GLIC: Implementing Great Lakes Coastal Wetland Monitoring

Semiannual Progress Report

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INTRODUCTION

This project began on 10 September 2010. Most subcontracts were signed and in place with collaborating universities by late December 2010 or early January 2011. This project has the primary objective of implementing a standardized basin-wide coastal wetland monitoring program that will be a powerful tool to inform decision-makers on coastal wetland conservation and restoration priorities throughout the Great Lakes basin. Project outcomes include 1) development of a database management system; 2) development of a standardized sample design with rotating panels of wetland sites to be sampled across years, accompanied by sampling protocols, QAPPs, and other methods documents; and 3) development of background documents on the indicators.

There have been no changes to our project's objectives.

Summary of past activities:
Our primary activities in our first year involved developing our Quality Assurance Project Plan (signed March 21, 2011), developing the site selection mechanism, selecting our sites, and conducting our field work (wetland sampling), which began in late April/early May and continued through mid-September, 2011. All primary project personnel met in mid-January of 2011 to work through methods and details of all aspects of the project. During the first year, crews successfully sampled 176 sites with crew members that had completed extensive training sessions and passed all training requirements, including field sampling and identification tests. Crews then successfully entered the field data and completed quality control procedures and identified macroinvertebrate samples and entered those data.

During our second year, we revised and updated our QAPP (signed March 28, 2012), updated our site selection system to include site revisits that will help track wetland condition through time and assess year-to-year variability at the site level, and held a meeting with all project lead personnel (February 2012) to find solutions to issues that arose during our first year. In our second field season, we sampled 206 sites. Teams entered and QC'd all of the data from the second field season, and PIs resolved taxonomic issues that arose. Data managers and programmers enabled calculation of most metrics and IBIs within the project database.

During our third year, PIs worked on metrics specific to vegetation zones that currently lack IBIs. As part of this process, we began investigating the stability of metrics based on a comparison of the data from the original sampling and site re-visits. All co-PIs and many field crew leaders met in the Detroit area (January 2013). Our QAPP did not need to be updated, and all co-PIs re-signed it March 2013. Our site selection system required minor modification to better handle benchmark sites (sites of special interest for restoration or protection).
244 sites were selected for potential sampling. Of these, 32 were benchmark sites and 12 were temporal re-sample sites, with the remaining 200 sites selected by the original "random draw" that placed sites in the sampling panels. 201 of these sites were sampleable in 2013.

During our fourth year, project PIs and field crew chiefs again met (Midland Michigan, January 15, 2014) to discuss any aspects of the project needing attention and to help ensure that all teams continue to sample in the same manner across the entire Great Lakes basin. Topics at the 2014 meeting included adding other options for some of the water quality analyses (the QAPP and water quality SOP were updated for this purpose in March 2014), and issues with hybridization among fish species within certain genera (bullheads, gar, sunfishes). Both of these issues are discussed in more detail in this report.

PROJECT ORGANIZATION

Figure 1 shows our project organization.

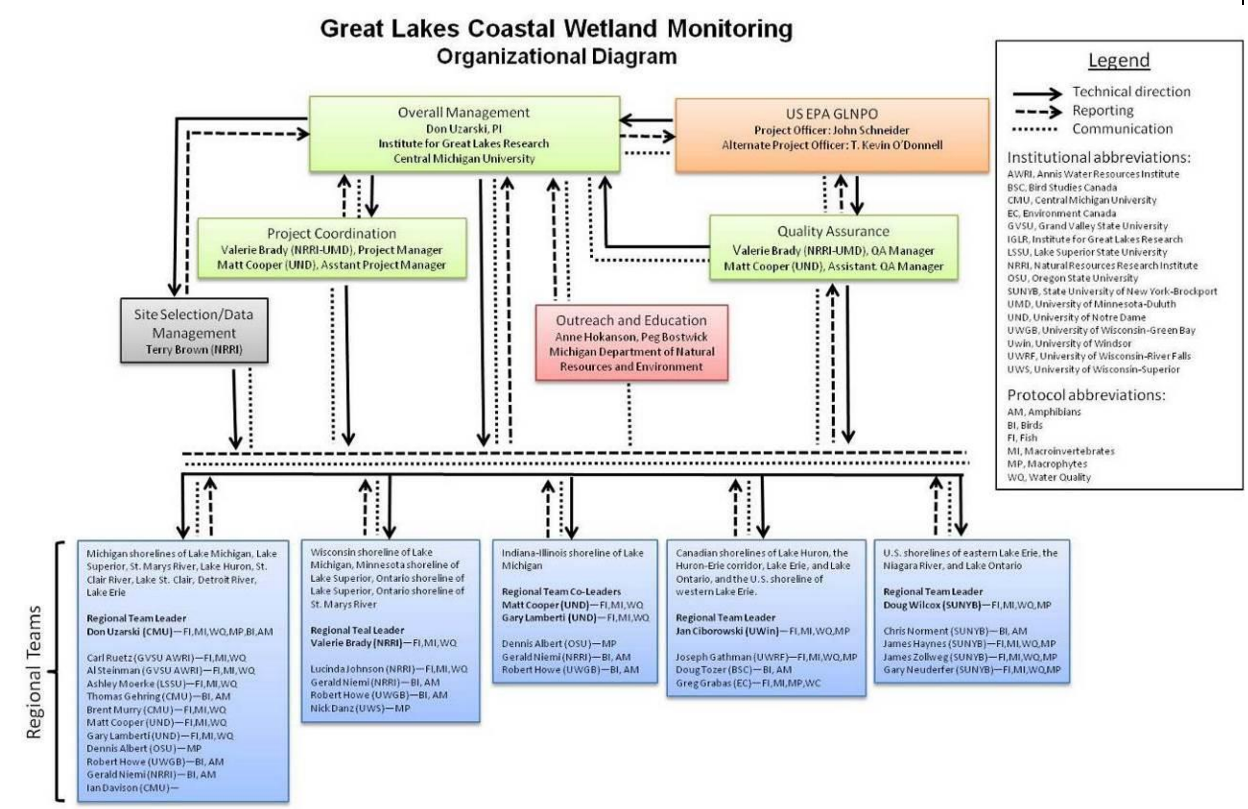

Figure 1. Organizational chart for the project showing lines of technical direction, reporting, and communication separately.

Please note that since our project started we have had two changes in primary personnel (both approved by US EPA). Ryan Archer of Bird Studies Canada was replaced by Doug Tozer. At the Michigan Department of Environmental Quality, Peg Bostwick retired and was replaced by

Anne Hokanson, who recently changed her name to Anne Garwood. No major personnel changes have taken place during this reporting period, although Matt Cooper has been awarded his doctoral degree and has relocated to Central Michigan University. He continues to hold the same roles on the project as he did previously.

PROJECT TIMELINE

The project timeline remains unchanged and we are on-schedule (Table 1).

Table 1. Timeline of tasks and deliverables for the Great Lakes Coastal Wetland Monitoring Project.

	'10	2011				2012				2013				2014				2015			
Tasks	**F**	**W**	**Sp**	**Su**	**F**	**W**	**Sp**	**Su**	**F**	**W**	**Sp**	**Su**	**F**	**W**	**Sp**	**Su**	**F**	**W**	**Sp**	**Su**	**F**
Funding received	X																				
PI meeting		X				X				X				X				X			X
Site selection system designed		X																			
Site selection implemented			X			X				X				X				X			
Sampling permits acquired			X				X				X				X				X		
Data entry system created			X	X																	
Field crew training			X	X			X	X			X	X			X	X			X	X	
Wetland sampling			X	X			X	X			X	X			X	X			X	X	
Mid-season QA/QC evaluations				X				X				X				X				X	
Sample processing & QC					X	X			X	X			X	X			X	X			X
Data QC & upload to GLNPO						X	X			X	X			X	X			X	X		X
GLAS database report		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Report to GLNPO			X		X		X		X		X		X		X		X		X		X

SITE SELECTION

Year four site selection was completed in March 2014 and was essentially the same as site selection for year three. Benchmark sites (sites of special interest for restoration or protection) can be sampled more than once in five years, and may be sites that were not on the original sampling list. The selection modification for these sites involved specifying exactly which teams will sample these sites each year, allowing bird and amphibian crews, which have greater sampling capacity, to visit these sites more often than other crews.

Original data on Great Lakes coastal wetland locations

The GIS coverage used was a product of the Great Lakes Coastal Wetlands Consortium (GLCWC) and was downloaded from http://www.glc.org/wetlands/data/inventory/glcwc_cwi_polygon.zip on December 6, 2010. See http://www.glc.org/wetlands/inventory.html for details.

Site Selection Tool, completed in 2011, minor updates in 2012 and 2013

Background
In 2011, a web-based database application was developed to facilitate site identification, stratified random selection, and field crew coordination for the project. This database is housed at NRRI and backed up routinely. It is also password-protected. Using this database, potential wetland polygons were reviewed by PIs and those that were greater than four ha., had herbaceous vegetation, and had a lake connection were placed into the site selection random sampling rotation (Table 2). See the QAPP for a thorough description of site selection criteria.

Table 2. Preliminary counts, areas, and proportions of the 1014 Great Lakes coastal wetlands deemed sampleable following Great Lakes Coastal Wetland Consortium protocols based on review of aerial photography. Area in hectares.

Country	Site count	Site percent	Site area	Area percent
Canada	386	38%	35,126	25%
US	628	62%	105,250	75%
Totals	**1014**		**140,376**	

Note that the actual number of sampleable wetlands will fluctuate year-to-year with lake level and continued human activity. Based on the number of wetlands that proved to be sampleable thus far, we expect that the total number of sampleable wetlands will be between 900 and 1000.

The wetland coverage we are using shows quite a few more wetlands in the US than in Canada, with an even greater percent of US wetland area (Table 2). We speculate that this is partly due to poor representation of Georgian Bay (Lake Huron) wetlands in the sampleable wetland database. This area is also losing wetlands rapidly due to a combination of glacial rebound, low water levels, and topography that limits the potential for coastal wetlands to migrate downslope with falling water levels. Another component of this US/CA discrepancy is the lack of coastal wetlands along the Canadian shoreline of Lake Superior due to the rugged topography and geology. A final possibility is unequal loss of wetlands between the two countries, but this has not been investigated.

Strata

Geomorphic classes
Geomorphic classes (riverine, barrier-protected, and lacustrine) were identified for each site in the original GLCWC dataset. Many wetlands inevitably combine aspects of multiple classes, with an exposed coastal region transitioning into protected backwaters bisected by riverine elements. Wetlands were classified according to their predominant geomorphology.

Regions
Existing ecoregions (Omernik 1987, Bailey and Cushwa 1981, CEC 1997) were examined for stratification of sites. None were found which stratified the Great Lakes' shoreline in a manner that captured a useful cross section of the physiographic gradients in the basin. To achieve the intended stratification of physiographic conditions, a simple regionalization dividing each lake into northern and southern components, with Lake Huron being split into three parts and Lake Superior being treated as a single region, was adopted (Figure 2). The north-south splitting of Lake Michigan is common to all major ecoregions systems (Omernik / Bailey / CEC).

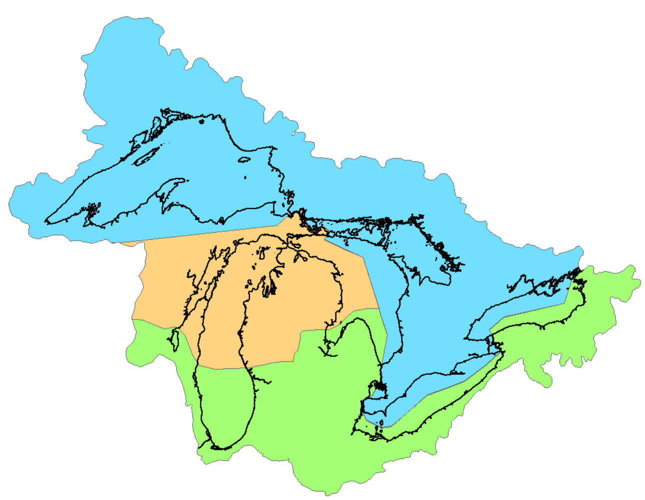

Figure 2. Divisions of lakes into regions. Note that stratification is by region *and* lake, so northern Lake Erie is not in the same region as Lake Superior, etc.

Panelization

Randomization
The first step in randomization was the assignment of selected sites from each of the project's 30 strata (10 regions x 3 geomorphic classes) to a random year or panel in the five-year rotating panel. Because the number of sites in some strata was quite low (in a few cases less than 5, more in the 5-20 range), simple random assignment

would not produce the desired even distribution of sites within each strata over time. Instead it was necessary to assign the first fifth of the sites within a stratum, defined by their pre-defined random ordering, to one year, and the next fifth to another year, etc.

In 2012, sites previously assigned to panels for sampling were assigned to sub-panels for re-sampling. The project design's five year rotation with a 10% re-sampling rate requires five panels, *A*-*E*, and ten sub-panels, *a*-*j*. If 10% of each panel's sites were simply randomly assigned to sub-panels in order *a*-*j*, sub-panel *j* would have a low count relative to other sub-panels. To avoid this, the order of sub-panels was randomized for each panel during site-to-sub-panel assignment, as can be seen in the random distribution of the '20' and '21' values in Table 3.

For the first five-year cycle, sub-panel *a* will be re-sampled in each following year, so the 20 sites in sub-panel *a* of panel *A* were candidates for re-sampling in 2012. The 20 sites in sub-panel *a* of panel *B* were candidates for re-sampling in 2013, and so on. In 2016, when panel *A* is being sampled for the second time, the 21 sites in sub-panel *a* of panel *E* will be candidates for re-sampling, and in 2017, when panel *B* is being sampled for the second time, the 21 sites in sub-panel *b* of panel *A* will be candidates for re-sampling.

Table 3. Sub-panel re-sampling, showing year of re-sampling for sub-panels *a*-*c*.

	Subpanel										
Panel	**a**	**b**	**c**	**d**	**e**	**f**	**g**	**h**	**i**	**j**	**TOTAL**
A: 2011 2016 2021	20/2012	21/2017	21/2022	20	21	20	21	21	21	21	207
B: 2012 2017 2022	20/2013	20/2018	20/2023	21	20	21	21	20	21	21	205
C: 2013 2018 2023	21/2014	21/2019	21/2024	21	21	20	21	21	21	21	209
D: 2014 2019 2024	22/2015	21/2020	21/2025	21	21	21	21	21	21	21	211
E: 2015 2020 2025	21/2016	20/2021	21/2026	21	21	21	20	21	21	21	208

Workflow states

Each site was assigned a particular 'workflow' status. During the field season, sites selected for sampling in the current year will move through a series of sampling states in a logical order, as shown in Table 4. The *data_level* field is used for checking that all data have been received and their QC status. Users set the workflow state for sites in the web tool, although some states can also be updated by querying the various data entry databases.

Team assignment

With sites assigned to years and randomly ordered within years, specific sites were then assigned to specific teams. Sites were assigned to teams initially based on expected zones of logistic practicality, and the interface described in the 'Site Status' section was used to exchange sites between teams for efficiency and to better assure that distribution of effort matches each team's sampling capacity.

Table 4. Workflow states for sites listed in the Site Status table within the web-based site selection system housed at NRRI. This system tracks site status for all taxonomic groups and teams for all sites to be sampled in any given year. Values have the following meanings: -1: site will not generate data, 0: site may or may not generate data, 1: site should generate data, 2: data received, 3: data QA'd.

Name	Description	Data_level
too many	Too far down randomly-ordered list, beyond sampling capacity for crews.	-1
Not sampling BM	Benchmark site that will not be sampled by a particular crew.	-1
listed	Place holder status; indicates status update needed.	0
web reject	Rejected based on regional knowledge or aerial imagery in web tool.	-1
will visit	Will visit with intent to sample.	0
could not reach	Proved impossible to access.	-1
visit reject	Visited in field, and rejected (no lake influence, etc.).	-1
will sample	Interim status indicating field visit confirmed sampleability, but sampling has not yet occurred.	1
sampled	Sampled, field work done.	1
entered	Data entered into database system.	2
checked	Data in database system QA-checked.	3

Field maps

Three-page PDF maps are generated for each site for field crews each year. The first page depicts the site using aerial imagery and a road overlay with the wetland site polygon boundary (using the polygons from the original GLCWC file, as modified by PIs in a few cases). The image also shows the location of the waypoint provided for navigation to the site via GPS. The second page indicates the site location on a road map at local and regional scales. The third page lists information from the database for the site, including tags, team assignments, and the history of comments made on the site, including information from previous field crew visits.

Browse map

The *browse map* feature allows the user to see sites in context with other sites, overlaid on either Google Maps or Bing Maps road or aerial imagery. Boat ramp locations are also shown when available. The *browse map* provides tools for measuring linear distance and area. When a site is clicked, the tool displays information about the site, the tags and comments applied to it, the original GLCWC data, links for the next and previous site (see *Shoreline ordering* and *Filter sites*), and a link to edit the site in the site editor.

2014 Site Selection

Site selection for 2014 resulted in 251 sites selected for potential sampling. Of these, 31 are benchmark sites and 13 are temporal re-sample sites, with the remaining 207 sites selected by the original "random draw" that places sites in the sampling panels. There are more than 10% of sites in the "benchmark" category because several teams have taken on additional sites at the special request of other agencies or groups (see *individual team reports* and *letters of support*) without sacrificing the number of random sites sampled. Benchmark and resample sites are sorted to the top of the sampling list because they are the highest priority sites to be sampled.

Wetlands have a "clustered" distribution around the Great Lakes due to geological differences. As has happened each sampling season so far, several teams ended up with fewer sites than they had the capacity to sample, while other teams' assigned sites exceeded their sampling capacity. Within reason, teams with excess sampling capacity expanded their sampling boundaries to assist neighboring over-capacity teams in order to maximize the number of wetlands sampled. The site selection and site status tools are used to make these changes.

TRAINING

All personnel responsible for sampling invertebrates, fish, macrophytes, birds, amphibians, and water quality received training and were certified prior to sampling in 2011. During that first year, teams of experienced trainers held training workshops at several locations across the Great Lakes basin to ensure that all PIs and crews were trained in Coastal Wetland Monitoring methods. Now that PIs and crew chiefs are experienced, field crew training is being handled by each PI at each regional location. All crew members still had to pass all training tests, and PIs still conducted mid-season QC. As has become standard protocol, the trainers were always available via phone and email to answer any questions that arose during training sessions or during the field season.

The following is a synopsis of the training to be conducted by PIs this spring (2014): Each PI or field crew chief trained all field personnel on meeting the data quality objectives for each element of the project; this included reviewing the most current version of the QAPP, covering site verification procedures, providing hands-on training for each sampling protocol, and reviewing record-keeping and archiving requirements, data auditing procedures, and certification exams for each sampling protocol. All field crew members had to pass all training certifications before they were allowed to work unsupervised. Those who did not pass all training aspects were only allowed to work under the supervision of a crew leader who had passed all training certifications.

Training for bird and amphibian field crews includes tests on amphibian calls, bird vocalizations, and bird visual identification. These tests are based on an on-line system established at the

University of Wisconsin, Green Bay – see http://www.birdercertification.org/GreatLakesCoastal. In addition, individuals were tested for proficiency in completing field sheets, and audio testing was done to ensure their hearing is within the normal ranges. Field training was also completed to ensure guidelines in the QAPP are followed: rules for site verification, safety issues including caution regarding insects (e.g., Lyme's disease), GPS and compass use, and record keeping.

Fish, macroinvertebrate, and water quality crews were trained on field and laboratory protocols. Field training included selecting appropriate sampling locations, setting fyke nets, identifying fish, sampling and sorting invertebrates, and collecting water quality and covariate data. Laboratory training included preparing water samples, titrating for alkalinity, and filtering for chlorophyll. Other training included GPS use, safety and boating issues, field sheet completion, and GPS and records uploading. All crew members were required to be certified in each respective protocol prior to working independently.

Vegetation crew training also included both field and laboratory components. Crews were trained in field sheet completion, transect and point location and sampling, GPS use, and plant curation. Plant identification was tested following phenology through the first part of the field season. All crew members were certified in all required aspects of sampling before starting in the field unless supervised.

Additional training on data entry and data QC was provided by Valerie Brady and Terry Brown through a series of conference calls/webinars during the late summer, fall, and winter of 2011. All co-PIs and crew leaders responsible for data entry participated in these training sessions and each regional laboratory has successfully uploaded data. Additional training on data entry, data uploading, and data QC is being provided as needed, particularly when new data entry personnel are added, or when a team is experiencing difficulties.

Certification

To be certified in a given protocol, individuals must pass a practical exam. Certification exams were conducted in the field in most cases, either during training workshops or during site visits early in the season. When necessary, exams were supplemented with photographs (for fish and vegetation) or audio recordings (for bird and amphibian calls). Passing a given exam certifies the individual to perform the respective sampling protocol(s). Since not every individual is responsible for conducting every sampling protocol, crew members were only tested on the protocols for which they are responsible. Personnel who were not certified (e.g., part-time technicians, new students, volunteers) were not be allowed to work independently nor to do any taxonomic identification except under the direct supervision of certified staff members. Certification criteria are listed in the project QAPP. For some criteria, demonstrated proficiency during field training workshops or during site visits is considered adequate for certification. Training and certification records for all participants are collected by regional team leaders and copied to Drs. Brady and Cooper (QC managers), and Uzarski (lead PI). Note that the training and certification procedures explained here are separate from the QA/QC evaluations explained in the following section. However, failure to meet project QA/QC standards requires participants to be re-trained and re-certified.

Documentation and Record

All site selection and sampling decisions and comments are archived in the site selection system created by Dr. Terry Brown (see “site selection”). These include comments and revisions made during the QC oversight process.

Regional team leaders archive copies of the testing and certification records of all field crew members. Summaries of these records are also archived with the lead PI (Uzarski), and the QA managers (Brady and Cooper).

Web-based Data Entry System

A web-based data entry system was developed in 2011 to collect field and laboratory data. The open source Django web application framework was used with the open source postgresql database as the storage back end, with a separate application for each taxonomic group. Forms for data entry are generated automatically based on an XML document describing the data structure of each taxonomic group’s observations. Each data entry web form is password-protected, with passwords assigned and tracked for each individual.

Features of note include:

- fine-grained access control with individual user logins, updated every winter;
- numerous validation rules of varying complexity to avoid incorrect or duplicate data entry;
- custom form elements to mirror field sheets, e.g. the vegetation transects data grid; this makes data entry more efficient and minimizes data entry errors;
- domain-specific utilities, such as generation of fish length records based on fish count records;
- dual-entry inconsistency highlighting for groups using dual-entry for quality assurance;
- user interface support for the highly hierarchical data structures present in some groups' data.

The web-based data retrieval system for project researchers allows “raw”, QC’d data to be downloaded by PIs of each taxonomic group. Additionally, most of the metric and IBI calculations have been automated and can be generated simply by re-running the scripts. The data retrieval system uses the same technologies as the data entry system. Password access is tracked separately for the data retrieval system, and is again tracked individually.

EPA GLNPO has been given access to the retrieval system and data, located at http://beaver.nrri.umn.edu/glrimon/dv/folder/. The public, if they access this site, can see summaries of numbers of sites sampled by the various crews for the different taxonomic groups. Other features are only visible to those with a password.

The data download system has been expanded with the capability of serving static files as well as tabular data queried on demand for the database server. Static file serving is used to deliver data in Excel and Access-ready formats. These datasets are intended to give fine-grained access for data analysis by PIs. These files also provide a complete backup of the project data in a format that does not require the database server to be running to allow access.

We have also developed an interactive map available as a website that will allow users to visualize and download site level attributes such as IBIs and invasive species counts for wetlands basin wide. This web-based tool requires no specialized software on the user's system. Tools for defining a user-specified area of interest will provide results in regional and local contexts. Authorized users (i.e., agency personnel and other managers) will be able to drill down to specific within-site information to determine what factors are driving an individual site's scores.

Data is continuously backed up using a live backup system (Write Ahead Log storage from the database backend), with nightly mirroring of the backup system to a separate location (from NRRI to the UMD campus).

RESULTS-TO-DATE (2011-2014)

A total of 176 wetlands were sampled in 2011, with 206 sampled in 2012, 201 in 2013, and 216 sampled in 2014 for an overall total of 799 Great Lakes coastal wetland sampling events in four years (Table 5). Note that this is not the same as the number of unique wetlands sampled because of temporal re-sampling events and benchmark sites that are sampled in more than one year.

As in previous years, more wetlands were sampled on the US side, due to the uneven distribution of wetlands between the two countries. The wetlands on the US side also tend to be larger (see area percentages, Table 5). When compared to the total number of wetlands targeted to be sampled by this project (Table 2), we are achieving our goals of sampling 20% of US wetlands per year, both by count and by area. However, 66% of total sites sampled have been US coastal wetlands, with 80% of the wetland area sampled on the US side. Overall, not yet correcting for sites that have been sampled more than once, we have sampled about 80%

of US coastal wetlands by count and by area. With respect to the entire Great Lakes, the project has sampled about 80% of coastal wetlands by count and area.

Table 5. Counts, areas, and proportions of the 799 Great Lakes coastal wetlands sampled from 2011 through 2014 by the GLIC: Coastal Wetland Monitoring Project. Percentages are of overall total sampled. Area in hectares.

Country	Site count	Site %	Site area	Area %
Canada				
2011	50	28%	3,303	13%
2012	82	40%	7,917	27%
2013	71	35%	7,125	27%
2014	72	33%	6,781	20%
CA total	**275**	**34%**	**25,126**	**22%**
US				
2011	126	72%	22,008	87%
2012	124	60%	21,845	73%
2013	130	65%	18,939	73%
2014	144	67%	26,836	80%
US total	**524**	**66%**	**89,628**	**78%**
Overall Totals	**799**		**114,754**	

Teams may have been able to sample more sites this year due to higher lake levels on Lakes Michigan and Huron, which allowed crews to access sites and areas that have been dry or inaccessible in previous years. This highlights the difficulty of precisely determining the number of sampleable coastal wetlands in the Great Lakes.

The sites sampled in 2014 are shown in Figures 3 and 4 and are color coded by which taxonomic groups were sampled at the sites and by wetland types, respectively. Many sites were sampled for all taxonomic groups. Sites not sampled for birds and amphibians typically were sites that were impossible to access safely, and often related to private property access issues. Most bird and amphibian crews do not operate from boats since they need to arrive at sites in the dark or stay until well after dark. There are also a number of sites sampled only by bird and amphibian crews because these crews can complete their site sampling more quickly and thus have the capacity to sample more sites than do the fish, macroinvertebrate, and vegetation crews.

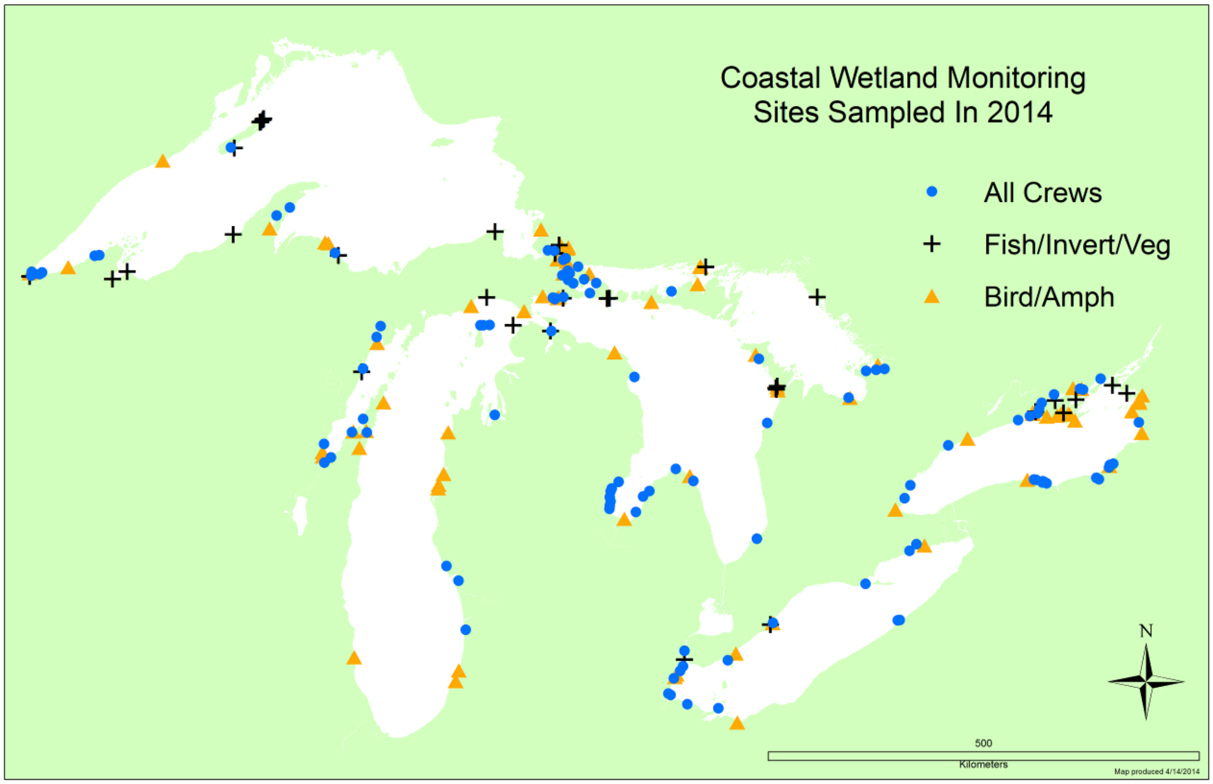

Figure 3. Locations of the 216 Great Lakes coastal wetlands sampled in 2014, color-coded by taxonomic groups. Sites assigned only to bird and amphibian crews (due to their greater sampling capacity) are shown with a gold triangle.

Wetland types are not distributed evenly across the Great Lakes due to fetch, topography, and geology (Figure 4). Lacustrine wetlands occur in more sheltered areas of the Great Lakes within large bays or adjacent to islands. Barrier-protected wetlands occur along harsher stretches of coastline, particularly in sandy areas, although this is not always the case. Riverine wetlands are somewhat more evenly distributed around the Great Lakes. Note that revisit sites (Figure 4, blue stars) were sampled in 2012 and then again in 2013 to track and account for temporal variation in metrics and indicators. Furthermore, continued low water levels of lakes Michigan, Huron, and Erie require that all indicators are relatively robust to Great Lakes water level decadal variations.

Benchmark sites are sites that are either added to the overall site list and would not have been sampled as part of the random selection process, or are sites that are considered a reference of some type and are being sampled more frequently. Sites that would not have been sampled typically were too small, disconnected from lake influence, or are not a wetland at this time, and thus did not fit the protocol. These sites are added back to the sampling list by request of researchers, agencies, or others who have specific interest in the sites. Many of these sites are scheduled for restoration, and the groups who will be restoring them need baseline data against which to determine restoration success. Each year, Coastal Wetland Monitoring (CWM) researchers are getting many requests to provide baseline data for restoration work; this is occurring at a frequency great enough for us to have difficulty accommodating the extra effort.

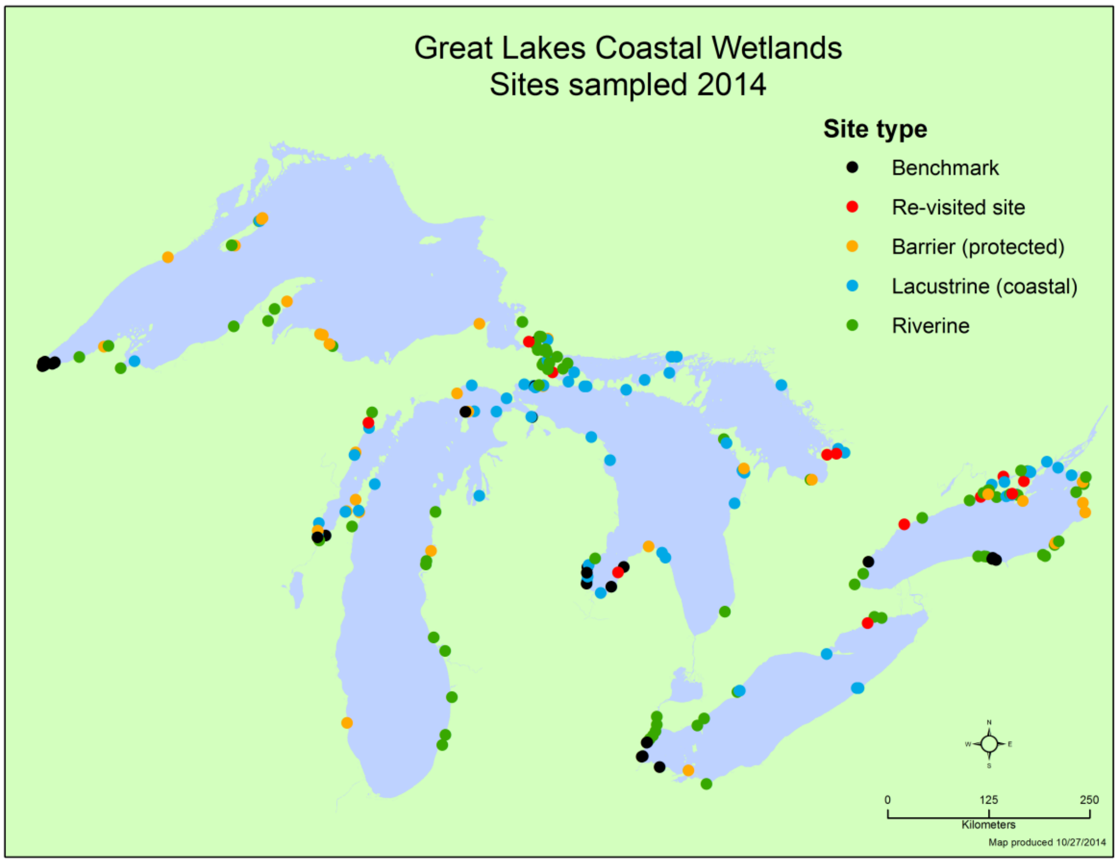

Figure 4. Locations of the 216 Great Lakes coastal wetlands sampled in 2014, color-coded by site type. Wetland types exhibit a clumped distribution across lakes due to geology and topography.

As of 2014, we have 59 sites designated as “benchmark.” Of these, 23 (39%) are to evaluate restoration efforts and 17 (28%) serve as reference sites for their area or for nearby restoration sites. Almost all benchmark sites are in the US.

Determining whether Benchmark sites would have been sampled at some point as part of the random site selection process is somewhat difficult because some of the exclusion conditions are not easy to assess without site visits. Our best estimate is that approximately 60% of the 17 benchmark sites from 2011 would have been sampled at some point, but they were marked “benchmark” to either sample them sooner (to get ahead of restoration work for baseline sampling) or so that they could be sampled more frequently. Thus, about 40% of 2011 benchmark sites were either added new because they are not (yet) wetlands, are small, or were missed in the wetland coverage, or would have been excluded for lack of connectivity. This percentage decreased in 2012, with only 20% of benchmark sites being sites that were not already in the list of wetlands scheduled to be sampled. In 2013, 30% of benchmark sites were not on the list of random sites to be sampled by CWM researchers in any year, and most were not on the list for the year 2013. For 2014, 26% of benchmark sites were not on the list of sampleable sites, and only 20% of these benchmark sites would have been sampled in 2014. There are a number of benchmark sites that are being sampled every year or every other year to collect extra data on these locations.

We can now compile good statistics on Great Lakes coastal wetlands because we have sampled about 80% of the medium and large, hydrologically-connected coastal wetlands on the Great Lakes. Wetlands contained approximately 25 bird species on average; some sampled benchmark sites had as few as 1 species, but richness at high quality sites was as great as 60 bird species (Table 6). There are many fewer calling amphibian species in the Great Lakes (8 total), and coastal wetlands averaged about 4 species per wetland, with some benchmark wetlands containing no calling amphibians (Table 6). However, there were wetlands where all 8 calling amphibian species were heard over the three sampling dates.

Table 6. Bird and calling amphibian species in wetlands; summary statistics by country. Data from 2011 through 2014.

Country	**Site count**	**Mean**	**Max**	**Min**	**St. Dev.**
Birds					
Can.	242	28.0	58	8	10.3
U.S.	449	22.0	60	1	11.6
Amphibians					
Can.	227	4.2	8	1	1.7
U.S.	446	3.6	7	0	1.5

Bird and amphibian data in Great Lakes coastal wetlands by lake (Table 7) shows that wetlands on most lakes averaged 20 to almost 30 bird species, with Lake Ontario coastal wetlands averaging the fewest species. The greatest number of bird species at a wetland occurred on Lake Michigan, with Lake Huron a close second, followed by Erie, Superior, and Ontario with the fewest maximum species at a wetland. These data include the benchmark sites, many of which are in need of restoration, so the minimum number of species is quite low (as few as a single species) for some of these wetlands.

Calling amphibian species counts show less variability among lakes simply because fewer of these species occur in the Great Lakes. Wetlands averaged three to four calling amphibian species regardless of lake (Table 7). Similarly, there was little variability by lake in maximum or minimum numbers of species. At some benchmark sites and cold springs no calling amphibians were detected.

Table 7. Bird and amphibian species found in Great Lakes coastal wetlands by lake. Mean, maximum, and minimum number of species per wetland for wetlands sampled from 2011 through 2014.

	Birds				Calling amphibians			
Lake	**Sites**	**Mean**	**Max**	**Min**	**Sites**	**Mean**	**Max**	**Min**
Erie	88	22.8	53	4	81	3.1	7	0
Huron	208	25.6	58	2	214	3.8	7	0
Michigan	118	23.2	60	1	109	3.5	7	0
Ontario	180	21.5	45	8	170	4.4	8	1
Superior	96	27.7	52	11	98	3.6	7	0

An average of 10 to about 13 fish species were collected in Canadian and US Great Lakes coastal wetlands, respectively (Table 8). Again, these data include sites in need of restoration, and some had very few species. On the other hand, the wetlands with the highest richness had as many as 23 (CA) or 28 (US) fish species. The average number of non-native fish species per wetland was approximately one, though some wetlands had as many as 5 (US). An encouraging sign is that there are wetlands in which no non-native fish species were caught in fyke nets, although some non-native fish are adept at net avoidance (e.g., European carp).

Table 8. Total fish species in wetlands, and non-native species; summary statistics by country for sites sampled from 2011 through 2014.

Country	**Sites**	**Mean**	**Max**	**Min**	**St. Dev.**
Overall					
Can.	120	10.1	23	2	4.0
U.S.	283	13.4	28	2	5.3
Non-natives					
Can.	120	0.7	3	0	0.7
U.S.	283	0.7	5	0	0.9

Combining 2011 through 2014 data, there were no non-native fish species caught at 49% of the Great Lakes coastal wetlands sampled, but 36% had one non-native species (Figure 5). More than one non-native species was captured at many fewer sites. It is important to note that the sampling effort at sites was limited to one night using passive capture nets, so these numbers are likely quite conservative, and wetlands where we did not catch non-native fish may actually harbor them.

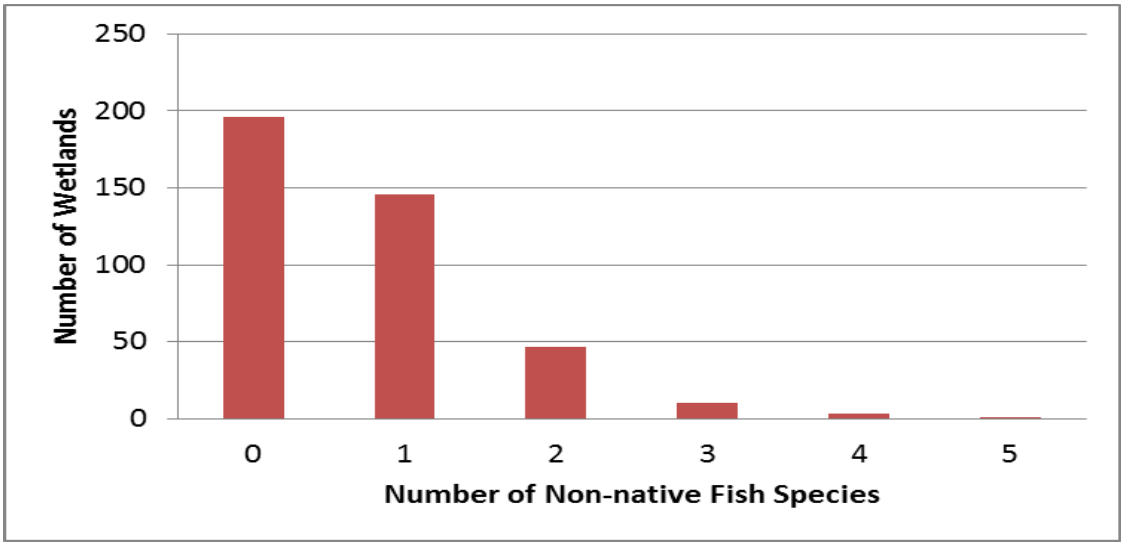

Figure 5. Number of Great Lakes coastal wetlands containing non-native fish species. Data from 2011 through 2014.

Total fish species did not differ greatly by lake, averaging 12-15 species per wetland (Table 9). Lake Ontario wetlands had the lowest maximum number of species, with the other lakes all having similar maximums of 27-28 species. Since sites in need of restoration are included, some of these sites had very few fish species, as low as two. Lake Huron wetlands averaged the lowest mean number of non-native fish taxa. All other lakes had a similar average number of non-native fish species per wetland, about 1. Having very few or no non-native fish is a positive, however, and all lakes had some wetlands in which we caught no non-native fish. This result does not necessarily mean that these wetlands are free of non-natives, unfortunately. Our single-night net sets do not catch all fish species in wetlands, and some species are quite adept at avoiding passive capture gear. For example, common carp are known to avoid fyke nets. When interpreting fish data it is important to keep in mind the well-documented biases associated with each type of sampling gear. For example, active sampling gears (e.g., electrofishing) are better at capturing large active fish, but perform poorly at capturing smaller fish, forage fish, and young fish that are sampled well by our passive gear.

Table 9. Fish total species and non-native species found in Great Lakes coastal wetlands by lake. Mean, maximum, and minimum number of species per wetland. Data from 2011 through 2014.

		Fish (Total)			Non-native		
Lake	**Sites**	**Mean**	**Max**	**Min**	**Mean**	**Max**	**Min**
Erie	51	12.2	27	2	1.1	4	0
Huron	136	11.6	27	2	0.4	2	0
Michigan	52	13.7	28	5	0.9	4	0
Ontario	108	12.4	23	4	0.8	3	0
Superior	54	14.1	28	3	0.9	5	0

Macroinvertebrates from 2014 sampling are still being identified and entered into the database. Thus, the following information has not been updated since the previous report. The average number of macroinvertebrate taxa (taxa richness) per site was about 40 (Table 10), but some wetlands had more than twice this number. Sites scheduled for restoration and other taxonomically poor wetlands had fewer taxa [17 (CA) or 12 (US)]. So far we have found at least one species of non-native macroinvertebrate in every wetland we have sampled for macroinvertebrates, emphasizing the widespread distribution of non-native species throughout the Great Lakes. On a more positive note, the average number of non-native invertebrate taxa in coastal wetlands was less than 2, with a maximum of no more than 4 taxa (Table 10). Again, we must point out that our one-time sampling may not be capturing all of the non-native taxa at wetland sites. In addition, some non-native macroinvertebrates are quite cryptic, resembling native taxa, and may not yet be recognized as invading the Great Lakes.

Table 10. Total macroinvertebrate taxa in Great Lakes coastal wetlands, and non-native species; summary statistics by country. Data from 2011, 2012, and 2013.

Country	Sites	Mean	Max	Min	St. Dev.
Overall					
Can.	111	40.1	78	17	15.2
U.S.	237	40.4	86	12	17.6
Non-natives					
Can.	111	1.2	2	1	0.4
U.S.	237	1.4	4	1	0.7

There is some variability among lakes in the mean number of macroinvertebrate taxa per wetland. Lake Erie and Ontario wetlands averaged about 35 taxa (Table 11), while lakes Huron, Superior, and Michigan averaged about 45 taxa. The maximum number of invertebrate taxa was higher in lakes Huron and Michigan wetlands (80 or more) than for the most invertebrate-rich wetlands in the other lakes, which have a maximum of about 70 taxa. Wetlands with the fewest taxa may be sites in need of restoration and have between 12 taxa (Erie) and 19 taxa (Michigan). Patterns are likely being driven by differences in habitat complexity, which may in part be due to the loss of wetland habitats on lakes Erie and Ontario from diking (Erie) and water level control (Ontario). This has been documented in numerous peer-reviewed publications. Minimum numbers, as noted above, may also be driven by benchmark sites that are slated for restoration. There is little variability among lakes in non-native taxa, although Erie and Huron had wetlands with 4 non-native macroinvertebrate taxa.

Table 11. Macroinvertebrate total taxa and non-native species found in Great Lakes coastal wetlands by lake. Mean, maximum, and minimum number of taxa per wetland. Data from wetlands sampled in 2011, 2012, and 2013.

		Macroinvertebrates (Total)			Non-native		
Lake	**Sites**	**Mean**	**Max**	**Min**	**Mean**	**Max**	**Min**
Erie	41	34.9	72	12	1.6	4	1
Huron	121	43.4	80	13	1.3	4	1
Michigan	51	43.7	86	19	1.3	2	1
Ontario	85	33.8	68	12	1.2	2	1
Superior	50	44.9	69	15	1.3	2	1

Not all of the wetland vegetation data had been entered into the database and QC'd as of this report writing, so wetland plant data will be even more complete in the spring report. On average, there were approximately 45 wetland plant (macrophyte) species per wetland (Table 12), but the maximum number was almost 90 species. Some sites were quite depauperate in plant taxa (some having almost none), particularly in highly impacted areas that were no longer wetlands but were sampled because they are designated for restoration.

Table 12. Total macrophyte species in Great Lakes coastal wetlands, invasive species and US at-risk species; summary statistics by country. Data from 2011 through 2014.

Country	Site count	Mean	Max	Min	St. Dev.
Overall					
Can.	149	45.6	87	8	17.1
U.S.	312	43.6	89	1	16.4
Invasives					
Can.	149	3.7	8	0	2.0
U.S.	312	3.4	9	0	2.1
At risk					
U.S.	312	0.1	2	0	0.33

Invasive vegetation is commonly found in Great Lakes coastal wetlands. Those that we sampled averaged 3-4 invasive species (Table 12). Note that species classified as "invasives" are often non-native as well, but do not have to be to receive that designation. For example, some cattail (*Typha*) species are considered invasive although they are native taxa. Some wetlands contained as many as 9 invasive macrophyte species, but there were wetlands in which no invasive plant species were found. It is unlikely that our sampling strategy would miss significant invasive macrophytes in a wetland. However, small patches of cryptic or small-stature non-natives could be missed. Invasive species are a particularly important issue for restoration work. Restoration groups often struggle to restore wetland sites without having invasive species become dominant.

We currently have trustworthy information about at-risk wetland vegetation for only the US side of the Great Lakes. At-risk species (federal and state-designated) were not commonly encountered during sampling, as can be seen in Table 12. The average number of at-risk species per site was nearly zero, with most sites having no at-risk species; the maximum found at a site was only two species. This may be partly due to the sampling methods, which do not include a random walk through all habitats to search for at-risk species.

Lake Huron wetlands had the greatest mean number of macrophyte species, with Lake Erie wetlands having much lower mean numbers of species than wetlands on the other Great Lakes (Table 13). Maximum species richness in Lake Erie wetlands was lower than wetlands on the other Great Lakes, and even Lake Erie restoration sites had fewer minimum species. Average numbers of invasive species were highest in lakes Erie and Ontario and lowest in Lake Superior wetlands. Lake Superior had the lowest maximum number of invasive macrophytes in a wetland, with all the other lakes having about the same maximum number (7-9 species). Lake Ontario is the only lake with no sampled wetlands being free of non-native species.

Table 13. Macrophyte total species and invasive species found in Great Lakes coastal wetlands by lake. Mean, maximum, and minimum number of species per wetland. Data from 2011 through 2014.

		Macrophytes (Total)			Invasives		
Lake	**Sites**	**Mean**	**Max**	**Min**	**Mean**	**Max**	**Min**
Erie	57	27.2	69	1	4.5	8	0
Huron	152	53.0	89	15	2.6	7	0
Michigan	70	46.6	83	4	3.3	7	0
Ontario	119	41.1	87	8	5.2	9	1
Superior	63	42.0	78	21	1.7	5	0

Our macrophyte data have reinforced our understanding of the numbers of coastal wetlands that contain invasive plant species (Figure 6). Only 9% of 461 sampled wetlands lacked invasive species, leaving 91% with at least one. Sites were most commonly invaded by 2 – 6 plant species and 7% of sites contained 7 or more invasive species. Detection of invasive species is more likely for plants than for organisms that are difficult to collect such as fish and other mobile organisms, but we may still be missing small patches of invasives in some wetlands.

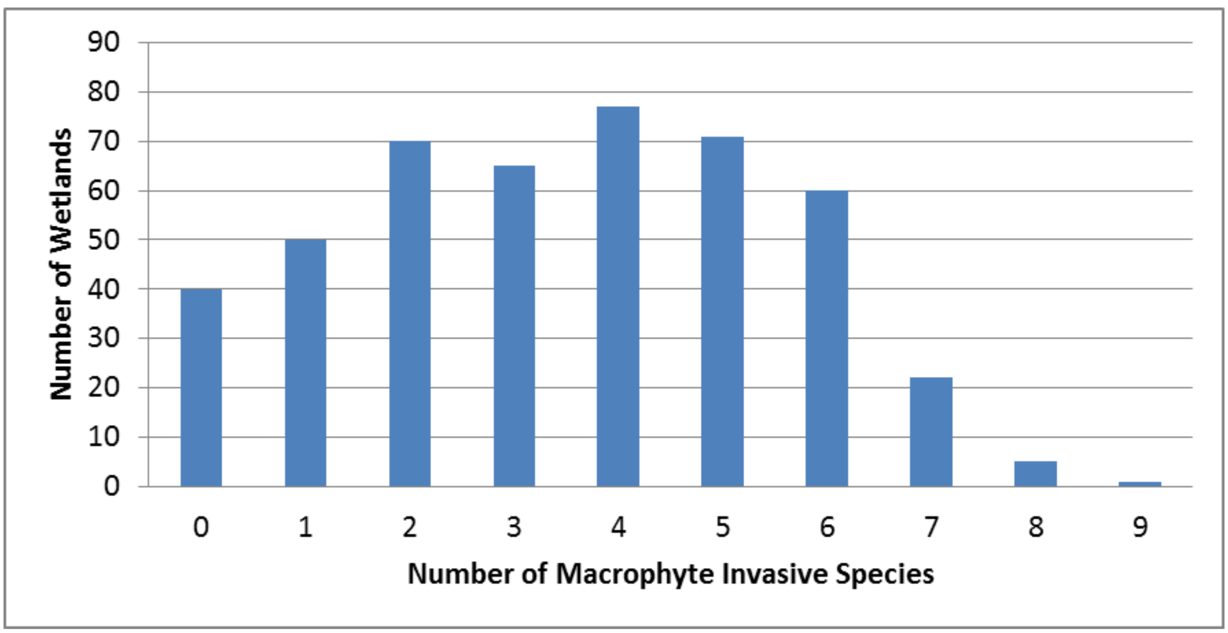

Figure 6. Number of Great Lakes coastal wetlands containing invasive plant species based on 2011 through 2014 data.

In the fall of 2012 we began calculating metrics and IBIs for various taxa. We are evaluating coastal wetland condition using a variety of biota (wetland vegetation, aquatic macroinvertebrates, fish, birds, and amphibians).

Macrophytic vegetation (only large plants; algal species were not included) has been used for many years as an indicator of wetland condition. One very common and well-recognized indicator is the Floristic Quality Index (FQI); this evaluates the quality of a plant community using all of the plants at a site. Each species is given a Coefficient of Conservatizm (C) score based on the level of disturbance that characterizes each plant species' habitat. A species found in only undisturbed, high quality sites will have a high C score (maximum 10), while a weedy species will have a low C score (minimum 0). These C scores have been determined for various areas of the country by plant experts; we used the published C values for the midwest. The FQI is an average of all of the C scores of the species growing at a site, divided by the square root of the number of species. The CWM wetland vegetation index is based largely on C scores for wetland species.

The map (Figure 7, updated and revised for this report) shows the distribution of Great Lakes coastal wetland vegetation index scores across the basin. Note that there are long stretches of Great Lakes coastline that do not have coastal wetlands due to topography and geology. Sites with low FQI scores are concentrated in the southern Great Lakes, where there are large amounts of both agriculture and urban development, and where water levels may be more tightly regulated (e.g., Lake Ontario), while sites with high FQI scores are concentrated in the northern Great Lakes. Even in the north, an urban area like Duluth, MN may have high quality wetlands in protected sites and lower quality degraded wetlands in the lower reaches of estuaries (drowned river mouths) where there are legacy effects from the pre-Clean Water Act era, along with nutrient enrichment or heavy siltation from industrial development and/or sewage effluent. Benchmark sites in need of restoration will also have lower condition scores. Note that this IBI has been updated and adjusted since the start of the project, accounting for the shift in condition scores for a handful of sites. This adjustment was necessary to reflect changes in the taxonomic treatment of many marsh plants in the 2012 Michigan Flora and Flora of North America.

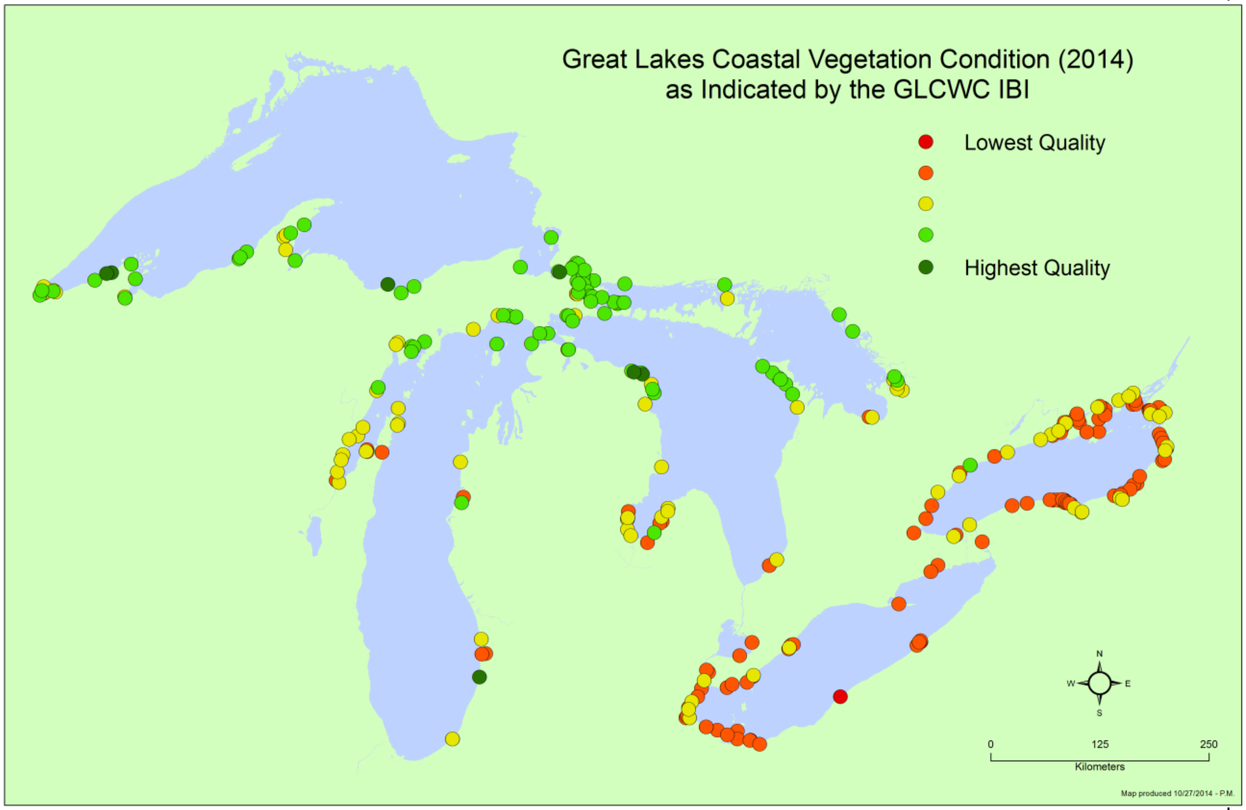

Figure 7. Condition of coastal wetland vegetation at sites across the Great Lakes. Circle color indicates vegetation community quality. The indicator is labeled "draft" while this indicator is investigated for robustness against varying water levels and latitude. Based on data from 2011 through 2014.

Another of the IBIs that was developed by the Great Lakes Coastal Wetlands Consortium uses the aquatic macroinvertebrates found in several of the most common vegetation types in Great Lakes coastal wetlands: sparse bulrush (*Schoenoplectus*), dense bulrush (*Schoenoplectus*), and wet meadow (multi-species) zones. We have calculated these IBIs for 2011, 2012, and 2013 sites that contain these habitat zones (Figure 8). Minor adjustment of metrics is continuing, so maps are not directly comparable across reports.

The lack of sites on lakes Erie and Ontario and southern Lake Michigan is due to either a lack of wetlands (southern Lake Michigan) or because these areas do not contain any of the three specific vegetation zones that GLCWC used to develop and test the invertebrate IBI. Many areas contain dense cattail stands (e.g., southern Green Bay, much of Lake Ontario), for which we do not yet have a reviewed macroinvertebrate IBI. We are developing IBIs for additional vegetation zones to cover these sites, but these IBIs have not yet been validated so they are not included here.

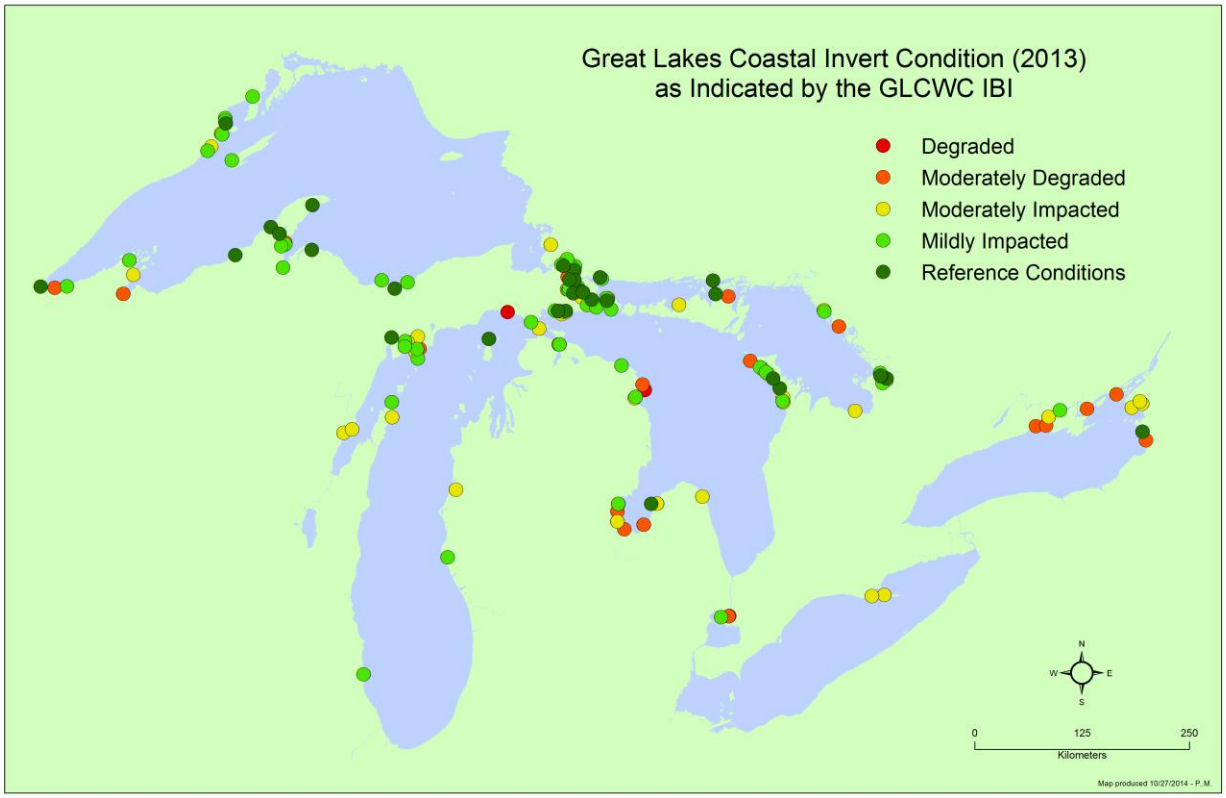

Figure 8. Condition of coastal wetland macroinvertebrate communities at sites with bulrush or wet meadow zones. The indicator is labeled “draft” while more zone IBIs are calculated. Based on data from 2011 through 2013.

We are currently able to report draft fish IBI scores for wetland sites containing bulrush and/or cattail zones (Figure 9). These are the two zone types with GLCWC validated fish IBIs. Because of the prevalence of cattail zones on in Erie and Ontario wetlands, this indicator provides more site scores than the macroinvertebrate indicator. Only a few wetlands rank as high quality with the fish IBI. We are still working to determine whether we have set the criteria for this indicator too stringently, or if fish communities really are relatively degraded in many areas.

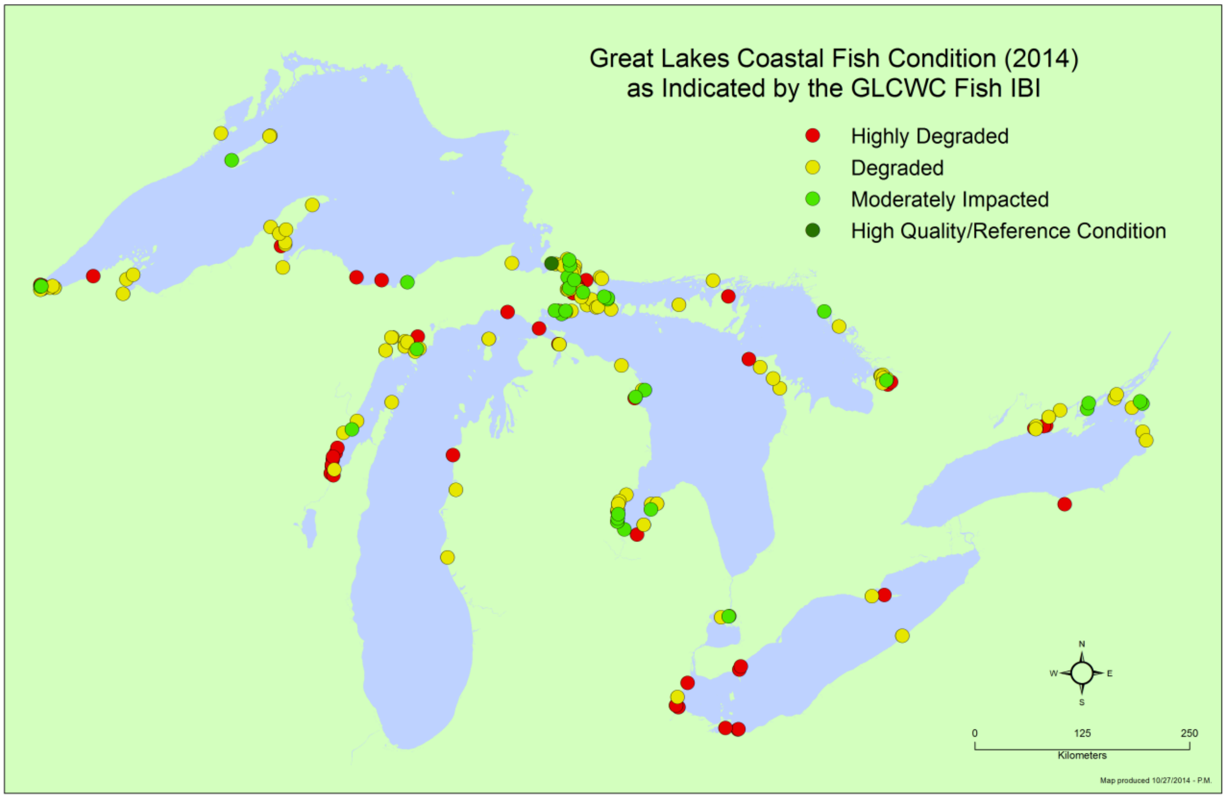

Figure 9. Condition of coastal wetland fish communties at sites with bulrush or cattail zones. The indicator is labeled “draft” while more zone IBIs are developed. Based on data from 2011 through 2014.

Fish PIs have been in the process of updating and expanding the fish-based IBIs of Uzarski *et al*. (2005). Fish data collected from 2011-2013 at 254 wetlands were used to develop and test the IBIs. Metrics were evaluated against numerous indices of anthropogenic disturbance derived from measurements of water quality and surrounding land cover. Disturbance indices included individual land cover and water quality variables, principal components combining land cover and water quality variables, a previously published landscape-based index (SumRel; Danz *et al*. 2005), and a rank-based index combining land cover and water quality variables (RankSum; Uzarski *et al*. 2005). Multiple disturbance indices were used to ensure that IBI metrics captured various dimensions of human disturbances.

We divided fish, water quality, and land cover data into separate “development” and “testing” sets for metric identification/calibration and final IBI testing, respectively. Metric identification and IBI development generally followed previously established methods (e.g., Karr *et al*. 1981, USEPA 2002, Lyons 2012) in which 1) a large set of candidate metrics was calculated; 2) metrics were tested for response to anthropogenic disturbance or habitat quality; 3) metrics were screened for responses to anomalous catches of certain taxa, for adequate range of responses, and for highly redundant metrics; 4) scoring schemes were devised for each of the final metrics; 5) the final set of metrics was optimized to improve the fit of the IBI to anthropogenic disturbance gradients; and 6) the final IBI was validated against an independent data set.

Final IBIs were composed of 10-15 metrics for each of four vegetation types (bulrush [*Schoenoplectus* spp.], cattail [*Typha* spp.], water lily [*Brassenia, Nuphar, Nymphaea* spp.], and submersed aquatic vegetation [SAV, primarily *Myriophyllum* or *Ceratophyllum* spp.]). Scores of all IBIs correlated well with values of anthropogenic disturbance indices using the development and testing data sets. Correlations of IBIs to disturbance scores were also consistent among each of the three years. The new and expanded fish-based IBIs were included in a manuscript that will be submitted for publication in the journal *Wetlands*. After the paper has passed the peer-review process, we will incorporate the new IBIs into our reporting for this project. We anticipate that the next semi-annual report will include these new IBIs.

Avian and amphibian responses to landscape stressors can be used to inform land managers about the health of coastal wetlands and the landscape stressors that affect these systems (Howe *et al*. 2007). A bird index based on the Index of Ecological Condition (IEC) method developed by Dr. Robert Howe has now been calculated for Great Lakes coastal. The IEC is a biotic indicator of ecological health first described by Howe *et al*. (2007a,b) and modified by Gnass-Giese *et al*. (2014). Calculation of an IEC involves two steps: 1) modeling responses of species to a measured reference or stressor gradient (typically completed by prior research), and 2) calculating IEC values for new sites based occurrences (e.g., presence/absence, abundance, frequency) of multiple species or taxonomic groups at the site. The method applies an iterative maximum likelihood approach for calculating both species-response functions and IEC values. Functions for calculating the biotic responses to environmental stressors (BR models) are useful as stand-alone applications of environmental gradient analysis. This indicator should be considered a draft because we are still exploring its implications and are still analyzing whether adjustments sufficiently account for differences due to latitude across the entire Great Lakes basin.

The indicator is shown on separate scales for the northern and southern parts of the Great Lakes basin because of the differences in amounts of agriculture and development between these two areas (Figure 10). This can be seen in particular along the eastern coast of Lake Michigan on either side of the north/south split in the basin. We may have to do some adjustments to avoid discrepancies in treatment of sites that are close to the boundary line. However, benchmark sites also exhibit low bird IBI scores even in locations such as Duluth, on Lake Superior.

As noted above, there is little diversity in amphibians across Great Lakes wetlands. We have had some success with an amphibian indicator relying on spring peeper (*Pseudacris crucifer*) density at wetlands. It is unclear whether or not this will prove to be a reliable indicator since it is based on a single species.

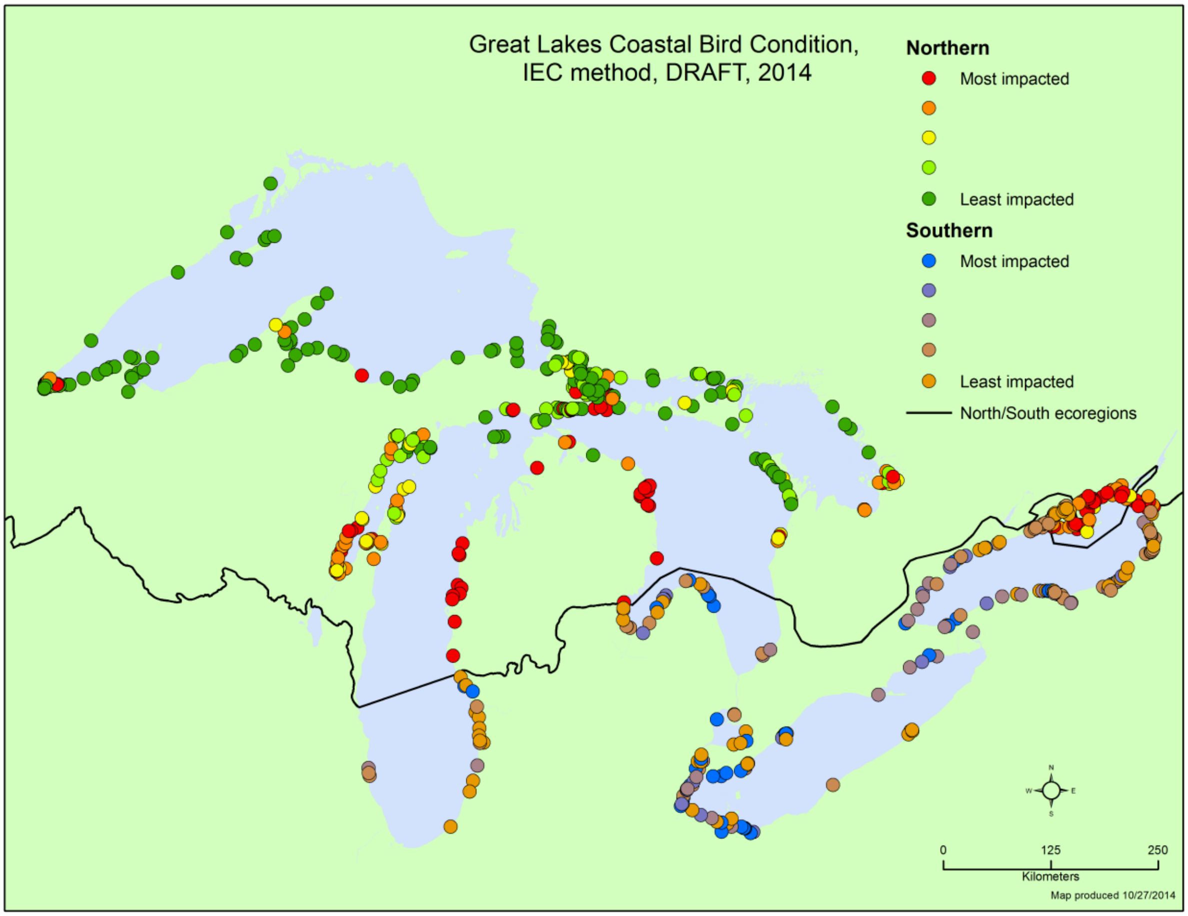

Figure 10. Condition of coastal wetland bird communties. This indicator is based on the IEC method, and it works best when shown separately for the northern and southern areas of the Great Lakes because of the differences in the amount of agriculture and developed land between these two areas (see text for details). Based on data from 2011 through 2014.

PUBLIC ACCESS WEBSITE

We have created a publically accessible website to inform managers, agency personnel, and the interested public about the basics of our project (Figure 11). The website's primary function is to house a web-based tool that allows varying levels of access to our results, depending on the user's data needs and who they work for.

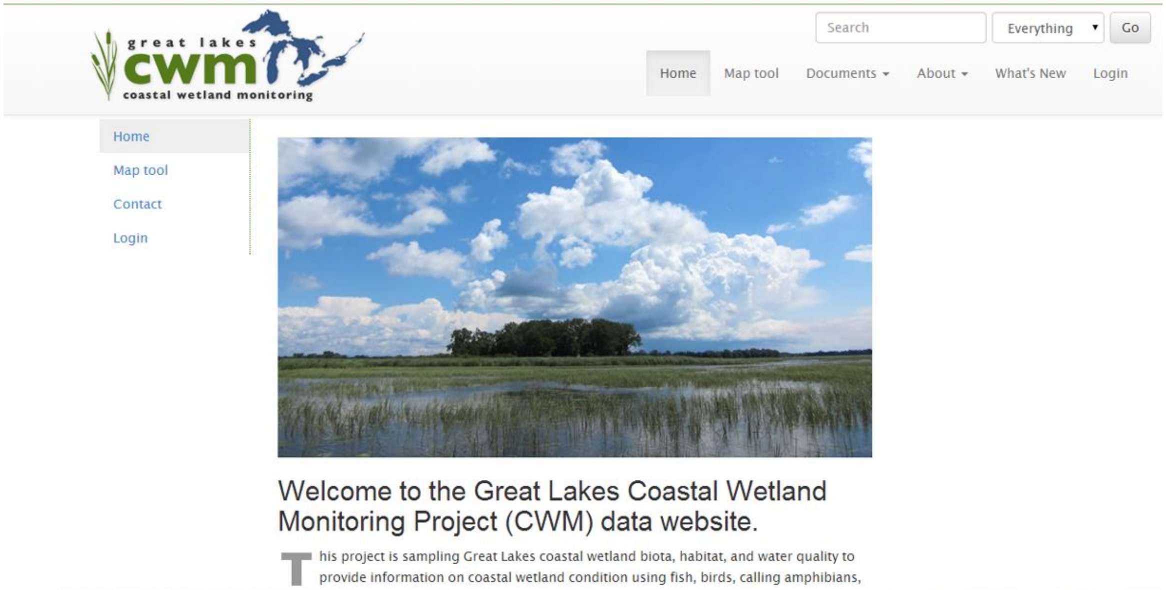

Figure 11. Front page of the new Great Lakes Coastal Wetland Monitoring public website, www.greatlakeswetlands.org.

In addition to features commonly found in map-based web interfaces (e.g., layer switching, swapping of base-maps, panning and zooming), the tool will provide custom functionality relevant to coastal wetland monitoring (Figure 12). Users will be able to examine sites ranked by Indices of Biological Integrity (IBIs) and other attributes, look at taxa lists, and peruse site information in the context of a particular region of interest, as well as whole lakes or the entire basin.

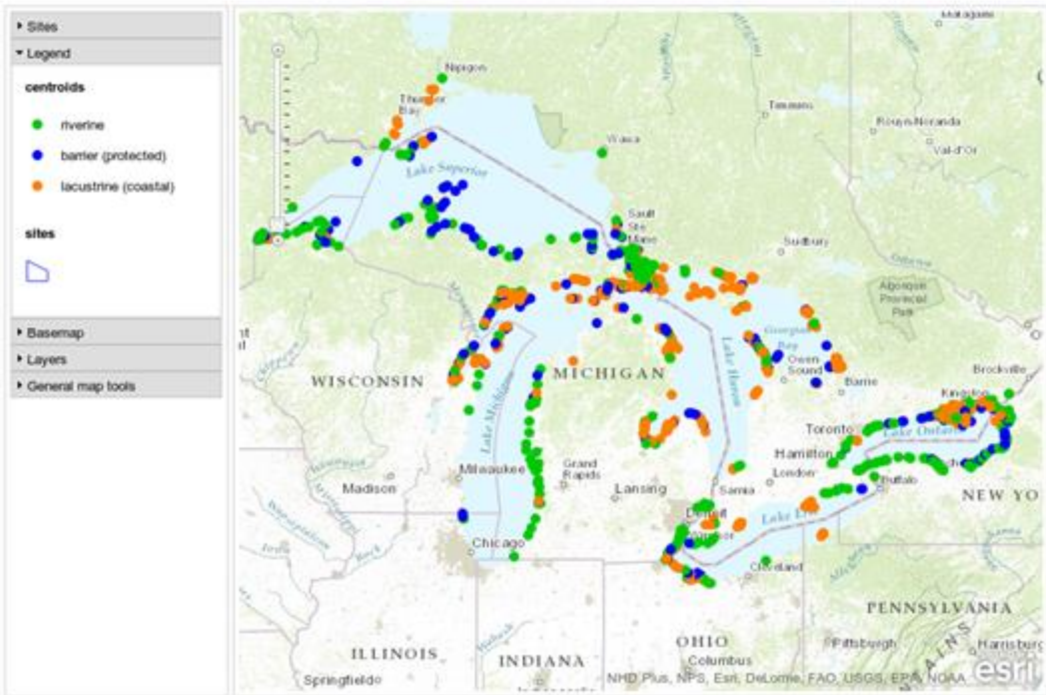

Figure 12. Default view of all sites in the database, color-coded by wetland type (riverine, barrier-protected, or lacustrine).

Users can change the coding schema for the sites shown in the display map to show what year(s) sites were sampled (Figure 13), what types of data are available for a site, and what the site condition is as indicated by the various biotic groups sampled. Users can select areas of the map to zoom to so that they can better view site information.

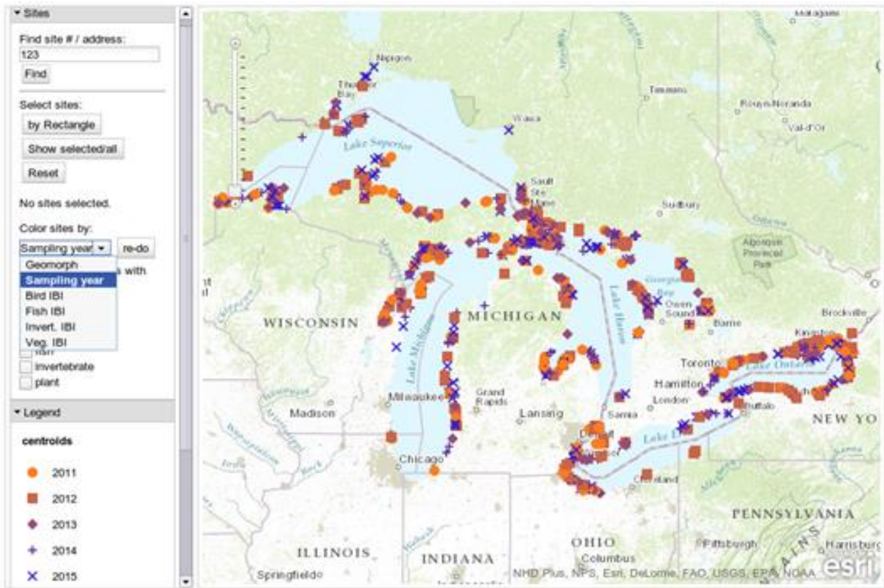

Figure 13. View by sampling year. Sites sampled in more than one year show the most recent year of sampling.

Wetland condition values can be selected for any of the IBIs currently available (fish, macroinvertebrates, or wetland vegetation) and displayed for the whole basin using the

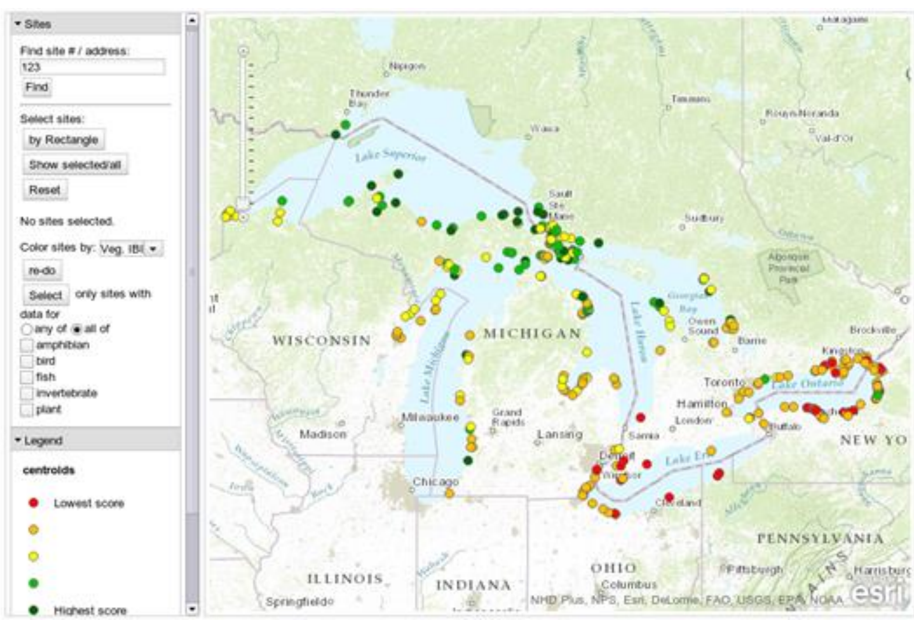

Figure 14. Wetland condition based on the wetland macrophyte IBI displaying sites for the whole basin for which there are data.

calculated normal scaling for the IBI (Figure 14).

The tool also allows users to draw a box around sites of interest at any scale, such as all of Lake Erie, or just Green Bay, or just the St. Louis River estuary (Figure 14). Once selected, any IBI can be re-scaled for just the sites on display to color-code the sites based on their range of scores. This removes the sites from the basin-wide condition narrative and simply shows the user which sites are in best to worst condition for that indicator for that area. Thus, rescaled maps must be carefully explained to others and should not be shown without explanation because this view forces sites to be displayed from best to worst even if there is very little actual difference in site scores. The advantage is that this allows easy color-coded separation of sites that, when compared to all Great Lakes wetlands, appear to all have about the same condition scores (Figure 15 inset). By rescaling these sites, managers can see at a glance which wetlands

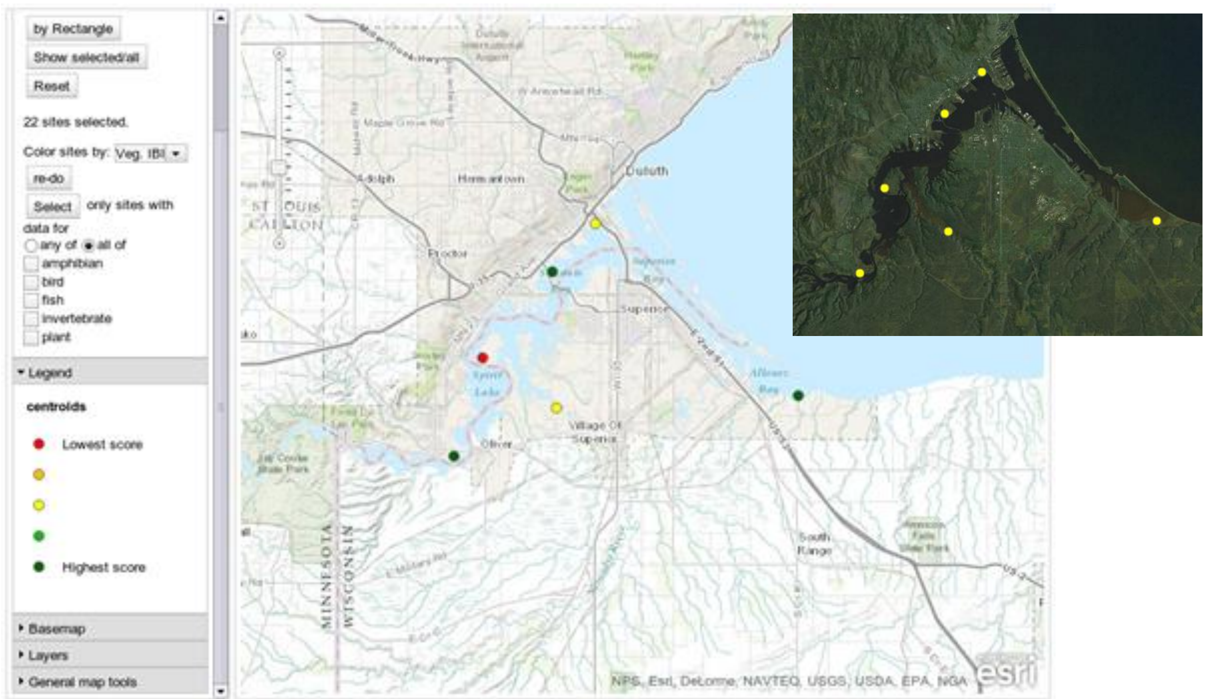

Figure 15. Wetlands in the St. Louis River estuary, Lake Superior, color-coded by wetland vegetation IBI scores that have been re-scaled for the sites shown. Inset shows original site coding for these wetlands in the context of all the wetlands across the Great Lakes.

have the highest and lowest scores for their area of management or interest (Figure 15).

The web tool will have different levels of access based on the type of user (e.g., general public, management, researcher, etc.). This will be controlled by user login. Depending on their level of access, users will be able to drill down at individual sites to see lists of species found (Figure 16), non-native species, IBI scores and their composite metrics, and potentially other site information.

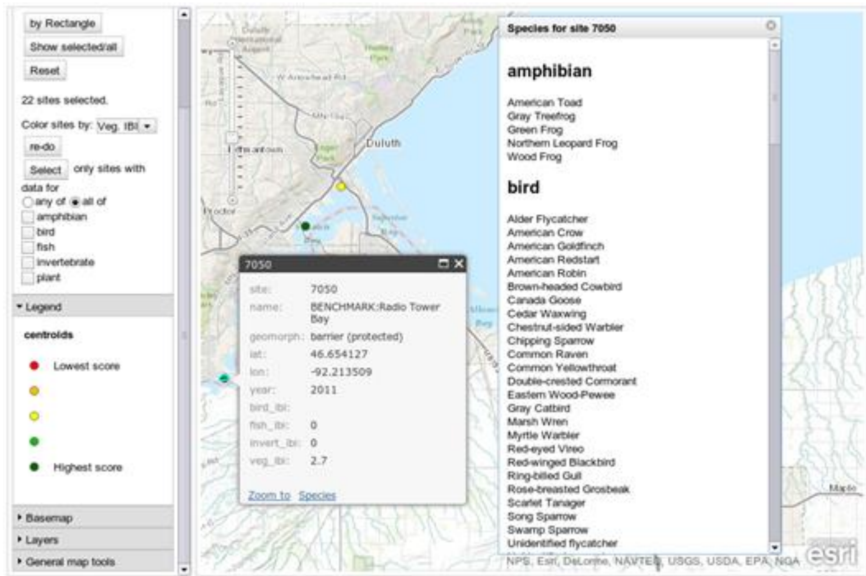

Figure 16. Example display of species lists for a specific site.

Arrangements for the long-term post-project hosting of the public website have been finalized - Central Michigan University will be providing hosting and maintenance. Currently development, deployment, and management systems are being transferred from the staging site hosted at NRRI to CMU.

TEAM REPORTS

WESTERN REGIONAL TEAM: Jerry Niemi (Birds and Amphibians), Valerie Brady and Lucinda Johnson (Fish and Macroinvertebrates), Nicholas Danz (Vegetation), and Rich Axler (Water Quality)

Field Training

Birds and Amphibians

Training for amphibian surveys was held on 23 April 2014 and bird crew training took place 24 – 26 May 2014. Training involved instructing crews on how to conduct standardized field surveys, on basic travel procedures, and on appropriate field safety measures. Individuals are trained to proficiently complete field sheets and audio testing is also completed to insure that their hearing is within the normal range. Rules for site verification, safety issues including caution regarding insects (e.g., Lyme's disease), GPS and compass use, and record keeping are also included in field training to insure that the guidelines in the QAPP are being followed. All individuals involved in conducting the surveys have taken and passed each of the following tests on 1) amphibian calls, 2) bird vocalization, and 3) bird visual identification that are based on an on-line system established at the University of Wisconsin, Green Bay – see http://www.birdercertification.org/GreatLakesCoastal, prior to conducting surveys. Note that field observers who have become certified in previous years are not required to become certified again in future years. All new and returning field observers reviewed the QAPP and SOPs.

Fish, Macroinvertebrates, Vegetation, and Water Quality
Fish, macroinvertebrate, vegetation, and water quality sampling training was in Duluth, Minnesota, and Superior, Wisconsin, in mid-June 2014 and continued in Green Bay, Wisconsin at the end of June/early July. Several fish/invertebrate/water quality crew members returned from previous seasons, but the crew also included 4 new members. This year the vegetation crew included some trained botanists sampled sites in the UP and northern Lake Michigan. All field technicians were trained in and tested on all standard procedures, including a field-based fish or vegetation identification exam (depending on the crew). Training included how to determine if a site meets project criteria, all aspects of sampling the site, proper recording of data on datasheets, GPS use and uploading, water quality sample collection and meter calibration (fish/invert crew only), as well as sample processing. Much of the training takes place in the field at a typical coastal site to ensure field members learn (or review) appropriate techniques. Safety training covered aspects of field safety including safe boating; protection against the elements, animals, insects, and plants; and what to do when things go wrong. A CPR/AED/first aid class was also provided to fish/invert crew members.

Sampling permits were obtained from state fisheries management agencies, parks, and various other entities (the states of Minnesota, Wisconsin, and Michigan, the National Park Service, and various state parks). The US Forest Service decided that no special permits are necessary for any sampling on their lands across the Great Lakes states. We have renewed our University of Minnesota Institutional Animal Care and Use Committee permit for fish sampling.

Site selection

Birds and Amphibians
In 2014, a total of 60 sites were initially selected to be surveyed for birds and amphibians. Of these sites, 28 were rejected either prior to visiting the wetland (web reject) or following reconnaissance visits to each remaining site (visit reject) for one of the following reasons: 1) inaccessible or unsafe to access, 2) no trespassing signs and owners could not be contacted, 3) wetland areas were unsuitable for sampling (e.g., wetland lacked connectivity to the lake), 4) exceeded the sampling capacity or was logistically infeasible for the crew to complete in 2014 but should be visited in subsequent years, or 5) benchmark site was not being sampled, the reason for which would most likely be found in reason four (Table 14). Because of the duration and extent of ice cover and cold weather last spring, the minimum nighttime temperatures required to sample amphibians at sites along Lake Superior were not reached until late in

spring, therefore surveys extended into the second week of July. Amphibian crews were able to sample sites in northern Lake Huron beginning 06 May and bird surveys began 29 May. Sampling was completed by 12 July 2014.

Table 14. List of reasons sites were rejected in 2014. The number of sites rejected for birds and amphibians are listed by reason for site rejection. Of the 60 sites initially selected to be surveyed by the western regional team, 28 were rejected.

Reason for site rejection	**Bird**	**Amphibian**
Not sampling benchmark	3	5
Could not access site	1	2
Web reject	12	12
Visit reject	9	9

The 30 sites that were sampled by bird and amphibian field crews stretched from the Duluth-Superior harbor area both northeast along the shore of Lake Superior and Ontario and eastward along the south shore of Lake Superior to the eastern end of the Upper Peninsula of Michigan and into northeast Lake Huron. In 2014, several island sites were also sampled, including 1 site in Wisconsin (Clough Island) and 1 site in Michigan on Isle Royale (Caribou Creek Wetland). Of the 30 sites sampled, 7 were benchmark sites selected because they were of interest for restoration potential. These sites were located in the St. Louis River estuary and are in some stage of planning for restoration work. Restoration activities for the sites are being coordinated by the Minnesota Pollution Control Agency and the US Fish and Wildlife Service, with many collaborators from multiple agencies and university research groups.

Fish, Macroinvertebrates, Vegetation and Water Quality
Initial site selection for fish/macroinvertebrate and vegetation crews was 58 sites. Of these, 9 were over the crew capacity limit, 13 actually belonged to other teams (the Uzarski team sampled Isle Royale sites this year), another 7 were benchmark sites specific to bird/amphibian crews, and 7 sites were rejected. Four sites were web-rejected due to not meeting project criteria for connectivity, wetland presence, lake influence, or safe access and the other 3 were rejected on the ground either due to safe access issues or lack of lake influence.

The NRRI fish/invertebrate/water quality field crews visited 24 coastal wetlands of Great Lakes Superior (15 wetlands) and Michigan (9 wetlands). Eight of the wetlands were benchmark sites, one was a resample, and 15 were new sites. Of the 24 sites visited, we rejected 3 as not meeting Coastal Wetland Monitoring sample criteria, and of the remaining 21 sites we were able to sample 16 for fish. All 21 sites were sampled for invertebrates, habitat, and water quality. One additional benchmark site was sampled for invertebrates, habitat, and water quality as a courtesy to conservation partners, but it is not actually a coastal wetland and those data were not included in the database.

The vegetation field crews conducted surveys between July 3 and August 03 in Wisconsin, Michigan, and Minnesota. Throughout the survey region, only one wetland was excluded from surveys due to inaccessibility. All surveyed sites were reached by canoe, with the longest paddling distance about 2 miles. Most wetlands were accessible with less than a ¼ mile paddle.

Field sampling and preliminary interesting findings

PIs and crews have quite a bit more data to work with after 3 years of sampling. Researchers, graduate students, and technical staff have been spreading the word about our project and results at national, regional, and local conferences, meetings, and workshops. A list of these presentations from previous years is included and will be updated for the spring report.

Birds and Amphibians

Each of the 30 sites sampled in 2014 was visited a total of four times between 06 May and 12 July. At each site, three surveys were conducted for amphibians and two surveys were completed for birds, one of which occurred on the same evening as an amphibian survey.

Amphibians

A list of amphibians recorded during the 2014 surveys is provided in Table 15. A total of 10 species were recorded throughout our study sites. The average number of amphibian species recorded at each site was 4, with a minimum of 1 species counted at 2 wetland sites, including Florence Bay-Pickett Bay Wetland on Isle Royale, MI and Anchor Island in NE Lake Huron. The two sites with six species recorded were at the Bark Bay Wetland, a priority wetland site in Bayfield, WI owned by the WDNR, and Point Charles, Little Lake George wetland in NE Lake Huron.

Spring peepers were the most abundant species observed in all wetlands sampled, accounting for nearly half of the amphibian observations and the majority of full chorus observations (Table 15). Bullfrog (*Rana catesbeiana*), regarded as an invasive species in Great Lakes region, was observed in four wetland sites, two on Lake Superior and two in NE Lake Huron. Notably, Blanchard's cricket frog (*Acris crepitans blanchardi*) was observed in Echo Bay, a large barrier (protected) wetland complex in NE Lake Huron. There were multiple sites where Mink Frog (*Rana septentrionalis*) were observed this year, all of which were in wetlands on Lake Superior, 3 at barrier (protected) wetlands and 2 in riverine wetlands.

Table 15. List of amphibians recorded during 2014 surveys. The number of individuals counted and the number of full choruses observed (# of individuals cannot be estimated) are provided for each species.

Species	Number of Individuals	Number of Observations (Full Chorus)
American toad (*Bufo americanus*)	30	0
Blanchard's cricket frog (*Acris crepitans blanchardi*)	2	0
Bullfrog (*Rana catesbeiana)*	5	0
Chorus frog (western/ boreal –*P.triseriata & P.maculatas*)	12	0
Green frog (*Rana clamitansmelanota*)	250	4
Gray treefrog (*Hyla versicolor*)	174	32
Mink frog (*Rana septentrionalis*)	12	0
Northern leopard frog (*Rana pipiens*)	4	0
Spring peeper (*Pseudoacris crucifer*)	470	128
Wood frog (*Rana sylvatica*)	134	8
Total	**1093**	**172**

Birds

Birds were surveyed twice at each site between 29 May and 12 July. Surveys occurred once in the morning and once in the evening. There were a total of 100 identifiable species observations and 4,006 individual birds recorded. The five most abundant species observed accounted for approximately 39% of all observations. These species, in order of decreasing abundance, were Ring-billed Gull (*Larus delawarensis*), Red-winged Blackbird (*Agelaius phoeniceus*), Canada Goose (*Branta canadensis*), Common Yellowthroat (*Geothlypis trichas*), and Song Sparrow (*Melospiza melodia*).

In the Western Great Lakes region there have been many observations of birds of special concern in the vicinity of the wetlands or using the wetland complexes in 2014 (Table 16). The most noteworthy observation was that of a Yellow Rail (*Coturnicops noveboracensis*) in Toulouse Bay wetland in NE Lake Huron, which was the first recorded observation for this species in the monitoring program. Some of the other unique and important observations included secretive marsh birds such as American Bittern (*Botaurus lentiginosus*), Virginia Rail (*Rallus limicola*), and Least Bittern (*Ixobrychus exilis*). American Bitterns were observed in five wetlands including, Echo Bay, a large barrier (protected) wetland in NE Lake Huron where seven individuals were observed. There were nine Virginia Rail observed at this wetland, including an observation of adults with fledglings. Virginia Rail were also observed at two other wetlands including two individuals in a benchmark site in the St. Louis River estuary (SLRE). The Least Bittern was observed in a riverine wetland (Little Pokegama Bay), a benchmark site also located in the SLRE. The two Least Bittern observations from the SLRE in 2013 were from a riverine benchmark wetland located on Clough Island.

Eleven Bald eagles (*Haliaeetus leucocephalus*) were observed. In the Duluth-Superior area alone there are at least four nesting pairs of Bald Eagles: three nests within the SLRE and one within 0.5 mi of the shoreline within the city limits of Duluth. Additional species of interest include: Common Loon (*Gavia immer*), which were observed in eight wetlands. Three of the 11 observations were at Caribou Creek Wetland on Isle Royale. Pied-billed Grebe (*Podilymbus podiceps*) were observed at five sites, with multiple individuals observed in the Echo Bay and Toulouse Bay wetlands in NE Lake Huron. Sandhill Crane (*Grus canadensis*) were observed in nine wetlands. Of the 65 individuals observed, 62% were observed at the Everen's Point, St. Joseph Island wetland in NE Lake Huron. Common Tern (*Sterna hirundo*) observations occurred at four wetland locations, all in NE Lake Huron.

Birds of special concern were observed in 26 of the 30 wetland sites surveyed in 2014. Four of the six benchmark sites surveyed also had birds of special concern including three sites in Wisconsin (Nemadji River, Kimball's Bay, and Little Pokegama Bay), and one site in Minnesota (Mud Lake). The lack of observations of Black Tern, Forster's Tern, and Caspian Tern (all species of concern throughout the Great Lakes) is of particular interest and concern.

Table 16. List of birds of special interest recorded during 2014 surveys **and t**he number of individuals observed. Observations that occurred in at least one benchmark location are also **indicated** (*).

Species	Number of Individuals
Sandhill Crane (*Grus canadensis*)	65
Wilson's Snipe (*Gallinago delicata*)	39*
Common tern (*Sterna hirundo*)	13
American Bittern (*Botaurus lentiginosus*)	12*
Virginia rail (*Rallus limicola*)	12*
Bald Eagle (*Haliaeetus leucocephalus*)	11*
Common Loon (*Gavia immer*)	11
Pied-billed Grebe (*Podilymbus podiceps*)	11
Sora Rail (*Porzana carolina*)	6*
Great Blue Heron (*Ardea herodias*)	3
Belted Kingfisher (*Megaceryle alcyon*)	3
Least Bittern (*Ixobrychus exilis*)	1*
Yellow Rail (*Geothlypis trichas*)	1

Fish, Macroinvertebrates, and Vegetation

NRRI crews fished a total of 30 vegetation zones which were composed of 10 different vegetation types. In total, we captured more than 13,000 fish represented by 47 species. Invasive fish species were present at 10 sites and were most frequently common carp, round goby, and tubenose goby. The NRRI crew did not find any rusty crayfish at our sites sampled in 2014. In past years we have caught them Green Bay-area wetlands.

After looking at the USGS's Nonindigenous Aquatic Species tracking website (http://nas2.er.usgs.gov/), we realized that we have been finding faucet snails (*Bithynia tentaculata*) in locations from which they do not appear to have been previously reported. We are in the process of compiling this information to send to the USGS NAS web master.

While faucet snails were first reported this year from the St. Louis River Estuary (collected by USEPA in a 2012 sampling event), our crew and other researchers began finding them in the estuary in 2011 but mistakenly thought that they were known to be here because of a 2006 report by USEPA of a faucet snail operculum being found in the estuary. We have also found these snails in the apparently unreported locations of Little Suamico River, southern Green Bay, Lake Michigan; just south of Pensaukee, in Green Bay, Lake Michigan; near Oconto, Green Bay, Lake Michigan; Peshtigo River, Green Bay, Lake Michigan; Escanaba River in northern Lake Michigan; and Rapid River in northern Lake Michigan. This puts locations of these snails up and down the western coast of Green Bay and northern Lake Michigan. These snails also seem to be unreported in Michigan's Upper Peninsula, but our crews collected them near Au Train and in Pilgram River near Houghton, both in the Lake Superior watershed, in addition to the UP locations in the Lake Michigan watershed.

Painted turtles were common by-catch and Eastern snapping turtles were less common in fyke nets, with 131 and 7 captured, respectively. At one Lake Superior wetland within the St. Louis River Estuary, our group captured a spiny softshell turtle *(Apalone spinifera)* (Figure 17). While not a threatened or endangered species, they are infrequently captured; this spiny softshell turtle was the only individual found in the last four years of CWM sampling across all fish/bug teams. The St. Louis River is listed as an Area of Concern (AOC) for 9 beneficial use impairments, among them are contaminated sediments. Michigan DNR indicate spiny softshells are affected by pollution, so the occurrence of this spiny softshell may be a hopeful sign that some parts of the St. Louis River are recovering from their commercial heritage.

Figure 17. Spiny softshell turtle (*Apalone spinifera*) collected in a fyke net at site within the St. Louis River, WI Area of Concern (AOC).

One interesting phenomenon around the Green Bay area of Lake Michigan is the regular occurrence of gar that are likely hybrids between shortnose and longnose species (Figure 18). The Wisconsin Department of Natural Resources recently documented a number of hybrid individuals in the Fox River watershed, but not within Green Bay proper. In 2013 the NRRI field crew encountered gar exhibiting mixed traits which suggested hybridization, and in 2014 we developed a plan project-wide to collect fin-clip tissue samples to genetically test for hybridization. NRRI collected 22 tissue samples that await DNA analysis, and we will continue to collect fin clips from gar encountered in 2015.

Figure 18. A top-of-snout photo of a possible shortnose gar x longnose gar hybrid (*Lepisosteus oculatus* x *osseus*). In 2014 NRRI field crews collected DNA from 22 possible hybrid individuals in the Green Bay, WI area for genetic analysis to verify hybridization.

The vegetation survey crew particularly noticed the effects of beach grooming on wetlands along the shores of northwestern Lake Michigan within the borders of the state of Michigan, which allows this activity. Unfortunately, the higher water levels have not stopped some property owners from continuing to attempt to manage wetland vegetation, even though it is now in the water and should now be protected by law. Crews noticed property owners using heavy machinery to attempt to channelize and drain vegetated areas that, in all probability, were dry the past two years. These locations were reported to the Michigan Department of Environmental Quality as part of our collaboration with Anne Garwood (who was Anne Hokansen).

Two wetlands were sampled with special permission from tribal entities. A wetland in the Kakagon Slough on Lake Superior was accessed and sampled with special permission from the Bad River Band of Lake Superior Chippewa, and we received permission from the Keweenaw Bay Indian Community to sample a site on the Keweenaw Peninsula. NRRI continues to work hard to maintain good relationships with the tribes through the Coastal Wetland Monitoring project.

2014 Sample Processing, Data Entry, and QC

All 2014 bird, amphibian, fish, habitat, and field water quality data have been entered into the database and QC'd. The PIs conducted mid-season checks by visiting a few sites and verifying that proper protocol was being implemented. Macroinvertebrate identification will take place throughout the winter, with data entry and QC completed in time for the spring report. Lab water quality data should be completed, entered, and QC'd by the end of November.

Metrics and Indicator Calculations

PIs on the vegetation project have been working to analyze temporal patterns in floristic quality metrics (e.g. mean Coefficient of Conservatism, FQI). We are asking how much these metrics change from year to year in typical situations and in other cases where water level changes or human influences have been substantial through time. Throughout 2014, N. Danz has been analyzing data from 2011-2013 surveys to characterize interannual variability in wetland floristic quality. During this survey period, annual water levels across the Great Lakes experienced relatively minor changes. For 36 wetlands that experienced no human disturbance and were surveyed in more than one year, mean coefficient of conservatism (C) and weighted mean coefficient of conservatism (wC) differed very little between years. Mean annual differences were within ±1.2 for C and ±1.5 for wC. These patterns of change may serve as a baseline amount of temporal variability against which future changes in floristic quality can be judged. More analytical work on these data will continue during Fall 2014.

Leveraged benefits

One site that is actually not a coastal wetland was sampled under special request by State Natural Area managers and private landowners of the Bayshore Bluff Lands. The landowners and managers are working together to conserve this small spring-fed wetland, but required more data to help them make important decisions. The NRRI field crew was able to sample invertebrates following the Coastal Wetland Monitoring methods and will supply them with the data to aid their conservation efforts.

Data from the benchmark site Suamico River Area Wetland was requested by and shared with personnel from the Wisconsin Department of Natural Resources and The Nature Conservancy, who are involved in the restoration activities to re-connect a diked area with Green Bay. In 2011 NRRI sampled outside the diked area following CWM methods, and in 2013 we sampled within the diked area as a special request. The data were summarized for fish, invertebrates, water quality, birds, and vegetation and shared with David Halfmann (WDNR) and Nicole Van Helden (TNC).

The Wisconsin Department of Natural Resources requested (and funded) a special report on sites sampled using CWM protocols around Clough Island within the St. Louis River Area of

Concern (AOC). Their interests were to see if CWM data indicated any differences in habitat or species composition/abundances among Clough Island and other St. Louis River sites, and also how Clough Island compared to other nearby Lake Superior coastal wetlands. The 46 page report was submitted to Cherie Hagan of the WDNR in May of 2014.

Central Basin Regional Team: Don Uzarski, Dennis Albert (Vegetation), Thomas Gehring and Robert Howe (Birds and Amphibians), Carl Ruetz (Fish), and Matt Cooper (Macroinvertebrates)

Field Training

Central Basin Team members responsible for fish, macroinvertebrate, and water quality monitoring conducted their own training among their respective field teams in 2014. This was deemed sufficient given that all teams had a majority of technicians returning from 2013. Additionally, one crew member from GVSU went in the field with the CMU crew to receive hands-on training of the field sampling protocols. All field crews, regardless of whether they had returning technicians, conducted pre-season certification and certification records were sent to the project QA officers. All crews also completed a mid-season check to verify that protocols were being followed correctly and these records were also sent to the project QA officers.

Central Basin bird and amphibian crews were tested for identification of calling amphibian and bird calls and were trained in proper field procedures prior to initiation of 2014 field work. Amphibian training was completed by 14 March 2014 and bird training was completed by 15 May 2014. Online testing was used for identification of amphibians and birds by sight and sound and all crew members reached proficiency before sampling. Michigan plant crews were trained and certified by Dennis Albert in Pellston, MI June 16- 19, 2014. Two plant samplers passed the test and were certified to lead a sampling team, while two were certified only to work as assistants.

Other Fieldwork Preparation

All field crews sampling fish obtained IACUC approval from their respective institutions and received necessary sampling permits from the Michigan Department of Natural Resources, US Forest Service, and various other land management agencies prior to starting fieldwork. Seasonal technicians were interviewed and hired in late winter through spring at each institution. All necessary equipment and supplies were purchased in late spring. Maintenance and repair of boats, vehicles, nets, water quality sampling equipment, and other supplies was completed during the spring and early summer. Central Basin Team members held a conference call and several e-mail conversations to determine the most efficient way to split up sites among the central basin crews.

2014 Field Season

Central Michigan University

The CMU crew contained a combination of experienced crew leaders (Tom Langer and Neil Schock) along with graduate (experienced members) and undergraduate (new) technicians. All members were subjected to performance assessment in identification of fish, invertebrate and habitat assessment in May 2014 with Don Uzarski performing the mid-year QC performance check on 21 July 2014.

The CMU crew sampled 26 of 29 originally-assigned sites and sampled an additional 6 sites (1 transferred and 5 added) for a total of 32 sampled sites. Successful sampling occurred from June through August 2014 with sites in Lakes Erie (5), Huron (17), Michigan (5) and Superior (6). This included a site transferred to CMU for fish and invertebrate sampling due to permitting issues for Canadian crews sampling in the US waters. On Isle Royale, several sites were web-rejected for lack of surface connection and/or sampling trip logistics that precluded accessing the sites. Due to the cost of the trip and the limited ability for return visits, the CMU crew visited 5 additional sites while on the island. Two of these sites were visit-rejected. Additionally, two sites on Lake Michigan were visit-rejected due to lack of zones with surface connection and/or lack of zones meeting the minimum size criteria.

Amphibian surveys were conducted 15 March to 10 July 2014 and bird surveys were completed 15 May to 10 July 2014. Wetlands were sampled three separate times for amphibians and two separate times for birds. Sampling for amphibians and birds occurred in coastal wetlands of the Lower Peninsula of Michigan, eastern Upper Peninsula of Michigan, and sites in western Lake Erie, Ohio. A total of 44 wetland sites (including 12 benchmark sites) were surveyed for birds and 43 wetlands were sampled for amphibians. Seven sites were not sampled because they could not be accessed safely for night sampling. An additional 3 sites were web/visit rejected. Three teams, each with two members, were used throughout the sampling season.

Lake Superior State University

Three crew members were trained and certified in sampling protocols in June. A part-time volunteer was also trained and assisted with summer sampling. From late June to August, the LSSU crew visited 10 sites to determine if they met the sampling criteria and if there were access issues. One site was not sampled because of a lack of connection to the lake, and one site was web-rejected based on satellite and aerial photos. Crews returned to 9 sites and collected water quality, macroinvertebrate, and fish data and samples (along with other associated measurements) for all vegetation zones identified. Collected water samples were mailed to Central Michigan University in early October for dissolved nutrient analyses and filters were sent to the University of Notre Dame in September for chlorophyll *a* analyses. The former crew leader for GVSU was hired in September to identify collected macroinvertebrates.

Grand Valley State University

The GVSU crew sampled all eight wetland sites that were assigned for invertebrates and water quality, and sampled six sites for fishes, invertebrates, and water quality. Water depth exceeded the 1 m maximum for fish sampling at one site where we did not sample fish, and accessibility issues prevented us from transporting fyke nets to the other field site where we did not sample fish because we had hike over 7 km (round trip) to get to and from the site. All sampling was conducted during July-August 2014 and coincided with maturation of plants, which made for easier identification of plant zones. Our main challenges were large sites that took time to survey to determine a specific area to sample within the wetland, difficult access, and deep water with soft sediments.

University of Notre Dame

The Notre Dame crew visited nine wetlands and sampled eight wetlands, which included a total of 16 vegetation zones. One site was visit-rejected because it did not contain a connected wetland with vegetation zones of sufficient size to sample. Because two lead field crew members relocated to Central Michigan University in August, much of the work originally assigned to Notre Dame will be done at CMU. Water and invertebrate samples collected by the UND crew in 2014 have been transferred to Central Michigan University and will be processed during the fall and winter. Chlorophyll *a* samples will continue to be processed at Notre Dame for the 2014 and 2015 sampling years.

Oregon State University

Field sampling for vegetation was completed at 44 sites within Michigan, including sites on Lakes Superior, Michigan, Huron, St. Clair, and Erie, and the St. Marys River, including 12 benchmark sites. A Garden Island benchmark site, as well as an additional Garden Island site and a Hog Island site were not sampled due to safety concerns and stormy weather. Lack of water-taxi access resulted in lack of access to some Isle Royale sites, limiting Isle Royale sampling to sites in the western portion of the island. Sampling teams had access problems with five other sites along the St. Marys River. The sampling team could also not get permission for access to a site on Grosse Isle or at Mona Lake. The plant team director, Dennis Albert, reviewed all unknown plants collected by the sampling crews.

Sample Processing and Data Entry

Central Michigan University

100% of the field survey data (habitat, disturbance, fyke net data) from the 2014 season has been uploaded to the central database and QC'd. 75% of the aquatic macroinvertebrate identification has been completed with data entered into the online database. Invertebrate data QC will begin in December 2014. Water quality analysis has begun and will be completed by the end of December. All 2014 amphibian and bird survey data were uploaded and have been QC'd.

Lake Superior State University

100% of the field survey data (habitat, disturbance, fyke net data) from the 2014 season has been entered and QC'd. 100% of the water samples collected were analyzed for alkalinity and chloride, filtered, and/or sent to other laboratories for analysis. 40% of macroinvertebrate samples have been identified and verification by other labs will be completed over the winter. Incomplete data entry for 2013 (e.g., lab data) was finished and QC'd during summer 2014. Macroinvertebrate data from 2013 samples needs to be verified (for identification issues) and corrected in the database. This will be completed over the winter.

Grand Valley State University

The Ruetz Lab is in the process of completing field data entry and QC checking for fish and invertebrate data. This was delayed because the lab recently hired a new staff member who will be responsible for the task. All field data for water quality, fish and invertebrates will be entered and QC'd by the end of October. Invertebrate identification will begin in October or November and will be completed before Year 5 field work begins.

University of Notre Dame

100% of field survey data from the 2014 season has been entered into the central database and QC'd. Water quality analysis has begun (at CMU) and will be complete by the end of December. Chlorophyll *a* extraction and analysis has begun and will be complete by the end of October. Sediment sample processing will be complete by the end of December. As noted above, invertebrate samples collected by the UND crew in 2014 will be processed at CMU.

Oregon State University

PI Dennis Albert reviewed all field forms prior to data entry. Data entry has been hampered by early loss of sampling staff; plant data is currently being entered by Dennis Albert and assistants from University of Minnesota Duluth. All data is expected to be entered and QC'd by late October, 2014.

Quality Assurance / Quality Control

All Central Basin field crews (CMU, GVSU, UND, LSSU, and OSU) reviewed and signed the QAPP and SOPs during the spring, prior to field sampling. Crew members were then certified or re-certified for each protocol they would be responsible for conducting. Supervising PIs/Co-PIs conducted the mid-season checks in most cases. All field crews passed these evaluations and no corrective actions were necessary during the 2014 field season. Documentation for these mid-season QA/QC checks has been filed with the QA managers and lead PI Uzarski. All data entered into the data management system has already or will soon be QC'd. Quality issues were detected for a subset of invertebrate taxa identified in 2013 samples. These issues are being rectified by having an expert macroinvertebrate IDer from the GVSU crew join the LSSU staff to re-process LSSU's 2013 invertebrate samples. Identification and data entry will be complete and updated in the database by November 2014. The expert IDer will remain on LSSU's staff to process 2014 samples.

Other Notes

<u>Lake Superior State University</u>

As was mentioned in previous reports, NOAA is leading efforts on a restoration of flow through the Little Rapids in the St. Marys River. Construction will begin in spring 2015, and it is projected to restore over 50 acres of critical spawning habitat for many native freshwater fishes and provide important nursery and rearing habitat in backwater areas. Sugar Island wetland #3 was added as a benchmark in 2013 to characterize changes in fish communities. Continued monitoring of this site before and after restoration will help identify changes to existing wetlands and to their use by fishes and other aquatic organisms at various life stages.

No expansions of the invasive species European frog-bit (*Hydrocharis morsus-ranae*) were documented in either Lake Michigan or Lake Superior. However, the LSSU fish and invertebrate crew identified a large patch of frog-bit at Raber Bay Wetland. Rayber Bay Wetland is located in the St. Marys River, Lake Huron watershed. The LSSU crew worked with the East Mackinac/Chippewa/Luce County Conservation District to initiate a response to the invasion. Over 600 lbs of frog-bit was hand-pulled from the Raber Bay Resort boat launch in an effort to minimize spread throughout the river (Figure 19). The article was published in the local Soo Evening news and was also featured on social media (Facebook and Twitter).

Figure 19. LSSU fish and invertebrate sampling crew helped hand-pull the invasive European frog-bit after they discovered it at a boat launch near a wetland they were sampling in northern Michigan.

University of Notre Dame

Leadership team member Matt Cooper contributed writing and reviews of the methods paper writing effort being led by Don Uzarski. Cooper also produced a manuscript updating fish-based IBIs for Great Lakes coastal wetlands. This manuscript was a chapter of Cooper's Ph.D. dissertation and will be submitted for publication to the journal *Wetlands*. Cooper also presented results from these analyses at the Michigan Wetlands Association meeting in Grand Rapids, MI in August.

Grand Valley State University

In addition to field work, co-PI Carl Ruetz reviewed the methods paper (organizing comments from the American side of the fish and invertebrate teams) as well as providing comments on draft manuscripts focused on refining the fish IBI. Additionally, the Ruetz lab has continued to investigate the identification of brown and black bullheads. They obtained results from DNA barcoding to verify identification made based on morphological and meristic characteristics, and are in the process of using microsatellites to further investigate differences between the DNA barcoding and morphological and meristic characteristics. Ruetz collaborated with NRRI field crew chief Josh Dumke (NRRI) on this work. Dumke collected 99 bullheads as part of wetland sampling surveys for this investigation.

Oregon State University

Todd Lemein (OSU graduate student) continued to work on classification of Great Lakes wetland plant communities using 2011-2012 data. The OSU team worked with Laura Chavez (Michigan Tech University) to assist in initiation of sampling protocols for studying paired treated and untreated *Phragmites* plots in the late spring and early summer. Dennis Albert met at Pinconning Marsh on Saginaw Bay with the North American Wetlands Conservation Council in mid-June to discuss the GLRI marsh monitoring project, as well as another GLRI restoration project. Dennis Albert met with tribal biologists of the Sault Ste. Marie tribe, Dartmouth University professor Nick Reo, and a post-doc to discuss use of GLRI marsh data collected at St. Marys River and Sugar Island for a tribal coastal restoration project.

Presentations from this project were made by OSU team members at the Society of Wetland Scientists conference in Portland, OR (first week of June 2014). At the SWS meeting, Todd Lemein presented “Correlation of Physical Factors to Coastal Wetland Vegetation Community Distribution in the Laurentian Great Lakes”, utilizing data from all of the GLRI vegetation sampling teams. Dennis Albert presented “Evaluating Temporal Variability of Floristic Quality Indices in Laurentian Great Lakes Coastal Wetlands”, summarizing GLRI data and previous work by collaborators Nick Danz, Doug Wilcox, and Joe Gathman.

Important results from 2014:

1. No new invasive plant species were documented in Michigan.
2. Both sampling teams continued to separate *Phragmites australis* occurrences into native and invasive populations to improve tracking of invasiveness of this species. There did not seem to be any problems making this separation.
3. Signs of invasive *Phragmites australis* treatment with herbicides were seen again in the 2014 sampling season at several sites in Saginaw Bay, Lake Huron, and Lake Erie. Indications are that another invasive species, *Lythrum salicaria* (purple loosestrife), established aggressively following treatment at one Saginaw Bay site, and less aggressively at a second site. Algae blooms were extensive at both sites, and at the one site where below-ground biomass was examined, there appeared to be mortality of native emergent vegetation as well as *Phragmites*. Both native perennials and invasive *Phragmites* re-established in the treated stands two or three years following treatment.
4. Mowing and *Phragmites* treatment by private landowners continue to be documented at sites on Lake Huron, the St. Marys River, and Lake Michigan. Sampling continues to be incomplete or partial at these heavily managed sites, as land owners are often unwilling to allow samplers access to the shorelines.

5. No new rare plants were encountered in any of the plots in 2014. As in past years, several orchids were found in the coastal wetlands, including Loesel's twayblade (*Liparis loeselii*), rose pogonia (*Pogonia ophioglossoides*), grass-pink (*Calopogon tuberosus*), and hooded ladies'-tresses (*Spiranthes romanzoffiana*). None of these orchids are federally or state listed species, but as orchids they have protection from commercial harvest under state regulations.
6. Sampling was much slower with increased water levels and samplers on Lake Erie complained of greater risk from boaters and personal water craft because deeper water levels allowed them to use motors closer to shore.

Future work

All Central Basin crews are currently conducting laboratory work (e.g., remaining water quality and sediment analyses, chlorophyll *a*, and macroinvertebrate identification). Water quality, and chlorophyll *a* analyses will be completed by early November and sediment analysis will be completed by the end of December. Processing of 2014 macroinvertebrate samples is currently on schedule for completion by early spring 2015. Macroinvertebrate quality control procedures, including trading samples among laboratories will also be conducted over the coming months. All Central Basin crews will also begin photo interpretation of sampling sites for the 2015 field season and develop a strategy for efficient sampling.

Eastern U.S. Regional Team: Douglas Wilcox (Vegetation), Chris Norment (Birds and Amphibians), James Haynes (Fish), and Gary Neuderfer (Macroinvertebrates)

Site Selection

The College at Brockport worked with Environment Canada in late winter to redistribute site assignments to match crew capacities. Seven Environment Canada sites were reassigned to Brockport for fish, aquatic macroinvertebrate, water quality, and vegetation sampling, and two of those sites were also reassigned to Brockport for bird and amphibian sampling. Three sites within the Rochester embayment were added to the 2014 Brockport list as benchmarks. Buck Pond, Braddock Bay, and Buttonwood Creek received benchmark tags to collect data related to several restoration projects that are currently being planned or have been implemented in the Rochester Area of Concern.

Training

Half of the crew members from 2013 returned in 2014; thus, training sessions with principal investigators served as refreshers for many of the crew members. Dr. Christopher Norment certified the bird and amphibian crew members on species ID using visual and auditory cues, distance estimations, and appropriate data collection methods. All surveyors passed the appropriate certification exams prior to the beginning of sampling.

Fish, aquatic macroinvertebrate, and water quality crew members were trained and certified on setting fyke nets, sweeping for macroinvertebrates, water quality meter use and calibration, proper QA skills, fish identification, and vegetation-zone identification by Dr. James Haynes (co-PI, fish), Gary Neuderfer (co-PI, macroinvertebrates), and Brad Mudrzynski (field crew chief) in spring 2014. All fish, macroinvertebrate, and water quality crew members met all sampling standards set by the project. Finally, all crew members passed the mid-season QA check administered by Dr. Douglas Wilcox (PI) on July 22-23.

Vegetation crew members were trained on plant identification, proper transect layout, percent cover estimations, GPS use, and data collection methods by Dr. Douglas Wilcox in early June at Brush Creek. All crew members met the standards set forth in the project QAPP, including a species identification exam in the field. All crew members also passed the mid-season QA check on July 22-23.

Sampling

Bird and Amphibian Sampling

The Brockport bird and amphibian crew successfully sampled 23 of 28 assigned sites between 1 April and 10 July. Three of the sites were not sampled due to lack of safe access, and two sites lacked a semi-permanent connection to the lake.

Fish, Macroinvertebrate, Water Quality, and Vegetation Sampling

The Brockport sampling crew began sampling on 23 June and finished on 13 August. Two of the 24 assigned sites were not semi-permanently connected to the lake, and one site was not safely accessible; therefore, sampling was limited to 21 sites. Cranberry Pond, a designed repeat site from 2013, was not sampled for fish due to lack of suitable boat access and lack of water shallower than 120 cm adjacent to floating cattail mats.

Laboratory Work

Fish crew members have identified all of the unknown fish samples that were brought back for further investigation. Laboratory-generated water quality analyses by NRRI are 80% complete, with the remaining 20% of the data yet to be generated. Macroinvertebrate identification has just begun in the lab and is anticipated to be complete by before February 2015. Data quality control checks have not started on laboratory-generated water quality data.

Data Entry and QA

Data entry for birds, amphibians, field-level water quality, macroinvertebrates, fish, and vegetation is 100% complete. Quality control checks are 100% complete for fish and field-recorded water quality and macroinvertebrates, while vegetation, bird, and amphibian data are approximately 95% complete.

Reports from the 2014 Field Season

Invasive Species

The College at Brockport continued to note an increase in the range and prevalence of water chestnut (*Trapa natans*) in 2014. Water chestnut was observed in six of Brockport's 21 sampled sites. Water chestnut was not found in one of those sites when Brockport sampled in 2011. While driving past another site in 2014, the Brockport crew noted a complete monoculture within the main channel; water chestnut was not present when this site was sampled in 2011. All new observations of water chestnut have been reported to the appropriate agencies and were uploaded to iMapInvasives.org for future control efforts. Other common invasive plant species included cattail (*Typha angustifolia* and *Typha* x *glauca*), which continue to be the dominant emergent plant at all Lake Ontario sites visited, Eurasian watermilfoil (*Myriophyllum spicatum*), and curly-leaf pondweed (*Potamogeton crispus*). A small number of invasive fish species were caught, including round goby (*Neogobius melanostomus*), which was caught at five sites but in low numbers, and common carp (*Cyprinus carpio*), which was found in three sites with fewer than three per site.

Working with Local Groups

The College at Brockport designated three sites as benchmarks for 2014: Buck Pond, Buttonwood Creek, and Braddock Bay. Data collection at Buck Pond will assist two restoration projects led by Ducks Unlimited. One project was completed in the winter of 2013/2014 and the other will start in the winter of 2014/2015. Data collected will serve both projects. Buttonwood Creek will also be restored in 2014/2015 by Ducks Unlimited; therefore, data collected in the summer of 2014 will add to its pre-restoration dataset. Finally, the U.S. Fish and Wildlife Service cut a channel through the emergent cattail monoculture at Braddock Bay in 2014 to reconnect a shallow open water area to the bay for fish spawning. Additionally, the U.S. Army Corps of Engineers is currently in the design phase of a large barrier re-creation project for Braddock Bay with the intent of protecting a large area of wetland from wave-induced erosion. Cattail control and sedge/grass meadow restoration are also part of the project. Data collected in the summer of 2014 will help with both of these Braddock Bay restoration projects.

The College at Brockport communicated with a number of groups, including the NYS Department of Environmental Conservation, The Nature Conservancy, The Finger Lakes Partnership for Regional Invasive Species Management, and the U.S. Fish and Wildlife Service on the increasing number of areas affected by water chestnut. Additionally, Brockport helped to coordinate and perform a water chestnut pull based on the results of their summer sampling at Braddock Bay in hopes of preventing the small infestation from taking over larger portions of the bay.

Canadian and US Western Lake Erie Regional Team: Jan Ciborowski, Joseph Gathman, Katya Kovalenko (Water Quality, Fish and Macroinvertebrates), Janice Gilbert (Vegetation), Doug Tozer (Birds and Amphibians), and Greg Grabas (north shore of Lake Ontario – Water Quality, Fish, Macroinvertebrates, Vegetation)

Field Training

Birds and Amphibians

Training for birds and amphibians was delivered by PI Doug Tozer on April 29, 2014 at Bird Studies Canada National Headquarters in Port Rowan, Ontario. New crew members (only a few) received the full training, while returning crew members (most of the crew) received a refresher on protocols. Topics covered included the project's objectives and methodology, and site selection procedures and station placement guidelines within selected wetlands. The amphibian and bird survey field protocols were covered in detail. Training also included methods of reporting, safety, data entry, and assessed new crew members' ability to use GPS instruments with adequate precision and accuracy as per the quality assurance project plan. New crew members were tested for comprehension of the topics using a written and practical test. All people collecting data also successfully completed the online amphibian and bird identification tests. A mid-field-season check was subsequently made in June at Long Point on Lake Erie by Doug Tozer. No problems were identified.

Fish, Macroinvertebrates, Vegetation and Water Quality

Canadian Wildlife Service (CWS) field crew members who worked with fishes, macroinvertebrates, and water quality sampling were trained by co-PI Greg Grabas and field lead Daniel Rokitnicki-Wojcik in the Toronto Region during June and July field visits**.** A number of crew members returned from previous years and all members participated in training on project protocols. The sampling protocol, technical equipment use, occupational health and safety, and field-based decision-making were covered in detail over multiple days. Crew members were assessed in the field and lab for proper sample collection, data recording, GPS use, field lab water processing, equipment calibration, and lab sample preparation and storage. An experienced staff member was paired with new personnel to reinforce project protocols and ensure high data quality.

For the CWS crew, Daniel Rokitnicki-Wojcik acted as the fish sampling lead. Greg Grabas trained the water quality and invertebrate sampling crew led by Zing-Ying Ho. Daniel Rokitnicki-Wojcik also led the vegetation sampling and identification and was assisted by Greg Grabas. Various summer students and Canadian Wildlife Service personnel assisted in data collection and acted as data recorders. A mid field-season check was conducted in late-July. No problems were identified.

University of Windsor field crew members who worked with fishes, macroinvertebrates, and water quality sampling had been trained during the previous field season by co-PI Joseph Gathman in the Windsor region during late May and early June**.** Most of these crew members had worked on the project in 2013, and so only a review and refresher of protocols was needed for those individuals. The review included instruction in GPS use, assessment of whether sites met project criteria (open water connection to lake, presence of a wetland, safe access for crew), identification of vegetation zones to be sampled, water quality sample collection, preprocessing and shipping to water quality labs, calibrating and reading field instruments and meters, setting, removing, cleaning and transporting fyke nets, and protocols for collecting and preserving macroinvertebrates. Crews received additional training and testing in field data and lab entry. All field personnel were given refreshers in basic fish identification training.

University of Windsor had 4 returning experience crew leaders, including Janice Gilbert (vegetation lead for the team), and Joseph Gathman (project co-PI). Several returning crew members have been previously trained in fish identification at the Royal Ontario Museum. All field team members were also given field and lab safety training, and were required to re-read the Standard Operating Procedures for the project.

Vegetation surveys for U Windsor were conducted by expert botanists Janice Gilbert (returning each year since 2011) and Dan Barcza (returning from 2012 and 2013) and returning plant ecologist Carla Huebert. They received the same general instructions and project orientation as did the other groups. In addition, they reviewed the specific vegetation sampling methodology and data recording methods outlined in the QAPP and modified at the January 2013 Principal Investigators meeting.

Water Quality Samples
Water quality sampling followed the protocols dictated by the QAPP as developed by the GLWMP water quality team (PI Dr. Rich Axler). Metered measurements were made and water samples were collected at the time that fyke nets were placed in the water. Water samples were stored refrigerated on ice in darkness until the evening, at which time they were processed and prepared for shipment to the analytical laboratory. With the exception of Chlorophyll *a* samples (which were shipped and analyzed by colleagues at Notre Dame University), all laboratory analysis was conducted by Environment Canada's National Laboratory for Environmental Testing (NLET) in Burlington, ON. The lab received samples by overnight express courier to ensure that they complied with QAPP specified holding times. All analyses have been completed. Field-based measurements have been entered into the water quality database. Analytical laboratory data have been entered into the database, and are receiving final QA review.

Site selection and field sampling, and results

Birds and Amphibians

Bird and amphibian field crews evaluated 62 sites that had been selected and ordered for potential sampling in 2014 (33 on Lake Ontario, 18 on Lake Huron, and 11 on Lake Erie). Of these, 10 were not surveyed because access was unobtainable (despite valiant efforts by surveyors) and 4 were rejected because the sites did not meet the project's criteria for sampling. Six of these 14 "missed" sites were on Lake Huron, 6 were on Lake Ontario, and 2 were on Lake Erie. Forty-seven sites were visited (each on 5 occasions) and sampled for amphibians and birds.

Fish, Macroinvertebrates, Water Quality, and Wetland Vegetation
The CWS crew visited and evaluated 11 locations along the north shore of Lake Ontario. All but three of these sites had been assessed by the bird and amphibian field crews. Two sites were rejected prior to field visits because they occurred on aboriginal land for which we did not have permission to sample. One site was visited but was deemed only suitable for vegetation sampling due to a lack of inundated vegetation zones that met the size criteria. Of the 11 sites, 5 were resamples from 2013 of which one was included as a new benchmark site (Rattray Marsh). Rattray Marsh was included as an additional site at the request of Credit Valley Conservation Authority to provide post-restoration data to track the success of their wetland restoration project.

The fish and macroinvertebrate and vegetation crews evaluated 49 sites [11 on Lake Ontario as described above), 34 on lakes Erie and Huron or the connecting channels, and 4 in Michigan (Detroit River or western Lake Erie) at the request of Denis Albert of the Michigan Team]. All of these sites had also been assessed by the bird and amphibian field crews. Five sites were not sampled because permission was not granted either by a landowner (1 case) or because they were on aboriginal land for which we did not have permission to sample (4 sites). Three sites were visited but deemed unsafe or inaccessible, and 4 were otherwise unsuitable (too small, not connected to a Lake or lacking in wetland habitat). Thus, a total of 36 sites was actually sampled [8 by CWS on Lake Ontario, 2 by Windsor on Lake Ontario, 10 on Lake Erie (1 of which was in Ohio, and two of which were in Michigan) and 16 in Lake Huron (including the North Channel, St. Marys River and Manitoulin Island)].

Vegetation was sampled at 37 sites. Of these, 33 sites were also suitable for water quality and macroinvertebrate sampling, while only 27 of these sites were also suitable for fish sampling. The full suite of water quality, fishes, macroinvertebrates and wetland vegetation was assessed at these 27 sites by our group (19 by Windsor, 8 by CWS on Lake Ontario). Of the 4 Michigan sites visited to assist the Michigan field team (Vegetation PI Denis Albert) in surveys, two sites could not be sampled due access limitations. One site required boat access and weather was too rough (over 3 days) to permit this. A second site was gated and could not be visited. The two other sites were successfully sampled.

Benchmark sites

Three benchmark sites were identified for sampling in 2014 (Crane Creek, in the Ottawa National Wildlife Refuge, OH, and Bronte Creek and Rattray Marsh, on the north shore of Lake Ontario). The Crane Creek site continues to be a study area of interest to the USGS, who wished to see how the findings of their GLRI-funded work compared with the results of surveys using the standardized Coastal Wetland Monitoring methodology (K. Kowalski, USGS, Ann Arbor, MI, *pers. C omm.*). This site had been sampled in 2012 and 2013. We will continue our collaboration with the USGS team to compare our among-year estimates of variation with their repeated-sampling-within-year design. This will provide important information on the degree to which a single, synoptic visit represents the community as assessed by repeated sampling over the course of a field season. The Bronte Creek site was visited in collaboration with staff aquatic ecologists from Conservation Halton, who are developing their own program. Our field crew met with the Halton ecologists to demonstrate our methods. However, only vegetation, water quality and invertebrates were sampled. Repeated requests to confer with members of the City of Oakville staff for permission to sample fish went unanswered. Rattray Marsh was sampled by CWS at the request of the Credit Valley Conservation Authority.

Data Entry and Quality Assurance

All amphibian, bird, fish, vegetation and field-collected water quality data have been compiled, entered into the database, and quality-assured. Macroinvertebrate sample identifications are in progress. We have received, entered and Quality Assured laboratory analyses of Water quality data from all but 6 sites.

Significant Observations

Birds and Amphibians:
Of note were 120 point occurrences of 10 Ontario bird species at risk:

Species	COSEWIC Status	No. Occurrences
Bald Eagle	special concern	6
Barn Swallow	threatened	39
Bank Swallow	threatened	23
Black Tern	special concern	4
Bobolink	threatened	3
Chimney Swift	threatened	1
Common Nighthawk	threatened	2
Eastern Meadowlark	threatened	6
King Rail	endangered	1
Least Bittern	threatened	24

Also of note were 12 occurrences of Chorus Frog, which is listed as threatened in Canada.

Fishes and Invertebrates:
Round gobies (*Neogobius melanostomus*) were observed at 5 of 10 Lake Ontario wetlands that were fished, illustrating that this invasive species is persisting in the Great Lakes nearshore ecosystem. Several other species of note were observed at several locations during the 2014 field season. A warmouth, 2 pugnose shiners and a spotted gar were captured at a Long Point Wetland, Lake Erie.

Sampling for fishes in Canada requires permits for Scientific Collection of Aquatic Species (Ontario Ministry of Natural Resources), compliance with the Province of Ontario's Environmental Protection Act (Ontario Ministry of Natural Resources), and Species At Risk (Fisheries & Oceans Canada). All permits had been approved both by CWS and by the University of Windsor at the start of the sampling season. Reports to the permit granting agencies have been completed in draft form and will be sent to both regional administrators Records of fishes caught will also be sent to local conservation groups in Ontario where appropriate.

Our SARA permit with DFO stipulates that we are required to provide both DFO and OMNR with all records (as well as verification) of specimens collected. This is especially true of species at risk. As identified above, records of spotted gar, pugnose shiner and warmouth have been of particular note over the course of the project. Our sampling through CWM has increased the number of Canadian locales from which spotted gar has been reported from 2 to 6, including several significant geographic range extensions. This is one more testament to the value of the program.

Reptiles
The Canadian Wildlife Service – Ontario Region is responsible for developing the Recovery Strategy and Management Plan for multiple turtle species in Canada. As required under the Species at Risk Act (SARA), critical habitat is a required component of the Recovery Strategy for four at risk turtles: Blanding's turtle (*Emydoidea blandingii*), Eastern musk turtle (*Sternotherus odoratus*), spotted turtle (*Clemmys guttata*), and spiny softshell turtle (*Apalone spinifera*). Critical habitat is based on the suitable habitat where turtles have been observed. Examples of suitable habitat are wetlands and watercourses such as marshes, rivers, and some lakes. Incidental observations from the Great Lakes coastal wetland monitoring project have identified many suitable habitat locations for proposal as candidate critical habitat in the Recovery Strategy for Multi-Turtle Species. The data provided from GLRI were invaluable in providing multiple turtle sightings, thus identifying additional critical habitat sites. In particular, 11 Eastern snapping turtles (*Chelydra serpentina*) were recorded at 5 Lake Ontario wetlands. Three other individuals were seen at two sites on the north shore of Lake Erie. This will help identify additional coastal wetlands of conservation significance for this species of special concern. Painted turtles were observed at 4 sites – three on Lake Erie and one in Severn Sound of Lake Huron.

Collaborations

The CWS team engaged in discussion and/or site visits with the following individuals or groups during the 2014 field season:

- Kate Hayes and Paul Biscaia (Credit Valley Conservation Authority). They requested the addition of Rattray Marsh as a benchmark site to access standardized wetland monitoring data to track multi-year restoration project success.

- Jeff Robinson (Environment Canada, Protected Areas Coordinator, Canadian Wildlife Service) - provided access to Wellers Bay National Wildlife Area to receive standardized baseline coastal wetland data for future comparisons.

- Corina Brdar (Ontario Ministry of Natural Resources and Forestry, Ontario Parks, Presqu'ile Provincial Park) – provided access to provincial park, information sharing, and requested reconnaissance for European Water Chestnut (*Trapa natans*) establishment while conducting CWM sampling.

- Heather Pankhurst (Central Lake Ontario Conservation Authority) – provided access to Lynde Creek Marsh and information sharing.

Project Leverage Examples

In September 2014, Canadian Wildlife Service – Ontario Region received a request from the Committee on the Status of Endangered Wildlife in Canada (COSEWIC) to provide records of the federally and provincially listed threatened species spotted gar (*Lepisosteus oculatus*) to contribute to an update on the status of this species in Canada. COSEWIC is comprised of a group of experts who use the best available science to determine and designate the national status of wildlife in Canada. Under the Species at Risk Act, the government of Canada will take COSEWIC's designations into consideration when establishing the legal list of wildlife species at risk.

Special efforts were continued in 2014 to develop and foster good stakeholder relationships and to establish collaborations with local groups around the Great Lakes with whom we could interact, explain the purpose and value of the project, and possibly solicit collaborations. Although we continue our efforts to contact the environmental liaison individuals for First Nations lands we again had limited success in collaborating with them.

We engaged in discussion and/or site visits with the following individuals or groups during the 2014 field season:

- Greg Mayne (Environment Canada, Canadian Cochair, Lake Huron Binational Partnership), Scott Parker (Parks Canada, Fathom Five National Park), and Geoff Peach

(Lake Huron Center for Coastal Conservation) We provided summaries of coastal wetland condition on the Bruce Peninsula and other Lake Huron locations. We will continue to work with these individuals in summarizing wetland condition in anticipation of preparing a report for the Lake Huron Binational Partnership on the current status of Lake Huron and research needs leading to the 2016 Intensive Study Year for Lake Huron.

- Kurt Kowalski (USGS; work at Crane Creek marsh, Ottawa National Wildlife Reserve) - comparing methods and presumably results of USGS vs. CWM initiatives. We sampled Crane Creek Marsh as a Benchmark site again in 2014. Collaboration with the USGS lab is continuing. We will apply both CWM metrics and GLEI-derived indicators of fish and plant condition to both our annual data (collected over 3 consecutive years) with scores calculated from the biweekly sampling program that USGS conducted in 2013. This will allow us to compare among-year with within-year variability both on sampling effectiveness and on the precision of multimetric and multivariate indicator scores calculated from the data.

- Old Woman Creek National Estuarine Research Reserve - providing results and possibly benchmarking site for future sampling

- Kensington Conservancy (Lake Huron's North Channel near Bruce Mines) – we have coordinated with them over the last three years, mainly for information-sharing on sites

ASSESSMENT AND OVERSIGHT

The project QAPP was approved and signed on March 21, 2011. A revised QAPP (r3) was approved and signed on March 19, 2012. The QAPP_r3 was reviewed again by project co-PIs and their technical staffs during the fall of 2013 and was discussed at the January 2014 coordination meeting in Midland, MI. After review, it was determined that two areas required updates prior to the 2014 field season. These changes included:

1) Adding ion chromatography methods for determination of soluble reactive P (Dionex Method AN 254), total P (Dionex Method AN 254 with persulfate digestion), and ammonium (Dionex Method AN 141). These additions are contained in QAPP Table BB4.2.

2) Addition of a new wetland flora for use in Great Lakes coastal wetlands. The new flora, *The Field Manual of Michigan Flora* (Voss and Reznicek 2012) from the University of Michigan Press, incorporates the most recent taxonomic treatments of the Flora of North America and contains all wetland plants found throughout the region. All taxonomic changes in the new flora were reviewed by project plant experts over the

previous field season and appropriate cross-walks were formulated to ensure data consistency among project years.

One additional change was made to the standard operating procedure for vegetation sampling:

3) Removal of the requirement to map dense areas of invasive plants that fall within 20 m of sampling transects. The project plant PIs determined that the current transect/quadrat sampling protocol is adequately assessing invasive plant expansion and this extra mapping step did not add sufficient information to warrant the extra time required.

All project co-PIs re-signed the QAPP_r4 on February 15, 2014 and our US EPA Project Officer and Quality Assurance Officer re-signed the QAPP on March 13, 2014.

Major QA/QC elements that were carried out over the previous 12 months include:

- Training of all new laboratory staff responsible for macroinvertebrate sample processing: This training typically takes place in the fall and is conducted by experienced technicians at each regional lab, overseen by the respective co-PI or resident macroinvertebrate expert. Those labs without such an expert sent their new staff to the closest collaborating lab for training.

- Training of all fish, macroinvertebrate, vegetation, bird, amphibian, and water quality field crew members following the QAPP and SOPs. This included passing tests for procedural competence, as well as identification tests for fish, vegetation, birds, and amphibians. Training certification documents were archived with the lead PI and QA managers.

- GPS testing: Every GPS unit used during the 2014 field season was tested for accuracy and its ability to upload data to a computer. Field staff collected a series of points at locations that could be recognized on a Google Earth image (e.g., sidewalk intersections) then uploaded the points to Google Earth and viewed the points for accuracy. Precision was calculated by using the measurement tool in Google Earth. Results of these tests have been archived and referenced to each GPS receiver by serial number.

- Review of sites rejected after initial site visits: In cases where a site was rejected during a site visit, the reason for rejection was documented by the field crew in the site selection database. The project QA officers (Brady and Cooper) then reviewed these records to ensure consistency among crews. Occasionally, field crew leaders contacted Uzarski, Brady, or Cooper by cell phone when deciding whether to reject a site. However, given that most crew leaders have been with the project for over 3 years, they are able to make these decisions more independently than in previous years.

- Collection and archiving of all training/certification documents and mid-season QA/QC forms from regional labs: These documents have all been PDF'd and will be retained as a permanent record for the project.

- Maintenance, calibration, and documentation for all field meters: All field meters were calibrated and maintained according to manufacturer recommendations. Calibration/maintenance records are being archived at each institution.

- Collection of duplicate field samples: Precision and accuracy of many field-collected variables is being evaluated with duplicate samples. Duplicate water quality samples were collected at approximately every 10th vegetation zone sampled. A summary of these results is included below.

- QC checks for all data entered into the data management system (DMS): Every data point that is entered into the DMS is being checked to verify consistency between the primary record (e.g., field data sheet) and the database. This has been completed for 2011-2013 data and is mostly complete for 2014 data. QC should be complete for 2014 data in the spring.

- Linking of GPS points with field database: Inevitably, errors creep in when crew type in GPS waypoint names and numbers. Even a space or capitalization in the wrong place can break the link between the GPS database file and the field data database. All non-linking points between these two databases were assessed and corrected in 2013. Each winter this correction will be done for the previous field season's GPS waypoints.

- Macroinvertebrate QC checks: Each regional lab that is processing macroinvertebrate samples 'blindly' traded 2013 samples with another lab. Swaps were made between labs that sampled wetlands at a similar latitude to ensure familiarity with the taxa being evaluated. For swapped samples, the sending laboratory had previously identified the samples and labeled vials with a coding system so that the receiving laboratory did not have the ID or the location where the sample had been collected. The receiving lab then processed the sample as usual and sent the IDs and counts to the QA managers. For IDs that differed between the labs, the source of variation was determined. In many cases a slight difference in counts was due to the integrity of the archived sample (e.g., a small specimen being broken in two at some point in the process). For cases where taxa IDs varied, the true taxon ID is being determined by regional experts. Where necessary, archived samples are being re-evaluated and the database updated accordingly. This system identified inconsistencies between two labs for 2013 samples. These inconsistences are currently being corrected by re-identifying a subset of taxa. The taxa in question were checked by a regional expert and correct identifications were made. The inexperienced IDer making the original identifications erred in attempting to identify specimens that were damaged or too young to be identified to genus. Macroinvertebrate IDers across the project were reminded that it is better to leave ID's at less-specific taxonomic resolution than to guess. Identifications by the original IDer are being re-checked in the event that other corrections are needed.

- Mid-season QC checks: These were completed by PIs for each of the field crews to ensure that there were no sampling issues that developed after training and while crews were sampling on their own.

- Creation/maintenance of specimen reference collections: Reference collections for macroinvertebrates, fish, and plants have either been created or are being maintained and updated by each regional team. Macroinvertebrate reference collections, in particular, were developed or expanded as these samples were processed. Labs that have uncommon invasive specimens (e.g., faucet snail, New Zealand mud snail, etc., are preparing reference specimens to share with other labs. Vegetation reference collections are often being kept in collaboration with local herbaria.

- Data Quality Objectives (DQO) for laboratory analyses: Participating water quality laboratories have generated estimates of precision, bias, accuracy, representativeness, completeness, comparability, and sensitivity for all water quality analyses. These metrics will be linked to the primary data that is being generated (see example report below).

Example Water Quality QC Information

Laboratory Quality Assurances:

Water quality analyses from 2014 have been partially completed by the NRRI Central Analytical Laboratory, Central Michigan University's Wetland Ecology Laboratory, Grand Valley State University's Annis Water Resources Institute, and Environment Canada's National Laboratory for Environmental Testing. Laboratory results from 2014 have passed (or will pass) the criteria shown below (Table 17).

Table 17. Data acceptance criteria for water quality analyses.

QA Component	Acceptance Criteria
External Standards (QCCS)	± 10%
Standard curve	$r^2 \geq 0.99$
Blanks	± 10%
Blank spikes	± 20%
Mid-point check standards	± 10%
Lab Duplicates	± 15% RPD* for samples above the LOQ**
Matrix spikes	± 20%

**Relative Percent Difference (RPD):* While our standard laboratory convention is to analyze 10% of the samples in duplicate and use %RSD (100 * CV) of the duplicates as a guide for accepting or rejecting the data, another measure of the variation of duplicates is RPD: RPD = ((|x1-x2|)/mean) *100.
** LOQ = *Limit of Quantification:* The LOQ is defined as the value for an analyte great enough to produce <15% RSD for its replication. LOQ = 10(S.D.) where 10(S.D.) is 10 times the standard deviation of the gross blank signal and the standard deviation is measured for a set of two replicates (in most cases).

Variability in Field Replicates:
An analysis of field duplicate variability for the three project years is shown in Table 18. It is important to note that for many constituents, the variability within sample sets is related to the mean concentration, and as concentrations approach the method detection limit (MDL), the variability increases dramatically. A calculation of field replicate variability with values at or near the level of detection will often result in high RPDs. For example, if the chlorophyll measurements on a set of field duplicates are 0.8 µg/L and 0.3 µg/L, mean = 0.6, resulting in a RPD of 91% (RPD = [abs (rep a-rep b)/ (rep a+ rep b)/2)]*100, but since the MDL is ± 0.5 µg/L, this can be misleading.

The same can occur with analyte lab duplicates, and in these instances the QA officer will determine whether data are acceptable. It is also important to note that RPD on field duplicates incorporates environmental (e.g., spatial) variability, since duplicate samples are collected from adjacent locations, as well as analytical variability (e.g., instrument drift). Therefore, RPD of field duplicates is generally higher than RPD of laboratory duplicates. Table 18 below lists average RPD values for each year of the project (2011-2014). Higher than expected average RPD values were associated with a preponderance of near detection limit values for ammonium, nitrate, and soluble reactive phosphorus (SRP), and high spatial variability for chlorophyll and turbidity. Other variables, such as alkalinity and chloride, had values that were well above detection limit and low spatial variability; therefore, these values had much lower average RPD. Acceptance of data associated with higher than expected RPD was determined by the QA officers. As the full set of water quality data become available, the 2014 RPD table will be expanded as in the spring 2014 report.

Table 18. Assessment of field duplicate sample variability in relative percent difference (RPD) for water quality parameters. Each value represents a mean for all RPDs calculated for the given year. Results from 2011-2013 are shown, with the number of duplicate pairs in parentheses.

		Mean Relative Percent Difference (n)			
	Max expected	2011	2012	2013	2014
Alkalinity	10%	4.1% (12)	8.9% (11)	3.6% (13)	6.8% (15)
Ammonium	10%	54.8% (14)	21.9% (13)	58.5% (11)	50.6% (7)
Chloride	20%	1.9% (12)	6.6% (10)	8.9% (12)	13.2% (9)
Chlorophyll	30%	36.8% (10)	31.0% (11)	39.8% (8)	45.1% (4)
Color	10%	11.7% (14)	5.1% (11)	6.9% (13)	10.3% (9)
Nitrate	10%	23.8% (12)	23.3% (11)	10.2% (5)	6.8% (7)
SRP	10%	19.3% (9)	21.8% (9)	13.6% (7)	47.4% (7)
Total N	30%	10.3% (13)	9.9% (13)	7.4% (12)	7.3% (3)
Total P	30%	19.6% (13)	26.7% (13)	29.0% (12)	45.5% (5)
T-tube	NA	12.9% (7)	7.9% (6)	17.9% (8)	9.1% (15)
Turbidity	10%	26.6% (9)	22.7% (6)	23.2% (5)	10.0% (5)

The maximum expected RPD values are based on the MN Pollution Control Agency quality assurance project plan provided for the Event Based Sampling Program (http://www.pca.state.mn.us/index.php/water/water-types-and-programs/surface-water/surface-water-financial-assistance/event-based-sampling-grants.html#for-grantees).

Communication among Personnel

Regional team leaders and co-PIs continue to maintain close communication as the project enters into the fourth year of macroinvertebrate identification, data QC, and metric calculation. All primary project members will meet again during the winter to discuss and resolve taxonomic issues that may affect metric calculations. Revised IBI metrics for additional zones are also being discussed among project PIs.

The current version of the QAPP and SOPs (Revision 4) is an improvement over the previous version in that some minor inconsistencies have been eliminated, some additional clarification has been added, additional methodology for soluble reactive P, total P, and ammonium has been added, and a new wetland flora has been approved for use. We anticipate that very little revision will be required for Year 5.

Regional team leaders and co-PIs have held conference calls and e-mail discussions regarding site selection and field work preparation throughout the duration of the project. Most PIs spent the first week of field season in the field with their crew to ensure that all protocols were being followed according to the standards set forth in the QAPP and SOPs and to certify or re-certify crew members. Nearly every crew consisted of >50% returning and experienced personal, which made the training period for 2014 very efficient. PIs then visited their teams again during the middle of the season to ensure that all sampling was conducted in accordance with the training and the QAPP. PIs kept in close contact with crews via cell phone, text, and email, and the leadership team was also always available via cell phone and text to answer the most difficult crew questions. In 2014, questions were often about how to deal with higher water levels and unusual vegetation zones created by these greater depths, while in previous years low water level problems plagued crews.

Required Corrective Action

During the spring of 2014 the QA managers discovered that one bird and amphibian crew failed to meet training and certification requirements for the 2013 field season, and to some extent for the 2012 season. These issues were reported in the spring 2014 report. The QA managers discussed these issues with the senior bird and amphibian co-PIs and with the project lead PI to determine an appropriate course of action. It was determined that 1) all members of this crew would be required to provide documentation of correct and timely passage of the on-line certification tests prior to being allowed to sample, 2) the co-PI responsible for the crew would increase their level of oversight compared to previous years, 3) crew members would consult with other regional crews whenever they are uncertain about a procedure, and 4) potentially compromised data will be checked by senior bird co-PIs and will be flagged or removed from the dataset if the data are not comparable to nearby similar wetlands. These corrective actions were completed over the past six months and 2014 sampling followed appropriate protocols.

Additionally, identification of a subset of invertebrate taxa at one regional laboratory was found to be inconsistent with other labs. These inconsistencies were discovered during blind trading of 2013 samples. Corrective actions to rectify this issue have included auditing samples for the entire project (2011-2013) for the lab in question and hiring an experienced taxonomist from a different regional lab to re-process samples for the samples in question. This process will be complete by the end of 2014. In addition, all macroinvertebrate ID labs were reminded that there should be no guessing in an attempt to more specifically identify damaged or young specimens. We anticipate that no additional corrective actions will be necessary for this issue.

Overall

No major injuries were reported by any field crew members during this fourth sampling season. This is due to the leadership and safety consciousness of PIs, field crew chiefs, and field team leaders. This safety record is even more impressive considering the number of crew members in the field all summer long and the weather conditions and remote locations in which they work. PIs continued to be impressed by the work ethics of their field crews, their willingness to work long hours day after day, to successfully sample under quite adverse conditions, and to conduct that sampling in accordance with strict QA procedures. From the PI and QA managers' perspectives, the fourth field season was highly successful.

The quality management system developed for this project has been fully implemented and co-PIs and their respective staff members followed established protocols very closely, relying on the QAPP and SOPs as guiding documents. QA managers were also encouraged by each crew's continued willingness to contact their supervisors or, in many cases, the project management team when questions arise. The fourth year of this project was extremely successful.

LEVERAGED BENEFITS OF PROJECT

This project has generated a number of spin-off projects and serves as a platform for many graduate and undergraduate thesis topics. In addition, project PIs are collaborating with many other groups to assist them in getting data for areas that are or will be restored or that are under consideration for protection. Finally, the project supports or partially supports a number of jobs (jobs created/retained). All of these are detailed below.

Spin-off Projects (cumulative since project inception)

Conservation Assessment for Amphibians and Birds of the Great Lakes:

To examine the role of Great Lakes wetlands in the conservation of birds in North America, an effort has been initiated to assess the importance of these coastal wetlands as migratory or breeding grounds. A similar effort will also be initiated for amphibians, because many of the amphibians (and birds) living in these coastal wetlands have been identified as endangered (e.g. Northern Cricket Frog), threatened, or of special concern (e.g. Northern Leopard Frog) in multiple states. The Great Lakes have many large, intact freshwater wetlands in the interior portion of the North American continent. Their unique character, size, and plant composition supports populations of many species of amphibians and birds.

A recent study targeting Sedge and Marsh Wren distributions within Great Lakes coastal wetlands modeled habitat and landscape characteristics against presence/absence of each species at multiple spatial scales. This analysis will determine how these characteristics influence the distribution and abundance of species breeding habitat. Classification trees were used to predict both Sedge and Marsh Wren presence and relative high abundance (≥3 wrens/site). The best classification trees (i.e. those with the lowest classification error) predict Sedge Wrens to be present in wetlands with >9% woody wetlands, and in high abundance in wetlands with <3% cattails and >4% meadow vegetation. Marsh Wrens were positively associated with emergent vegetation and cropland, and in high abundance in wetlands with >14% cattails. Probability maps were created based on best fitting models to help predict breeding habitat. These results suggest which characteristics of Great Lakes coastal wetlands are important to these two wetland-obligate bird species, and can be useful to inform management plans for these species. These models can also be developed for other obligate wetland species (Table 19) within Great Lakes wetlands.

The extensive data that have been gathered based on US EPA funding, such as the Great Lakes Environmental Indicators project and the Great Lakes Coastal Wetlands Consortium, as well as by Bird Studies Canada, will provide critical input to this assessment. The proposed large-scale modeling effort will be one of the broadest analyses in terms of sample size and geographic area. It will also serve as a valuable tool for future management decisions relating to Great Lakes wetland conservation.

Table 29. List of species considered to be either wetland obligate species (bold) or indicators of wetland condition.

Common name	Scientific Name	Common name	Scientific Name
Canada Goose	*Branta canadensis*	European Starling	*Sturnus vulgaris*
Mallard	***Anas platyrhynchos***	Northern Cardinal	*Cardinalis cardinalis*
Pied-billed Grebe	***Podilymbus podiceps***	**Sedge Wren**	***Cistothorus platensis***
American Bittern	***Botaurus lentiginosus***	American Goldfinch	*Carduelis tristis*
Least Bittern	***Ixobrychus exilis***	Mourning Dove	*Zenaida macroura*
Virginia Rail	***Rallus limicola***	**Alder Flycatcher**	***Empidonax alnorum***
Sora	***Porzana carolina***	Gray Catbird	*Dumetella carolinensis*
Common Moorhen		Bobolink	*Dolichonyx oryzivorus*
Sandhill Crane	***Grus canadensis***	Baltimore Oriole	*Icterus galbula*
Black Tern	***Chlidonias niger***	American Redstart	*Setophaga ruticilla*
Willow Flycatcher	***Empidonax traillii***	Bald Eagle	*Haliaeetus leucocephalus*
Marsh Wren	***Cistothorus palustris***	Northern Harrier	*Circus cyaneus*
Common Yellowthroat	***Geothlypis trichas***	Brown-headed Cowbird	*Molothrus ater*
Swamp Sparrow	***Melospiza georgiana***	Brown Thrasher	*Toxostoma rufum*
Red-winged Blackbird	***Agelaius phoeniceus***	White-throated Sparrow	*Zonotrichia albicollis*
Yellow-headed Blackbird	***Xanthocephalus xanthocephalus***	Killdeer	*Charadrius vociferus*
Common Grackle	*Quiscalus quiscula*	**American Coot**	***Fulica americana***
American Robin	*Turdus migratorius*		

North Maumee Bay Survey of Diked Wetland vs. Un-Diked Wetland: Erie Marsh Preserve is being studied as a benchmark site for the CWM project. As a benchmark site, Erie Marsh Preserve will serve as a comparison against randomly-selected project sites, and will be surveyed each year of the CWM project. Benchmark sampling began prior to Phase 1 of a planned restoration by The Nature Conservancy, allowing for pre- and post-restoration comparisons. In addition, biota and habitat within the diked wetlands area will be compared to conditions outside of the dike, but still within the preserve. These data will also be used for post-construction comparisons to determine what biotic and abiotic changes will occur once restoration efforts have reconnected the dike to the shallow waters of Lake Erie.

Cattails-to-Methane Biofuels Research: CWM crews collected samples of invasive plants (hybrid cattail) which are being analyzed by Kettering University and their Swedish Biogas partner to determine the amount of methane that can be generated from this invasive. These samples will be compared to their data set of agricultural crops, sewage sludge, and livestock waste that are currently used to commercially generate methane. The cattails-to-methane biofuels project is also funded (separately) by GLRI.

Correlation between Wetland Macrophytes and Wetland Soil Nutrients: CWM vegetation crews collected wetland soil samples and provided corresponding macrophyte data to substantially increase the number of sites and samples available to the USEPA Mid-Continent Ecology Division. USEPA MED researchers studied wetland macrophyte and wetland soil nutrient correlations. The MED laboratory ran the sediment nutrient analyses and shared the data with CWM PIs.

Comparative study of bulrush growth between Great Lakes coastal wetlands and Pacific Northwest estuaries. This study includes investigation of water level effects on bulrush growth rates in Great Lakes coastal wetlands. With leveraged funding from NSF for the primary project on bulrush ability to withstand wave energy.

Braddock Bay, Lake Ontario, Sedge Meadow Restoration: Braddock Bay is being studied as a benchmark site in conjunction with the US Army Corps of Engineers to assess the current extent of, and potential restoration of, sedge meadow. CWM crews are collecting pre- and post-restoration data to help plan and implement restoration activities. The results will help build a model for future sedge meadow restoration in Lake Ontario to mitigate the harmful impacts of invasive cattails and provide habitat for fish and wildlife species. Additionally, this project will be expanded in conjunction with Ducks Unlimited to four nearby wetlands, pending funding from NOAA.

Thunder Bay AOC, Lake Superior, Wetland Restoration: Nine wetlands around Thunder Bay were sampled for macroinvertebrates, water quality, and aquatic vegetation by CWM crews in 2013 using methods closely related to CWM methods. These data will provide pre-restoration baseline data as part of the AOC delisting process. Wetlands sampled included both wetlands in need of restoration and wetlands being used as a regional reference. All of this sampling was in addition to normal CWM sampling, and was done with funding from Environment Canada.

Common Tern Geolocator Project: In early June 2013, the NRRI CWM bird team volunteered to assist the Wisconsin DNR in deploying geolocator units on Common Terns nesting on Interstate Island. In 2013, 15 birds between the ages of 4-9 yrs old were outfitted with geolocators. Body measurements and blood samples were also taken to determine the sex of each individual. In June of 2014, geolocators were removed from seven birds that returned to nest on the island. Of the seven retrieved geolocators, four were from female birds and three from males. The data collected during the year will be used to better understand the migratory routes of Common Terns nesting on Interstate Island. This is the first time that geolocators have been placed on Common Terns nesting in the Midwest, which is important because this species is listed as threatened in Minnesota and endangered in Wisconsin. Tracking Common Terns throughout their annual cycle will help identify locations that are important during the non-breeding portion of their life cycle. Data are currently being analyzed by researchers at the Natural Resources Research Institute in Duluth MN.

Support for Un-affiliated Projects

CWM PIs and data managers continue to provide data and support to other research projects around the Great Lakes even though no CWM PIs are actual collaborators on these projects. Dr. Laura Bourgeau-Chavez at Michigan Tech University is working on a project to map the spatial extent of Great Lakes coastal wetlands using GIS and satellite information to help in tracking wetland gains and losses over time (Implementation of the Great Lakes Coastal Wetlands Consortium Mapping Protocol, funded by GLRI). We have provided her with vegetation data and sampling locations each year to assist with this effort. Dr. Bourgeau-Chavez was also just given funding to assess herbicide effectiveness against *Phragmites* in Green Bay and Saginaw Bay. CWM data are being used to find the best locations, provide baseline data, and provide pointers on site access (from field crew notes) in support of this project.

Reports on new locations of non-native and invasive species

Vegetation sampling crews and PIs have been pro-active over the years in reporting new locations of invasive vegetation. Fish and macroinvertebrate PIs and crews have also realized that they may be discovering new locations of invasive species, particularly invasive macroinvertebrates. To ensure that all new sightings get recorded, we are pulling all records of non-native fish and macroinvertebrates out of the database once a year and sending these records to the Nonindigenous Aquatic Species tracking website maintained by USGS (http://nas2.er.usgs.gov/).

Requests for Assistance Collecting Monitoring Data

CWM PIs have received many requests to sample particular wetlands of interest to various agencies and groups. In some instances the wetlands are scheduled for restoration and it is hoped that our project can provide pre-restoration data, and perhaps also provide post-restoration data to show the beginnings of site condition improvement, depending on the timing. Such requests have come from the St. Louis River (Lake Superior), Maumee Bay (Lake Erie), and Rochester (Lake Ontario) Area of Concern delisting groups, as well as the Great Lakes National Park Service and the Nature Conservancy (sites across lakes Michigan and Huron for both groups). Several requests involve restorations specifically targeted to create habitat for biota that are being sampled by CWM. Examples include: a NOAA-led restoration of wetlands bordering the Little Rapids of the St. Marys River to restore critical spawning habitat for many native freshwater fishes and provide important nursery and rearing habitat in backwater areas; TNC-led restoration of pike spawning habitats on Lake Ontario and in Green Bay; a US Army Corps of Engineers project in Green Bay to create protective barrier islands and restore many acres of aquatic and wetland vegetation; a USACE project to improve wetland fish and vegetation habitat in Braddock Bay, Lake Ontario, and a New York state project to increase nesting habitat for state-endangered black tern. Many of these restoration activities are being funded through GLRI, so through collaboration we increase efficiency and effectiveness of restoration efforts across the Great Lakes basin.

At some sites, restoration is still in the planning stages and restoration committees are interested in the data CWM can provide to help them create a restoration plan. This is happening in the St. Louis River AOC, in Sodus Bay, Lake Ontario, and for the Rochester NY AOC.

Other groups have requested help sampling sites that are believed to be in very good condition (at least for their geographic location), or are among the last examples of their kind, and are on lists to be protected. These requests have come from The Nature Conservancy for Green Bay sites (they are developing a regional conservation strategy and attempting to protect the best remaining sites); the St. Louis River AOC delisting committee to provide target data for restoration work (i.e., what should a restored site "look" like); and the Wisconsin DNR Natural Heritage Inventory has requested assistance in looking for rare, endangered, and threatened species and habitats in all of the coastal wetlands along Wisconsin's Lake Superior coastline. Southern Lake Michigan wetlands have mostly been lost, and only three remain that are truly coastal wetlands. CWM PIs are working with Illinois agencies and conservation groups to collaboratively and thoroughly sample one of these sites, and the results will be used to help manage all 3 sites.

Other managers have also requested data to help them better manage wetland areas. For example, the Michigan Clean Water Corps requested CWM data to better understand and manage Stony Lake, Michigan. Staff of a coal-fired power plant abutting a CWM site requested our fish data to help them better understand and manage the effects of their outfalls on the resident fish community. The Michigan Natural Features Inventory is requesting our data as part of a GLRI-funded invasive species mapping project. The US Fish and Wildlife Service requested all data possible from wetlands located within the Rochester, NY, Area of Concern as they assess trends in the wetlands and compare data to designated delisting criteria. The NERR on Lake Erie (Old Woman Creek) has requested our monitoring data to add to their own. The

University of Wisconsin Green Bay will use our data to monitor control of *Phragmites* in one of their wetlands, and hope to show habitat restoration. Thunder Bay National Marine Sanctuary (Lake Huron) has requested our data to facilitate protection and management of coastal resources within the Sanctuary.

The College at Brockport has been notifying an invasive species rapid-response team led by The Nature Conservancy after each new sighting of water chestnut. Coupling the monitoring efforts of this project with a rapid-response team helped to eradicate small infestations of this new invasive before it became a more established infestation.

We are also now receiving requests to do methods comparison studies. For example, USGS and Five Fathom National Marine Park have both requested data and sampling to compare with their own sampling data.

Overall, CWM PIs have had many requests to sample specific wetlands. It has been challenging to accommodate all requests within our statistical sampling design and our sampling capacities.

Student Research Support (will be updated for spring report)

Graduate Research with Leveraged Funding:

- Importance of coastal wetlands to offshore fishes of the Great Lakes: Dietary support and habitat utilization (Central Michigan University; with additional funding from several small University grants).
- Spatial variation in macroinvertebrate communities within two emergent plant zones in Great Lakes coastal wetlands (Central Michigan University; with additional funding from CMU).
- Invertebrate co-occurrence patterns in the wetlands of Northern and Eastern Lake Michigan: the interaction of the Harsh-Benign Hypothesis and community assembly rules (Central Michigan University; additional funding from CMU)
- Functional indicators of Great Lakes coastal wetland health (University of Notre Dame; additional funding by Illinois-Indiana Sea Grant).
- Evaluating environmental DNA detection alongside standard fish sampling in Great Lakes coastal wetland monitoring (University of Notre Dame; additional funding by Illinois-Indiana Sea Grant).
- Nutrient-limitation in Great Lakes coastal wetlands (University of Notre Dame; additional funding by the UND College of Science).
- A summary of snapping turtle (*Chelydra serpentina*) by-catch records in Lake Ontario coastal wetlands (with additional funding by University of Toronto).

- Evaluating a zoobenthic indicator of Great Lakes wetland condition (with additional funding from University of Windsor).
- Testing and comparing the diagnostic value of three fish community indicators of Great Lakes wetland condition (with additional funding from GLRI GLIC: GLEI II and University of Windsor).
- Quantifying Aquatic Invasion Patterns Through Space and Time: A Relational Analysis of the Laurentian Great Lakes (University of Minnesota Duluth; with additional funding and data from USEPA)

Undergraduate Research with Leveraged Funding:

- Production of a short documentary film on Great Lakes coastal wetlands (Notre Dame University; additional funding by the UND College of Arts and Letters).
- Heavy metal and organic toxicant loads in freshwater turtle species inhabiting coastal wetlands of Lake Michigan (Notre Dame University; additional funding by the UND College of Science).
- *Phragmites australis* effects on coastal wetland nearshore fish communities of the Great Lakes basin (University of Windsor; with additional funding from GLRI GLIC: GLEI II).
- Sonar-derived estimates of macrophyte density and biomass in Great Lakes coastal wetlands (University of Windsor; with additional funding from GLRI GLIC: GLEI II).
- Effects of disturbance frequency on the structure of coastal wetland macroinvertebrate communities (Lake Superior State University; with additional funding from LSSU's Undergraduate Research Committee).
- Resistance and resilience of macroinvertebrate communities in disturbed and undisturbed coastal wetlands (Lake Superior State University; with additional funding from LSSU's Undergraduate Research Committee).

Graduate Research without Leveraged Funding:

- Impacts of drainage outlets on Great Lakes coastal wetlands (Central Michigan University).
- Effects of anthropogenic disturbance affecting coastal wetland vegetation (Central Michigan University).
- Great Lakes coastal wetland seed banks: what drives compositional change? (Central Michigan University).
- Spatial scale variation in patterns and mechanisms driving fish diversity in Great Lakes coastal wetlands (Central Michigan University).

- Building a model of macroinvertebrate functional feeding group community through zone succession: Does the River Continuum Concept apply to Great Lakes coastal wetlands? (Central Michigan University).
- Impacts of mute swan herbivory in Great Lakes coastal wetlands (Central Michigan University).
- Impacts of muskrat herbivory in Great Lakes coastal wetlands (Central Michigan University).
- Mute swan interactions with native waterfowl in Great Lakes coastal wetlands (Central Michigan University).
- Effects of turbidity regimes on fish and macroinvertebrate community structure in coastal wetlands (Lake Superior State University and Oakland University).
- Scale dependence of dispersal limitation and environmental species sorting in Great Lakes wetland invertebrate meta-communities (Notre Dame University).
- Spatial and temporal trends in invertebrate communities of Great Lakes coastal wetlands, with emphasis on Saginaw Bay of Lake Huron (University of Notre Dame).
- Model building and a comparison of the factors influencing sedge and marsh wren populations in Great Lakes coastal wetlands (University of Minnesota Duluth).
- The effect of urbanization on the stopover ecology of Neotropical migrant songbirds on the western shore of Lake Michigan (University of Minnesota Duluth).
- Assessing the role of nutrients and watershed features in cattail invasion (*Typha angustifolia* and *Typha* x *glauca*) in Lake Ontario wetlands (The College at Brockport).
- Developing captive breeding methods for bowfin (*Amia calva*) (The College at Brockport).
- Water chestnut (*Trap natans*) growth and management in Lake Ontario coastal wetlands (The College at Brockport).
- Functional diversity and temporal variation of migratory land bird assemblages in lower Green Bay (University of Wisconsin Green Bay).
- Effects of invasive *Phragmites* on stopover habitat for migratory shorebirds in lower Green Bay, Lake Michigan (University of Wisconsin Green Bay).
- Plant species associations and assemblages for the whole Great Lakes, developed through unconstrained ordination analyses (Oregon State University).
- Genetic barcoding to identify black and brown bullheads (Grand Valley State University).

Undergraduate Research without Leveraged Funding:

- Sensitivity of fish community metrics to net set locations: a comparison between Coastal Wetland Monitoring and GLEI methods (University of Minnesota Duluth).
- Larval fish usage and assemblage composition between different wetland types (Central Michigan University).
- Determining wetland health for selected Great Lakes Coastal Wetlands and incorporating management recommendations (Central Michigan University).
- Invertebrate co-occurrence trends in the wetlands of the Upper Peninsula and Western Michigan and the role of habitat disturbance levels (Central Michigan University).
- Is macroinvertebrate richness and community composition determined by habitat complexity or variation in complexity? (University of Windsor, under the Zoobenthos - macrophyte relationships in Great Lakes coastal wetlands framework). Completed.
- Effects of habitat complexity on trophic structure of macroinvertebrate communities (University of Windsor, under the Zoobenthos - macrophyte relationships in Great Lakes coastal wetlands framework). Completed.

Jobs Created/Retained (per year, except grad students; will be updated for spring report):

- Principle Investigators (partial support): 14
- Post-doctoral researchers (partial support): 1 (0.25 FTE)
- Total graduate students supported on project (summer and/or part-time): 30
- Undergraduate students (summer and/or part-time): 52
- Technicians (summer and/or partial support): 25 (~12 FTE)
- Volunteers: 21

Total jobs at least partially supported: 122 (plus 21 volunteers trained)

Presentations about the Coastal Wetland Monitoring Project (inception through spring 2014)

Albert, Dennis. 2013. Use of Great Lakes Coastal Wetland Monitoring data in restoration projects in the Great Lakes region. 5th Annual Conference on Ecosystem Restoration, Schaumburg, IL. July 30, 2013. 20 attendees, mostly managers and agency personnel.

Albert, Dennis. 2013. Data collection and use of Great Lakes Coastal Wetland Monitoring data by Great Lakes restorationists. Midwestern State Wetland Managers Meeting, Kellogg Biological Station, Gull Lake, MI, October 31, 2013. 40 attendees; Great Lakes state wetland managers.

Bozimowski, A.A., B.A. Murry, and D.G. Uzarski. Invertebrate co-occurrence patterns in the wetlands of northern and eastern Lake Michigan: the interaction of the harsh-benign hypothesis and community assembly rules. 55th International Conference on Great Lakes Research, Cornwall, Ontario.

Bozimowski, A. A., B. A. Murry, P. S. Kourtev, and D. G. Uzarski. 2014. Aquatic macroinvertebrate co-occurrence patterns in the coastal wetlands of the Great Lakes: the interaction of the harsh-benign hypothesis and community assembly rules. Great Lakes Science in Action Symposium, Central Michigan University, Mt. Pleasant, MI. April.

Bracey, A. M., R. W. Howe, N.G. Walton, E. E. G. Giese, and G. J. Niemi. Avian responses to landscape stressors in Great Lakes coastal wetlands. 5th International Partners in Flight Conference and Conservation Workshop. Snowbird, UT, August 25-28, 2013.

Brady, V., D. Uzarski, and M. Cooper. 2013. Great Lakes Coastal Wetland Monitoring: Assessment of High-variability Ecosystems. USEPA Mid-Continent Ecology Division Seminar Series, May 2013. 50 attendees, mostly scientists (INVITED).

Brady, V., G. Host, T. Brown, L. Johnson, G. Niemi. 2013. Ecological Restoration Efforts in the St. Louis River Estuary: Application of Great Lakes Monitoring Data. 5th Annual Conference on Ecosystem Restoration, Schaumburg, IL. July 30, 2013. 20 attendees, mostly managers and agency personnel.

Brady, V. and D. Uzarski. 2013. Great Lakes Coastal Wetland Fish and Invertebrate Condition. Midwestern State Wetland Managers Meeting, Kellogg Biological Station, Gull Lake, MI, October 31, 2013. 40 attendees; Great Lakes state wetland managers.

Brady, V., D. Uzarski, T. Brown, G. Niemi, M. Cooper, R. Howe, N. Danz, D. Wilcox, D. Albert, D. Tozer, G. Grabas, C. Ruetz, L. Johnson, J. Ciborowski, J. Haynes, G. Neuderfer, T. Gehring, J. Gathman, A. Moerke, G. Lamberti, C. Normant. 2013. A Biotic Monitoring Program for Great Lakes Coastal Wetlands. Society of Wetland Scientists annual meeting, Duluth, MN, June 2013. 25 attendees, mostly scientists, some agency personnel.

Brady, V., D. Uzarski, T. Brown, G. Niemi, M. Cooper, R. Howe, N. Danz, D. Wilcox, D. Albert, D. Tozer, G. Grabas, C. Ruetz, L. Johnson, J. Ciborowski, J. Haynes, G. Neuderfer, T. Gehring, J. Gathman, A. Moerke, G. Lamberti, C. Normant. 2013. Habitat Values Provided by Great Lakes Coastal Wetlands: based on the Great Lakes Coastal Wetland Monitoring Project. Society of Wetland Scientists annual meeting, Duluth, MN, June 2013. 20 attendees, mostly scientists.

Cooper, M.J. Great Lakes coastal wetland monitoring: chemical and physical parameters as co-variates and indicators of wetland health. Biennial State of the Lakes Ecosystem Conference, Erie, PA, October 26-27, 2011. Oral presentation.

Cooper, M.J. Coastal wetland monitoring: methodology and quality control. Great Lakes Coastal Wetland Monitoring Workshop, Traverse City, MI, August 30, 2011. Oral presentation.

Cooper, M.J., D.G. Uzarski, and G.L. Lamberti. GLRI: coastal wetland monitoring. Michigan Wetlands Association Annual Conference, Traverse City, MI, August 30-September 2, 2011. Oral presentation.

Cooper, M.J. Monitoring the status and trends of Great Lakes coastal wetland health: a basin-wide effort. Annual Great Lakes Conference, Institute of Water Research, Michigan State University, East Lansing, MI, March 8, 2011. Oral presentation.

Cooper, M.J., G.A. Lamberti, and D.G. Uzarski. Monitoring ecosystem health in Great Lakes coastal wetlands: a basin-wide effort at the intersection of ecology and management. Entomological Society of America, Reno, NV, November 13-16, 2011. Oral presentation

Cooper, M.J., and G.A. Lamberti. Taking the pulse of Great Lakes coastal wetlands: scientists tackle an epic monitoring challenge. Poster session at the annual meeting of the National Science Foundation Integrative Graduate Education and Research Traineeship Program, Washington, D.C., May 2012. Poster presentation.

Cooper, M.J., J.M. Kosiara, D.G. Uzarski, and G.A. Lamberti. Nitrogen and phosphorus conditions and nutrient limitation in coastal wetlands of Lakes Michigan and Huron. Annual meeting of the International Association for Great Lakes Research. Cornwall, Ontario. May 2012. Oral presentation.

Cooper, M.J., G.A. Lamberti, and D.G. Uzarski. Abiotic drivers and temporal variability of Saginaw Bay wetland invertebrate communities. International Association for Great Lakes Research, 56th annual meeting, West Lafayette, IN. June 2013. Oral presentation.

Cooper, M.J., D.G. Uzarski, J. Sherman, and D.A. Wilcox. Great Lakes coastal wetland monitoring program: support of restoration activities across the basin. National Conference on Ecosystem Restoration, Chicago, IL. July 2013. Oral presentation.

Cooper, M.J. and J. Kosiara. Great Lakes coastal wetland monitoring: Chemical and physical parameters as co-variates and indicators of wetland health. US EPA Region 5 Annual Wetlands Program Coordinating Meeting and Michigan Wetlands Association Annual Meeting. Kellogg Biological Station, Hickory Corners, MI. October 2013. Oral presentation.

Cooper, M.J. Implementing coastal wetland monitoring. Inter-agency Task Force on Data Quality for GLRI-Funded Habitat Projects. CSC Inc., Las Vegas, NV. November 2013. Web presentation, approximately 40 participants.

Cooper, M.J. Community structure and ecological significance of invertebrates in Great Lakes coastal wetlands. SUNY-Brockport, Brockport, NY. December 2013. Invited seminar.

Cooper, M.J. Great Lakes coastal wetlands: ecological monitoring and nutrient-limitation. Limno-Tech Inc., Ann Arbor, MI. December 2013. Invited seminar.

Cooper, M.J., D.G. Uzarski, and V.J. Brady. A basin-wide Great Lakes coastal wetland monitoring program: Measures of ecosystem health for conservation and management. Great Lakes Wetlands Day, Toronto, Ont. Canada, February 4, 2014. Oral presentation.

Danz, N.P. 2014. Floristic quality of Wisconsin coastal wetlands. Oral presentation at the Wisconsin Wetlands Association 19th Annual Wetlands Conference, LaCrosse, WI. Audience mostly scientists.

Dumke, J.D., V.J. Brady, J. Ciborowski, J. Gathman, J. Buckley, D. Uzarski, A. Moerke, C. Ruetz III. 2013. Fish communities of the upper Great Lakes: Lake Huron's Georgian Bay is an outlier. Society for Wetland Scientists, Duluth, Minnesota. 30 attendees, scientists and managers.

Dumke, J.D., V.J. Brady, R. Hell, A. Moerke, C. Ruetz III, D. Uzarski, J. Gathman, J. Ciborowski. 2013. A comparison of St. Louis River estuary and the upper Great Lakes fish communities (poster). Minnesota American Fisheries Society, St. Cloud, Minnesota. Attendees scientists, managers, and agency personnel.

Dumke, J.D., V.J. Brady, R. Hell, A. Moerke, C. Ruetz III, D. Uzarski, J. Gathman, J. Ciborowski. 2013. A comparison of wetland fish communities in the St. Louis River estuary and the upper Great Lakes. St. Louis River Estuary Summit, Superior, Wisconsin. 150 attendees, including scientists, managers, agency personnel, and others.

Dumke, J.D., V.J. Brady, J. Erickson, A. Bracey, N. Danz. 2014. Using non-degraded areas in the St. Louis River estuary to set biotic delisting/restoration targets. St. Louis River Estuary Summit, Superior, Wisconsin. 150 attendees, including scientists, managers, agency personnel, and others.

Gathman, J.P. 2013. How healthy are Great Lakes wetlands? Using plant and animal indicators of ecological condition across the Great Lakes basin. Presentation to Minnesota Native Plant Society. November 7, 2013.

Gilbert, J.M., N. Vidler, P. Cloud Sr., D. Jacobs, E. Slavik, F. Letourneau, K. Alexander. 2014. *Phragmites australis* at the crossroads: Why we cannot afford to ignore this invasion. Great Lakes Wetlands Day Conference, Toronto, ON, February 4, 2014.

Gilbert, J.M. 2013. Phragmites Management in Ontario. Can we manage without herbicide? Webinar, Great Lakes *Phragmites* Collaborative, April 5, 2013.

Gilbert, J.M. 2012. *Phragmites australis*: a significant threat to Laurentian Great Lakes Wetlands, Oral Presentation, International Association of Great Lakes Wetlands, Cornwall, ON, May 2012

Gilbert, J.M. 2012. *Phragmites australis:* a significant threat to Laurentian Great Lakes Wetlands, Oral Presentation to Waterfowl and Wetlands Research, Management and Conservation in the Lower Great Lakes. Partners' Forum, St. Williams, ON, May 2012.

Gnass-Giese, E. E., R. Howe, A. Wolf, N. Miller, and N. Walton. An ecological index of forest health based on breeding birds. 2013. Webpage: http://www.uwgb.edu/biodiversity/forest-¬-index/

Gurholt, C.G. and D.G. Uzarski. 2013. Into the future: Great Lakes coastal wetland seed banks. IGLR Graduate Symposium, Central Michigan University, Mt. Pleasant, MI. March.

Gurholt, C.G. and D.G. Uzarski. 2013. Seed Bank Purgatory: What Drives Compositional Change of Great Lakes Coastal Wetlands. 56th International Association for Great Lakes Research Conference, Purdue University, West Lafayette, IN. June.

Howe, R.W., R.P. Axler, V.J. Brady, T.N. Brown, J.J.H. Ciborowski, N.P. Danz, J.P. Gathman, G.E. Host, L.B. Johnson, K.E. Kovalenko, G.J. Niemi, and E.D. Reavie. 2012. Multi-species indicators of ecological condition in the coastal zone of the Laurentian Great Lakes. 97th Annual Meeting of the Ecological Society of America. Portland, OR.

Kosiara, J.M., M.J. Cooper, D.G. Uzarski, and G.A. Lamberti. 2013. Relationships between community metabolism and fish production in Great Lakes coastal wetlands. International Association for Great Lakes Research, 56th annual meeting. June 2-6, 2013. West Lafayette, IN. Poster presentation.

Lamberti, G.A., D.G. Uzarski, V.J. Brady, M.J. Cooper, T.N. Brown, L.B. Johnson, J.H. Ciborowski, G.P. Grabas, D.A. Wilcox, R.W. Howe, and D.C. Tozer. 2013. An integrated monitoring program for Great Lakes Coastal wetlands. Society for Freshwater Science, Jacksonville, FL.

Lamberti, G.A., D.G. Uzarski, V.J. Brady, M.J. Cooper, T.N. Brown, L.B. Johnson, J.J. Ciborowski, G.P. Grabas, D.A. Wilcox, and R.W. Howe. An integrated monitoring program for Great Lakes coastal wetlands. Society for Freshwater Science Annual Meeting. Jacksonville, FL. May 2013. Poster presentation.

Lamberti, G.A. Pacific Salmon in Natal Alaska and Introduced Great Lakes Ecosystems: The Good, the Bad, and the Ugly. Department of Biology, Brigham Young University. Dec 5, 2013. Invited seminar.

Langer, T.A., K. Pangle, B.A. Murray, and D.G. Uzarski. 2014. Beta Diversity of Great Lakes Coastal Wetland Communities: Spatiotemporal Structuring of Fish and Macroinvertebrate Assemblages. American Fisheries Society, Holland, MI. February.

Langer, T., K. Pangle, B. Murray, D. Uzarski. 2013. Spatiotemporal influences, diversity patterns and mechanisms structuring Great Lakes coastal wetland fish assemblages. Poster. Institute for Great Lakes Research 1st Symposium, MI. March.

Mudrzynski, B.M., D.A. Wilcox, and A. Heminway. 2012. Habitats invaded by European frogbit (Hydrocharis morsus-ranae) in Lake Ontario coastal wetlands. INTECOL/Society of Wetland Scientists, Orlando, FL.

Mudrzynski, B.M., D.A. Wilcox, and A.W. Heminway. 2013. European frogbit (Hydrocharis morsus-ranae): current distribution and predicted expansion in the Great Lakes using niche-modeling. Society of Wetland Scientists, Duluth, MN.

Schmidt, N. C., Schock, N., and D. G. Uzarski. 2013. Modeling macroinvertebrate functional feeding group assemblages in vegetation zones of Great Lakes coastal wetlands. International Association for Great Lakes Research Conference, West Lafayette, IN. June.

Schmidt, N.C., N.T. Schock, and D.G. Uzarski. 2014. Influences of metabolism on macroinvertebrate community structure across Great Lakes coastal wetland vegetation zones. Great Lakes Science in Action Symposium, Central Michigan University, Mt. Pleasant, MI. April.

Schock, N.T. and D.G. Uzarski. Stream/Drainage Ditch Impacts on Great Lakes Coastal Wetland Macroinvertebrate Community Composition. 55th International Conference on Great Lakes Research, Cornwall, Ontario.

Schock N.T., Uzarski D.G., 2013. Habitat conditions and macroinvertebrate communities of Great Lakes coastal habitats dominated by wet meadow, Typha spp. and Phragmites australis: implications of macrophyte structure changes. International Association for Great Lakes Research Conference, West Lafayette, IN. June.

Schock, N.T., B.A. Murry, D.G. Uzarski 2014. Impacts of agricultural drainage outlets on Great Lakes coastal wetlands. Great Lakes Science in Action Symposium, Central Michigan University, Mt. Pleasant, MI. April.

Schoen, L.S., J.J. Student, and D.G. Uzarski. 2014. Reconstruction of fish movements between Great Lakes coastal wetlands. American Fisheries Society, Holland, MI. February.

Sherman, J.S., T.A. Clement, N.T. Schock, and D.G. Uzarski. 2012. A comparison of abiotic and biotic parameters of diked and adjacent open wetland complexes of the Erie Marsh Preserve. 55th International Conference on Great Lakes Research, Cornwall, Ontario.

Sherman, J.J., and D.G. Uzarski. 2013. A Comparison of Abiotic and Biotic Parameters of Diked and Adjacent Open Wetland Complexes of the Erie Marsh Preserve. 56th International Conference on Great Lakes Research, West Lafayette, IN. June.

Smith, D.L., M.J. Cooper, J.M. Kosiara, and G.A. Lamberti. 2013. Heavy metal contamination in Lake Michigan wetland turtles. International Association for Great Lakes Research, 56th annual meeting. June 2-6, 2013. West Lafayette, IN. Poster presentation.

Unitis, M.J., B.A. Murry and D.G. Uzarski. 2012. Use of coastal wetland types by juvenile fishes. Ecology and Evolutionary Ecology of Fishes, Windsor, Ontario. June 17-21.

Uzarski, D.G. 2011. Great Lakes Coastal Wetland Monitoring for Restoration and Protection: A Basin-Wide Effort. State Of the Lakes Ecosystem Conference (SOLEC). Erie, Pennsylvania. October 26.

Uzarski, D.G. 2011. Coastal Wetland Monitoring: Background and Design. Great Lakes Coastal Wetland Monitoring Meeting. MDEQ; ASWM. Acme, Michigan. August 29.

Uzarski, D.G., N.T. Schock, T.A. Clement, J.J. Sherman, M.J. Cooper, and B.A. Murry. 2012. Changes in Lake Huron Coastal Wetland Health Measured Over a Ten Year Period During Exotic Species Invasion. 55th International Conference on Great Lakes Research, Cornwall, Ontario.

Uzarski, D.G., M.J. Cooper, V.J. Brady, J. Sherman, and D.A. Wilcox. 2013. Use of a basin-wide Great Lakes coastal wetland monitoring program to inform and evaluate protection and restoration efforts. International Association for Great Lakes Research, West Lafayette, IN. (INVITED)

Uzarski, D.G. 2013. A Basin Wide Great Lakes Coastal Wetland Monitoring Plan. Region 5 State and Tribal Wetlands Meeting: Focusing on Wetland Monitoring and Assessment around the Great Lakes. October 31. Kellogg Biological Station, Hickory Corners, MI.

Uzarski, D.G. 2013. Great Lakes Coastal Wetland Assessments. Lake Superior Cooperative Science and Monitoring Workshop. September 24-25. EPA Mid-Continent Ecology Division Lab, Duluth, MN.

Uzarski, D.G. 2013. A Basin-Wide Great Lakes Coastal Wetland Monitoring Program. 5th National Conference on Ecosystem Restoration. July 29-August 2. Schaumburg, IL.

Uzarski, D.G., Cooper, M.J., Brady, V., Sherman, J.J., and D.A. Wilcox. 2013. Use of a Basin Wide Great Lakes Coastal Wetland Monitoring Program to inform and Evaluate Protection and

Restoration Efforts. 56th International Conference on Great Lakes Research, West Lafayette, IN.

Uzarski, D., M. Cooper and V. Brady. 2014. Implementing a Basin-wide Great Lakes Coastal Wetland Monitoring Program. Webinar for Sustain Our Great Lakes, Jan. 29, 2014. On-line webinar for Great Lakes researchers, managers, agency personnel, and environmental groups. Attendance approximately 400.

Walton, N.G., E.E.G. Giese, R.W. Howe, G.J. Niemi, N.P. Danz, V.J. Brady, T.N. Brown, J.H. Ciborowski, J.P. Gathman, G.E. Host, L.B. Johnson, E.D. Reavie, and K.E. Kovalenko. 2013. How do different taxa respond to landscape stressors in Great Lakes coastal wetlands? 98th Annual Meeting of the Ecological Society of America. Minneapolis, MN, August 4-9.

Webster, W.C. and D.G. Uzarski. 2012. Impacts of Low Water level Induced Disturbance on Coastal Wetland Vegetation. 55th International Conference on Great Lakes Research, Cornwall, Ontario.

Wheeler, R. and D.G. Uzarski. 2012. Spatial Variation of Macroinvertebrate Communities within Two Emergent Plant Zones of Great Lakes Coastal Wetlands. 55th International Conference on Great Lakes Research, Cornwall, Ontario.

Wheeler, R.L. and D.G. Uzarski. 2013. Effects of Vegetation Zone Size on a Macroinvertebrate-based Index of Biotic Integrity for Great Lakes Coastal Wetlands. 56th International Conference on Great Lakes Research, West Lafayette, IN. June.

Wilcox, D.A. and B.M. Mudrzynski. 2011. Wetland vegetation sampling protocols under the Great Lakes Coastal Wetland Monitoring program: experience in Lake Ontario. State of the Lakes Ecosystem Conference, Erie, PA. (INVITED)

Wilcox, D.A. and B.M. Mudrzynski. 2012. Implementing Great Lakes coastal wetlands monitoring: southern Lake Ontario. SUNY Great Lakes Research Consortium Conference, Oswego, NY. (INVITED)

Wilcox, D.A. 2012. Wetland restoration options under the Great Lakes Restoration Initiative. SUNY Great Lakes Research Consortium Conference, Oswego, NY. (INVITED)

Wilcox, D.A., D.G. Uzarski, V.J. Brady, M.J. Cooper, and T.N. Brown. 2013. Great Lakes coastal wetland monitoring program assists restoration efforts. Fifth World Conference on Ecological Restoration, Madison, WI.

Wilcox, D.A., D.G. Uzarski, V.J. Brady, M.J. Cooper, and T.N. Brown. 2014. Wetland restoration enhanced by Great Lakes coastal wetland monitoring program. Society of Wetland Scientists, Portland, OR.

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Gnass-Giese, E.E., R.W. Howe, A.T. Wolf, N.A. Miller, and N.G. Walton. 2014. Sensitivity of breeding birds to the "human footprint" in western Great Lakes forest landscapes. In review.

Howe, R.W., R. R. Regal, J.M. Hanowski, G.J. Niemi, N.P. Danz, and C.R. Smith. 2007a. An index of ecological condition based on bird assemblages in Great Lakes coastal wetlands. Journal of Great Lakes Research 33 (Special Issue 3): 93-105.

Howe, R.W., R. R. Regal, G.J. Niemi, N.P. Danz, J.M. Hanowski. 2007b. A probability-based indicator of ecological condition. Ecological Indicators 7:793-806.

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