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Memorandum

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Date: July 25, 2016

Project: LEEDCo – Icebreaker

To: Jennifer Norris, ODNR
Jeff Tyson, ODNR
Scudder Mackey, ODNR
Megan Seymour, FWS

CC: Lorry Wagner, LEEDCo & other LEEDCo team members

SUBJECT: *Quarterly Report for Aquatic Sampling: Project Icebreaker Pre-Construction Monitoring*

1. Project Background

The purpose of this memorandum is to provide an update to the Ohio Department of Natural Resources (ODNR) – Division of Wildlife (ODW) on progress-to-date for pre-construction monitoring for the Lake Erie Energy Development Corporation's (LEEDCo) Project Icebreaker. Monitoring is being conducted during the 2016 season to fulfill requirements of the "Aquatic Sampling Protocols for Offshore Wind Development for the Purpose of Securing Submerged Land Leases". This update covers project activities from May to July 2016 and includes the dates of fieldwork, summary of metadata from the field events, preliminary observations from these events, and any deviations from the original sampling plan. Fieldwork and preliminary data summaries are categorized by the three major types of monitoring including fish community/lower trophic level, physical habitat, and fish behavior. The memorandum fulfills the requirement to provide quarterly updates to ODW of project status and preliminary findings.

Sampling Plan

Monitoring and analysis are being conducted in accordance with the sampling plan that was submitted by LimnoTech to ODW on April 15, 2016. Discussion of the sampling plan took place at a meeting at the ODW office in Columbus, OH on May 3, 2016. The meeting was led by Jennifer Norris and Jeff Tyson from ODW and by Megan Seymour from the U.S. Fish and Wildlife Service. Subsequent to that meeting ODW provided feedback on several sections of the sampling plan (via email on May 8), but has not provided feedback on all items of the sampling plan. An updated monitoring plan will be submitted to ODW once all feedback has been received on the remaining sections and LEEDCo and ODW reach agreement on the remaining sampling items that aren't finalized yet. A brief summary of the project progress and ODW review status is provided in Table 1 below.

Table 1. Status of sampling and ODW review.

Sampling Category		May	Jun	Jul	Aug	Sep	Oct	ODW Review Status
Fish Community								
	Hydroacoustic		s	s			s	Finalized
	Larval Fish	s	s	s				Finalized
	Juvenile	s			s		s	Finalized
	Zooplankton	s	s	s	s	s	s	Finalized
	Phytoplankton	s	s	s	s	s	s	Finalized
	Benthos	s					s	Finalized
Physical								
	Chemistry (discrete)	s	s	s	s	s	s	Finalized
	Chemistry (continuous)	d	m	m	m	m	r	Open ? To ODNR
	Substrate Mapping	s						Use '15 survey
	Hydrodynamic	d	m	m	m	m	r	No ODNR comments
Fish Behavior								
	Acoustic Telemetry							Open ? To ODNR
	Fixed Acoustic							No ODNR comments
	Noise	d	m	m	m	m	r	Finalized
	Aerial Surveys	s	s	s	s	s	s	Finalized
	<-- task completed	d=deploy, m=maintain, r=retrieve, s= sample						

2. Field Events Summary

The following section includes a summary of the field event dates and tasks performed during the months of May, June and July 2016. Table 2 provides a listing of the exact dates that each of the field tasks were completed for each month.

Table 2. Dates of field activities by sample type

		May	June	July
Fish Community				
	Hydroacoustic	23-May	2-Jun	5-Jul
	Larval Fish	24-May	26-Jun	20-Jul
	Juvenile	21-May	NA	NA
	Zooplankton	10-May	16-Jun	7-Jul
	Phytoplankton	10-May	16-Jun	7-Jul
	Benthos	9-May	NA	NA
Physical				
	Chemistry (discrete)	10-May	16-Jun	7-Jul
	Chemistry (continuous)	11-May	15-Jun	6-Jul
	Substrate Mapping	NA	NA	NA
	Hydrodynamic	11-May	15-Jun	6-Jul
Fish Behavior				
	Noise	11-May	15-Jun	6-Jul
	Aerial Surveys	20-May, 22-May	5-Jun, 6-Jun, 30-Jun	3-Jul

Sampling Stations

Sampling stations are listed below in Table 3. The table lays out, by category, which stations or transects were sampled for each type of sampling, during each sampling event. A graphical depiction of the stations is shown in Figure 1. Turbine stations ICE2 and ICE6 represent the centers of the two 1-min by 1-min project area grids, whereas Turbine station ICE4 represents the center of both turbine grids, and is the location of continuous monitoring equipment. Reference station 1 is located approximately 1 mile to the west of Turbine station ICE4, and serves as the second continuous monitoring station. The GPS position of each station is shown in Table 4. The transects for mobile acoustic surveys are located down the center (C) of the project grid, and to the east (E), and west (W) in adjacent reference areas. Transect C extends from Turbine stations ICE1 to ICE7, transect W extends from Reference station 2 to 3, and transect E extends from Reference station 4 to 6. The transects have a southeast to northwest orientation and therefore, are directly aligned with the orientation of the proposed turbines.

Table 3. Updated sampling stations by sample type (x=sample).

		Reference Stations						Turbine Stations							Transects		
Task Description		1	2	3	4	5	6	ICE1	ICE2	ICE3	ICE4	ICE5	ICE6	ICE7	C	E	W
Fish Community	Mobile Acoustic														x	x	x
	Larval Fish	x							x				x				
	Juvenile	x							x				x				
	Zooplankton	x	x	x	x	x	x		x				x				
	Phytoplankton	x	x	x	x	x	x		x				x				
	Benthos	x							x				x				
Physical	Chemistry (discrete)	x	x		x	x	x		x				x				
	Chemistry (continuous)	x									x						
	Substrate Mapping	not sampled															
	Hydrodynamic	x									x						
Fish Behavior	Acoustic telemetry	not sampled															
	Fixed Acoustic	not sampled															
	Noise	x									x						
	Aerial Surveys	will follow larger grid															

Table 4. Table of updated stations with latitude and longitude coordinates

Turbine Station	Latitude	Longitude	Reference Station	Latitude	Longitude
ICE1	41.60072	81.80055	1	41.60867	-81.82550
ICE2	41.60616	81.80602	2	41.62539	-81.84210
ICE3	41.61159	81.81150	3	41.59184	-81.80890
ICE4	41.61702	81.81697	4	41.60899	-81.79150
ICE5	41.62246	81.82245	5	41.62493	-81.80810
ICE6	41.62789	81.82793	6	41.63990	-81.82370
ICE7	41.63333	81.83340			

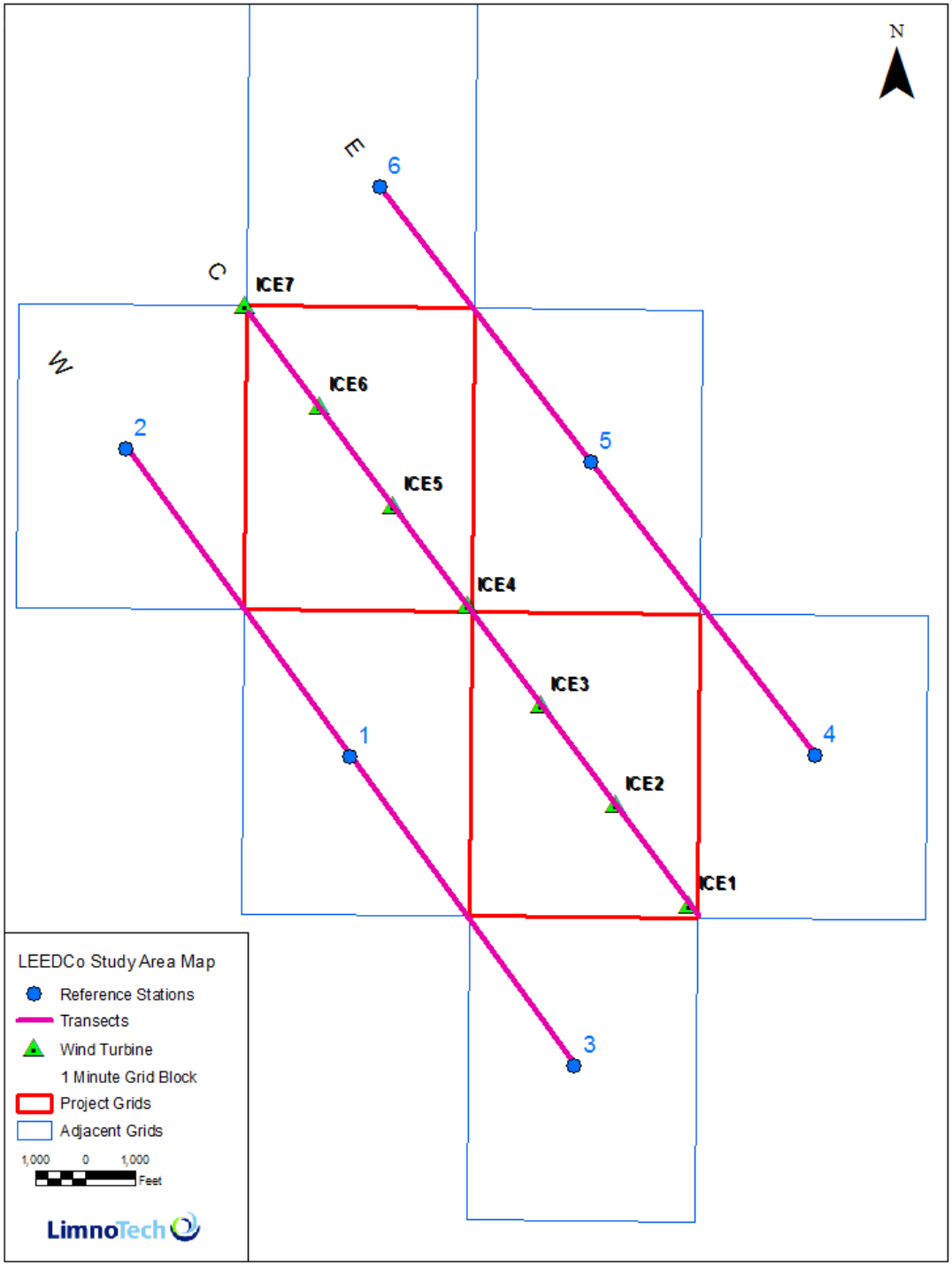


Figure 1. Map of project area with turbine, sampling station, and transect locations.

3. Fish Community/ Lower Trophic Level

This section covers mobile acoustic surveys, larval fish, juvenile fish, zooplankton, phytoplankton, and benthic sampling.

Mobile Acoustics

Hydroacoustic monitoring was conducted on June 2 and July 5, 2016. Per discussions with the ODNR, each monitoring event was completed at least half an hour after sunset and within four days of the new moon phase. Sampling was completed across three transects, one down the center of the project grid and turbine locations, and two transects in adjacent grid cells. Methods and sampling design followed the Standard Operating Procedure (SOP) for Fisheries Acoustic Surveys in the Great Lakes (FASGL; Park-Stetter et al. 2009). A BioSonics DT-X portable echo sounder surface unit at an emitting frequency of 120kHz with a 6° split beam transducer was pole-mounted and towed along sampling transects. Equipment was calibrated following manufacturer recommended procedures prior to each survey. A second bottom echograph was collected during each event per request by ODW. Example screenshots from the data collection software from each event are shown in Figure 2.

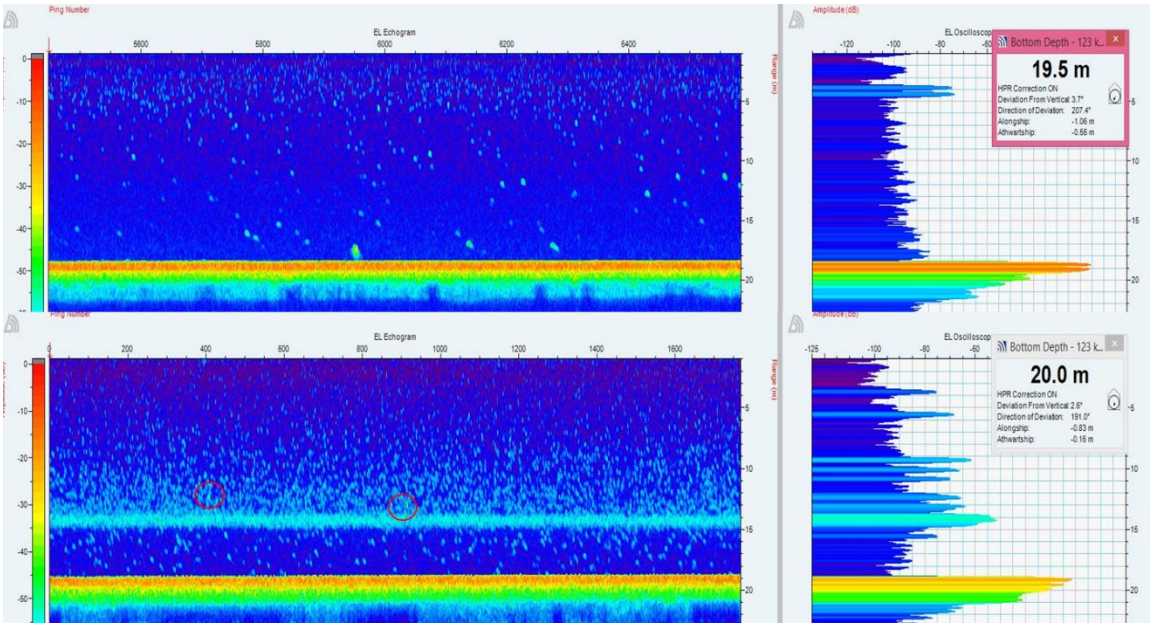


Figure 2. Screenshots from mobile acoustics trawls on June 2 (top) and July 5 (bottom).

A thermocline was present during the July 5, 2016 event, which is evident at 15 meters. This thermocline corresponded to the temperature profile from buoy 45164. Data analysis and fish density calculations will be completed according to the FASGL guidelines. The main output from this task will be an estimate of the total fish densities within the project area and adjacent reference transects.

Larval Fish

Larval fish sampling was conducted on May 24 and June 26, 2016. Three replicate, five minute tows were completed at three locations. These included two turbine locations (Turbine station ICE2 and Turbine station ICE6) and one reference site (Reference 1). A 1X2m frame, 500micron Neuston net was used to collect the fish according to the ODW ichthyoplankton sampling protocols. Following collection, samples were concentrated and preserved in 95% ethanol, and delivered to the BSA Environmental Services lab for

taxonomic identification. The available results from the May and June events are summarized in Table 5. None of the samples from the May event contained any larval fish and only two larval fish were found in the June replicate. We consulted with ODW (Jeff Tyson via email on July 19) and no change in collection methods were suggested. To date not all samples have been counted/analyzed yet. Table 5 below indicates which samples have been counted.

Table 5. Ichthyoplankton results from May 24, 2016 and June 26-27, 2016 sampling events.

Site	Rep	Date	Time	Tally
Turbine 2	1	5/24/2016	13:44	0
Turbine 2	2	5/24/2016	14:11	0
Turbine 2	3	5/24/2016	14:23	0
Reference 1	1	5/24/2016	14:50	0
Reference 1	2	5/24/2016	15:09	0
Reference 1	3	5/24/2016	15:18	0
Turbine 6	1	5/24/2016	15:45	0
Turbine 6	2	5/24/2016	16:03	0
Turbine 6	3	5/24/2016	16:17	0
Turbine 2	1	6/26/2016	15:40	not counted
Turbine 2	2	6/26/2016	16:25	0
Turbine 2	3	6/26/2016	16:47	not counted
Turbine 2	4	6/27/2016	9:41	not counted
Reference 1	1	6/26/2016	17:33	not counted
Reference 1	2	6/26/2016	17:59	1
Reference 1	3	6/26/2016	18:27	not counted
Reference 1	4	6/27/2016	9:22	not counted
Turbine 6	1	6/27/2016	8:07	not counted
Turbine 6	2	6/27/2016	8:31	1
Turbine 6	3	6/27/2016	9:41	not counted
Nearshore	1	6/26/2016	19:46	not counted

Note: not counted samples will be processed in August

The lack of fish could be due to several factors, which include the following: the sampling stations are located far offshore with little near-shore mixing of ichthyoplankton; during the day, fish are likely to stay lower in the water column to minimize predation; and fish follow the diel vertical plankton cycle for feeding. Specifically, the first event occurred on a sunny day with no wave action and little mixing, and consequently, the fish may have been located in deeper waters. In addition, the presence of the thermocline may have also interfered with larval fish in the subsurface. Lastly, with the unusually warm winter, most of the fish may have hatched and had experienced advanced growth rates earlier in the spring.

Juvenile Fish

Juvenile fish sampling was conducted on May 21, 2016. Three replicate, ten minute tows were completed at the two turbine locations (Turbine station ICE2 and Turbine station ICE6) and one reference site (Reference 1). Due to an unforeseen delay in the manufacturing of the sampling net (i.e., a flat-bottom otter trawl with a 10.7 meter head rope and 12-mm bar mesh in the cod end), a replacement flat-bottom otter trawl net, which was 7.7 meters, was used. The net was supposed to be delivered in 6 weeks, but was delayed by over 12 weeks by the manufacturer. The 10.7 meter net will be used in future trawling events. Trawl catches were sorted by species and age-category (e.g., age-0, age-1, age-2+) and then enumerated. A subsample of 30 individuals per species and age category was measured for total length (nearest mm) and weight (nearest 0.1 g). The combined results from the three replicate surveys at each location from the May event are summarized in Figure 3. The species composition was relatively consistent across all locations and replicates. White Perch, age category #1, Yellow Perch, age categories #1 and 2, and Rainbow smelt (age category #3) dominated the trawls. Walleye, Goby and Emerald Shiner were collected in select trawls in low numbers (n=0-4).

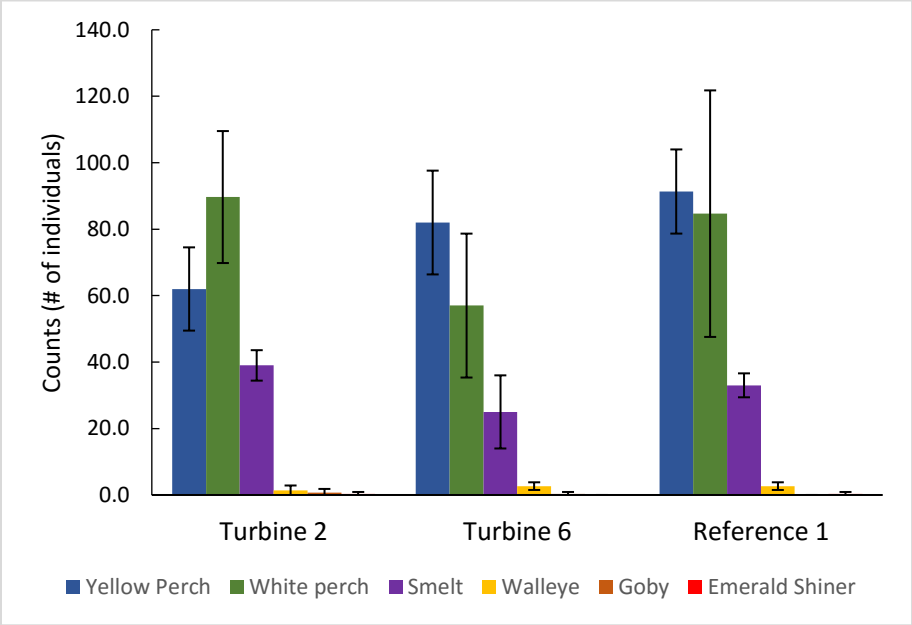


Figure 3. The mean (± SD) for each species collected at each location (n=3 replicate trawls) on the May 21, 2016 event.

Zooplankton

Zooplankton samples were collected in conjunction with the phytoplankton, benthos and water chemistry samples. Samples were collected at six reference locations and two turbine stations in May and at six reference location and three turbine stations in June and July. The additional turbine site (ICE4) will be sampled in all subsequent events. Field collection methods were based on the Lake Erie Coordinated Lower Trophic Level Assessment. A weighted zooplankton net (0.5 m in diameter, 64 micron mesh), with a flow meter 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 water so all plankton were transferred to the collection jar. Samples were concentrated through a 64 micron screen and preserved with 5% Lugol's Iodine solution. Sub-samples were removed for plankton identification to taxonomic genus (species when available) and then enumerated.

Laboratory protocols for identification, enumeration and biomass estimates followed methods that BSA Environmental Services has been using for several years. A Quality Assurance Project Plan (QAPP) was used to ensure high quality data. Methods and quality assurance plans for zooplankton enumeration are available upon request. Samples were stored following analysis, and samples were retained following identification. Any exotic species found were identified to species level. The results from the May and June events are summarized in Table 6 and Table 7 summarizes the zooplankton present for each month.

Table 6. The number of species, number of organisms/L and the biomass for all zooplankton in each sample are summarized for the May and June sampling events.

	Turbine 2		Turbine 4		Turbine 6		Reference 1		Reference 2	
	May	June	May	June	May	June	May	June	May	June
Number of Species	20	14	-	14	14	12	17	14	14	15
Number/L	1094	933	-	623	2688	333	1124	564	1606	2532
Biomass (ug d.w./L)	400	289	-	572	1252	700	276	952	868	1272

	Reference 3		Reference 4		Reference 5		Reference 6		All Sites	
	May	June	May	June	May	June	May	June	May	June
Number of Species	15	13	19	14	15	13	16	16	16±2	14±1
Number/L	1669	1312	962	506	2393	318	1613	953	1644±620	897±693
Biomass (ug d.w./L)	648	1037	410	475	709	403	580	974	643±311	741±333

Table 7. The species present across all locations from the May and June 2016 sampling events are summarized.

May	June
Bosmina longirostris	Asplanchna priodonta
Brachionus calyciflorus	Bosmina longirostris
calanoid copepodid	Bythotrephes longimanus
Conochilus unicornis	calanoid copepodid
cyclopoid copepodid	Conochilus unicornis
Daphnia galeata	Corbicula fluminea veliger
Daphnia retrocurva	cyclopoid copepodid
Diacyclops thomasi	Daphnia galeata
Dreissena veliger	Daphnia retrocurva
Eurytemora affinis	Diacyclops thomasi
Filinia terminalis	Eurytemora affinis
Kellicottia longispina	Gastropus stylifer
Keratella cochlearis	Kellicottia longispina
Keratella quadrata	Keratella cochlearis
Leptodiaptomus ashlandi	Keratella quadrata
Leptodora kindtii	Leptodiaptomus ashlandi
nauplii	Leptodora kindtii
Notholca laurentiae	Mesocyclops edax
Ploesoma truncatum	nauplii
Polyarthra vulgaris	Polyarthra vulgaris
Synchaeta spp.	Skistodiaptomus oregonensis
veliger quagga	Synchaeta spp.

The results were variable across all sites for biomass and numbers/L; however, in general, the species composition remained similar. The species composition was typical of most Lake Erie samples, made up of mostly calanoid and cyclopod copepods, rotifers, water fleas and the larval crustaceans (nauplii). The native predatory water flea, *Leptodora kindtii* was present in all of the May samples, and the invasive, predatory spiny waterflea *Bythotrephes longimanus* was present in all of the June samples.

Phytoplankton

Phytoplankton samples were collected in conjunction with the zooplankton, benthos and water chemistry samples. Samples were collected at six reference locations and two turbine stations in May and at six reference locations and three turbine stations in June and July. The additional turbine site will be sampled in all subsequent events. Field methods as well as sampling and laboratory protocols were taken from the Lake Erie Coordinated Lower Trophic Level Assessment. Briefly, an integrated tube/hose sampler was lowered to just above the lake bottom to complete the sampling. A weighted rope was attached to the end of the hose to avoid hitting the bottom. Samples were concentrated and preserved with 4% Lugol's Iodine solution. Samples were processed according to the BSA Environmental Services Laboratory method, which follows The

Ohio State University's (OSU) Aquatic Ecological Lab processing protocols. A general summary across all locations for May and June is presented in Table 8. Table 9 provides a list of all genus present for each month.

Table 8. The number of genera, number of cells per liter and the total biovolume for all phytoplankton in each sample are summarized for the May and June sampling events.

	Turbine 2		Turbine 4		Turbine 6		Reference 1		Reference 2	
	May	June	May	June	May	June	May	June	May	June
Number of Genus	15	12	-	10	12	14	18	12	15	9
Cells/L	9.7E+06	5.0E+05	-	7.5E+06	9.9E+06	1.9E+06	9.3E+06	2.7E+06	8.3E+06	3.1E+06
Total Biovolume (um^3/L)	7.0E+09	3.5E+08	-	7.9E+08	2.5E+09	7.7E+07	1.9E+09	2.5E+08	2.8E+09	7.1E+08

	Reference 3		Reference 4		Reference 5		Reference 6		All Sites	
	May	June	May	June	May	June	May	June	May	June
Number of Genus	18	9	15	9	22	13	13	11	16	11
Cells/L	1.2E+07	5.0E+05	1.1E+07	4.7E+05	7.8E+06	4.6E+05	1.5E+07	1.8E+06	1E+07	2097680
Total Biovolume (um^3/L)	8.7E+09	3.5E+07	3.5E+09	1.2E+08	2.2E+09	1.4E+08	4.3E+09	1.7E+08	4.1E+09	2.94E+08

Table 9. Genera present across all locations from the May and June 2016 sampling events.

May	June
Asterionella	Asterionella
Aulacoseira	Achnanthidium
Chlamydomonas	Aphanizomenon
Chlorella	Aulacoseira
Cocconeis	Carteria
Coelastrum	Ceratium
Cryptomonas	Chlamydomonas
Cyclotella	Chlorella
Cymatopleura	Chroococcus
Diatoma	Chrysococcus
Fragilaria	Cryptomonas
Gomphonema	Cyclotella
Lindavia	Dinobryon
Mallomonas	Dolichospermum
Monoraphidium	Fragilaria
Navicula	Gomphosphaeria
Nitzschia	Kephyrion
Oocystis	Lindavia
Plagioselmis	Monoraphidium
Planktolyngbya	Nitzschia
Planktothrix	Oocystis
Rhodomonas	Plagioselmis
Scenedesmus	Planktolyngbya
Sphaerocystis	Planktothrix
Stephanodiscus	Quadrigula
Surirella	Sphaerocystis
Synedra	Stephanodiscus
	Staurastrum sp.

In May, the Bacillariophyta (diatoms) were the dominate plankton with *Aulacroseria* the most common genus, followed by the Clorophyta dominated by the *Chlorella* genus. In June, the cyanobacteria (blue-green algae) were the most dominant with *Chroococcus* the most common genus. Chlorophyta (green algae) were dominant as well with the most common genus being *Chlorella spp*. The rest of the samples were made up of Bacillariophyta, Chrysophyta (golden algae) and Cryptophyta.

Benthos

Benthic samples were collected in conjunction with the zooplankton, phytoplankton and water chemistry samples. Samples were collected at one reference location and two turbine stations in May. Field methods were based on the Lake Erie Coordinated Lower Trophic Level Assessment. Briefly, three replicate ponar grabs of bottom sediment were collected. Benthos were removed, preserved, and sorted to the nearest taxonomic order or aquatic functional group and then enumerated. The counts (mean ±SD) for each genus are summarized in Table 10. All benthos collected fell into three main groups, Bivalves, Insecta, and Oligochaeta. Their densities were relatively consistent across the three locations.

Table 10. The mean density (number per square meter) and standard deviation (in parentheses) are presented of each taxa across three replicate ponars at each location.

Taxa	Turbine 2	Turbine 4	Reference 1
Oligochaeta	548 (86)	663 (375)	491 (156)
Corbicula fluminea	657 (334)	376 (74)	606 (320)
Chironomus sp.	267 (87)	229 (41)	159 (74)
Procladius sp.	6.4 (9)	13 (18)	19.1 (15.6)
Tanytarsus sp.	12.8 (18)	38 (31)	13 (9)

4. Physical Habitat

Water Chemistry (Discrete)

Discrete grab sampling for water chemistry and water clarity measurements were conducted on May 12, June 16, and July 7, 2016 at six reference locations and Turbine stations ICE2, ICE4, and ICE6 (Table 11). The sampling event on May 12 did not include Turbine 4 as it was not required by ODW, but was later added by LimnoTech to provide additional water chemistry results at the same station where continuous measurements are being recorded. An integrated tube was lowered to the lake bottom for a total water column collection that was emptied into a stainless steel bucket and then sub-sampled into separate bottles for analysis of nitrogen, phosphorus, and chlorophyll-*a* samples. A Secchi disk was lowered into the water column until it was no longer visible to measure water clarity (Figure 4) and a Li-COR submersible light meter was lowered from the surface at 0.5 meter increments to determine light extinction. Water chemistry and clarity results from May 12 and June 16 are provided in Table 12 and Table 13.

An YSI EXO2 water quality sonde was used to collect profiles of water temperature, dissolved oxygen, conductivity, turbidity, chlorophyll-a, blue-green algae, and pH at all reference and turbine locations in May, June, and July. The sonde was lowered from the surface to the bottom and data logged in one second intervals. An example of the profiles taken on May 24 and June 16 at Turbine station ICE4 are shown in Figure 5.

Table 11. Reference and Turbine locations where discrete chemistry samples were taken in May and June.

		Reference Stations											
Task Description		1		2		3		4		5		6	
		May	June	May	June	May	June	May	June	May	June	May	June
Discrete Chemistry	Chlorophyll	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
	Total P	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
	PAR Extinction	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
	DO/Temp Profile	x	x	x	x	x	x	x	x	x	x	x	x

		Turbine Stations													
Task Description		ICE1		ICE2		ICE3		ICE4		ICE5		ICE6		ICE7	
		May	June	May	June	May	June	May	June	May	June	May	June	May	June
Discrete Chemistry	Chlorophyll			x	x							x	x		
	Nitrate+NO2			x	x							x	x		
	Total P			x	x							x	x		
	TKN			x	x							x	x		
	PAR Extinction			x	x							x	x		
	Secchi Depth			x	x							x	x		
	DO/Temp Profile	x	x	x	x	x	x	x	x	x	x	x	x	x	x

Table 12. May and June water chemistry measurements

	Chlorophyll-a (µg/L)		**Nitrate+Nitrite (mg/L)**		**Total P (µg/L)**		**TKN (mg/L)**		**Total N (mg/L)**	
ID	May	June	May	June	May	June	May	June	May	June
Reference 1	2.59	0.37	0.88	0.49	13.12	12.87	0.29	0.23	1.16	0.72
Reference 1-D	2.51		0.88		1.16		0.24		1.12	
Reference 2	1.83	0.42	0.93	0.41	14.98	5.76	0.29	0.24	1.21	0.65
Reference 3	2.17	0.47	0.75	0.52	10.98	4.72	0.26	0.26	1.01	0.78
Reference 3-D		0.47		0.53		5.19		0.20		0.73
Reference 4	2.78	0.47	0.83	0.48	10.78	12.85	0.26	0.21	1.09	0.70
Reference 5	2.81	0.28	0.95	0.46	13.40	12.08	0.27	0.22	1.22	0.68
Reference 6	2.82	0.27	0.95	0.39	12.23	8.84	0.25	0.25	1.20	0.63
Turbine 2	3.14	0.66	0.83	0.52	16.01	5.03	0.40	0.25	1.23	0.77
Turbine 4		0.30		0.48		7.28		0.21		0.70
Turbine 6	2.14	0.25	0.95	0.43	17.35	5.54	0.38	0.24	1.33	0.68
Field Blank	0.00	0.00	0.01	0.00	-1.80	-1.24	-0.01	-0.02	0.00	-0.02
Equipment Blank	0.01		0.00		5.85		0.05		0.05	

(Method detection limit: Nitrate+Nitrite -0.22 mg/L, Total Phosphorus (Total P)- 3.15 ug/L, Total Kjeldahl Nitrogen (TKN)– 0.04 mg/L, Total Nitrogen (Total N) – 0.04 mg/L)

Table 13. May and June water clarity and light extinction results

	Secchi Depth (ft)		PAR Extinction Coeff. (m^{-1})	
ID	May	June	May	June
Reference 1	6.2	24.5	-0.24	-0.1
Reference 1-D				
Reference 2	6.4	27	-0.2	-0.1
Reference 3	7.4	26	-0.19	-0.15
Reference 3-D				
Reference 4	7.2	33	-0.2	-0.1
Reference 5	5.8	24	-0.26	*
Reference 6	6.2	26.5	-0.22	-0.09
Turbine 2	6.5	34	-0.21	-0.1
Turbine 4				
Turbine 6	5.8	23.5	-0.22	-0.1

Note: * denotes low quality PAR measurements

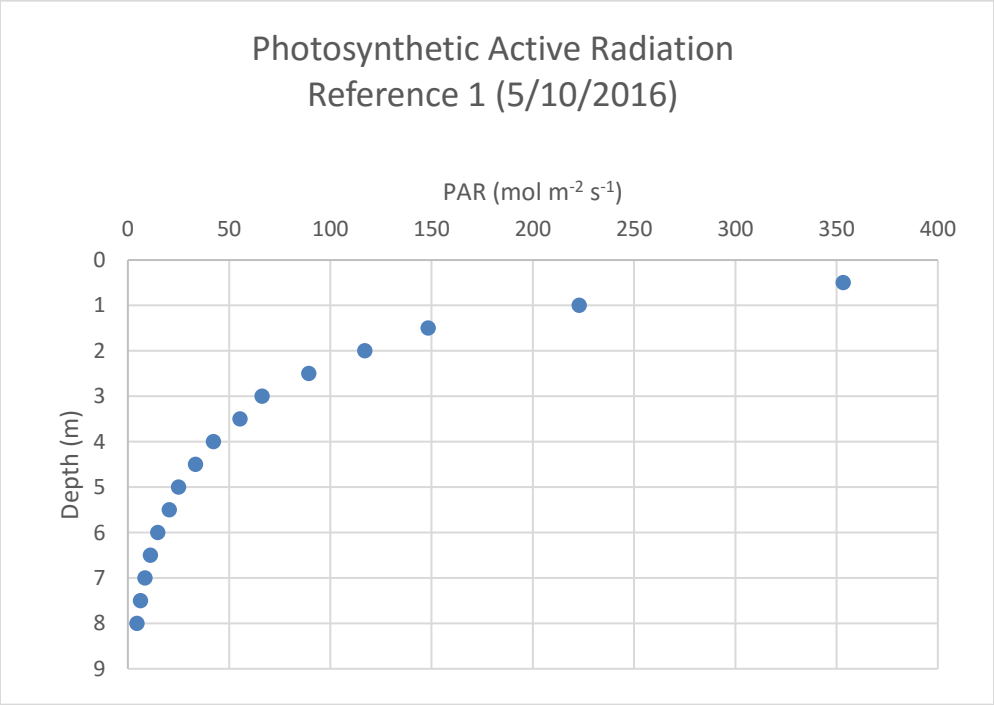


Figure 4. Photosynthetic active radiation (PAR) (mol $m^{-2}s^{-1}$) measurements taken on 5/24/2016 at Reference 1

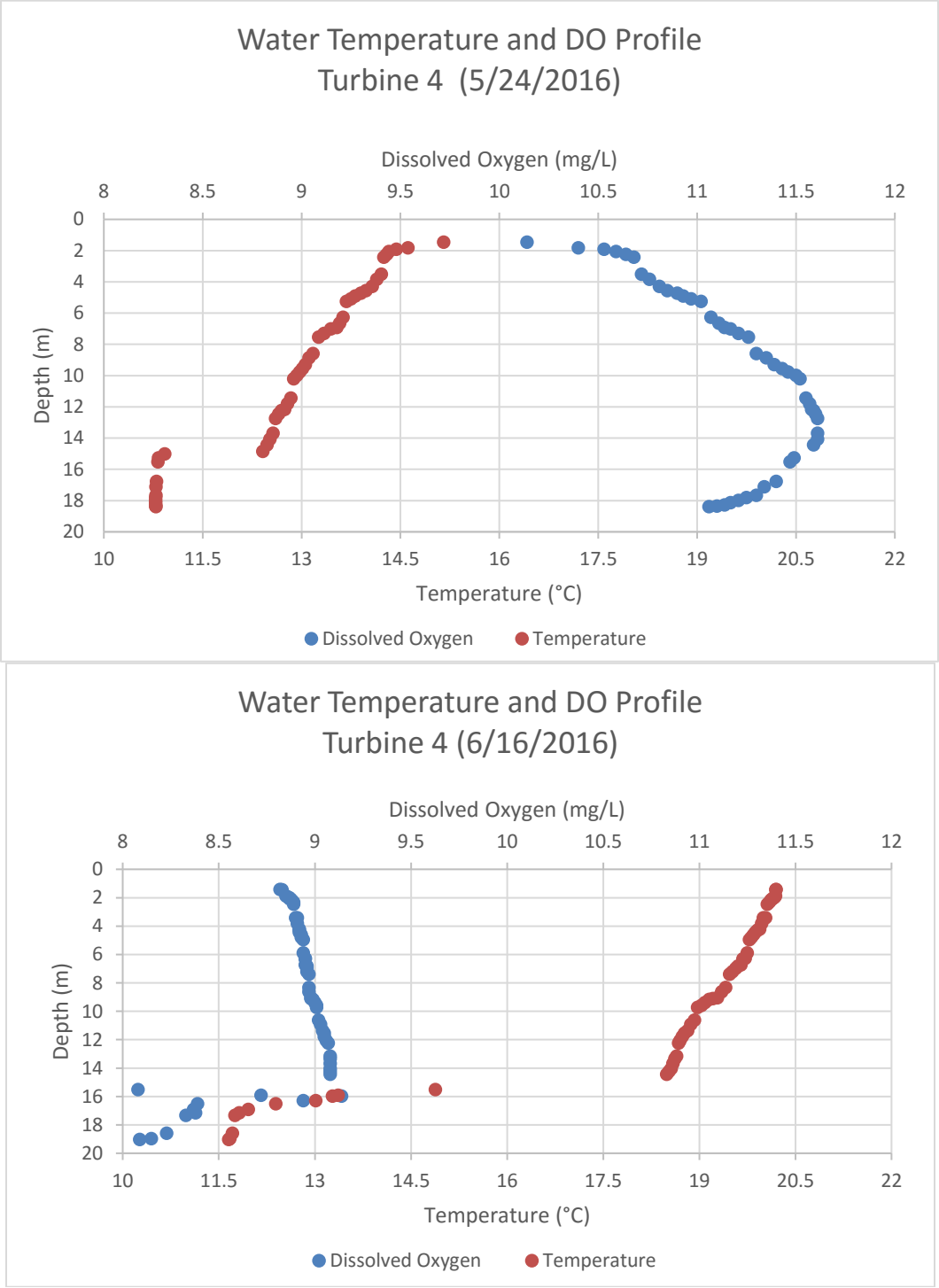


Figure 5: Water temperature (°C) and dissolved oxygen (mg/L) profile taken at Turbine 4 on 5/4/2016 and 6/16/2016.

Water Chemistry (Continuous)

Continuous water chemistry sampling sensors were deployed at Reference 1 and Turbine station ICE4 on May 11, 2016 to monitor photosynthetic active radiation (PAR), water temperature and dissolved oxygen. The Odyssey PAR loggers were placed 47 feet from the lake bottom and configured to output data every ten minutes (Figure 6). Two HOBO temperature sensors were installed one meter below the water surface and above the lake bottom and provide data every ten minutes. A YSI logger (OMS 600) was installed one meter above the lake bottom to record dissolved oxygen, conductivity, and temperature every hour (Figure 7). A malfunction in the memory card on the YSI logger at Reference 1 resulted in dissolved oxygen not being recorded from May 11 to June 15, 2016. A summary of the number of days collected by continuous sensors is located in Table 14.

Table 14: Number of days collected by continuous sensors

		Turbine 4		Reference 1	
Continuous Measurements	**Task Description**	May	June	May	June
	Surface Water Temperature	21	30	21	30
	Bottom Water Temperature	21	30	21	30
	Bottom Dissolved Oxygen	21	30	0	15
	Photosynthetic Active Radiation	21	30	21	30
	Water Current Profile	21	30	21	30
	Background Noise	21	30	21	30

Buoy 45164, which is also maintained by LimnoTech and is deployed ten miles northeast of the central turbine location in 70 feet of water, provides hourly water temperature from the surface to 60 feet below the surface at two meter increments. The temperature profile from Buoy 45164 in Figure 9 illustrates the development and the depth of the thermocline from May 29, 2016 to June 29, 2016. Buoy 45164 also provides hourly bottom dissolved oxygen and temperature measurements.

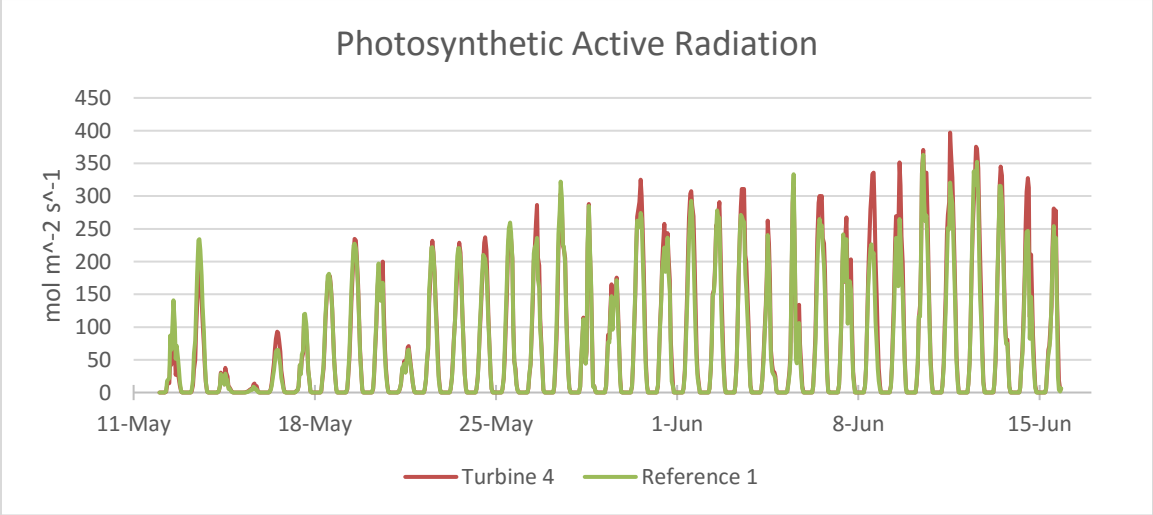


Figure 6: Photosynthetic active radiation (mol m^{-2} s^{-1}) measured 47 feet from the lake bottom at Turbine 4 and Reference 1.

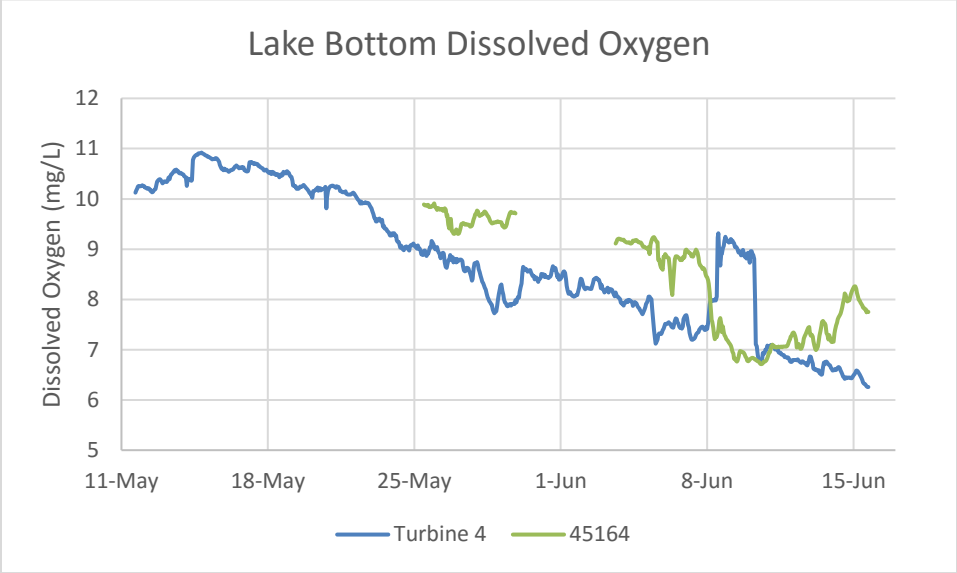


Figure 7: Lake bottom dissolved oxygen (mg/L) at Turbine 4 and Buoy 45164.

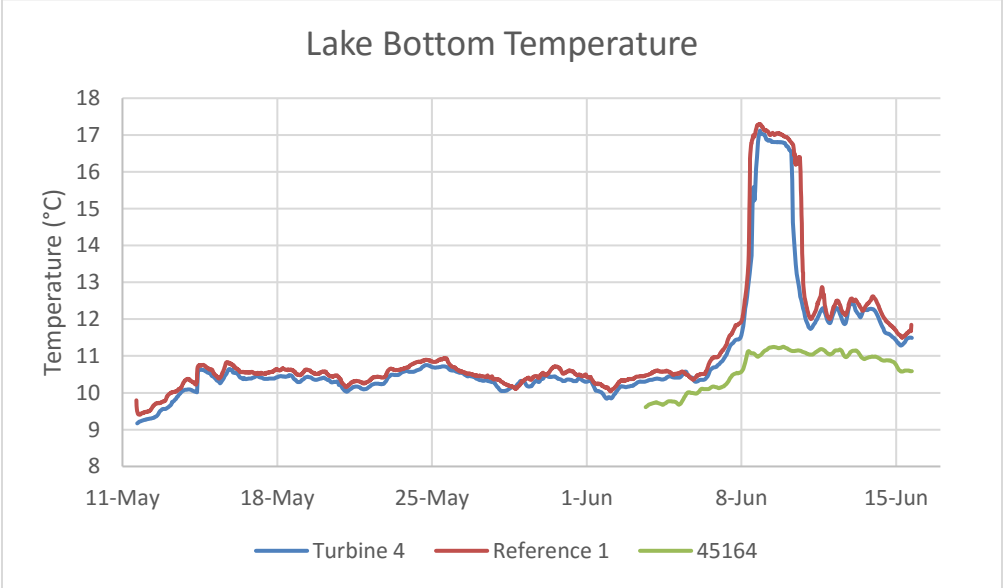


Figure 8. Lake bottom temperature at Turbine 4, Reference 1, and Buoy 45164.

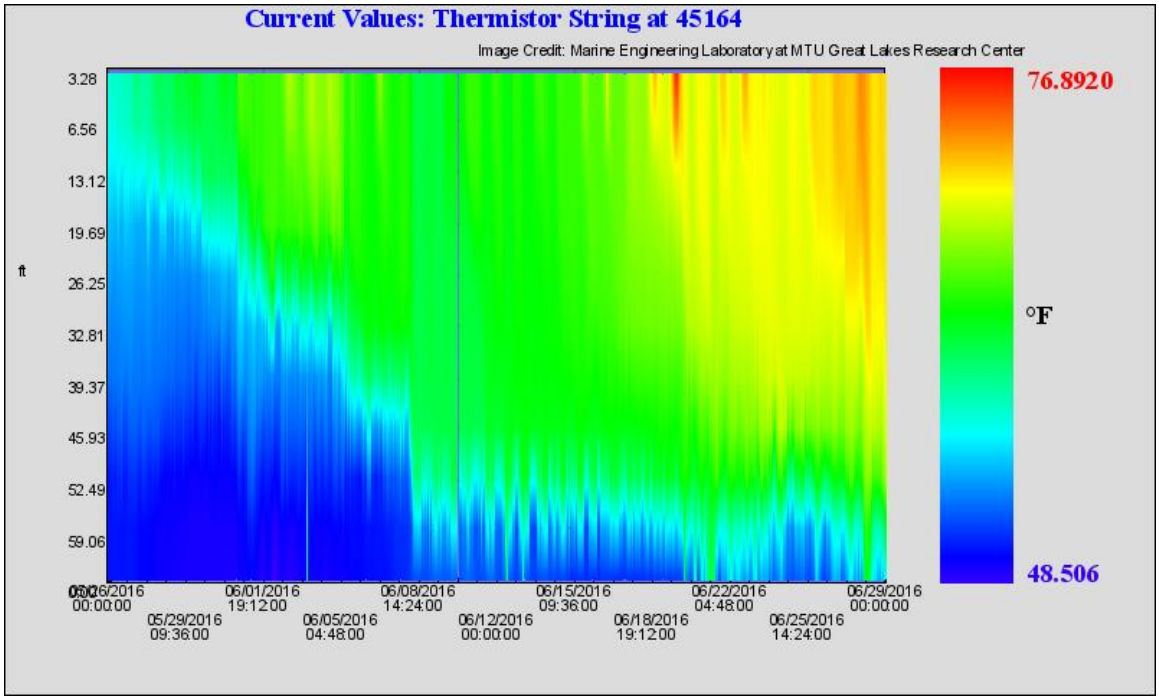


Figure 9. Buoy 45164 water temperature profile from May 29, 2016 to June 29, 2016

Hydrodynamic

An Acoustic Doppler Current Profiler (ADCP) RDI Workhorse (Sentinel-1200kHz) was deployed at Reference 1 and a Nortek ADCP (AWAC AST 1MHz) was deployed at Turbine station ICE4 on May 11, 2016. The water velocity and direction data were logged hourly for each meter of the water column at both locations and additional wave data was recorded at Turbine 4. Water velocity and directional data from the lake surface and bottom is illustrated in Figure 10 for May 12, 2016 to June 16, 2016. The Nortek ADCP wave height and Buoy 45169 wind speed was also implemented to better understand the lake hydrodynamics (Figure 11 and Figure 12).

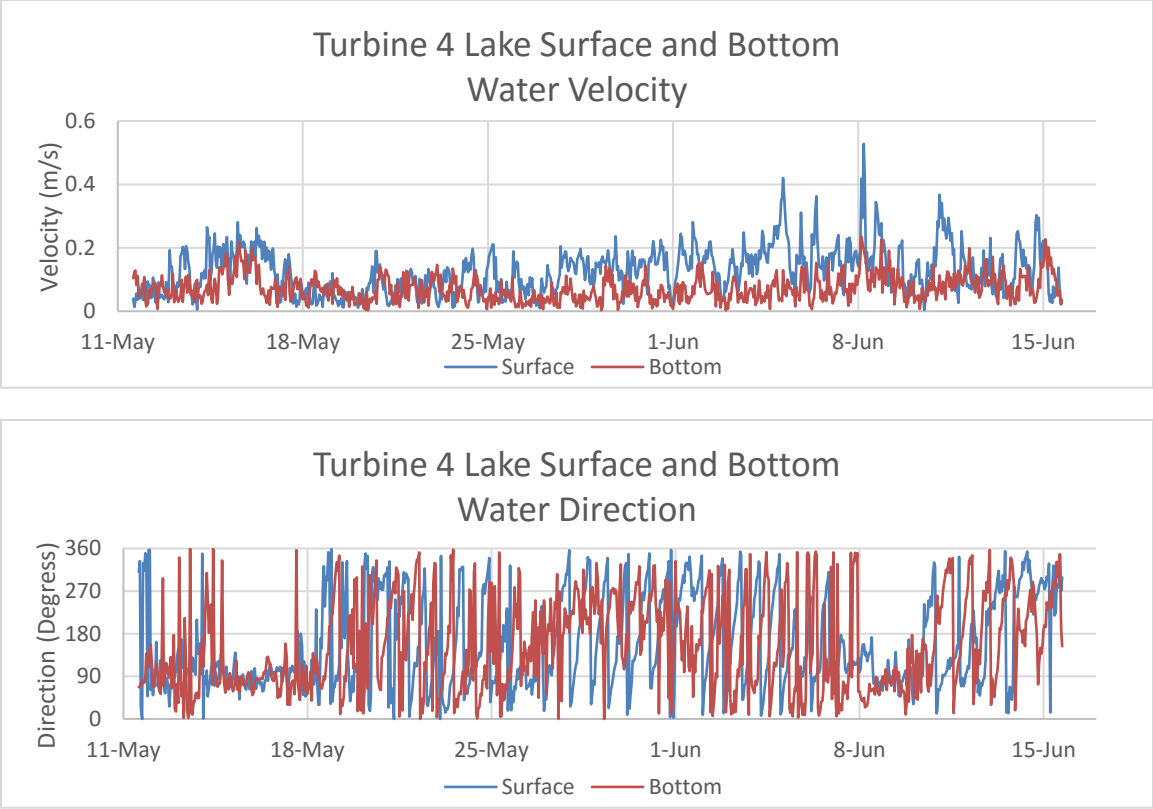


Figure 10: Lake surface and bottom water velocity (top) and direction (bottom).

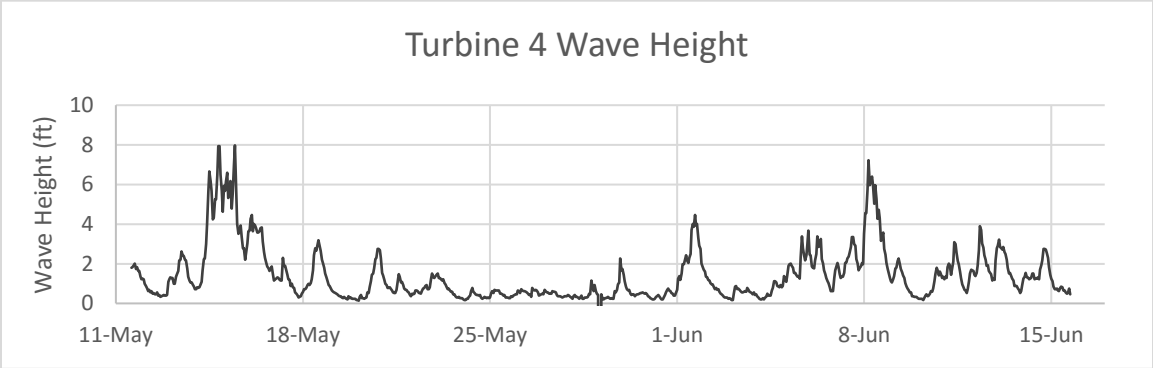


Figure 11: Wave height (m) at Turbine 4.

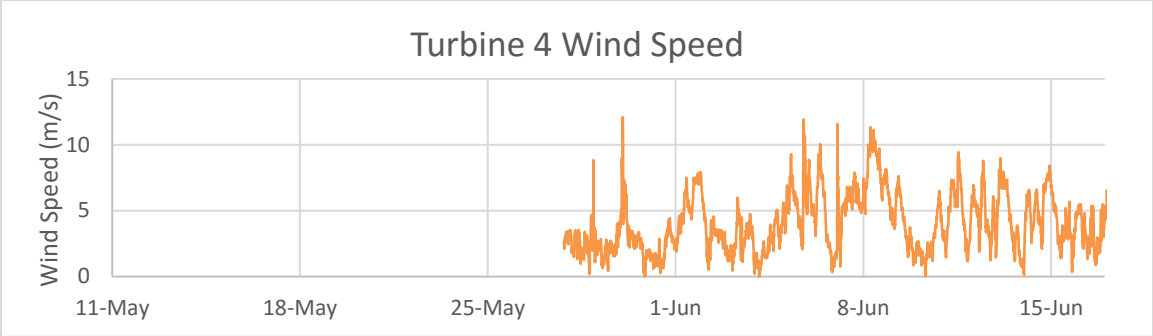


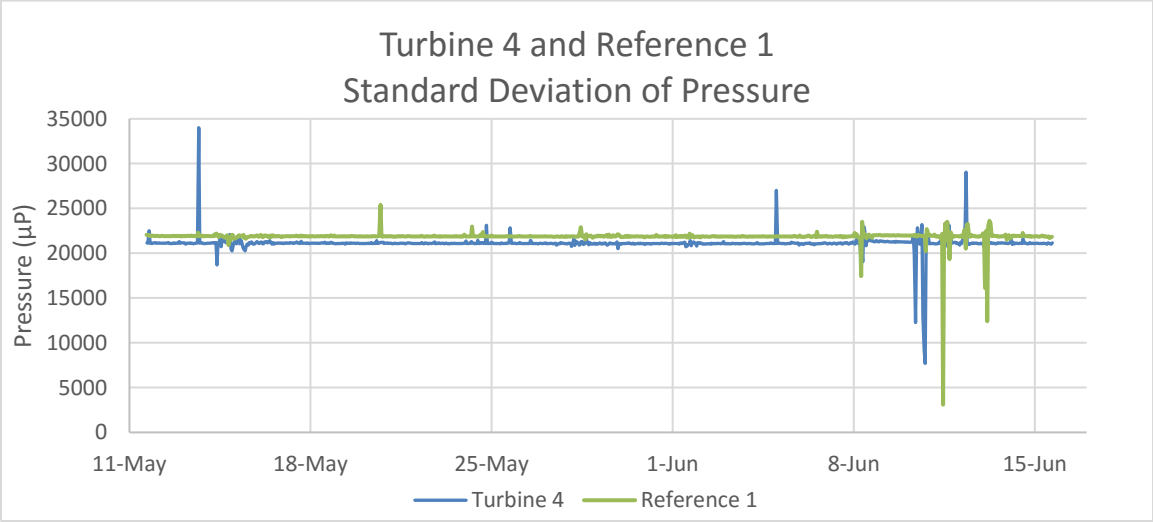
Figure 12: Wind speed (m/s) from buoy 45169 located at Turbine 4.

5. Fish Behavior

Noise

An OceanSonics Smart Hydrophone Soundtrap device was installed at Turbine station ICE4 and Reference station 1 two meters above the lake bottom to record 30 minutes every hour at 72 kHz. The Soundtraps were also set up to record water temperature every 10 minutes. High frequency pressure was processed from the raw data and the standard deviation was calculated for each 30 minute sample as an initial view of time periods with large sound variations (Figure 13). Raw data were retrieved in June and July and data processing and interpretation will be supported by the Cornell Bioacoustics team.

Figure 13: Standard deviation of each hourly 30 minute sound recording at Turbine 4 and Reference 1.



Aerial Surveys

Aerial surveys were conducted by Aerial Associates, Inc. within the study grid provided by the ODNR. Overflights were completed every third week, twice during the week (on one weekday and one weekend day), beginning on May 20, 2016. To date, surveys have been completed on May 20, May 22, June 5, June 6, June 30, and July 3 2016. The boat counts have varied from weekdays to weekends with a range of five boats on Monday June 6 to 188 boats on Sunday July 3, 2016. A summary of the boat counts across the survey area is shown in Table 15 below. Besides the boat count, Aerial Associates also provided airborne digital photography for quality control purposes for two of the surveys. A review of the images to date shows that pilot manual counts are accurate and are providing the information needed to assess boat traffic in the project area and surrounding Cleveland area. Boats within the Cleveland breakwalls or beached near swimming areas were not counted as part of the offshore boat survey. The surveys were limited to good weather days when aerial visibility was adequate and were at the discretion of the pilot. Count days were also coordinated to coincide with ODW creel surveys on Lake Erie.

Table 15. Preliminary count of boats in study area and surrounding Cleveland Area

Date	Type	Boats
Friday, May 20, 2016	Weekday	6
Sunday, May 22, 2016	Weekend	22
Sunday, June 5, 2016	Weekend	96
Monday, June 6, 2016	Weekday	5
Thursday, June 30, 2016	Weekday	66
Sunday, July 3, 2016	Weekend	188