

Lake Michigan Monitoring Coordination Council

Lake Michigan Nearshore Monitoring



2013 Inventory and Assessment of Results

March 2014

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Great Lakes and Lake Michigan Background

The Great Lakes are the largest surface freshwater system on the Earth. They contain about 84 percent of North America's surface fresh water and hold 20 percent of the world's freshwater. The region includes more than 10,000 miles of coastline and numerous globally rare plant and animal species. The Great Lakes are also a dominant part of the physical and cultural heritage of North America. Shared with Canada and spanning more than 750 miles from west to east, these vast inland freshwater seas provide water for consumption, transportation, power and a host of other uses. In addition, the Great Lakes support a wide range of recreational and economic activities, including vibrant tourism and a sport fishing industry that contributes \$4 billion to the economy.

Lake Michigan is the second largest of the Great Lakes. It is the only Great Lake entirely within the United States. The northern part is in the colder, less developed upper Great Lakes region. It is sparsely populated, except for the Fox River Valley, which drains into Green Bay. This bay has one of the most productive Great Lakes fisheries but receives the wastes from the world's

largest concentration of pulp and paper mills. The more temperate southern basin of Lake Michigan is among the most urbanized areas in the Great Lakes system. It contains the Milwaukee and Chicago metropolitan areas, with over 11 million people dependent on the lake for drinking water. This region represents about one-fifth of the total population of the Great Lakes basin.



Since the release of the original Lake Michigan Lakewide Management Plan (LaMP) in 2000, several key indicators point to the continuing concern for the health of the ecosystem:

- Beach season data exhibited a continued number of beach closings.
- Data reveal that a critical layer of the Lake Michigan aquatic food web continues to disappear, and with the continued discovery of new aquatic invasive species, the integrity of the food web of Lake Michigan is in question.
- PCBs and Mercury are both detected

in Lake Michigan fish. This is such a prevalent problem that 44 states now have Mercury fish advisories, and a national advisory has been issued for certain ocean fish pointing to a problem

of global proportions. Both air deposition and sediment problems in Great Lakes Areas of Concern (AOC) drive the PCB fish advisories.

- Climatic pattern changes, whether temporary or permanent, are lowering lake levels as well as raising concerns about groundwater levels and lake/groundwater interaction and diversion.
- The interaction between ground water and surface water is becoming better understood in the Lake Michigan basin as declines in water levels from over pumping result in regional declines in baseflow levels in streams that affect habitat. Seventy-nine percent of Lake Michigan water originates as ground water, more than any other of the Great Lakes.
- With the increased attention to national security, the issue of protecting the lake's vast supply of fresh drinking water has become a higher priority.

In spite of its large size, Lake Michigan is sensitive to the effects of a wide range of pollutants. Major stresses on the lake include toxic and nutrient pollution, invasive species and habitat degradation. Sources of pollution include the runoff of soils and farm chemicals from agricultural lands, stormwater from impervious surfaces, waste from cities, discharges from industrial areas and leachate from disposal sites. The large surface area of the lake also makes it vulnerable to direct atmospheric pollutants that fall as rain, snow, or dust on the lake surface, or exchange as gases with the lake water. Outflows from Lake Michigan are relatively small (less than 1 percent per year) in comparison with the total volume of water. Pollutants that enter the lake are retained in the system and become more concentrated with time.

Despite these concerns, Lake Michigan supports many beneficial uses. For example, it provides drinking water for 10 million people; has internationally significant habitat and natural features; supports food production and processing; supplies fish for food, sport, and culture; has valuable commercial and recreational uses; and is the home of the nation's third-largest population center. Furthermore, significant progress is being made to remediate the legacy of contamination in the basin. Specifically, the Great Lakes Legacy Act has provided significant funding which has been used for remediation of contaminated sediments, supporting ongoing and successful actions to restore the Areas of Concern (AOC) designated under the Great Lakes Water Quality Agreement.

Project Background and Purpose

The Lake Michigan Monitoring Coordinating Council (LMMCC) has worked to coordinate and support consistent, scientifically defensible monitoring methods and collaboration for data comparability since 1999. The LMMCC is comprised of members from a variety of federal and state agencies, universities and non-governmental organizations with a common interest in monitoring the quality of Lake Michigan. In the fall of 2008, the LMMCC formed a Nearshore Monitoring (NEMO) Workgroup to plan for collaborative nearshore monitoring work during the 2010 Intensive Field Year under the Great Lakes-wide Cooperative Science and Monitoring Initiative (CSMI), and in conjunction with the US EPA's National Coastal Conditions Assessment (NCCA).

The 2013 survey of Lake Michigan monitoring activities described in this report continues Lake Michigan basin efforts to coordinate nearshore monitoring and provide access to data that can benefit agency management activities and citizen actions alike to improve the health of Lake Michigan. This Great Lakes Restoration Initiative (GLRI) project titled *Evaluating and Enhancing Lake Michigan Nearshore Monitoring* provides stakeholders with an inventory of monitoring metadata that will form the backbone of a larger database to house the data itself that will better provide an overall assessment of the health of the Lake's nearshore.

In partnership with the Lake Michigan Nearshore Monitoring (NEMO) Workgroup of the LMMCC, this project collected both recent (post-Lake Michigan 2010-2011 Intensive Year) and historic nearshore monitoring information and data to determine monitoring coverage and strengths, identify data gaps, and recommend monitoring strategies and lessons learned to improve the efficiency, in terms of both personnel and funding, of future Lake Michigan nearshore monitoring.

At the foundation of this project is one of the Lake Michigan Lakewide Management Plan's (LaMP) 12 key questions: Do we have enough information, data, understanding, and indicators to inform the decision-making process? In attempting to answer this question, this report provides information that can be used to help address four key criteria/questions from the GLRI Action Plan for nearshore monitoring in the Great Lakes:

1. Did the nearshore monitoring programs provide the necessary scientific basis to assess the physical, chemical and biological integrity of the efforts needed?
2. Did the nearshore monitoring programs help target future restoration and protection efforts needed?
3. Did the nearshore assessments conducted establish baseline conditions of environmental quality and variability of the nearshore waters, bottom substrate, and biota?
4. Did the nearshore monitoring conducted build on U.S. EPA's National Coastal Assessment framework?

In fall 2010 and spring 2011 Lake Michigan was sampled intensively in conjunction with the U.S. EPA NCCA, along with monitoring funded by the Great Lakes Restoration Initiative (GLRI) and other funding sources. This collaborative effort was guided, in part, by the LMMCC's Nearshore Plan. Three special GLRI-funded studies collected commonly consumed fish to be tested for Omega3, pharmaceuticals and flame retardant chemicals at sites along the boundaries of National Parks, at embayments, and at 30 other sites along Lake Michigan. Nearshore monitoring of various biological, chemical, and physical parameters was conducted by the four states surrounding Lake Michigan and by other entities, as well as U.S. EPA's Great Lakes National Program Office using the Lake Guardian research vessel.

This report focuses on sharing and evaluating results of a Lake Michigan nearshore monitoring inventory conducted in the winter and spring of 2013. The project builds on 12 years of work of the LMMCC to "enhance coordination, communication, and data management among agencies and other organizations that conduct or benefit from monitoring efforts in the Lake Michigan

basin in the interest of supporting the Lake Michigan LaMP” (as stated in the Lake Michigan LaMP). The project used the Lake Michigan NEMO Workgroup’s workplan as a guide. Project staff summarized and analyzed inventory data and provides recommendations in this report for improving efficiencies and collaborative monitoring opportunities in the Lake Michigan basin.

Outcomes of this work will include increased information for stakeholder participation in the Lake Michigan LaMP, strengthened dissemination of information on nearshore issues, enhanced implementation of priority restoration and protection projects, and improved management of monitoring programs and resources. The hope is that this project and report will lead to a more effective use of nearshore monitoring data that will result in more informed management decisions and strategies to advance protection and restoration of the Lake Michigan nearshore ecosystem.

Lake Michigan Nearshore Monitoring Inventory

To achieve the above-stated purpose, the Great Lakes Commission, with the guidance of the Lake Michigan NEMO Workgroup, conducted a survey of organizations that monitor Lake Michigan natural resources and water quality, over both the short- and long-term, that impact the Lake’s nearshore. This includes not only the nearshore and offshore water resources of Lake Michigan, but also tributaries, coastal wetlands, beaches, drowned river mouths, embayments, ground water, inland lakes, lake bottoms, river mouths and substrates, shoreline areas, stormwater conveyance systems, the water column, and water treatment facility intakes.

Target organizations for this survey included federal, state, and tribal government agencies, universities, local sewerage and planning districts, and non-governmental organizations. Results of the survey identified important monitoring work that was conducted through the GLRI, the NCCA, Great Lakes Observing System (GLOS) Lake Michigan projects, state and tribal monitoring initiatives, and other programs. We were especially interested in monitoring that took place since 2009 (when a previous inventory was conducted through the NEMO Workgroup), but were also interested in more historical monitoring efforts that are still active today, as well as projects that continue beyond 2013.

The intent of the survey was to collect important information and data necessary to identify as much nearshore and associated resource monitoring taking place around the basin as possible, as well as to identify monitoring gaps. The fields of the inventory compiled via the survey that are discussed in this report include:

- Funding Programs/Resources
- Standard Project Objective
- Organizations that Created Data
- Watershed – 8-Digit Hydrologic Unit Code (HUC)
- Resource Component Sampled
- Media Sampled
- Parameters Sampled
- Sampling Frequency (Start Date/End Date, etc.)
- Sampling Platform
- Publications

All survey results are accessible via the LMMCC-NEMO web page at www.glc.org/lmmcc/nemo. The fields not discussed in this report, which are generally not suitable for analysis, include:

- Project Name
- Percent of Project Funding (per project)
- Project Start Date
- Project End Date
- Project Objective – Textual Description
- Data Management System
- Data Hosting Organization
- Data Portal URL
- Project Website for More Information
- Comments
- Contact Name
- Contact Organization
- First Name
- Last Name
- Email Address
- Phone Number
- Lake Name
- Latitude
- Longitude
- Status
- Project Keywords
- Waterbody

For each of the ten fields listed above that are discussed in this report, a summary of that category's data from the inventory is provided followed by gaps/recommendations, except for Publications.

Science in the Great Lakes (SiGL) Mapper

As a follow-up to the inventory, USGS personnel are contacting survey respondents to request additional site detail information that will be included in USGS' [Science in the Great Lakes \(SiGL, pronounced "seagull"\) mapper](#). This online metadata portal allows users to search for individual sampling sites from current and historical monitoring efforts throughout the Great Lakes basin and identify areas or topics that need further study. It also provides contact information on how to obtain the referenced datasets. The SiGL mapper supports a variety of topics and projects including hydrologic, biologic, climatic, remote sensing, and modeling. While the SiGL mapper does not contain native datasets, it provides detailed information about product descriptions and objectives, sampling locations and parameters, data access, and contact information for the project lead or data manager. The SiGL mapper can be found online at its new URL: <http://wim.usgs.gov/SIGL/SIGLMapper.html>

The SiGL mapper is currently under redevelopment to improve performance and usability, provide more flexible and robust search options, expand the available project data, and include additional functionality such as custom download and printing. A new online data submission tool, the SiGL Data Management System (SiGL DMS) will allow data contributors to upload information directly into the mapper as well as provide access for on-the-fly editing.

The SiGL mapper started in 2010 out of a need to capture information gathered during the Lake Michigan Monitoring Coordination Council's CSMI inventory effort. Coupled with the Great Lakes Restoration Initiative and the Lakewide Management Plans (LaMPs), the original LaMP

mapper was born. It was recently renamed as the Science in the Great Lakes Mapper to encourage users and data contributors to see it not only as a product supporting the LaMPs, but all science being done in the Great Lakes basin. By providing a big-picture perspective of Great Lakes scientific activities, the SiGL mapper can help users efficiently identify research gaps and strategically plan future sampling efforts.

More information on this phase will be publicly available upon USGS completion of collected site data.

Funding Programs/Sources, Percent of Project Funding and Project Costs

Summary – Funding Programs/Resources

Of the 168 sources of funding identified in the inventory, approximately 90 were concretely different. An exact number cannot be provided due to variations in the level of detail of the responses. In some cases, specific programs within funding agencies were identified. In other cases, an agency was identified but the program responsible for distributing the funds was not. In a handful of instances, a response consisted simply of “federal” or “state” or “local” or “various”. The GLRI, a significant funding source in the Great Lakes region since 2010, is included by name in 19 responses. However, monies from the initiative are distributed by a number of agencies and may have been used to fund all or part of other projects in the inventory without the GLRI being mentioned by name.

Thirty-one of the 150 projects described, one-fifth of those responding to the survey, identified more than one source of funding. Ten of those projects, worth a combined total of over \$650,000, were supported by three or more funders. One project, a USGS stream gaging program in Wisconsin, had support from eight sources, including two federal agencies, one state agency, one regional NGO, one local agency and three tribes.

As a means of summarizing funding data, the funding sources named in the survey results were divided into ten categories. Five of those categories are actually specific state or federal funding programs, singled out because they funded all or part of a large number of projects:

- Federal Sport Fish Restoration Funds: 27 projects
- GLRI: 21 projects
- NOAA-CZM: 18 projects
- Great Lakes Salmon Stamp Funds: 10 projects
- Commercial Fishing License Fees / Funds: 10 projects

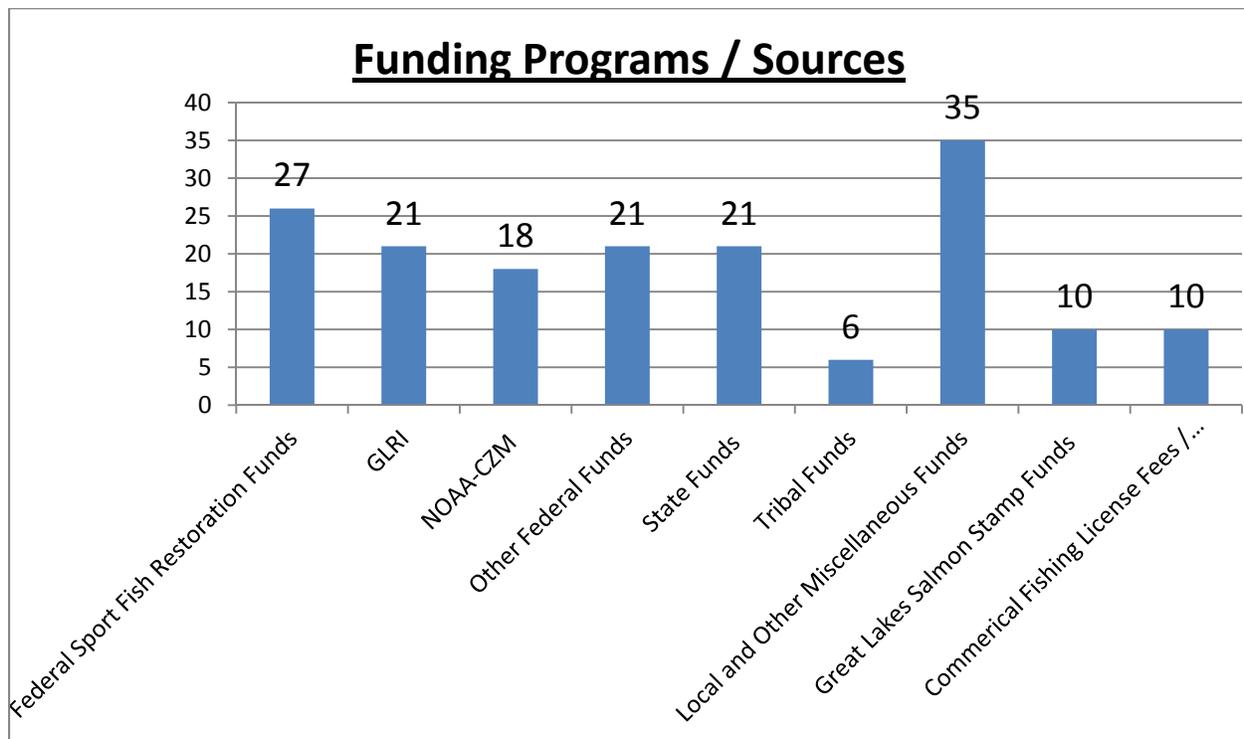
The other five categories are more general, based on level of government:

- Other Federal Funds: 21 projects
- State Funds: 21 projects

- Tribal Funds: 6 projects
- Local: 18 projects
- NGO/Private/University/Other: 17 projects

Federal funds supported 86 of the projects described in the survey results. 38 projects were supported by state funds and 41 received funds from local, tribal or non-governmental sources. Again, a number of the projects in the survey were funded by multiple sources.

With the recent infusion of funds from the GLRI over the past several years, it is not surprising to see the GLRI near the top of the list in terms of number of Lake Michigan monitoring projects funded (21). It is interesting to note, however, that one separate pot of money – the Federal Sport Fish Restoration Funds – was at the top with 26 projects funded. Coupled with this funding source, other sources that specifically funded Lake Michigan fishery-related monitoring include the Great Lakes Salmon Stamp Funds (10 projects) and the Commercial Fishing License Fees/Funds (10 projects). Some of the tribal funds were also used to fund fishery-related projects. Most of these fisheries projects took place in Wisconsin watersheds of Lake Michigan.



Summary – Project Costs

One-hundred-thirty of the 150 surveys reported project cost as an annual amount or in conjunction with a project period that allowed estimation of annual cost. The others either did not provide a clear response or did not provide project costs at all. The median cost for all projects reported in the survey was \$50,000. However, reported project costs ranged from a low of \$500 (supporting funds for two fish population assessments) to a high of over \$3,000,000 (an Indiana Environmental Protection Agency study of avian botulism funded under

GLRI). Based on projects where annual cost is either clearly indicated or can be readily derived from the project duration, average project costs are over \$100,000 per year for multi-year projects. Five of the projects identified in the inventory received over \$1,000,000 – all of these are multi-year projects and the project cost reported is assumed to be cumulative.

Recommendations

Federal and state funding play an important role in nearshore monitoring projects on Lake Michigan. The GLRI has provided funding for a number of new projects since 2010, but a long history of projects funded by other federal and state programs was demonstrated by the number of ongoing projects reported in the survey that precede GLRI. The majority of projects reported in the survey received some level of federal and/or state funds. The projects with the largest amounts of funding received that money through federal and/or state programs.

Also noted was the large number of projects reporting support from state and federal programs related to fisheries. These projects were typically funded somewhat below the median, generally between \$2,500 and \$25,000, but they constitute over 40 of the 150 projects that responded to the survey.

At the same time, funding from tribal, local agencies and non-governmental organizations supported approximately one third of the projects reported.

Due to the large number of federally-funded projects (86 in all) and the comparatively lower number of state and tribal-funded projects, it is recommended that more federal monitoring dollars are allocated to the states/tribes. This would (1) allow states to “move money” faster than what occurs at the federal level and (2) enable states/tribes, which generally have a closer pulse on the needs for Lake Michigan monitoring given they are more closely connected to work at the watershed level than federal government agencies, to allocate funding toward high-priority monitoring needs identified through this closer relationship at the local/watershed level.

Standard Project Objective

Summary

Participants in the Lake Michigan NEMO Workgroup were interested in what “standard project objective(s)” (SPO) each project had as its goal(s) or mandates. The workgroup devised the categories below, which were used in the inventory to ask the question: *Select the project objective that most closely matches your project. You may choose more than one.* For instance, a project could be both an “assessment” and “regional”. Since respondents were allowed to select more than one, there are a total of 565 SPO’s for the 150 projects in the inventory.

Of the 19 project objectives respondents could choose from, 12 primarily describe thematic/subject area objectives. Theme-oriented project objectives were addressed with the following frequency:

Project Objective	Count
Assessment	136
Trend Analysis	81
Research	46
Ecosystem Health	41
Human Health	30
Project Specific	22
Pollution Event	19
Regulatory Benchmark	12
Permit Compliance	10
Bioaccumulation	9
Reconnaissance/Occurrence Survey	9
Storm Event	9
Other (see below)	6

Note: Six project objectives were added by survey respondents using the “Other” category. Each entry was associated with a separate project and in all cases, the project included other objectives. These six unique project objectives are:

1. Beach Health
2. Cultural Resource Study
3. Education
4. Navigational Maintenance
5. Real-time Lake Observing Technology
6. Total Phosphorous

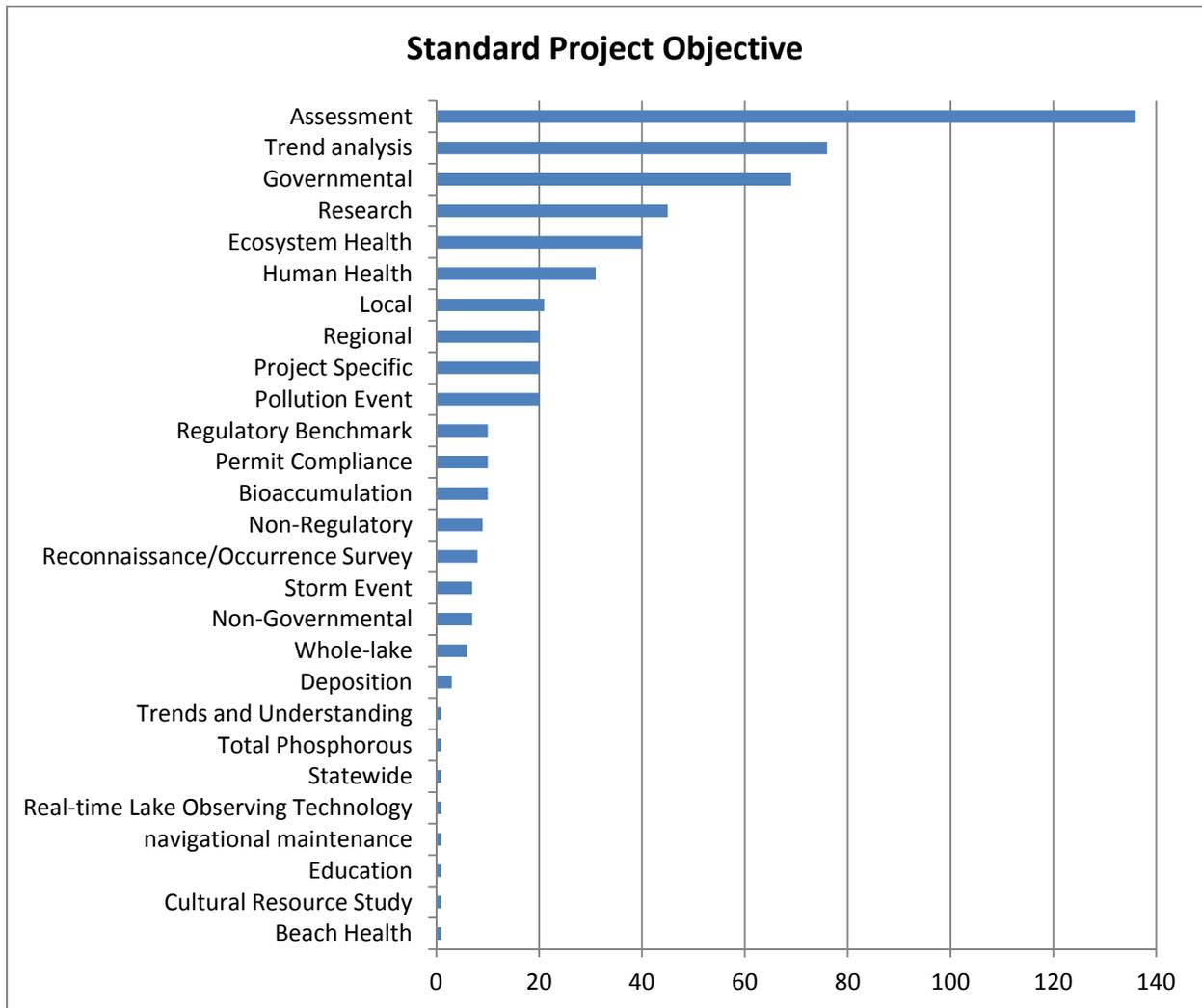
Many projects indicated whether or not the study was associated with governmental or regulatory activities:

Project Objective	Count
Governmental	71
Non-Governmental	7

In addition, some respondents provided a general indication of the geographic extent of their project. Three responses were provided in the survey that related to the project’s spatial extent – Regional, Local and Whole Lake. One study entered a description of “Statewide” using the “Other” field.

Project Objective	Count
Regional	20
Local	19
Whole Lake	7
Statewide (used the “Other” response option)	1

Of the 150 projects in the inventory, 136 are assessments of one form or another. This indicates that we are collectively assessing the status of the Lake Michigan nearshore in many specific areas, both geographically and via many different monitoring parameters and methods. Of note, nearly half (71) of the projects are “governmental” monitoring projects with a comparatively lower number (7) at the non-governmental level. Additionally, a relatively high number of projects (81) are for the purposes of a trend analysis, indicating that many entities are monitoring the changing conditions of Lake Michigan and its nearshore over time. This may also account for over a quarter (27%) of the projects conducting ecosystem health monitoring.



Gaps and Recommendations

It appears at the governmental level, most of the data collection is focused on conducting assessments, trend analyses, and monitoring ecosystem health. However, the inventory data also tells us that there may be a need to focus efforts more at the local/non-governmental/watershed level. However, it is hard to judge if monitoring Lake Michigan tributaries and other connecting resources is sparse at this level or if this is a result of a low number of respondents from that specific target audience to the survey. Either way there is good reasoning for involving more local watershed groups in the nearshore and associated monitoring projects, perhaps via more direct funding and/or partnerships. This would lead to more local ownership of monitoring projects involving the nearshore. This could greatly enhance efforts that call for local input, in particular the Areas of Concern program, where local advisory councils have a major role in decision-making and monitoring the health and recovery of these once highly polluted areas. In addition, a very small number of projects (10) are for the purpose of permit compliance. Perhaps with all of the monitoring personnel out there, a greater utilization of these monitoring resources could “multi-task” in handling permit compliance work. Understandably, there would be a need for specific training on compliance-related issues, but if looked upon as an investment in this area, many federal and state dollars could be saved in the longer term.

As indicated in the data and graph above, there were several other types of monitoring objectives reported with relatively low numbers (less than 10 projects). One could surmise we are not monitoring those categories good enough, however, it’s more likely that these were secondary objectives or categories (such as beach health and Total P) where there are many researchers monitoring them who are part of large groups, such as the Great Lakes Beach Association, that were not reached with this survey.

Organizations that Created Data

Summary

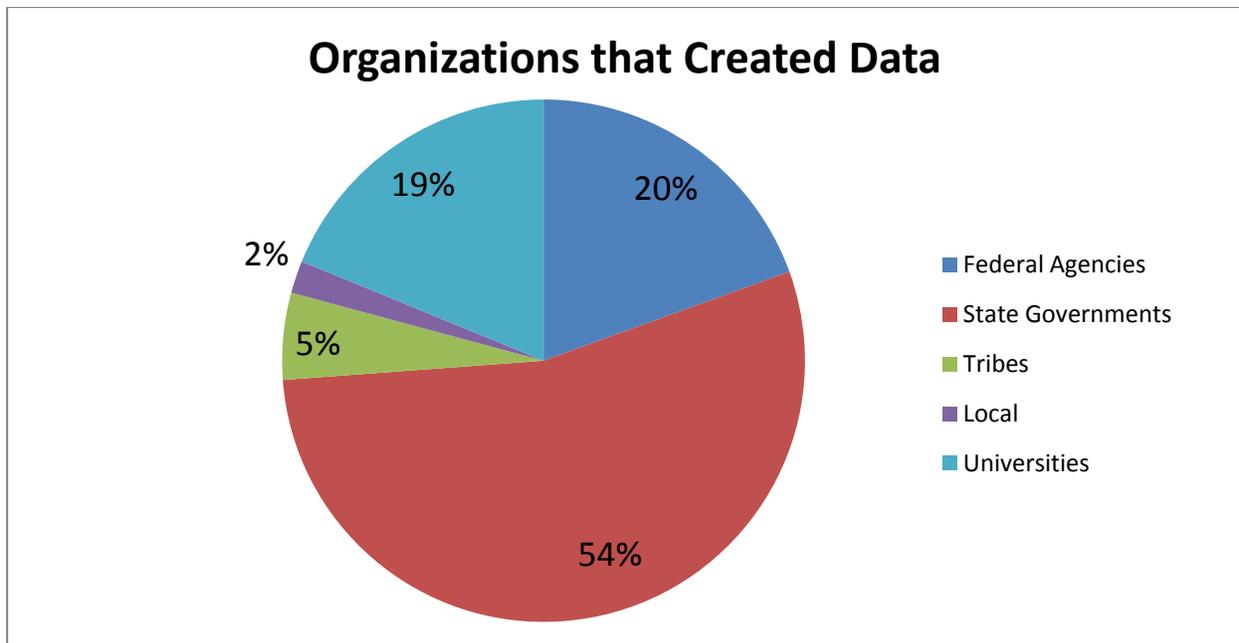
This category accounts for those organizations that were actually out in the field collecting monitoring data. Nearly all respondents that indicated they were the “Organizations that Created Data” also claimed to be the “Data Hosting Organization”. The table below is an alphabetized list of these organizations and the number of projects they listed in the inventory:

Organizations that Created Data	Number of Projects Listed in Inventory
Bad River Band of Chippewa Indians	1
Central Michigan University	2
Grand Traverse Band of Ottawa and Chippewa Indians	1
Grand Valley State University	2
Great Lakes Inventory and Monitoring Network	1
Green Bay Metropolitan Sewerage District	1
Hope College	1

Illinois Department of Natural Resources	2
Illinois Environmental Protection Agency	3
Indiana Department of Environmental Management	4
Little Traverse Bay Band of Odawa Indians	3
Macatawa Area Coordinating Council	1
Michigan Department of Environmental Quality	13
Michigan Department of Natural Resources	7
Michigan State University	7
Michigan Technological University	3
Milwaukee Metropolitan Sewerage District	1
National Oceanic and Atmospheric Administration	1
Northwestern Michigan College	1
Oneida Tribe of Indians of Wisconsin	1
Sault Ste. Marie Tribe of Chippewa Indians	2
U.S. Army Corps of Engineers	1
U.S. Environmental Protection Agency	2
U.S. Geological Survey	24
University of Michigan	5
University of Wisconsin, Milwaukee	4
University of Wisconsin, Oshkosh	3
Wisconsin Department of Natural Resources	52

Contrary to the “Funding Programs/Sources” category, state governments (and a handful of tribes) conducted more than half the monitoring of all projects creating data. The Wisconsin Department of Natural Resources submitted slightly over one-third of all projects in the inventory, with a majority of these projects in the fisheries area. Federal agencies and universities each conducted about one-fifth of the monitoring, with local groups conducting a comparatively small slice of the monitoring.

The survey developers note, however, that these are simply numbers of projects and their respective organizations that participated in our inventory effort; it is likely that many more local/watershed groups are out there monitoring but we were either not successful in reaching them or they were simply overwhelmed by or didn’t have time for our survey. Many local groups are strictly run and operated by volunteers.



Gaps and Recommendations

In order to garner more participation from local/watershed groups and glean more site-specific data from the monitoring these groups conduct, a separate survey should be funded and undertaken, focused on this segment of monitoring organizations around the Lake Michigan basin. Such a survey could be written for and tailored to the local/watershed/volunteer monitoring groups, e.g., using a shorter, less-time-consuming survey instrument.

Watersheds – 8-Digit Hydrologic Unit Code (HUC)

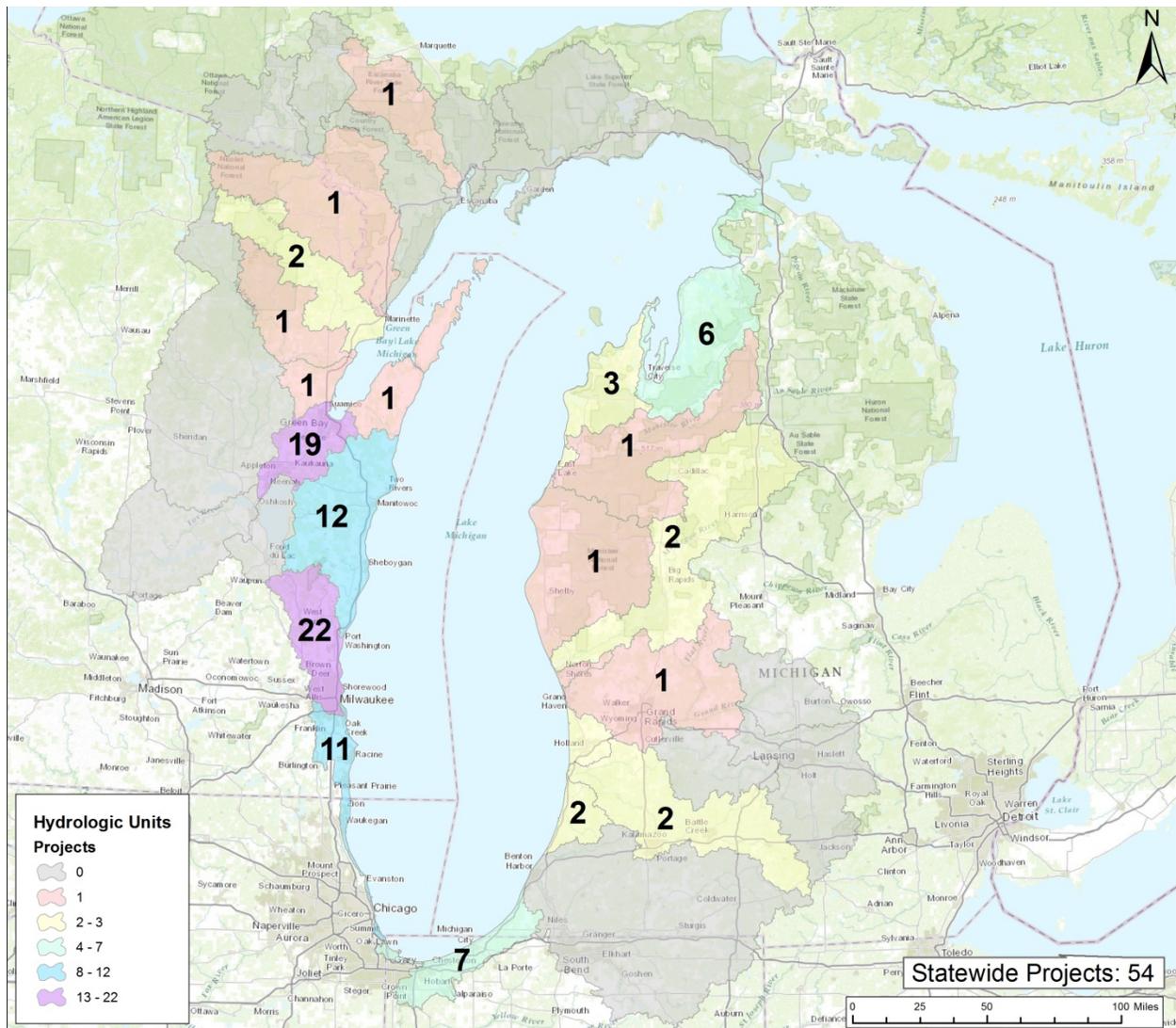
Summary

Participants were asked to select an 8-digit HUC watershed in which the monitoring takes place for a project. All Lake Michigan 8-digit HUCs were included as possible choices, with an additional selection of “statewide” for those projects that covered other parts of a state outside of the Lake Michigan and/or Great Lakes basin, or organizations that have projects in the Lake Michigan watershed whose monitoring efforts extend to one or more of the other Great Lakes. The table below includes an alphabetical list of 8-digit-HUC watersheds that were selected by respondents with the number of projects in parentheses for that particular watershed. The number of “Statewide” projects is at the bottom of the list. The projects and their watersheds are depicted graphically in the map on page 16.

Watershed – 8-Digit-HUC	Number of Projects Per Watershed
Betsie-Platte 04060104	3
Black-Macatawa 04050002	2
Boardman-Charlevoix 04060105	6
Door-Kewaunee 04030102	1
Duck-Pensaukee 04030103	1
Escanaba 04030110	1
Kalamazoo (AOC) 04050003	2
Little Calumet-Galien (AOC) 04040001	7
Lower Fox (AOC) 04030204	19
Lower Grand 04050006	1
Manistee 04060103	1
Manitowoc-Sheboygan (AOC) 04030101	12
Menominee (AOC) 04030108	1
Milwaukee (AOC) 04040003	22
Muskegon (AOC) 04060102	2
Oconto 04030104	1
Pere-Marquette-White (AOC) 04060101	1
Peshigo 04030105	2
Pike-Root (Waukegan) (AOC) 04040002	11
Statewide	54

It is evident from the data above that there *appears* to be more monitoring occurring on the Wisconsin/Illinois side of Lake Michigan. However, when comparing sides of the lake, 54 of the inventory entries reporting “statewide” monitoring projects are in Michigan. This tells us that a majority of state monitoring personnel who completed the survey on the Wisconsin/Illinois side narrowed their entries down to specific watersheds to a larger degree, while Michigan personnel included Lake Michigan watersheds, to a large extent, as part of their statewide monitoring programs.

There are many possible other reasons for this disparity, including different budget priorities in Michigan compared to those in Wisconsin, e.g., different areas of focus and work effort with regard to the use of limited monitoring-related funds.



Gaps and Recommendations

If the survey response disparity mentioned above is not the result of differing degrees of survey participation, it can, in part, represent differences in program focus or local engagement. The LMMCC may want to consider working with state volunteer monitoring organizations to develop an inventory of regional (within states) and local monitoring programs and, if appropriate, prepare to conduct active outreach directed toward them that encourages their participation.

To rectify differences in reporting where monitoring projects occur at the 8-digit HUC level, future surveys will focus on establishing consistency with reporting methods among those completing the surveys.

All told, survey respondents identified projects that took place in 19 of the 34 8-digit HUC watersheds around Lake Michigan. In other words, information about monitoring efforts was

provided for 56% of the Lake Michigan basin’s natural water source divisions. There are a few notable gaps among the missing watersheds:

- **Chicago Area Waterway System (CAWS):** The CAWS is an approximately 130-mile array of natural and constructed rivers, canals, locks, and other structures in Chicago and northwest Illinois. The waterway system diverted water from Lake Michigan and created a connection across the mid-continental divide to the Mississippi River watershed. There are five connections between the CAWS and Lake Michigan, and the Chicago Sanitary and Ship Canal connects the system to the Illinois River and the Mississippi River watershed. The CAWS provides important benefits to the Chicago region, including conveying treated wastewater, supporting commercial shipping, managing flood water, and moving recreational boats and tour boats.¹ Separating the two watersheds is proposed to prevent the movement of Asian carp and other aquatic invasive species (AIS) between them via the CAWS. Many researchers are studying the various aspects of the system, including the movement of AIS. Due to the significance of this ongoing work to the Lake Michigan ecosystem, it is important that the monitoring data and information from this watershed is made available and shared with the LMMCC, the NEMO Workgroup, and other researchers who look at the “bigger picture” of the health of Lake Michigan.
- **Manistique River AOC:** A collaboration of local, state and federal entities are working together to complete the last remaining restoration actions needed to delist the Manistique River AOC. These actions will address the contamination causing fish consumption advisories and restrictions on dredging activities.² Monitoring the progress on the restoration of these impairments is critical to the eventual delisting of the Manistique River as an Area of Concern. Coordinating monitoring data collection and reporting not only in the Manistique River AOC, but in all AOCS, would be helpful in increasing our understanding of the Lake Michigan nearshore.
- In addition to the Manistique River AOC data gap, there appears to be a large gap in the area directly north of Lake Michigan. This tells us that a stronger outreach effort is needed to reach watershed communities along the lake in Michigan’s Upper Peninsula.
- **St. Joseph River:** The St. Joseph River watershed is located in the southwest portion of the Lower Peninsula of Michigan and the northwestern portion of Indiana, draining into Lake Michigan in the city of St. Joseph, MI. It is a large watershed that drains 4,685 square



St. Joseph River Watershed

¹ Great Lakes Commission and Great Lakes and St. Lawrence Cities Initiative. January 2012. Restoring the Natural Divide: Separating the Great Lakes and Mississippi River Basins in the Chicago Area Waterway System.

² U.S. Environmental Protection Agency. Manistique River Area of Concern web page: <http://www.epa.gov/greatlakes/aoc/manistique/index.html>

miles, via 3,742 river miles, from 15 counties in Michigan.³ Since the mid-1990s, upon the formation of the group Friends of the St. Joe River, the river and its watershed has received much attention to address a number of water quality issues including erosion, sediments, nutrients, habitat loss, wetlands, animal waste, pesticides, PCBs, urbanization and land use, biota, combined sewer overflows, pathogens, hydrologic modification, and litter. There is a large collection of data and information online regarding the watershed and the accomplishments of monitoring and cleanup efforts over the years, yet no projects were reported in the survey.

- A stronger tie-in is needed among key watershed personnel with the LMMCC, the NEMO Workgroup, and other researchers on current/ongoing efforts and associated monitoring to fully assess the status of this large river watershed and its impacts on Lake Michigan.
- Few or no monitoring projects were reported for several smaller watersheds in more rural areas of the Lake Michigan basin. The LMMCC should reach out to groups in these areas to encourage their participation in the next inventory as well as their sharing of monitoring efforts and associated data.

Resource Component Sampled

Summary

Participants were asked to indicate the resource component or components they monitor from the following list:

- Medium nearshore
- Shallow nearshore
- Offshore
- Beaches
- Coastal wetlands
- Drowned river mouths
- Embayment
- Ground water
- Harbors
- Inland lakes
- Lake
- Lake bottom (benthic province)
- River mouths
- River substrates
- Shoreline
- Stormwater conveyance system
- Tributary

³ <http://www.stjoeriver.net>

- Water column (variable depths; pelagic province)
- Water treatment facility intake

Survey results were analyzed to determine what projects are monitoring which components, where via the following questions and tables:

What % of the projects monitored each resource type?

Sorted alphabetically by Resource Type:

Resource Type	Percent of Projects Listed
Beaches	19%
Coastal wetlands	13%
Drowned river mouths	10%
Ground water	4%
Harbors	15%
Inland lakes	17%
Medium nearshore (between 30-80m depth for Lake Michigan)	39%
Offshore (greater than 80m depth for Lake Michigan)	28%
River mouths	21%
River substrates	7%
Shallow nearshore (less than 30m depth for Lake Michigan)	54%
Shoreline	14%
Tributary	62%
Unknown	3%
Water column (variable depths; pelagic province)	10%
Water treatment facility intake	2%

Sorted by percent of projects monitoring specific Resource Types:

Resource Type	Percent of Projects Listed
Tributary	62%
Shallow nearshore (less than 30m depth for Lake Michigan)	54%
Medium nearshore (between 30-80m depth for Lake Michigan)	39%
Offshore (greater than 80m depth for Lake Michigan)	28%
River mouths	21%
Beaches	19%
Inland lakes	17%
Harbors	15%
Shoreline	14%
Coastal wetlands	13%
Drowned river mouths	10%

Water column (variable depths; pelagic province)	10%
River substrates	7%
Ground water	4%
Unknown	3%
Water treatment facility intake	2%

Also present: "all habitats within the watersheds" (1 project); Grand Traverse Bay (1 project)

1. What % of the projects monitored multiple resource types?

Fifty-nine out of 150 projects (39%) monitored a single resource type, with a breakdown shown in the table below. The remaining 61% of projects monitored multiple resource types, including various combinations of the resource types listed in the table and others that only appeared as part of projects monitoring multiple resource types.

Resource Type	Number of Projects	Percent of Projects Listed
Beaches	5	3%
Coastal wetlands	3	2%
Ground water	1	1%
Harbors	2	1%
Inland lakes	2	1%
Offshore (greater than 80m depth)	1	1%
Shallow nearshore (less than 30m depth)	11	7%
Shoreline	3	2%
Tributary	28	19%
Unknown	2	1%
Water treatment facility intake	1	1%

2. What % of the projects did work in the lakes themselves?

Resource types tentatively defined as "lake":

- Lake
- Lake bottom (benthic province)
- Shallow nearshore
- Medium nearshore
- Offshore
- Embayments
- Shoreline
- Water column (pelagic province)

Projects working solely in the lakes: 56 (37%)

3. What % of the projects did work in areas adjacent to the lakes?

Resource types defined as "lake-related":

- Beaches
- Coastal wetlands
- Drowned river mouths
- Ground water

- Harbors
- Inland lakes
- River mouths
- River substrates
- Tributary
- Water treatment facility intake

Projects working solely in lake-related areas outside the lakes: 68 (45%)

Projects working both in the lakes and in related areas: 24 (16%)

Gaps and Recommendations

When sorting by percent of projects monitored for each resource type, tributaries (62%) and shallow nearshore (54%) are shown to be receiving the most attention, with offshore showing a strong response (39%). This is not surprising, given the focus on the nearshore by the likes of the Great Lakes Water Quality Agreement, the GLRI, and the Lake Michigan LaMP. Since tributaries have a large impact on the nearshore, funding is well-spent to monitor this resource component, as well as the nearshore itself.

However, there are other resource components that have substantial impact on the nearshore, yet very low numbers were reported (i.e., ground water, water treatment facility intakes). Again, there are likely large target groups from these areas that the survey did not reach. Other resource components with relatively low response rate that may deserve additional attention include:

Coastal wetlands: Coastal wetlands, which provide habitat for many species and function as filtering mechanisms, represent only 13% of the projects listed. Although there is a large GLRI project funding coastal wetland monitoring through 2015, continuous monitoring of this important resource should not be neglected by funding programs beyond 2015.

River substrates: River substrates are another resource component that surprisingly has only 7% representation (7 projects) in the inventory. Three of these projects have finite project end dates within two years. Given the focus on contaminated sediments as a major source of water quality degradation, it is imperative that river substrates continue to receive attention and funding.

Beaches: Although beaches have 19% of projects in the inventory, we also must point out that this resource component is deserving of continuous focus and funding. With the recent cutback in the federal BEACH grant program that funds state monitoring of beach water quality, there is likely to be a large gap in this area in the near future. Given the public use of beaches for recreational purposes and the human health aspects tied to the cleanliness of beaches, it is imperative that beach monitoring does not languish and that new or other sources of funding be directed toward this resource component. Local governments are financially constrained already and looking to them to pick up the slack does not bode well for the region's beaches.

Media Sampled

Summary

Participants were asked to select from a list of 20 potential media they sample. The following table below is sorted by percent of projects listed in the inventory:

Media Sampled	Number of Projects Listed in Inventory	Percent of Projects Listed
Fish	70	47%
Water	57	38%
Invertebrates	25	17%
Algae	15	10%
Birds	14	9%
Phytoplankton	12	8%
Air	10	7%
Sediment – Lake	9	6%
Sediment – River	9	6%
Sediment – Suspended	9	6%
Amphibians	6	4%
Tissue	6	4%
Zooplankton	6	4%
Carcasses – Birds	5	3%
Carcasses – Fish	5	3%
Dunes	5	3%
Vegetation	5	3%
Waterfowl	4	3%
Carcasses – Other	1	1%
Other (1)	1	

It is clear from the results above that fish are being sampled heavily in Lake Michigan, with 70, or 47% of projects, studying fish, with an additional five projects sampling fish carcasses. Over one-third of projects (57) are sampling water. Aside from these two heavily sampled media, there were 25 projects, or 17%, sampling invertebrates. The remaining media have been sampled to a lesser degree, at 10% or less of projects responding for each.

Gaps and Recommendations

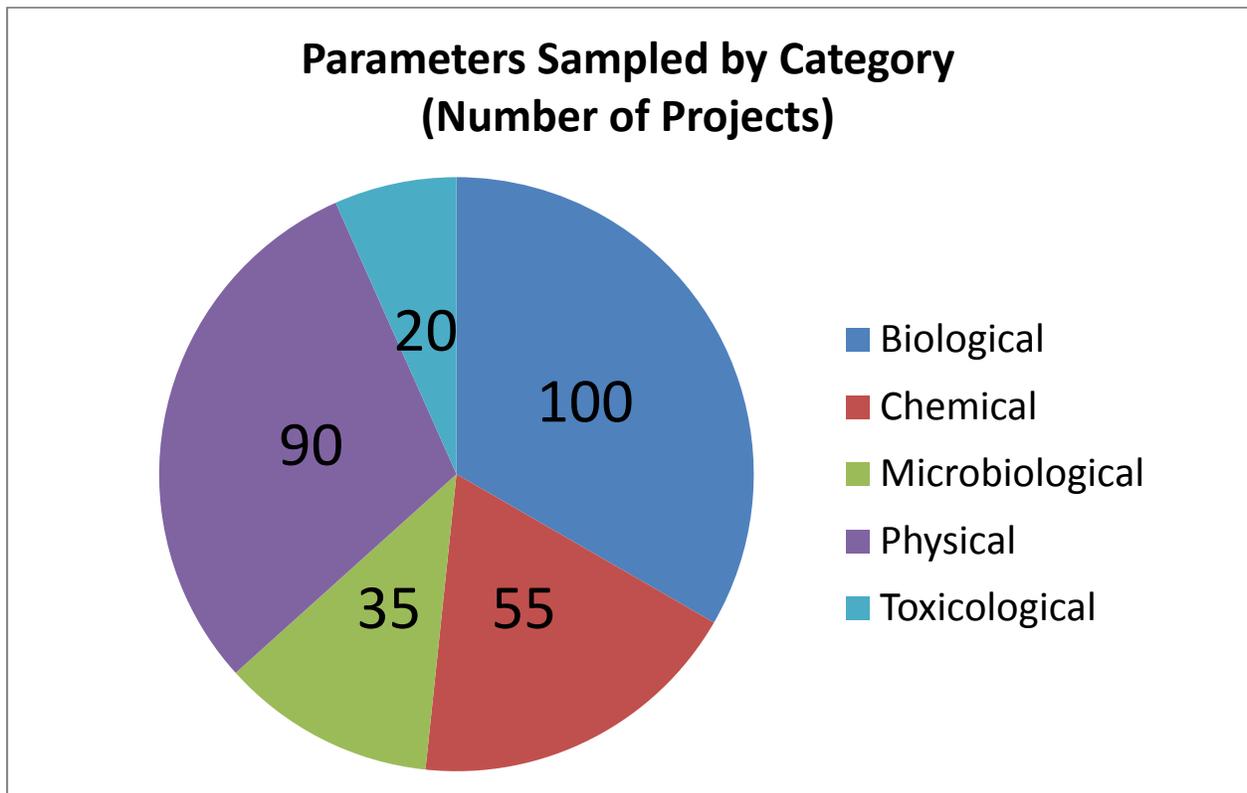
Given some of the major ecological problems found in the Lake Michigan nearshore, particularly regarding heavy cladophora beds, invasive species, over-abundance of nutrients, botulism, and the resulting bird, fish, and other wildlife mortality, perhaps more funding and/or collaboration should be directed at other less-sampled media. Some of these media could include sediment, vegetation, phyto- and zooplankton, and algae to ensure a larger coverage of sampling and monitoring of these types of media. Many of these lesser-sampled media, including those mentioned above as well as fish and wildlife, are indicators used in Areas of

Concern to measure restoration of beneficial uses. They are also important indicators of water quality and habitat.

Parameters Sampled

Summary

Biological and physical parameters are being monitored the most heavily in the Lake Michigan basin according to inventory numbers. (See pie chart below.) Chemical parameter monitoring is a distant third, followed by the microbiological and toxicological categories.



Note: The pie chart above only shows the numbers of *projects* conducting these five broad categories of monitoring. A single project could conduct more than one type of biological monitoring, for instance. Hence, the total individual parameters monitored per category are as follows:

Category of Monitoring	Total Parameters Sampled
Biological	404
Chemical	306
Physical	687
Microbiological	44
Toxicological	21

Note that although the pie chart indicates there are more projects monitoring biological parameters than physical parameters, the total number of physical parameters being monitored largely outweighs the total number of biological parameters being monitored.

Gaps and Recommendations

The inventory numbers indicate that there has been a heavy focus on biological and physical parameter monitoring in the Lake Michigan basin. With the many issues involving chemical pollutants in the basin and nearshore (e.g. nutrient and Phosphorus loading), this category could use additional attention to ensure a more balanced approach to the larger monitoring picture for the lake, and in particular, it's nearshore. Microbiological and toxicological sampling could essentially have larger numbers as well, however, they may have been better reported by those conducting beach monitoring and other forms of pathological monitoring that were not in the main target audience of the survey.

Sampling Frequency

Summary

Though sampling frequency is very project-specific based on the parameters being sampled and funding timelines, there are still some interesting data that can be looked at in terms of start/end dates and what that means for project continuity over both the short- and long-term:

- 94 of 150 projects have a declared start year of 2010 or later.
- Of the 94 projects with a start date of 2010 or later, 33 will end by 2015 or earlier.
- 34 of 150 projects have a declared start year of 2009 or earlier.
- 22 projects do not have a declared start year.

From the above data, we *could* conclude that 94 projects conceivably received GLRI funding.

- 18 projects do not have a declared end year.
- 41 of 150 projects have a declared end year that did not imply an open-ended project (end year < 2099).
- Of these 41, eight projects have already closed and 33 end in 2015 or earlier.
- Based on Sampling Start Date and Sampling End Date, eight projects run for one year. All of them are within the GLRI timeframe – two in 2012 and six in 2013.

Based on inventory data, we can only say with certainty that 21 projects received GLRI funding, but it would be valid to speculate that anywhere from 30 to 48 did actually get at least some GLRI money. Overall this tells us that, based on sampling frequency, the GLRI plays an integral role in the funding of Lake Michigan nearshore monitoring projects. It is important to repeat that 33 projects end in 2015 or earlier.

Recommendations

Though some of these projects may be short-term in nature, some may need to be extended and funded beyond 2015 to achieve the continuity and validity of data needed to conduct trend analyses or long-term resource assessments.

Sampling Platform

Summary

There are hundreds of various types of sampling platforms identified in the 150 projects in the inventory. Yet many projects share common types of equipment used to conduct their sampling.

Recommendations

The inventory, available at www.glc.org/lmmcc/nemo provides a comprehensive list of equipment used by monitoring personnel throughout the Lake Michigan basin. It is recommended that when in need of additional equipment or supplies, project personnel look over this list and identify partners with whom they may be able to share equipment with or, even better, collaborate on their monitoring activities. If there is funding and support from its members, the LMMCC could conceivably maintain an inventory of sampling platforms and equipment to facilitate this sharing of physical monitoring resources.

Coordination of Monitoring Resources and Results

In addition to coordination of monitoring resources through communication and other electronic tools such as the inventory, the LMMCC should continue to seek means of sharing monitoring results. Large-scale, long-term monitoring programs usually have an associated data sharing service. For example, a number of state and federal environmental programs share data through the National Environmental Data Exchange Network (Exchange Network), a cooperative effort by the states and U.S. EPA. Smaller projects could submit data using this channel as well if appropriate data handling mechanisms can be developed. One Exchange Network pilot project involving the Wisconsin Department of Natural Resources and the Michigan Department of Environmental Quality, the Large Aquatic Ecosystems Data Exchange, is working specifically on this. The project is developing a means of sharing monitoring data from independent monitoring programs through the Exchange Network. The results of this pilot project will be shared with organizations in the Great Lakes region, including the LMMCC, when they become available.

Other, less ambitious data sharing options might include a simple online clearinghouse of monitoring results. Project metadata and contact information, and in some cases, perhaps even the monitoring results, could be housed on a website hosted by an LMMCC partner, by U.S. EPA or by a regional information sharing site such as the Great Lakes Information Network.

Project Summary

Nearshore sampling and monitoring is a key component of the Lake Michigan LaMP; nonetheless, monitoring efforts can be enhanced to be more comprehensive and efficient. The LaMP explicitly states that *“Monitoring programs use these observations to take the pulse of the Great Lakes, assess natural variability, drive ecosystem forecasting models, and assess the progress of restoration efforts. Current monitoring challenges in the Lake Michigan basin include: incomplete inventories of federal, state/provincial and municipal observation and monitoring.”*

It is our hope that this project’s inventory and this report helped to address this challenge. We received 150 individual inventory entries on various monitoring projects related to the Lake Michigan nearshore. Though we know there are many more that we did not receive for one reason or another, our inventory and this report should provide a basis to help address the Lake Michigan LaMP’s key question related to monitoring: *“Do we have enough information, data, understanding, and indicators to inform the decision-making process?”*

Though it was not in the realm of this project to develop indicators of environmental health, we can now address, at least in part, the second half of the question above. Breaking the question down into parts, first, *do we have enough information and data?* This begs the question, *“What is enough?”* In order to inform the decision-making process, we must first know what information is out there and available.

By helping to design the inventory fields, the Lake Michigan NEMO Workgroup enabled the gathering of nearshore monitoring information in a comprehensive manner. Although we’d like to think we have *“enough”* information at this juncture to inform the decision-making process and help address management questions, we can be sure that we do not have *“enough”* information via this project. However, we encourage managers and other stakeholders to sift through the inventory when attempting to address specific questions on particular categories of information found in the inventory. The answers just may be there.

The next part of the question is, *“Do we have enough understanding to inform the decision-making process? The term “understanding” is in itself subjective. Do we have enough understanding?* Using individual categories of the inventory to answer this question will likely not address this question. However, when looking at the Lake Michigan nearshore system as a whole, this inventory and report should provide *“enough”* information on what monitoring is taking place in terms of sampling parameters, where it is taking place, how it is being accomplished, when it is taking place, how often, and why it is being conducted. Hence, Great Lakes managers and other stakeholders should have a better *understanding* and solid scientific basis, given the breadth of information now available, to make more informed decisions and address ecosystem health and restoration priorities.

Finally, we must talk about project continuity and funding. As mentioned in the section on Sampling Frequency, there are over 30 monitoring projects that end prior to 2015. These are

largely due to the influx of Great Lakes Restoration Initiative funds. GLRI funds concretely helped Lake Michigan managers and monitoring personnel gather much more environmental data than otherwise would have been obtainable. Though we should now have sufficient information available to establish a solid baseline for assessing the health of Lake Michigan at this point in time, the ecosystem is forever changing. Managers and stakeholders need to conduct a “full court press” to keep a pipeline of monitoring funds available to continue to feed this solid baseline of information available going forward. This inventory should be updated on an annual basis to keep information current for well-informed decision-making based on “real time” data.

Future funding will also help monitoring efforts in digging yet deeper to gain more specific information to help address the many ecosystem health issues abound in the basin. Only through this constant vigilance on the importance of monitoring the Lake Michigan nearshore and its entire basin will we be able to truly and comprehensively assess its health and work more efficiently and collaboratively toward making Lake Michigan truly a GREAT Lake.

Compendium of Recommendations

1. **Continue efforts to fund a group to build a solid program of data collection, reporting, exchange, and integration for the Lake Michigan basin.** The LMMCC has delivered on this recommendation since 1999. Continuing these services and others that will allow for more enhanced surveys of metadata for Lake Michigan will build upon LMMCC efforts to date and create a robust knowledge base for managerial decision making in the basin.
2. **More federal monitoring dollars should be allocated to states/tribes.** This would (1) allow states to “move money” faster than what occurs at the federal level and (2) enable states/tribes, which generally have a closer pulse on the needs for Lake Michigan monitoring given they are more closely connected to work at the watershed level than federal government agencies, to allocate funding toward high-priority monitoring needs identified through this closer relationship at the local/watershed level.
3. **Focus monitoring efforts more at the local/non-governmental/watershed level.** By involving more local watershed groups in the nearshore and associated monitoring projects, via more direct funding and/or partnerships, more local ownership of monitoring projects would occur. This could greatly enhance efforts that call for local input, in particular the Areas of Concern program.
4. **Utilize monitoring resources to “multi-task” in handling permit compliance work.** Understandably, there would be a need for specific training on compliance-related issues, but if looked upon as an investment in this arena, many federal and state dollars could be saved in the longer-term.

5. **Conduct a separate survey and corresponding inventory focused on local/watershed groups and volunteer monitoring organizations.** Such a survey could be written for and tailored to the local/watershed/volunteer monitoring groups, e.g., using a shorter, less-time-consuming survey instrument. The survey would likely garner more participation from these groups and glean more site-specific data, however, the LMMCC should conduct active outreach directed at them that encourages their participation.
6. **Ensure there is continued focus, continuity of long-term monitoring, and funding directed toward some “nearshore-associated” resource components that may have been under-reported or are in need of extra attention.** These include river mouths, beaches, inland lakes, harbors, shorelines, coastal wetlands, drowned river mouths, the water column, river substrates, ground water, and water treatment facility intakes. These resource components have substantial impact on the nearshore, yet had much fewer projects reported in the survey compared to the likes of tributary monitoring and monitoring of the nearshore itself.
7. **New sources of funding should be directed toward beach monitoring.** Given the public use of beaches for recreational purposes and the human health aspects tied to the cleanliness of beaches, it is imperative that beach monitoring does not languish due to cutbacks in federal BEACH Act funding.
8. **Additional funding and/or collaboration should be directed at lesser-sampled media like sediment, vegetation, phyto- and zooplankton, and algae to ensure a larger coverage of sampling and monitoring of these types of media.** Given some of the major ecological problems found in the Lake Michigan nearshore, and the fact that these media are indicators used in Areas of Concern to measure restoration of beneficial uses and are important indicators of water quality and habitat, further and continuous attention is warranted to these media types.
9. **Some projects that end in 2015 or earlier should be extended and funded beyond 2015.** This will help achieve the continuity and validity of data needed to conduct trend analyses or long-term resource assessments.
10. **Monitoring project personnel should look over the inventory’s “sampling platform” column which lists equipment and supplies used by various projects and identify partners with whom they may be able to share equipment with or collaborate on their monitoring activities.** If there is funding and support from its members, the LMMCC could conceivably maintain an inventory of sampling platforms and equipment to facilitate this sharing of physical monitoring resources.

Publications

Current status and trends in Muskegon Lake, Michigan

Available online through the *Journal of Great Lakes Research*.

A long-term monitoring program was initiated in 2003 to determine the ecological status of Muskegon Lake, a Great Lakes Area of Concern. This paper presents data generated from the first three years of the monitoring program, discusses how the data are being used to establish and justify lake restoration targets, and assesses how water quality conditions have changed over time.

Status of the Stocks Report (Lake Trout and Lake Whitefish) – No description or source available. Contact Kevin Donner, kdonner@ltbbodawa-nsn.gov.

LTBB Surface Water Quality Program Baseline Assessment Report

Available at <http://www.ltbbodawa-nsn.gov/Departments/Environmental/SWQPP/Baseline%20Report.pdf>

This baseline assessment assists in determining the best approach for LTBB to pursue protection efforts for Tribal surface waters within the reservation boundaries and/or surface waters directly affecting reservation waters.

Use of isotopes to identify sources of ground water, estimate ground-water-flow rates, and assess aquifer vulnerability in the Calumet region of northwestern Indiana and northeastern Illinois. Available at http://in.water.usgs.gov/newreports/abstracts/gw_isotopes-abs.html

Ground water age-dating to evaluate groundwater vulnerability to contamination. Wells in the network were sampled during 1998 and 2000 and samples were analyzed for oxygen and hydrogen isotopic content to evaluate ground water ages and by inference, relative flow rates through parts of the aquifer. This information allows inferences about potential future renovation of ground water quality as site mitigation and brownfield redevelopment progresses.

Indiana Harbor and Canal Ambient Air Monitoring Program: Construction Phase Annual Report 2011. Available at

<http://www.lrc.usace.army.mil/Missions/CivilWorksProjects/IndianaHarbor/AirQualityData.aspx>
Ambient air monitoring data, including polycyclic aromatic hydrocarbons (PAH), polychlorinated biphenyls (PCB), volatile organic compounds (VOC), metals, and Total Suspended Particulates (TSP) are currently being collected as part of the Indiana Harbor and Canal Confined Disposal Facility construction project. The construction project is located on the former Energy Cooperative, Inc. refinery site. Two monitoring locations are used: the south site (adjacent to the Indiana Harbor Canal just south of the ECI property), and the East Chicago High School. This report presents a summary of the mean concentrations for both monitoring sites, for a number of compounds. Data are analyzed based on the location of the monitoring station, the season (corresponding to the average temperature), and whether construction activities are occurring on site.

2011 Milwaukee River Report Card

Available at <http://www.milwaukeekeeper.org/content/2011reportcard>

This is Milwaukee Riverkeeper's most recent report card summarizing their data, as well as MMSD and WDNR data for the Milwaukee River Basin. They also have publications on their chloride and bacteria monitoring, but not currently online.

Improved Cladophora Monitoring Through Remote Sensing: Final Report

No online source available. Contact: Amanda Grimm, aggrimm@mtu.edu

The Final Report summarizes the EPA-funded Great Lakes Restoration Initiative (GLRI) project of the same name. The overall findings of this project can be found in a companion executive summary report.

Michigan's Underwater Observatory

Article in: *Environmental Monitor*, Fondriest Environmental, Spring 2012

GVSU's buoy floats on Muskegon Lake monitoring water quality.

Grand Valley Research Buoy Now Collecting Data in Muskegon Lake

Article in: *GVNow, News from GVSU*, April 26, 2012

State-of-the-art environmental sensors measuring weather and water quality on a Grand Valley State University monitoring buoy in Muskegon Lake were deployed for the 2013 summer season. The unit transmitted near real-time data for public use over the Internet.

Lake Sentinel: Observatory for ecosystem changes in Muskegon Lake

Article in: *Interchange* (Magazine of the Regional Math and Science Center, GVSU, Vol. 19, No. 4 (2012))

With funding from the US Environmental Protection Agency, Grand Valley State University established a state of the art buoy-based multi-sensor observatory in Muskegon Lake to track physical, chemical and biological changes taking place in real-time. Hourly time-series data will be used to assess indicators of ecosystem change such as food web structure, water quality, and harmful algal blooms. Data is readily accessible through web and regional observing networks for monitoring, research, education, and outreach - supporting the ongoing restoration of this coastal Great Lakes environment.

USGS Annual Water Data Report – No description available.

Available at <http://wdr.water.usgs.gov/>

Water resources data are published annually for use by engineers, scientists, managers, educators, and the general public. These archival products supplement direct access to current and historical water data provided by the National Water Information System (NWIS).

Use of real-time monitoring to predict concentrations of select constituents in the Menomonee River drainage basin, Southeast Wisconsin, 2008-9

Available at <http://pubs.er.usgs.gov/publication/sir20125064>

This report describes the process used to create regression models to estimate real-time concentrations and loads of selected water-quality constituents in the Menomonee River

drainage basin based on data from real-time water-quality monitors. The regression models presented in this report may help provide the Milwaukee Metropolitan Sewerage District (MMSD) with a means to document improvements in water quality related to capital projects, assist with basin planning efforts, and provide water-quality information to communities served by MMSD and the general public.

MMSD WQ Data Summary Statistics Report

Available at <http://v3.mmsd.com>

Annual Summary Statistics report for 13 different water quality monitoring surveys for Milwaukee River Basin and nearshore Lake Michigan.

Water- and sediment-quality effects on Pimephales promelas spawning vary along an agriculture-to-urban land-use gradient

Available at <http://www.sciencedirect.com/science/article/pii/S0048969711008382>

Evaluation of fish spawning in relation to water- and sediment- quality and how these relate to the influence of urban land use within the watershed.

Water-Quality Characteristics for Selected Sites Within the Milwaukee Metropolitan Sewerage District Planning Area, Wisconsin, February 2004-September 2005

Not available online. Contact: Steven Corsi, srcorsi@usgs.gov

This is a summary of hydrologic, geographic, physical, biological, and chemical data for the major streams, and their adjacent corridors within Milwaukee Metropolitan Sewerage District planning area.

Additional Publications

There were many additional publications referred to in a general sense throughout the inventory. However, none of these provided specific titles. They were generally referred to as “annual reports”, “triennial reports”, “reports to EPA”, “biosurvey reports”, etc. Some of the publications listed in the inventory with these types of titles provided web sites. Please check the inventory online at www.glc.org/lmmcc/nemo for additional information.

Appendix

2013 Lake Michigan Nearshore Monitoring Inventory. Available for download at www.glc.org/lmmcc/nemo