October 27, 2010

UNITED STATES OF AMERICA
NUCLEAR REGULATORY COMMISSION
Before the Atomic Safety and Licensing Board

In the Matter of:	)	Docket No. 52-033
The Detroit Edison Company	)	
(Fermi Nuclear Power Plant, Unit 3)	)	
	)	

INTERVENORS' MEMORANDUM IN OPPOSITION TO DTE'S 'MOTION FOR SUMMARY DISPOSITION OF CONTENTION 6'

Now come Intervenors Beyond Nuclear, Citizens for Alternatives to Chemical Contamination, Citizens Environmental Alliance of Southwestern Ontario, Don't Waste Michigan, Sierra Club (Michigan Chapter), Keith Gunter, Edward McArdle, Henry Newnan, Derek Coronado, Sandra Bihn, Harold L. Stokes, Michael J. Keegan, Richard Coronado, George Steinman, Marilyn R. Timmer, Leonard Mandeville, Frank Mantei, Marcee Meyers, and Shirley Steinman (hereinafter "Intervenors"), by and through counsel, and set forth their opposition to the "Motion for Summary Disposition of Contention 6" brought by DTE, the Applicant.

Introduction

DTE considers Contention 6 to be one of omission insofar as the ASLB pared the originally-petitioned challenge down to (in DTE's words) "absence of a discussion of the potential contribution of chemical effluent and thermal discharges from the proposed Fermi Unit 3 to algal production in Lake Erie and the potential proliferation of the newly identified species of harmful algae." DTE Motion at 1. Be that as it may, Intervenors maintain that there are issues of material fact which, when coupled with hedge-language used by DTE as to "likelihoods", demonstrate that summary disposition is unwarranted and the contention must proceed to a merits hearing.

Legal Principles Governing Summary Disposition

Where a contention alleges the omission of particular information or an issue from an application, and the information is supplied later by the applicant, the contention is moot. *Amergen Energy Co., LLC* (Oyster Creek Nuclear Generating Station), LBP-06-16, 63 NRC 737, 742 (2006). However, Intervenors believe that important omitted information has been, at best, only partially supplied on this issue. As the attached "Statement of Facts Demonstrating Issues of Material Fact" reveals, DTE has not considered pertinent scientific literature which suggests that the cyanobacterium algae, *Lyngbya wollei*, has been found within 4 lake-surface miles of the site of Fermi 3; that *Lyngbya* is spreading and likely to prosper in substantial volumes immediately offshore from Fermi 3; and that the algae's successful colonization will probably be assisted both by the understated thermal plume and chemical effluent predicted to emanate from Fermi 3 on a continuing basis throughout plant operations.

The burden of proof with respect to summary disposition rests upon DTE, which must demonstrate the absence of any genuine issue of material fact. *Advanced Medical Systems, Inc.* (One Factory Row, Geneva, Ohio 44041), CLI-93-22, 38 NRC 102 (1993); *Dairyland Power Cooperative* (La Crosse Boiling Water Reactor), LBP-82-58, 16 NRC 512, 519 (1982), citing *Adickes v. Kress and Co.*, 398 U.S. 144, 157 (1970). Summary disposition is not appropriate when the movant fails to carry its burden of setting forth all material facts pertaining to its summary disposition motion. *Gulf States Utilities Co.* (River Bend Station, Unit 1), LBP-95-10, 41 NRC 460, 466 (1995). Thus, if a movant fails to make the requisite showing, its motion may be denied even in the absence of any response by the proponent of a contention. *La Crosse, supra,* 16 NRC at 519.

The moving party fails to meet its burden when the filings demonstrate the existence of a genuine material fact, when the evidence introduced does not show that the nonmoving party's position is a sham, when the matters presented fail to foreclose the possibility of a factual dispute, or when an issue arises as to the credibility of the moving party's evidentiary material. *Entergy Nuclear Vermont Yankee, L.L.C., and Entergy Nuclear Operations, Inc.* (Vermont Yankee Nuclear Power Station), LBP-06-5, 63 NRC 116, 122 (2006).

A summary disposition nonmovant is entitled to the favorable inferences that may be drawn from any evidence submitted. *See Sequoyah Fuels Corp.* (Gore, Oklahoma Site Decontamination and Decommissioning Funding), LBP-94-17, 39 NRC 359, 361, *aff'd*, CLI-94-11, 40 NRC 55 (1994). *Vermont Yankee*, LBP-06-5, 63 NRC at 121-22 (citing *Advanced Med. Sys., Inc., supra*.

Facts Demonstrating Issues of Material Fact

DTE claims that there has been no *Lyngbya wollei* identified at the Monroe Power Plant outfall. That plant is a DTE coal burning facility located 6 miles downstream (and southeast of) the proposed Fermi 3 site. DTE's statement is belied by an authoritative study performed and document by scientists at a University of Toledo laboratory, who in 2008 found traces of the miscroscopic *Lyngbya wollei* bacterium in waters off Sterling State Park, which is located between the Monroe Power Plant and Fermi 3. Statement of Facts ¶ 3.

While DTE has committed to not use phosphorous compounds for the control of corrosion and scaling at Fermi 3 after operations commence, it remains that a substantial amount of calcium will be pumped into the lake in Fermi 3's effluent. Statement of Facts ¶ 4. Calcium boosts the growth of *Lyngbya. Id.* The construction phase of Fermi 3 will also see calcium runoff from the excavation for the structural foundations, because the shallow bedrock in the vicinity is limestone, which contains calcium. Statement of Facts ¶ 5.

The bacterium also develops in poorly-lit lake bottom circumstances. The murkiness in Lake Erie waters off Fermi 3 will be increased by turbidity during the plant's construction and post-construction phases as a consequence of extensive dredging operations. Statement of Facts ¶ 6.

DTE has grossly understated the size and nature of the thermal plume which will flow from Fermi 3's cooling tower. While DTE maintains that Fermi operations will cause a 9' X 12' plume while pumping tens of millions of gallons of lakewater through its cooling system at the height of summer heat, calculations predicated on DTE's data show that Fermi 3 will routinely each day return at least 75.126 acre-feet of up to 96 degree F. water to Lake Erie, in the shallow (average depth 24 feet) western basin. Statement of Facts ¶ 4.

Conclusion

Intervenors have demonstrated differences of material fact on key issues. Changing the high-volume maintenance chemistry, which will then be disposed of as industrial waste in Lake Erie, may not be so "likely" to avoid a *Lyngbya wollei* problem in the vicinity of Fermi 3 as its proponents believe. Understating the true dimensions of the thermal plume which will emanate from Fermi 3 does not *ipse dixit* exculpate DTE from the environmental consequences of toxic cyanobacterium development. Erie's western basin averages about 24 feet of depth. Seventy-five acre-feet per day of thermal pollution equals 6 or 7 surface acres of 96 degree F. water daily, each of them 10 to 12 feet deep (the depth offshore from Fermi 3 is 8 to 13 feet). Power plants commonly create an artificial micro-climate from thermal pollution, and Fermi 3 will be no different. DTE has failed to explain, in any but a conclusory fashion, how Fermi 3 will not add to the poorly-understood *Lyngbya wollei* problem in Lake Erie. The Corps of Engineers has said that the impacts of *Lyngbya wollei* "are just beginning to be observed and documented." USACE "Western Lake Erie Basin Study: Maumee Bay Watershed Assessment," http://www.wleb.org/documents/assessments/Maumee%20Bay%20Final%20Assessment%20091509.pdf.

An evidentiary hearing is necessary if a genuine issue of material fact is in dispute. *Advanced Medical Systems, Inc.* (One Factory Row, Geneva, Ohio 44041), CLI-93-22, 38 NRC 98, 119-20 (1993). Intervenors dispute several critical factual claims advanced by DTE with significant evidence. Consequently, DTE's Motion should be denied and Contention 6 set for hearing.

Respectfully,

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In the Matter of:	)	Docket No. 52-033
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STATEMENT OF FACTS DEMONSTRATING ISSUES OF MATERIAL FACT, IN SUPPORT OF INTERVENORS' OPPOSITION TO DTE'S 'MOTION FOR SUMMARY DISPOSITION OF CONTENTION 6'

Now come the Intervenors herein, by and through counsel, and set forth material facts in support of their opposition to Applicant's "Motion for Summary Disposition of Contention 6."

1. At p. 27 (of the .pdf) of its February 15, 2010 letter (from Peter W. Smith, Director, Nuclear Development–Licensing and Engineering, DTE, NRC3-10-0005, "Detroit Edison Company Response to NRC Requests for Additional Information Letter No. 2 Related to the Environmental Review" (ADAMS Accession No. ML100541329)), DTE states that:

> The Monroe Power Plant, which is located several miles closer to the Maumee Bay than the Fermi site and generates a more robust thermal plume than Fermi 2, has no record of cyanobacterium, including *Lyngbya wollei*, at its outfall. This lack of observation is provided first by means of visual inspections by plant operators as part of the plant's NPDES permit. In addition, Detroit Edison biologists performed research within the plant's thermal plume from August through September since 2006. During the course of this research no observations of cyanobacterium, including *Lyngbya wollei,* have been made.

2. DTE's evidence is suspect. The actual observational data and testing techniques the utility gathered concerning, or applied on, *Lyngbya wollei* have not been made a matter of record, only DTE's conclusions. *Lyngbya* is a bacterium which grows on lake bottom surfaces and floats to the surface only when there is a buildup of gas beneath the mats that form. The bacterium itself is a tiny filament which can be viewed in the water column only by means of a compound microscope, so it is likely not to be visible to the naked eye during NPDES visual inspections, unless matted and floating in gigantic colonies.

3. An authoritative study of the Western Lake Erie Basin in 2008 found *Lyngbya* present offshore near Sterling State Park, which lies between the Monroe Power Plant (which is 2 miles south) and the site of Fermi 3 (which is 4 miles north). Bridgeman and Penamon, "*Lyngbya wollei* in Western Lake Erie," Journal of Great Lakes Research 36 (2010) 167, 168, Fig. 1 (copy of article attached). While the authors note that *Lyngbya* is "scarce" offshore from Sterling, it is nonethless present and their data is two years old. Since 2008, *Lyngbya*'s presence in Lake Erie is on the increase.

4. At ¶ 6 of its "Statement of Material Facts on Which No Genuine Issue Exists," DTE "credits the use of treatment chemicals that do not contain phosphorus or nitrogen compounds" for minimizing the effects Fermi 3 operations will have on *Lyngbya wollei*. However, the improved chemistry of Fermi 3 effluent to flow into Lake Erie will still deposit calcium (table, ER Rev. 2, p. 3-49, where Table 3.6-2 lists among "Effluent Chemical Constituents," calcium, at an average 71.9 ppm). Calcium is a nutrient source for *Lyngbya wollei*, see Joyner, "Growth Dynamics and Management of the Cyanobacterium, *Lyngbya wollei*, in NC and FL," powerpoint presentation, slides 13, 17, 18, http://www.ncsu.edu/wrri/conference/2006ac/pdf/Joyner.pdf. The entire region including the Fermi site rests on limestone bedrock. (FSAR), Rev. 1 - Chapter 02 - Site Characteristics - Section 02.04 - Hydrology ML091760823. Limestone contains calcium, and there will inevitably be runoff of calcium into Lake Erie from excavation to build the Fermi 3 foundation.

5. *Lyngbya* will also prosper with thermal heat exuded from Fermi 3 during operations. DTE's conclusion (¶ 6 of "Statement of Material Facts on Which No Genuine Issue Exists") that, "given the size and timing of the thermal discharges from Fermi Unit 3, the thermal plume is *unlikely to substantially stimulate algal growth*" (Emphasis supplied) is suspect. This conclusion stems from DTE's minimization of the thermal plume to a 9' X 12' surface area of Lake Erie in late summer. The size of the thermal plume which is calculable from dimensions contained in the ER is predicted to be an estimated maximum 75.126 acre-feet per day @ 96 degrees F.[1] The plume is thus likely to help sustain *Lyngba,* which already has demonstrated winter-hardiness, through the colder seasons.

6. Bridgeman and Penamon identify one of the reasons for the rapid onset of *Lyngbya* colonies in the Maumee Bay (20 miles south of the Fermi site in Lake Erie's western basin) as the bacterium's ability to thrive in murky lake bottom circumstances, caused by turbid water conditions. *Id.* pp. 168-69. Large-scale dredging during the construction of Fermi 3, described at ER Rev. 1 pp. 4-24, 4-25, 4-30, 4-31, 4-49, 4-52, as well as recurring dredging activities for a barge slip and intake embayment as ongoing operations and maintenance (p. 4-52) will cause, by DTE's admission, turbidity and benthic disruptions.

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[1]From ER page 3-17 Ch. 3 Rev. 1: Discharge of 17,000 gpm x 60 min. x 24 hrs. = 24,480,000 gal. per day / 325,851 U.S. gal./acre = 75.127 ac.-ft.

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CERTIFICATE OF SERVICE

I hereby certify that copies of "Intervenors' Opposition to 'Motion for Summary Disposition of Contention 6'" and "Statement of Facts Demonstrating Issues of Material Fact, in Support of Intervenors' Opposition" have been served on the following persons via Electronic Information Exchange this 27th day of October, 2010:

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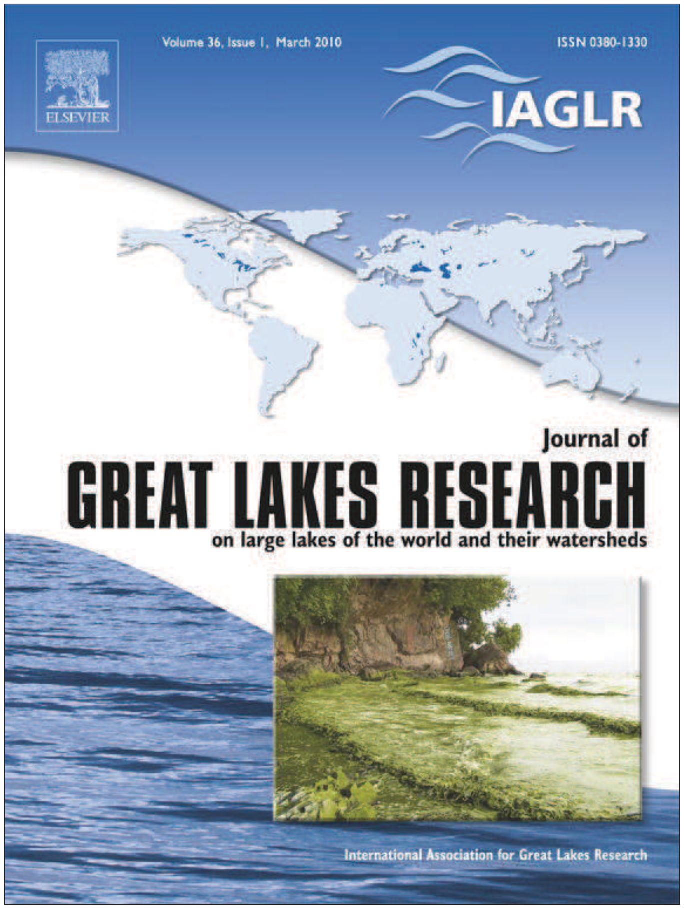
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Lyngbya wollei in western Lake Erie

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A B S T R A C T

We report on the emergence of the potentially toxic filamentous cyanobacterium, *Lyngbya wollei* as a nuisance species in western Lake Erie. The first indication of heavy *L. wollei* growth along the lake bottom occurred in September 2006, when a storm deposited large mats of *L. wollei* in coves along the south shore of Maumee Bay. These mats remained intact over winter and new growth was observed along the margins in April 2007. Mats ranged in thickness from 0.2 to 1.2 m and we estimated that one 100-m stretch of shoreline along the southern shore of Maumee Bay was covered with approximately 200 metric tons of *L. wollei*. Nearshore surveys conducted in July 2008 revealed greatest benthic *L. wollei* biomass (591 g/m^2 ± 361 g/m^2 fresh weight) in Maumee Bay at depth contours between 1.5 and 3.5 m corresponding to benthic irradiance of approximately 4.0–0.05% of surface irradiance and sand/crushed dreissenid mussel shell-type substrate. A shoreline survey indicated a generally decreasing prevalence of shoreline *L. wollei* mats with distance from Maumee Bay. Surveys of nearshore benthic areas outside of Maumee Bay revealed substantial *L. wollei* beds north along the Michigan shoreline, but very little *L wollei* growth to the east along the Ohio shoreline.

Introduction

The filamentous cyanobacterium *Lyngbya wollei* (Farlow ex Gomont) Speziale and Dyck is a freshwater nuisance alga in the southeastern United States (Speziale and Dyck, 1992). *L. wollei* is commonly found from North Carolina to northern Florida where it is usually described as growing in mats along the bottom of ponds and reservoirs or, in larger water bodies, in shallow, protected embayments (Speziale and Dyck, 1992; Cowell and Botts, 1994; Stevenson et al., 2004). Recently, molecular phylogenetic analysis of southern populations indicates that *L. wollei* encompasses at least two species (Joyner et al., 2008). In southern states, *L. wollei* mats may become perennial (Speziale and Dyck, 1991) and typically become apparent in summer when mats float to the surface where they may become a nuisance by clogging waterways (Beer et al., 1986). Reports of *L. wollei* are not limited to the south. Descriptions of floating *Lyngbya* mats (probably *L. wollei*) in New England ponds date to the nineteenth century (Speziale and Dyck, 1992). Recently, *L. wollei* infestations have been reported in two shallow lakes in Whiteshell Provincial Park near Winnipeg, Manitoba (Winnipeg Free Press 2003) where it is believed that the cyanobacterium was accidentally introduced by boats and trailers that are transported to southern states during winter. In the Great Lakes region, *L. wollei* has recently been found to dominate the benthic macroalgae in a section of the St. Lawrence River that is influenced by the discharge of nearby nutrient-rich tributaries (Vis et al., 2008). In addition to the nuisance caused by large mats, North American blooms of *L. wollei* have been found to produce paralytic shellfish toxins (PSTs) (Carmichael et al., 1997; Onodera et al., 1997), but to date the Lake Erie strain has not been reported to contain PSTs.

In 2006, large shoreline mats of a filamentous cyanobacterium fitting the description of *L. wollei* appeared in western Lake Erie. Genetic and morphological analyses of this material indicated that Lake Erie *L. wollei* could be grouped with one of the distinct *L. wollei* subclusters (OTU3) found in the Florida panhandle region (J. Joyner, personal communication). While it remains uncertain whether the nuisance strain is an introduced form of *L. wollei* from southeastern U.S.A., or a strain previously recorded in Lake Erie, *Plectonema wollei* (Taft, 1942), the sudden appearance, size and endurance of the mats has caused great concern among shoreline property owners, beach managers, and public officials. In this report, we provide observations on the location, size, and biomass of shoreline mats and nearshore growing regions.

Materials and methods

Samples of the cyanobacterial mats along the shoreline and bottom of Maumee Bay were collected between April 2007 and July 2008 (Fig. 1). Identification of *L. wollei* in Lake Erie was made using the description by Speziale and Dyck (1992). Cell and filament dimensions were measured using a Leica compound microscope at 400×. Initial assistance in identification was provided by R. Lowe at

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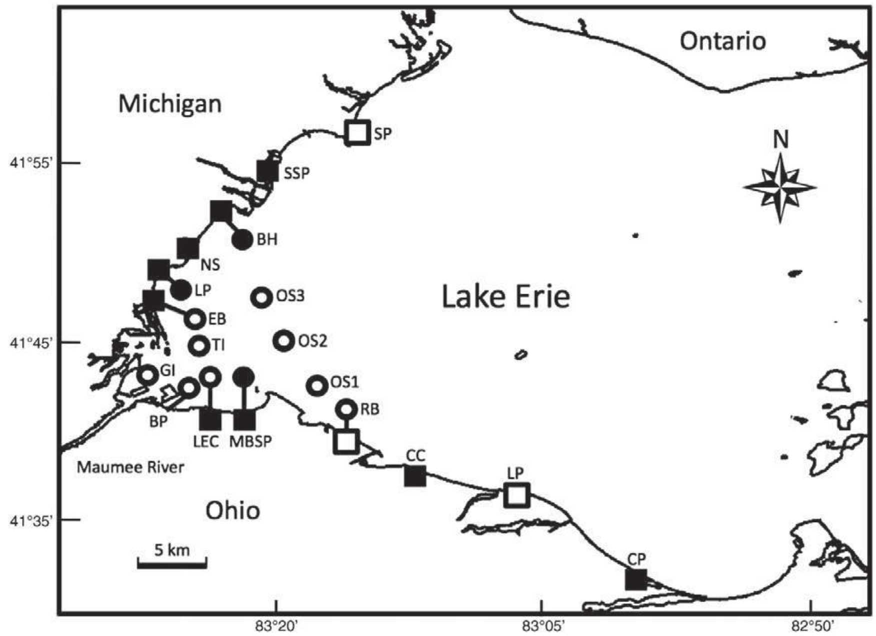

Fig. 1. Locations of shoreline survey (squares) and benthic samples (circles) in western Lake Erie in 2008. Closed symbols represent presence of *L. wollei* and open symbols represent absence. Lines represent transects with several additional samples collected across depth contours. Sites counterclockwise along the shore: Stony Pont (SP), Sterling State Park (SSP), Bolles Harbor (BH), North Shore (NS), Luna Pier (LP), Erie Beach (EB), Bayshore Plant (BP), Lake Erie Center (LEC), Maumee Bay State Park (MBSP), Reno Beach (RB), Crane Creek (CC), Locust Point (LP), Camp Perry (CP). Additional lake sites: Grassy Island (GI), Turtle Island (TI), Offshore (OS 1–3).

Bowling Green State University and later confirmed by preserved samples sent to B. Speziale (B. Speziale, Clemson University, personal communication).

A survey for the presence of *L. wollei* along the shoreline of southwestern Lake Erie was conducted in June and July 2008 along an 87 km stretch of shoreline from Stony Point, Michigan to Port Clinton, Ohio (Fig. 1). Beaches and other publicly accessible locations were surveyed visually and if filamentous algae were present, samples were collected for later identification. Benthic surveys for submerged *L. wollei* mats were conducted from small boats in July 2008 at 12 locations in or adjacent to Maumee Bay (Fig. 1). At several nearshore locations, a series of bottom samples were collected in transects perpendicular to the shoreline (indicated by lines in Fig. 1) along a range of bottom contours ranging from 0.5 m to 5 m in depth. The presence of *L. wollei* mats was detected using a benthic rake, and an Ekman grab sampler. The benthic rake was used to identify the presence of *L. wollei* beds at depths up to 3.5 m. If *L. wollei* was detected, 5 grab samples were collected at the location. *L. wollei* from each grab sample was separated from sediments using a sieve bucket (Wildco, 500 um mesh) for later biomass determination. At depths >3.5 m, grab samples only were collected. At the location that probably had the densest growth of *L. wollei* (Bolles Harbor 2), the thickness of the *L. wollei* bed prevented penetration by either an Ekman or a petite Ponar dredge. Samples from each location were examined using a compound microscope to identify algal filaments. *L. wollei* fresh wet was determined by pressing extraneous water from samples and then weighing. Dry weight was determined by drying samples at 65 °C to a constant weight.

Subsurface irradiance measurements, which are used here to calculate typical benthic irradiance in Maumee Bay were made at various locations in Maumee Bay and western Lake Erie between May and October of 2002–2005 as part of a water quality monitoring program. Measurements were made using an integrating quantum radiometer (LI-188B, Li-Cor, Inc.) equipped with a spherical sensor. The average irradiance just beneath the water surface (0 m) was calculated from all measurements ($N = 112$) and the average extinction coefficient for photosynthetically active radiation (K_{PAR}) for nearshore areas was calculated using only measurements taken within Maumee Bay or adjacent regions that are frequently subject to the turbid conditions of the Maumee River plume ($N = 61$).

The size and volume of the *L. wollei* mat along a 100 m relatively sheltered section of shoreline near the University of Toledo Lake Erie Center (Fig. 1, LEC) was estimated using a 60-m tape measure and graduated 1.3 m dowel rods to probe the thickness of the mat. A grid pattern was established along the shore with the thickness of the mat probed every 2 m. A post-hole digger was used in several locations to verify that the dowel rods accurately gauged mat thickness. Volume was calculated by dividing the mat into sections (ridges and low areas), multiplying mat thickness by surface area of the sections, then summing over the sections. Fresh biomass of the mat was estimated by weighing 12 L buckets full of cyanobacteria to determine *L. wollei* biomass per liter.

Results

Shoreline mats

Shoreline residents along southern Maumee Bay reported that mats of filamentous algae first appeared on their property following an unusual period from August 28 to September 2, 2006 when strong winds blew from the northeast for 6 consecutive days. During this period, wind speeds averaged 23 km/h (NOAA Databuoy Station SBI01)). The strong northeasterly winds temporarily elevated water levels in Maumee Bay to 50–100 cm above the season average (NOAA Station 9063085, Toledo) and caused extensive wave action along the shoreline. When the lake calmed and the water receded on September 2, mats of *L. wollei* were left behind on the shore. Shoreline areas protruding into the lake were not affected, while coves received large mats. We calculated that the 100 m shoreline in a small cove (sheltered on three sides) near the Lake Erie Center (Fig. 1, LEC) received approximately 200 metric tons of *L. wollei*.

The appearance of this large biomass over the course of a few days suggests that *L. wollei* had been growing unnoticed in Maumee Bay for most of the summer before being dislodged by the storm. Plankton tows collected in Maumee Bay between May and August 16, 2006 as part of a monitoring program did not contain filaments, indicating that *L. wollei* was not present in the water column during most of the summer. Shoreline mats were resistant to decay over the winter of 2006–2007, with green, potentially viable filaments found a few centimeters below the dried crust formed by the mat surface. In April 2007, substantial fresh material was added to the mats. Throughout the summer of 2007, terrestrial plants colonized the shoreline mats until in some places the mats were no longer visible beneath the vegetation. In early October, 2007, submerged mats growing at depths of 1-2 m at Maumee Bay State Park (Fig. 1, MBSP) were observed in the process of separating from the bottom and floating to the surface. On October 8, floating mats estimated in size from 3 to 150 m^2 were observed floating as far as 15 km from shore. Fragments of dreissenid mussels were often found entangled on the underside of floating mats. During this period, prevailing winds were from the south and west, therefore there was little addition to the shoreline mats. In April 2008 and again in April 2009, fresh material was observed either growing at the margin of the shoreline mats, or being washed ashore.

Shoreline survey

In July of 2008, a survey of *L. wollei* presence was conducted at 12 locations along the Lake Erie Shoreline between Stony Point, Michigan (SP) and Port Clinton, Ohio. *L. wollei* was found at 9 of the 12 locations (Fig. 1). In general, the prevalence of *L. wollei* on the shoreline decreased with increasing distance from Maumee Bay. Along the Michigan shoreline, *L. wollei* was scarce at locations (Fig. 1: SSP, SP) north of Bolles Harbor (Fig. 1, BH), where most of the filamentous algae found on the shore was *Cladophora* sp. Likewise, on the Ohio shoreline, *L. wollei* became increasing scarce east of Maumee Bay (Fig. 1: RB, SC, LP, CP). The material washed ashore in Maumee Bay and along the Michigan shoreline adjacent to the bay appeared to be fresh, suggesting transport from nearby growing areas. *L. wollei* masses that were found on the shoreline east of Maumee Bay near Swan Creek (SC) and Camp Perry (CP) had filaments that were fragmented and upon microscopic examination, found to be largely dead or senescent, suggesting transport from a more distant location.

Benthic mats

In order to determine areas of active growth, benthic surveys for submerged *L. wollei* mats were conducted in July 2008 at 12 main locations in or adjacent to Maumee Bay (Fig. 1). The greatest biomass of benthic mats was observed at two locations, Bolles Harbor (BH) and Maumee Bay State Park (MBSP), at distances of about 250–500 m from the shore at water depths from 1.5 to 3.5 m (Table 1). Mats of lower biomass were found over a similar range of depths near Luna Pier, MI. Very little benthic *L. wollei* was detected at sites east of Maumee Bay (Table 1: RB) or at offshore sites (Table 1: OS1, OS2, OS3).

Measurements of PAR were used to determine irradiance levels in benthic areas where *L. wollei* was prevalent. The average sub-surface (0 m) light level measured from 2002 to 2004 was 1638 μE/m^2 s, and the average of nearshore PAR extinction coefficients (K_{PAR}) was 2.19. Applying the average K_{PAR} value to the average 0 m light level produced average mid-day benthic irradiance values of 61.3 μE/m^2 s (about 4% of subsurface light) at a depth of 1.5 m and 0.8 μE/m^2 s (about 0.05% surface light) at a depth of 3.5 m. In transects conducted perpendicular to shore from bottom depths between 0.5 m to 5.0 m, little *L. wollei* was found at depths shallower than 1 m, presumably due to wave action. *L. wollei* biomass increased with increasing depth to a maximum at depths between 1.6 m (BH1) and 3.5 m (LP2). At depths deeper than 3.0–3.5 m, *L wollei* density tended to decrease. At most locations, substrate type did not change markedly with increasing depth. Although dissolved nutrient concentrations (N and P) were not measured for this study, a previous study indicates that nutrient concentrations decline over a span of several kilometers with increasing distance from the mouth of the Maumee River (Moorhead et al., 2003). Also, summer nutrient concentrations are usually sufficient to grow large blooms of nuisance algae (*Microcystis* sp.) throughout the bay. We would not expect a steep nutrient gradient over the range of the few hundred meters in which *L. wollei* beds were most prevalent. Therefore we suspect that the decrease in *L. wollei* density with depth was due more to light limitation than change in substrate type or nutrient concentrations.

Although no quantitative data were collected on substrate type, we observed some general associations between *L. wollei* and substrate type. In most cases where *L. wollei* appeared to be growing in place, the substrate consisted of sand, dreissenid clusters, fragmented dreissenid shells, or a mixture of the three. *L. wollei* mats were not found growing on very soft, silt sediments (Table 1: EB1–2, OS2–3), and only trace amounts were detected on hard, compacted clay bottom (Table 1: RB 1–5, OS1, TI).

Table 1
Location, water depths, and substrate types of sampling sites including wet and dry weights of *L. wollei* from 5 replicate benthic grabs plus or minus standard error. Where quantitative measurements could not be taken, + indicates trace amounts of *L. wollei*, ++ moderate, +++ heavy, and ++++ indicates *L. wollei* mat too dense for sampling with dredges. Samples were collected June–July 2008.

Location	Depth (m)	Wet wt. (g/m^2)	Dry wt. (g/m^2)	Substrate
Bolles Harbor				
BH1	1.6	156 ± 122	23 ± 18	Sand, dreissenids
BH2	2.6	++++		Sand, dreissenids
BH3	3.3	115 ± 41	25 ± 8	Sand, dreissenids
Luna Pier				
LP1	2.0	2 ± 2	0.8 ± 0.7	Sand, dreissenids
LP2	3.5	53 ± 25	9 ± 4	Sand, dreissenids
LP3	4.1	1 ± 1	0.2 ± 0.2	Sand, dreissenids
Erie Beach				
EB1	2.7	0	0	Silt
EB2	5.0	0	0	Silt
Turtle Is. (TI)	2.0	+		Compacted sediment
Grassy Is. (GI)	1.5	0	0	Soft
Bayshore Plant				
BP1	2.0	0	0	compacted, cobble
BP2	2.4	0	0	compacted, cobble
BP3	2.8	0	0	compacted, cobble
L. Erie Center				
LE1	1.9	+		Sand, dreissenids
LE2	2.3	++		Sand, dreissenids
LE3	2.7	+++		Sand, dreissenids
LE4	3.1	0	0	Sand, dreissenids
LE5	3.4	0	0	Sand, dreissenids
Maumee Bay SP				
MBSP1	0.5	0	0	Sand
MBSP2	1.5	+		Sand
MBSP3	2.0	591 ± 361	75 ± 45	Sand, dreissenids
MBSP4	2.8	501 ± 167	70 ± 23	Sand, dreissenids
MBSP5	3.1	186 ± 122	27 ± 16	Sand, dreissenids
MBSP6	3.4	164 ± 164	22 ± 22	Sand, dreissenids
MBSP7	3.5	2 ± 2	0.5 ± 0.5	Sand, dreissenids
Reno Beach				
RB1	1.0	0	0	Sand, dreissenids
RB2	2.0	0	0	Sand, dreissenids
RB3	3.1	0	0	Sand, dreissenids
RB4	4.1	2 ± 2	0.5 ± 0.5	Sand, dreissenids
RB5	5.3	1 ± 1	0.2 ± 0.2	Sand, dreissenids
Offshore Sites				
OS1	5.2	0	0	Compacted
OS2	5.8	0	0	Silt
OS3	6.5	0	0	Silt

Discussion

The recent blooms of *Lyngbya wollei* in western Lake Erie are part of a trend towards increased coverage and biomass of filamentous benthic algae in the Laurentian Great Lakes exemplified by the re-emergence of *Cladophora* sp. in eastern Lake Erie (Higgins et al., 2005) and Lake Michigan (Bootsma et al., 2005). The shift toward benthic macroalgae has been attributed in large part to the colonization of nearshore regions by dreissenid mussels which provide habitat for *Cladophora* by improving water clarity thereby increasing light to the benthos, recycling nutrients for algal growth, and providing surfaces for algal attachment (Hecky et al., 2004). In many ways, Maumee Bay would seem to be highly suitable for benthic macroalgae; it is rich in nutrients, shallow, and warm. However, while *Cladophora* has returned to nuisance levels in other nearshore areas of Lake Erie, Maumee Bay has remained relatively *Cladophora*-free.

The scarcity of *Cladophora* in Maumee Bay in Maumee Bay can likely be attributed to two resources: light and substrate. The minimum mid-day irradiance for *Cladophora* growth in Lake Erie has been reported to be about 50 μE/m^2 s (Lorenz et al., 1991). Given the high levels of suspended sediments and high average K_{PAR} in Maumee Bay, *Cladophora* would be restricted to a narrow band around the shoreline at depths less than about 1.6 m. In addition to light levels, *Cladophora* is limited by the availability of suitable substrate for attachment. The rocky substrates preferred by *Cladophora* are uncommon in the Maumee Bay region, where typical bottom types are sand, silt, and consolidated sediments. Although dreissenid shells provide attachment for *Cladophora*, the shallower regions where there is enough light for *Cladophora* growth generally have few intact dreissenid clusters. More common in this high-energy environment is a layer of crushed dreissenid shells that is not suitable for *Cladophora* attachment (Higgins et al., 2005).

In contrast to *Cladophora*, southern U.S. strains of *L. wollei* require much less light (Pinowska et al., 2007), and therefore can grow at greater depths or under more turbid conditions. If the Lake Erie strain is similar to the southern strains in its low light requirements, this could help to explain the distribution of *L. wollei* in turbid Maumee Bay where peak biomass of *L. wollei* usually occurred at depths between 2.0 and 2.8 m, corresponding to average benthic irradiances between 18 and 53 μE/m^2 s. Pinowska et al., 2007 reported optimum light levels of 50 μE/m^2 s for southern L. wollei strains. Also, *L. wollei* does not require an attachment to hard substrates. Observations by divers in Maumee Bay indicate that *L. wollei* filaments form a loose association with the substrate by becoming partially buried in the types of sandy or crushed dreissenid shell substrates that are common in Maumee Bay. Gentle water currents were not seen to dislodge *L. wollei*, but divers could dislodge the mats with a light tug. Based on the prevailing light and substrate characteristics, much of the Maumee Bay area could be expected to be better habitat for *L. wollei* than for *Cladophora* sp. In most locations sampled, the type of substrate that supported the greatest density of *L. wollei* was a mixture of fragmented dreissenid shells and sand, therefore it is possible that by providing improved substrate, the colonization of western Lake Erie by zebra and quagga mussels may have assisted *L. wollei* in becoming established.

The nearshore areas beyond Maumee Bay have not been fully explored for benthic *L. wollei* mats, but the lack of fresh material washing ashore in 2008 suggests that benthic mats may not have been present east of Maumee Bay at that time. More recent observations indicate that the biomass of *L. wollei* washing ashore east of Maumee Bay has increased, however it is unknown whether this material represents an eastward expansion of benthic mats or washout from Maumee Bay. There could be several factors that affect the expansion of *L. wollei* east along the Lake Erie shoreline. These factors include nutrient concentrations (N, P), which are high in Maumee Bay, but decrease sharply with distance from the bay (Moorhead et al., 2008), greater bottom slope, which narrows the suitable depth contours for *L. wollei* growth, and less protection from wave energy.

Because of the difficulty of sampling year-round in western Lake Erie, the annual growth patterns of *L. wollei* in Lake Erie remain poorly understood. The appearance of substantial fresh *L. wollei* growth on the Lake Erie shoreline each April is especially intriguing because water temperatures at that time are much lower than the summer temperatures usually associated with cyanobacterial blooms. Following the brief period in April when fresh biomass is deposited on the shoreline, *L. wollei* grows unobtrusively on the bottom during the summer months until late summer when mats begin to separate from the bottom and float to the surface. This pattern suggests that benthic mats are growing during the summer months until they reach sufficient thickness to trap gas bubbles underneath, which then causes the mats to become buoyant. This pattern of bubble accumulation and mat separation has been observed frequently in the southeastern U.S. strains of *L. wollei* (Speziale et al., 1991) with the difference that in the warmer climate, mats are benthic throughout the winter and become buoyant earlier in the spring or summer.

The maximum biomass/m^2 observed in western Lake Erie in 2008 was nearly 3 times higher than that observed in the St. Lawrence River in 2005 (27 g dry wt./m^2, Vis et al., 2008), but about 11 times lower than what has been recorded for *L. wollei* in the southeastern U.S. (6.6 kg/m^2 fresh weight, Speziale et al., 1991; 1 kg/m^2 dry wt., Cowell and Botts, 1994). However, it is likely that benthic biomass in Lake Erie frequently exceeds the maximum reported here because mats may have continued to accumulate biomass for a month or more after our sampling in July. Also in some of the areas of densest growth, benthic mats were too thick for penetration by Ekman or petite Ponar dredges.

In summary, since 2006, *L. wollei* has become established as a reoccurring nuisance algal species in the Maumee Bay region of western Lake Erie, with benthic mats growing throughout the summer and surface mats appearing in late summer. Patterns of biomass on the lake bottom suggest that *L. wollei* grows best at depths between about 1.5 and 3.5 m in a substrate of mixed sand and fragmented dreissenid shells, which would mean that a large portion of Maumee Bay may be potential habitat for *L. wollei*. The general decrease in *L. wollei* prevalence with increasing distance from Maumee Bay suggests that conditions outside of the bay are less suitable for *L. wollei* growth. However, the great mobility of floating *L. wollei* mats in late summer suggests that *L. wollei* will be able to disperse along the shoreline and eventually inhabit most shoreline areas having local conditions that are suitable for its growth.

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