Western Lake Erie
Report Card

Scores and Scoring Methodology

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The development process and methods for the Western Lake Erie report card

A general overview

Ecosystem health assessments have become more common in recent years, and report cards are being produced by a variety of groups from small, community-based organizations to large partnerships. Ecological report cards provide a numeric score and are considered a public-friendly way to provide a timely and geographically detailed assessment of ecosystems.

Environmental monitoring has been conducted in Western Lake Erie basin and watershed for many years and there is a need to communicate the data collected. Synthesizing and integrating the data into a document that is accessible to the general public and stakeholder groups throughout the western Lake Erie region informs the community of the health of their local environment. However, not all the information that is generated by this process can fit into a public-friendly report card. The following pages describe in detail the methods and scoring procedures used to develop the Western Lake Erie report card.

A number of steps were taken in the development of the report card. The first full stakeholder workshop was conducted November 27–28, 2018 at Castaway Bay in Sandusky, Ohio. Attendees included members of the Lake Erie Foundation and stakeholders from the City of Defiance, City of Toledo, City of Oregon, Lucas County, University of Toledo, Heidelberg University, USGS, NOAA, EPA, LimnoTech, Ohio Lake Erie Commission, Ohio EPA, Ohio Sea Grant, and the Nature Conservancy. The main goals of the November workshop were to conceptualize the system and identify key values, threats, and potential indicators.

Following the first workshop a webinar occurred February 4, 2019 to review the results of the workshop and plan the next steps for indicator selection, data sourcing, and data analysis.

The second workshop was held April 24–25, 2019 at University of Toledo's Lake Erie Center in Oregon, Ohio. This workshop helped to further define the indicators, data sources, and thresholds for scoring. The reporting region maps were finalized as well as the list of indicators.

After the workshops, numerous conference calls occurred to source data, review data analysis and report card scores, and design and produce content for the report card. Working groups were established to provide expert review and input for both the lake and watershed analysis. Several in-person meetings occurred in October and November 2019 to meet with stakeholders in Michigan and Ontario. These meetings resulted in the acquisition of additional data for the report card. A webinar on December 19, 2019 reviewed the report card scoring in preparation for the scores to be finalized.

The report card provides a transparent, timely, and geographically detailed assessment of the overall health of the Western Lake Erie basin and its watershed using mostly 2018 data. In addition to the scores, background information about key features, values, and threats in Western Lake Erie, discussion about the main results, and key stories were included in the report card document. In the years that follow, additional indicators can be added to the analysis, and thresholds can be refined based on further research.

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Introduction

Ecological report cards are a public-friendly way to provide a timely and geographically detailed assessment of ecosystems. Report cards provide a numeric score, allowing for quick results that are understandable to a broad audience. One key aspect of report cards is that they integrate and synthesize diverse data sources and types. Over the last ten years, report cards have gained popularity as a communication tool in the United States (Chesapeake Bay, Gulf of Mexico, Mississippi River, Long Island Sound, Everglades) as well as on an international scale (Great Barrier Reef, Australia; Chilika Lake, India; Orinoco River, Colombia; Guanabara Bay, Brazil).

Existing data collected over many years provides an excellent platform and material to develop a report card that synthesizes, interprets, and disseminates information about the region. Ultimately, the Lake Erie Foundation plans to use this iterative process of creating report cards to improve community and management awareness and understanding of the status of health of the Western Lake Erie basin and watershed in a succinct format. The primary objectives of this project are to collate and compile data, review relevant indicators, and synthesize information to effectively report the environmental status of the Western Lake Erie basin and watershed.

Determining indicators

Figure 1 illustrates the process of report card production. There are four main steps: 1) Indicator selection and approach, which includes assessing currently available data as well as the "ideal" datasets, 2) Indicator development, which includes developing targets or thresholds (discussed more in the next section) for each indicator, 3) Integrating indicators into an overarching index, and 4) Communicating the results through a report card product. Fundamentally, all report cards should be based on indicators and indices that are scientifically defendable, preferably peer-reviewed, and transparent. The data and methods underlying the report card should be understandable and clear to all audiences, should they want to focus on individual metrics that make up indicators or indices.

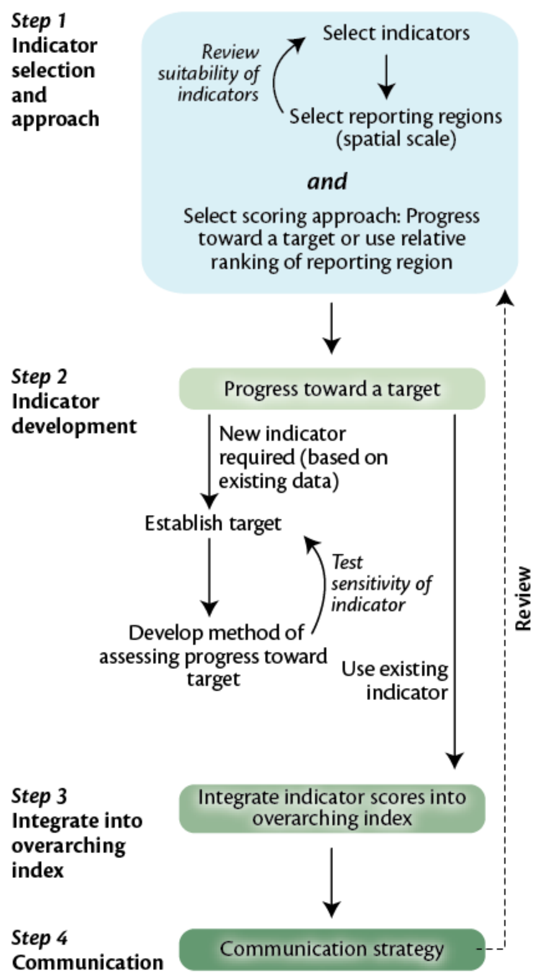

Figure 1: The report card process.

For the Western Lake Erie Report Card, several stakeholder workshops were convened throughout the duration of the project. One of the main goals of the workshops was to determine potential indicators for the report card (image at right). The workshop started with a full list of potential indicators from the following categories: water quality, fisheries, wildlife, human health, toxic contaminants, and others. As the discussions continued, an ideal list of report card indicators was collated. From there, the spatial and temporal resolutions of the indicators were determined to ensure that there was sufficient amount, coverage, and frequency of available data for the analysis. Other indicators not currently in the report card can be incorporated in the future with additional research and supported monitoring programs.

Participants at the first Western Lake Erie Report Card workshop held November 2018 in Sandusky, Ohio.

Region and sub-region determination

Regions and sub-region areas are usually determined based on geographic features (such as geology or land use) or hydrology (such as drainage basin size, water circulation patterns, or water flow). For example, if there is an upstream portion, a mixing portion, and a "receiving waters" portion, those could be three sub-regions of a river. All sub-regions must have enough sampling sites to be scientifically rigorous and provide consistent analysis.

The regions for the Western Lake Erie Report Card were determined by the stakeholders during the workshops, webinars, and follow up meetings. The lake regions (Figure 2) were based on conditions in the lake and professional scientific judgement. There are six regions in the lake, the Northwest (1), Southwest (2), Maumee (3), Northeast (4), Eastern Islands (5), and Sandusky (6).

The watershed regions (Figure 3) were determined by using the 8-digit HUC watershed boundaries in the US and the tertiary watershed boundaries in Canada. Some of the HUC 8 watersheds were combined for those regions with insufficient data. There are thirteen watershed regions, the Upper Thames (1), Lower Thames (2), Essex (3), Detroit (4), Raisin/Huron (5), Tiffin (6), St. Joseph (7), St. Marys (8), Upper Maumee (9), Auglaize (10), Lower Maumee (11), Cedar/Portage (12), and Sandusky (13).

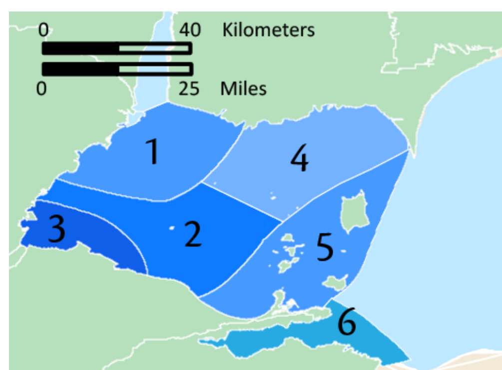

Figure 1: Western Lake Erie report Card lake regions.

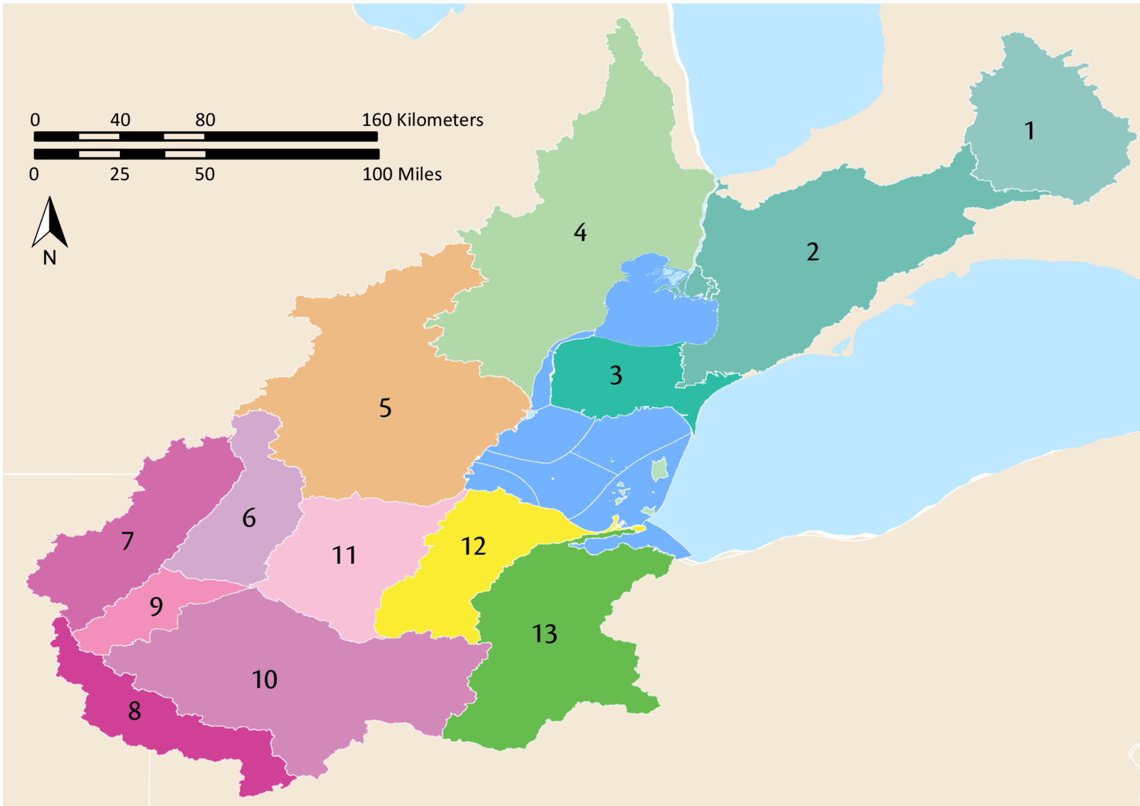

Figure 2: Western Lake Erie Report Card watershed regions.

Indicator thresholds and scoring

The indicators in this report card help answer the question "How healthy is the Western Lake Erie and its watershed?" For the Western Lake Erie (lake), the indicators were total phosphorus, dissolved phosphorus, total nitrogen, nitrate+nitrite, chlorophyll *a*, walleye, yellow perch, emerald shiner, bloom index, source water toxin, and recreational toxin. For the western Lake Erie watershed, the indicators were total phosphorus, dissolved phosphorus, total nitrogen, nitrate+nitrite, total suspended solids, fish, marcoinvertebrates, habitat quality, fish consumption, source water toxin, and pesticides. The indicators were compared to scientifically derived thresholds or goals. For each region, the indicators were combined into an overall health index, which is presented as a percent score. The region scores were area-weighted and combined into the overall Western Lake Erie lake score and overall Western Lake Erie watershed score.

Once the indicators were identified, targets or thresholds for each indicator were developed. Establishing targets for each indicator can be done by using pre-existing standard thresholds from the scientific literature or determining acceptable management goals. Ideally, a threshold indicates a tipping point where current knowledge predicts an abrupt change in an aspect or some aspects of ecosystem condition. Thus, from the perspective of choosing meaningful, health-related thresholds, this must be the point beyond which prolonged exposure to unhealthful conditions actually elicits a negative response for the environment or human health. For example, prolonged exposure to dissolved oxygen concentrations below criteria thresholds elicits a negative response in aquatic systems by either compromising the biotic functions of an organism (reduced reproduction) or causing death.

More generally, however, thresholds represent an agreed-upon value or range of values indicating that an ecosystem is moving away from a desired state and toward an undesirable state. Recognizing that many managed ecosystems have multiple and broad-scale stressors, another perspective is to define a threshold as representing the level of impairment that an environment can sustain before resulting in significant (or perhaps irreversible) damage. When selecting thresholds, it is important to recognize that there are many already available and there might be preexisting thresholds available to use for the chosen indicators. A good place to start looking for existing thresholds and goals is in other report card methods or scientific reports and publications.

One way to develop threshold values, if none exist, is to relate them to management goals, which can be used to guide the selection of appropriate indicators. Even with the definition of agreed-upon thresholds, there is still the question of how best to use these threshold values in management and governance. Recognizing this challenge, thresholds can still be effectively used to track ecosystem change and define achievable management goals for the restoration, preservation, and conservation of an ecosystem. As long as threshold values are clearly defined and justified, they can be updated in light of new research or management goals and, therefore, can provide an important focus for the discussion and implementation of ecosystem management. Alternatively, if stressors are correctly identified and habitats appropriately classified, there should be multiple attributes (indicators) of the biological community that discriminate in predictable and significant ways between the least and most impaired habitat conditions. Reference communities can then be characterized using these data, which in turn can be used to develop threshold values.

In order to determine thresholds for the Western Lake Erie basin and watershed, working groups of scientific experts were engaged. Data was sourced from many places including, Ohio Environmental Protection Agency (Ohio EPA), National Oceanic Atmospheric Administration Great Lakes Environmental Research Laboratory (NOAA GLERL), Environment Canada, Ohio State University (OSU), Great Lakes Environmental Database (GLENDA), Bowling Green State University (BGSU), University of Toledo Great Lakes Observing System (UT GLOS), Lake Erie Yellow Perch Task Group, Lake Erie Walleye Task Group, Ohio Department of Natural Resources (Ohio DNR), National Oceanic Atmospheric Administration (NOAA), Heidelberg University, University of Michigan-NCSU-GLERL, LimnoTech, Indiana STORET, USGS Ohio-Kentucky-Indiana Water Science Center, USGS Great Lakes Science Center, University of Purdue, and Ontario's Provincial (Stream) Water Quality Monitoring Network (PWQMN).

Western Lake Erie Basin Thresholds

Total phosphorus

The total phosphorus (TP) threshold used was the US EPA threshold 0.015 mg/L. For each TP sample, the measurement was compared to the threshold on a pass/fail basis. When the TP value was <0.015 mg/L, it equaled a passing score (100%). When the TP value was >=0.015 mg/L, it equaled a failing score (0%). Year-round data from 2018 were analyzed. The data sources were Ohio EPA, NOAA GLERL, Environment Canada, OSU, GLENDA, and BGSU.

Dissolved phosphorus

The dissolved phosphorus (DP) threshold used was 0.001 mg/L from Tomlinson (et al. 2010). For each DP sample, the measurement was compared to the threshold on a pass/fail basis. When the DP value was <0.001 mg/L, it equaled a passing score (100%). When the DP value was >=0.001 mg/L, it equaled a failing score (0%). Year round data from 2018 were analyzed. The data sources were NOAA GLERL, Environment Canada, UT GLOS, OSU, GLENDA, and BGSU.

Total nitrogen

The total nitrogen (TN) threshold used was 0.8 mg/L from Chaffin (et al. 2014). For each TN sample, the measurement was compared to the threshold on a pass/fail basis. When the TN value was <0.8 mg/L, it equaled a passing score (100%). When the TN value was >=0.8 mg/L, it equaled a failing score (0%). Year round data from 2018 were analyzed. The data sources were Ohio EPA, Environment Canada, OSU, GLENDA, and BGSU.

Nitrate+Nitrite

The nitrate+nitrite (NN) threshold used was 0.1 mg/L from Chaffin (et al. 2014). For each NN sample, the measurement was compared to the threshold on a pass/fail basis. When the NN value was <0.1 mg/L, it equaled a passing score (100%). When the NN value was >=0.1 mg/L, it equaled a failing score (0%). Year round data from 2018 were analyzed. The data sources were Ohio EPA, NOAA GLERL, Environment Canada, OSU, and BGSU.

Chlorophyll *a*

The chlorophyll *a* (Chla) threshold used was the Lake Erie Lakewide Management Plan threshold 3.6 µg/L. For each Chla sample, the measurement was compared to the threshold on a pass/fail basis. When the Chla value was <3.6 µg/L, it equaled a passing score (100%). When the Chla value was >=3.6 µg/L, it equaled a failing score (0%). Data from April 1–September 30, 2018 were analyzed. The data sources were Ohio EPA, NOAA GLERL, Environment Canada, UT GLOS, NOAA GLERL, OSU, GLENDA, and BGSU.

Walleye

The walleye indicator is a measure of walleye abundance. Walleye abundance is estimated by ADMB (AD Model Builder) catch-age analysis for the entire Lake Erie area, not just the western basin. The walleye abundance indicator was the 2018 data scored based on the long-term mean (1984–2017). The long-term mean was 53.159 (millions of fish). The 2018 value was divided by the long-term mean and then multiplied by 100 to come up with a score. This data is from the Lake Erie Walleye Task group, which reports on walleye status annually. The task group membership includes Michigan Department of Natural Resources, New York Department of Environmental Conservation, Ohio Department of Natural Resources, Ontario Ministry of Natural Resources and Forestry, and the Pennsylvania Fish and Boat Commission.

Yellow perch

The yellow perch indicator is a measure of yellow perch abundance. The abundance is estimated by ADMB (AD Model Builder) catch-age analysis for the western basin. The yellow perch abundance indicator was the 2018 data scored based on the long-term mean (2000–2017). The long-term mean was 40.833 (millions of fish). The 2018 value was divided by the long-term mean and then multiplied by 100 to come up with a score. This data is from the Lake Erie Yellow Perch Task group, which reports on yellow perch status annually. The task group membership includes Michigan Department of Natural Resources, New York Department of Environmental Conservation, Ohio Department of Natural Resources, Ontario Ministry of Natural Resources and Forestry, and the Pennsylvania Fish and Boat Commission.

Emerald shiner

The emerald shiner indicator is a measure of emerald shiner abundance. The abundance is estimated by SCANMAR trials, trawling effort distance, and catches from the August interagency trawling program for the western basin. The emerald shiner abundance indicator was the 2018 data scored based on the long-term mean (1988–2017). The long-term mean was 124.898 (millions of fish). The 2018 value was divided by the long-term mean and then multiplied by 100 to come up with a score. This data is from the Report of the Lake Erie Forage Task group, which reports on emerald shiner status annually. The task group membership includes Michigan Department of Natural Resources, New York Department of Environmental Conservation, Ohio Department of Natural Resources, Ontario Ministry of Natural Resources and Forestry, the Pennsylvania Fish and Boat Commission, The State University of New York (SUNY – Buffalo State College), United States Fish and Wildlife Service, United States Geological Survey – Great Lakes Science Center, and Fisheries and Oceans Canada. The raw data itself was not in the report, but it was sent by Eric Weimer at ODNR.

Bloom index

The bloom index indicator is based on NOAA's Lake Erie Severity Index 2. This index is published every year and was developed by NOAA, Heidelberg University, University of Michigan–NCSU–GLERL, and LimnoTech. The index is based on the amount of biomass over the peak 30-days of the bloom. For more information visit the Bloom Index Website. The bloom index calculated the bloom at 3.6 for 2018. This value was converted to the 0–100% scale using the following thresholds and equations.

Table 1: Bloom index thresholds and report card scale conversion equations.

Bloom index	Score	Equation
10	0	y = -8.3333x + 83.333
4	50	y = -12.5x + 100
2	75	y = -12.5x + 100
0	100	y = -12.5x + 100

Source water toxin

The source water toxin indicator measures the amount of microcystin in raw water that is taken to be treated before being used for drinking water. The threshold used was the Ohio EPA public drinking water supply beneficial use cyanotoxin indicators threshold 1 µg/L. For each microcystin sample, the measurement was compared to the threshold on a pass/fail basis. When the microcystin value was <1 µg/L, it equaled a passing score (100%). When the microcystin value was >=1 µg/L, it equaled a failing score (0%). Year-round data from 2018 were analyzed. Data is specifically from drinking water intakes only. Regions 1 and 4 had no data for this indicator. Data is from Ohio EPA.

Recreational toxin

The recreational toxin indicator measures the amount of microcystin in water that is located where people recreate. The threshold used was the US EPA recreational water quality criteria threshold 8 μg/L. For each microcystin sample, the measurement was compared to the threshold on a pass/fail basis. When the microcystin value was <8 μg/L, it equaled a passing score (100%). When the microcystin value was >=8 μg/L, it equaled a failing score (0%). Data from the recreational season (Memorial Day to Labor Day) May 28–September 3, 2018 were analyzed. Region 4 had no data for this indicator. Data is from Ohio EPA, NOAA GLERL, UT GLOS, OSU, and BGSU.

Western Lake Erie Watershed Thresholds

Total phosphorus

The total phosphorus (TP) threshold used was the US EPA ecoregion threshold 0.07635 mg/L. For each TP sample, the measurement was compared to the threshold on a pass/fail basis. When the TP value was <0.07635 mg/L, it equaled a passing score (100%). When the TP value was >=0.07635 mg/L, it equaled a failing score (0%). Year-round data from 2018 were analyzed. The data sources were Environment Canada, Ontario Ministry of the Environment, Conservation and Parks (MECP), Heidelberg, USGS Michigan, USGS Ohio, USGS Indiana, Indiana STORET, Purdue, OSU, Ohio EPA, and NOAA GLERL

Dissolved phosphorus

The dissolved phosphorus (DP) threshold used was based on the working group recommendation. The threshold was 0.02 mg/L. For each DP sample, the measurement was compared to the threshold on a pass/fail basis. When the DP value was <0.02 mg/L, it equaled a passing score (100%). When the DP value was >=0.02 mg/L, it equaled a failing score (0%). Year-round data from 2018 were analyzed. The data sources were Environment Canada, Ontario MECP, Heidelberg, USGS Michigan, USGS Ohio, Purdue, OSU, and NOAA GLERL.

Total nitrogen

The total nitrogen (TN) threshold used was the US EPA ecoregion threshold 2.18 mg/l. For each TN sample, the measurement was compared to the threshold on a pass/fail basis. When the TN value was <2.18 mg/l, it equaled a passing score (100%). When the TN value was >=2.18 mg/l, it equaled a failing score (0%). Year-round data from 2018 were analyzed. The data sources were Ontario MECP, Indiana, Heidelberg, USGS Michigan, USGS Ohio, Ohio EPA, and OSU.

Nitrate+Nitrite

The nitrate+nitrite (NN) threshold used was the Ohio EPA warm water habitat threshold 1.5 mg/L. For each NN sample, the measurement was compared to the threshold on a pass/fail basis. When the NN value was <1.5 mg/L, it equaled a passing score (100%). When the NN value was >=1.5 mg/L, it equaled a failing score (0%). Year-round data from 2018 were analyzed. The data sources were Environment Canada, Ontario MECP, Indiana, Heidelberg, USGS Michigan, USGS Ohio, Purdue, and OSU.

Total suspended solids and turbidity

The total suspended solids (TSS) threshold used was the Maumee Watershed Action Plan, 2014 threshold 25 mg/L. For each TSS sample, the measurement was compared to the threshold on a pass/fail basis. When the TSS value was <25 mg/L, it equaled a passing score (100%). When the TSS value was >=25 mg/L, it equaled a failing score (0%). Year-round data from 2018 were analyzed. The data sources were Environment Canada, Heidelberg, and Indiana Storet. One region that had insufficient TSS data was region 4. In order to include that region in the analysis, we used turbidity as a proxy for TSS in that one region. The turbidity threshold was also from the Maumee Watershed Action Plan, 2014, and was 10.4 NTU. When the turbidity value was <10.4 NTU, it equaled a passing score (100%). When the turbidity value was >=10.4 NTU, it equaled a failing score (0%). Year-round data from 2018 were analyzed. Turbidity data for region 4 came from USGS Michigan. Region 3 was not scored as there were no data for TSS or turbidity.

Fish

The fish indicator is based on indices of biotic integrity (IBI) calculated by each of the states. The thresholds used were directly taken from the suggested breakpoints of condition for each state's IBI. These thresholds were then converted to the report card scale using the equations described in the tables below. Data used was from 2014–2018. The data sources were Michigan EGLE, Ohio EPA, and Indiana IDEM. No data was available for Ontario. For Michigan, the breakpoints are in Table 2 and the threshold equations are in Table 3.

Table 2: Michigan fish IBI breakpoints and narratives.

Fish IBI	Narrative
5 to 10	Excellent
-4 to 4	Acceptable
-5 to -10	Poor

Table 3: Michigan fish IBI report card score conversion equations.

Fish IBI	Report card score	Equation
10	100	y = 0.25x - 15
5	80	y = 0.1667x - 8.3333
-5	20	y = 0.1667x - 8.3333
-10	0	y = 0.25x - 10

For Ohio, the breakpoints are in Table 4 and the threshold equations are in Table 5.

Table 4: Ohio fish IBI breakpoints and narratives.

IBI	Narrative
50–60	exceptional
46–49	very good
38–45	good
34–37	marginally good
28–32/33	fair
18–27	poor
12–17	very poor

Table 5: Ohio fish IBI report card score conversion equations.

Report Card Score	IBI	Equation
100	60	
80	50	y = 0.5x + 10
75	46	y = 0.8x - 14
55	38	y = 0.4x + 16
50	34	y = 0.8x - 6
45	28	y = 1.2x - 26
25	18	y = 0.5x + 5.5
0	12	y = 0.24x + 12

For Indiana, there is only one breakpoint identified, which is “a stream segment is non-supporting for aquatic life use when the monitored fish community receives an Index of Biotic Integrity (IBI) score of less than 35 which is considered "Poor" or "Very Poor"”. For each Fish IBI score, the score was compared to the threshold on a pass/fail basis. When the Fish IBI score was >=35, it equaled a passing score (100%). When the Fish IBI score was <35, it equaled a failing score (0%).

Macroinvertebrates

The macroinvertebrate indicator is based on indices of biotic integrity (IBI) calculated by each of the states and the province. The thresholds used were directly taken from the suggested breakpoints of condition for each state and province’s IBI. These thresholds were then converted to the report card scale using linear equations (Table 7). The data sources were Michigan EGLE, Ohio EPA, Indiana IDEM and Ontario Benthos Biomonitoring Network through the Ontario Conservation Authorities. Data used was from 2014–2018 for Michigan, Ohio, and Indiana. Data used for Ontario was 2011–2015 and 2012–2016, see below. For Michigan, the breakpoints are in Table 6 and the threshold equations are in Table 7.

Table 6: Michigan macroinvertebrate IBI breakpoints and narratives.

IBI	Narrative
5 to 9	Excellent
-4 to 4	Acceptable
-5 to -9	Poor

Table 7: Michigan macroinvertebrate IBI report card score conversion equations.

MIBI	Report card score	Equations
9	100	y = 0.2x-11
5	80	y = 0.1667x - 8.3333
-5	20	y = 0.1667x - 8.3333
-9	0	y = 0.2x - 9

For Ohio, they use a macroinvertebrate index of community integrity (ICI). The Ohio breakpoints are in Table 8 and the threshold equations are in Table 9.

Table 8: Ohio macroinvertebrate ICI breakpoints and narratives.

ICI	Narrative
46–60	exceptional
42–44	very good
34–40	good
30–32	marginally good
14–28	fair
8–12	poor
<=6	very poor

Table 9: Ohio macroinvertebrate ICI report card score conversion equations.

Score	ICI	Equation
100	60	
90	45	y = 1.5x - 90
80	41	y = 0.4x + 9
60	33	y = 0.4x + 9
40	29	y = 0.2x + 21
20	13	y = 0.8x - 3
0	0	y = 0.65x

For Indiana, there is only one breakpoint identified, which is "a stream segment is non-supporting for aquatic life use when the monitored macroinvertebrate community receives an IBI score of less than 36 (on a scale of 12-60 for macroinvertebrate communities) which is considered "Poor" or "Very Poor"". For each Macroinvertebrate IBI score, the score was compared to the threshold on a pass/fail basis. When the Macroinvertebrate IBI score was >=36, it equaled a passing score (100%). When the Macroinvertebrate IBI score was <36, it equaled a failing score (0%).

For Ontario, the data is a macroinvertebrate HBI or FBI (Hilsenhoff's Family Biotic Index). Data is from the Ontario Benthos Biomonitoring Network through the Ontario Conservation Authorities. The data from the Upper Thames and Lower Thames regions are from 2011-2015. The data for the Essex region is from 2012-2016.

Table 10: Ontario benthic macroinvertebrate FBI breakpoints and letter grades.

Benthic FBI score	Point score	Letter grade
0–4.25	5	A
4.26–5	4	B
5.01–5.75	3	C
5.76–6.5	2	D
6.51–10	1	F

Table 11: Ontario benthic macroinvertebrate FBI report card score conversion equations.

FBI	Score	Equation
0	100	$y = -4.6948x + 100$
4.26	80	$y = -26.667x + 193.6$
5.01	60	$y = -26.667x + 193.6$
5.76	40	$y = -26.667x + 193.6$
6.51	20	$y = -26.667x + 193.6$
10	0	$y = -5.7307x + 57.307$

Habitat

The habitat indicator is based on habitat quality indices (HQIs) or Qualitative Habitat Evaluation Indices (QHEIs) calculated by each of the states. The thresholds used were directly taken from the suggested breakpoints of condition for each state's HQI. These thresholds were then converted to the report card scale using linear equations (Table 13). Data used was from 2014–2018. The data sources were Michigan EGLE, Ohio EPA, and Indiana IDEM. For Michigan, the breakpoints are in Table 12 and the threshold equations are in Table 13.

Table 12: Michigan Habitat Quality Index breakpoints and narratives.

Habitat Index	Description
>154	Excellent
105–154	Good
56–104	Marginal
<56	Poor

Table 13: Michigan Habitat Quality Index report card score conversion equations.

QHEI	Report card Score	Equation
260	100	y = 5.25x - 265
155	80	y = 1.6667x + 21.667
55	20	y = 2.75x
0	0	y = 2.75x

For Ohio, the breakpoints are in Table 14 and the threshold equations are in Table 15.

Table 14: Ohio Habitat Quality Index breakpoints and narratives.

QHEI	Narrative
>=75	excellent
60–74	good
45–59	fair
30–44	poor
<30	very poor

Table 15: Ohio Habitat Quality Index report card score conversion equations.

Score	QHEI	Equation
100	90	
80	75	y = 0.75x + 15
60	60	y = 0.75x + 15
40	45	y = 0.75x + 15
20	30	y = 0.75x + 15
0	15	y = 0.75x + 15

For Indiana, there is only one breakpoint identified, which is “"After collecting many years' worth of data, IDEM has determined that a QHEI total score of <51 is poor for habitat, meaning habitat quality could have a negative effect on the biological communities present."”. For each QHEI score, the score was compared to the threshold on a pass/fail basis. When the QHEI score was >=51, it equaled a passing score (100%). When the Macroinvertebrate IBI score was <51, it equaled a failing score (0%).

Source water toxin

The source water toxin indicator measures the amount of microcystin in raw water that is taken to be treated before being used for drinking water. The threshold used was the Ohio EPA public drinking water supply beneficial use cyanotoxin indicators threshold 1 µg/L. For each microcystin sample, the measurement was compared to the threshold on a pass/fail basis. When the microcystin value was <1 µg/L, it equaled a passing score (100%). When the microcystin value was >=1 µg/L, it equaled a failing score (0%). Year round data from 2018 were analyzed. Data is specifically from drinking water intakes only. Data was from Ohio EPA.

Fish consumption

The fish consumption indicator is based on fish consumption advisories. The thresholds are based on how often you can eat the fish per month (Table 16). The data were from Ohio, Michigan, and Ontario.

Table 16: Fish consumption advisory thresholds and corresponding report card score.

Servings per month	Score
0	0
<1	10
1	20
2	30
4	40
8	50
12	60
16	70
24	80
32	90
unrestricted	100

Pesticides

Atrazine data was compiled and scored to represent pesticides in the watershed. The threshold used was the US EPA, Safe Drinking Water Act, Maximum contaminant level for Atrazine in drinking water: 3μg/L. Data were from WQIS, USGS Michigan, and USGS Ohio. This indicator only had data in six of the watershed reporting regions. It was also decided that Atrazine alone did not sufficiently describe the condition of pesticides in the watershed. This indicator was ultimately not included in the report card, but additional work can incorporate it in future report cards.

Scoring

Once thresholds have been identified, data are scored using either a pass/fail or multiple threshold method. Ideally, multiple thresholds are used to provide some gradation of results from poor to excellent, rather than just pass or fail, but this may not be appropriate for all indicators.

A pass/fail scoring method is a simple method used to calculate indicator scores based on whether or not an ecologically relevant threshold was met. The process outlined below uses dissolved oxygen as an example, and results are scored on a scale of 0 to 100%, where the higher percentage values represent more healthy conditions (Figure 4).

1. Sort data by station.

Region	Site	Date	TP (mg/L)
1	ON02GD9041	01/23/18	0.519
1	ON02GD9041	02/21/18	0.312
1	ON02GD9041	02/28/18	0.0439
1	ON02GD9041	03/21/18	0.0143
1	ON02GD9041	04/03/18	0.0141
1	ON02GD9041	04/17/18	0.0813
1	ON02GD9041	05/01/18	0.0215
1	ON02GD9041	05/15/18	0.074
1	ON02GD9041	05/30/18	0.0617
1	ON02GD9041	06/26/18	0.0929
1	ON02GD9041	07/17/18	0.134
1	ON02GD9041	07/31/18	0.0559
1	ON02GD9041	08/14/18	0.0461
1	ON02GD9041	08/28/18	0.0745
1	ON02GD9041	09/11/18	0.0581
1	ON02GD9041	09/25/18	0.0518
1	ON02GD9041	10/09/18	0.0563
1	ON02GD9041	10/23/18	0.0253
1	ON02GD9048	01/23/18	0.105
1	ON02GD9048	02/21/18	0.34
1	ON02GD9048	02/28/18	0.107
1	ON02GD9048	03/21/18	0.0212
1	ON02GD9048	04/03/18	0.0625
1	ON02GD9048	04/17/18	0.0885
1	ON02GD9048	05/01/18	0.0688
1	ON02GD9048	05/15/18	0.0545
1	ON02GD9048	05/30/18	0.0353
1	ON02GD9048	06/26/18	0.0775
1	ON02GD9048	07/17/18	0.102
1	ON02GD9048	07/31/18	0.0609
1	ON02GD9048	08/14/18	0.0825
1	ON02GD9048	08/28/18	0.0605
1	ON02GD9048	09/11/18	0.0759
1	ON02GD9048	09/25/18	0.0537
1	ON02GD9048	10/09/18	0.0501
1	ON02GD9048	10/23/18	0.0266

2. Calculate the score for each data point. Ex: If TP<0.07625 mg/l, the score = pass (or 100).

Region	Site	Date	TP (mg/L)	Threshold	TP Score
1	ON02GD9041	01/23/18	0.519	0.07625	0
1	ON02GD9041	02/21/18	0.312	0.07625	0
1	ON02GD9041	02/28/18	0.0439	0.07625	100
1	ON02GD9041	03/21/18	0.0143	0.07625	100
1	ON02GD9041	04/03/18	0.0141	0.07625	100
1	ON02GD9041	04/17/18	0.0813	0.07625	0
1	ON02GD9041	05/01/18	0.0215	0.07625	100
1	ON02GD9041	05/15/18	0.074	0.07625	100
1	ON02GD9041	05/30/18	0.0617	0.07625	100
1	ON02GD9041	06/26/18	0.0929	0.07625	0
1	ON02GD9041	07/17/18	0.134	0.07625	0
1	ON02GD9041	07/31/18	0.0559	0.07625	100
1	ON02GD9041	08/14/18	0.0461	0.07625	100
1	ON02GD9041	08/28/18	0.0745	0.07625	100
1	ON02GD9041	09/11/18	0.0581	0.07625	100
1	ON02GD9041	09/25/18	0.0518	0.07625	100
1	ON02GD9041	10/09/18	0.0563	0.07625	100
1	ON02GD9041	10/23/18	0.0253	0.07625	100
1	ON02GD9048	01/23/18	0.105	0.07625	0
1	ON02GD9048	02/21/18	0.34	0.07625	0
1	ON02GD9048	02/28/18	0.107	0.07625	0
1	ON02GD9048	03/21/18	0.0212	0.07625	100
1	ON02GD9048	04/03/18	0.0625	0.07625	100
1	ON02GD9048	04/17/18	0.0885	0.07625	0
1	ON02GD9048	05/01/18	0.0688	0.07625	100
1	ON02GD9048	05/15/18	0.0545	0.07625	100
1	ON02GD9048	05/30/18	0.0353	0.07625	100
1	ON02GD9048	06/26/18	0.0775	0.07625	0
1	ON02GD9048	07/17/18	0.102	0.07625	0
1	ON02GD9048	07/31/18	0.0609	0.07625	100
1	ON02GD9048	08/14/18	0.0825	0.07625	0
1	ON02GD9048	08/28/18	0.0605	0.07625	100
1	ON02GD9048	09/11/18	0.0759	0.07625	100
1	ON02GD9048	09/25/18	0.0537	0.07625	100
1	ON02GD9048	10/09/18	0.0501	0.07625	100
1	ON02GD9048	10/23/18	0.0266	0.07625	100

3. Calculate the score for each site by averaging the scores for each data point in that site.

Region	Site	Date	TP (mg/L)	Threshold	TP Score	Site Scores
1	ON02GD9041	01/23/18	0.519	0.07625	0	72
1	ON02GD9041	02/21/18	0.312	0.07625	0	
1	ON02GD9041	02/28/18	0.0439	0.07625	100	
1	ON02GD9041	03/21/18	0.0143	0.07625	100	
1	ON02GD9041	04/03/18	0.0141	0.07625	100	
1	ON02GD9041	04/17/18	0.0813	0.07625	0	
1	ON02GD9041	05/01/18	0.0215	0.07625	100	
1	ON02GD9041	05/15/18	0.074	0.07625	100	
1	ON02GD9041	05/30/18	0.0617	0.07625	100	
1	ON02GD9041	06/26/18	0.0929	0.07625	0	
1	ON02GD9041	07/17/18	0.134	0.07625	0	
1	ON02GD9041	07/31/18	0.0559	0.07625	100	
1	ON02GD9041	08/14/18	0.0461	0.07625	100	
1	ON02GD9041	08/28/18	0.0745	0.07625	100	
1	ON02GD9041	09/11/18	0.0581	0.07625	100	
1	ON02GD9041	09/25/18	0.0518	0.07625	100	
1	ON02GD9041	10/09/18	0.0563	0.07625	100	
1	ON02GD9041	10/23/18	0.0253	0.07625	100	

4. Calculate the region score by averaging all site scores in each region.

Region	Site	Site Scores	Region Scores
1	ON02GD9041	72	64
1	ON02GD9048	61	
1	ON02GD9056	44	
1	ON02GD9057	83	
1	ON02GD9058	74	
1	ON02GD9059	61	
1	ON02GD9061	56	
2	ON02GE0007	29	34
2	ON02GE1000	19	
2	ON02GE1005	75	
2	ON02GE1006	33	
2	ON02GE1007	14	
2	ON02GE9055	33	
2	ON02GE9056	39	
2	ON02GG1000	30	

Figure 3: Example scoring method.

For the Western Lake Erie, all indicators were assessed through a pass/fail criteria or multiple threshold criteria. Once each indicator was compared to a pass/fail or multiple threshold scale and assigned a score, it was averaged into a station score. Then, each station score within a sub-region was averaged together to a sub-region score for that indicator. Each overall sub-region score is area-weighted into the overall score. An example of the scoring for the Basin is below. For all indicators, the scoring scale follows a 20-point scale of 0–100%, (Table 17).

Table 17: Scoring scale and description.

Score (%)	Description
80–100	Very good
60–80	Good
40–60	Moderate
20–40	Poor
0–20	Very poor

Final scores were divided to provide a clearer picture of health (Figure 5). This scale provides information about small improvements or declines in ecosystem health. This scale allows evaluation of small changes in ecosystem health, even at the very poor, and poor ranges.

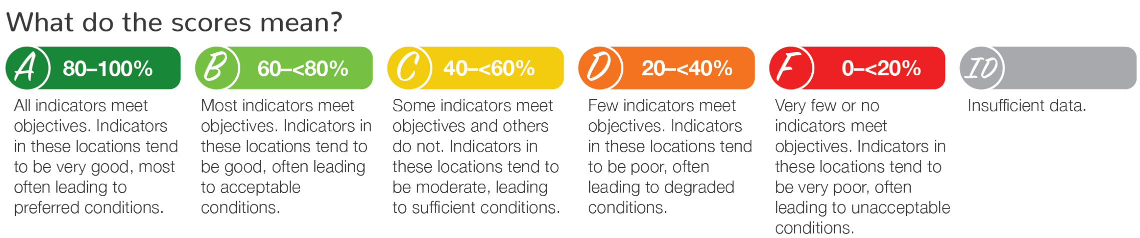

Figure 4: Detailed report card scoring narratives.

Quality Assurance/Quality Control

After the report card data are analyzed, a second person re-checks all the data spreadsheets. All numbers are compared to original spreadsheets to make sure there are not any errors transferring data. All calculations are also checked, to ensure equations have been entered correctly, and applied to the correct cells in the spreadsheet. The current dataset is small enough to check every indicator and every calculation. As datasets become larger and more complex, a subset of data is checked. This is done by comparing the current year's indicator score to last year's indicator score. If the score is different by 33% (or a pre-determined amount) between one year and the next, those data are flagged and checked for accuracy. This can be completed during the production of the second Western Lake Erie Report Card. Having proper quality assurance and quality control methods is vital to maintaining the integrity of the data and consistency in the information reported.

Combining indicators into indices

Overarching indices give a much better integrated assessment, and therefore representative score, of an ecosystem's health than can be achieved using a single metric. These indices comprise multiple metrics that are ranked according to a threshold value and then averaged together. Multi-metric health indices have become commonplace in resource and ecosystem management. The majority of these indices focus on stream macroinvertebrates and fish, but more recently, indices have been developed using various water quality and biotic parameters. There are many parameters that can be included, and all need to be properly evaluated in terms of what they add to the robustness of the indices. Robustness refers to the ability of the indicator or index to perform well under a range of conditions. More simplistic indices may lack relevant parameters or the spatial and temporal resolution that make indices more robust or effective for regional comparisons, while very complex indices may have indicators that do not necessarily contribute much to the robustness of the index. Hence, the main objective is to select the appropriate type and number of indicators that, when combined into an index, give a robust and accurate representation of an ecosystem's health and are understandable to the majority of users.

For Western Lake Erie, three indices were developed to help synthesize the data and obtain an overall score of the health of the lake: a Water Quality Index, a Fish Index, and an Algal Blooms Index. These three indices combined create the overall lake ecosystem health score. For Western Lake Erie watershed, three indices were developed to help synthesize the data and obtain an overall score of the health of the watershed: a Water Quality Index, a Biology Index, and a Toxics Index. These three indices combined create the overall watershed ecosystem health score.

Issues of concern

Other indicators

During the workshops and subsequent webinars, additional indicators that were explored and discussed as being important to calculating the health of Western Lake Erie and its watershed.

Landscape indicators were deemed important to include as watershed health indicators for the report card. The indicators discussed were land use, land cover, cover crops, winter cover crops, tillage practices, soil health and forest cover. Although these indicators were not able to be implemented in this version of the report card, they merit consideration for inclusion in a revised, future report card.

Socio-economic indicators were deemed important to include as part of the report card scoring for both the lake and the watershed. Some of the ideas discussed included trying to include indicators related to policy, economics, media, human actions, human beliefs, engagement, implementation, awareness, and education. Although indicators were not able to be developed in this version of the report card, they merit consideration for inclusion in the future.

Lake St. Clair

Lake St. Clair is an important part of the Western Lake Erie region. The lake connects Lake Huron to Lake Erie through the St. Clair and Detroit Rivers. There were no 2018 in-lake water quality monitoring data available. There were limited data available from 2016, and earlier, but those data were only available from sites on the shoreline. There were fish data available for Walleye, Yellow perch, and Spottail shiner (recommended instead of Emerald shiner). The fish data were from 2018. Because of the lack of water quality data available, Lake St. Clair was not scored in the report card. In-lake monitoring would allow the lake to be included in report card scoring in the future.

Data availability

Some regions in the watershed did not have many monitoring sites for specific indicators. A minimum number of sites for each region was not established; instead, as much data as was available was used to score the indicators and regions. In the future, a minimum number of sites per region (possibly 5) and samples per site should be determined and those sites or indicators that do not meet the minimum data requirements should be excluded. A few examples are listed below:

- Total phosphorus: region 5 had 2 sites, region 13 had 3 sites, and region 6 had 4 sites.
- Dissolved phosphorus: region 5 had 1 site, regions 4, 6, 10, and 12 had 2 sites, and region 13 had 3 sites.
- Total nitrogen: regions 4, 5, and 12 had 1 site, regions 6 and 10 had 2 sites, and region 13 had 3 sites.
- Nitrate nitrite: region 12 had 1 site, regions 5 and 10 had 2 sites, and regions 6 and 13 had 3 sites.
- Total suspended solids: region 3 had no sites, regions 5, 10, and 12 had 1 site, region 6 had 2 sites, and region 13 had 3 sites.

In Ontario, there was no data available for the Fish IBI or for the Habitat IBI. This affected regions 1, 2, and 3. In this case, the biology category scores are only based on the data that was available, which was data about macroinvertebrates.

In regions 12 and 13 (two of Ohio's regions), there was no data available for any of the biology category indicators. This is due to the nature of the sampling, which rotates around the state so that data are not collected every year. For this reason, 5 years of data was examined, but even within 10 years of data, these regions did not have adequate monitoring. For regions 12 and 13, there is no score for the biology category, and the overall scores are only based only on water quality indicators and toxics indicators.

Communication through a report card

Ecological report cards provide performance-driven numeric scores that represent the relative ecological health of a geographic region or component of the ecosystem. They are an important tool for integrating diverse data types into simple scores that can be communicated to decision makers and the general public. In other words, large and often complex amounts of information can be made understandable to a broad audience.

Ecological report cards enhance monitoring, management, and research in several ways. For monitoring, report cards justify continued monitoring by providing timely and relevant feedback to managers and can have the added benefit of accelerating data analyses. For management, they provide accountability by measuring the success of restoration efforts and identifying impaired regions or issues of ecological concern. This catalyzes improvements in ecosystem health through the development of peer pressure among local communities. Report cards also can guide restoration efforts by creating a targeting scheme for resource allocation. For the research community, they can lead to new insights through integration schemes that reveal patterns not immediately apparent, help to design a conceptual framework to integrate scientific understanding and environmental values, and help to develop scaling approaches that allow for comparison in time.

Ecosystem health assessments have become more common in recent years, and report cards are being produced by a variety of groups from small, community-based organizations to large partnerships. Although methods, presentation, and content of report cards vary, the underlying premise is the same: to build community awareness and raise the profile of health impairment issues and restoration efforts.

Some common elements of report cards include

1. A map of the watershed or region
2. A grade stamp

3. The year(s) of the report card
4. A summary of the key features (e.g., ecosystem types, recreation activities)
5. A "What You Can Do" or what is occurring to improve conditions section

For the Western Lake Erie Report Card numerous meetings were conducted to plan the content, layout, and design of the documents. Many iterations of the report card occurred as the document evolved into its final state. The report card provides background information on the region, impacts to the ecosystems, information about key issues, and information about what the public can do to make a difference, in addition to the methods, scores, and grades. This report card provides a much-needed synthesis of monitoring data being collected in both the watershed and lake in a visually appealing and engaging manner. The Western Lake Erie report card includes the five basic elements listed above. In addition, more detailed discussion of some of the pertinent issues in the region are included, including algal blooms, the Maumee River, and Sandusky Bay. The report card website also includes additional information and downloads of the report card document at www.lakeeriereportcard.org.

Conclusions

Overall, the monitoring programs and resulting data collected in the Western Lake Erie basin and watershed provided an excellent base from which to produce a report card. The scores and grades were synthesized into a public-friendly document that can inform and engage its readers. This is the first time this has been done for Western Lake Erie.

The process of producing the report card, from the initial workshop to the final stages of the report card, was made possible by funding from Lucas County, Ohio; City of Toledo, Ohio; and City of Oregon, Ohio through the Lake Erie Foundation. The collective efforts of many other organizations also made the report card possible, including but not limited to Bowling Green State University, City of Defiance, Defiance College, Environment Canada, Heidelberg University, Indiana DEM, Lake Erie Waterkeeper, Limnotech, Michigan EGLE, NOAA, Ohio DNR, Ohio EPA, Ohio Sea Grant, Ohio State University, Ontario MECP, and University of Toledo. This effort cannot be understated in regards to completing an excellent product that is relevant, topical, and a useful communication tool.

It is recommended that the report card be updated regularly with the continuous participation and inclusion of stakeholders in the Western Lake Erie region. In future report cards, with increased sampling and new indicators measured, the integrity and quality of the data will increase and provide guidance for management actions toward restoration and conservation of Western Lake Erie.

Web resources

Western Lake Erie Report Card
www.lakeeriereportcard.org

Integration & Application Network
ww.ian.umces.edu

University of Maryland Center for Environmental Science
www.umces.edu

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