testing of, and offshore collision monitoring data gathered by, the system to date. At present, we are still in the process of obtaining this information to more fully evaluate the suitability of the WT Bird system for the IWP.

VESSEL-BASED RADAR EVALUATION

The ODNR and USFWS have asked that IWP collect baseline data using radar prior to construction to be able to portray the altitudinal height and distribution of nocturnal migrants over the Project site. This spatial distribution data would be compared to the data collected in post-construction radar surveys to determine if the Project has an avoidance or attraction effect.[2] After a long series of discussions with ODNR and USFWS, the IWP team proposed conducting vessel-based radar monitoring at the Project site as a solution for satisfying the Agencies' informational objectives. IWP issued a Request For Information (RFI) for providing vessel-based radar monitoring in the spring of 2017 to three radar technology and service providers who had been selected after screening a broader field of candidate providers. The RFI incorporated the specific sampling parameters and data gathering/analysis requirements that had been recommended by the USFWS, and was reviewed and approved by USFWS before being issued to the three radar providers. In response to this RFI, each of the three providers provided a fully developed proposal to provide the requested vessel-based radar monitoring services. After reviewing the proposals, the IWP team and the USFWS could not agree whether any of the proposals would satisfy the defined informational objectives. In order to resolve this disagreement, ODNR, USFWS and IWP agreed to obtain the opinion of a third

[2] We note that the recently released Bureau of Ocean Energy Management (BOEM) Guidelines for avian and bat pre-construction surveys do not require collection of radar data.

party radar expert, and contacted Dr. Robb Diehl of the US Geological Survey (USGS), who agreed to perform the review. The language from the MP associated with the ODNR-IWP MOU regarding this agreement is as follows:

"The ODNR, USFWS and IWP have retained an objective third party radar expert (Dr. Robb Diehl, USGS) to determine whether collection of pre-construction radar data at the project site on a vessel is feasible and will achieve the study objectives. A recommendation on the viability and precise design of any pre-construction radar is expected by the Fall of 2017. A decision on the final design of any post-construction radar will be made following the determination regarding pre-construction vessel based radar."

In recognition of this agreement, the Ohio Power Siting Board (OPSB) suspended its consideration of IWP's application of a certificate of environmental compatibility until the Diehl report was received and the radar monitoring issue resolved.

Dr. Diehl submitted his final report in late December, 2017, after incorporating reviews of an earlier draft by two pre-eminent radar ornithology experts. The report contains a large amount of technical complexity, and provides commentary on several technical challenges associated with the proposed work. The report indicated a preferred vendor and design choice from among the proposed approaches, along with specific technical recommendations for improving it beyond what was originally specified in the proposal. The IWP team has discussed the report with Dr. Diehl and expressed its willingness to move forward with the approach recommended by him. However, notwithstanding the parties' agreement to solicit Dr. Diehl's expert opinion and the conclusions expressed in his report, the USFWS has maintained its objections to the viability of vessel-based radar.

In the interest of reaching consensus on radar monitoring to be performed for the Project, the IWP team arranged a meeting with representatives of the USFWS, IWP, WEST, and Locke Lorde, LLC, at the USFWS Region 3 headquarters in Bloomington, Minnesota on January 9, 2018.

After a productive meeting, IWP remains in discussions with USFWS Region 3 leadership regarding potential methods for implementing vessel-based radar or other practicable approaches that would provide the survey data sought by the wildlife agencies and address the USFWS's concerns.

BIRD AND BAT CONSERVATION STRATEGY (BBCS)

The MOU refers to the BBCS in the "Adaptive Management and Mitigation" section, describing the understanding between IWP and ODNR regarding these elements with the following statement, "A comprehensive adaptive management plan specifying all of the impacts avoidance, minimization and mitigation measures to be implemented, including quantitative impact thresholds that trigger additional mitigation contingencies, will be developed in consultation with the agencies and included in the Project's Bird and Bat Conservation Strategy

(BBCS)." During the fall of 2017, WEST completed the first draft of the BBCS for the Project. IWP submitted this draft to the USFWS for its review, and received emailed comments back from the USFWS on November 21, 2017. The IWP team held a teleconference with USFWS in early December to discuss comments on the draft BBCS. The BBCS is a living document. While the current BBCS draft contains complete, or near-complete, versions of most of the typical elements of a BBCS (a summary of the Project and bird and bat risk assessment, description of the impact avoidance/minimization/mitigation measures to which the Project team has already committed, and a record of agency coordination), the adaptive management and mitigation sections of the BBCS are still in development, as specific impact thresholds and adaptive management measures will be dependent upon the precise nature of the post-construction monitoring data objectives. IWP expects to complete the development of this section of the BBCS in the coming months, in coordination with the ODNR, USFWS, and other stakeholders.

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Appendix A

2017 Final Bat Acoustic Survey Report

Icebreaker Wind Bat Activity Monitoring

(March 21 to November 14, 2017)

Lake Erie, Ohio

Final Report

February 15, 2018

Prepared for:

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The Icebreaker Bat Activity Monitoring Final Report is being provided by Western EcoSystems Technology Inc. (WEST) to the Ohio Department of Natural Resources (ODNR) pursuant to the Memorandum of Understanding (MOU) between ODNR and Icebreaker Windpower Inc. (IWP) filed July 20, 2017, which MOU adopts the Avian and Bat Monitoring Plan (“MP”) dated July 17, 2017, as well as reporting requirements and other commitments of the parties in regard to construction and operation of the Icebreaker Wind Project (Project), a 20.7 megawatt offshore wind demonstration project proposed 12.9 – 16 kilometers (km) (8-10 miles) off the shore of Cleveland, Ohio. IWP currently has an application for a Certificate of Environmental Compatibility and Public Need pending at the Ohio Power Siting Board, which has been assigned case no. 16-1871-EL-BGN.

This report covers all bat monitoring activities undertaken by the WEST team related to items described in the MOU for the entirety of the 2017 bat activity season as defined by ODNR, covering monitoring efforts from March 21 through November 15, 2017. WEST was assisted in the bat monitoring efforts by LimnoTech and Conserve First LLC, who took primary responsibility for deploying, maintaining, and retrieving data from the buoys and acoustic monitors used for this survey.

METHODS

As defined in the MP, the primary objectives of the bat acoustic monitoring were:

- Characterize the exposure of bats to potential impacts from the Project, pre- and post-construction.
- Characterize the potential behavioral responses of bats to the presence of the Project.
- Characterize bat species composition, activity, and seasonal patterns between the Project site and off site.

The exposure, behavioral responses, bat species composition, activity, and seasonal patterns of use were characterized through the use of acoustic bat detectors.

Overview of Bat Diversity

The Project is within the species distribution range of seven bat species. The state of Ohio lists the following species as state species of concern: little brown bat (*Myotis lucifugus*), big brown bat (*Eptesicus fuscus*), tri-colored bat (*Perimyotis subflavus*), silver-haired bat (*Lasionycteris noctivagans*), eastern red bat (*Lasiurus borealis*), and hoary bat (*Lasiurus cinereus*; ODNR 2012). The evening bat (*Nycticeius humeralis*) is within the range but is not a species of concern.

Table 1. Bat species with potential to occur within the Icebreaker Wind Project Bat Survey Area categorized by minimum echolocation call frequency.

Common Name	Scientific Name
High-Frequency (greater than 30 kHz)	
eastern red bat[1,3]	*Lasiurus borealis*
little brown bat[1]	*Myotis lucifugus*
evening bat[1]	*Nycticeius humeralis*
tri-colored bat[1,2]	*Perimyotis subflavus*
Low-Frequency (less than 30 kHz)	
big brown bat[1]	*Eptesicus fuscus*
hoary bat[1,3]	*Lasiurus cinereus*
silver-haired bat[1,3]	*Lasionycteris noctivagans*

[1] species known to have been killed at wind energy facilities
[2] currently being considered for listing by the U.S. Fish and Wildlife Service under the endangered species act
[3] long-distance migrant
Data source: Bat Conservation International (BCI) 2017
kHz = kilohertz

Study Area and Deployment Schedule

Bat acoustic surveys were conducted at one location within the proposed Project, and two locations outside the Project (Figure 1). Results in this report are a summary of our findings at all of the surveyed locations, referred to in the report at the Icebreaker Wind Project Bat Survey Area.

Five stations were monitored with Song Meter full-spectrum ultrasonic detectors (SM3 and SM4; Wildlife Acoustics, Inc.; Concord, Massachusetts) from either March 21 or March 23 through November 14, 2017, with the exception of the "seven mile" elevated, which was monitored from July 11 to August 30, 2017. The original plan described monitoring as starting on March 15 and ending November 15; detectors were not deployed at the stations until March 21 and 23, 2017, due to unsafe lake conditions, and were removed from the stations on November 14, 2017, due to weather conditions. Microphones were deployed at the following stations located within and outside the Project (Table 2, Figure 1):

- "Seven-mile" lower: Located within the Project at roughly one meter (m) above water level on a seven-mile buoy[1]

- "Seven-mile" elevated: Located within the Project at 10 m elevation on a second seven-mile buoy.

- Three-mile lower: Located outside the Project at roughly one m above water level at a three-mile buoy

- Crib elevated: Located outside the Project at an approximate 50 m elevation on the Cleveland water intake crib, and

[1]Both of the seven-mile buoys are nine miles offshore, at the Project site

- Crib lower: Located outside the Project site at an approximate three m elevation on the Cleveland water intake crib.

Acoustic monitoring began at the seven-mile lower station on March 21, 2017 (two SM4 detectors were deployed), and at the three-mile lower, crib elevated and crib lower stations on March 23, 2017 (one SM4 detector was deployed at each station). An additional SM4 detector was deployed at the crib elevated station on June 1, 2017, to add redundancy and further reduce the risk of data loss. Due to a detector failure, an SM3 detector was used on a temporary basis at the crib elevated station from June 8 to June 20, 2017. Additional SM4 detectors were deployed at the three-mile lower and crib lower stations on June 21, 2017, to add redundancy and further reduce the risk of data loss. As discussed below, SM4/SM3 microphones are more sensitive and record more bat calls than Anabat (Adams et al. 2012). Therefore, it is difficult to compare the results of this survey with results of other bat surveys that utilized Anabat detectors.

LimnoTech and Aaron Godwin of Conserve First LLC worked with WEST to install microphones and data loggers throughout 2017 on the Cleveland Crib and buoys. LimnoTech and Aaron Godwin received approval from the City of Cleveland prior to installation of bat detectors on the crib. LimnoTech visited each logger every two to three weeks to download data and ensure the logger and microphone were working correctly. Acoustic bat data were sent to WEST for processing after each visit.

The ODNR asked Icebreaker to test deployment of an additional elevated detector within the Project area, hereafter referred to as the seven-mile elevated station. LimnoTech designed an experimental system that included a detector elevated 10-m above water level on a pole attached to an offshore buoy. On July 11, 2017, a SM4 detector was deployed at the seven-mile elevated station (on a second buoy of the same design as the original seven-mile buoy, and moored near it), and on July 19, 2017, a second SM4 detector was deployed at the seven-mile elevated location for redundancy. On September 6, 2017, it was discovered that the 10 m pole on the seven-mile elevated station had snapped off of the buoy in high winds and/or high waves. On September 20, 2017, a dive team recovered one detector from the seven-mile elevated station from the bottom of the lake. Based on the recovered data, WEST inferred that the seven-mile elevated station went into the lake on August 31, 2017; the unit recorded data through the morning of August 31, but the detector did not turn on or record any data the night of August 31, 2017.

On November 14, 2017, detectors deployed at the seven-mile lower, three-mile lower, crib elevated, and crib lower stations were removed for the season (Table 2).

Table 2. Station deployment schedule at the Icebreaker Wind Project Bat Survey Area from March 21 to November 14, 2017.

Station	Station ID	Microphone Placement	Detector Type	Deployed Date	Takedown Date
Seven-mile elevated 1	X7.elevated.1	Elevated 10 m	SM4	July 11	August 30
Seven-mile elevated 2	X7.elevated.2	Elevated 10 m	SM4	July 19	August 30
Seven-mile lower 1	X7.lower.1	Water-level+one m	SM4	March 21	November 14
Seven-mile lower 2	X7.lower.2	Water-level+one m	SM4	March 21	November 14
Three-mile lower 1	X3.lower.1	Water-level+one m	SM4	March 23	November 14
Three-mile lower 2	X3.lower.2	Water-level+one m	SM4	June 21	November 14
Crib elevated 1	crib.elevated.1	Elevated 50 m	SM4	March 23	November 14
Crib elevated 2	crib.elevated.2	Elevated 50 m	SM4	June 1	November 14
Crib lower 1	crib.lower.1	Water-level+three m	SM4	March 23	November 14
			SM3	June 8	June 20
Crib lower 2	crib.lower.2	Water-level+three m	SM4	June 21	November 14

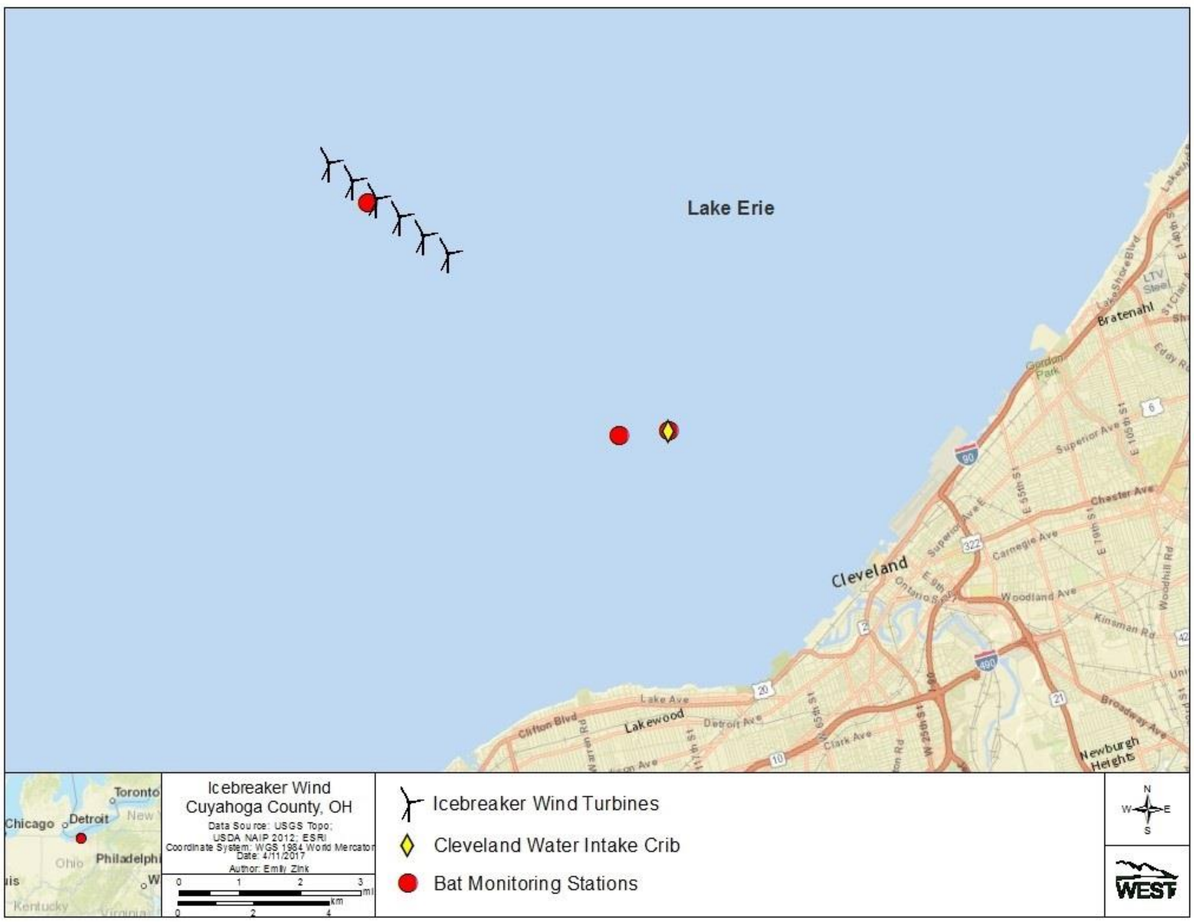

Figure 1. Acoustic sampling locations at the Icebreaker Wind Energy Project in 2017. The red dot among the turbines is the "seven-mile" location, where two buoys containing ultrasound microphones are located in close proximity to one another, and the red dot to the west of the Cleveland Water intake crib is the "three-mile buoy" location (see text). The "seven-mile" location is nine miles offshore at the Project site.

Data Collection and Call Analysis

Acoustic detectors were programmed to turn on 30 minutes before sunset and continue running until 30 minutes after sunrise the following morning throughout the monitoring period. A night of recording (hereafter referred to as detector-night) was defined as 30 minutes before sunset to 30 minutes after sunrise; for example, the night of September 4th began 30 minutes before sunset on September 4th and ended 30 minutes after sunrise on September 5th. If a detector failed at any time during the recording night, that night was not counted as a successful detector-night.

Bat passes were sorted into two groups based on their minimum frequency. High frequency (HF) bats such as eastern red bats, tri-colored bats, and *Myotis* species typically have minimum frequencies greater than 30 kilohertz (kHz). Low frequency (LF) bats such as big brown bats, silver-haired bats, and hoary bats typically emit echolocation calls with minimum frequencies below 30 kHz. HF and LF species that may occur in the study area are listed in Table 1.

Bat passes were identified to species where possible, depending on call quality. Bat call files recorded at all stations were initially identified to species using Wildlife Acoustics Kaleidoscope Pro (v4.2.0) automated acoustic identification program[2]. WEST bat biologists qualitatively (manually) reviewed each file to determine if they were bat calls or noise, and to verify species if possible. Unidentifiable calls lacked the necessary diagnostic characteristics needed to make a correct identification, contained primarily approach phase calls[3], or were of too poor quality to identify. Unidentified bat calls were classified either as high frequency unknown (calls greater than 30 kHz) or low frequency unknown (calls less than 30 kHz). In some cases, bat calls shared characteristics between two species, and were classified accordingly. For example, big brown bat and silver-haired bat calls, eastern red bat and evening bat calls, and eastern red bat and tri-colored bat calls, can be difficult to distinguish from one another in certain cases. Bat calls that fit that definition were labeled as EF_LN for big brown/silver-haired bats, LB_NH for eastern red/evening bats or LB_PS for eastern red/tri-colored bats.

Statistical Analysis

The number of bat passes per detector-night was used as the standard metric for measuring bat activity. A bat pass was defined as a sequence of at least two echolocation calls (pulses) produced by an individual bat with no pause between calls of more than one second (Fenton 1980). The same bat could be recorded echolocating during multiple passes at a given station; therefore, bat pass rates represent an index of bat activity, and do not represent numbers of individuals at each recording location. For example, 10 bats could echolocate near a detector once on a given night, or one bat could echolocate near a detector 10 times on a given night; both situations would result in 10 bat passes per detector-night. .The number of bat passes was

[2] Kaleidoscope software, Wildlife Acoustics, 2017, Concord, Massachusetts

[3] Approach phase calls refer to certain calls that bats make as they approach prey items. These calls are highly variable, and may have different characteristics than the regular echolocation calls on which most identification processes, both automated and manual, are based, confounding identification of such calls.

determined by a WEST bat biologist with significant experience in acoustic analysis and identification of bat calls.

The sampling period was broken down into different seasons (spring, summer, and fall) based on migratory patterns seen in bats, to provide information on how the bats are using the areas in the vicinity of the recording stations during different times of the year. Spring migration season (spring) was defined as March 21 to May 14, 2017. Summer maternity season (summer) was defined as May 15 to July 31, 2017. Fall season (fall) was defined as August 1 to November 15, 2017, and the fall migration period (FMP; July 30 to October 14) was included as a subset of the fall season. The FMP was defined by WEST as a standard for comparison with activity estimates from other wind energy facilities. During the FMP, bats begin moving toward wintering areas, and many species of bats initiate reproductive behaviors (Cryan 2008). This period of increased landscape-scale movement and reproductive behavior is often associated with increased levels of bat fatalities at operational onshore wind energy facilities (Arnett et al. 2008; Arnett and Baerwald 2013).

The period of peak sustained bat activity was defined as the seven-day period with the highest average bat activity. If multiple seven-day periods equaled the peak sustained bat activity rate, all dates in these seven-day periods were reported. This and all multi-detector averages in this report were calculated as an unweighted average of total activity (bat passes per detector-night) at each detector.

RESULTS

Acoustic detectors were deployed at the seven-mile elevated, seven-mile lower, three-mile lower, crib elevated, and crib lower stations for a total of 999 nights (station nights). Detectors were operational on 939 nights, (successful station nights; Table 3) resulting in a 93.7% success rate (including seven-mile elevated station during deployment of the station July 11 to August 30, 2017).

The MOU specified that detectors should be managed to ensure they operated correctly during at least 80% of the survey period. The seven-mile elevated station was not included in the following overall percent success calculations due to the experimental nature of the sampling. The overall project success during the warm season, defined as the nights of March 15 through November 15, 2017 by the MOU, was 90.2%, meeting the 80% minimum requirement of monitoring nights (Figure 2). The only nights where Figure 2 shows zero percent operational were nights that detectors were not deployed at the Project.

Duplicate detectors were deployed at each station for all or part of 2017 monitoring to add redundancy and further reduce the risk of data loss. Deployed nights include all nights that a detector was deployed at a station. Successful station nights include the number of nights at least one detector was functional at a station. Therefore, two detectors (both functioning) deployed at a station for one night equals one deployed night and one successful station night, or two detectors deployed for three nights, both functioned night one, one functioned night two, and neither functioned night three equals three deployed nights and two successful station nights. Non-successful detector nights were due to detector or microphone failure likely due to harsh weather conditions and/or lightning strikes.

Table 3. Operational success at the Icebreaker Wind Project Bat Survey Area, defined by detector-nights of acoustic data, by station and season.

	Station					
	Seven-Mile Elevated*	**Seven-Mile Lower**	**Three-Mile Lower**	**Crib Elevated**	**Crib Lower**	**Overall**
Spring	NA	55	40	53	52	200
Summer	21	78	58	75	78	310
Fall	30	105	105	89	100	429
Successful Detector- Nights	51	238	203	217	230	939
Number of Nights Detectors Were Deployed at a Given Station	51	238	238	238	238	999
Total Nights Available (full warm season)	246	246	246	246	246	1230
Success During Deployment	**100%**	**100%**	**86.0%**	**91.6%**	**97.1%**	**93.7%****
Success of Total Warm Season	**N/A**	**96.8%**	**82.5%**	**88.2%**	**93.5%**	**90.4%****

* Seven-mile elevated station was not included in overall percent success calculations
** includes only seven-mile lower, three-mile buoy, crib elevated, and crib lower stations

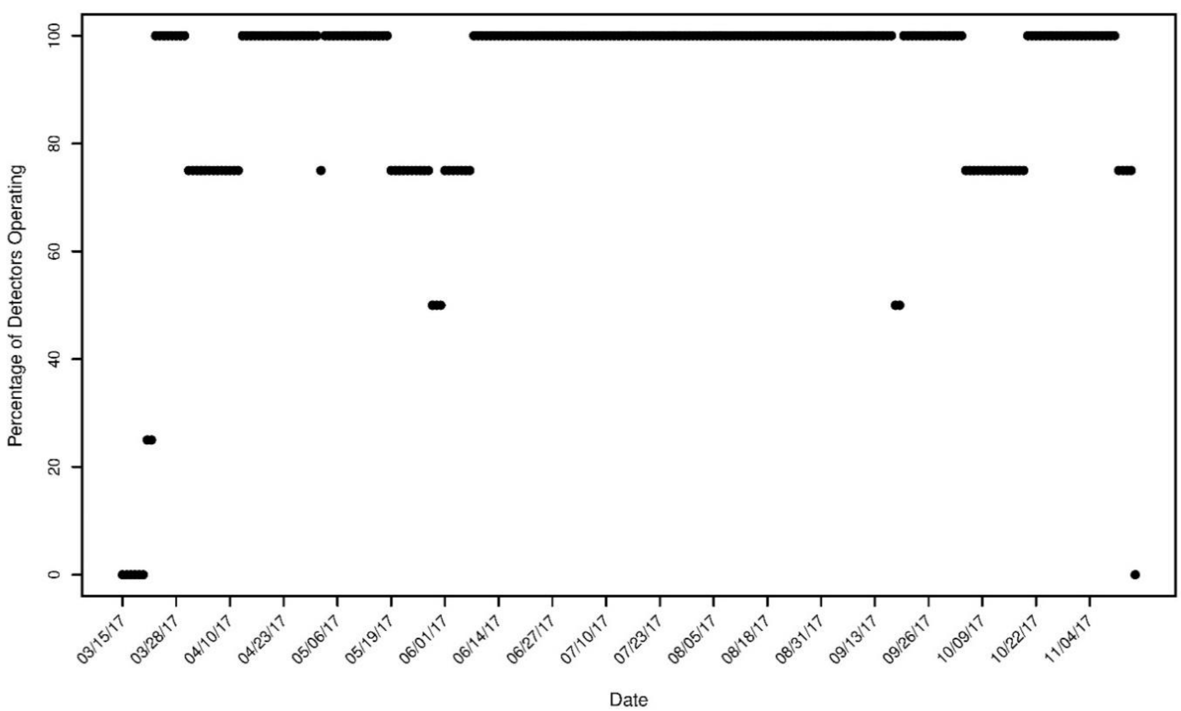

Figure 2. Operational success defined by successful station nights at the seven-mile lower, three-mile lower, crib elevated, and crib lower stations at the Icebreaker Wind Project Bat Survey Area during each night of deployment from March 15 to November 15, 2017. This does not incorporate the seven-mile elevated station due to the experimental nature of its deployment.

Overall Bat Activity

All 10 detectors at all five stations recorded a total of 10,114 bat passes on 1,531 successful detector nights[4]. The eight detectors deployed at seven-mile lower, three-mile lower, crib elevated, and crib lower stations from March 21 through November 14, 2017 recorded a total of 9,389 bat passes on 1,453 successful detector nights[4] for a mean ± standard error of 6.8±0.7 bat passes per detector-night. Lower detectors recorded a total of 9,128 bat passes over 1,118 successful detector-nights, with an average of 8.8±1.0 bat passes per detector-night. Elevated detectors recorded a total of 261 bat passes on 335 detector-nights, with an average of 0.8±0.1 bat passes per detector-night (Table 4; Figure 3). Low-frequency bat passes (5,499 bat passes recorded) were recorded more commonly than high-frequency bat passes (3,890 bat passes recorded; Table 4). Due to the duplicate detectors deployed at the same station it is likely that the same bat could be recorded echolocating on both detectors at the same time. It is also possible that the same bat could be recorded echolocating during multiple passes at a given station (or detector); therefore, bat pass rates (bat passes / detector night), also referred to as bat activity in this report, are a more appropriate metric for comparing use between detectors. Bat pass rates represent an index of bat activity, and do not represent numbers of individuals at each recording location.

Table 4. Results of acoustic bat surveys conducted at the Icebreaker Wind Project Bat Survey Area from March 21 to November 14, 2017. Bat passes are separated by call frequency: high frequency (HF) and low frequency (LF) groups.

Station	Microphone Placement	Number of HF Bat Passes	Number of LF Bat Passes	Total Bat Passes	Detector-Nights	Bat Passes/ Night*
Seven-mile lower 1	Water-level+one m	467	518	985	238	4.1±0.5
Seven-mile lower 2	Water-level+one m	436	509	945	212	4.5±0.6
Three-mile lower 1	Water-level+one m	468	601	1,069	203	5.3±0.7
Three-mile lower 2	Water-level+one m	486	435	921	140	6.6±1.1
Crib elevated 1	Elevated 50 m	9	133	142	185	0.8±0.1
Crib elevated 2	Elevated 50 m	18	101	119	150	0.8±0.1
Crib lower 1	Water-level+three m	1,154	2,131	3,285	206	16.0±1.5
Crib lower 2	Water-level+three m	852	1,071	1,923	119	16.2±2.1
Total Lower		**3,863**	**5,265**	**9,128**	**1,118**	**8.8±1.0**
Total Elevated		**27**	**234**	**261**	**335**	**0.8±0.1**
Total		**3,890**	**5,499**	**9,389**	**1,453**	**6.8±0.7**

* ± bootstrapped standard error; m = meters

[4] Nightly success of every detector including duplicate detectors deployed at all stations except the 7-mi elevated station.

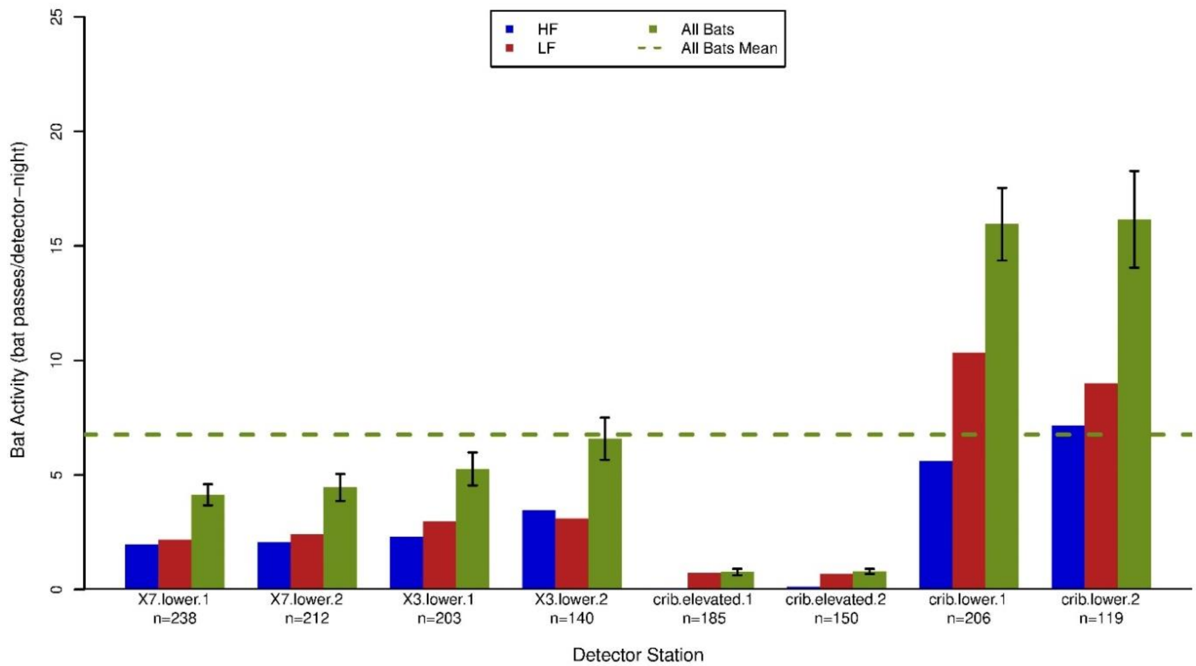

Figure 3. Number of high-frequency (HF) and low-frequency (LF) bat passes per detector-night recorded at all detectors and stations at the Icebreaker Wind Project Bat Survey Area from March 21 to November 14, 2017.
X7.lower = seven-mile buoy lower stations, X3.lower = three mile buoy lower stations

Bat activity varied between stations, with the highest activity seen at the crib lower detectors (16.0±1.6 and 16.2±2.1 bat passes per detector-night), and the lowest activity seen at the crib elevated detectors (0.8±0.1 and 0.8±0.1 bat passes per detector-night; Table 3). Bat activity decreased as distance from land increased. The three-mile lower detectors recorded an average of 5.3±0.7 and 6.6±1.1 bat passes per detector-night, and the seven-mile lower detectors recorded an average of 4.1±0.5 and 4.5±0.6 bat passes per detector-night (Table 3).

"Seven-Mile" Elevated Station

The seven-mile elevated station was deployed only during the middle of the warm season, July 11 to August 30, 2017. This time period included the end of the summer season, beginning of the fall season and the fall migration period. In order to focus on direct comparison of bat activity at the different stations during this time period a subset of all data recorded at all stations were analyzed. Bat activity was highest at the crib lower detectors (28.7±4.5 and 20.9±3.5 bat passes per detector-night), and lowest at the crib elevated detectors (2.4±0.5 and 1.0±0.2 bat passes per detector-night). Bat activity at the seven-mile elevated, seven-mile lower, and three-mile lower stations was similar, falling within the bootstrapped standard error of mean bat passes per detector-night (Table 5; Figure 4).

Table 5. Results of acoustic bat surveys conducted at the Icebreaker Wind Project Bat Survey Area from July 11 through August 30, 2017*. Bat passes are separated by call frequency: high frequency (HF) and low frequency (LF) groups.

Station	Microphone Placement	Number of HF Bat Passes	Number of LF Bat Passes	Total Bat Passes	Detector-Nights	Bat Passes/ Night**
Seven-mile elevated 1	Elevated 10 m	112	189	301	35	8.6±1.7
Seven-mile elevated 2	Elevated 10 m	171	253	424	43	9.9±1.8
Seven-mile lower 1	Water-level+one m	212	225	437	51	8.6±1.7
Seven-mile lower 2	Water-level+one m	203	266	469	51	9.2±1.6
Three-mile lower 1	Water-level+one m	176	263	439	51	8.6±1.7
Three-mile lower 2	Water-level+one m	200	233	433	51	8.5±1.5
Crib elevated 1	Elevated 50 m	8	87	95	40	2.4±0.5
Crib elevated 2	Elevated 50 m	10	42	52	51	1.0±0.2
Crib lower 1	Water-level+three m	556	737	1,293	45	28.7±4.5
Crib lower 2	Water-level+three m	486	578	1,064	51	20.9±3.5
Total Lower		**1,833**	**2,302**	**4,135**	**300**	**14.1±2.0**
Total Elevated		**301**	**571**	**872**	**169**	**5.5±0.8**
Total		**2,134**	**2,873**	**5,007**	**469**	**10.6±1.5**

* July 11 through August 30, 2017 is the time period that the seven-mile elevated stations were deployed
** ± bootstrapped standard error.
m = meters

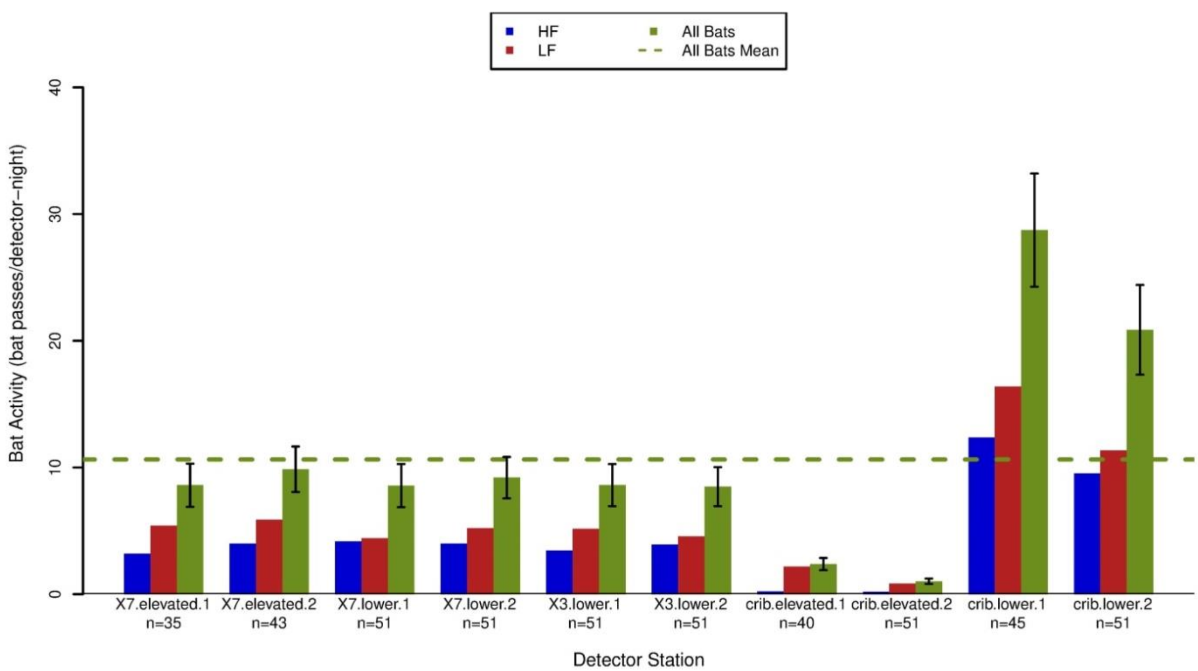

Figure 4. Number of high-frequency (HF) and low-frequency (LF) bat passes per detector-night recorded at all detectors and stations at the Icebreaker Wind Project Bat Survey Area from July 11 through August 30, 2017*.

X7. Elevated = seven-mile buoy elevated stations, X7.lower = seven-mile buoy lower stations, X3.lower = three mile buoy lower stations

* July 11 through August 30, 2017 is the time period that the seven-mile elevated stations were deployed

Seasonal Patterns of Bat Activity

Fall Migration Period

Data from the Seven-mile elevated station was excluded from seasonal comparisons of activity, because this station only operated during a portion of the fall migration period. Overall bat activity at the seven-mile lower, three-mile lower, crib elevated, and crib lower stations combined, was highest during the FMP with 10.0±1.4 bat passes per detector-night. Bat activity at lower stations was highest during the FMP with 13.2±1.9 bat passes per detector-night. Bat activity at elevated stations was highest during the summer season with 1.6±0.3 bat passes per detector-night.

Spring

Overall bat activity was lowest during the spring season with 1.7±0.6 bat passes per detector-night. The majority of bat activity during the spring season was attributed to low-frequency bats (1.6±0.6 bat passes per detector-night). There were very few high-frequency bats recorded during the spring (0.2±0.0 bat passes per detector-night). High-frequency bats were only recorded at lower stations in the spring.

Summer and Fall

Overall bat activity was higher during the summer season with 8.5±1.0 bat passes per detector-night than during the fall season with 7.0±1.0 bat passes per detector-night. Lower stations had slightly higher bat activity during the summer season (10.8±1.4 bat passes per detector-night) than during the fall season (9.2±1.5 bat passes per detector night). Crib elevated stations had higher bat activity in the summer season (1.6±0.3 bat passes per detector-night) than in the fall (0.3±0.1 bat passes per detector-night; Table 6; Figure 5).

Project Site – "Seven-mile" buoy

Bat activity at the seven-mile lower station was highest during the FMP with 9.2±1.4 bat passes per detector night, followed by fall with 6.3±1.0 bat passes per detector-night, summer with 4.1±0.8 bat passes per detector-night, and spring with 0.7±0.2 bat passes per detector-night. During the FMP and fall high-frequency bat activity was higher (FMP: 5.1±0.8 bat passes per detector-night; fall: 3.7±0.6 bat passes per detector-night) than low-frequency bat activity (FMP: 4.1±0.8 bat passes per detector-night; fall: 2.6±0.5 bat passes per detector-night). During the spring and summer low-frequency bat activity was higher (spring: 0.7±0.2 bat passes per detector-night; summer: 3.1±0.7 bat passes per detector-night) than high-frequency bat activity (spring: 0.1±0.0 bat passes per detector-night; summer: 1.0±0.2 bat passes per detector-night).

Table 6. The number of bat passes per detector-night recorded at the Icebreaker Wind Project Bat Survey Area during each season, separated by call frequency: high-frequency (HF), low-frequency (LF), and all bats (AB).

Station	Call Frequency	Spring March 21 – May 14*	Summer May 15 – July 31	Fall Aug 1 – Nov 15	Fall Migration Period Jul 30 – Oct 14
Seven-mile lower 1	LF	0.7	2.9	2.5	3.8
	HF	0.0	0.9	3.8	5.3
	AB	0.7	3.7	6.3	9.1
Seven-mile lower 2	LF	0.7	3.4	2.8	4.3
	HF	0.1	1.1	3.6	5.0
	AB	0.7	4.4	6.3	9.3
Three-mile lower 1	LF	1.7	4.7	2.5	4.0
	HF	0.1	2.3	3.1	4.5
	AB	1.8	7.0	5.6	8.5
Three-mile lower 2	LF	NA	4.4	2.6	3.8
	HF	NA	3.0	3.7	5.0
	AB	NA	7.4	6.2	8.7
Crib elevated 1	LF	0.1	1.7	0.2	0.5
	HF	0.0	0.1	0.0	0.1
	AB	0.1	1.8	0.2	0.6
Crib elevated 2	LF	NA	1.2	0.3	0.3
	HF	NA	0.1	0.1	0.1
	AB	NA	1.3	0.4	0.5
Crib lower 1	LF	4.8	16.0	8.4	14.3
	HF	0.6	6.7	7.9	12.5
	AB	5.4	22.7	16.3	26.8
Crib lower 2	LF	NA	12.4	7.2	8.6
	HF	NA	7.0	7.3	8.1
	AB	NA	19.4	14.5	16.7
Lower Totals	**LF**	**2.0±0.7**	**7.3±1.1**	**4.3±0.7**	**6.5±1.0**
	HF	**0.2±0.1**	**3.5±0.5**	**4.9±0.9**	**6.7±1.1**
	AB	**2.1±0.7**	**10.8±1.4**	**9.2±1.5**	**13.2±1.9**
Elevated Totals	**LF**	**0.1±0.1**	**1.5±0.2**	**0.2±0.1**	**0.4±0.2**
	HF	**0.0±0.0**	**0.1±0.0**	**0.1±0.0**	**0.1±0.1**
	AB	**0.1±0.1**	**1.6±0.3**	**0.3±0.1**	**0.5±0.2**
Overall	**LF**	**1.6±0.6**	**5.8±0.7**	**3.3±0.5**	**5.0±0.7**
	HF	**0.2±0.0**	**2.6±0.3**	**3.7±0.6**	**5.1±0.7**
	AB	**1.7±0.6**	**8.5±1.0**	**7.0±1.0**	**10.0±1.4**

* not all stations had duplicate detectors deployed during the spring season

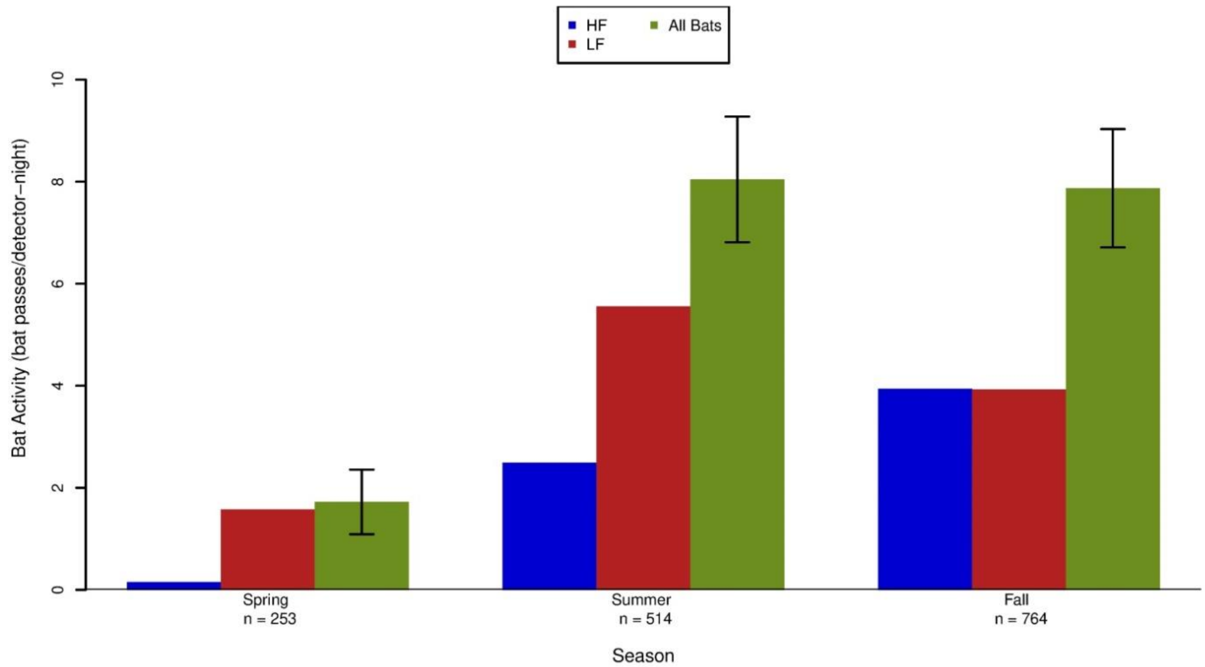

Figure 5. Seasonal bat activity by high-frequency (HF), low-frequency (LF), and all bats at the Icebreaker Wind Project Bat Survey Area from March 21 through November 14, 2017. The bootstrapped standard errors are represented on the 'All Bats' columns.

Overall weekly acoustic activity at the crib elevated and lower, three-mile buoy, and seven-mile lower buoy stations for all bats peaked from September 20 to September 26, 2017 with 31.7 bat passes per detector-night. Low-frequency bat activity peaked during the same time week as all bat activity with 14.1 bat passes per detector-night. High-frequency bat activity peaked slightly earlier, from September 18 to September 24, 2017 with 17.9 bat passes per detector-night. In all seasons high-frequency bat activity peaked earlier than low-frequency and all bat activity (Table 7; Figure 6). Overall bat activity gradually decreased for the remainder of the study period from September 26 through November 14, 2017 (Figure 6).

Table 7. Periods of peak activity for high-frequency, low-frequency, and all bats at the Icebreaker Wind Project Bat Survey Area from March 21 to November 14, 2017.

	High-Frequency			Low-Frequency			All Bats		
Season	**Start**	**End**	**Bat passes per detector-night**	**Start**	**End**	**Bat passes per detector-night**	**Start**	**End**	**Bat passes per detector-night**
Spring	4/9	4/15	0.5	4/24	4/30	5.5	4/24	4/30	5.8
Summer	7/17	7/23	5.9	7/25	7/31	11.1	7/25	7/31	16.7
Fall	9/18	9/24	17.9	9/20	9/26	14.1	9/20	9/26	31.7
FMP	9/18	9/24	17.9	9/20	9/26	14.1	9/20	9/26	31.7
Overall	9/18	9/24	17.9	9/20	9/26	14.1	9/20	9/26	31.7

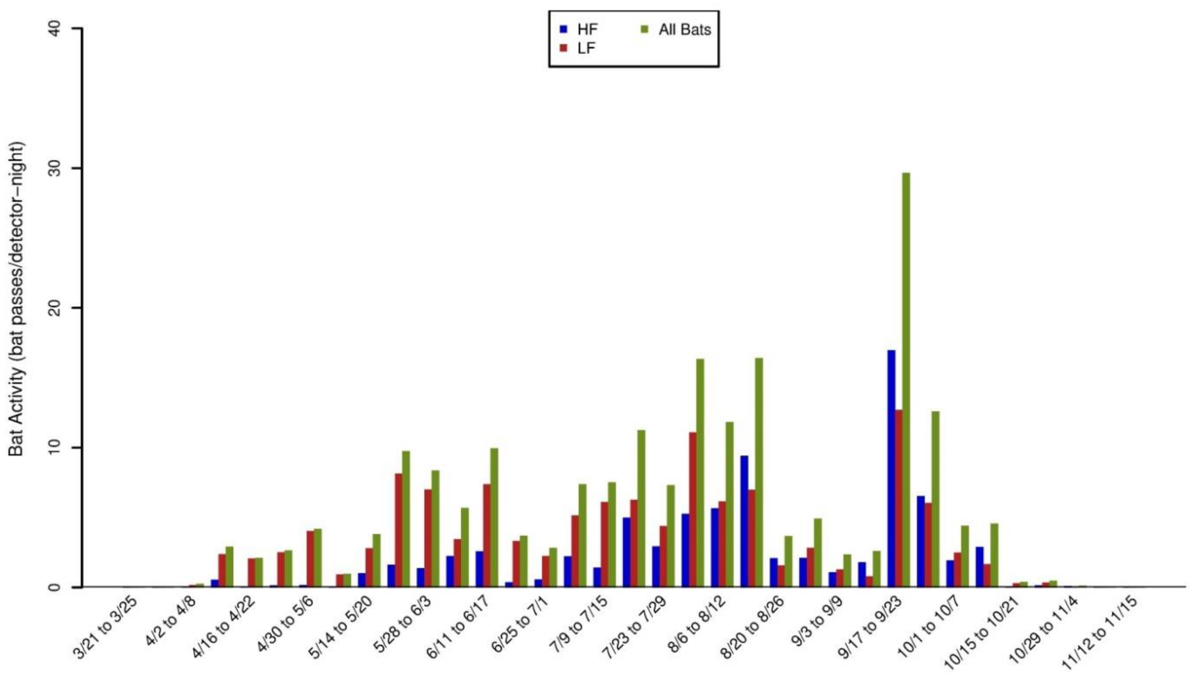

Figure 6. Weekly patterns of bat activity by high-frequency (HF), low-frequency (LF), and all bats at the Icebreaker Wind Project Bat Survey Area from March 21 to November 14, 2017.

Overall weekly acoustic activity at the seven-mile lower station for all bats peaked from September 20 to September 26, 2017 with 20.8 bat passes per detector-night. Low-frequency bat activity peaked from August 28 to September 3, 2017 with 10 bat passes per detector-night. High-frequency bat activity peaked from September 17 to September 23, 2017 with 14.4 bat passes per detector-night (Table 8).

Table 8. Periods of peak activity for high-frequency, low-frequency, and all bats at the Icebreaker Wind Project Seven-mile lower station from March 21 to November 14, 2017.

	High-Frequency			Low-Frequency			All Bats		
Season	**Start**	**End**	**Bat passes per detector-night**	**Start**	**End**	**Bat passes per detector-night**	**Start**	**End**	**Bat passes per detector-night**
Spring	4/8	4/16	0.3	4/12	4/21	2.1	4/12	4/21	2.2
Summer	7/16	7/25	2.4	7/25	7/31	7	7/25	7/31	8.6
Fall	9/17	9/23	14.4	8/28	9/3	10	9/20	9/26	20.8
FMP	9/17	9/23	14.4	8/28	9/3	10	9/20	9/26	20.8
Overall	9/17	9/23	14.4	8/28	9/3	10	9/20	9/26	20.8

Species Composition

Overall Bat Species Activity

Kaleidoscope isolated a total of 10,426 bat passes files from all seasons, detectors, and stations; this number also includes files containing bat calls that could not be identified to species by Kaleidoscope. WEST biologists identified 10,114 bat passes of these passes to species or species group (high- or low-frequency unknown, EF_LN, LB_NH or LB_PS; Table 9). There were 312 bat passes that were identified as bats by Kaleidoscope that were determined to be noise files during manual review.

Long-distance migratory species were the three most commonly identified bat species across all stations, accounting for approximately 80% of all bat activity. Eastern red bats were the most commonly identified species with a total of 4,097 bat passes (40.5%) recorded across all stations. Hoary bats were the second most commonly identified species with a total of 2,454 bat passes (24.3%) recorded across all stations. Silver-haired bats were the third most commonly identified species with a total of 1,545 bat passes (15.3%) recorded across all stations. Big brown bats were the fourth most commonly identified species with a total of 1,210 bat passes (12.0%) recorded across all stations. Less commonly identified species included low-frequency unknown bats (440 bat passes [4.4%]), big brown/silver-haired bat group (292 bat passes [2.9%]), high-frequency unknown bats (45 bat passes [0.4%]), tri-colored bats (13 bat passes [0.1%], eastern red/evening bat group (10 bat passes [0.1%]), eastern red/tri-colored bat group (7 bat passes [0.1%]), and little brown bats (1 bat pass [0.01%]; Table 9 and Table 10) All species across all seasons had higher activity at the lower stations than the elevated stations.

At the Project site, seven-mile lower buoy (nine miles offshore), long-distance migratory species were the three most commonly identified bat species at the seven-mile lower and elevated stations, accounting for approximately 80% of all bat activity. Eastern red bats were the most commonly identified species with a total of 1,159 bat passes (53.8%) recorded at the seven-mile elevated and lower stations for the entire duration of sampling. Hoary bats were the second most commonly identified with a total of 630 bat passes (29.2%) recorded. Silver-haired bats were the third most commonly identified species with a total of 365 bat passes (16.9%) recorded. Other less commonly recorded species included big brown bats (273 bat passes [7.9%]), tri-colored bats (three bat passes [less than 0.1%]), and little brown bats (one bat pass [less than 0.1%]). The little brown bat and tri-colored bats were both recorded at the seven-mile lower stations.

Bat species diversity was highest at the seven-mile lower station with the following six bat species identified: big brown, eastern red, hoary, silver-haired, little brown, and tri-colored bats. Five bat species and five bat species groups were identified at the crib lower station: big brown, eastern red, hoary, silver-haired, and tri-colored bats. The crib elevated station had the lowest bat diversity, with the following four bat species identified: big brown, eastern red, hoary, silver-haired bats (Figure 7).

Table 9. Number of bat calls qualitatively verified at the Icebreaker Wind Energy Project Bat Survey Area from March 21 to November 14, 2017.

Station	EF_LN	EPFU	LABO	LACI	LANO	LB_NH	LB_PS	MYLU	PESU	UNHF	UNLF	All Bats
Seven-mile elevated 1	10	28	112	124	13	0	0	0	0	0	14	**301**
Seven-mile elevated 2	8	51	170	137	31	0	0	0	0	1	26	**424**
Seven-mile lower 1	24	97	454	176	179	1	0	0	2	10	42	**985**
Seven-mile lower 2	26	97	423	193	142	1	0	1	1	10	51	**945**
Three-mile lower 1	44	85	461	269	184	0	0	0	0	7	19	**1,069**
Three-mile lower 2	26	76	475	211	90	2	0	0	0	9	32	**921**
Crib elevated 1	0	5	9	107	16	0	0	0	0	0	5	**142**
Crib elevated 2	1	1	17	75	19	0	0	0	0	1	5	**119**
Crib lower 1	107	488	1,141	719	690	1	2	0	6	4	127	**3,285**
Crib lower 2	46	282	835	443	181	5	5	0	4	3	119	**1,923**
Total Lower	**273**	**1,125**	**3,789**	**2,011**	**1,466**	**10**	**7**	**1**	**13**	**43**	**390**	**9,128**
Total Elevated	**19**	**85**	**308**	**443**	**79**	**0**	**0**	**0**	**0**	**2**	**50**	**986**
Total	**292**	**1,210**	**4,097**	**2,454**	**1,545**	**10**	**7**	**1**	**13**	**45**	**440**	**10,114**

EF_LN = big brown /silver –haired bat group, EPFU = big brown bat, LABO = eastern red bat, LACI = hoary bat, LANO = silver haired bat, LB_NH = eastern red/evening bat group, LB_PS = eastern red/tri-colored bat group, MYLU = little brown bat, PESU = tri-colored bat, UNHF = high frequency unidentified, UNLF = low frequency unidentified.

Table 10. Percentage[1] of bat calls qualitatively verified at the Icebreaker Wind Energy Project Bat Survey Area from March 21 to November 14, 2017.

Station	EF_LN	EPFU	LABO	LACI	LANO	LB_NH	LB_PS	MYLU	PESU	UNHF	UNLF	All Bats
Seven-mile elevated 1	3.4%	2.3%	2.7%	5.1%	0.8%	0.0%	0.0%	0.0%	0.0%	0.0%	3.2%	**3.0%**
Seven-mile elevated 2	2.7%	4.2%	4.1%	5.6%	2.0%	0.0%	0.0%	0.0%	0.0%	2.2%	5.9%	**4.2%**
Seven-mile lower 1	8.2%	8.0%	11.1%	7.2%	11.6%	10.0%	0.0%	0.0%	15.4%	22.2%	9.5%	**9.7%**
Seven-mile lower 2	8.9%	8.0%	10.3%	7.9%	9.2%	10.0%	0.0%	100%	7.7%	22.2%	11.6%	**9.3%**
Three-mile lower 1	15.1%	7.0%	11.3%	11.0%	11.9%	0.0%	0.0%	0.0%	0.0%	15.6%	4.3%	**10.6%**
Three-mile lower 2	8.9%	6.3%	11.6%	8.6%	5.8%	20.0%	0.0%	0.0%	0.0%	20.0%	7.3%	**9.1%**
Crib elevated 1	0.0%	0.4%	0.2%	4.4%	1.0%	0.0%	0.0%	0.0%	0.0%	0.0%	1.1%	**1.4%**
Crib elevated 2	0.3%	0.1%	0.4%	3.1%	1.2%	0.0%	0.0%	0.0%	0.0%	2.2%	1.1%	**1.2%**
Crib lower 1	36.6%	40.3%	27.8%	29.3%	44.7%	10.0%	28.6%	0.0%	46.2%	8.9%	28.9%	**32.5%**
Crib lower 2	15.8%	23.3%	20.4%	18.1%	11.7%	50.0%	71.4%	0.0%	30.8%	6.7%	27.0%	**19.0%**
Total Lower	**93.5%**	**93.0%**	**92.5%**	**81.9%**	**94.9%**	**100%**	**100%**	**100%**	**100%**	**95.6%**	**88.6%**	**90.3%**
Total Elevated	**6.5%**	**7.0%**	**7.5%**	**18.1%**	**5.1%**	**0.0%**	**0.0%**	**0.0%**	**0.0%**	**4.4%**	**11.4%**	**9.7%**
Total[2]	**2.9%**	**12.0%**	**40.5%**	**24.3%**	**15.3%**	**0.1%**	**0.1%**	**<0.1%**	**0.1%**	**0.4%**	**4.4%**	**100.0%**

EF_LN = big brown /silver –haired bat group, EPFU = big brown bat, LABO = eastern red bat, LACI = hoary bat, LANO = silver haired bat, LB_NH = eastern red/evening bat group, LB_PS = eastern red/tri-colored bat group, MYLU = little brown bat, PESU = tri-colored bat, UNHF = high frequency unidentified, UNLF = low frequency unidentified.

[1] Calculated by taking the number of species bat passes recorded at a detector or station type divided by the total number of species bat passes recorded.

[2] Calculated by taking the number of species bat passes recorded divided by the all bats total number of bat passes recorded at the Icebreaker Wind Energy Project.

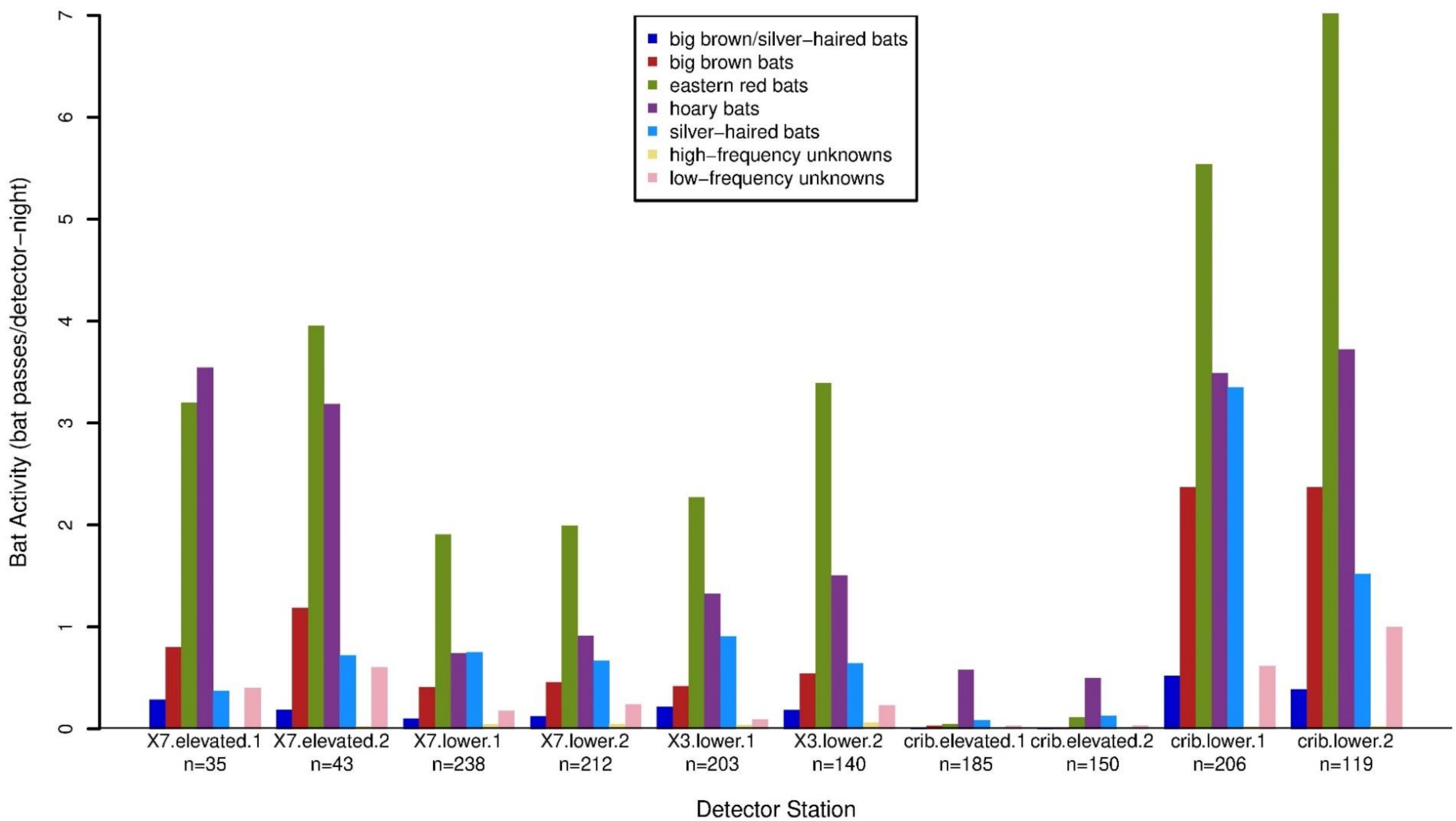

Figure 7. Bat species present at each detector location and station at the Icebreaker Wind Project Bat Survey Area from March 21 to November 14, 2017.

X7.elevated = seven-mile buoy elevated stations, X7.lower = seven-mile buoy lower stations, X3.lower = three mile buoy lower stations

Seasonal Patterns of Bat Species Activity

Spring season was defined as beginning March 21 through May 14, 2017. There were 430 bat passes identified to species or species group during the spring season. Silver-haired bats were the most commonly identified species during the spring, with 312 bat passes (72.6%) recorded across all stations. Big brown bats, eastern red bats, and hoary bats were identified in low numbers during the spring season; eastern red bats with 37 bat passes (8.6%), big brown/silver-haired bat group with 33 bat passes (7.7%), hoary bats with 22 bat passes (5.1%), and big brown bats with 17 bat passes (4.0%). There were eight bat passes (1.9%) categorized into the low-frequency unknown group, and one bat pass (0.2%) categorized into the high-frequency unknown group (Table 11 and Table 12).

Summer season was defined as May 15 through July 31, 2017. There were 4,230 bat passes identified to species or species group during the summer season. Hoary bats were the most commonly identified species during the summer, with 1,359 bat passes (32.1%) recorded across all stations. Eastern red bats were the second most commonly identified species during the summer, with 1,258 bat passes (29.7%) recorded across all stations. Silver-haired bats and big brown bats were recorded in moderate numbers during the summer season; silver-haired bats (622 bat passes [14.7%]), and big brown bats (606 bat passes [14.3%]). Additional species detected in lower numbers included: low-frequency unknown group (215 bat passes [5.1%]), big brown/silver-haired bat group (157 bat passes [3.7%]), high-frequency unknown group (eight bat passes [0.2%]), tri-colored bats (three bat passes [0.1%]), eastern red/evening bat group (one bat pass [less than 0.1%]), and eastern red/tri-colored bat group (one bat pass [less than 0.1%]; Table 13 and Table 14).

Table 11. Number of bat calls qualitatively verified at the Icebreaker Wind Energy Project Bat Survey Area during the spring season (March 21 – May 14, 2017).

Station	EF_LN	EPFU	LABO	LACI	LANO	LB_NH	LB_PS	MYLU	PESU	UNHF	UNLF	All Bats
Seven-mile lower 1	1	0	2	5	30	0	0	0	0	0	0	**38**
Seven-mile lower 2	0	0	3	2	33	0	0	0	0	0	1	**39**
Three-mile lower 1	1	3	2	3	58	0	0	0	0	1	2	**70**
Crib elevated 1	0	0	0	0	4	0	0	0	0	0	0	**4**
Crib lower 1	31	14	30	12	187	0	0	0	0	0	5	**279**
Total Lower	**33**	**17**	**37**	**22**	**308**	**0**	**0**	**0**	**0**	**1**	**8**	**426**
Total Elevated	**0**	**0**	**0**	**0**	**4**	**0**	**0**	**0**	**0**	**0**	**0**	**4**
Total	**33**	**17**	**37**	**22**	**312**	**0**	**0**	**0**	**0**	**1**	**8**	**430**

EF_LN = big brown /silver –haired bat group, EPFU = big brown bat, LABO = eastern red bat, LACI = hoary bat, LANO = silver haired bat, LB_NH = eastern red/evening bat group, LB_PS = eastern red/tri-colored bat group, MYLU = little brown bat, PESU = tri-colored bat, UNHF = high frequency unidentified, UNLF = low frequency unidentified.

Table 12. Percentage[1] of bat calls qualitatively verified at the Icebreaker Wind Energy Project Bat Survey Area during the spring season (March 21 – May 14, 2017).

Station	EF_LN	EPFU	LABO	LACI	LANO	LB_NH	LB_PS	MYLU	PESU	UNHF	UNLF	All Bats
Seven-mile lower 1	3.0%	0%	5.4%	22.7%	9.6%	0%	0%	0%	0%	0%	0%	**8.8%**
Seven-mile lower 2	0%	0%	8.1%	9.1%	10.6%	0%	0%	0%	0%	0%	12.5%	**9.1%**
Three-mile lower 1	3.0%	17.6%	5.4%	13.6%	18.6%	0%	0%	0%	0%	100%	25.0%	**16.3%**
Crib elevated 1	0%	0%	0%	0%	1.3%	0%	0%	0%	0%	0%	0%	**0.9%**
Crib lower 1	93.9%	82.4%	81.1%	54.5%	59.9%	0%	0%	0%	0%	0%	62.5%	**64.9%**
Total Lower	**100%**	**100%**	**100%**	**100%**	**98.7%**	**0%**	**0%**	**0%**	**0%**	**100%**	**99.1%**	**99.1%**
Total Elevated	**0%**	**0%**	**0%**	**0%**	**1.3%**	**0%**	**0%**	**0%**	**0%**	**0%**	**0.9%**	**0.9%**
Total[2]	**7.7%**	**4.0%**	**8.6%**	**5.1%**	**72.6%**	**0%**	**0%**	**0%**	**0%**	**0.2%**	**1.9%**	**100%**

[1] Calculated by taking the number of species bat passes recorded at a detector or station type divided by the total number of species bat passes recorded.
[2] Calculated by taking the number of species bat passes recorded divided by the all bats total number of bat passes recorded at the IWP.

Table 13. Number of bat calls qualitatively verified at the Icebreaker Wind Energy Project Bat Survey Area during the summer season (May 15 – July 31, 2017).

Station	EF_LN	EPFU	LABO	LACI	LANO	LB_NH	LB_PS	MYLU	PESU	UNHF	UNLF	All Bats
Seven-mile elevated 1	5	10	42	76	3	0	0	0	0	0	7	**143**
Seven-mile elevated 2	1	7	23	40	3	0	0	0	0	0	2	**76**
Seven-mile lower 1	14	40	66	82	64	0	0	0	0	0	23	**289**
Seven-mile lower 2	5	35	53	92	36	0	0	0	0	4	15	**240**
Three-mile lower 1	24	45	136	141	55	0	0	0	0	0	7	**408**
Three-mile lower 2	9	37	117	105	22	0	0	0	0	4	9	**303**
Crib elevated 1	0	4	8	98	11	0	0	0	0	0	5	**126**
Crib elevated 2	1	0	6	58	11	0	0	0	0	0	4	**80**
Crib lower 1	71	277	523	457	365	1	0	0	2	0	75	**1,771**
Crib lower 2	27	151	284	210	52	0	1	0	1	0	68	**794**
Total Lower	**150**	**585**	**1,179**	**1,087**	**594**	**1**	**1**	**0**	**3**	**8**	**197**	**3,805**
Total Elevated	**7**	**21**	**79**	**272**	**28**	**0**	**0**	**0**	**0**	**0**	**18**	**425**
Total	**157**	**606**	**1,258**	**1,359**	**622**	**1**	**1**	**0**	**3**	**8**	**215**	**4,230**

EF_LN = big brown /silver –haired bat group, EPFU = big brown bat, LABO = eastern red bat, LACI = hoary bat, LANO = silver haired bat, LB_NH = eastern red/evening bat group, LB_PS = eastern red/tri-colored bat group, MYLU = little brown bat, PESU = tri-colored bat, UNHF = high frequency unidentified, UNLF = low frequency unidentified.

Table 14. Percentage[1] of bat calls qualitatively verified at the Icebreaker Wind Energy Project Bat Survey Area during the summer season (May 15 – July 31, 2017).

Station	EF_LN	EPFU	LABO	LACI	LANO	LB_NH	LB_PS	MYLU	PESU	UNHF	UNLF	All Bats
Seven-mile elevated 1	3.2%	1.7%	3.3%	5.6%	0.5%	0%	0%	0%	0%	0%	3.3%	**3.4%**
Seven-mile elevated 2	0.6%	1.2%	1.8%	2.9%	0.5%	0%	0%	0%	0%	0%	0.9%	**1.8%**
Seven-mile lower 1	8.9%	6.6%	5.2%	6.0%	10.3%	0%	0%	0%	0%	0%	10.7%	**6.8%**
Seven-mile lower 2	3.2%	5.8%	4.2%	6.8%	5.8%	0%	0%	0%	0%	50%	7.0%	**5.7%**
Three-mile lower 1	15.3%	7.4%	10.8%	10.4%	8.8%	0%	0%	0%	0%	0%	3.3%	**9.6%**
Three-mile lower 2	5.7%	6.1%	9.3%	7.7%	3.5%	0%	0%	0%	0%	50%	4.2%	**7.2%**
Crib elevated 1	0%	0.7%	0.6%	7.2%	1.8%	0%	0%	0%	0%	0%	2.3%	**3.0%**
Crib elevated 2	0.6%	0%	0.5%	4.3%	1.8%	0%	0%	0%	0%	0%	1.9%	**1.9%**
Crib lower 1	45.2%	45.7%	41.6%	33.6%	58.7%	100%	0%	0%	66.7%	0%	34.9%	**41.9%**
Crib lower 2	17.2%	24.9%	22.6%	15.5%	8.4%	0%	100%	0%	33.3%	0%	31.6%	**18.8%**
Total Lower	**95.5%**	**96.5%**	**93.7%**	**80%**	**95.5%**	**100%**	**100%**	**0%**	**100%**	**100%**	**91.6%**	**90%**
Total Elevated	**4.5%**	**3.5%**	**6.3%**	**20%**	**4.5%**	**0%**	**0%**	**0%**	**0%**	**0%**	**8.4%**	**10%**
Total[2]	**3.7%**	**14.3%**	**29.7%**	**32.1%**	**14.7%**	**<0.1%**	**<0.1%**	**0%**	**0.1%**	**0.2%**	**5.1%**	**100%**

[1] Calculated by taking the number of species bat passes recorded at a detector or station type divided by the total number of species bat passes recorded.
[2] Calculated by taking the number of species bat passes recorded divided by the all bats total number of bat passes recorded at the IWP.

Fall season was defined as August 1 through November 14, 2017. There were 5,454 bat passes identified to species or species group during the fall season. Eastern red bats were the most commonly identified species during the fall, with 2,802 bat passes (51.4%) recorded across all stations. Hoary, silver-haired, and big brown bats were other commonly identified species during the fall season, with 1,073 hoary bat passes (19.7%), 611 silver-haired bat passes (11.2%), and 587 big brown bat passes (10.8%) recorded across all stations. Additional species detected in lower numbers included: low-frequency unknown group (217 bat passes [4.0%]), big brown/silver-haired bat group (102 bat passes [1.9%]), high-frequency unknown group (36 bat passes [0.7%]), tri-colored bats (10 bat passes [0.2%]), eastern red/evening bat group (nine bat passes [0.2%]), and eastern red/tri-colored bat group (six bat passes [0.1%]). The only little brown bat pass identified was recorded during the fall season (one bat pass [less than 0.1%]; Table 15 and Table 16).

The FMP overlaps with the end of the summer season and beginning of the fall season, beginning July 30 and ending October 14, 2017. There were 6,018 bat passes identified to species or species group during the FMP. Species activity during the FMP was similar to the fall season. The most commonly identified species during the FMP were eastern red bats (2,962 bat passes [49.2%]), followed by hoary bats (1,219 bat passes [21.5%]), big brown bats (713 bat passes [11.8%]), and silver-haired bats (618 bat passes [10.3%]). The little brown bat pass was recorded at the seven-mile lower station during the FMP (Table 17 and Table 18).

Table 15. Number of bat calls qualitatively verified at the Icebreaker Wind Energy Project Bat Survey Area during the fall season (August 1 – November 14, 2017).

Station	EF_LN	EPFU	LABO	LACI	LANO	LB_NH	LB_PS	MYLU	PESU	UNHF	UNLF	All Bats
Seven-mile elevated 1	5	18	70	48	10	0	0	0	0	0	7	**158**
Seven-mile elevated 2	7	44	147	97	28	0	0	0	0	1	24	**348**
Seven-mile lower 1	9	57	386	89	85	1	0	0	2	10	19	**658**
Seven-mile lower 2	21	62	367	99	73	1	0	1	1	6	35	**666**
Three-mile lower 1	19	37	323	125	71	0	0	0	0	6	10	**591**
Three-mile lower 2	17	39	358	106	68	2	0	0	0	5	23	**618**
Crib elevated 1	0	1	1	9	1	0	0	0	0	0	0	**12**
Crib elevated 2	0	1	11	17	8	0	0	0	0	1	1	**39**
Crib lower 1	5	197	588	250	138	0	2	0	4	4	47	**1,235**
Crib lower 2	19	131	551	233	129	5	4	0	3	3	51	**1,129**
Total Lower	**90**	**523**	**2,573**	**902**	**564**	**9**	**6**	**1**	**10**	**34**	**185**	**4,897**
Total Elevated	**12**	**64**	**229**	**171**	**47**	**0**	**0**	**0**	**0**	**2**	**32**	**557**
Total	**102**	**587**	**2,802**	**1,073**	**611**	**9**	**6**	**1**	**10**	**36**	**217**	**5,454**

EF_LN = big brown /silver –haired bat group, EPFU = big brown bat, LABO = eastern red bat, LACI = hoary bat, LANO = silver haired bat, LB_NH = eastern red/evening bat group, LB_PS = eastern red/tri-colored bat group, MYLU = little brown bat, PESU = tri-colored bat, UNHF = high frequency unidentified, UNLF = low frequency unidentified.

Table 16. Percentage[1] of bat calls qualitatively verified at the Icebreaker Wind Energy Project Bat Survey Area during the fall season (August 1 – November 14, 2017).

Station	EF_LN	EPFU	LABO	LACI	LANO	LB_NH	LB_PS	MYLU	PESU	UNHF	UNLF	All Bats
Seven-mile elevated 1	4.9%	3.1%	2.5%	4.5%	1.6%	0%	0%	0%	0%	0%	3.2%	**2.9%**
Seven-mile elevated 2	6.9%	7.5%	5.2%	9.0%	4.6%	0%	0%	0%	0%	2.8%	11.1%	**6.4%**
Seven-mile lower 1	8.8%	9.7%	13.8%	8.3%	13.9%	11.1%	0%	0%	20%	27.8%	8.8%	**12.1%**
Seven-mile lower 2	20.6%	10.6%	13.1%	9.2%	11.9%	11.1%	0%	100%	10%	16.7%	16.1%	**12.2%**
Three-mile lower 1	18.6%	6.3%	11.5%	11.6%	11.6%	0%	0%	0%	0%	16.7%	4.6%	**10.8%**
Three-mile lower 2	16.7%	6.6%	12.8%	9.9%	11.1%	22.2%	0%	0%	0%	13.9%	10.6%	**11.3%**
Crib elevated 1	0%	0.2%	0%	0.8%	0.2%	0%	0%	0%	0%	0%	0%	**0.2%**
Crib elevated 2	0%	0.2%	0.4%	1.6%	1.3%	0%	0%	0%	0%	2.8%	0.5%	**0.7%**
Crib lower 1	4.9%	33.6%	21.0%	23.3%	22.6%	0%	33.3%	0%	40%	11.1%	21.7%	**22.6%**
Crib lower 2	18.6%	22.3%	19.7%	21.7%	21.1%	55.6%	66.7%	0%	30%	8.3%	23.5%	**20.7%**
Total Lower	**88.2%**	**89.1%**	**91.8%**	**84.1%**	**92.3%**	**100%**	**100%**	**100%**	**100%**	**94.4%**	**85.3%**	**89.8%**
Total Elevated	**11.8%**	**10.9%**	**8.2%**	**15.9%**	**7.7%**	**0%**	**0%**	**0%**	**0%**	**5.6%**	**14.7%**	**10.2%**
Total[2]	**1.9%**	**10.8%**	**51.4%**	**19.7%**	**11.2%**	**0.2%**	**0.1%**	**<0.1%**	**0.2%**	**0.7%**	**4.0%**	**100%**

[1] Calculated by taking the number of species bat passes recorded at a detector or station type divided by the total number of species bat passes recorded.
[2] Calculated by taking the number of species bat passes recorded divided by the all bats total number of bat passes recorded at the IWP.

Table 17. Number of bat calls qualitatively verified at the Icebreaker Wind Energy Project Bat Survey Area during the fall migration period (July 30 – October 14, 2017).

Station	EF_LN	EPFU	LABO	LACI	LANO	LB_NH	LB_PS	MYLU	PESU	UNHF	UNLF	All Bats
Seven-mile elevated 1	8	25	86	72	12	0	0	0	0	0	12	**215**
Seven-mile elevated 2	7	50	155	114	30	0	0	0	0	1	26	**383**
Seven-mile lower 1	8	64	394	112	87	1	0	0	2	10	24	**702**
Seven-mile lower 2	20	71	376	125	74	1	0	1	1	6	42	**717**
Three-mile lower 1	23	47	343	146	77	0	0	0	0	6	12	**654**
Three-mile lower 2	19	50	375	120	74	2	0	0	0	5	27	**672**
Crib elevated 1	0	1	5	17	1	0	0	0	0	0	0	**24**
Crib elevated 2	0	1	8	19	2	0	0	0	0	0	0	**30**
Crib lower 1	5	240	630	298	133	0	2	0	4	3	54	**1,369**
Crib lower 2	21	164	590	268	128	5	4	0	3	3	66	**1,252**
Total Lower	**96**	**636**	**2,708**	**1,069**	**573**	**9**	**6**	**1**	**10**	**33**	**225**	**5,366**
Total Elevated	**15**	**77**	**254**	**222**	**45**	**0**	**0**	**0**	**0**	**1**	**38**	**652**
Total	**111**	**713**	**2,962**	**1,291**	**618**	**9**	**6**	**1**	**10**	**34**	**263**	**6,018**

EF_LN = big brown /silver –haired bat group, EPFU = big brown bat, LABO = eastern red bat, LACI = hoary bat, LANO = silver haired bat, LB_NH = eastern red/evening bat group, LB_PS = eastern red/tri-colored bat group, MYLU = little brown bat, PESU = tri-colored bat, UNHF = high frequency unidentified, UNLF = low frequency unidentified.

Table 18. Percentage[1] of bat calls qualitatively verified at the Icebreaker Wind Energy Project Bat Survey Area during the fall migration period (July 30 – October 14, 2017).

Station	EF_LN	EPFU	LABO	LACI	LANO	LB_NH	LB_PS	MYLU	PESU	UNHF	UNLF	All Bats
Seven-mile elevated 1	7.2%	3.5%	2.9%	5.6%	1.9%	0%	0%	0%	0%	0%	4.6%	**3.6%**
Seven-mile elevated 2	6.3%	7.0%	5.2%	8.8%	4.9%	0%	0%	0%	0%	2.9%	9.9%	**6.4%**
Seven-mile lower 1	7.2%	9.0%	13.3%	8.7%	14.1%	11.1%	0%	0%	20%	29.4%	9.1%	**11.7%**
Seven-mile lower 2	18.0%	10%	12.7%	9.7%	12.0%	11.1%	0%	100%	10%	17.6%	16.0%	**11.9%**
Three-mile lower 1	20.7%	6.6%	11.6%	11.3%	12.5%	0%	0%	0%	0%	17.6%	4.6%	**10.9%**
Three-mile lower 2	17.1%	7.0%	12.7%	9.3%	12.0%	22.2%	0%	0%	0%	14.7%	10.3%	**11.2%**
Crib elevated 1	0%	0.1%	0.2%	1.3%	0.2%	0%	0%	0%	0%	0%	0%	**0.4%**
Crib elevated 2	0%	0.1%	0.3%	1.5%	0.3%	0%	0%	0%	0%	0%	0%	**0.5%**
Crib lower 1	4.5%	33.7%	21.3%	23.1%	21.5%	0%	33.3%	0%	40%	8.8%	20.5%	**22.7%**
Crib lower 2	18.9%	23.0%	19.9%	20.8%	20.7%	55.6%	66.7%	0%	30%	8.8%	25.1%	**20.8%**
Total Lower	**86.5%**	**89.2%**	**91.4%**	**82.8%**	**92.7%**	**100%**	**100%**	**100%**	**100%**	**97.1%**	**85.6%**	**89.2%**
Total Elevated	**13.5%**	**10.8%**	**8.6%**	**17.2%**	**7.3%**	**0%**	**0%**	**0%**	**0%**	**2.9%**	**14.4%**	**10.8%**
Total[2]	**1.8%**	**11.8%**	**49.2%**	**21.5%**	**10.3%**	**0.1%**	**0.1%**	**<0.1%**	**0.2%**	**0.6%**	**4.4%**	**100%**

[1] Calculated by taking the number of species bat passes recorded at a detector or station type divided by the total number of species bat passes recorded.
[2] Calculated by taking the number of species bat passes recorded divided by the all bats total number of bat passes recorded at the IWP.

In addition to the analysis of bat acoustic recordings described above, WEST also performed a statistical analysis of the correlation between the seven-mile lower and seven-mile elevated detector bat activity levels. This analysis was specifically requested by the IWP team based on discussions with ODNR, who requested that this additional analysis be performed to address the question of whether the data being gathered at these two recording stations was truly additive, as would be the case if the two data streams were found to be uncorrelated, or largely redundant, or if the two data streams were highly correlated. The results of this analysis showed bat activity at lower and elevated stations were highly correlated. The analysis was presented in a separate report provided by WEST to the IWP team, dated October 31, 2017. This report was submitted to ODNR on November 1, 2017, revised in response to ODNR comments on the initial draft, and the revised draft is attached as Appendix A.

DISCUSSION

The MOU signed by IWP and ODNR describes the goals of bat monitoring as 1) to document existing conditions and patterns of use by species of concern at the Project site; 2) to document changing conditions and patterns of use by species of concern and their associated habitats as a result of Project construction and operations at the Project site; 3) to develop and implement effective mitigation and adaptive management strategies to minimize avian and bat resource impacts; 4) to evaluate the feasibility of various monitoring protocols in an offshore setting; and 5) to better understand how offshore wind projects in Lake Erie or the Great Lakes may affect birds and bats. The bat monitoring completed in 2010 by Tetra Tech and 2017 by WEST measured patterns of use within and outside the Project site, and provides a baseline to which use can be compared after construction.

Offshore monitoring of bats provides unique challenges that on-shore facilities do not face. Humid conditions and harsh weather can cause bat detectors to malfunction more often than desired; despite the harsh conditions, detector success rates exceeded the 80% goal desired by ODNR, and met the intentions of the MOU. Use of redundant detectors at stations and regular checks of equipment by LimnoTech increased the success rate. The ability of SM4/3 detectors to handle moist conditions also increased the success rate relative to other detectors typically used collect bat activity at wind-energy projects, such as Anabat.

ODNR requested a detector be raised as high as possible within the Project site to better assess bat use closer to the rotor swept zone of turbines; in response, LimnoTech deployed an experimental offshore buoy with a 10-m carbon fiber pole attached to the buoy. The detector was placed near the buoy and the microphone was elevated to the top of the 10-m pole. The detector operated successfully until the bolts connecting the pole to the buoy failed and the pole broke off from the buoy. The failure of the bolts was likely due to high winds and large waves, illustrating the logistical challenges associated with monitoring bat activity in offshore environments. As described in Appendix A, attached, data collected from the 10-m detector was highly correlated with data collected at a nearby detector located near water level, suggesting that both detectors recorded bat calls within similar airspaces. Wave action and harsh weather associated with offshore environments make it impractical to collect acoustic bat data at heights greater than approximately 10-m for the majority of the active bat season. Collecting this additional data from elevated buoys is unlikely to provide additional insight into the existing conditions and patterns of use by bats at the Project site.

Previous Study Results

Acoustic studies using ultrasonic bat detectors provide a way to sample bats in locations, such as open water, that would not be able to be sampled using traditional bat capture methods. A wide variety of bat detectors exist on the market; however, different detector models use different technology and microphones to record bat echolocation calls (Downes 1982 and Fenton 2000). A study by Adams et al. (2012) compared five different bat detector models, and found that there is significant variation in detection ability of different bat detectors. Different detector models use different microphone types, such as directional and omnidirectional microphones. Omnidirectional microphones have a greater chance of recording bat echolocation calls than a directional microphone (Limpens and McCraken 2004). Direct comparison between studies that used different recording methods and technology should be made with caution, understanding that there are innate differences in the ability of different bat detectors to detect and record bat echolocation calls. Adams et al. (2012) showed Anabat detectors to consistently record fewer calls than four other detector types, including Wildlife Acoustics SM2 detectors. For example, Anabat units recorded approximately 5 synthetic bat calls played at 10-m from detectors at 25Khz compared to approximately 15 calls recorded by the SM2 detector.

Tetra Tech conducted a bat activity study (Svedlow et al. 2012) using some stations that were also monitored WEST in 2017. Svedlow et al. (2012) found different, generally lower, bat activity rates than the study by WEST. Different bat detectors were deployed in the two studies. In 2010, Anabat SD1 bat detectors were deployed and, in 2017, SM4/SM3 bat detectors were deployed. SD1 bat detectors use a directional microphone that is not waterproof (requires additional housing to protect the microphone); whereas the SM4 bat detectors use an omnidirectional waterproof microphone that is better suited for off-shore bat activity monitoring. SM4/SM3 microphones are more sensitive and record more bat calls than Anabat detectors. The differences in detector type preclude direct comparison of the number of bat passes recorded in 2017 to Svedlow et al. (2012) or most land-based wind-energy projects that used Anabat detectors. Generally, both the WEST study and Svedlow et al. (2012) found a similar species composition, along with seasonal activity trends (higher activity in the summer and fall) at the recording locations. Both WEST and Svedlow et al. (2012) documented significantly more bat activity at the lower detector on the crib compared to other detectors. Svedlow et al. (2012) suggested the reason for the increase activity was that bats were attracted to the crib, the reasons for which were unclear but could be related to insects congregating around lights on the crib.

CONCLUSIONS

The results of this study provide a valuable baseline to which use and mortality can be compared post-construction. For example, the bat species recorded, and the timing of bat activity was similar to patterns of mortality at on-shore wind-energy facilities (Arnett et al. 2008); post-construction monitoring can be used to determine if bat mortality off-shore at the Project also follows patterns observed at on-shore facilities. While it is tempting to use activity rates recorded during this study to precisely predict post-construction mortality rates by comparing our results to Svedlow et al. (2012) or projects located on-shore, the ability of SM detectors to record significantly more bat calls than Anabats makes these comparisons inappropriate. Most existing studies of on-shore wind-energy facilities Ohio and elsewhere have utilized Anabat detectors to characterize bat activity, which record significantly fewer bat passes.

The lack of empirical relationships between pre-construction bat activity and post-construction bat mortality rates also precludes precise predictions of bat mortality rates. Research completed to date has not shown a strong correlation between pre-construction bat activity rates and post-construction bat mortality rates. Baerwald and Barclay (2009) found a significant positive association between pass rates measured at 30 m and fatality rates for hoary and silver-haired bats across five on-shore wind projects in southern Alberta; however, only 31% of the variation in activity and mortality was explained during their study. Hein et al. (2013) were unable to find a significant relationship between bat activity and mortality in a review of 12 wind projects in the US with adequate pre-construction activity data and post-construction mortality data, and similar to Baerwald and Barclay (2009), a small portion of variation in fatalities (21.8%) was explained by bat activity. Differences in survey methodologies could partially explain the lack of correlation; however the propensity for bats to be attracted to turbines is the more likely explanation for the lack of strong correlation between pre-construction bat activity estimates and post-construction bat mortality rates (Jameson and Willis 2014, Cryan et al. 2014).

Gordon and Erickson (2016) assessed risk to bats from the Project based on available data, and predicted that bat fatality rates would be within the broad range of mortality recorded at on-shore wind-energy facilities, and there was a low potential for collision risk of species protected under the endangered species act. The results of this study are consistent with the conclusions of Gordon and Erickson (2016).

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Appendix A: Memorandum RE Analysis of the Correlation Between Low and High Microphones in the Daily Patterns of Bat Acoustic Activity Recorded at the Buoys at the Icebreaker Wind Project Site During Summer, 2017 (Revised December 30, 2017)

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December 30, 2017

Beth Nagusky
Icebreaker Wind, Inc.
1938 Euclid Avenue, Suite 200
Cleveland, OH 44114

RE: Analysis of the correlation between low and high microphones in the daily patterns of bat acoustic activity recorded at buoys located at the Icebreaker Wind Project site during summer, 2017

Dear Ms. Nagusky,

Icebreaker Wind, Inc. (IWI) requested that Western EcoSystems Technology, Inc. (WEST) prepare a data summary including a quantitative analysis of the strength of the correlation between high (10 meters above water surface) and low (2 meters above water surface) microphones located on buoys within the Icebreaker Project site, in the daily patterns of bat acoustical activity detected at these microphones during the period of time during which data was gathered at both high and low microphones (July 11 – August 30, 2017). This memorandum presents our findings with regard to this request.

Please let me know if you have any questions regarding the data or analysis presented herein.

Sincerely,

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WEST, Inc.
512-229-8399
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Field Sampling

The data analyzed in this memorandum are bat acoustic data gathered with four SM4 bat acoustic detectors deployed on two buoys deployed roughly 300m from one another within the Icebreaker Wind Project site, roughly 9 miles from the shore of Cleveland, Ohio. Two detectors were deployed on each buoy. On one buoy, both detectors were deployed at an elevation roughly 2 meters above the water's surface. These are referred to herein as the "low" detectors. On the other buoy, the microphones for the detectors were deployed atop a carbon fiber pole, such that they were located at an elevation roughly 10 meters above the water's surface. These are referred to herein as the "high" detectors. Further details regarding these deployments, the buoys, the detectors, and the acoustic data processing and analysis methods is provided in the MOU signed between IWI and the Ohio Department of Natural Resources[1] and the first quarterly report on bat acoustic monitoring prepared by WEST[2].

Analysis Methods

The objective of the present analysis was to examine the strength of the correlation between the high and the low detectors in the patterns of nightly variation in bat acoustic activity, or "calls," recorded at each of these locations during the period where simultaneous recordings were gathered at both high and low detectors, extending from 11 July through 30 August, 2017.

To this end, we performed a two-tiered analysis. The first comprised a simple investigation of correlation involving dates for which all four detectors successfully obtained data. The second comprised a more involved analysis incorporating data from detectors on days for which at least one detector type's data of bat calls was available. Table 1 describes the temporal ranges during which different detectors successfully collected data.

Prior to analysis, nightly call-count data were first normalized by adding one, and then transformed via the log function. The variable used for this analysis was nightly total bat call counts. Thus, there is no analysis of patterns over hourly time within nights. Only the pattern of night to night variation in total nightly calls was analyzed.

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[1] Icebreaker Windpower Inc., 2017. Response and Application Second Supplement. Avian and Bat MOU. Memorandum of Understanding between the Ohio Department of Natural Resources and Icebreaker Windpower, Inc. in the matter of the Application of Fred Olsen Renewables USA LLC/Icebreaker Windpower Inc. for a Certificate to construct a wind-powered electric generation facility. Case # 16-1871-EL-BGN. Filed July 20, 2017.

[2] Matteson, A., B. Hale, C. Gordon, and R. E. Good, 2017. Icebreaker Wind Bat Monitoring, Lake Erie, Ohio. Interim report March 21-August 14, 2017. Prepared for Icebreaker Wind, Inc. by Western EcoSystems Technology, Inc.

Table 1: Date ranges of data included in both analysis strategies, with respect to each of the four detectors. For a date to be included in the Correlation analysis, data must have been recorded at all four detectors. For inclusion in the Analysis of Covariance, data need only have been recorded at one of the two Detectors of a particular Altitude. Column N describes the number of nights of data from that Detector contributing to that analysis strategy

Altitude	Detector	Correlation Date Range	N	Analysis of Covariance Date Range	N
High	1	Jul 19 – Aug 14	27	Jul 11 – Aug 14	35
	2	Jul 19 – Aug 14	27	Jul 19 – Aug 30	43
Low	1	Jul 19 – Aug 14	27	Jul 11 – Aug 30	51
	2	Jul 19 – Aug 14	27	Jul 11 – Aug 30	51

Correlation

In order to obtain an initial simple snapshot of the underlying data, correlation patterns between the log-call counts recorded via the high detectors were compared with the same from the low. Generally speaking, correlation analyses investigate the relative strength of the correlation between two variables by pairing each value of the first variable with a corresponding value in the second.

To ensure an appropriate comparison between the high- and low-altitudes, the nightly data recorded at both detectors, for each altitude, were averaged. Thus, for any one day, the two available data points of that altitude type were reduced to one data point. Dates for which one of the detector data points were missing for an altitude were removed from consideration. In this way, 27 paired observations covering the temporal range from Jul 19 – Aug 14, inclusive, were obtained for initial correlation investigations, with one variable describing average low logged call-counts, and the other high.

To estimate the correlation between the log-count data recorded from both altitudes, standardized high-altitude calls were regressed against the same of low-altitude calls via simple linear regression. When performed in this way, the slope estimate from the resulting model equals the correlation r between the regressor and outcome. Squaring of the slope estimate, in this case the correlation, provides the coefficient of determination r^2. The coefficient of determination identifies the proportion of variance of log-scale high-altitude calls explained by the variability in log-scale low-altitude calls.

The same log-scale simple linear regression was then repeated, but with non-standardized original values. From this regression of high-altitude log-counts against low-altitude log-counts, the values of the intercept and slope were obtained and assessed. Data exhibiting high correlation between high-altitude log-counts and low-altitude log-counts should have estimated regression intercepts close to zero, and estimated slopes close to one. In this case, this means that high-altitude log-counts can be accurately predicted via low-altitude log-counts alone, or vice versa.

Analysis of Covariance

The correlation analysis described above only incorporates data on dates for which all four detectors were functioning. However, different detectors were functioning on different days (Table 1). Use of all the available data, including those dates on which at least one detector of an altitude was non-functioning, requires a different analysis.

Analysis of covariance is a statistical technique that combines regression with analysis of variance. Statistical regression, as applied here, allows for the trending of bat calls against time. Analysis of variance identifies statistical differences between categorical groups, or in this case, the mean number of bat calls recorded at discrete detector altitudes. Here then, an analysis-of-covariance model allows for the evaluation of trends in bat calls over time over categorical detector altitude ("high" or "low"), along with nuisance parameters (replicated detector), in one modeling framework.

Via its regression-like structure, analysis of covariance allows for the control of possible confounding variables which could influence the accuracy of simple correlation, as described above. It also allows for the use of all data, even on days for which only one of the four detectors was functioning. Finally, it also permits more complicated covariance structures.

To identify important predictors of log call-counts recorded over time, an initial analysis-of-covariance model was fit. The initial model considered categorical detector altitude, time, their interaction, and replicated detector. Consideration of an interaction allows for independent trending of detector-altitude bat-call time series, within one modeling framework. As applied here, the presence of an interaction of log call-counts against time, with respect to high and low detectors, would graphically result in the two temporal high- and low-trends not being parallel.

However, prior to the investigation and possible removal of individual variables, possible call-count lag-1 autocorrelation was assessed via examination of four autocovariance plots for each of the two detectors at each of the high and low altitudes. Lag-1 autocorrelation is the tendency for the call-count at a detector on any one night to correlate with values from the previous night. Lag-1 autocorrelation, a type of covariance structure, was assessed by fitting the initial-model analyses of covariance models described above, in restricted maximum-likelihood models with and without an overall lag-1 autocorrelation variance structure. Statistical significance of the overall autocorrelation was then assessed via a likelihood-ratio test.

After the initial assessment of lag-1 autocorrelation, and assuming its removal, analysis of covariance was then run in a sequential manner to assess for the significance of individual model covariates. Modeling followed a backwards regression fitting procedure, in which more complicated models were considered first. Variables were removed, one-by-one, if the use of a one-degree-of-freedom likelihood ratio test exhibited a p-value greater than 0.05. In this case, we concluded that this variable did not contribute significantly to the explanatory value of the model, and it was removed. The procedure was then repeated with the newly simplified model. The procedure was stopped when all included variables exhibited sufficiently low p-values. In these subsequent tests involving only fixed effects, maximum likelihood was used.

The models were first assessed for significance of replicated detector. Next, the interaction was evaluated, followed by detector height. The time trend was the final covariate evaluated. In all cases, evaluation of the next covariate only proceeded if the likelihood-ratio test of the previous covariate was not significant (thereby ensuring its previous removal).

Results

Correlation

The first-look of correlation between low- and high-altitude log call-counts, following the averaging of non-missing nightly detector data, was r = 0.8744, 90% CI: (0.8442, 0.8991), with a coefficient of determination r^2 = 76.46%.

The regression of nightly averaged log-counts of high versus low led to an intercept estimate of 0.3606, 90% CI: (0.0827, 0.6385) and slope estimate of 0.8440, 90% CI: (0.6910, 0.9970).

Figure 1 depicts the 27 nightly counts of bat-calls, averaged over detector, for each of the high and low altitudes utilized in the correlation analysis.

Analysis of Covariance

Examination of autocovariance plots suggested no significant autocorrelation. Further, results from the first likelihood-ratio test examining lag-1 autocorrelation were non-significant (p=0.3629). Analysis-of-covariance model fitting suggested removal of the following covariates due to low explanatory value: replicated detector (p=0.7735), time-altitude interaction (p=0.8207), and altitude (p=0.3666). Nonetheless, because of the interest in altitude as a potential explanatory factor, we present data from a model that included altitude as an explanatory factor (the second-to-last model), as well as a final model, which retained only date and an intercept as factors governing the night-to-night variation in total bat calls.

Figure 2 illustrates all four time series (two high detectors and two low detectors). All four time series exhibit similar patterns. Figure 2 also includes a model fit for each of the detectors from the second-to-last model (the one that retained altitude as an explanatory factor, even though the model selection process showed that altitude did not explain a significant amount of variation in nightly bat calls).

Conclusion/Discussion

Our initial simple correlation analysis, using dates for which data were available from all four detectors, led to the conclusion that the patterns of daily variation in bat call activity are highly correlated between the high-altitude and low-altitude detectors. This suggests that either one of the altitudes alone could be used to assess the temporal trend of bat calls at the Icebreaker Wind Project site, within altitudes sampled by detectors placed between 2m and 10m altitude.

The plot of high-altitude vs low-altitude counts of calls shows a preponderance of nights with very low numbers of calls, and a greater number of points above the light-gray line of perfect fit on such nights (Figure 1). To explore the effect of this pattern on the correlation, we repeated the regression of nightly averaged high-altitude log-counts versus low-altitude log-counts with regression forced through the origin. Regressing in this way led to a slope estimate of 1.0487, 90% CI: (0.9506, 1.1468). This strong value very near one aligns with the strong correlation result discussed earlier, and indicates that the result of high correlation between high and low altitude detectors is stable when the intercept is stabilized at the origin.

The correlation reported here of r = 0.8744, after averaging nightly detector data, is incredibly strong. Similarly, the strong slope estimate of 1.0487 following a forced fitting through the origin, suggests that for the period covered by the correlation analysis (July 19 through August 14), the nightly call totals for high and low detectors were statistically the same.

An expanded statistical effort, designed to use all the data, even on nights when at least one detector was not operational, found similar evidence of sameness in the high and low log call-count patterns. This expanded analysis-of-covariance effort, which incorporated more data, considered possible autocorrelation, and tested for possible confounders, led to a similar "sameness" result. That result indicated no statistically significant difference between detector altitudes at the alpha = 0.05 level. Thus, the analysis-of-covariance analysis echoes the conclusion of sameness suggested from the correlation analysis.

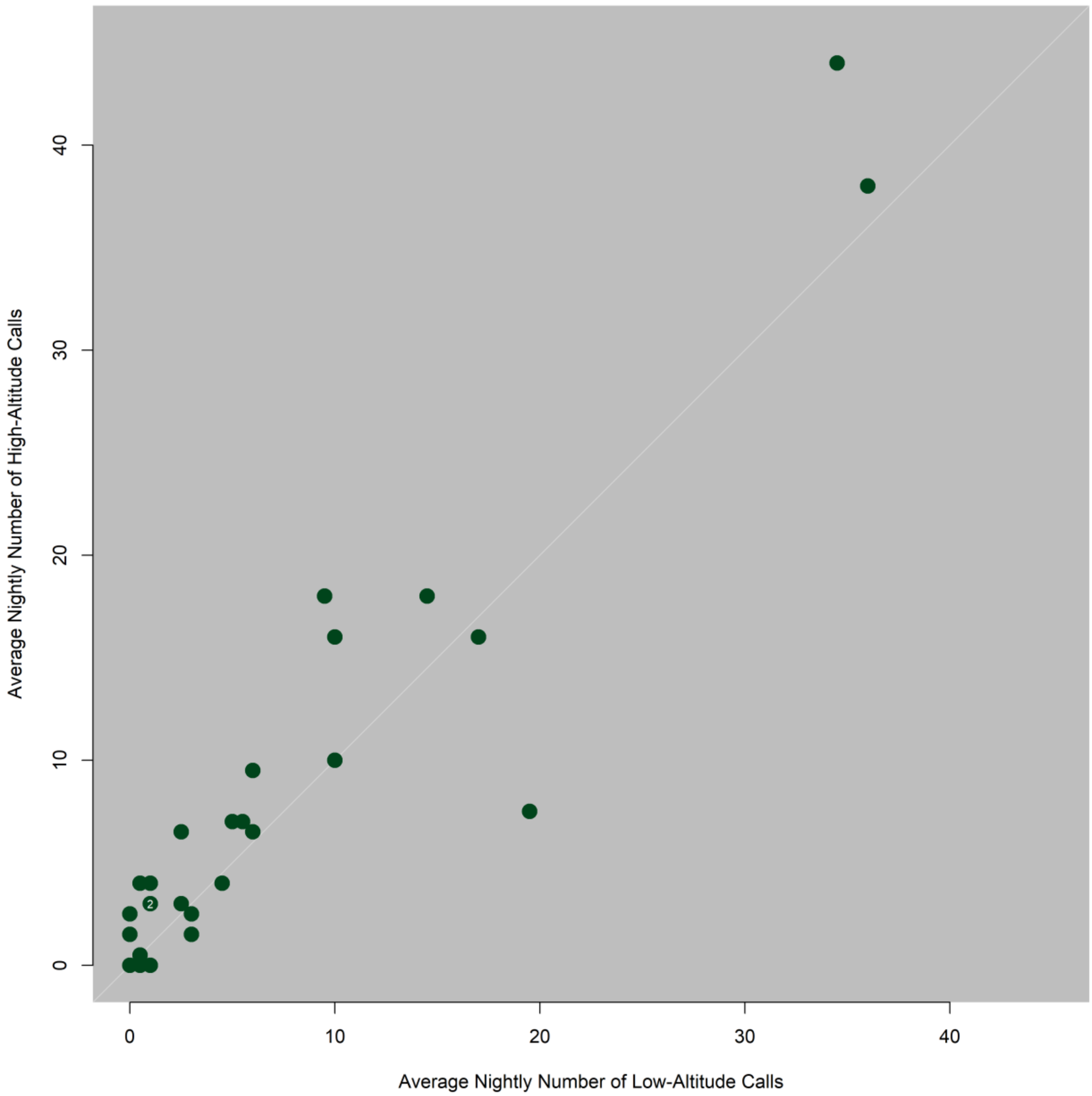


Figure 1: Number of High- vs. Low-Altitude Calls. Each data point represents one night. Each point's coordinate reflects the nightly average value for each altitude. Note that the only nights included in this analysis were nights for which data was gathered from all four detectors (July 19-August 14). One data point that was identical for two nights is labeled "2". The light gray zero-intercept and slope-one line of perfect fit are highlighted.

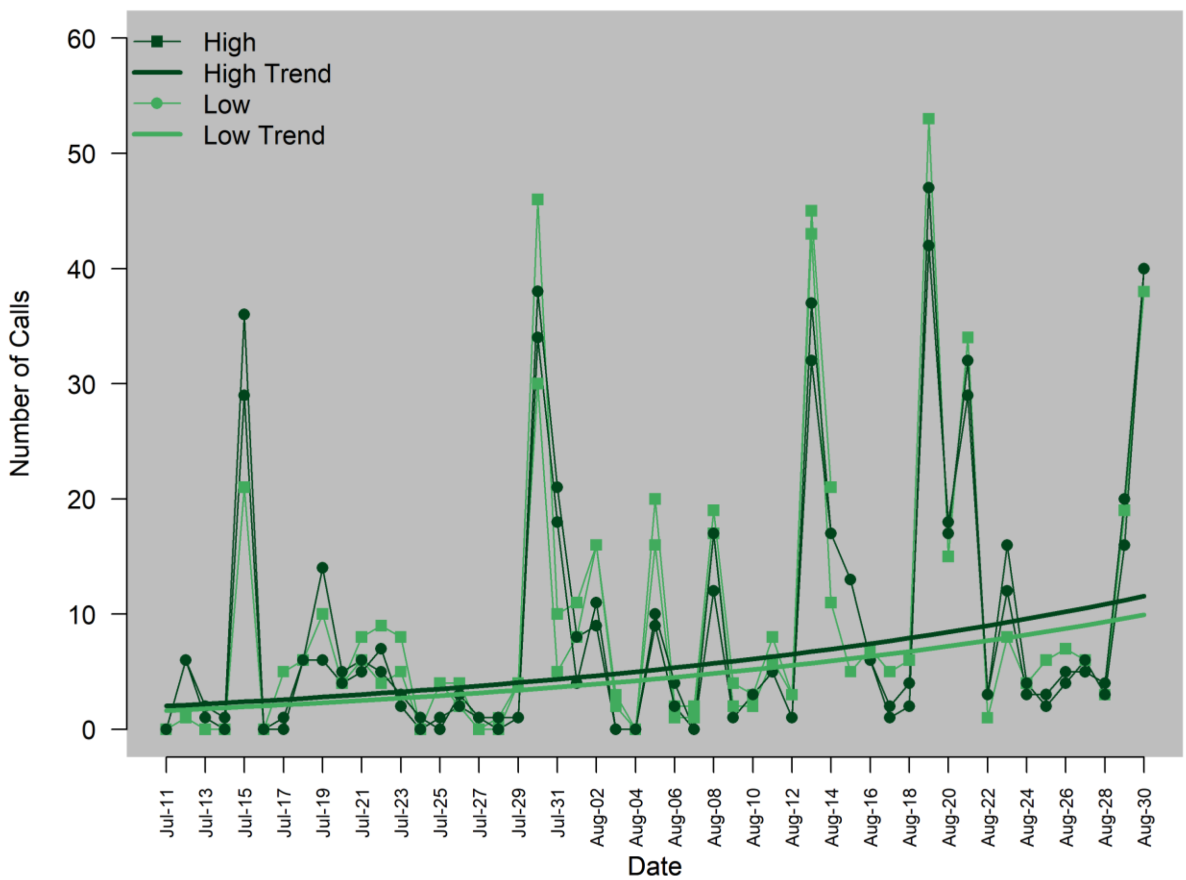
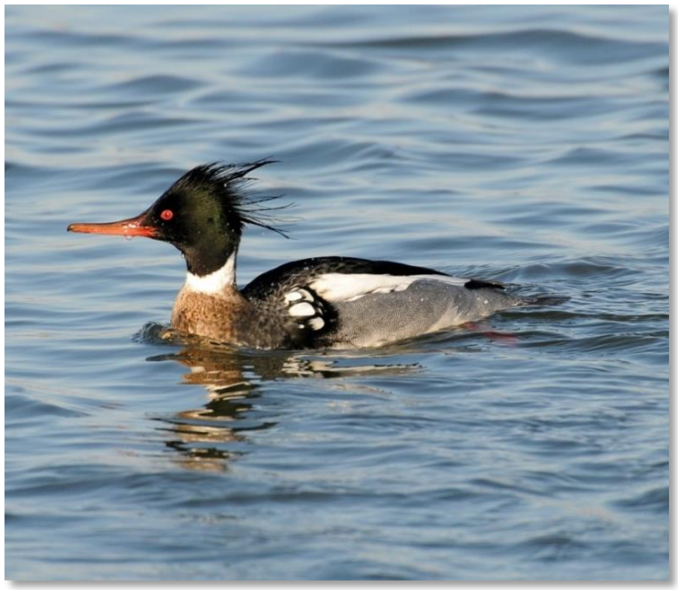


Figure 2: Number of Calls versus Date for High and Low Altitudes at Each of Two Detectors. Each night records the number of bat calls up to four distinct points, with two detector points for High Altitude and two for Low Altitude. The trend lines depict the temporal trends for each altitude, using the model from the covariance analysis that retained altitude, as well as date (the "second-to-last" model, see text).

Appendix B

Aerial Waterfowl and Waterbird Survey Interim Report for the Proposed Icebreaker Wind Project Cuyahoga County, Ohio

Aerial Waterfowl and Waterbird Survey
Interim Report
for the Proposed Icebreaker Wind Project
Cuyahoga County, Ohio



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February 14, 2018

WEST Inc.

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INTRODUCTION

Icebreaker Windpower, Inc. (IWP or Applicant) is proposing to construct Icebreaker Wind, a 6-turbine offshore wind energy demonstration project (Project) in Lake Erie, approximately 13 – 16 kilometers (km; 8 – 10 miles [mi]) off the shore of Cleveland, Ohio. This report documents the study and field survey efforts for the Aerial Waterfowl and Waterbird study for the period from 16 October 2017 through 5 February 2018. The survey effort follows the *Aerial Waterfowl and Waterbird Study Plan* dated August 8, 2017 that was developed for inclusion in the IWP Monitoring Plan and submitted to the Ohio Power Siting Board on August 18, 2017. The objective for the 2017 - 2018 survey effort is to characterize waterfowl and waterbird species, numbers, distribution, and use of the Project area from fall through spring, the non-breeding season.

STUDY AREA

The survey area extends five km (3.1 mi) from the proposed turbines and encompasses 145 km^2 (35,830 acres) of US waters within Lake Erie (Figure 1). Water depths range from 15 – 20 meters (m; 49 – 66 feet [ft]) over mud substrates, with limited areas of sand and clay.

STUDY METHODS

A transect approach was used to sample the survey area using double-observer distance sampling protocol and a fixed-wing aircraft. The double-observer sampling approach was used to aid in resolving variability among observers in bird detection and density estimation. Observers each collected data independently, and isolated from other observers. Orientation of the sampling transects perpendicular to the proposed turbine string follows a gradient design. Parallel transects have been established 2.2 km (1.37 mi) apart, and perpendicular to the orientation of the turbine string (Figure 1). The seven 10-km (6.2-mi) transects were flown during each survey. Surveys were scheduled to be flown every two weeks beginning 15 October 2017 – 31 May 2018, with additional surveys possible during extensive ice cover when the next scheduled survey may not capture the icing conditions. For each regularly scheduled survey, three random assignments were made, including:

- the survey time within daylight hours (early-day [0500-1000H]; mid-day [1000-1400H]; later-day [1400-1900H]),
- the first transect surveyed for the day (transects 1 – 7), and
- initial flight direction (northeast or southwest).

Flights were completed using a Cessna 185 (high-wing, 4-seat plane) with amphibious landing gear. High wing mounts ensure maximum visibility, and amphibious landing gear ensured ability to land on Lake Erie if necessary. Each of the seven transects was sampled completely for each survey. Surveys were flown at 76 m (249 ft) above ground level, at flight speeds of 150 km per hour (hr; 93 mi per hr). Due to minimal observations of birds within the project area during

October, we collected additional observational data during the approach and departure to and from the Project. This additional observational data was collected to ensure that the data set captures the variability and physical conditions of the nearshore environment, and to ensure there are adequate observations to develop the detection models necessary for estimating density within the Project. Off-transect observations cannot be used for density estimation in the off-transect area because the data is not collected on consistent paths/transects. Similarly, during a period of extensive ice cover in late December/early January, an additional survey was flown to document bird use of the survey area and the ice status, with additional off-project aerial observations to capture information on the distribution of waterbirds and ice in the area.

Data collection followed a pre-established field form that is completed verbally and recorded into a voice recorder during the flight (Appendix A). Variables on the field form follow pre-defined variable definitions to aid in the objectivity of the observations. Distance to birds from the transect line were estimated using distance bands and the Dioptra App for Android to determine the angle of observation (Figures 2 and 3). Following the flight, observers immediately transcribed audio observations and referenced Dioptra images to complete the field forms prior to data entry. Field forms were subsequently entered into a relational database to store, retrieve, and organize field observations. All recordings, images, and paper data forms were backed up, and retained for reference.

RESULTS

Regular aerial waterbird surveys began on 16 October 2017 and were completed every two weeks through 5 February 2018 (Table 1). Nine of 17 regular flights have been flown, and one additional ice condition aerial survey was completed on 4 January 2018 to document rapid ice formation within the Project area and surrounding area. Since late December, ice coverage within the project has been variable (0-90%), with most of the ice present in slushy brash to small floes.

The following is an interim summary of the observations to date; data have not been finalized in the formal WEST quality assurance and quality control (QA/QC) process; therefore, details are expected to change and results should be considered as preliminary.

During surveys to date, 13 species were observed during the flights with 11 species confirmed within the Project area (Table 2). Among the observations within the Project area, 68% were identified as gulls, including Herring (11.6%, *L. argentatus*), Ring-billed (11.3%, *Larus delawarensis*), Bonaparte's (1.6%, *Chroicocephalus philadelphia*), and Great Black-backed gull (1.7%, *L. marinus*); unidentified gulls compose 41.8% of all observations with 67% of these unidentified resting on the ice or water, and 29% flying through the Project. In contrast, among the off-transect observations seen between the Project area and the southern Lake Erie shoreline during the approach to, and departure from the Project, mergansers (Common [*Mergus merganser*], Red-breasted [*M. serrator*], and unidentified mergansers) represented 34% of observations; Red-breasted Mergansers comprised 18.5% of all observations not in the project area. To date, no raptors or eagles have been observed during surveys, in the Project area, or over nearby waters.

Sixty-four percent of all bird observations have been outside the project boundary; 36% of all observations were within the project boundary (Figure 4-6; Table 2). Of birds within the Project area, 74.3% of birds were seen singly and 14.2% were observed in small groups (2 – 5 birds). Within the project area, the flock size by species to date is 4.9 birds (18.2 SD). In contrast, observations outside the project, flock size by species is 11.2 birds (41.7 SD), with 56.2% observations having a group size of 1, and 21.8% were observed in small groups (2 – 5 birds). Twenty-two percent of observations outside the project area had a group size of 6-300 birds.

SURVEY AND REPORT STATUS

Eight regularly scheduled survey flights remain in the 2017 – 2018 aerial waterbird survey effort. WEST will continue to monitor icing conditions on Lake Erie for deploying up to two additional ice condition surveys. After completion of the survey effort in May, data will undergo an extensive QA/QC process prior to the analysis, with reporting following.

Table 1. Proposed and completed aerial waterbird surveys including randomly assigned survey window, starting transect, and direction for 2017 – 2018.

Week Starting	Survey Completed	Survey	Survey Window	Survey Start Time	Transect Start	Direction (Heading)
15-Oct-2017	16-Oct-2017	Reg#1	mid-day (1000-1400H)	1200H	4	NE (55°)
29-Oct-2017	1-Nov-2017	Reg#2	early-day (0500-1000H)	0800 H	6	SW (235°)
12-Nov-2017	13-Nov-2017	Reg#3	later-day (1400-1900H)	1500H	6	NE (55°)
26-Nov-2017	27 Nov-2017	Reg#4	mid-day (1000-1400H)	1200H	5	NE (55°)
10-Dec-2017	11-Dec-2017	Reg#5	early-day (0500-1000H)	0800 H	3	NE (55°)
24-Dec-2017	27-Dec-2017	Reg#6	later-day (1400-1900H)	1400H	2	SW (235°)
Ice#1	4-Jan-2017	Ice#1	early-day (0500-1000H)	1000H	1	NE (55°)
7-Jan-2018	9-Jan-2018	Reg#7	mid-day (1000-1400H)	1100H	1	NE (55°)
21-Jan-2018	25-Jan-2018	Reg#8	early-day (0500-1000H)	0800 H	5	SW (235°)
4-Feb-2018	5-Feb-2018	Reg#9	later-day (1400-1900H)	1500H	3	SW (235°)
18-Feb-2018		Reg#10	mid-day (1000-1400H)	1200H	2	SW (235°)
4-Mar-2018		Reg#11	early-day (0500-1000H)	0800 H	2	SW (235°)
18-Mar-2018		Reg#12	later-day (1400-1900H)	1500H	4	SW (235°)
1-Apr-2018		Reg#13	mid-day (1000-1400H)	1200H	1	SW (235°)
15-Apr-2018		Reg#14	early-day (0500-1000H)	0800 H	4	NE (55°)
29-Apr-2018		Reg#15	later-day (1400-1900H)	1500H	7	NE (55°)
13-May-2018		Reg#16	mid-day (1000-1400H)	1200H	6	SW (235°)
27-May-2018		Reg#17	early-day (0500-1000H)	0800 H	7	NE (55°)
Ice#2	if needed					
Ice#3	if needed					

Table 2. Counts[a] of birds by species observed in the Icebreaker Wind Project (Pr; from seven transects) or during nearby off-transect (OT) flights nearby, with results summarized by date (16 October 2017 – 5 February 2018), and survey type (Regular [Reg] or Ice [Ice]).

		16-Oct Reg#1	1-Nov Reg#2	13-Nov Reg#3		27-Nov Reg#4		11-Dec Reg#5		27-Dec Reg#6		4-Jan Ice#1		9-Jan Reg#7		25-Jan Reg#8		5-Feb Reg#9	
Common Name	**Scientific Name**	**Pr**	**Pr**	**Pr**	**OT**	**Pr**	**OT**	**Pr**	**OT**	**Pr**	**OT**	**Pr**	**OT**	**Pr**	**OT**	**Pr**	**OT**	**Pr**	**OT**
Ring-Necked Duck	*Aythya collaris*				9														
Unid. Scaup	*Aythya spp.*														4				
Black Scoter	*Melanitta americana*						8										5		
Unid. Scoter	*Melanitta spp.*		15			1													
Long-Tailed Duck	*Clangula hyemalis*									2									
Bufflehead	*Bucephala albeola*					1													
Common Goldeneye	*Bucephala clangula*									1		8			45		4		49
Common Merganser	*Mergus merganser*													1					
Red-Breasted Merganser	*Mergus serrator*				1				232	4		14	12 2		365	9	34	3	
Unid. Merganser	*Mergus spp.*					1			300			4	2		230	19	16		94
Unid. Duck				11	5	4	1		205			31		1	201	539	190		54
Bonaparte's Gull	*Chroicocephalus philadelphia*	5	10	2		9	5	6	7	1	4	2			4				
Ring-Billed Gull	*Larus delawarensis*	16	6		3	8	4	20	50	9	16	25	9	39	24	77	10	53	18
Herring Gull	*Larus argentatus*		1			1	1		4	1	3	25	2	32	54	37		163	4
Great Black-Backed Gull	*Larus marinus*											10	1	5	38	11		12	11
Unid. Gull	*Larus spp*	65	14		8	34	9	8	170	11	61	12	49	15	104	74	72	704	10 57
Common Loon	*Gavia immer*		1	4	1	1	1		1										
Unid. Loon	*Gavia spp.*					1													
Double-Crested Cormorant	*Phalacrocorax auritus*	12	3		1			2	12										
Unid. Passerine							2												
Unid. Large Bird								1			1			1		11			
Raw Count*		98	50	17	28	61	31	37	981	29	85	131	185	94	1069	777	331	935	1287
Survey distance (km)		70	70	70	24	70	29.7	70	32.5	70	32	70	40	70	100.5	70	26.4	70	32

[a] Counts include observations by two of the three observers in plane (front right and rear left) and does not represent the unreconciled final double-observer survey results. Results presented are the number of individual birds observed per survey without double counting

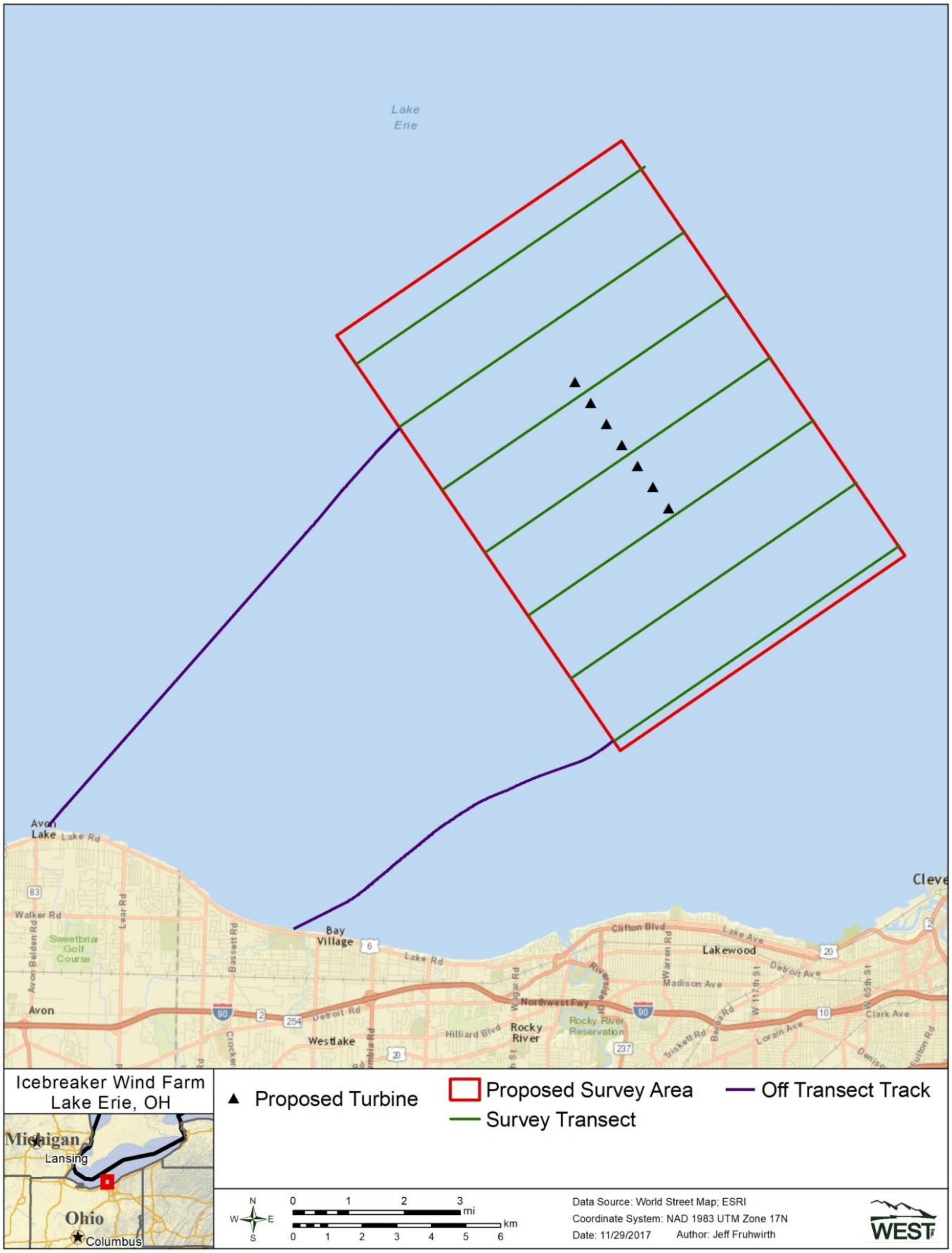

Figure 1. Location of the aerial survey area (red), survey transects (green), and example off-transect survey areas sampled on 13 November 2017 (purple) for Icebreaker Wind.

Figure 2 Example of Dioptra App image from aerial survey on 27 November 2017 Icebreaker Wind regular survey. Image documents location within yellow circle of one loon swimming near Transect #7 in the project.

Figure 3 Example of Dioptra App image from aerial survey on 9 January 2018 Icebreaker Wind regular survey. Location documents two Great Black Back Gull adults resting on "ice cake" ice type off-transect, outside the project.

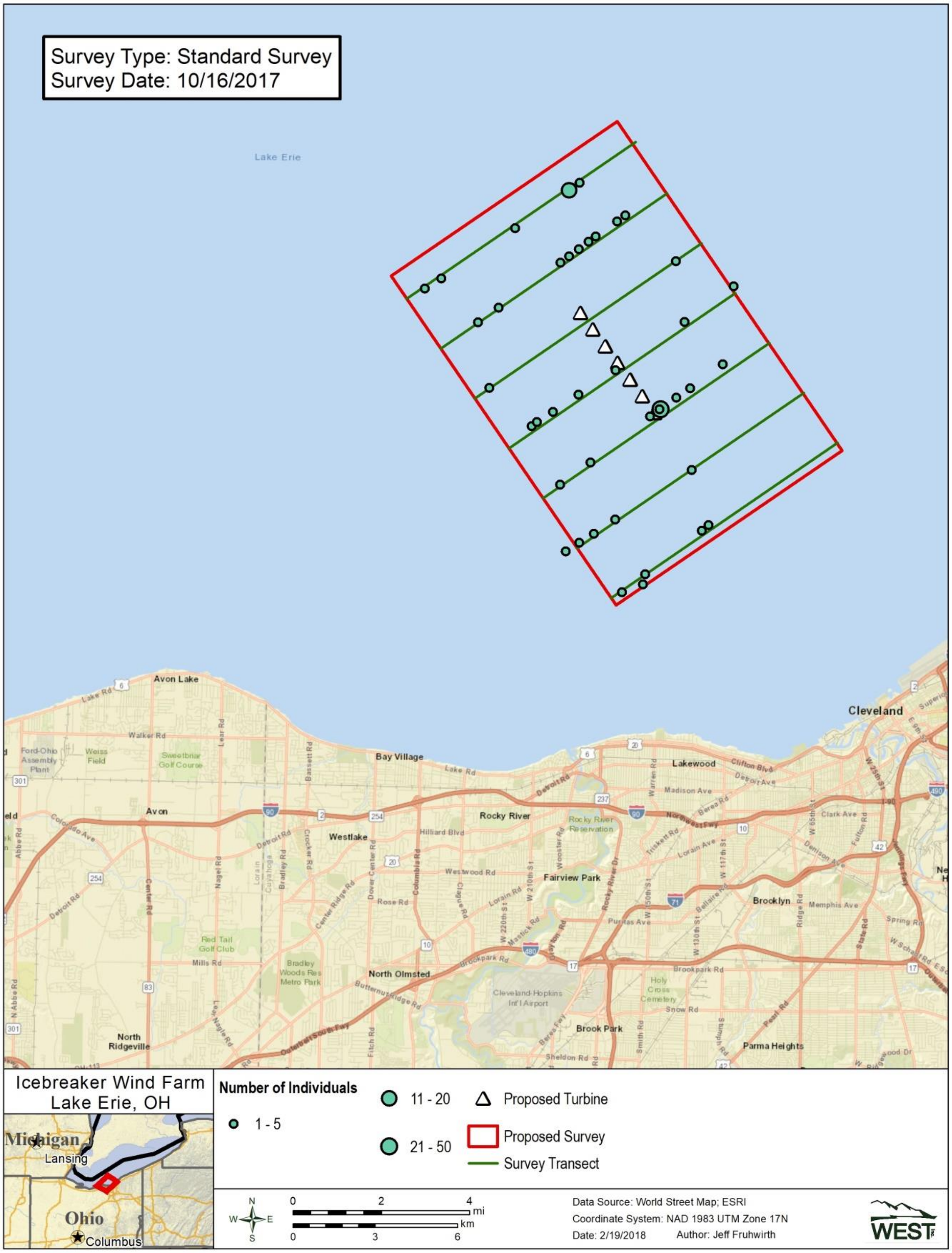

Figure 4. Location of the aerial survey area (red), survey transects (green), and number of birds (green; size of symbol indicates count) observed on October 16, 2017 for Icebreaker Wind. Counts include observations by two of the three observers in plane (front right and rear left) and do not represent the unreconciled final double-observer survey estimates.

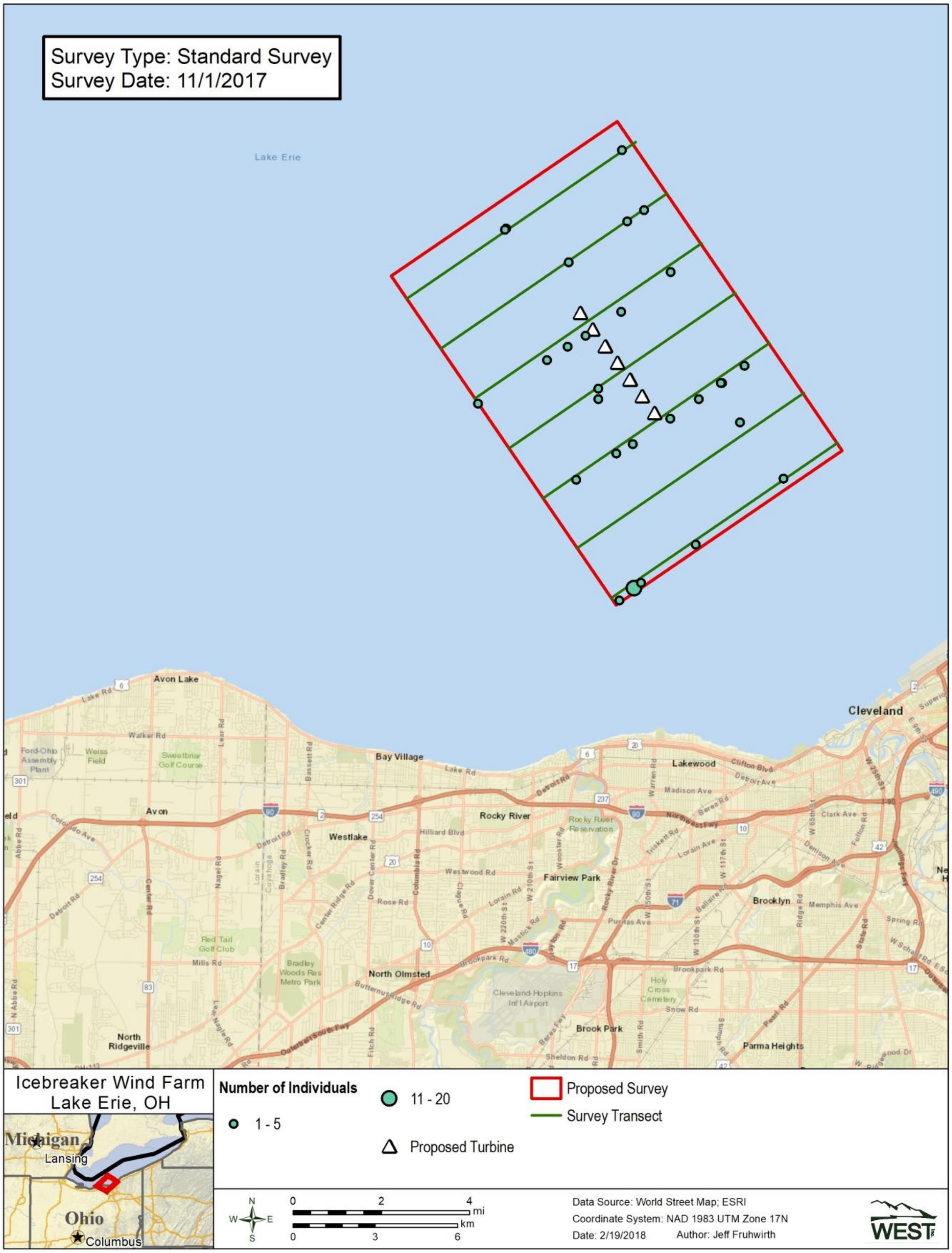

Figure 5. Location of the aerial survey area (red), survey transects (green), and number of birds (green; size of symbol indicates count) observed on November 1, 2017 for Icebreaker Wind. Counts include observations by two of the three observers in plane (front right and rear left) and do not represent the unreconciled final double-observer survey estimates.

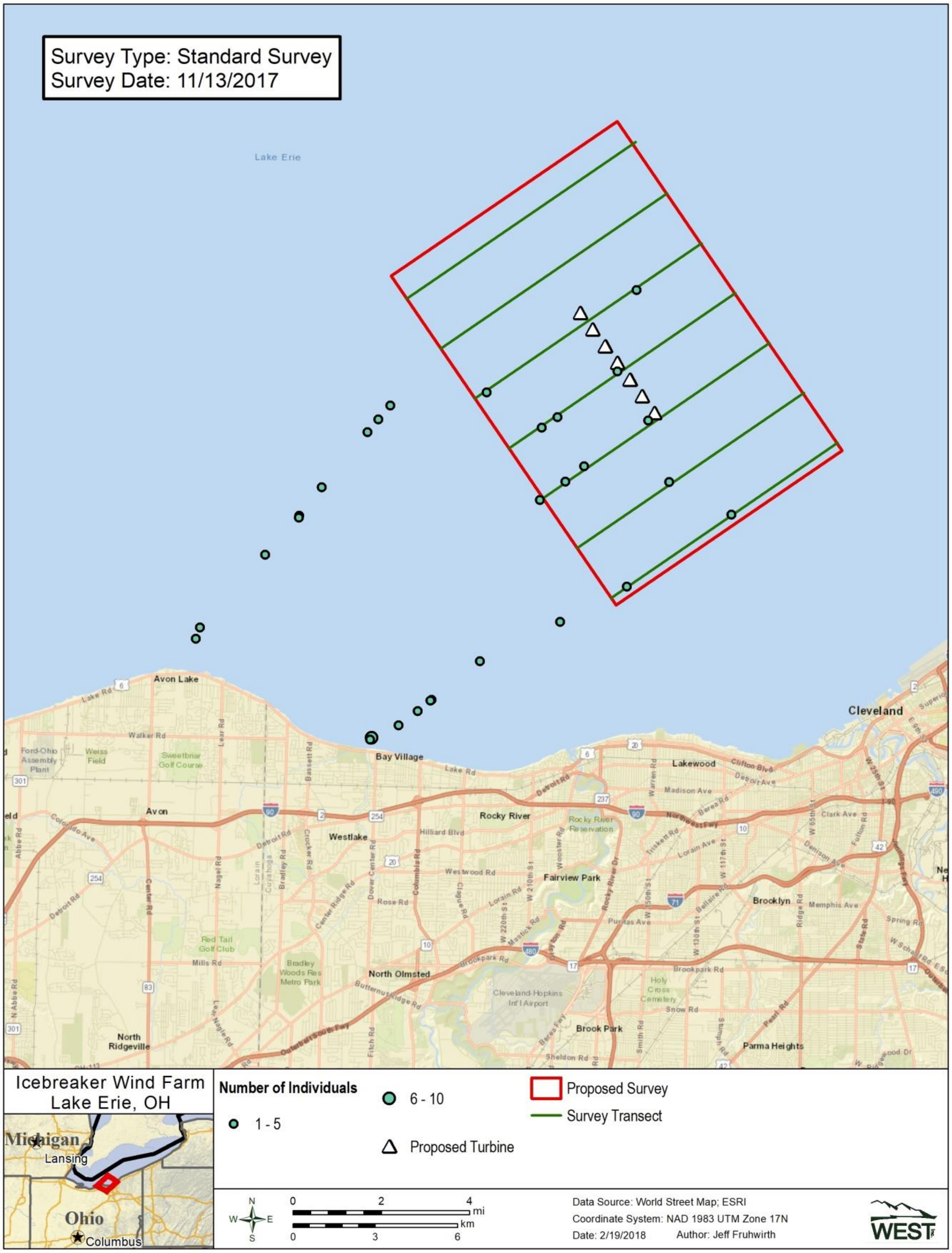

Figure 6. Location of the aerial survey area (red), survey transects (green), and number of birds (green; size of symbol indicates count) observed on November 13, 2017 for Icebreaker Wind. Counts include observations by two of the three observers in plane (front right and rear left) and do not represent the unreconciled final double-observer survey estimates.

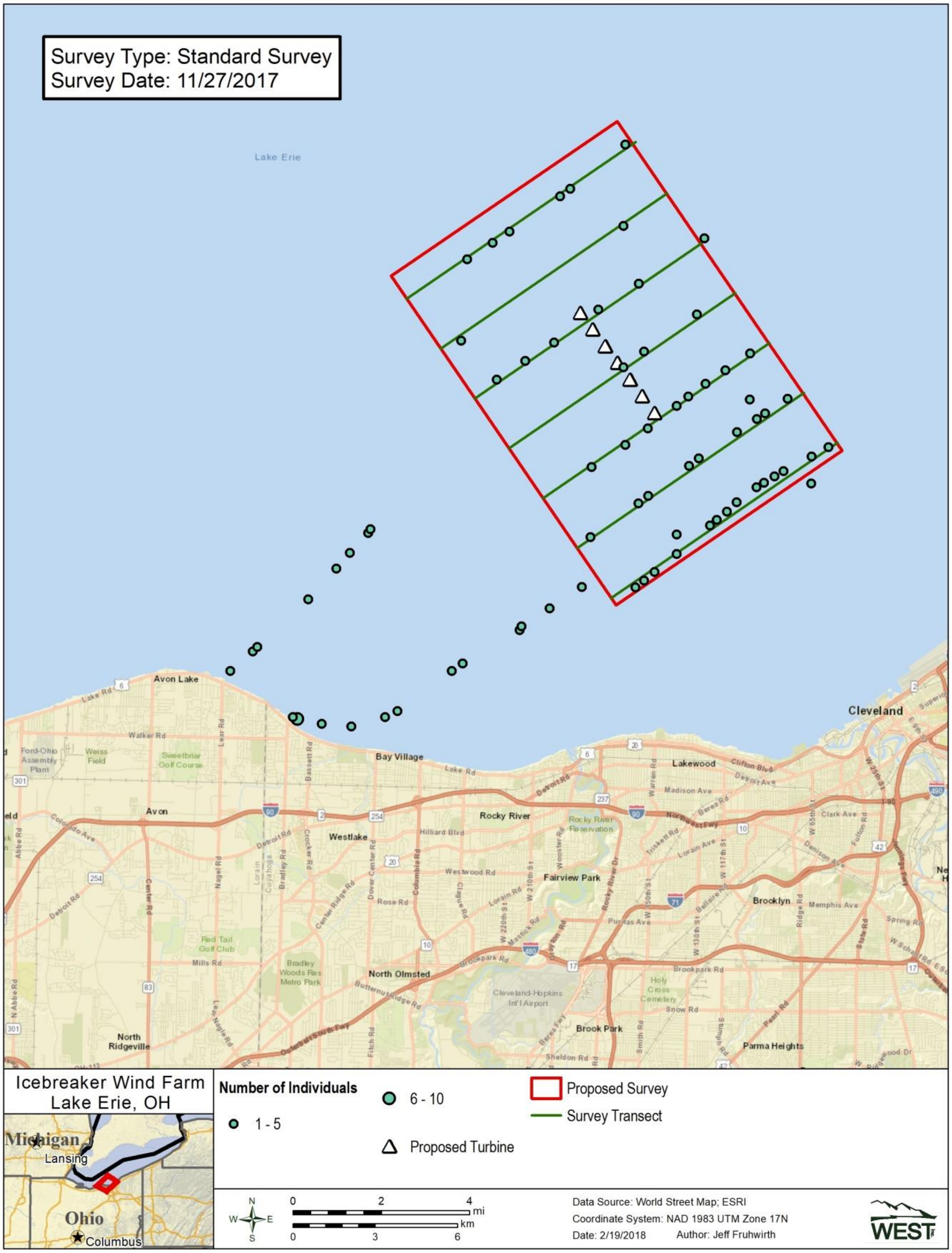

Figure 7. Location of the aerial survey area (red), survey transects (green), and number of birds (green; size of symbol indicates count) observed on November 27, 2017 for Icebreaker Wind. Counts include observations by two of the three observers in plane (front right and rear left) and do not represent the unreconciled final double-observer survey estimates.

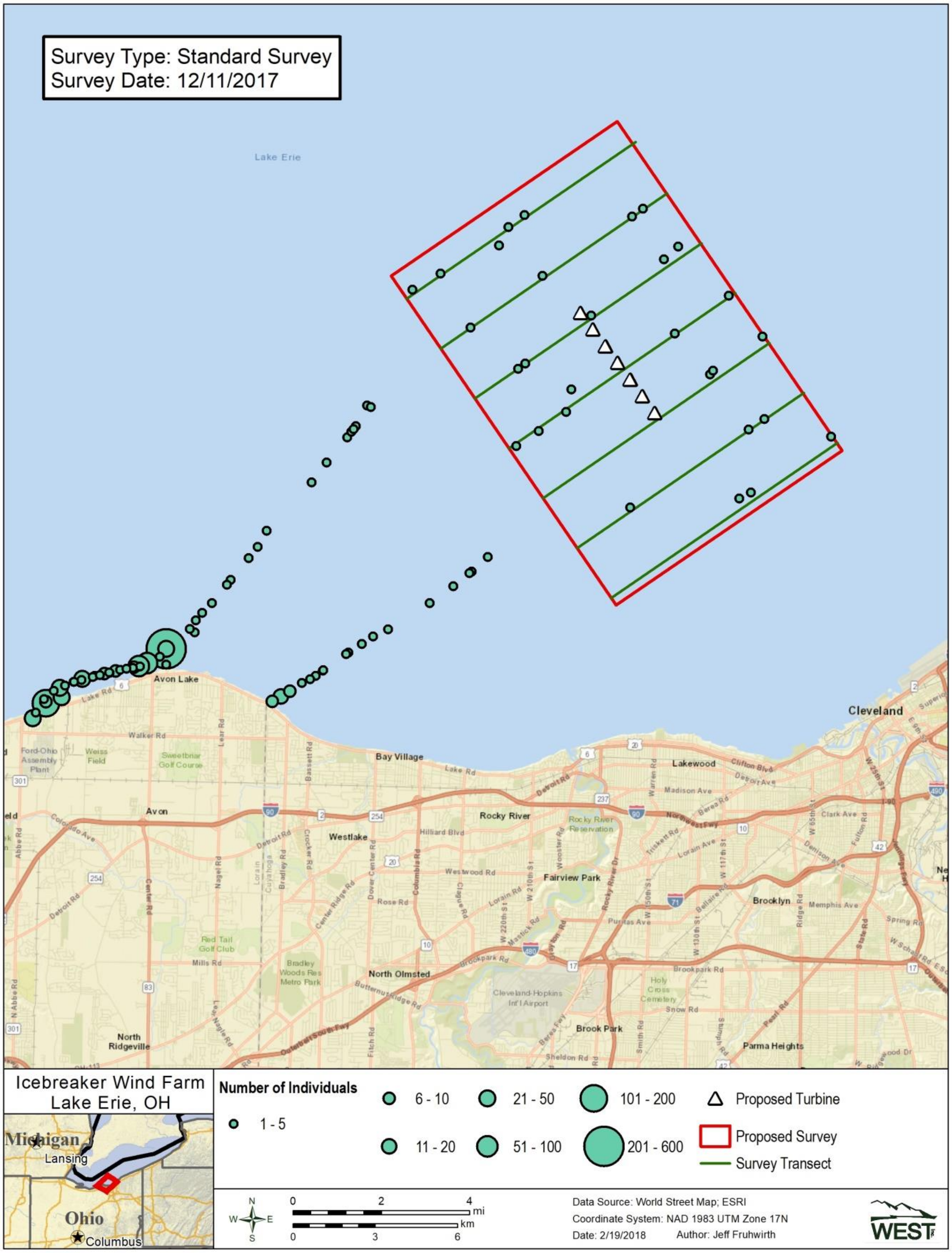

Figure 8. Location of the aerial survey area (red), survey transects (green), and number of birds (green; size of symbol indicates count) observed on December 11, 2017 for Icebreaker Wind. Counts include observations by two of the three observers in plane (front right and rear left) and do not represent the unreconciled final double-observer survey estimates.

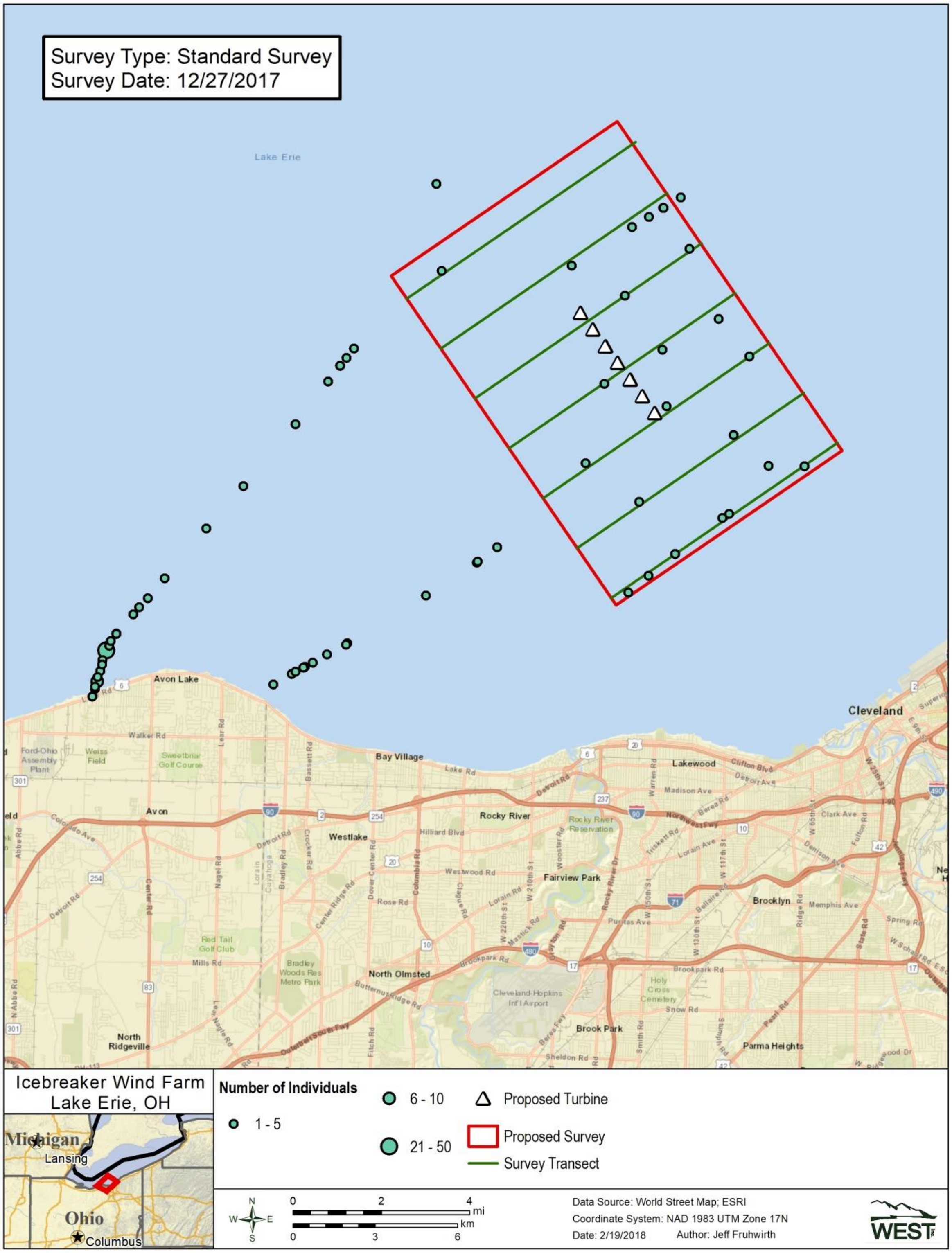

Figure 9. Location of the aerial survey area (red), survey transects (green), and number of birds (green; size of symbol indicates count) observed on December 27, 2017 for Icebreaker Wind. Counts include observations by two of the three observers in plane (front right and rear left) and do not represent the unreconciled final double-observer survey estimates.

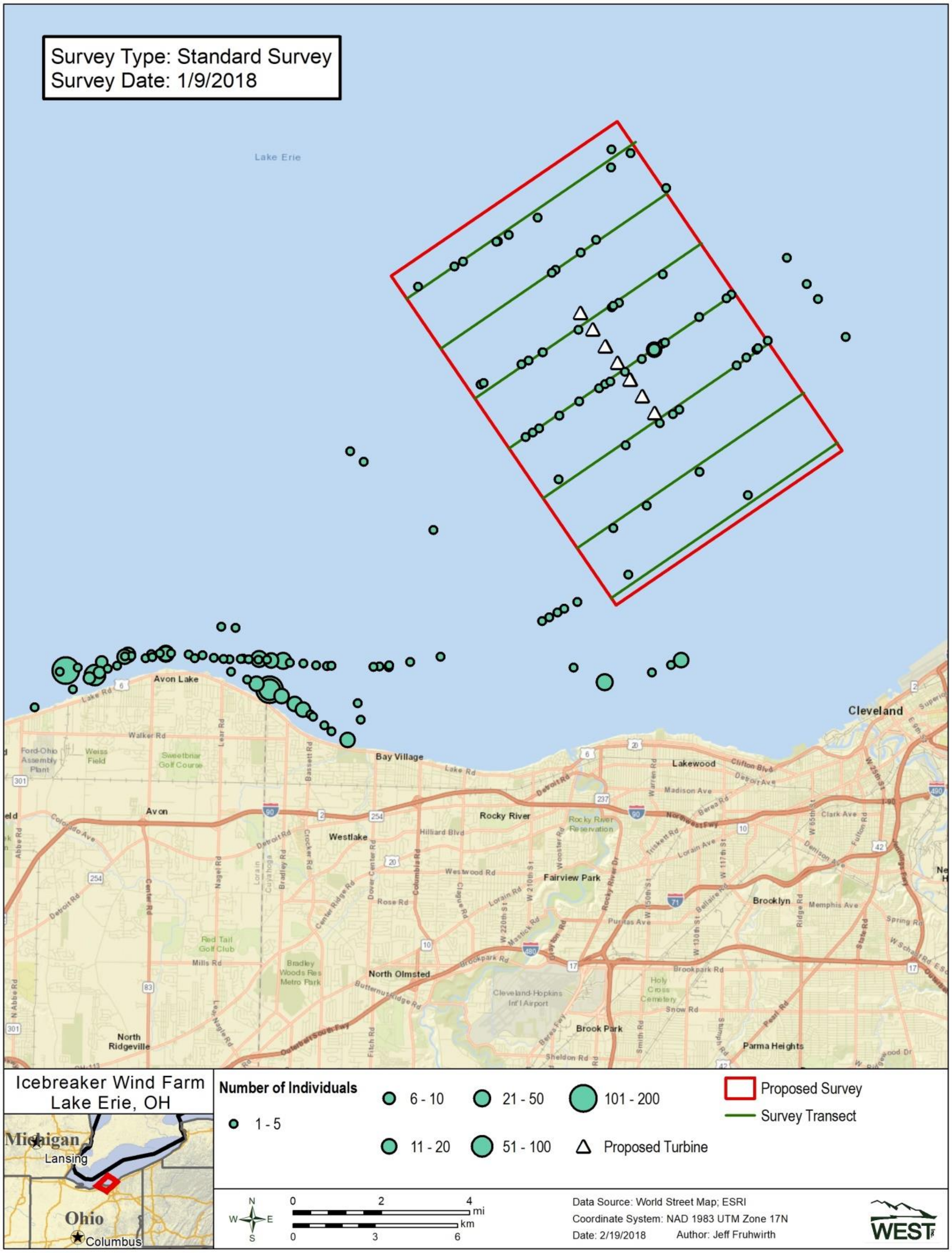

Figure 10. Location of the aerial survey area (red), survey transects (green), and number of birds (green; size of symbol indicates count) observed on January 9, 2018 for Icebreaker Wind. Counts include observations by two of the three observers in plane (front right and rear left) and do not represent the unreconciled final double-observer survey estimates.

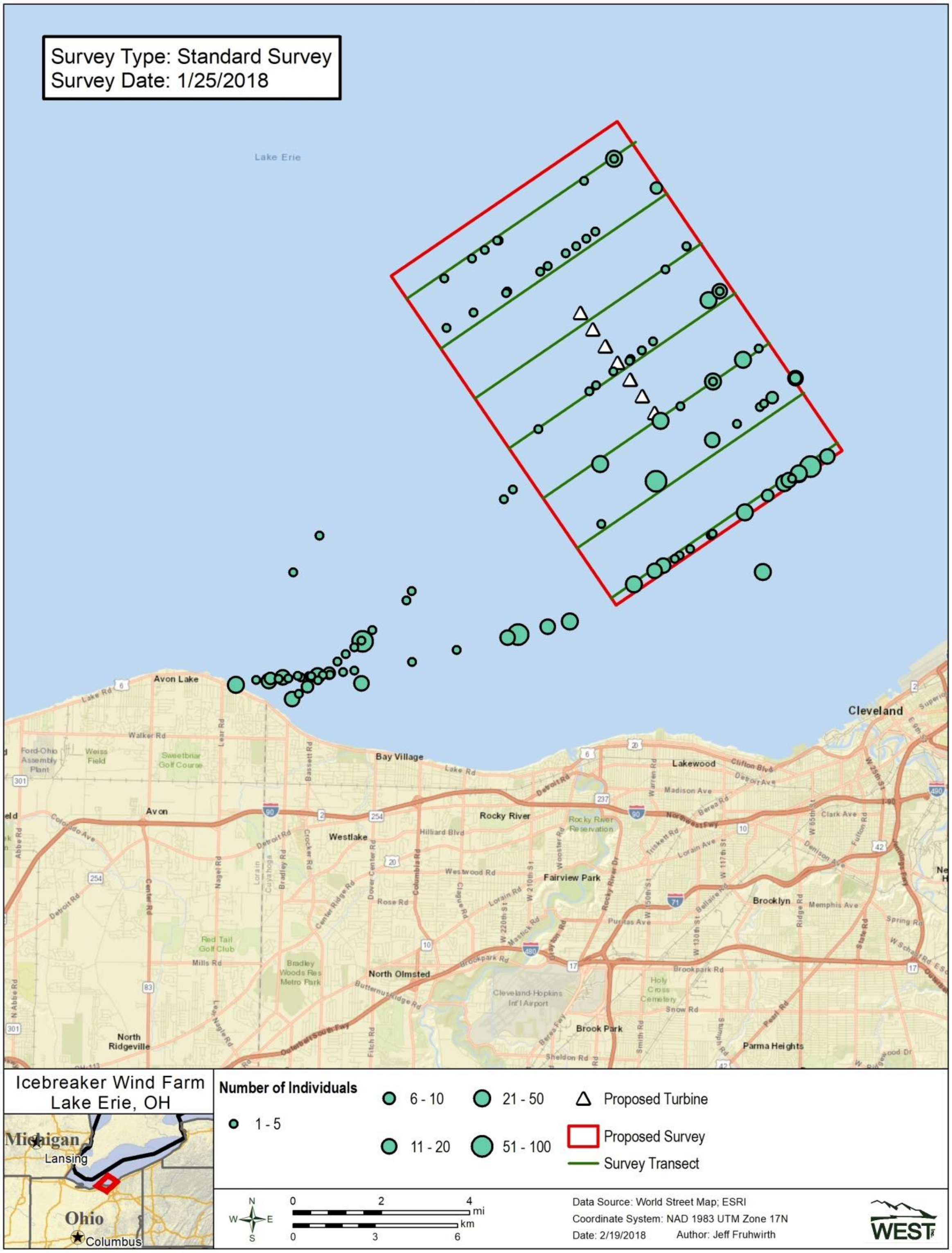

Figure 11. Location of the aerial survey area (red), survey transects (green), and number of birds (green; size of symbol indicates count) observed on January 25, 2018 for Icebreaker Wind. Counts include observations by two of the three observers in plane (front right and rear left) and do not represent the unreconciled final double-observer survey estimates.

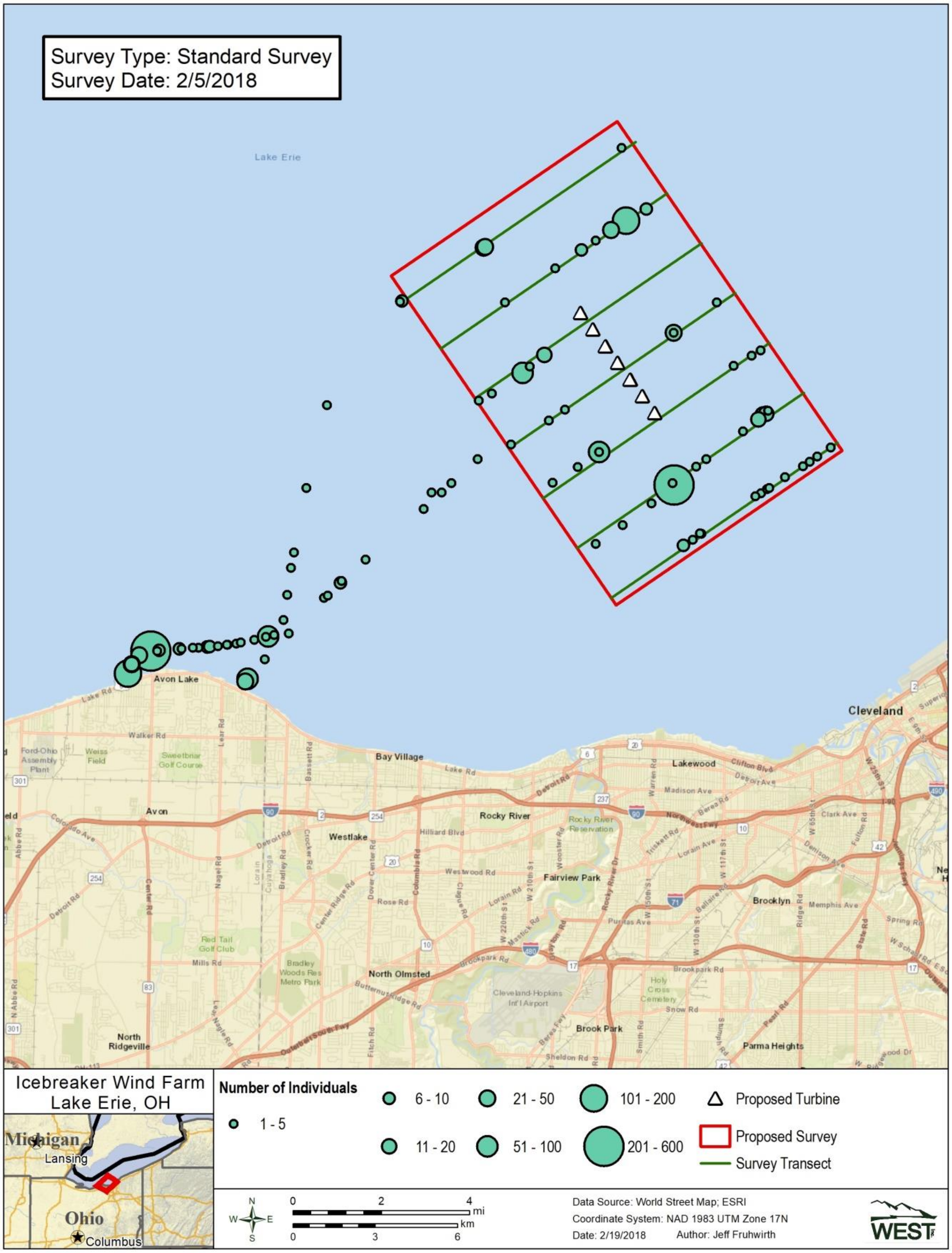

Figure 12. Location of the aerial survey area (red), survey transects (green), and number of birds (green; size of symbol indicates count) observed on February 5, 2018 for Icebreaker Wind. Counts include observations by two of the three observers in plane (front right and rear left) and do not represent the unreconciled final double-observer survey estimates.

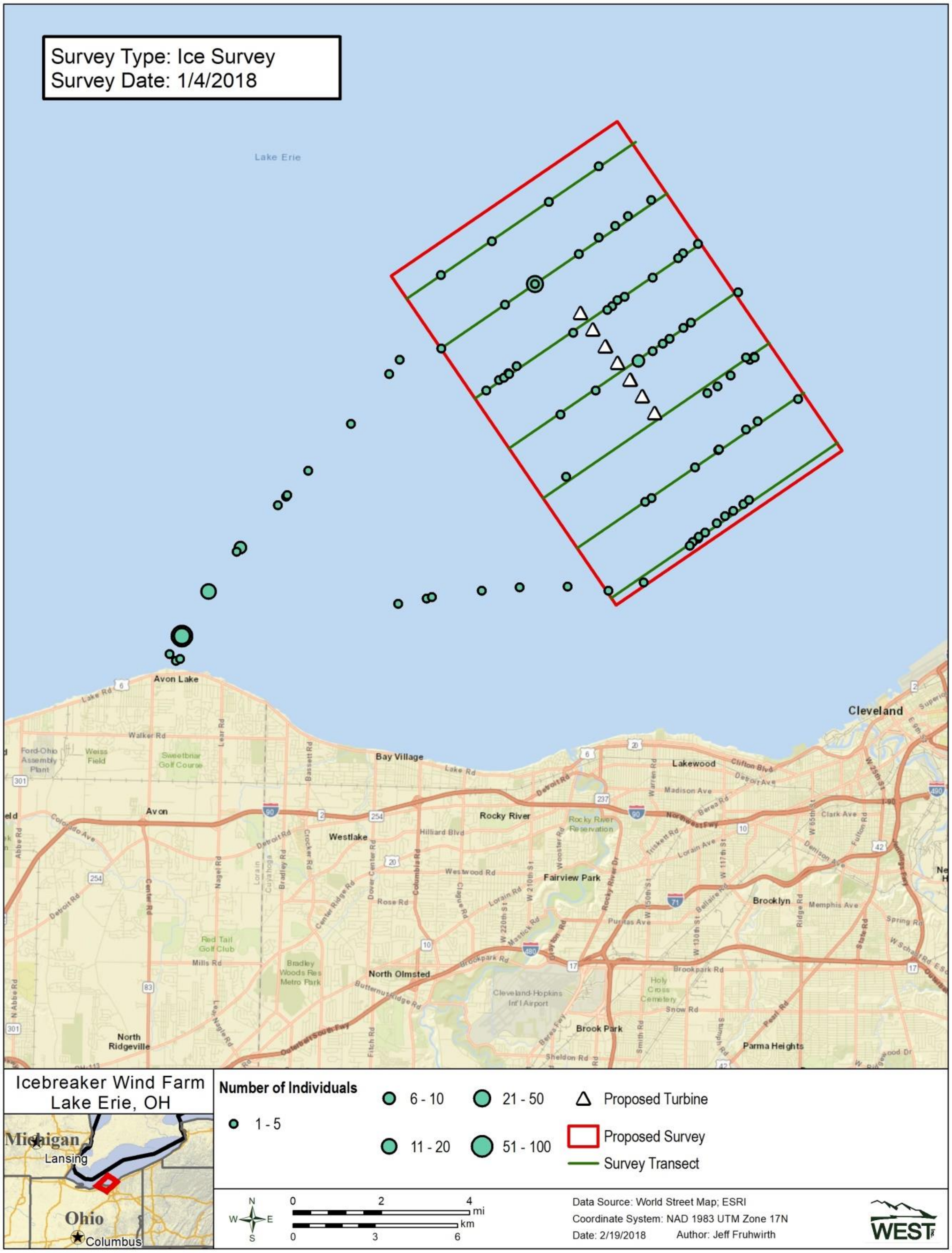

Figure 13. Location of the aerial survey area (red), survey transects (green), and group size of birds (green; size of symbol indicated count) observed during ice concentration survey on Jan 4, 2018 for Icebreaker Wind. Counts include observations by two of the three observers in plane (front right and rear left) and do not represent the unreconciled final double-observer survey estimates.

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Appendix A. Western EcoSystems Technology, Inc. Datasheet and Variable Definitions Used in the Icebreaker Wind Aerial Surveys

Icebreaker – Aerial Survey Transects Datasheets for Waterfowl/Waterbirds Datasheet Instructions

In brief

- Data Sheets should be completed for each transect (9 transects, 1-7 + Wander during every survey.)
- Each of the 3-people flying has the responsibility of completing a set of data sheets (at least 7 sheets).
- After the flight, you will transcribe your voice recording to complete the rest of the datasheet, do a QAQC of your data, QAQC someone else's data, and complete data entry.
- Scan data sheets to Google Drive before submitting datasheets to crew leader.
- Crew Leader will mail already scanned and entered datasheets to Jennifer Stucker by priority mail to WEST's Minneapolis office.

Data sheet variables – for each transect

Field	Explanation	Source
Header Fields		
Survey Type	Choose 1. Regularly Scheduled Survey or special survey to document birds and ice	Crew Leader/Schedule
Transect#	Number/Letter **1 – 7** **W- W**ander for off-transect and ice flight	Call out - Crew Lead – Pilot GPS
Survey Direction	Choose 1.	GPS or Dioptera (center)
Observer	Observer initials	
Seat (in plane)	Choose 1. Front Right, Back Left, Back Right	
Date	MM/DD/YYYY	
Start/End time	24HR - Time of transect start or end	Pilot/Crew lead announces
Cloud Cover	Estimate nearest 10%	Observation
Glare	Your perception for TRANSECT 1-4	Data sheet
Beaufort #	Choose1: 1 - 4	*see* Beaufort Scale Sheet
Wind Direction	Choose 1. N, NE, E, SE, S, SW, W, NW	Burke Lakefront Airport - weather
Wind Speed	Average, min, max(gust) **mph**.	Burke Lakefront Airport - weather
Temperature	Temperature in **F°**	Burke Lakefront Airport - weather
Body Fields		
Time	24H **HH:MM.SS**	Dioptera - picture
Latitude	41.XXXXXX	Dioptera - picture
Longitude	-81.XXXXXX	Dioptera - picture
Ice%	Percentage of ice cover at bird observation	*See* Ice Concentration Sheet
Ice Type	Characteristics/Form of Ice 0-12	*See* Ice Form Sheet
Observer Angle	Perpendicular Observation Angle to bird	Dioptera – picture (right)

Distance Band	Estimated distance to bird (flock) in **m** **X *for non-standard survey altitude*.**	**Rulers** (by -seat/altitude) **Marks** on wing supports
Flock/Grp ID	Sequential numbers to each “flock”	Assign during transcription
Mixed Flock	Yes or No. If group is more than one species &/or sex it is mixed = yes	
Spp/Obs ID	Sequential numbers to each species/sex within the Flock/Group ID	Assign during transcription
Species	Species observed – 4-letter codes @ transcription	*see* Icebreaker List of Expected Species
Sex	Male, Female, Unknown	
Age	Juvenile, Immature, Adult, Unknown	
Behavior 1	First or dominant behavior observed	*see* Behavior Reference
Behavior 2	(optional) a 2nd behavior seen	
Associated With	Feature in/on water (air) that birds are seen with	*See* Associated with Reference
Comments		

WEST

Icebreaker

Seat ☐Front-R ☐Back-L ☐Back-R

Survey Type Standard | Ice **Transect#** ______ **Survey Direction** NE | SW **Observer:** *(Initials)* _________

Date: *(MM/DD/20YY)* ______/______/20___ **Start time** (24hr) ___:___ **End time** (24hr) ___:___ **Cloud Cover:** ____% **Glare**

- ☐ 0 none
- ☐ 1 slight/grey
- ☐ 2 Bright on the observer's side
- ☐ 3 Bright forward of the vessel

Wind Dir: N | NE | E | S | SE | SW | W | NW **Max Visibility:** ______ *km* **Temp:** ____ *°F* **Beaufort#** _____

Average Wind Speed: ______ **Wind Speed Range:** *(min-max)* ______–______ *mph*

Time 24 h HH:MM.SS	Latitude (41.xxxxxx)	Longitude (-81.xxxxxx)	Obser. Angle (xx°)	Dist. Band	Flock/Grp ID	Spp/Obs ID	Mixed Flock	Species	# Individuals	Sex	Age	Behavior 1	(Behavior 2)	Assoc. With	Ice %	Ice Type	Comments
___ ___.__	41.___ ___ ___ ___	-81.___ ___ ___ ___	__ __					__ __ __ __									
___ ___.__	41.___ ___ ___ ___	-81.___ ___ ___ ___	__ __					__ __ __ __									
___ ___.__	41.___ ___ ___ ___	-81.___ ___ ___ ___	__ __					__ __ __ __									
___ ___.__	41.___ ___ ___ ___	-81.___ ___ ___ ___	__ __					__ __ __ __									
___ ___.__	41.___ ___ ___ ___	-81.___ ___ ___ ___	__ __					__ __ __ __									
___ ___.__	41.___ ___ ___ ___	-81.___ ___ ___ ___	__ __					__ __ __ __									
___ ___.__	41.___ ___ ___ ___	-81.___ ___ ___ ___	__ __					__ __ __ __									
___ ___.__	41.___ ___ ___ ___	-81.___ ___ ___ ___	__ __					__ __ __ __									
___ ___.__	41.___ ___ ___ ___	-81.___ ___ ___ ___	__ __					__ __ __ __									
___ ___.__	41.___ ___ ___ ___	-81.___ ___ ___ ___	__ __					__ __ __ __									
___ ___.__	41.___ ___ ___ ___	-81.___ ___ ___ ___	__ __					__ __ __ __									
___ ___.__	41.___ ___ ___ ___	-81.___ ___ ___ ___	__ __					__ __ __ __									
___ ___.__	41.___ ___ ___ ___	-81.___ ___ ___ ___	__ __					__ __ __ __									
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___ ___.__	41.___ ___ ___ ___	-81.___ ___ ___ ___	__ __					__ __ __ __									
___ ___.__	41.___ ___ ___ ___	-81.___ ___ ___ ___	__ __					__ __ __ __									
___ ___.__	41.___ ___ ___ ___	-81.___ ___ ___ ___	__ __					__ __ __ __									
___ ___.__	41.___ ___ ___ ___	-81.___ ___ ___ ___	__ __					__ __ __ __									

from Dioptra App.; Grayed out fields complete during transcription

Transcription ________ Paper QAQC ________ Computer/Paper QAQC ______

1 **Record @ each transect start:**

- Your name
- Date & Time
- Transect #
- Seat in plane

2 **Record @ Each Observation**

Dioptra

Distance Band

Mixed Flock

Species

 # Individuals by spp/sex

Sex

Age

Behavior(s)

Assoc. With

Ice %

Ice Type

Mergansers	common merganser	**Goose**	Canada goose
	hooded merganser		cackling goose
	red-breasted merganser		unidentified goose
	unidentified merganser	**Swan**	trumpeter swan
Grebes	horned grebe		tundra swan
	red-necked grebe		mute swan
	unidentified grebe		unidentified swan
Loons	common loon	**Tern**	common tern
	red-throated loon		Caspian tern
	unidentified loon		black tern
Cormorant	double-crested cormorant		unidentified tern
Coot	American coot	**Jaeger**	long-tailed jaeger
Gull	unidentified gull		pomarine jaeger
	Bonaparte's gull		parasitic jaeger
	glaucous gull		unidentified jaeger
	great black-backed gull	**Heron**	great blue heron
	lesser black-backed gull		great egret
	ring-billed gull		snowy egret
Scoter	white-winged scoter		black-crowned night-heron
	black scoter		green heron
	surf scoter	**Crow**	American crow
	unidentified scoter	**Vulture**	turkey vulture
Diving	lesser scaup	**Eagle**	bald eagle
	greater scaup		unidentified eagle
	unidentified scaup	**Shorebird**	Unid.shorebird
	long-tailed duck		Unid.passerine
	common goldeneye	**Hawk**	red-tailed hawk
	ruddy duck		northern harrier
	bufflehead		unidentified buteo
	ring-necked duck		unidentified accipiter
Dabblers	American black duck		unidentified raptor
	American widgeon	**Pigeon**	rock pigeon
	mallard		unidentified pigeon
	northern pintail		unidentified dove
	redhead	**Unknown**	Unid. bird (small)
	canvasback		Unid. bird (medium)
	unidentified duck		Unid. bird (large)

BEHAVIORS

(FL) Flapping flight

(SW) Sitting on water

(CI) Milling - Circling - Gliding

(FE) Feeding

(SC) Scavenging

(KL) Kleptoparasitizing

(CA) Carrying fish

(DI) Diving (on surface to under water)

(PL) Plunge Diving (Foraging by plunge diving)

(TO) Take-off

(LA) Landing

(RE) Resting/Sleeping

(UA) Under Attack - (predation or kleptoparastism)

(FO)Following - (following a boat)

(IN) Injured or unwell

(OI) Oiled

(DE) Dead

ASSOCIATED WITH

(FI) Fish

(WF) Water front (two water masses - river mouth/bay)

(LI) Litter (plastic and human garbage, debris)

(DE) Debris (non-human - trees/branches)

(NI) Near ice

(OI) On ice

(NP) Near with a Platform (e.g. turbine or crib)

(OP) Sitting on a platform

(NB) Near/on a buoy

(BF) Near a fishing vessel (commercial/recreational)

(BR) Near recreational water craft (motor or sail)

(BS) Near shipping vessel

(SV) Submerged Aquatic Veg

(NO) Near/In oil slick

SEX

Male
Female
Unknown

AGE

Adult
Juvenile
Immature
Unknown

DISTANCE BANDS

A: <60 m
B: 60-100m
C: 100-150m
D: 150- 200m
E: 200- 250m
F: 250- 300m
G: 300- 350m
H: 350- 400m
I: 400-450m
J: 450-500m
K: >500m
X: Non-standard survey altitude

Ice Concentration

Code	Concentration %	Description	
0	< 10%	"open water"	
1	20-30%	"very open drift"	
2	40%	"open drift"	
3	50%	"open drift"	
4	60%	"open drift"	
5	70-80%	"close pack"	
6	90%	"very close pack"	
7	100%	"compact"	

modified from: Gjerdrum, C., D.A. Fifield, and S.I. Wilhelm. 2012. Eastern Canada Seabirds at Sea (ECSAS) standardized protocol for pelagic seabird surveys from moving and stationary platforms. Canadian Wildlife Service Technical Report Series No. 515. Atlantic Region. vi + 37 pp. (http://publications.gc.ca/collections/collection_2012/ec/CW69-5-515-eng.pdf)

Ice Form

Code	Name	Description
0	New	small, thin, newly formed, dinner plate-sized pieces
1	Pancake	rounded floes 30 cm - 3 m across with ridged rims
2	Brash	broken pieces < 2 m across
3	Ice Cake	level piece 2 - 20 m across
4	Small Floe	level piece 20 - 100 m across
5	Medium Floe	level piece 100 -500 m across
6	Big Floe	level, continuous piece 500 m - 2 km across
7	Vast Floe	level, continuous piece 2 - 10 km across
8	Giant Floe	level, continuous piece > 10 km across
9	Strip	a linear accumulation of sea ice < 1 km wide
10	Belt	a linear accumulation of sea ice from 1 km to over 100 km wide
11	Beach Ice or Stamakhas	irregular, sediment-laden blocks that are grounded on tidelands, repeatedly submerged, and floated free by spring tides
12	Fast Ice	ice formed and remaining attached to shore

modified from Gjerdrum, C., D.A. Fifield, and S.I. Wilhelm. 2012. Eastern Canada Seabirds at Sea (ECSAS) standardized protocol for pelagic seabird surveys from moving and stationary platforms. Canadian Wildlife Service Technical Report Series No. 515. Atlantic Region. vi + 37 pp. (http://publications.gc.ca/collections/collection_2012/ec/CW69-5-515-eng.pdf)

Codes for Sea State and Beaufort Wind Force

Wind Speed (knots)	mph (low)	mph (high)	kmh (low)	kmh (low)	Sea state code and description	Beaufort wind force and description
0	0	0	0	0	**0** Calm, mirror-like	**0** calm
01 – 03	1	3	2	6	**0** Ripples with appearance of scales but crests do not foam	**1** light air
04 – 06	5	7	7	11	**1** Small wavelets, short but pronounced; crests do not break	**2** light breeze
07 – 10	8	12	13	19	**2** Large wavelets, crests begin to break; foam of glassy appearance; perhaps scattered white caps	**3** gentle breeze
11 – 16	13	18	20	30	**3** Small waves, becoming longer; fairly frequent white caps	**4 moderate breeze**
17 – 21	20	24	31	39	**4** Moderate waves with more pronounced form; many white caps; chance of some spray	**5** fresh breeze
22 – 27	25	31	41	50	**5** Large waves formed; white foam crests more extensive; probably some spray	**6** strong breeze
28 – 33	32	38	52	61	**6** Sea heaps up; white foam from breaking waves blows in streaks in direction of wind	**7** near gale
34 – 40	39	46	63	74	**6** Moderately high long waves; edge crests break into spindrift; foam blown in well-marked streaks in direction of wind	**8** gale
41 – 47	47	54	76	87	**6** High waves; dense streaks of foam in direction of wind; crests of waves topple and roll over; spray may affect visibility	**9** strong gale
48 – 55	55	63	89	102	**7** Very high waves with long overhanging crests; dense foam streaks blown in direction of wind; surface of sea has a white appearance; tumbling of sea is heavy; visibility affected	**10** storm
56 - 63	64	72	104	117	**8** Exceptionally high waves; sea is completely covered with white patches of foam blown in direction of wind; edges blown into froth; visibility affected	**11** violent storm
64 +	74	>74	119	>119	**9** Air filled with foam and spray; sea completely white with driving spray; visibility seriously affected	**12** hurricane

modified from Gjerdrum, C., D.A. Fifield, and S.I. Wilhelm. 2012. Eastern Canada Seabirds at Sea (ECSAS) standardized protocol for pelagic seabird surveys from moving and stationary platforms. Canadian Wildlife Service Technical Report Series No. 515. Atlantic Region. vi + 37 pp. (http://publications.gc.ca/collections/collection_2012/ec/CW69-5-515-eng.pdf)

Icebreaker Windpower, Inc.
Case No. 16-1871-EL-BGN
Fourth Supplement to Application
March 22, 2018

Attachment 5

Evaluation of Icebreaker Wind Project Vendor Proposals for Radar-Based Monitoring of Flying Animals
December 2017
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Evaluation of Icebreaker Wind project vendor proposals for radar-based monitoring of flying animals

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Prepared for:

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Prepared by:

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December 2017

Table of contents

I. Executive Summary

This report evaluates different radar data collection options proposed by vendors responding to a Lake Erie Energy Development Corporation request for information in relation to a wind energy facility, the Icebreaker Wind project, proposed for western Lake Erie. The evaluation considers five vendor options proposed by three vendors, here referred to as VendorA, VendorB, and VendorC, and is based on 15 different criteria and informed by a variety of radar-related concepts. Among the most important criteria are concern over the ability to gather data on altitude-specific migration traffic rate or density and behavioral response to turbine presence (pre- versus post-construction), and the ability do so with high reliability while avoiding contamination by clutter, primarily from insects and the lake surface. The evaluation was based solely on the ability of these systems to provide useful data toward the goal of understanding the biology of the airspace under review; no consideration was given to vendor cost estimates.

Initial examination of these criteria narrowed the field to two options referred to as VendorA and VendorC (Option2). For reasons expanded upon below, VendorA proposed the approach most likely to succeed among vendor responses and other information provided that forms the basis of this evaluation. This should not be taken to mean VendorA's approach is not without concern, particularly over the ability to track targets in an offshore setting where sea clutter will likely pose a persistent problem that is magnified by a rolling and pitching barge.

Owing to perceived shortcomings of vendor responses, the report concludes by seeking to identify an approach to address the challenge of monitoring vertebrate behavior in an offshore setting that would increase the likelihood of gathering useful data. For this reason, I suggest numerous modifications to VendorA's approach. I also suggest a couple alternative radar configurations that represent advances or variations on some of the vendor design options that may increase the likelihood of gathering useful data in an offshore setting.

II. Introduction

This opinion is offered to inform on how pre- and post-construction biological radar data is gathered in relation to the offshore Icebreaker Wind project proposed for an area within Lake Erie approximately 14 km northwest of Cleveland, Ohio. The report evaluates five vendor options to the Lake Erie Energy Development Corporation (LEEDCo) Request for Information (RFI) from three separate vendors referred to here as VendorA, VendorB, and VendorC. The number of options is necessarily constrained by the limited number of vendor responses, and one wonders what radar configurations might be available from other vendors and whether they might represent more suitable solutions. Although the vendor proposals considered here are specific to this case, certain aspects of the evaluation may have application in other settings.

Among other things, the best radar solutions will minimize ambiguity on the identity of the targets while simultaneously gathering the most accurate data on target altitude and lateral position. The kinds of radar units that come closest to that capability, portable tracking radars (Larkin and Diehl 2012), are rare in biological circles (to my knowledge there are three in the world), because they are costly to acquire and challenging to maintain. Therefore, most studies of this type necessarily make compromises owing to the limits of readily available and affordable technology, and an evaluation of this kind necessarily examines those trade-offs.

The evaluation is narrowly defined. Documents reviewed for this opinion include the LEEDCo RFI, all vendor responses to the RFI, vendor responses to US Fish and Wildlife Service (USFWS) questions, USFWS suggested study characteristics, the WEST, Inc review of RFI responses, and some LEEDCo application figures and exhibits. The report is also informed by discussions with LEEDCo/WEST and biologists within the USFWS. The evaluation was based solely on the ability of these systems to provide quality data toward the goal of understanding the biology of the airspace under review; no consideration was given to vendor cost estimates. Also, this is strictly a technical evaluation of remote sensing equipment (radar) that in no way endorses any specific vendor or takes a position on the proposed wind development itself.

The radar hardware available for these studies consists of repurposed commercial-off-the-shelf (COTS) marine-grade units commonly used for navigation by ships of varying sizes. Although companies deploying these units make at best modest changes to radar hardware (usually the antenna), they often develop sophisticated software processing capabilities to better accommodate the biological mission of these radars. Often the details of post-processing algorithms and the extent to which their performance has been assessed against verified datasets are not known as they are considered trade secrets. As such, I am in a poor position to evaluate certain claims made by vendors about their software capabilities (e.g., target discrimination) except where those claims intersect with the more evident capabilities of their hardware. I am also not evaluating non-radar remote sensing technologies or other forms of data collection that might inform on metrics relevant to this wind facility (e.g., methods for detecting and quantifying animal-rotor impacts in offshore settings).

It is recognized that this report may be received as guidance concerning radar data collection in relation to other wind energy projects. Caution in this regard is advised. The concepts discussed here may not apply elsewhere, since environmental, biological, and geographical circumstances vary from project to project. Also, as with all technologies, advances in hardware and software capabilities are expected that should improve airspace monitoring. With this in mind, I follow my conclusions by offering some alternative approaches for radar data collection that may improve on some of the shortcomings present among vendor proposals. In this way, the report attempts, however modestly, to live beyond its immediate suggestions regarding current vendor capabilities.

III. Basis for Evaluation

The LEEDCo RFI calls for study seasons generally consistent with the timing of passerine migration; in fall from 15 August to 31 October, and in spring from 15 April to 31 May. Knowing the primary biological targets of interest, small migratory songbirds and bats (hereafter “vertebrates” except where otherwise appropriate), is relevant to the evaluation, since the efficacy of proposed radar design and operational characteristics varies depending on the animals under consideration. As for larger birds, aerial surveys will map diurnal waterbird distributions. However, waterbirds may be diurnal or nocturnal migrants and subject to the same vulnerabilities as the smaller vertebrates that are the focus of this study. The study design should consider expanding current field seasons to include dates associated with migrating waterbirds. Viable radar operation, data collection, and reporting as described by vendors are evaluated based on the following criteria. These are coded respectively by topic (O#, D#, R#) for reference later in the report.

a. Operation

O1. Operation overseen by trained or experienced technicians

O2. Data collection monitored by on-site personnel or remotely monitored to ensure continuous operation with minimal interruption during study periods

O3. Hardware suitably armored against harsh environment conditions

O4. Radar setting sufficient to allow threshold levels (≥80%, as specified in the RFI) of reliable data collection with minimal impact from sea clutter and other sources of motion-based noise

b. Data collection

D1. Automated and continuous operation during the study period with data collection occurring during ≥80% of the study period where precipitation does not obscure data (in two-radar systems, this threshold applies to both radars individually since they gather complementary data). Data collection occurs throughout the diel without bias, or with bias in favor of periods when vertebrate movement is at a low ebb.

D2. Radars capable of gathering data on sufficient numbers of vertebrates to produce a statistically reliable estimate of key behaviors with hourly or better temporal resolution

D3. Methods of target recognition minimize the presence of insects while maximizing the inclusion of vertebrates in resulting datasets

D4. Data gathered on target direction, ground speed, and altitude; not necessarily on the same individual

D5. Noise mitigation sufficient to cope with a highly dynamic clutter environment that includes aircraft, sea clutter, and other non-target sources of radar echo

D6. Horizontal and vertical range capabilities of radars sufficient to capture vertebrate movements over an area representative of the scale of the proposed development, especially with respect to the rotor swept area

D7. Radar observations supported by collection of on-site weather information that includes data on wind speed and direction, temperature, and air pressure with high temporal resolution

D8. Use of the same system, approach, and setting for both pre- and post-construction studies to help ensure data comparability

c. Reporting

R1. Altitude-specific traffic rate and/or density and ability to detect evidence of avoidance/attraction behavior in post-construction studies

R2. Methods of quantification account for sources of variation (i.e., detection probability which is a function of sample volume, gain, radar cross-section (RCS), wavelength) which could introduce bias in traffic rate or density estimates, coverage, or other metrics

R3. Study reports provide a clear presentation of results and fully describe methodological approaches

IV. Supporting Concepts

The Basis for Evaluation (III) considers a range of technical issues associated with radar-based data collection on the detection and behavior of flying animals. Below I briefly review some of the topics taken into account in considering vendor proposals. Because many trade-offs exist among the various topics, I cross-reference between topics where appropriate.

a. Antennas

Two different types of antennas are proposed among the vendor responses to the RFI. Open-array antennas, also referred to as a T-bar antennas, are usually COTS antennas that produce a non-radially symmetric fan beam pattern. Operating in the horizontal plane, open-array antennas produce a 'narrow' yet 'tall' beam pattern that generally produces moderate gain. By contrast, parabolic antennas produce a usually narrow radially symmetric beam pattern, sometimes referred to as a pencil beam.

There are trade-offs to these antennas for biological applications. Open-array antennas are generally capable of covering much larger airspaces in a single sweep and require no or little hardware modification. This may leave them more susceptible to gathering data on >1 target within a single sample volume, which can complicate target identity and tracking though this is usually a minor concern. Use of parabolic antennas in biological portable radar work has a long history (e.g., Bruderer and Steidinger 1972). Relatively few radar operations outside academia deploy radars refit to accept parabolic antennas, presumably owing primarily to differences in the nature of their use. They generally sweep out smaller airspaces which may be a disadvantage in circumstances where rapid comprehensive coverage is considered necessary (e.g., airport monitoring for large birds). Parabolic antennas produce a relatively discrete beam pattern and concentrate radio energy in ways that often produce considerable gain. Gain varies with the diameter of the antenna, radar wavelength (IV.h), and RCS of the target (IV.g), and higher gain enables radar sampling at longer ranges than open-array antennas, all else being equal. They also possess much greater ability to locate flying animals in 3-dimensional space, a capability open-array antennas cannot reliably claim.

Depending on the nature of their deployment, antenna types differ in their susceptibility to sea clutter, but all are susceptible (IV.c). COTS open-array antennas operating in the horizontal plane are highly susceptible to sea clutter. Clutter persists even when these antennas are angled in an attempt to elevate the base of the radar beam above the sea surface. The same antennas rotating in the vertical plane are susceptible to clutter when sweeping through the horizon and from ~90° side lobes. Parabolic antennas operating at low elevation are also highly susceptible to sea clutter owing to the presence and impact of side lobes that may themselves have appreciable gain (e.g., Skolnik 1980, pg. 224). The discrete beam pattern of parabolic antennas allows them to be elevated above the horizon so as to potentially avoid some of the impacts from sea clutter. In this way (and not necessarily in relation to target 'tracking') either an open-array antenna rotating in the vertical plane or a parabolic antenna considerably elevated above the horizon may be less susceptible to sea clutter and the movement of a floating platform (IV.e) than an open-array antenna operating in the horizontal plane.

b. Aspect

All radar operations will be influenced by aspect, or body orientation with respect to the radar whereby flying animals are more readily detected side-on than head- or tail-on. The extent that aspect impacts quantification by radar varies depending on a variety of factors, not least the manner of data collection and the degree that movements of flying animals exhibit shared orientation. Data on the heights of flying animals gathered by open-array antennas rotating in the vertical plane may be susceptible to variation in body orientation in ways that may impact quantification. When the vertical plane of rotation is parallel to the general direction of movement, flying animals produce long track lengths. However, detection probability decreases on the horizons, since animals detected head- or tail-on produce a smaller RCS. The effect may be particularly acute at S-band if animals detected head- or tail-on become weak Rayleigh scatterers (e.g., Drake and Reynolds 2012, pg. 52). Alternatively, if the plane of rotation is perpendicular to the general direction of animal movement, the radar detects animals side-on throughout its rotation, and the detection probability should be uniform. Heights determined using elevated parabolic antennas may be less susceptible to variation in aspect, because part of the horizontal rotation is always perpendicular to the movement. (This is also true of open-array antennas rotating in the horizontal plane, sans information on height.) Also, animals moving toward or away from a radar are detected obliquely by an elevated beam rather than directly head- or tail-on which should produce higher RCS, all else being equal.

c. Clutter

In broadest terms, clutter refers to unwanted radar scatter. Sources of clutter for these purposes include insects, instances where multiple weather (usually precipitation), the sea surface (sea clutter), boats, planes, and turbines in post-construction studies. All vendors consider clutter and offer varying solutions in their reported ability to cope with it. However, sea clutter is a pernicious problem that even a fixed platform is unlikely to resolve. Open-array antennas operating horizontally from a fixed platform over open water experience severe clutter and the problem persists with open-array antennas rotating in the vertical plane and parabolic antennas (S. Gauthreaux, pers. comm.).

d. Data impacts

Missing data can occur for a variety of not necessarily independent reasons including limits to radar equipment, loss of power, malfunction of data gathering equipment, unfavorable data gathering conditions (IV.c, IV.e), and human error. The impact may be local; for example, most magnetron-based radars used in biological research experience a brief period of time during transmission when the radar is essentially deaf to its own echoes. This period is called a main bang or simply bang, and as a result, targets very near the radar are generally undetectable. Data impacts also occur at a seasonal scale; for example, a standard for how much data is necessary to adequately represent seasonal vertebrate movement (≥80%) has been proposed for this project. There is concern that excessive loss of data may render observations related to migratory passage moot if they fail to capture the occasional yet unpredictable large movements that almost inevitably occur with songbird migration. While considerable effort should be made to ensure a robust operation is in place, data loss or drop outs will likely occur.

Comparing data collection during calm and rough sea days would allow assessment of whether data was compromised during poor weather conditions in an effort to inform future sampling efforts. The primary cause of compromised data would likely be the inability to acquire or maintain tracks through successive sweeps of the radar either owing to sea clutter or barge movement. Clutter from the sea and other sources can cause tracking algorithms to produce false tracks that are spurious. Motion of the barge may also cause a target to be dropped and reacquired which may be interpreted as a separate track depending on the sophistication of the tracking software. If present, both of these factors can artificially inflate estimates of traffic rate. The magnitude of these errors would be expected to vary with conditions and the manner in which data were collected.

To help determine the meaningfulness of such loss, it may be useful to supplement offshore radar data collection with analysis of contemporaneous data from the fortuitously close Cleveland, OH NEXRAD station (KCLE). Advances in NEXRAD quantification enable estimates of vertebrate density (Chilson et al. 2012) that could be used to verify migration traffic rate (MTR) or density estimates determined by portable radar. This form of corroboration would help ensure any data drops did not correspond with particularly large migratory movements during the study, recognizing that this approach is imperfect given the complexity of movements that may occur in the vicinity of coasts (Archibald et al. 2017, Diehl et al. 2003) and that KCLE has an imperfect view of low altitude movements (Nations and Gordon 2017).

e. Platforms

Two platforms have been considered for this work, although all vendors propose to deploy radars on a floating barge anchored at four points to minimize platform movement. An alternative is to construct a fixed monitoring platform embedded in the lake bed. The latter has the distinct advantage of being stable in all lake conditions, whereas a floating platform will roll, pitch, and yaw in response to wave action. Differences of opinion exist regarding the practicality of establishing a fixed platform, a concern that is beyond the scope of this evaluation, although I again note here that a fixed platform is unlikely to address the problem of sea clutter (IV.c). Floating platforms have been used to gather radar data on biological targets for many years in support of both basic and applied biology (e.g., Larkin et al. 1979, Alerstam et al. 2001, Desholm et al. 2004).

As an alternative to construction of a fixed platform, vendors could mount just the radar to a stabilizing gimbal fastened to the barge. Vendors do not advocate such an approach, presumably owing to cost and complexity, and an evaluation of the costs and benefits of adopting this approach is beyond the scope of this evaluation. Motion of the platform will necessarily introduce errors into all movement-based radar metrics. Although these would tend to average out assuming no systematic bias in barge movement, certain observations of individual movements may be more sensitive to barge motion (e.g., the movements of animals in the vicinity of turbines in a post-construction study). The effects of barge movement on radar-determined animal movement data can in principle be corrected by sampling the three axes of a vessel-mounted gimbal or inertial measurement unit and use those data to adjust target position observations (Larkin et al. 1979).

f. Post-construction

Response by birds and bats to the presence of wind turbines may be studied as a comparison between pre- and post-construction behavior, which is facilitated by adopting the same study design before and after construction. Detection of behavior consistent with avoidance or attraction during post-construction then becomes a consideration in evaluating vendor options.

Birds and bats may respond differently to turbines with some indication that birds may largely avoid turbines while bats may be attracted (Cryan et al. 2014); however, this is an ongoing area of research. Turbine avoidance will usually take two general forms: lateral change in direction or change in height. Horizontal avoidance of turbines by flying animals moving laterally may be detectable by most radar systems using antennas rotating in the horizontal plane (e.g., Desholm and Kahlert 2005) unless that avoidance behavior occurs within the clutter field of the turbine or is disrupted by sea clutter. Avoidance by increasing height poses different and in some ways greater detection challenges for radar. Detecting change in height may manifest primarily in two different ways that depend largely on radar siting and/or antenna positioning with respect to a turbine. An open-array antenna rotating in the vertical plane can capture these movements for a given turbine for animals approaching from a given direction if the radar is properly sited. A parabolic antenna rotating in the horizontal plane but properly elevated may also capture behavior consistent with these movements, perhaps independent of animals approaching direction and in such a way as to avoid turbine clutter (IV.c).

Attraction to turbines by flying animals might be expected to produce much the opposite behavioral patterns on radar, although the nature of attraction necessarily moves the animal closer to a primary source of clutter. Clutter produced by turbines is dynamic and often obscures nearby animal movement, so the range from the turbine at which flying animals respond matters and may vary with turbine visibility which in turn likely varies with ambient light conditions (e.g., day versus night, moonlight, anthropogenic light).

g. Target identity

Knowing with reasonable certainty the identity of radar targets is arguably one of the greatest challenges facing radar biology and one of the most important to get right. Even "identity" is subject to some interpretation as it could refer to any of a number of taxonomic levels. Depending on certain radar metrics and our knowledge of animal morphology, behavior, and natural history, radar targets may be identified down to species (e.g., O'Neal et al. 2010) or at best to phylum (e.g., most other radar studies that attempt target discrimination). Considerable room for uncertainty in identity is created by the combined effects of the diversity of flying animals, their overlapping biology, and the wide range of hardware, software, and operational properties of radars. All else being equal, as one moves toward more coarse taxonomic classifications, flying animals tend to diverge in their biology and natural history in ways that make them more distinguishable on radar (i.e., it is considerably easier to distinguish vertebrates from insects than it is warblers from thrushes).

Biologists have long sought the ability to distinguishing different target types by their radar parameters. Radars are capable of generating a number of metrics on flying animals including speed, direction, height, track, wingbeat rate, wing flap behavior, RCS, orientation, and in many cases change and rates of change for these metrics.

Given the hazards posed by wind turbines to bats in particular, there is considerable interest in being able to reliably distinguish birds from bats via radar so as to apportion the hazard. Despite their taxonomic differences, convergent evolution together with certain allometric constraints have contributed to there being considerable overlap in the size and behavior of many bird and bat species. Erratic flight often attributed to bats is not necessarily a reliable distinguishing characteristic of bats; bats may well engage in straight-line flight similar to most nocturnal migratory birds, and the flight paths of some bird species can be quite erratic (e.g., common nighthawks, swallows). To date, no published radar methods reliably distinguish bird from bat echoes based on radar properties alone. This is not to be confused with highly reliable radar data on bats captured under idiosyncratic circumstances where knowledge of natural history, not the radar metrics themselves, offers high confidence in the identity of the biological target (e.g., Mirkovic et al. 2016, Horn and Kunz 2008). Fittingly, no vendor specifically identifies the ability to distinguish small birds from bats in radar data, but two give some consideration to distinguishing vertebrates from insects.

Currently, the three primary approaches for attempting to distinguish vertebrates from insects are based on 1) RCS, 2) airspeed, and 3) wingbeat rate. All have advantages and disadvantage. Two of these approaches, RCS and wingbeat rate, are considered among vendor responses. Currently, use of wingbeat rate is considered the most accurate approach to distinguishing vertebrates from insects.

Airspeed

A flying animal's airspeed is its rate of movement with respect to the surrounding air (Gauthreaux and Belser 1998), and vertebrates may be broadly distinguishable from insects by their airspeeds. Vertebrates often exhibit powered flight that produces high airspeeds relative to their insect counterparts which are generally weaker fliers that often essentially drift with the wind and therefore exhibit relatively low airspeeds. Radars measure the ground speed of flying animals, the rate of movement with respect to the ground. Ground speed results from the combined influence of an animal's airspeed and wind speed. A flying animal with an airspeed of 5 $m \cdot s^{-1}$ flying in the same direction as a 5 $m \cdot s^{-1}$ wind will have a 10 $m \cdot s^{-1}$ ground speed. Under windless conditions, ground speed equals airspeed. If local altitude specific wind conditions are known, the wind vector can be subtracted from an animal's ground speed to yield the animal's airspeed. Airspeeds below, say, 7 $m \cdot s^{-1}$ (the thresholds have varied over the years), are more likely insects (Larkin 1991).

Although it does have advantages, the airspeed approach to discrimination is relatively crude. Vertebrate and insect airspeed distributions overlap considerably (Larkin 1991). Vertebrate airspeeds may easily fall below specified thresholds, while not all insects are weak fliers. A more conservative approach would set two thresholds between which targets would be categorized as 'ambiguous'; although the arbitrariness of the thresholds matters, there is the risk of consistently and unwittingly excluding species that classify as ambiguous, and far too many meaningful targets may be excluded from further analysis. There are also challenges to knowing wind conditions at an animal's altitude, especially at sea where only surface data will be collected. Often, surface wind measures are correlated with winds aloft, especially over the low altitudes that concern wind energy. However, wind shear over short altitudinal distances occurs and will introduce error into airspeed estimates. The usual solution to this is to routinely launch radiosondes, an option not available to radar operations considered here, at least not at the radar site. Advantages of this method include that it can be applied using data from widely used track-while-scan radars operating in the horizontal plane; it is independent of operating frequency or antenna type, and it does not rely on sophisticated software for computation.

Radar cross-section

Wavelength matters (IV.h). Arguably one of the great advantages of S-band radar with respect to target discrimination is the theoretically reduced impact of insect clutter (IV.c) in the data. At S-band, most insects are likely to be so-called Rayleigh scatterers, meaning they produce reliably weak radar echoes relative to their larger vertebrate counterparts. This has implications for the resulting biological data. First, the presence of insect clutter should be considerably reduced, especially at range where power density within the radar beam is sufficiently weak that insect echoes are below the noise threshold of the radar (i.e., undetectable). Also, when weak insect echoes do occur, it may be possible to design either real-time or post-processing algorithms that can reliably remove much of this clutter by threshold filtering on RCS. However, owing to their longer wavelengths, S-band radars likely also inadvertently remove small vertebrates in ways that cannot be easily resolved. X-band radars tend to have the opposite problem.

One of the challenges of using X-band radar to study vertebrates is its susceptibility to biological clutter from insects (IV.h). At X-band, small- to mid-sized vertebrates and large insects return radar echoes that are non-linearly related to the actual size of the animal (Vaughan 1985). For these so-called Mie or resonance scatterers, an animal's actual size cannot be readily inferred from its RCS; some insects can actually produce larger echoes than vertebrates. For this reason, insects cannot reliably be removed from radar data by relatively simple RCS thresholding at X-band (Fig. 1), and vendor approaches that use RCS thresholding risk including some large

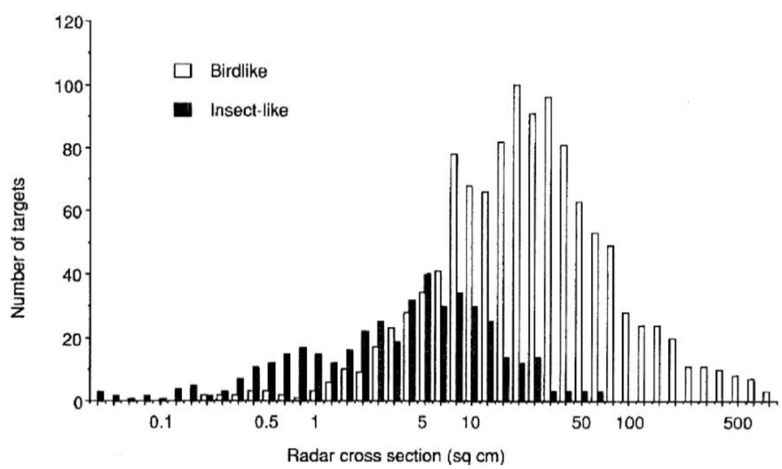

Fig. 2. Estimated radar cross section, σ, of all birdlikc ($n=1159$) (*unshaded bars*) and insectlike ($n=438$) (*solid bars*) targets for which wing beat data were available

Figure 1. X-band radar cross-sections of bird-like and insect-like targets determined by wing beat rate. Consistent with Drake and Reynolds (2012, pg127) there is considerable overlap between targets types for cross-sections measuring 1-10 cm^2 (from Larkin 1991).

insects and rejecting some small vertebrates. This may be a particular concern for the wind energy industry (which presumably is not interested in deterrence or mitigation associated with insects) if, for example, on a given night insects happen to fly at lower altitudes than vertebrates. As with airspeed, a more conservative approach would set two RCS thresholds between which targets would be categorized as 'ambiguous'. Here again the arbitrariness of the thresholds matters, as there is the risk of consistently and unwittingly excluding species that classify as ambiguous, and far too many meaningful targets may be excluded from further analysis. A more accurate approach might require targets to satisfy both RCS and airspeed thresholds to be classified as vertebrates.

Wingbeat rate

Wingbeat rate is considered the most reliable method of distinguishing vertebrates from insects (Schmaljohann et al. 2008). Both wingbeat rate and airspeed-based approaches are also less aspect (IV.b) dependent than RCS-based discrimination. Like RCS, wingbeat rate measurement occurs entirely within the radar domain, no external data sources are required as with airspeed-based discrimination. Insects tend to beat their wings at much higher rates than vertebrates (Drake and Reynolds 2012) which allows for less ambiguous threshold-based discrimination than with other methods. Moreover, the wingbeat patterns themselves aid in discrimination; for example, flap-coast wing beating is characteristic of many bird species.

Measuring wing beat rate requires software and hardware modifications and data sampling procedures that, while relatively well understood, are not common. Multiple vendors already possess some of the necessary software infrastructure (e.g., high-speed AD sampling of radar 'video' signal) upon which to build this capability. The radar beam must be positioned to dwell on the flying animal for a duration long enough to estimate wingbeat rate, generally a half second or longer. This is not possible with the usual antenna rotation scheme found in COTS radars and employed by all vendors. VendorB is able to discriminate using wingbeat rate by rotating a parabolic antenna about a vertical axis thereby sufficiently increasing dwell time on the target. Other applications of this method would require stationary beam sampling strategies (unfamiliar to most users) to obtain wingbeat records. This requires hardware modifications to control antenna position in both elevation and azimuth (VII.a).

h. Wavelength

Vendor responses to the RFI included a total of five radar deployment options, four of those options propose use of X-band (~3-cm wavelength) radars, and one an S-band (~10-cm wavelength) radar. The different bands have numerous advantages and disadvantages, perhaps most relevant among them for these purposes concerns target discrimination in relation to RCS (IV.g).

V. Vendor Proposals

All vendors propose to use an anchored barge as a platform to conduct radar operations (IV.e). Each vendor response is evaluated in part in relation to the ability of their proposed operation to accommodate platform movement owing to sea state. In all cases, it appears vendors propose to work remotely through LEEDCo or some other representative rather than maintain experienced staff on site (III.a.O1). Although the latter is the more desirable approach, remote operation can be effective provided systems are monitored for their operational state in real time, and those acting on vendors' behalf are sufficiently empowered to address issues as they arise.

The effect of sea clutter and platform stability on data collection remains a lingering concern for all vendors in relation to achieving meaningful data collection (III.b.D1), although there is ample precedent for radar-based scientific data collection on floating platforms at sea (IV.e). It is this uncertainty that results in a 'fair' or 'poor' rating for criteria III.a.O4 and III.b.D5 in Table 1.

Three vendor options remove insect targets by threshold sampling on RCS at X-band with seemingly little regard to the considerable variation in RCS across target types (in the case of VendorA, as evidenced by their own citations in the caption of their Figure 1). Specifically, the detection probabilities for each size class of target may vary considerably depending on aspect (IV.b) and for many, the impact of Mie scattering (IV.g) which can be pronounced for vertebrate- and insect-sized targets at X-band. Threshold filtering based on RCS will naturally vary depending on where the threshold is set which in turn will determine how many insects are retained as vertebrates, or how many vertebrates are rejected as insects. Very small insects are likely Reyleigh scatterers at X-band and can reliably be rejected by this method. Only VendorB (Option2) uses wingbeat rate analysis for target discrimination.

Rather than be discursive concerning the various advantages and disadvantages of the vendor responses across all bases for evaluation (III), I attempt to rank the performance of each vendor response for each evaluation criterion in terms of good, fair, and poor in Table 1. The narrative below is reserved for highlights and specific points not evident from the table.

Table 1. Comparison of vendor responses with respect to the Basis for Evaluation criteria (III), assessed as good, fair, or poor.

	VendorA	VendorB (Option1)	VendorB (Option2)	VendorC (Option1)	VendorC (Option2)
Operation					
O1	FAIR	FAIR	FAIR	FAIR	FAIR
O2	GOOD	POOR	GOOD	GOOD	GOOD
O3	GOOD	GOOD	GOOD	GOOD	GOOD
O4	POOR	POOR	FAIR	POOR	POOR
Data					
D1	FAIR	FAIR	GOOD	FAIR	FAIR
D2	GOOD	GOOD	FAIR	GOOD	GOOD
D3	FAIR	POOR	GOOD	POOR	POOR
D4	GOOD	GOOD	FAIR	GOOD	GOOD
D5	POOR	POOR	FAIR	POOR	POOR
D6	GOOD	GOOD	POOR	GOOD	GOOD
D7	GOOD	FAIR	POOR	GOOD	GOOD
D8	GOOD	GOOD	GOOD	GOOD	GOOD
Reporting					
R1	GOOD	GOOD	POOR	GOOD	GOOD
R2	GOOD	GOOD	GOOD	FAIR	GOOD
R3	GOOD	GOOD	GOOD	GOOD	GOOD

a. VendorA

VendorA proposes to measure animal movements using volume scans, essentially stacking data from different elevational sweeps of a parabolic antenna, similar to the manner many weather radars operate. This method is effective for this purpose, although its data refresh rate at a given altitude (and depending on how they post-process data) would be less frequent than that of a rotating open-array antenna.

These differences in temporal resolution should matter little, however, in producing adequately updated information on animal movements (III.b.D4).

Vertical (90° from horizon) scanning directly over the radar would measure animal location in altitude with approximately the same precision as an open-array antenna rotating in the vertical plane. VendorA mentions limitations to this approach, but they do not include any concern over the impact of the main bang (IV.d). Depending on the type of radar, orientation of the antenna, and data processing methods, the range of this deafness may well include the rotor swept area, a possibility that is most acute when the antenna is pointed vertically but may also be a concern at lower elevation angles (V.b).

It is unclear how is the radar is 'tuned' at the start of the season and what sources of error or changes in the environment (other than clutter) require it to self-adjust. It is also unclear what the differences are between adjusted and unadjusted counts, though from context this likely refers to the application or not of detection probability correction. 'Many tools' are claimed for data validation, but it is unclear what is meant by validation, what are the tools, and what metrics require validating.

VendorA's response to the RFI was the most thorough of all the vendors and generally addresses the relevant issues (although I was surprised by the large number of minor grammatical errors). VendorA has experience with radar-based monitoring in relation to wind energy but not in offshore settings.

<u>Advantages</u>

- VendorA is correct in its general assessment of the advantages of a pencil-beam produced by a parabolic antenna over its open-array counterparts, especially in relation to their ability to provide a 3-dimensional position of flying animals (IV.a). This negates the need to deploy a two-radar system, simplifying the overall operation which in turn decreases the likelihood of technical difficulties during operation. However, the single radar design, while attractive from the standpoint of simplicity, also removes any redundancy. Failure of VendorA to track targets owing to barge motion results in complete loss of data, an less likely outcome for two-radar systems employing complementary sampling. Pencil beams are not without error in estimating position, and I would be interested in knowing how VendorA estimates that error which they seem to refer to as covariance, especially in the vertical dimension where even a narrow 4° beam is 35 m wide at 500 m range. Regardless, the practical effects of this uncertainty would be minor and average out across many tracked targets.

- A parabolic antenna and its associated beam properties may be more robust to the effects of sea clutter introduced by roll and pitch of the barge relative to a horizontally rotating open-array antenna. In no way should this suggest parabolic antennas are without concern in this regard (see below).
- VendorA has far more thoroughly studied the Icebreaker Wind project environment and crafted a more detailed and informed response than the other vendors.

<u>Disadvantages</u>

- I wonder about the ability of a 4° beam to maintain target tracking in the presence of seas that cause the barge to roll or pitch by an appreciable proportion of this beam width. Momentarily dropping targets in a track is a reality of any track-while-scan system (IV.d), and VendorA may have software that can cope with this eventuality, though perhaps not to the degree posed by a moving platform. It is entirely unknown to me how much the anchored barge is expected to pitch and roll in response to wave action on Lake Erie.
- VendorA and their equipment are untested operating in offshore environments, so there is the greater risk of otherwise avoidable problems occurring during operation. The vendor addresses many of the known challenges, so the risk is likely relatively minor.
- The capacity for VendorA to elevate their antenna may reduce clutter but is unlikely to eliminate it sufficient to reliably enable data collection on horizontal and altitudinal movements. Considerable unknowns exist depending largely on the impact of side lobes.

b. VendorB

VendorB (Option1) has numerous shortcomings in relation to operation (specifically, II.a.O2 and III.a.O4) and data gathering (specifically, III.b.D3 and II.b.D5) that render it the least desirable among the available options (Table 1). I do not comment on it further here. VendorB (Option2), however, represents a truly unique offering, and although when operating alone it has severe limitations in this particular application, it is nonetheless worth commenting upon. The capabilities of this radar were familiar to me before this evaluation was brought to my attention. The general approach is described in Chapman et al. (2003), and I first learned of this specific radar at a European Radar Aeroecology conference in Rome, Italy in early 2017. I was also invited to be an external reviewer for a graduate thesis from the University of Exeter that demonstrated some of the capabilities of this radar.

Advantages

- VendorB (Option2) rotates, or rather nutates, around a vertical axis in a way that enables it to gather data on height, speed, direction, and identity of the same target.
- VendorB (Option2) is the only vendor response that discriminates targets based on wingbeat rate, the current state-of-the-art (IV.g). Other vendor options discriminate according to RCS thresholding of which there is meaningful overlap between vertebrates and insects at X-band.
- With a nearly vertically oriented scan strategy, this option should be relatively robust against the effects of sea clutter, although the impact of ~90° is a lingering concern.

Disadvantages

- Nutating exclusively about a vertical axis places the radar at maximum exposure to the limits of detecting and identifying animals flying at very low heights. Minimum height matters a great deal in relation to studies of wind turbine impacts. The lower boundary of the rotor swept area for the Vestes V126 turbines proposed for this project as indicated in the “Icebreaker Wind VIA” document is 20 m above the water surface. The radar would sit a few meters above the water surface, further reducing the distance from radar to minimum height of the rotor swept area. The minimum height (above radar) claimed for VendorB (Option2) is 50 m, leaving approximately 30 m of a 126 m diameter rotor height (24%) unsampled. The reasons for this limit are not discussed. The effects of the main bang likely play a large role (IV.d), although this may also be a height below which targets travel too fast through too narrow a beam for wingbeat rate to be reliably estimated. Given the latter, it is not clear whether or not the lower limit of detectability is the same as the lower limit of wingbeat rate-based target discrimination.

- Movement of the beam in response to seas may impact estimates of speed and direction given the manner by which VendorB (Option2) determines those measures (Wills 2017). Specifically, movement of the radar platform during target passage changes the time required for the target to complete its passage through the nutating beam volume which in turn will bias speed estimates high or low depending on the motion. So, while the estimates for individual targets may be suspect, these biases may be expected to average out across many individuals. I also wonder whether sea state might impact target discrimination software which is sensitive to dwell time of the target within the beam. Depending on conditions, this could effectively increase the minimum height above radar at which some targets can be discriminated/counted, further limiting the ability of this unit to monitor the rotor swept area.
- The narrow region of direct monitoring severely limits the ability of this radar by itself to inform on turbine avoidance/attraction behavior in a post-construction study (IV.f).

c. VendorC

In deploying portable Doppler radar, VendorC proposes use of capable and somewhat uncommon hardware in biological circles. This unit purports to confer some advantages to their proposed approach, but these are not critical to successful data collection. VendorC reports the smallest RCS detectable at 5.5 km range as 10 cm and

5 cm for their S- (Option1) and X-band (Option2) horizontal radars, respectively. Overall, more capable hardware and software are invested in horizontal versus vertical monitoring, the latter possibly being the more relevant dimension in this project.

VendorC is arguably the most detailed in terms of data analysis, especially with respect to their statistical approach for determining weather conditions that influence the numbers of vertebrates flying at rotor swept height. If the relationship between weather conditions and animal density at rotor swept height is known, it may be possible to examine historic weather patterns in the area (as is likely already known) to determine the frequency of weather conditions associated with increased risk to flying animals (e.g., Kirsch et al. 2015). While VendorC discusses these capabilities at some length, any vendor that generates raw data on animal movements and weather conditions can provide those data such that a third party might generate the same or similar analyses as needed.

<u>Advantages</u>

- The wide vertical antenna angles (25° and 16°) of the horizontal radars increase the likelihood of maintaining target tracks despite barge movement.
- The Doppler capability of VendorC (Option2) enables a clutter filtering capability that may render it less sensitive to turbine clutter in ways that improve the ability of this radar to detect movements of vertebrates near turbines. This would presumably have value in post-construction studies examining vertebrate responses to actual structure.
- VendorC is the only vendor to offer some mechanism to correct radar-determined movements for the effects of barge roll, pitch, and yaw (3-axis accelerometers, IV.e).

<u>Disadvantages</u>

- VendorC vertical radar observations are gathered once every 5 sec using screen captures, presumably skipping every other sweep. The reason for this is unclear and compromises any effort at target tracking (to the extent that's desirable, see VII.b). MTR or vertically stratified measures of animal density are critical to this application of radar, yet VendorC documents no approach for target discrimination for these data. The “MUSE software” is not operational on the vertical radar presumably because it is based on analysis of entirely different methods of sampling used by the horizontal radars (high speed AD samples of radar ‘video’ signal output). Indeed, target discrimination generally is unclear across all radars, although it appears to be RCS-based on horizontal radars. Discrimination from aircraft are mentioned (which may identify their primary source of business), but there is no mention of insects which are by far the greater source of airborne clutter.

- The tracking advantage noted above assumes that pitch and roll of the barge does not produce sufficient sea clutter to interfere with data collection altogether. The reported false-positive rate for vertebrates when wave heights exceed 1 m is unknown for Option2. Response by VendorC to follow-up questions shows they have not deployed their horizontal radars from boats, so the impact of sea clutter remains a concern.
- Height bins are relatively coarse (50 m) but perhaps workable in pre-construction studies. However, the low spatial resolution compromises VendorC’s ability to document animal responses to the presence of turbines in post-construction studies.

VI. Conclusions

Far too many unknowns are present to anticipate the outcome of radar work in relation to this project. Use of a barge magnifies an already existing problem, that seas will introduce clutter into radar data. The question becomes one of identifying what vendor approach among those presented is most likely to yield meaningful data collection. Taking into consideration that not all evaluation criteria are equal in their importance, Table 1 effectively narrows the field to two best options, VendorA and VendorC (Option2). (As a side note, VendorB (Option2) stands out for its novel design and best target discriminating capability. This option might be preferred in stable environments where target detection at minimum altitude and response to structure is not a concern in follow-up studies, although my European colleagues have some concerns over the reliability of ground speed estimates.) Arguably, the most important data criteria for a radar system in relation to the Icebreaker Wind project concern the ability to gather data on altitude-specific MTR or density and behavioral response to turbine presence (pre- versus post- construction comparison to attempt to assess avoidance/attraction), and the ability do so with high reliability (≥80% of available time) while avoiding contamination by clutter, primarily from insects and the lake surface.

VendorC (Option2) may well outperform other options in relation to documenting behavioral response to turbines, however this capability is cast into some doubt given uncertainties associated with how well the Doppler radar performs on vessels in relation to sea clutter. More critically, it appears little attention is given to target discrimination in vertically oriented radar data which may be the most valuable in relation to assessing animal's exposure to wind turbines.

VendorA's use of parabolic antennas has advantages unique among these vendor responses. Many desired capabilities are addressed, perhaps most important among them is the ability to elevate a highly discrete beam as a means of attempting to reduce the impact of sea clutter, if only because this proves challenging for open-array antennas rotating in a horizontal plane (but see below). Less clear is how tracking would perform across sweeps on a rolling and pitching barge. VendorA reports that tracking could tolerate 2° of pitch or roll, but it is easy to envision greater barge movement.

In sum, VendorA proposes the approach most likely to succeed among the vendor responses and other information provided that forms the basis of this evaluation. This is not to suggest VendorA's approach is without concern, particularly over target discrimination, the ability to track from a moving platform, and the impact of sea clutter. Designing a radar study from the ground up is beyond the scope of this review, however I offer some suggestions that may increase the likelihood of gathering meaningful data on vertebrates using VendorA's basic approach.

- Current RCS-based target discrimination might be improved by also including an airspeed-based approach (IV.g). Neither achieves the accuracy of wingbeat rate analyses which a rotating radar prohibits (but see VII.a below). However, the combined approach of requiring vertebrate targets to meet both RCS and airspeed criteria may increase the likelihood of proper target classification. Data on wind is required to estimate target airspeed, and VendorA proposes to gather surface wind data from a barge. The usefulness of surface wind data decreases with altitude owing to wind shear. However, surface wind data are more likely to usefully inform airspeeds at rotor swept heights, since turbines are relatively close to the lake surface.

- Concerning tracking, VendorA may consider refitting their radar with a smaller diameter antenna to increase beam width as a means of increasing the likelihood of maintaining tracks (sensu VII.a). Ideally, a barge pitch and roll test would be conducted to determine whether and/or how frequently barge movement would exceed the ability for VendorA to track.
- Elevation of the parabolic antenna considerably above the horizon would likely result in decreased clutter relative to open-array antennas rotating in the horizontal plane. Clutter will persist, however, and it is likely that even gathering data from a fixed platform will not satisfactorily address the problem (IV.c). As such, and in consultation with my colleague S. Gauthreaux, I suggest an alternative approach. Parabolic antennas radiate in relatively discrete patterns where side lobes, a primary cause of clutter, may be pronounced but distinct. As such it may be possible to considerably reduce the impact of sea clutter by blocking side lobe energy through installation of a radar fence on the periphery of the proposed barge. (The fence is unlikely to work as cleanly with an open-array antenna, because the beam radiates power in a less discrete manner.) To benefit most from the fence, the radar should be positioned relatively close to the barge surface (and must therefore be well armored against freeboard seas). Otherwise the fence must be elevated to capture side lobes which would require assembling more structure. It is unclear how much wave motion would impact the barge, but conceivably the fence could be positioned and the antenna elevated to account for barge movement. (Note, increasing antenna elevation angle will simultaneously tend to increase the lowest height at which the radar can detect targets owing to the impact of the main bang (IV.d).) This

in turn can interfere with directly monitoring heights consistent with the rotor swept area, depending on the angle of elevation and impacts of the bang.) Finally, to further reduce the impact of side lobes, the proposed smaller diameter antenna could be outfitted with a cuff ringed with material designed to absorb radio energy (radar-absorbent material or RAM). Some of these clutter-mitigating tactics are described in greater detail in Larkin and Diehl (2012).

The adjustments described above would require the obvious adjustments to hardware as well as re-computing detection probabilities and adjusting volume scan elevations. These would appear to be relatively minor modifications and the developer could likely bear the cost. Also, concurrent data from the KCLE NEXRAD station could be used to help identify the data consequences for periods when lake conditions may result in data dropouts (IV.d).

Finally, I would hope reports resulting from this work are subject to peer-review, and that track data of individual animals, clutter maps, and reports are placed in the public domain so that others may benefit from the knowledge gained by this effort.

VII. Alternative Configurations

None of the proposed radar configurations is without shortcomings; indeed, it is difficult to envision any reasonable scenario that does not bring some limitation. The conclusions of this evaluation should not promote a static standard, but rather an evolving one that upgrades with advances in technology. Most relevant among the limitations described above are those associated with target discrimination (III.b.D3) and ability to accommodate sea clutter and a moving platform (III.a.O4).

All options offer trade-offs on the ideal capability; to obtain reliable, high accuracy data on ground speed, direction, altitude, and target identity on the same individual, and to do so with sufficient spatial and temporal coverage to detect behavioral responses to turbines. For example, four of five vendor options examined trade better target discrimination capability for spatial coverage. Under some circumstances this may be a desirable trade-off (e.g., airport monitoring for large birds) but perhaps not in relation to wind energy monitoring for primarily small vertebrates. Another example, VendorA forgoes the 2-dimensional comprehensive coverage of open-array antennas in favor of acquiring more spatially constrained 3-dimensional data on individuals using only one radar. The necessity of such trade-offs prompts one to ask: what are the most important capabilities for offshore radar monitoring, and are there alternative radar configurations that might better capture those capabilities? As mentioned in the Conclusions (VI), the most important data criteria for radar systems monitoring flying animals in relation to an offshore wind facility likely concern the ability to gather data on altitude-specific MTR or density and response to turbine presence, and the ability do so with high reliability while avoiding contamination by clutter, primarily insects and sea clutter.

Below I suggest a couple alternative radar deployment scenarios that represent advances or variations on some of the vendor design options suggested here. The people employed by these and other vendors are often highly knowledgeable, and it would surprise me if some of the concepts presented below have not been considered. Investing in research and development (to the extent required) and deployment is another matter, however. What works best serving a flight safety role may not be as well suited to wind turbine monitoring of the kind considered here. There is a tendency among the vendors to promote the comprehensiveness of coverage by one mechanism or another (e.g., stacked volume scans, wide-angle sweeps using open-array antennas). However, the goal here, as with many other wind operations, is to learn something about MTR or animal density, how that density is vertically stratified, how animals respond to stimuli or structure, and how these measures vary through time. With the possible exception of response to stimuli/structure, comprehensive data collection is not required for such measures.

a. Adaptable sampling

None of the vendor options satisfactorily addresses all the challenges such operations face in an offshore context and in other settings as well. Target discrimination is a persistent concern in radar biology, and one of the most common shortcomings among vendors concerns target discrimination where only VendorB

(Option2) employs the current state-of-the-art of wingbeat rate analysis. In this option, the confined airspace monitored increases dwell time on the target allowing wingbeat rate estimation but also limits the radar in other ways that are important to these studies and presumably others (V.b). As with VendorB (Option2), VendorA also employs parabolic antennas and does so with some sophistication by including elevation control, but continuous rotation at angles considerably less than 90° (vertical) prevents the radar from gathering wingbeat rate data.

A common property among all vendor options is a rotating antenna where reliance on the internal COTS azimuthal motor essentially drives all data collection. This is an appealing option; the motors are time-testing, highly reliable, and armored against harsh environmental conditions. COTS antenna rotation is also well suited to airport monitoring concerning bird aircraft strike hazards, which may comprise the bulk of many vendors' business. However, programmable azimuth and elevation control allows highly customizable sampling strategies that can be finely tuned to the needs of a given study. As vendors are no doubt aware, obtaining control over azimuth represents a considerable but hardly extraordinary hardware and software modification.

Consider an X-band radar outfitted with a ~6° parabolic antenna and software control over antenna position in azimuth and elevation. A sampling strategy that alternates between stationary beam sampling (Drake et al. 2002) and rotation enables serial data collection on wingbeat rate, altitude, and speed and direction from one radar (see Drake and Reynolds 2012, Ch. 5). The parabolic antenna would possess generally advantageous clutter mitigating properties if paired with modifications described above (VI), and the wider beam width would limit the impact of sea motion on target tracking where a barge or boat serves as the data collection platform. Trade-offs remain, but they are likely more tolerable. For example, the wider beam produces larger sample volumes (but still on par with most open-array antennas) that are more likely to include clutter in the form of multiple targets. The antenna also produces less gain (again, still on par with most open-array antennas) which limits range but not critically in this application. Detection of avoidance/attraction behavior would be consistent with VendorA (V.a). I am unaware of any vendors, including those not responding to this RFI, capable of implementing such a strategy in the near term.

b. Orthogonal sampling

In this concept, vertical sampling is favored over comprehensive horizontal sampling, because it focuses on altitude-based metrics (e.g., altitude-specific MITR) and would limit but not eliminate the impact of sea clutter. As discussed in Conclusions (VI), it may be possible to deploy a radar fence on a barge-sized structure to limit the impact of ~90° side lobes in a manner similar to that described in Buler and Diehl (2009).

Most applications of biological radar use a rotating antenna to enable a track-while-scan capability that allows sequential locations on a target to be linked into tracks that allow estimates of target speed and direction. However, the speed and direction of individual animals is not required to obtain estimates of mean speeds and directions of populations of animals moving through an airspace.

In this approach, two radars with open-array antennas are deployed rotating in orthogonal vertical planes (Figure 2). Each radar by itself will usually show some rate of animal movement along the axis of rotation but this is not a reliable indicator of speed for that individual, since we do not know its direction of travel. However, when averaged across a number of individuals, this mean relative speed constitutes one component of a two-dimensional vector. Combining the relative speed components from the two orthogonal planes would allow one to compute height-specific mean and standard deviation speeds and directions. The calculation can be repeated hourly or over whatever time frame allows sufficient samples to accumulate for the calculation (it would not require many) to estimate the

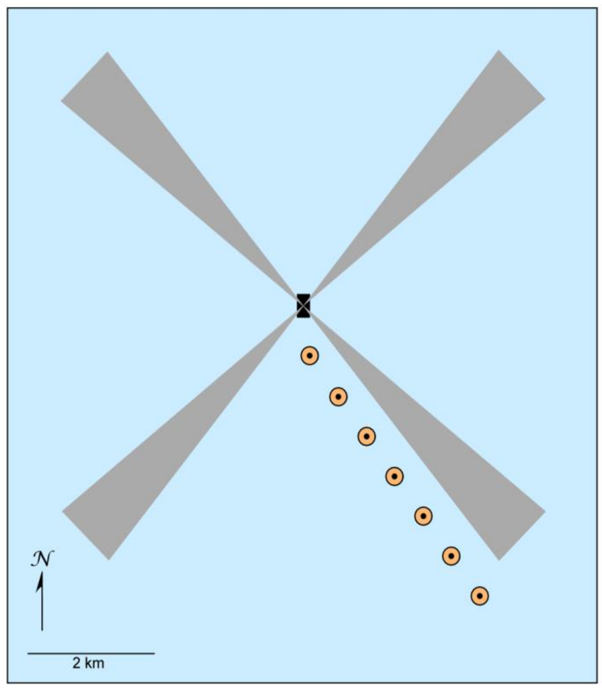

Figure 2. Conceptual layout of the orthogonal orientations of the vertical planes of rotation of two open-array antennas as they might be positioned during fall migration. During spring, the system would adopt a mirror configuration with respect the turbine array. The black rectangle represents the platform supporting the radars, gray wedges approximate the hypothetical horizontal coverage of 12° fan beams, and orange circles represent turbines.

components. Careful deployment with respect to a given turbine array should enable examination of behavioral response to turbines, especially where pre-construction data are available as reference, but the analysis would be more nuanced than examining tracks measured by horizontally rotating radars.

This approach relies on available software and hardware technology, so it should be relatively cost effective to deploy. Since it employs rotating antennas, the ability to use state-of-the-art target discrimination is compromised (only RCS-based approaches are possible; airspeeds cannot be used since the ground speeds of individuals is unknown) in favor of simplicity, cost effectiveness, clutter mitigation (from the sea and possibly turbines as well, depending on implementation), and the ability to examine behavioral response to structure, in this case turbines. Behavioral response may be subtle (which does not mean undetectable) given the limited coverage. As with other radar arrangements, pre- versus post-construction movement along, say, the southeast coverage area can be compared. It would also be possible during to compare movements along the southeast coverage to its counterpart to the northwest which would serve as an internal control of sorts. The desire for clutter mitigation is primarily but not exclusively a response to concerns over sea clutter in this evaluation. As with vendor responses, movement of a supporting barge or other floating platform would introduce error into vector component estimates of speed and direction, although these may average out (IV.e).

VIII. Acknowledgements

This report is informed by input from a variety of sources, among them the US Fish and Wildlife Service, LEEDCo, WEST Inc, and the Ohio Department of Natural Resources. Representatives from these organizations as well as two independent reviewers, Sidney Gauthreaux, Jr (who consulted briefly with VendorA) and Jeffrey Buler, provided helpful comments on an earlier draft. Ron Larkin also provided some useful confirmation. Any use or mention of trade, firm, or product names is for descriptive purposes only and does not imply endorsement by the US Government.

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Icebreaker Windpower, Inc.
Case No. 16-1871-EL-BGN
Fourth Supplement to Application
March 22, 2018

Attachment 6

United States Fish and Wildlife Service
Letter to
Ohio Department of Natural Resources
March 12, 2018

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IN REPLY REFER TO:

FWS/AES

MAR 12 2018

Gary Obermiller
Assistant Director
Ohio Department of Natural Resources
2045 Morse Road
Columbus, Ohio 43229

Dear Mr. Obermiller:

The U.S. Fish and Wildlife Service (Service) has provided technical assistance for the Icebreaker project since the early stages of project development. Service input has included Endangered Species Act consultation, migratory bird related technical assistance, and NEPA comments on the Department of Energy's (DOE) Draft Environmental Assessment. The intent of this coordination has been to promote pre- and post-construction data gathering and analyses sufficient to understand and minimize project impacts. It is important to clarify the Service's role in this process. Particularly for non-listed migratory birds (not including eagles) and bats, various authorities provide us with the responsibility to provide technical assistance and recommendations, but we are not decision makers in this context.

Regarding potential take of federally listed species, DOE has determined that LEEDCo's Project Icebreaker is not likely to adversely affect Indiana bat, northern long-eared bat, piping plover, rufa red knot, and Kirtland's warbler. The Service concurred with these determinations.

For pre-construction radar monitoring, a USGS expert (Dr. Robert Diehl) recently completed a report (December 2017) analyzing various radar proposals and identifying which vendor's proposal would have the likelihood of the most accurate data. Based on Dr. Diehl's report, LEEDCo subsequently worked with the preferred vendor (Accipiter Radar) to address specific concerns and recommendations. We appreciate that LEEDCo is working with the vendor to address concerns and incorporate recommendations from Dr. Diehl and the Service to increase the reliability of the monitoring program. Accipiter provided LEEDCo with a second proposal that would include placing the radar on a fixed platform, at a water intake crib a few miles offshore. The Service believes both proposals have trade-offs (i.e., vessel based at the project site vs. fixed platform several miles away) and uncertainties related to data collection and interpretation. However, both proposals have the potential to contribute meaningfully to migratory bird and bat exposure data for the project.

The Service agrees with stakeholders that post-construction fatality monitoring is of particular importance to the project. This is because pre-construction monitoring will indicate if birds and bats are flying in or near the project area, whereas post-construction monitoring will help determine if birds and bats are actually struck by the turbines. In recent discussions, LEEDCo indicated there have been advancements in fatality monitoring detector technology. LEEDCo shared with the Service an Oregon State University proposal to further develop this technology and implement research at the project site. LEEDCo noted another research proposal is pending from the Netherlands. The Service is encouraged that there is progress in this realm of technological development. The Service continues to recommend implementation of post-construction monitoring (whether it be this technology if shown to be effective or another valid method) as soon as the wind turbine project is operational.

The Service acknowledges that Icebreaker is a relatively small-scale demonstration project consisting of six turbines and as such has limited direct risk to migratory birds and bats. The Service's interest is in both reducing the risk to birds and bats from this project and also gaining useful data from the pre- and post-construction monitoring of the operation of Icebreaker to inform any future off-shore wind developments in the Great Lakes so that risk to birds and bats from such projects can be avoided or minimized.

We recognize that for an off-shore project such as Icebreaker, any pre- and post-construction monitoring strategies will have technological challenges and uncertainties as a result of the environmental conditions under which the project will operate. Based on LEEDCo's ongoing efforts to incorporate expert input for pre- and post-construction monitoring, the Service believes the monitoring will inform our understanding of project impacts on birds and bats. It will also advance the understanding of radar capabilities and monitoring strategies in an off-shore environment. We expect that pre- and post-construction monitoring will be tied to a strong adaptive management plan so that any necessary changes can be made as monitoring results are acquired to reduce impacts to birds and bats.

Thank you for the opportunity to provide input on the technology for the pre- and post-construction monitoring for the Icebreaker project. If you have any questions regarding this letter, please don't hesitate to contact me.

Sincerely,

Lori H. Nordstrom

Lori H. Nordstrom
Assistant Regional Director
Ecological Services
Midwest Region

cc: Dan Everson, Ohio Ecological Services Field Office, USFWS

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Case No(s). 16-1871-EL-BGN

Summary: Application Fourth Supplement to Application electronically filed by Christine M.T. Pirik on behalf of Icebreaker Windpower Inc.